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REVIEW OF THE FOOD IRRADIATION PROGRAM

GOVERNMENT
Storage

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH, DEVELOPMENT, AND RADIATION

OF THE

JOINT COMMITTEE ON ATOMIC ENERGY CONGRESS OF THE UNITED STATES

EIGHTY-NINTH CONGRESS

SECOND SESSION

ON

REVIEW OF THE FOOD IRRADIATION PROGRAM

SEPTEMBER 12, 1966

Printed for the use of the Joint Committee on Atomic Energy

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REVIEW OF THE FOOD IRRADIATION PROGRAM

MONDAY, SEPTEMBER 12, 1966

CONGRESS OF THE UNITED STATES,
SUBCOMMITTEE ON RESEARCH, DEVELOPMENT, AND
RADIATION, JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C.

The Joint Committee met at 10 a.m., pursuant to call, in room AE–1, the Capitol, Representative Melvin Price (chairman of the subcommittee) presiding.

Present: Representatives Price (chairman of the subcommittee), Holifield, and Hosmer; Senators Hickenlooper and Aiken.

Also present: John T. Conway, executive director; Edward J. Bauser, assistant director; Leonard M. Trosten, staff counsel; George F. Murphy, Jr., national security affairs; Jack Rosen, staff consultant; and William T. England, professional staff member.

Representative PRICE (presiding). The committee will be in order. Today we plan to review developments in the food irradiation programs which have occurred in the 15 months since our hearings of June 1965 on this subject.

COMMERCIALIZATION PHASE

In the spring of 1965, I stated that—

> In my view the next significant milestone that lies ahead is the achievement of what might be termed the commercialization of the food irradiation process.

We have not quite gotten to that milestone as yet.

We hope, however, to hear today from the Atomic Energy Commission, the Department of Commerce, and the Department of the Army about their plans to build a pilot-plant irradiation facility that will lead us into the commercialization phase.

I would like to take a moment to put this important program in its proper perspective. Large sums of Government funds are not being expended on this program, but we should not therefore conclude that this activity has little importance.

IMPORTANCE OF FOOD PRESERVATION

On the contrary, we must remember that approximately 25 percent of all the money spent by the individual consumer in the United States is for food. As high as this percentage is in this country an even higher percentage of the national product is spent on food in other nations of the world.

Clearly there is no more important item to the welfare of the people of the world than food. This is such a commonplace fact that we sel-

dom give thought to it. We should recognize that even small savings in the costs of food or savings in the amount of effort that must go into the preservation of food means great economic benefits to people everywhere and in particular to people who are on the threshold of starvation, as much of the world is.

Of course, there is another very important aspect concerning the preservation of food. All methods of preservation must be such as to assure the maintenance of the nutritional value after processing. Radiation in contrast to some other methods of processing does indeed preserve nutritional value.

Even an affluent society like our own has a real concern about spoilage and wastage of food and the preservation of nutritional value. Not only because food represents such a significant part of the individual's budget but because of the special situations that our country faces in providing our soldiers and our allies with nutritious food on a regular basis and under such adverse conditions as we are now experiencing in South Vietnam.

It does not take a cost-analysis type to figure out that if the shelf life of foods can be extended by several days or weeks, the logistics of providing for an army 7,000 miles from home can be decreased markedly—and we should remember the more important issues; namely, that health and morale are significantly enhanced.

My generation was taught, and I hope that it is still being taught, that it is a sin to waste food. I would extend that concept to the point of saying that a failure to utilize existing technology to prevent wastage and spoilage of food in a hungry world is also morally wrong.

REQUEST FOR PROGRAM REVIEW

Commissioner Ramey, would you please begin the formal testimony and tell us what the Atomic Energy Commission has accomplished in its food irradiation program during the past 15 months and where we stand relative to the building of a pilot plant irradiation facility that we talked about last June? Commissioner Nabrit, we are also very pleased to have you with us this morning as well.

I would like to state before we start the testimony that Congressman Bates, one of the members who has been very much interested in the food irradiation program over the years is necessarily absent—I say necessarily because there is an election in Massachusetts tomorrow—and only a circumstance like that could keep Mr. Bates away from one of these food irradiation hearings.

He has asked me to especially bring up two items on which he would like the Government witnesses to comment on.

PILOT PLANT IRRADIATOR

1. What actions does the U.S. Army intend to take to establish a pilot plant stage for irradiated foods?

I am posing these questions now so that the witnesses can touch on them automatically when they appear.

2. Specifically, what will the Army do now to foster the construction of the pilot plant meat irradiator?

FOOD AND DRUG ADMINISTRATION PROCEDURES

1. Does the Food and Drug Administration in its inquiry into the safety of irradiated food and the claims of the effectiveness of the process involve itself in the economics of the process?

2. Does FDA have a staff to look into the economics of the various processes or products they review?

3. Does it make any difference to the final approval or disapproval by the FDA as to what the costs of the irradiation process is as long as it is safe and effective?

When the Food and Drug Administration testifies I want them to bear in mind the questions that Mr. Bates would like to have some answers to.

Representative HOSMER. Mr. Chairman?

Representative PRICE. Mr. Hosmer.

INDUSTRIAL INTEREST IN FOOD IRRADIATION

Representative HOSMER. I would like to add that in connection with the hearings last time it became obviously apparent that the food industry of the United States was totally disinterested in spending any kind of money at all for these newer processes and insofar as the program is concerned from the military standpoint, perhaps there is justification to take care of the health and morale of the servicemen and keep them off K rations.

But unless this testimony brings forth that the industry itself has had some change of heart since last year and has come closer to the attitude of other industries that have come into the atomic field and are willing to put up their own funds, this program will probably be limited and constricted to that of a military nature for some time so far as my outlook on it is concerned.

Representative PRICE. I might state that we may have some interesting testimony along that line this afternoon from some of the industry representatives who have asked to be heard.

Representative HOSMER. They ought to come in 180 degrees away as compared to the way they came in last year.

Representative PRICE. Mr. Ramey, will you proceed with your statement?

STATEMENT OF JAMES T. RAMEY, COMMISSIONER, ACCOMPANIED BY DR. SAMUEL M. NABRIT, COMMISSIONER; R. E. HOLLINGSWORTH, GENERAL MANAGER; DR. SPOFFORD G. ENGLISH, ASSISTANT GENERAL MANAGER FOR RESEARCH AND DEVELOPMENT; DR. CHARLES L. DUNHAM, DIRECTOR OF DIVISION OF BIOLOGY AND MEDICINE; AND E. EUGENE FOWLER, DIRECTOR, DIVISION OF ISOTOPES DEVELOPMENT, ATOMIC ENERGY COMMISSION

Mr. RAMEY. I should like, Mr. Chairman, to express our appreciation for this opportunity to report to you on our accomplishments and plans in the Atomic Energy Commission food irradiation program since June 1965.

In addition to Commissioner Nabrit, we have here also our General Manager, Mr. Hollingsworth; Assistant General Manager for Research and Development, Dr. English; and Mr. Fowler, Director of our Isotopes Development Division, and also Dr. Dunham, Director of our Division of Biology and Medicine, and staff who will be available to answer questions.

As the committee will recall, my statement presented at the June 1965 hearings discussed the historical evolution of our program for development of low-dose radiation pasteurization to extend the marketable life of perishable foods.

As this information is on record, I will simply refer you to the previous hearings on this subject.

AEC OBJECTIVE FOR FOOD IRRADIATION PROGRAM

I would like, however, to restate the Atomic Energy Commission program objectives and to summarize our status as of June 1965.

From the beginning, we have stated that the objectives of the program were to conduct research on a relatively few foods and to bring them to the point of technical and practical feasibility. This included the establishment of wholesomeness and safety of such foods.

In general, our main efforts have been concerned with selected seafoods and fruits. We have tried, as we indicated in our original position statement, to proceed with the program as rapidly as is consistent with the state of the art and requirements for sound scientific research.

As a basis for orientation, I would like also to summarize the program status at the time of the last hearings. The seafood products in our program were responding well to radiation and we were at the point of submitting a clearance petition to the Food and Drug Administration. A number of fruits also were showing excellent response and animal feeding studies were about to begin.

The marine products development irradiator at Gloucester, Mass., had just become operational and preparations were underway for large-scale shipping, storage, and distribution tests through commercial channels. A number of packaging materials had been cleared by the FDA. Clearances for other packaging materials, as well as oranges, were under evaluation by the FDA. Finally, private industry interest and participation in food irradiation appeared to be accelerating.

CURRENT STATUS

With this as a point of departure, I will now outline our present status in the aforementioned areas. Let me point out that we are maintaining a continuing effort to define conditions for obtaining optimum product quality consistent with good process economics so I will limit my testimony to discussing highlights and special areas of interest.

It has been well confirmed that irradiation of fish and fruit should take place as soon after harvest or catch as possible. We have been concerned, therefore, about the time delay prior to irradiation under conditions of commercial practice.

Fresh fish, for example, is often landed a week or more after catch. Several surveys, however, have led us to believe that at least 70 percent of the fresh catch landed would be suitable for radiation treatment.

Accordingly, we feel the technology for the marine products on which we are working is sufficiently complete to permit us to devote primary efforts toward commercialization. I will discuss these efforts in a later section.

Significant progress has been made in developing techniques for avoiding textural damage in fruits which sometimes results from the levels of radiation required for effective rot and mold control.

Recent work with peaches and nectarines, for example, has demonstrated that a combination of hot water dip plus a radiation dose one-half of that previously required will result in equally effective control without textural damage.

This new technique is important because it will permit an extended shelf life and reduction in spoilage for these relatively high-cost foods.

Animal feeding (toxicity) studies on strawberries, apples, pears, sweet cherries, apricots, plums, and onions have been completed. These studies revealed no differences of biological importance between animals fed rations containing high amounts of the irradiated and non-irradiated test foods.

No significant biological differences have been detected to date in animals which are currently involved in long-term, chronic toxicity studies on irradiated softshell clams.

Long-term studies on irradiated bananas were recently initiated. Short-term animal feeding studies on irradiated mangoes and papayas will be initiated in the near future. Nutritional investigations on irradiated marine products have revealed no impairment of the biological quality and availability of protein.

IRRADIATION OF FISH FILLETS

Jointly with the Army, the Atomic Energy Commission filed a petition with the Food and Drug Administration in September 1965 requesting clearance for six marine products: fillets of haddock, pollack, ocean perch, cod, flounder, and sole.

The petition provides for processing by cobalt 60, cesium 137, 10 Mev electrons or 5 Mev X-rays. FDA has reviewed the petition, and we have agreed to furnish additional information related to efficacy and to microbiology.

Efficacy tests consist of shipping and storage tests of commercial-sized lots through commercial channels, with evaluation testing at appropriate points. Microbiological testing involves additional inoculated pack studies with *Clostridium botulinum*, type E. We estimate that we can provide the requested information in approximately 6 to 9 months.

IRRADIATION OF FRUITS

Last May, the FDA accepted for filing an AEC petition requesting clearance for irradiated strawberries using either cobalt 60 or cesium 137. We are hopeful that a clearance will be issued in the near future.

The most recent action concerning the petition regarding oranges, filed with the FDA in December 1963, is our provision last month

of supplemental data concerning commercial-type shipping and storage studies as requested by FDA.

We hope that positive action can now be taken on this petition, but if additional data of this nature is requested, it will be necessary to wait for the next growing season.

Furthermore, since our original work on this product, improvements in sanitation in handling California oranges have largely eliminated the need even for chemical treatment in that State. A need for irradiation does exist in Florida in connection with the control of stem end rot. There is a strong emphasis in Europe on the elimination of chemical treatment of foods (for example, biphenyl, used for mold control on oranges).

Radiation may prove to be an acceptable alternative which could permit the United States to maintain its export position.

PACKAGING MATERIALS AND OTHER PETITIONS

Since the last hearings, we have also obtained clearance for one additional packaging material from the FDA and have submitted three new petitions. The latter are under review.

I have attached, as appendix 1, a chart which summarizes all of our petition submissions and clearances as of this date.

Within the next 12 to 18 months, we expect to file petitions with FDA for onions, papayas, mangoes, shrimp, and soft-shelled clams.

With regard to the two fishery products, it may prove to be desirable to withhold submission of these petitions until the uncertainties regarding the petition now filed on six species of ocean fish fillets are resolved, particularly with reference to *Clostridium botulinum*, type E.

Additional petitions are planned for submission beginning calendar year 1968. For example, tomatoes are presently marketed at a more mature stage than formerly, and therefore, shelf-life extension by irradiation is a promising commercial application.

As we previously reported, irradiation of bananas, through inhibition of ripening, can double the shelf life of the Gros Michel variety.

However, a new variety of banana, the Valery, has been developed, and is quite resistant to spoilage during shipment. The irradiation of chicken for Salmonellae control is promising, and will form the basis for another petition.

Peaches, cherries, figs, asparagus, and mushrooms all involve interesting applications, but require further work in either the wholesomeness or technological area.

Oysters, halibut, and Dungeness crab are examples of fishery products for which petitions will also be prepared.

The FDA has recently proposed labeling requirements for both pasteurized and sterilized foods. Needless to say, we are concerned about the type of labeling requirement put into effect since this could influence consumer and industry acceptance of radiation processed foods. We have provided our comments to the FDA.

AEC AND FDA RELATIONSHIP

Let me conclude my discussion of our FDA relationships by stating that Commissioner Goddard met with Chairman Seaborg and the Commission in June to discuss the question of petition clearances.

The meeting was very useful in providing the Commission an opportunity to personally acquaint Dr. Goddard with the AEC's program and to obtain further guidance from him on FDA clearance procedures for radiation processed foods.

IRRADIATION DEVELOPMENT PROGRESS

Our irradiator development program, also discussed in some detail at the last hearings, continues to progress well. Currently, there are 12 units either in operation or under construction, which will directly support the food irradiation program.

Appendix 2 [1] is a listing of all the units, and includes their locations, descriptions, and purpose. Four of these are in the semicommercial capacity class and I will limit my comments to their status and functions.

A major purpose of these units is to support large-scale shipping, storage, and distribution tests of various products, in conjunction with private industry using commercial channels.

Additionally, these units permit the scaling up of laboratory research to near-commercial conditions thereby providing more realistic economic data. These irradiators also serve as a demonstration to industry of the practical feasibility of the process.

The first completed unit was the marine products development irradiator (MPDI), located in Gloucester, Mass., and operated for the AEC by the Bureau of Commercial Fisheries.

Use of this facility since its operational availability in March 1965 has gone according to plan. Cooperative efforts are being carried out with a number of industrial firms for large-scale shipping and storage tests. Results of these tests have been highly encouraging and will be discussed later in this statement.

The mobile gamma irradiator (MGI) is now located at the Davis campus of the University of California. This unit will permit a radiation capacity, heretofore lacking, for similar testing with fruits and vegetables. Our immediate goal was to get the unit into operation before the conclusion of the strawberry season. This has been done.

The grain products irradiator, located in Savannah, Ga., will be in full operation this fall. Both bulk and packaged grain products can be handled by this facility, which in this case, is directed toward insect control and disinfestation.

We would like to point out that the U.S. Department of Agriculture has contributed to the construction of the irradiator, and is primarily responsible for supporting its operation and associated work.

Representative PRICE. Who operates it?

Mr. FOWLER. The Department of Agriculture operates it, Mr. Price.

Mr. RAMEY. Prospects for use of radiation for preservation of tropical fruits has resulted in a cooperative program with the State of Hawaii. We are now constructing the Hawaii development irradiator, with a capacity to meet near-commercial-scale requirements for such products as papayas and mangoes. The State of Hawaii has provided the site and is presently constructing the building and supporting laboratories associated with the irradiator. They will also share the cost of the operation.

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[1] See page 12.

Barring unforeseen delays, completion of the irradiator will be early next year.

PRIVATE INDUSTRY INTEREST

Let me now turn to a discussion of private industry interest and activities. We feel such interest is growing significantly. At the same time, we would have to say that the food industry will not make heavy commitments to this new food processing method until a greater number of food clearances have been issued by the FDA.

Nevertheless, a number of individual food companies are actively cooperating with us in carrying out important aspects of our program which must precede commercial use.

For example, commercial transportation channels have been used to send irradiated and nonirradiated haddock fillets to principal seafood buyers of interested chainstores and other industry members located hundreds of miles away from our irradiator. As their contribution these experienced people tested the fillets over a period of time against their own commercial quality control standards.

Eight major food chains have participated in these tests and all have reported that the irradiated fillets continued to be acceptable for 6 to 14 days after the nonirradiated ones were no longer marketable.

It is interesting to note that when we start to speak to the buyers about the market potential of irradiated seafoods, they interrupt to tell us just what irradiated seafoods can do for them. Invariably, they want to know when seafoods will be cleared for sale. Some of these food chains have offered to make their supermarkets available for test marketing at the consumer level. This is the usual way of finding consumer attitudes, reactions and, most importantly, volume of repeat sales.

PORTABLE CESIUM IRRADIATOR

In cooperation with interested food processors and other industrial concerns, we plan to utilize a portable cesium irradiator for the purpose of on-site irradiation of products of interest to particular companies. In return for use of the irradiator, the companies will provide us the results of their tests.

The unit will be operational by this winter. Even though we have not yet publicly solicited industry participation, there are already over a dozen companies which have requested its use.

In developing a use schedule, we will give priority first to these companies which are processing products already cleared by FDA, or for which clearance has been requested.

PILOT PLANT MEAT IRRADIATOR

A subject of immediate interest to this committee is the pilot plant meat irradiator project. I will dwell on this only to the extent of stating the Commission's position since other witnesses will discuss the project in detail.

From the time the Army approached us to cooperate with them

under the aegis of the Department of Commerce, we have strongly supported this concept. This year we received congressional authorization of appropriation which will enable us to provide $170,000 for engineering and design assistance, as well as $230,000 for source procurement.

The concept of an industry built and operated plant with some Government encouragement is one which we strongly support. We also endorse the recommendations of the task force which studied this project, particularly the need for large volume procurement by the Department of Defense during the first few years.

It is our belief, too, that even during the first year, some capacity should be reserved for commercial activities. We are confident that if the recommended procurement levels in the task force report are met, there will be strong industry interest in the project.

In cooperation with the Department of the Army and the Department of Commerce, we are preparing to proceed expeditiously to solicit formal industry proposals upon approval of the task force recommendations by the concerned agencies.

In conclusion, I would like to emphasize that the low-dose radiation preservation of foods program has the full support and interest of the Commission. I would like to introduce for the record—appendix 3 [1]—the exchange of letters between Representative Price and Chairman Seaborg relating to this subject.

FUTURE OF PROGRAM

We are, of course, subject to fiscal limitations, and as I indicated in my testimony in June 1965, we must make a good case to justify continuing the program.

In this connection, we are having a cost-benefit analysis of the program prepared by a private firm, Daniel Yankelovich, Inc. For selected food items, this study is comparing the costs of bringing radiation pasteurization to full commercialization with the benefits, both tangible and intangible, which could be expected to accrue from the process. The completion date for the final report on this study is October 15, 1966. (See Extracts, app. 12, p. 281.)

At last year's hearings, I also stated that the program emphasis was changing to undertake activities designed to foster early commercialization of this technology. I believe that our program today fully reflects that statement of plans.

It is our intent to continue to emphasize the commercialization of this technology with confidence that radiation pasteurization of foods will play an important role in our economy.

That concludes my formal statement, Mr. Price. I would also mention that we have had active cooperation with the Department of Commerce and Department of the Army and the Bureau of Commercial Fisheries and other Government agencies in undertaking this program.

Representative PRICE. Thank you, Mr. Ramey, for your interesting statement. With your statement the record will include the appendixes you have offered.

(The documents referred to follow:)

[1] See p. 13.

APPENDIXES TO COMMISSIONER RAMEY'S STATEMENT

APPENDIX 1

Regulations and petitions on radiation preservation of foods

Product	Petitioner	Source	Dose	FDA petition			FDA regulation			Remarks
				Filing date	Reference, Federal Register		Issue date	Reference, Federal Register		
					Volume	Page		Volume	Page	
Bacon	U.S. Army	Cobalt 60	4.5–5.6 megarads	Aug. 17, 1962	28	8214	Feb. 8, 1963	28	1465	
Do	General Electric	5 Mev electron	do	June 5, 1963	28	5537	Aug. 30, 1963	28	9526	
Do	U.S. Army	10 Mev electron	do	Aug. 23, 1963	28	9329	Apr. 21, 1965	30	5631	
Do	AEC	Cesium 137	do	Dec. 18, 1963	28	13797	Apr. 1, 1964	29	4672	
Do	Radiation Dynamics, Inc.	X-rays from 5 Mev electron.	do	July 23, 1964	29	9910	Dec. 19, 1964	29	18056	
Wheat, wheat products	Brownell, et al	Gamma 22 Mev	20,000–50,000 rads	Oct. 4, 1962	28	1465	Aug. 21, 1963	28	9208	
Do	High voltage Engineer Corp.	5 Mev electron	do	Dec. 18, 1963	28	13797	Feb. 26, 1966	31	3196	
Do	AEC	Cesium 137	do	Sept. 1, 1964	29	12481	Oct. 10, 1964	29	14027	

White potato	do	do	5,000–10,000 rads	Apr. 1, 1964	29	12481	do	29	14027	
Do	U.S. Army	Cobalt 60, Cesium 137	do	Jan. 30, 1965	30	1013	do	29	14027	
Do	do	Cobalt 60	do	June 6, 1963	28	5588	July 8, 1964	29	9329	
Do	do	Cobalt 60, Cesium 137	15,000 rads	Jan. 30, 1965	30	1013	Nov. 9, 1965	30	11801	
Strawberries	AEC	Cobalt 60, cesium 137	100,000–250,000 rads	May 18, 1966	31	7256				Pending.
Citrus (oranges, lemons, grapefruit).	AEC/US Army	do	75,000–500,000 rads	Dec. 26, 1963	28	13797				Pending; see amendment.
Citrus (oranges)	do	do	75,000–300,000 rads							Amendment to citrus; submitted for filing May 4, 1965.
Marine products (haddock, pollock, ocean perch, cod, flounder, and sole).	do	Cobalt 60, cesium 137, 10 Mev electron, 5 Mev X-rays.	100,000–200,000 rads	Sept. 15, 1965	30	11801				Pending.
Packaging materials 9 classes of materials.	AEC	Gamma	1 megarad	Feb. 8, 1964	29	2318	Aug. 14, 1964	29	11651	
PACKAGING MATERIALS AMENDMENTS										
Cellophane (Saran-coated)	do	do	do	Feb. 18, 1965	30	9116	June 11, 1965	30	7599	
Nylon	do	do	do	Sept. 8, 1965	30	11400				
Polyester (Saran-coated)	do	do	do	July 30, 1965	30	9551				Pending.
Polypropylene, (Saran-coated)	do	do	do	do	30	9551				Do.
Six films	U.S. Army	do	6 megarads	July 21, 1965	30	9116				Do.
Parchment paper	do	do	do	Jan. 15, 1965	30	547	Mar. 12, 1965	30	3354	

APPENDIX 2

Irradiators supporting the AEC food irradiation program

Type	Description	Location	Purpose	Remarks
a. Research irradiators (4 total)	35,000 curie ^{60}Co source; capacity of 75 pounds per hour at 1 megarad dose, underwater irradiation in closed containers.	MIT, University of Florida, University of Washington, University of California.	Immediate research support at the research site.	All in operation.
b. Marine products development irradiator (MPDI).	250,000 curie ^{60}Co source; capacity 1,000 pounds per hour at 0.5 megarad; 4 pass quadrant irradiator.	USDI Laboratory, Gloucester, Mass.	Semicommercial seafood irradiation testing; cooperative industry programs.	Operable in early 1965.
c. Mobile gamma irradiator (MGI).	Truck-mounted, 60 ton unit; 100,000 curie ^{60}Co; capacity 1,000 pounds per hour at 0.2 megarad.	West coast (California initially).	Wide-scale demonstration of feasibility of fruit irradiation; economic determinations. Industry participation invited.	Operable in summer 1966.
d. Grain products irradiator (GPI).	30,000 curie ^{60}Co source; capacity 5,000 pounds per hour bulk grain or 2,800 pounds per hour packaged product at 25,000 rad dose.	USDA Labs, Savannah, Ga.	Bulk or packaged product disinfestation. Industry participation invited.	Do.
e. On-ship irradiator (3 total)	30,000 curie ^{60}Co source; transportable 17 ton unit, capacity at 150 pounds per hour at 0.1 megarad.	USDI, Gloucester, Mass., USDI, Seattle, Wash., Louisiana State University.	Placement on fishing vessels for immediate irradiation after catch.	Two units operable, third undergoing installation.
f. Portable irradiator	Under design. To be a ^{137}Cs source of 150,000 curies; portable, trailer mounted unit of about 18 tons.	On-site at industry locations	Demonstration unit for use by interested food processors.	Completion scheduled for late fall 1966.
g. Hawaii development irradiator.	250,000 curie ^{60}Co source; with capacity of 4,000 pounds per hour at doses of 100,000 rad.	Honolulu, Hawaii	Semicommercial irradiation of tropical fruits; economic determinations; test marketing in cooperation with industry.	Completion scheduled for early 1967.

APPENDIX 3

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
June 2, 1966.

Hon. GLENN T. SEABORG,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR DR. SEABORG: As you know, the Atomic Energy Commission's research and development program is exceedingly broad in scope and includes a wide range of projects extending from those vital to the common defense and security of this country, to those which might be described as incidental benefits deriving from peaceful uses of atomic energy. With such a broad program involving many scientific disciplines, it is understandably difficult for the Commissioners to find the time to give detailed attention to what might be described as major development projects; let alone time for close study and management of the smaller programs.

I am writing because of a continuing interest that I have had in the AEC's Food Irradiation Program, a program which is small in terms of funds and scientific manpower in relation to many other Commission efforts. I believe, however, that this program has far-reaching significance in terms of the benefits which it holds out for mankind. We are living in a time when world food supplies are inadequate to meet the demands of the present population. Predictions for the future envision even a more dismal picture than the present one. A large fraction of the world's food supplies is continuously being lost through bacterial spoilage as the result of improper or inadequate refrigeration. In addition, large quantities of vital grain products are ruined by insect infestation.

Radiation processing of food has demonstrated its capability to sterilize, pasteurize, and disinfest food products effectively. A great deal of scientific data concerning this program have been gathered, and for the most part they are favorable. As an example of a feasible application of radiation processing to a food product, it has been demonstrated that radiation treatment of poultry and poultry products is an effective means of preventing the spread of salmonella infection. The significance of preventing the spread of this infection was highlighted by President Johnson in the January 1966 Economic Report of the President as follows:

"Foodborne diseases are being increasingly recognized as a leading cause of acute sickness in this country and probably account for more illness than all other environmental elements combined. Salmonellosis—the most serious such disease—now is much more widespread than it was 15 years ago because of inadequate controls in new methods of food production and processing."

As you know, to date, the Food and Drug Administration has approved for general consumption only irradiated bacon, grain products, and potatoes. Other petitions for irradiated foods have been before the FDA for some time, and an increasing number are in preparation for submission in the near future.

As I have already indicated I have taken a personal interest in the Food Irradiation Program throughout the years, and a similar concern has been displayed by other members of the Joint Committee. I am disappointed that I have not seen evidence of an equally strong interest in this program on the part of the Commission. In my opinion, if you as Chairman of the AEC, were to display such an interest this would have a salutary impact, particularly with respect to encouraging the prompt, as well as thorough, review of petitions submitted for radiation processed foods.

I was very pleased—and I am sure that you were too—to see the invigorating effect on the Food Irradiation Program that resulted from the Food and Drug Administration's approval, in the spring of 1963, of irradiated bacon for consumption by the general public. I am growing concerned that we may have lost the momentum which resulted from this approval, and the subsequent favorable action on grain products and potatoes. Accordingly, I urge that you devote special attention to the needs of this program in order to help assure that the pace of progress, as measured by FDA clearance of specific petitions, be commensurate with the rate of accumulation of scientific data in this new and promising field.

I would appreciate receiving any comments you may have on the views which I have expressed.

Sincerely yours,

MELVIN PRICE,
Chairman, Subcommittee on Research, Development, and Radiation.

UNITED STATES ATOMIC ENERGY COMMISSION,
Washington, D.C., June 17, 1966.

Hon. MELVIN PRICE,
Chairman, Subcommittee on Research, Development, and Radiation, Joint Committee on Atomic Energy, Congress of the United States.

DEAR MEL: I am sympathetic to the views you have expressed on the AEC's Radiation Preservation of Foods Program, and I know that the other Commissioners join me in assuring you of our enthusiasm for this promising new technology. We have every intention of continuing to support the program vigorously. In fact, I and my colleagues have stated publicly on several occasions that we look forward to the time when the benefits of this process will become available to the consumer throughout the world. Yet, we recognize the complexities our scientists face in proving beyond reasonable doubt that radiation processing of foods does not adversely affect their quality and wholesomeness.

Procedures for obtaining clearances to permit unlimited public consumption of radiation-processed foods are both laborious and expensive to carry out, particularly because each class of food product is considered independently of other classes. Thus each petition for clearance represents a new approach, usually without precedent. Our concern over this protracted matter resulted in an intensive review of the status of the program about a year ago, prior to the hearings held on the same subject by the Joint Committee. Since that time we have had occasion to review the program specifically again as part of our general review of the AEC's budget submittal to Congress. For planning purposes, we have authorized extension of the program beyond FY 1967, subject to approval by the Bureau of the Budget and Congress. We fully appreciate the situation where the exhaustive detail required to assure process efficacy and wholesomeness could not have been anticipated in the earlier years, since no ground rules for the granting of clearances had been laid down at the inception of the program. In fact, the ground rules continue to change as we progress with the technology.

More recently—in fact, two weeks ago—the Commission began making arrangements to meet with Commissioner James Goddard of the Food and Drug Administration to discuss the objectives of the AEC program and then to explore with him any means by which the granting of clearances for irradiated foods could be expedited. This is not a matter of academic interest on our part. We know that many food processors are interested in one or more facets of the program and will not commit themselves further until the clearances are obtained. At this juncture, we are unable to anticipate the outcome of the meeting with Commissioner Goddard. I will be happy to advise you of the outcome.

From the operational side, several important advances have been made recently: (1) our large mobile irradiator has been delivered to California and will soon be in operation there, processing field crops in cooperation with the farming industry; (2) ground breaking for the large Hawaii Development Irradiator is planned for July 18; (3) a solicitation of proposals for a contract to operate our fourth portable food irradiator has been made, and upon completion of the irradiator in October, it will be put into service on a cooperative basis with several industrial firms in succession. One or more of these are particularly interested in the control of Salmonellae—a point mentioned in your letter; (4) the world's first grain irradiator will be put into operation this summer, at Savannah, Georgia, and will be made available to the grain and flour industry; (5) the petition to FDA for clearance of strawberries was submitted in April.

In still another direction, our study on the cost-benefit relationships of selected parts of the food program is progressing well, and we expect that our contractor will soon be able to begin the consumer attitude survey which is an integral part of the study.

In general, the program is progressing according to plan, and the granting of more clearances would be a most timely reward for the efforts that have been expended by you, the Joint Committee, the AEC, and its contractors.

Let me say in conclusion that your letter is a further stimulus to us to accomplish our objective in the most expeditious manner possible and that your continued support of the Radiation Preservation of Foods Program will be welcomed wholeheartedly.

Cordially,

Dr. GLENN T. SEABORG,
Chairman.

FDA CLEARANCES

Representative PRICE. I note the first table gives an idea of the clearances already granted and those you expect to go further into for which requests for clearances are pending.

Mr. RAMEY. Yes, sir.

Representative PRICE. I understand FDA will later discuss some of these. Under the food and drug laws radiation of food is assumed to adulterate the food unless the radiation complies with FDA regulations.

Could you tell us if in any instance known to you food processed by radiation has induced radioactivity?

Mr. RAMEY. Mr. Price, if it is permissible, I would like to have Dr. Dunham respond to that question. He is head of our Division of Biology and Medicine. I personally don't know of any cases.

Representative PRICE. Could you do it at this point, Dr. Dunham, instead of waiting for your later appearance?

Dr. DUNHAM. I expect Mr. Fowler is more qualified for this particular question but as I understand it, as far as using cobalt sources and this sort of thing there is no induced radioactivity at all. It is only if you get into high energy radiation—above 11.8 Mev for electrons for example—that you begin to get a bit.

Representative PRICE. I would like to say that while we are eager for expediting this program as much as possible we certainly as a committee don't want to be placed in a position of pushing the Food and Drug Administration into just haphazardly approving these clearances.

We have in mind the protection of the health of the eventual consumers. Personally, I have great confidence in the Food and Drug Administration. So I want the public to be assured that when the times comes that they do clear one of these it will be safe for human consumption.

Mr. RAMEY. I think particularly from our AEC discussions with Commissioner Goddard that he has a very practical approach and he certainly looks into these things. He has no ax to grind, and I don't think the FDA has, and they will be decided on their merits.

I believe the indication is that they will try to go about these applications on as fast a schedule as possible, consistent with safety.

Representative PRICE. For instance, the first petition I think on oranges was filed in December 1963 almost 3 years ago. That is a long time. But to be certain that we are absolutely taking everything into consideration in the protection of the consumer it may not be a long time.

While it seems a long time I would rather see it take a little while longer so that when the clearance does come through there will be a great deal more certainty on the part of the public that it is a safe item for human consumption. Mr. Hosmer?

Representative HOSMER. The Supreme Court coined a phrase in connection with its school desegregation decision which was "with all deliberate speed."

I am wondering whether the Food and Drug Administration is proceeding on that basis or "with all deliberate delay"?

Mr. RAMEY. We hope that these current petitions can be considered and acted on a little faster than 10 or 12 years, Mr. Hosmer.

Representative PRICE. I am certainly not urging delay but I do have the feeling that this is a new area in food preservation. I recognize the responsibilities of the Food and Drug Administration. I think they have the confidence of the public and I certainly want them to maintain that confidence. I think everyone interested in this program feels the same way about it.

We would like to see them expedite it as much as possible but not rush into it under pressure to approve something before they have all the available information necessary to make a proper decision.

Mr. RAMEY. Yes, sir.

TESTING IRRADIATED FOOD

Representative PRICE. Of course the AEC's job is to make certain that they see to it that the Food and Drug Administration has all the information available as quickly as possible.

Mr. RAMEY. Yes, sir.

Representative PRICE. Now, are any substances produced as a result of irradiation that have been proven harmful to the health of man or animals eating this food?

Mr. RAMEY. I would like to have Dr. Dunham comment on this. I recall very well along in 1959 and 1960 when there were thought to be some indications of such a possibility some of the members of the Joint Committee and its staff and others thought there might have been a few red herrings involved in that situation.

It proved out, as a result of subsequent research, that there weren't any problems at that time on the items that had been mentioned.

Representative PRICE. Dr. Dunham.

Dr. DUNHAM. There have been a good many thousands of mice, rats, and dogs fed irradiated food over the past 10 or 12 years now, both in the Quartermaster program where one talks about millions of rads of exposure and in the AEC program in which the doses are less, and there have been no toxic effects seen in these mammals. Also, I believe the Quartermaster fed some troops the food and found nothing by way of toxic effects.

Representative PRICE. Also, you have had tests with human beings.

Dr. DUNHAM. The Army did feed irradiated food to troop volunteers and found no deleterious toxic effects.

Representative PRICE. There were quite extensive tests at Fitzsimons Hospital. You had a group in there—what period of time was it that they were undergoing this test?

Dr. DUNHAM. I don't recall but it seems to me it was about 15 days.

Representative PRICE. Also, this committee on several occasions has been subjected to this food.

Dr. DUNHAM. It is pretty clear that these red herrings that Mr. Ramey talked about are the sort of thing that we ran into on onions. The general protocol calls for feeding 35 percent of the diet on irradiated food.

It turned out that both the control dogs, who ate non-irradiated onions, and the dogs who ate irradiated onions became quite anemic

and several dogs in each group died. I think that humans would become ill too, if 35 percent of their diet was onions.

Representative PRICE. Have you irradiated any red herrings?

STUDIES ON TOXIC SUBSTANCE

Dr. DUNHAM. We have another problem touched on in the authorization hearings which is the question of radiation inducing in carbohydrates some toxic material which might produce genetic damage.

We are working at this very hard now, particularly a group at Oak Ridge. The results obtained to date are conflicting in those culture systems used. The Oak Ridge people are attempting to clarify this problem at the present time.

On the other hand, the solutions irradiated by the Cornell Laboratory were proven to be toxic. Two preliminary and limited pilot studies have been done. One involved giving the material intravenuously to pregnant mice; this had no observable effect on litters or litter size, which suggests it is not going to have a genetic effect. The second study involved the feeding of irradiated and known toxic solutions to mice. No effect on the chromosomes of white blood cells was detected.

It looks as though there may be a different situation in a mammalian system where you have all sorts of mechanisms for detoxification.

Mr. RAMEY. Isn't it true for other types of food processing that they may also develop toxic substances that are subsequently detoxified in the digestive systems of mammals?

Dr. DUNHAM. I am sure this happens. There was a problem years ago on the matter of caramelization of sugars in foods. It was worked over very hard in the 1930's. I have a feeling we are dealing with the same sort of thing here.

DIFFERENT TYPES OF RADIATION

Representative PRICE. Mr. Ramey, on page 4 in connection with your testimony concerning the petition for fish fillets, you mentioned four different methods of processing. Will you explain each of these and tell us what differences exist in the end product?

Mr. RAMEY. Could I have Mr. Fowler explain that?

Mr. FOWLER. What we have here is simply a different kind of radiation source. In the case of cobalt and cesium, of course, we are talking about radioisotope radiation sources. In the case of the 10 Mev electrons and 5 Mev X-rays, we are talking about machine irradiation sources.

In practice, one would not expect any difference in the quality of the end product.

PROBLEMS OF GETTING FDA APPROVAL

Representative PRICE. Could you amplify for us what the problems are in connection with getting approval on irradiation of oranges? That is the one I mentioned where the first application was made in 1963. Is there any question of efficacy or health?

We have heard that questions on economics have come up in the approval process. If this is true, what are the facts on this item?

Mr. RAMEY. Again, I believe Mr. Fowler could respond. I think on the latter part of your question, on the economics as related to other methods of preservation as often happens in the field of atomic energy you have a moving target to keep up with. If the other methods of food preservation get improved or you get an improved variety of fruit, then you just have a harder time competing.

Mr. FOWLER. The delay in the petition for oranges has been brought about by the need to supply FDA additional supporting data on how oranges respond after irradiation treatment during normal commercial shipping, transportation, and storage type of tests.

We have just recently completed a series of these tests and have provided the data to the Food and Drug Administration in support of that application.

SHIPBOARD IRRADIATORS AND FISH PRODUCTS

Representative PRICE. One of the problems you mentioned on the irradiation of fish was the delay between the time of the catch and when they were delivered to the shore, as long as maybe a week. Have you ever thought of the idea of shipboard irradiators?

Mr. RAMEY. Yes, sir. Of course, as the testimony indicated, we do think even with this problem that 70 percent of the catch could be irradiated. But we are working on portable-type shipboard irradiators.

Mr. Fowler, perhaps, could describe this.

Mr. FOWLER. That is correct. We certainly recognize the desirability of providing the irradiation treatment as soon as possible after the catch or harvest of a particular food product. Because of this we have designed, built, and now installed fish irradiators on two fishing vessels operated for us by the Department of the Interior. They are currently in use.

Accordingly, we are applying the radiation dose very rapidly after the fish is caught. It is preliminary at this point in time to be able to speak clearly as to how much this benefits the process.

But certainly we are working on it very diligently.

Representative PRICE. What happens to the other 30 percent of the fish today—I know some of it winds up in the House restaurant—but seriously, what about the rest of it, the 30 percent that does not lend itself to irradation?

Mr. FOWLER. I think the answer is that this 30 percent does not provide fish of a quality that we want to put into the system for radiation treatment. It does not mean that the fish necessarily is of a quality that could not be consumed it simply is not of a quality that we want to use in the irradiation process.

Representative PRICE. Is it a quality that must be consumed almost immediately after a ship comes ashore?

Mr. FOWLER. I think that is probably the correct answer, that it is on the back end of the freshness cycle.

Representative HOSMER. It can be converted to nonhuman use, fishmeal, dog food, cat food, things like that?

Mr. FOWLER. That is right.

PILOT PLANT MEAT IRRADIATOR BASELOAD COMMITMENTS

Representative PRICE. It is good to see that the Commission is standing by its commitment for design and source assistance for a pilot-plant meat irradiator.

Do you believe a commitment from the Government as to a baseload is also needed if private industry is to come forward and risk capital funds in such a cooperative development?

Mr. RAMEY. Yes, sir, we believe that a partial commitment or a commitment on a partial baseload is certainly the preferable method, and probably may be, essential. AEC, in our experience in other areas, for example, on the question of reprocessing of fuel elements in the atomic power industry, we did make a commitment for a part of the baseload for a commercial plant. The plant did go forward and is operating now.

So we believe this is a very important way of going about the commercialization aspect. Whether or not someone will be willing to risk capital without a firm commitment on a baseload is something I think we will only find out about when we go out for proposals and possibly having alternates and seeing what industry will propose.

Representative PRICE. Mr. Ramey, you and I have taken a few rides on the requirements merry-go-round in the past.

Mr. RAMEY. Yes, sir.

Representative PRICE. I know you are somewhat of an expert on it. I hope you will listen today to the testimony of the other agencies and advise the committee about the existence or nonexistence of a commitments merry-go-round in this program.

Mr. RAMEY. Yes, sir. I think this is another case, or could be another case, of where they say you have to wait until your whole process is developed before you get your demand, and whether or not at the same time they say, "Well, you can't go ahead with your development because you don't have that commitment."

I think some of it may be a matter of semantics. The Defense Department now has sort of two types of requirements, an R. & D. requirement and a production or procurement requirement sort of setup.

We know that they are in a position to make commitments for development purposes for trying out products, this 150,000 pounds of the Army plus another 150,000 pounds of the Air Force and Navy that they will talk about in their testimony this afternoon.

Representative PRICE. Mr. Hosmer?

AEC FOOD IRRADIATION PROGRAM BUDGET

Representative HOSMER. Commissioner Ramey, I understand that the President last week told all the departments and agencies to take a good hard look at the appropriations they are getting and see if they could not slice off some of the actual spending.

What are your weak links in the food irradiation program that could get the ax? Or have you had a chance to examine it from that standpoint yet?

Mr. RAMEY. We have not had a chance in that sense to examine it. We have been going through our normal budget reviews looking to fiscal 1968.

Representative HOSMER. He is talking about the fiscal 1967 appropriations.

Mr. RAMEY. Yes, sir. But you sort of have to gear what we will be doing in the current fiscal year to what our plans are for the next year.

In other words, if we were going ahead next year with something that we think has some priority, then we wouldn't want to be cutting it back during the current year.

Representative HOSMER. Do I understand, then, at this point you don't know what, if any, you are going to cut out of the food irradiation program to comply with his instruction?

Representative PRICE. I don't think you have your appropriations yet, do you?

Mr. RAMEY. No, sir, we have our authorization but the appropriations have not been enacted for the current fiscal year.

Representative HOSMER. The President was speaking with a considerable degree of urgency so he must have shaken you all up.

Mr. RAMEY. Well, Mr. Hosmer, we have been working very diligently on the matter of how we can effect economies in line with the President's request. But I do believe that the appropriation requests that we have made for fiscal 1967, the current year, and looking to going ahead with this program, that we regard this food irradiation program as having some priority.

The amounts of funds are relatively low for this food irradiator project.

Representative PRICE. $1.7 million for fiscal 1967.

Mr. RAMEY. For the whole food irradiation program. And for the particular meat processing facility that we are talking to we would be providing the funds for the radiation source and for the design and development which would add up to several hundred thousand dollars.

Mr. CONWAY. The source you have already. It is just a matter of allocating that cost.

Mr. RAMEY. Yes, we will have to allocate that cost to the project. We look upon this as making a substantial contribution. For example, as the testimony will be brought out later this morning and this afternoon, if we can get FDA approvals on additional meat products, as for example, on ham, this could make a substantial savings for the Army's shipments abroad including to Vietnam, in terms of millions of pounds.

Representative HOSMER. I take it from this circumlocution that the AEC does not intend to cut anything out of the food irradiation portion of its activities?

Is that what I am supposed to conclude or is it that you just don't know at this point?

Mr. RAMEY. Mr. Hosmer, I would have to say the Commission has not specifically reviewed the food irradiation program in relation to our other priority programs, as to what would be done during the current year. We have looked at the food irradiation program very carefully in relation to next year and to what our objectives are, and we do consider it to have some priority as against other projects.

Representative HOSMER. That does not leave me with a hard, firm feeling of what your intentions are but I guess your intentions are not hard and firm.

Mr. RAMEY. No, sir. I can speak personally that I would recommend that the program go ahead at the levels that we have recommended, that is to say $1.7 million for the current year and looking to——

Representative HOSMER. If Dr. Nabrit disagrees with you, you will argue with him.

Representative PRICE. At $1.8 million for the next fiscal year.

CONSUMER ACCEPTANCE STUDIES AND PRIVATE INDUSTRY FINANCING

Mr. RAMEY. Well, that was our previously projected level. I think, depending on how some of these things go, it might be increased slightly.

Representative HOSMER. Mr. Ramey, I understand from your total text that the two big problems are FDA acceptance and consumer acceptance. Is that correct insofar as the use of radiation to preserve food is concerned?

Mr. RAMEY. Certainly, in terms of getting FDA clearance on these petitions that is one major area. The matter of consumer acceptance sort of has two parts. The first part of it is more of getting industry distributor acceptance, based on their prognosis of what the consumer will accept.

Representative HOSMER. That is, in the end, consumer acceptance, isn't it?

Mr. RAMEY. Yes, sir, but we don't believe necessarily that we will have to conduct extensive consumer-acceptance surveys or actual trial runs so much as going through the industry distribution process up to the consumer status.

Representative HOSMER. In other words, you figure if they can sell it to the public, they will go ahead with it.

Mr. RAMEY. Yes, sir. We do have extensive activities in cooperation with these large chains now looking to this type of industrial acceptance.

Representative HOSMER. Just what are these large chains and other people putting into this thing? Are they doing anything besides doing the same thing and enjoying the same expense they would with the normal products they handle?

Mr. FOWLER. The thing they are putting in, Mr. Hosmer, is their technical competence and their industrial marketing experience in evaluating radiation processed foods against conventionally processed and marketed foods.

This is a highly important contribution to our understanding as to whether or not this technology will be——

Representative HOSMER. They are not putting up the money, I take it.

Mr. FOWLER. How do you relate technical manpower? This is money to me.

Representative HOSMER. They are going to sell apples and oranges, irradiated or nonirradiated, and make the same profit on it probably. Apparently, what they are doing is totaling up some results and handing it over to you.

Mr. RAMEY. I think it goes beyond that. I think in the case of radiation processed fish that a number of these large chainstores in the country see a real advantage, a real potential advantage.

Representative HOSMER. That is not my question. My question is the money, the effort, what they are contributing to the whole effort.

Mr. RAMEY. They are contributing the side that goes to helping us carry out the testing program in terms of shipping and storage up to the marketplace at this point in time.

Representative HOSMER. Then the AEC and other Government agencies are putting up the money to develop the techniques of irradiation.

Mr. FOWLER. That is correct.

Representative HOSMER. Almost exclusively?

Mr. FOWLER. Almost exclusively.

FDA AND PRIVATE INDUSTRY

Representative HOSMER. The licensing effort is almost an exclusive activity in terms of AEC with the FDA?

Mr. FOWLER. That is correct, sir.

I would add there that there have been petitions to the FDA by private companies which have been either approved or are currently pending. So there is private effort in that area.

Representative HOSMER. I kind of gather, Mr. Ramey, that you intended to have us feel that as soon as this problem of consumer acceptance and of FDA clearance are over, these commercial companies are standing breathlessly in the wings to grasp irradiated products in their hand and place them on their shelves.

Is that really what the situation is?

COMMERCIAL INTEREST—PROCESSORS AND CHAINSTORES

Mr. RAMEY. We believe that with respect to the products that we have been working on intensively, which is to say fish and fruits, that there is this commercial interest and that they will proceed with commercial development and distribution.

Representative HOSMER. The picture that was presented to us by some of the companies was so different from that last time, that is why I am trying to seek out something more specific to indicate an increased interest than simply your statement:

> It is interesting to note that when we start to speak to buyers about the market potential of irradiated sea foods, they leap to tell us just what irradiated sea foods can do for them.

Who are "they" and how many of these eruptions occurred and how enthusiastic are they? What you said is somewhat ambiguous.

Mr. RAMEY. I believe our staff is encouraged by this interest of these big supermarket organizations who look on the market for seafoods as extending toward the Midwest for the distribution of these products. As I explained last year, some of the industrial interests wish us at this stage to retain this information as privileged information while they are deciding on participating in this market.

Mr. Fowler and the other witnesses can explain this in greater detail.

Representative HOSMER. What I am searching for is something specific like a conversation with Prudence Penny, Betty Crocker, or Chiquita Banana, or something like that.

Mr. FOWLER. We can say that, for example, the Giant Food chain here in Washington has a very strong interest in marketing radiation processed fish. Grand Union is another example. One of the largest food chainstores in the country, which, unhappily, we are not permitted to mention here, has gone to the extent of actually carrying out conceptual design studies on a production facility for radiation processing of fish.

Representative HOSMER. This is a food distribution company who also is a food processor?

Mr. FOWLER. This is a food distribution company and food processor, that is correct.

Representative HOSMER. One and the same company?

Mr. FOWLER. One and the same thing.

Representative HOSMER. Then you do have a processor that appears to be interested in making the investment required for irradiation?

Mr. FOWLER. That is correct. As I understand their attitude, the thing that is standing in the way is the clearance by the Food and Drug Administration of the petition for fish. They apparently do not have a problem about consumer acceptance or consumer attitude or economics.

I think they have convinced themselves that if we get the clearance they probably, will make the decision to go ahead.

Representative HOSMER. The Giant that you mentioned, they are not a processor as well as a distributor?

Mr. FOWLER. No.

Representative HOSMER. They would have to buy it from somebody?

Mr. FOWLER. That is correct.

Representative HOSMER. We have this example of fish and we have Giant and we have one unnamed company. There are thousands of companies in this business, thousands of food processors in this country. Can you give us some indication of whether this is a general interest among them or a few of them and a feel for its intensity?

Mr. FOWLER. I would say that the intensity since the time of the last hearing certainly has greatly increased.

Representative HOSMER. This is a very loose and ambiguous type of talk. Be a little more specific, will you?

Mr. FOWLER. I have said that one company has gone to the extent of carrying on conceptual studies for a facility.

Representative HOSMER. With their own money?

Mr. FOWLER. With their own money. We have been working with some 10 of the largest food chainstore companies in the country; my impression is that the interest among these companies, all of them, is strong.

Representative HOSMER. On fish?

Mr. FOWLER. On fish. That is correct.

Representative HOSMER. Anything else?

Mr. RAMEY. They are in the process. They are participating in this distribution, aren't they?

Mr. FOWLER. They are working with us on these large-scale tests, shipment, storage and distribution as I said earlier. We are using their technical competence and laboratory facilities for this purpose.

Representative HOSMER. Your big companies in the processing field like Pillsbury and Armour and all those people, they are not spending very much, are they?

Mr. FOWLER. In those cases, the amount of money being spent, at least in terms of what we understand, is modest.

Representative HOSMER. These are the ones that really you have to get to eventually if you are going to have a large-scale use of this?

Mr. RAMEY. Yes, sir.

Mr. FOWLER. I think eventually—at the same time if we can make an important step forward in getting some of the large food chain companies to market radiation processed fish that we will have made a major step forward. As many things go, other companies will fall in line after that.

Representative HOSMER. Thank you, Mr. Chairman.

PORTABLE IRRADIATORS; ADVANTAGES OF IRRADIATION OVER FROZEN FRUITS

Representative PRICE. Senator Aiken, I know you are interested in this.

Senator AIKEN. Yes, this is a very interesting subject. I am sorry that I could not get here sooner. I have been reading your report, Commissioner Ramey.

You have had experience with portable machines. Have you tried them on grain elevators to get rid of all kinds of bugs, carpet bugs, every other bug that infests a grain elevator? We have had a lot of trouble with that in past years.

Mr. RAMEY. We are in the process of completing a facility in Georgia. It is not a portable facility but it would work on this grain infestation problem.

Senator AIKEN. Do you think you could develop a portable plant?

Mr. FOWLER. We do have portable machines built now and in operation which could be backed up against, for example, a food processing area for certain kinds of tests. That is exactly what we are doing now with the mobile irradiator that we have out in California. It has been operational since last month to process strawberries.

Senator AIKEN. How do strawberries processed by irradiation compare with the frozen strawberry?

Mr. FOWLER. The quality of the fruit is very greatly enhanced over frozen strawberries.

Senator AIKEN. It is better?

Mr. FOWLER. Yes—through the radiation process.

Senator AIKEN. There is improved natural flavor and natural size also of the strawberry. Does it shrink with treatment?

Mr. FOWLER. You get no alteration in physical characteristics like that. There is a slight reddening of the strawberry which probably adds to its marketing value.

VERMIN IRRADIATION

Senator AIKEN. You have not tried irradiation as a means of getting rid of vermin here and there, everywhere, particularly around grain bins?

I suppose irradiation would destroy rats just as well as it would destroy many bugs.

Mr. FOWLER. We have not tried it for that purpose but I am sure you could deliver enough radiation. Whether or not it is practical, we don't know.

Senator AIKEN. You have not been trying that?

Mr. FOWLER. No.

COMPETITION IN FOOD IRRADIATION

Senator AIKEN. What have you been doing in the field of community irradiation plants or even family irradiation plants? Are you just depending on three or four big corporations taking over the entire business of irradiating foods?

Mr. FOWLER. We are approaching it that way looking at three or four large companies—although I would say it may turn out that practical economics would suggest, say, for example, with fish, that there would be a service kind of processing plant in the harbor at Boston to handle the load that comes in.

Senator AIKEN. I was thinking in terms of smaller communities like Putney, Vt., not Boston.

Mr. FOWLER. What I am saying is that it will boil down to economics as to whether it will make sense to have a central processing facility or whether a particular company has a sufficiently large volume that would justify building their own plant.

Senator AIKEN. You are thinking in terms of plants as you develop them now. I am thinking of plants that can be developed. You are working on that too on the development of small plants adaptable to community use?

Mr. FOWLER. We are certainly working and have smaller capacity facilities which we are using now.

Senator AIKEN. I would not be asking these questions if I had not been all through it in the frozen food field where it started out with a few big corporations only. Now you get your frozen food compartment built into every refrigerator you buy.

I don't expect you to go quite so far with irradiation. There would be a certain risk involved. But people also take overdoses of aspirin and I don't know how you can avoid all risks in the household.

IRRADIATION OF PLANTS, TREES, AND GRAINS

You haven't done anything with irradiation for outdoor use, have you, in getting rid of diseases and microbes and Dutch elm disease and things like that? Wouldn't that be a pretty worthwhile use for it?

Mr. FOWLER. Perhaps Dr. Dunham can talk here about selecting kinds of things that have been done with granary products and things like the screw-worm fly.

Dr. DUNHAM. I think your ideas are certainly well worth pursuing, Senator. You raised the question of using radiation to exterminate rats. The problem would be to corner the rat.

Senator AIKEN. Just bait the rats, don't try to corner them. When they get together, let them have it.

Dr. DUNHAM. It takes less radiation to destroy a rat than it does to preserve the food. This is not a wild idea at all.

Representative HOSMER. If you build a better rat trap, the world will beat a path to your door.

RADIATION HEAT FOR ORCHARDS AND OTHER RESEARCH

Senator AIKEN. I am thinking of better uses for radiation: the first assignment I gave the AEC has not been met yet, to develop a means of raising the temperature 3° or 4° in a peach orchard so as to save a crop.

They have not come through yet but it is still a good objective.

Mr. RAMEY. I believe there is going to be an atomic powerplant constructed in the State of Vermont.

Senator AIKEN. There are probably more en route.

Mr. RAMEY. So we are making some progress in the Northeast.

Senator AIKEN. And everybody is asking me what is going to be the effect on the fish in the river. You might be preparing a good answer for that.

Maybe these things are visionary but quick freezing was visionary, also. I well remember in the midthirties when one of the agricultural leaders of Massachusetts said a fellow down there in his State named Clarence Birdseye had developed a means of preserving food by freezing.

He said, "It will never mean anything to us but maybe you can be interested in it up in Vermont," and we were. In fact, we got 10 community plants before the rest of New England got any and it has developed into quite a business.

COMMUNITY OR REGIONAL IRRADIATION PLANTS

I think community food irradiation plants can, too. But it needs a lot of research. I am for providing whatever is necessary to carry on that research.

Mr. RAMEY. It also needs what we would call commercialization, getting potential outfits that could participate in it, get them interested and maybe even putting up a little money.

Senator AIKEN. I don't know whether we want another Comsat on our hands or not.

Mr. RAMEY. I was thinking more in terms of regional plants where you have some investment. As I understand it, there will be testimony this afternoon from one commercial organization that wants to go in with the State of New York in their installation in New York State on a radiation processing facility.

Maybe there might be a New England facility. It is worth looking into.

Senator AIKEN. I well remember how unenthusiastic the canning trade was over the quick-freezing process for a few years until they decided they could use it.

Mr. RAMEY. We ran into difficulty with people with a quick-freezing background who were not so interested in radiation pasteurization along in 1959 and 1960.

Senator AIKEN. However, they will offer to take it over when it is developed.

Representative PRICE. Thank you very much, Mr. Ramey and Dr. Nabrit. Now the next witness will be the Honorable James F. Collins, Under Secretary of Commerce.

Mr. Collins.

STATEMENT BY JAMES F. COLLINS, DEPUTY ASSISTANT SECRETARY FOR DOMESTIC BUSINESS POLICY, ACCOMPANIED BY JACK OSBURN, CHIEF, RADIATION BRANCH, BDSA

Mr. COLLINS. Thank you, Mr. Chairman. I think I have been confused with LeRoy Collins, the Under Secretary of Commerce. I have a statement, Mr. Chairman. I will go through with it.

Representative PRICE. You were on the official lineup of witnesses as Deputy Assistant Secretary for Domestic Business Policy.

Mr. COLLINS. That is correct, sir.

Mr. Chairman and members of the committee, I appreciate the opportunity to discuss our activities in the food irradiation program and the status of the pilot plant meat irradiator.

DEPARTMENT OF COMMERCE INTEREST IN FOOD IRRADIATION

The background of this program is well known to the committee and was fully discussed during prior hearings. The sterilization of food by irradiation promises to open new dimensions in food preservation.

The Department of the Army has long been aware of the potential significance of this program to the processing of food for consumption by the military. In fact, the Interdepartmental Committee on Radiation Preservation of Food was established at the suggestion of the Department of Defense and most of the research must be credited to the Army and to the Atomic Energy Commission.

The Department of Commerce attaches great importance to the food irradiation program because of its commercial potential. Within the Department, the Radiation Branch of the Food Industries Division of the Business and Defense Services Administration (BDSA) has responsibility for the commercialization of food irradiation and serves as the secretariat for the Interdepartmental Committee on Radiation Preservation of Food.

Other BDSA branches and industry divisions contribute their specialized knowledge to the program as needed.

We have found that industry knowledge of the technical advances achieved through research, and awareness of the commercial potential of irradiated food, have not kept pace with developments in the program.

Commercialization depends upon participation by well-informed private companies using the latest scientific, technical, and economic data. It also depends on a well-informed public—the consumer—who will make the ultimate decision as to the commercial feasibility of the process.

Accordingly, the Department is promoting commercial food irradiation through informational reports on the commercial feasibility and economic potentials of irradiated foods. Such reports are based on special research studies and disseminated widely throughout the food industry.

For example, a BDSA contract study for the Atomic Energy Commission resulted in the publication of a report entitled, "Current Status and Commercial Prospects for Radiation Preservation of Food." [1]

[1] Reproduced as app. 1, p. 285, in the JCAE hearings on Radiation Processing of Foods, June 1965.

About 4,500 copies were printed and demand by industry has exhausted the supply. A followup study on commercial prospects for select irradiated foods is now in progress and is expected to be completed in December 1966.

Just a few weeks ago the Department released a report entitled "Status of Irradiated Food Petitions to the U.S. Food and Drug Administration and U.S. Department of Agriculture" copies of which have been made available to the members of this subcommittee. (See app. 2, p. 119.)

So far, we have distributed more than 500 copies of the report. It is proving to be of value to Government as well as to industry and we plan to revise it from time to time as new petitions are submitted and approvals are granted.

Work is continuing on the study of costs and benefits involved in the use of irradiated foods by the military. This study, supported by the Army Laboratories in Natick, Mass., is expected to be completed in September 1967.

It will compare the costs of using irradiated food as ration components in the feeding system for military personnel in different geographical areas of the world, including Vietnam. The results of this study, while of primary interest to the military, will be of great value to industry in exploring commercial food irradiation.

CONSUMER EDUCATION ON IRRADIATED FOODS

The Department's close contact with industry in the food irradiation program is both formal—through participation in trade shows, exhibits, publications, and speeches—and informal through day-to-day correspondence and personal discussions with industry representatives.

We realize that commercial distribution of a new food process hinges not only on its merits but also on its acceptance by the consumer. A program of information directed toward the consumer is being formulated. We believe that consumers may need to be educated to the fact that irradiated foods are not radioactive.

Consumers must become confident that irradiated foods are not harmful to their health before they will purchase these foods in the local supermarkets. One approach to consumer education is exemplified in an article, prepared by the Department of Commerce, entitled "An Apron on the Atom: Irradiated Goods for Tomorrow's Dinners," which appeared in the Washington Sunday Star and which was distributed, through the Department's Sunday News Service, to more than 150 other major newspapers during August last year.

If you would like copies for the record, they are available.

(The newspaper article follows:)

[From the Sunday Star (Washington, D.C.), Aug. 15, 1965]

AN APRON ON THE ATOM: IRRADIATED FOODS FOR TOMORROW'S DINNERS

(By Mary Jane Fisher, U.S. Department of Commerce)

Housewives of the world, take heart! Your day of liberation from kitchen chores is in prospect, according to the U.S. Department of Commerce.

A new technique in preserving food by "ionizing radiation"—a spin-off benefit from the atomic research laboratory—has reached the stage where today's housewife, or her daughter, will be able by 1975 to serve unexpected dinner guests a delightful and nutritious meal that has been pre-cooked, packaged, and stored on her pantry shelf for as long as a year.

When her husband telephones at 4 p.m. and says, "Dear, the boss is in town and I'm bringing him home to dinner," she can coolly look over her stock of irradiated meat, fish, fruit, and vegetables and heat and serve a company dinner.

Except for canning, initially developed for Napoleon's troops, ionizing radiation is the first new way of preserving food since the age-old methods of drying, salting, smoking, fermentation, pickling, cold storage, and freezing—all processes known to our early ancestors.

ATOMIC ENERGY

Research on food irradiation has been conducted since the 1950's by the Department of Defense and the Atomic Energy Commission, under mandate from Congress to develop beneficial uses of atomic energy "to improve the general welfare and increase the standard of living."

In a recent study prepared for the AEC, the Food Industries Division of the Business and Defense Services Administration, a Commerce Department agency, predicts that "irradiation will be recognized as a major technique for food preservation within the decade." The study on "The Current Status and Commercial Prospects for Radiation Preservation of Food," was made as part of the Department's participation in a governmental committee on food radiation preservation involving nine agencies.

For the layman, the term "food irradiation" may conjure up a picture of a Goldfinger-type factory operation with nuclear beams scattering deadly rays in all directions. But in reality, it is no more dangerous than an outdoor barbecue. Technically, it involves exposing food to controlled doses of radiation, but it does not make food radioactive. Grilling hamburger, something many housewives do every day, is, in fact, preserving food by irradiation, with the infra-red rays emitted from the fire.

Products for which radiation preservation is believed to hold the most promise for commercial development in the coming years are chicken, turkey, beef, pork, ham, fish, shellfish, dehydrated vegetables, and a variety of fresh fruits including strawberries and sweet cherries. These are all products which compare favorably in taste after irradiation to fresh food. Of 28 different foods considered in the study, 17 were found to have "good" or "excellent" prospects.

The Food and Drug Administration already has cleared radiation-treated bacon, potatoes, wheat and wheat products for human consumption. Other clearances are pending. Under the Federal Food, Drug, and Cosmetic Act, irradiation is considered a food additive, and irradiated foods must be cleared for human consumption.

Next year, petitions will be submitted for approval of chicken, ham, and pork as well as for several marine products, including pollock, ocean perch, haddock, flounder, codfish, and sole. Requests for 1967 and 1968 will include crab, shrimp, halibut, and beef, as well as prunes, apricots, and nectarines.

Besides eliminating bacteria, preventing spoilage, and extending the life span of fresh foods from two weeks to as long as a year—which is about the shelf-life of canned goods—radiation preservation should result in food product improvements, such as helping to age wines, to decrease roasting time for coffee beans, enhancing coffee flavor, and to add zest to foods such as commercially-packed gefilte fish and dry soup mixes.

Irradiated food in no way resembles the K rations of World War II. The U.S. Army, which has the Nation's most complete food irradiation laboratories at Natick, Mass., discovered early in its tests that irradiation made the best cuts of beef too tender.

Preservation of food by radiation offers great promise in feeding the world's hungry and meeting future needs of a growing world population. Among the many nations carrying on irradiation research are Canada and the Soviet Union.

Because the world's population is expected to double from approximately three billion in 1960 to more than six billion in the year 2000, it will be necessary to create an additional world food production capacity equal to that developed from the beginning of the human race up to the year 1960. And the year 2000 is only 35 years away.

SHIPBOARD TREATMENT

Poultry and fresh fish will likely be the first irradiated foods available to housewives on local grocery shelves, and taste tests are already underway to determine future public acceptance.

Ocean fish, it has been found, can be irradiated on board ship after being caught, transported by truck as far inland as Salt Lake City or Kansas City, and

still taste fresh 30 days or longer. Among the irradiated fish and shellfish which have received high ratings on taste tests are King and Dungeness crab meat, sole fillets, shrimp and canned haddock fillets, fried clams, and clam chowder made from irradiated clams. Many of the tests have been made by the Army at Fort Lee, Va.

Trials on public acceptance of irradiated shrimp have been conducted in Tampa and St. Petersburg, Fla., as well as at Lafayette, Ind., and Louisville, Ky. Irradiated shrimp stored 15 to 20 days were preferred to non-irradiated shrimp stored the same length of time.

Two shipboard irradiators which can process 150 pounds of fish an hour have been built this year and will be put into operation by the U.S. Department of the Interior in conjunction with Louisiana State University.

PILOT PLANT MEAT IRRADIATOR

Mr. COLLINS. I would now like to discuss a specific aspect of this program, the successful operation by industry of one or more pilot plants, which we believe will facilitate full scale commercialization.

In our judgment, demonstration of irradiation as a food process in a commercially profitable pilot plant, built and operated by industry, would accelerate its acceptance by the remainder of the industry.

Radiosterilized meat offers some of the greatest challenges, both technically and economically, of any of the irradiated food products contemplated. We believe successful demonstration of the commercial feasibility of radiosterilized meat will accelerate the progress of the entire program. Consequently, most of our effort during the past year has been directed toward the establishment by industry of a pilot plant meat irradiator.

During the March 1965 meeting of the Interdepartmental Committee on Radiation Preservation of Food, the need for a pilot plant meat irradiator was discussed. In June of that same year, the idea was supported in testimony before this subcommittee.

As a result, in August 1965, Mr. Alexander B. Trowbridge, our Assistant Secretary for Domestic and International Business, and I met with officials of the Atomic Energy Commission and of the Department of the Army to discuss means of developing a cooperative program with industry to build and operate a pilot plant meat irradiator.

It was decided that an industry-Government conference should be called to obtain industry views on the subject.

INDUSTRY-GOVERNMENT CONFERENCE

Such a conference was held in September 1965, at which time the major objectives of the project were outlined to the executives of more than 40 companies and trade associations.

Very briefly, processing methods and costs involved would have to be adapted to the transition from laboratory sample testing to commercial plant production. Moreover, it was concluded that the Armed Forces should provide a market for a portion of the commercial quantities processed while a civilian market was tested and developed for the balance.

At this meeting Army representatives announced they were considering support for a private pilot plant with an annual capacity of 1 million pounds of sterilized meat. They indicated that during each of the first 3 years of the plant's operation the Army might purchase

150,000 pounds of items approved by the Food and Drug Administration and the U.S. Department of Agriculture.

Furthermore, the Army announced that it would encourage similar procurements by the Navy and Air Force. On its part, the Atomic Energy Commission indicated it might provide $180,000 for procurement of the radiation source for such a plant and $140,000 to support engineering and design.

The minutes of the conference are contained in appendix 12, page 665 of Radiation Processing of Foods, the record of the June 9 and 10, 1965, hearings before this subcommittee.

Industry response was favorable and an interagency task force representing Commerce, Army, and AEC was formed to work with industry in generating a specific proposal. The Commerce representative was appointed chairman of the task force. On June 6, 1966, the task force submitted its report and recommendations based on private meetings and other communications with more than 100 organizations which had expressed interest in the project.

Subject to the availability of funds, the report contemplates awarding a pilot plant contract by December of 1966 and the completion of construction of such a plant by May of 1968. I will not take your time to read from this report; however, I think it would be useful to emphasize some of the major conclusions and recommendations contained therein.

The amount of $320,000 contemplated by AEC to defray design, engineering, and radiation source costs was thought to be adequate. Moreover, the task force concluded that 10 or more companies would respond to a request for contract proposals to construct and operate a plant if the task force recommendations were reflected in the Atomic Energy Commission's request.

INTERAGENCY TASK FORCE RECOMMENDATIONS

The task force recommended that the Department of Commerce should assist the private operator of the pilot plant in developing a civilian market for irradiated foods by consumer education and other appropriate programs and by encouraging additional Government and non-Government purchases; that the Army Laboratories at Natick, Mass., should provide support for training company personnel to operate the pilot plant, provide technical liaison for solutions to problems which may arise during the first few years of the plant's operation; and also that the company selected to operate the plant should enjoy rights to patents and technological data to the extent these are the product of efforts and funds expended by the company.

However, the main concern of the task force related to the need for a substantial increase in Department of Defense procurement of irradiated meats from this plant during the first 5 years of operation.

Instead of the 300,000 pounds annual procurement level proposed at the Industry-Government Conference, the task force strongly recommended that the Department of Defense procure irradiated meats and poultry products from the plan at annual levels ranging between 600,000 to 800,000 pounds during the first 2 years and during the following 3 years at levels ranging between 300,000 to 500,000 pounds annually.

The recommendations of the task force have been concurred in by the Department of Commerce and by the Atomic Energy Commission. However, the Department of Army, while generally concurring with the report indicated that it could not procure irradiation-sterilized foods for regular troop feeding in the absence of FDA and USDA approvals and in the face of uncertainties as to product acceptability under conditions of commercial production.

DEPARTMENT OF DEFENSE NEEDS FOR IRRADIATED FOODS

The Navy and Air Force were reported as also unable to issue statements of intent to procure large quantities of irradiation-sterilized foods at the present time.

In view of the Army's position, I met on August 3 with officials of the three services and representatives of the other interested agencies to explore the likelihood of reaching the procurement levels recommended by the task force.

During the course of this meeting, it was reiterated by the Army that its research and development needs would warrant the annual purchase of 150,000 pounds of irradiated meats during the first 3 years of the pilot plant's operations and that jointly the other services would probably match the Army commitment, thus resulting in total military purchases of 300,000 pounds per year during the first 3 years.

However, regular military procurement, as contrasted with research and development procurement, could not be committed because of the uncertainties of (1) availability of funds, (2) FDA and USDA approvals, (3) acceptability of irradiated products, and (4) competitiveness of price and utilization as compared to other food products.

The discussion developed that companies seriously interested in responding to the pilot plant proposal are generally aware of the difficulties involved and would probably respond to a DOD statement of intent which was qualified to meet these contingencies.

In this light, the Department of the Army has reevaluated its future procurement needs for irradiated meats, and I understand that a representative of the Army will be testifying today before this committee as to their current position.

In conclusion, assuming FDA and USDA clearance and satisfactory results from test procurement, military requirements for irradiated meats may greatly exceed the 1 million pounds per year minimum capacity recommended for the pilot plant.

Of course, the pilot plant could easily be designed to permit future expansion of capacity without drastic structural modifications. In this connection, it should be noted that many of the interested companies are considering an expandable pilot plant.

Furthermore, if the pilot operation becomes a profitable economic venture, other plants undoubtedly would be built by industry to produce irradiated foods.

Mr. Chairman, this completes my statement. I will be glad to answer any questions.

AEC-FINANCED SUPPORT FOR PILOT PLANT

Representative PRICE. Thank you very much, Mr. Collins. I note your reference to the conference held in September 1965 between in-

dustry and Government representatives in which you point out that the Atomic Energy Commission indicated it might provide $180,000 for procurement of the radiation source for a pilot plant and $140,000 to support engineering and design.

I would point out in Mr. Ramey's statement, he refers to the request for authorization of the Commission, which authorization was eventually granted by the Congress, that the Commission upped these figures a little.

They provided $170,000 for engineering and design assistance instead of the $140,000 and $230,000 for source procurement instead of $180,000.

Mr. COLLINS. Thank you, Mr. Chairman.

Representative PRICE. I don't know whether you have got the money for that yet but at least you got the authorization. The Commission went beyond their commitment at the conference.

SALMONELLA CONTROL BY IRRADIATION

Mr. Collins, you do not mention anything in your statement concerning the possible use of radiation to control salmonellae. Doesn't irradiation have the potential of controlling this serious problem by such things as sterilizing chicken feed and eliminating salmonellae in poultry meat?

Mr. COLLINS. Yes; it does, Mr. Chairman. I have Mr. Jack Osburn, Chief of our Radiation Branch in BDSA on my left. He might want to elaborate on that further.

Representative PRICE. Mr. Osburn.

Mr. OSBURN. Yes, sir; on a preliminary basis, I think that salmonellae control is one of the more commercially attractive areas involved in food irradiation.

Perhaps because it is our understanding that for poultry meat, for instance, and frozen meat products that this is the only control method that might turn out to be feasible. Heat, of course, will kill salmonellae, but if you heat frozen meat for salmonellae control, it would have to be refrozen.

Representative PRICE. Senator Aiken.

Senator AIKEN. I would like to carry this a little bit further. Have you had cooperation from the poultry trade in regard to the control of *Salmonellae?*

Mr. OSBURN. Senator, we are looking at the problem from an economic standpoint. We are not the microbiologists with whom the poultry industry would probably be dealing.

However, I must say that segments of the poultry industry have expressed their interest in this problem and their concern with it.

Senator AIKEN. Is that concern geographic?

Mr. OSBURN. Senator, I don't know.

Senator AIKEN. The reason I asked that is that last year I got an appropriation through the Senate for the control and eradication of salmonellae pullarum which comes under several different names.

It is almost eradicated in the 13 or 20 Northeastern States. Strange to say, I met with opposition from the central West. Apparently, they were fearful that the Northeastern States would get the market for hatching eggs if it went through.

However, it is much broader than simple control of a single form of Salmonella. It seems to me that they would just fall over backward in order to cooperate with you in finding a means of treating the feed because we know it spreads through the feed largely.

I hope you are successful, more successful than I was, in getting the cooperation of the producers in this field. That is all, Mr. Chairman.

I thought this was a good place to point that out.

TRADE EXHIBITS AND IRRADIATED FOODS

Representative PRICE. Mr. Collins, you talked about the exhibits at the trade fair of some of the irradiated foods. Did the Department have an exhibit on food irradiation in the Switzerland Fair last week?

Mr. COLLINS. To my knowledge, it did not, Mr. Chairman. Those who should have been interested were less interested than others were because they have had great success in some instances in commercializing the sale of some of the atomic power plants built by American companies in Western Europe. Parenthetically, I might add the Department has been assisting these people for years and contributing to the achievement of this success.

They feel that they have a good foothold in some of the markets of Western Europe for atomic powerplants. Consequently, they feel that direct contact with the governments involved and the companies involved in the purchase of these atomic powerplants is probably more efficacious than participation at a fair, although of course, all these companies that are in the atomic powerplant business did participate in the fair.

Representative PRICE. Have you used any of the food irradiation exhibits in any of the overseas fairs?

Mr. COLLINS. I don't believe we have, Mr. Chairman. The reason is the current tentative position of food irradiation in the United States. We feel that we should have a more solid basis for commercialization of irradiated food in the United States before we go forward in a trade fair.

Representative PRICE. What were you referring then in your reference to participation in trade shows, exhibits, publications and speeches?

IMPROVING PUBLIC AND CONSUMER ACCEPTANCE

Mr. COLLINS. This would be a project of the Department of Commerce after we had established a pilot plant meat irradiator and we had received the FDA and USDA clearances.

Representative PRICE. I thought from your statement that it would appear to be something that you are already doing.

Mr. COLLINS. We are disseminating literature now and trying to create some general awareness of the program although by no means are we doing all that we could do when we feel we have a firmer base on which to proceed, Mr. Chairman.

Representative PRICE. You stress that commercialization of food irradiation is dependent on acceptance of food irradiation by the

customer. Do you think that there is a possibility you might be overstressing this at the present time?

Mr. COLLINS. That is a hard question for us to answer, Mr. Chairman. I would say it may be overstressed in the case of irradiation pasteurization of foods but possibly not overstressed in the radiation sterilization of foods: there is a good deal of commercial interest, as you know, in the radiation pasteurization process.

I think there is much more likelihood of rapid consumer acceptance of radiation pasteurization than there is of radiation sterilization since the radiation required is about 20 times less than for radiation sterilization.

Representative PRICE. Don't you think that the important thing here is assurance from the Food and Drug Administration that this is a safe food?

Mr. COLLINS. That is the essential prerequisite. Of course, it doesn't necessarily follow that there would be rapid consumer acceptance after the FDA approval is obtained. I think there will be some promotional work necessary to assure the average person that this food is not radioactive and that he won't be adversely affected if he eats it and that he won't receive additional roentgens buildup because he consumes this food over a period of time.

Representative PRICE. Senator Aiken.

IRRADIATION OF MILK

Senator AIKEN. Mr. Chairman, may I ask what agent or medium is used in irradiating milk?

Mr. COLLINS. I will have to defer to Mr. Osburn on this.

Mr. OSBURN. Senator Aiken, originally milk was irradiated with ultraviolet light. When I was in the milk business, sir, ergosterol was irradiated and added to milk as a source of vitamin D, more recently vitamin D from a nonirradiated source has been used.

Senator AIKEN. I might ask you why did you get out of the milk business but I think I know the answer.

Mr. OSBURN. I am sure you do, sir.

Senator AIKEN. Nevertheless, milk is sold as irradiated milk and has been for a long time. Has the consumer objected? In fact she has paid several times the cost of irradiating the extra in order to get it.

Mr. OSBURN. I think, Senator, the label stressed "vitamin D added." In other words, the added value was stressed and the process of irradiation was played down by being shown in pretty small print on the bottle cap.

Senator AIKEN. Nevertheless, she has paid extra for irradiated milk.

Mr. OSBURN. Yes, sir, because it had a distinct advantage.

Senator AIKEN. She might do the same for irradiated fish or peaches or something like that.

Mr. OSBURN. We would hope so.

Senator AIKEN. All you have to do is sell them, tell them the truth.

Mr. OSBURN. Right.

EXPEDITING THE PILOT PLANT MEAT IRRADIATOR

Representative PRICE. You have summarized the history, the long history of a plan for a pilot plant. What in your opinion could be done right now to expedite the next step in the food irradiation program?

Mr. COLLINS. I think it is a question of the ability of the U.S. Government to buy enough radiosterilized meat to assure that the interested companies will go forward and take up the proposal.

Representative PRICE. This points out the fact that the Armed Forces have a very definite and important interest in the program.

Mr. COLLINS. Yes, but I think it is fair to add, Mr. Chairman, that the FDA and USDA approvals are very necessary.

Representative PRICE. I think the FDA approval is the most important thing.

Mr. COLLINS. That is right.

Representative PRICE. After all these other things are done, without the FDA approval, the people just aren't going to be customers. They are not going to be the consumers that are necessary for the eventual and ultimate success of the food irradiation program.

Mr. COLLINS. Without anticipating the testimony of the Department of Defense, Mr. Chairman, I believe that the Army feels it doesn't really want to feed large quantities of irradiated food in the field until it is assured that there would be no harmful effects.

Representative PRICE. I would certainly hope that they would not.

Mr. COLLINS. That requires FDA approval.

Representative PRICE. The military, incidentally, were the ones that did most of the tests so far as human beings were concerned in the consumption of this food up to this point.

PRODUCT ACCEPTABILITY NEED FOR PILOT PLANT

Now, you speak about the uncertainties of the product acceptability under condition of commercial production, that is to a pilot plant, how are you ever going to find out about product acceptability under commercial production?

Mr. COLLINS. I believe this is a correct view, sir. We do need a pilot plant.

Representative PRICE. I think it is, too. I think until we get a pilot plant we are not going to get the answer to that question of product acceptability.

It has to be marketable and it has to be made available to consumers.

Mr. COLLINS. There has to be sufficient volume put through the pilot plant to test a broad spectrum of military consumer acceptance together with whatever civilian consumer market can be obtained after the FDA–USDA approvals are assured.

Representative PRICE. Mr. Collins, I am going to submit additional questions I have here because we would like to take at least one more witness this morning before the afternoon session in order to try to complete the schedule today.

INTERAGENCY TASK FORCE REPORT

Would you furnish the committee for the record your task force report?

Mr. COLLINS. I will be glad to do that, Mr. Chairman.

(The report referred to follows:)

REPORT[1] OF THE PILOT PLANT MEAT IRRADIATOR TASK FORCE

During the March 30, 1965 meeting of the Interdepartmental Committee on Radiation Preservation of Food, the need for a pilot plant irradiator for shelf-stable meat and poultry was discussed. The idea was supported in testimony before the Joint Committee on Atomic Energy, Congress of the United States, June 9–10, 1965.

In August 1965, AEC Commissioner James T. Ramey and Assistant Secretary of the Army Willis M. Hawkins met with Assistant Secretary of Commerce Alexander B. Trowbridge to discuss the establishment of a pilot plant meat irradiator. They concluded that industry should be encouraged to build and operate such a facility in cooperation with the Government. Secretary Trowbridge convened an Industry-Government Conference on September 24, 1965 (See Appendix I for Minutes), wherein executives of more than 40 companies and trade associations in the meat, poultry, and radiation industries heard the major objectives of the pilot plant project outlined:

(1) To introduce and test shelf-stable foods in rations for the Armed Forces in quantities larger than are possible with existing ionizing radiation facilities;

(2) To develop processing methods and solve potential problems associated with scaling up from laboratory to commercial production;

(3) To obtain processing costs and project the economics of the process to conditions of full-scale commercial production of radiosterilized foods; and

(4) To investigate, test, and develop a civilian commercial market for these foods.

Support offered by the Government included $140,000 from the Atomic Energy Commission to defray engineering and design costs plus an additional $180,000 to defray radiation source costs; and commitment by the Armed Forces to procure annually 300,000 pounds of the proposed one million pounds per year through-put for three years.

An Interagency Task Force was formed to make follow-up visits to those companies and organizations which had indicated an interest in the project. (See Appendix II.)

INDUSTRY REACTION

From November 1965 through mid-May 1966, 91 organizations notified the Task Force of their interest in participating in the project. Task Force Members met with 67 of these organizations, discussed the project with 13 more by telephone, and have been in contact with the remaining 11 by mail. See Appendix III for resume of the positions of individual organizations and the opinion of the Task Force in respect to their intent to submit proposals.

Factors affecting the establishment of the pilot plant emerged from these meetings and discussions—the more significant follow:

(1) Interest is not confined to the meat packing industry. Interest is also shown by cold storage warehouse operators, electron and x-ray machine manufacturers, architect and engineering firms, nuclear engineering companies, source fabricators, poultry growers and packers, local chambers of commerce and industrial development commissions, and individual entrepreneurs.

However, it is clear that participation by companies expert in meat and poultry marketing will be important in developing a civilian market for these shelf-stable foods and to the success of the project.

(2) In the United States, no one person or organization can speak for the meat industry. Companies which appear identical in terms of size, organization, marketing methods, and products have widely diverse viewpoints on meat irradiation.

[1] The restriction on the use of this Report is removed effective September 8, 1966, when the Report is separated from its Appendix III. W. B. Bennett, Director, Food Industries Division.

(3) The major obstacle to private investment in the pilot plant, as proposed at the conference, is the difficult prospect of selling about 700,000 pounds of irradiated meat per year in an untried market. Most companies suggested that the Government procure a substantially larger portion of annual production than initially offered and for a longer period of time, thus reducing final unit cost to the Government particularly during the first two years of operation.

(4) Lack of FDA and USDA clearances for meat products other than bacon, inhibits more active interest in the project.

(5) Lack of knowledge on consumer reaction to irradiated food contributes to this problem. However, many believe the use of irradiated foods by the Armed Forces will accustom the civilian population to the use of these foods and help reduce consumer resistance.

(6) Capital and processing costs are based on estimates, rather than experience. These costs are a critical factor in an industry which measures profits in fractions of a cent per sales dollar.

(7) Small- to medium-sized, specialized meat packers usually show more interest in participating in the project than do the larger, more highly diversified firms. However, the assets of the smaller packers are usually limited.

(8) Many small- and medium-sized meat packers exhibit a strong interest in *radiopasteurization*. Interest is particularly high among poultry packers and processors of prepared meats such as frankfurters, luncheon meats, and other comminuted meat products. These companies would be more interested in submitting proposals for a radiation sterilization pilot plant if radiopasteurization would be permitted in the same plant.

(9) Within the large meat packers there is often competition for dollars among divisions of the same company. Radiation is but one of the many innovations being considered and, in its present status, represents a higher risk and smaller return over a longer period of time than, for instance, investments in pharmaceuticals or fertilizers.

(10) Some companies, reluctant to invest in radiation facilities, are willing to buy custom irradiation services.

(11) Many companies are reluctant to invest in the pilot plant if they have no patent or proprietary rights to processes or products they might develop.

(12) While a general awareness of radiation exists, there is not sufficient direct experience to produce acceptable products.

CONCLUSIONS

In summary, it is highly unlikely that responsive proposals consistent with the pilot plant objectives will be received if Government assistance is limited to that initially offered. However, the Task Force has concluded that ten or more proposals may be expected, provided that—

(1) The Department of Defense increases substantially over a 5-year period the 300,000 pound annual procurement level proposed at the September 24, 1965 Industry-Government Conference. In this regard, the Task Force understands that current needs for shelf-stable ham for Viet Nam alone are in the order of 500,000 pounds per month.

(2) The AEC contributes $320,000 as proposed.

(3) The U.S. Army Natick Laboratories staff is available as research back-up to solve unexpected problems which might arise.

(4) The U.S. Army Natick Laboratories trains the operating personnel of the plant.

(5) The Department of Commerce lends appropriate assistance in commercialization efforts.

(6) The company receives equitable protection through patent or proprietary rights for products that may be developed.

(7) With approval of appropriate regulatory agencies, the company would be allowed to use any excess radiation capacity to process other commodities, both food and non-food.

RECOMMENDATIONS

Therefore, the Task Force strongly recommends that—

(1) The pilot plant have a minimum capacity of 1,000,000 pounds of radiosterilized meat (and poultry) products.

(2) The pilot plant be operated under USDA inspection.

(3) The Defense Department, particularly in view of current needs for Viet Nam, procure shelf-stable irradiated meat and poultry products, directly from the contractor, in accordance with the following levels:

Year:	*Pounds*
1st	600, 000–800, 000
2d	600, 000–800, 000
3d	300, 000–500, 000
4th	300, 000–500, 000
5th	300, 000–500, 000

(4) The staff of the U.S. Army Natick Laboratories provide scientific backup for problems which might arise during the first five years of pilot plant operations.

(5) The U.S. Army Natick Laboratories train sufficient company personnel to operate the pilot plant during the first five years of its operation.

(6) The AEC offer of $320,000 to defray design and source cost remain unchanged.

(7) Consistent with Departmental policy, the Department of Commerce assist in developing the civilian commercial market for irradiated foods by consumer education and other appropriate programs and by encouraging additional Federal, State, and local Government and non-Government agencies to buy irradiated foods.

(8) Except for Government use, the company be provided exclusive rights to the use of patents and technological data arising out of the contract for a period of time commensurate with the relative equities of the company and the Government of the project.

(9) So long as it does not compromise the objectives of the pilot plant, and with regulatory agency approval, the company be allowed to use any excess radiation capacity to process other foods and non-food commodities it might wish.

(10) The foregoing recommendations be incorporated in a request for proposals to be issued to industry by the AEC; and that the contract award be made after prior approvals of the Departments of Commerce and Army.

(11) Since one of the major objectives of the Pilot Plant is to obtain realistic costs, the procurement price of Government purchases should be on a cost plus incentive fee basis and should be so stated in the request for proposals.

(12) The Department of Defense officials (particularly the Defense Supply Agency) be consulted with regard to the future procurement by the Defense Department of portions of the output of the plant, and prior to issuance of the requests for proposals, send AEC a letter of intent to procure recommended herein.

(13) The Department of Defense should provide to the contractor, at the time the contract with AEC is executed, a statement of policy pertaining to the future procurement of the products of the pilot plant by the Department of Defense.

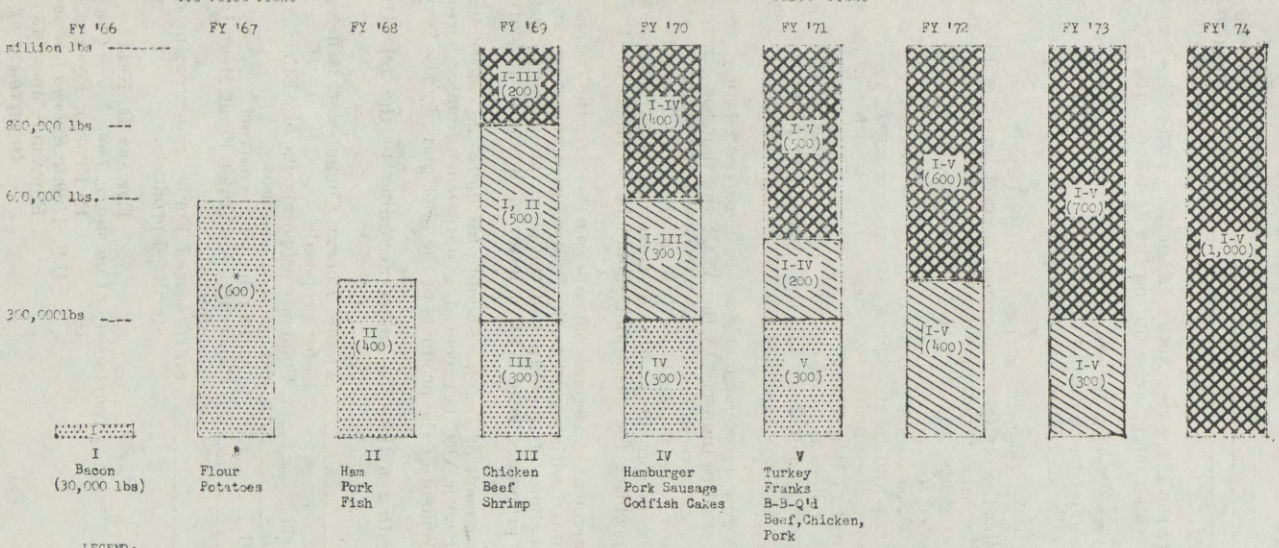
(14) Implementing actions be taken according to the following time schedule:

June 15, 1966	Atomic Energy Commission issues requests for proposals.
September 15, 1966	Company proposals due at AEC.
November 1, 1966	Selection of company.
December 1, 1966	Award pilot plant contract.
May 1, 1968	Construction of Pilot Plant Meat Irradiator completed.
July 1, 1968	Start Armed Forces procurement of radiosterilized products.

EDWARD R. KELLAM,
Department of Commerce, Task Force Chairman.
E. EUGENE FOWLER,
U.S. Atomic Energy Commission.
EDWARD S. JOSEPHSON,
Department of Army.

PILOT PLANT MEAT IRRADIATOR PROJECT : 1966 - 1974

(In thousands of pounds)



LEGEND:

-:DCD Committements For Test Procurement of Irradiated Foods

-:Proposed Additional DCD Procurement Necessary for Support of Project

-:Capacity Available for Commercial Production for Sales and Promotion

I, *, II, III, IV, V-:Products Scheduled for Clearance (USDA and FDA) and DCD Testing

(*) - Flour and Potatoes not included in Pilot Plant Meat Irradiator Project

IRRADIATION OF VEGETABLES

Senator AIKEN. Do I understand correctly that potatoes are the only vegetable approved by the FDA for processing through irradiation?

Mr. COLLINS. I believe that is correct.

Senator AIKEN. Yet, a potato is a vegetable that lends itself to dehydration almost better than any other vegetable. Does the FDA approve all vegetables as they may be dehydrated?

Mr. OSBURN. I am not sure I understood the question.

Senator AIKEN. Does the FDA approve the dehydration process for all vegetables?

Mr. OSBURN. I don't believe so, sir.

Senator AIKEN. I simply could not understand why they approved irradiated potatoes when a potato lends itself to dehydration so far as the armed services is concerned better than almost any other vegetable.

I understand the next witness will cover that, so I will withdraw the question.

Representative PRICE. Thank you, Mr. Collins and Mr. Osburn.

Mr. COLLINS. Thank you, Mr. Chairman.

Representative PRICE. The next witness will be Mr. J. Kenneth Kirk, Acting Associate Commissioner for Compliance, Food and Drug Administration.

STATEMENT OF J. KENNETH KIRK, ACTING ASSOCIATE COMMISSIONER FOR COMPLIANCE, FOOD AND DRUG ADMINISTRATION; ACCOMPANIED BY ALAN T. SPIHER, PETITIONS CONTROL BRANCH, BUREAU OF SCIENCE, FOOD AND DRUG ADMINISTRATION, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Mr. KIRK. Mr. Chairman, I have with me Alan T. Spiher, who is in our Petitions Control Branch, of the Bureau of Science. He deals with all of the petitions which come in.

Representative PRICE. You may proceed.

Mr. KIRK. Mr. Chairman, we are very glad to again appear before this committee to bring you up to date on the activities of the Food and Drug Administration as they relate to the national food irradiation program. I am J. K. Kirk, Acting Associate Commissioner for Compliance, FDA.

Mr. Robert S. Roe appeared before this committee on June 10, 1965. At that time he summarized the responsibilities of the Food and Drug Administration in the field of food irradiation and outlined what we had accomplished in discharging these responsibilities. I should now like to discuss what has happened since his appearance.

FOOD ADDITIVE AMENDMENT TO FEDERAL FOOD, DRUG, AND COSMETIC ACT

Summarizing briefly, the food additives amendment to the Federal Food, Drug, and Cosmetic Act requires the regulation of any source of radiation intended for the treatment of foods and defines intentionally irradiated foods as adulterated unless such use of radiation com-

plies with a food additive regulation promulgated in accordance with the law. The statute provides the regulations to be based on petitions supplying the following information, where applicable:

(*a*) A description of the radiation process;

(*b*) The proposed conditions of use;

(*c*) Data establishing that the radiation accomplishes the intended physical or other technical effect, and that the proposed amount is not higher than that reasonably necessary to produce the effect;

(*d*) Analytical methods to determine the amount of the radiation, if any present (where needed), and

(*e*) Investigations made with respect to the safety for use of the radiation including complete information about the methods and controls used in conducting the investigations.

In addition, the statute specifically directs, in part, that—

> No such regulations shall issue if a fair evaluation of the data * * * (A) fails to establish that the proposed use of the food additive under the conditions of use to be specified in the regulation will be safe: Provided, that no additive shall be deemed to be safe if it is found to induce cancer when ingested by man or animal * * * or (B) shows that the proposed use of the additive would promote deception of the consumer in violation of this Act or would otherwise result in adulteration or misbranding of food within the meaning of this Act.

FDA ACTIONS: TAKEN AND PENDING

In June 1965, when we last appeared before this committee, action was pending on four petitions in addition to the previously approved petition:

(1) Treatment of oranges to inhibit surface organisms, submitted by the Department of the Army and the Atomic Energy Commission.

(2) Treatment of wheat and wheat products with electrons for deinfestation, submitted by High Voltage Engineering Corp.

(3) Treatment of white potatoes for sprout inhibition, submitted by the Department of the Army.

(4) Treatment of food packaging materials, submitted by the Army.

Regulations have since been established for two of these—the treatment of wheat and wheat products, and the treatment of white potatoes. Additional data were required for the other two. An amendment for the orange petition was received on August 12, 1966, and is under evaluation. The petition for packaging materials mentioned above is being considered along with two later submissions for other packaging materials from the Army and AEC. An amendment to these three petitions was filed on August 1, 1966, and our review has been completed. We have advised the Army and the AEC that favorable action cannot be recommended upon the petitions as amended because the data lately submitted do not confirm the absence of induced radioactivity in the packaging materials or the substances extracted therefrom when simulated food solvents are used. On September 6 we received a letter from the Department of the Army requesting an additional 60 days for them to repeat the experiment on newly installed equipment. We are agreeing to this.

We have received the following new petitions since our last appearance before this committee:

Food additive petition 6M1833: A petition from Thomas J. Lipton, Inc., requesting the use of gamma radiation on dehydrated vegetables to increase the speed of cooking. We could not file this petition in the absence of certain feeding experiments which the petitioner plans to begin soon. FDA has reviewed and commented on their proposed protocols.

Food additive petition 6M1815: A petition submitted jointly by the Atomic Energy Commission and the Army for the irradiation of fresh fish to increase shelf life. Authorization was requested by AEC and granted to them permitting experimental studies on irradiated fish involving commercial handling, shipping, and storage. Further action on the petition awaits receipt of these data to support the required conclusion that the proposed radiation levels accomplish the intended effect and that the proposed use would not promote deception of the consumer or otherwise result in adulteration or misbranding of food.

Food additive petition 6M2024: A petition submitted by the AEC for the use of gamma radiation on fresh strawberries, to decrease spoilage and extent the shelf life. This petition was filed on May 18, 1966, and amended by additional data on July 6, 1966. It is still being evaluated. Indications are that some clarification of certain data may be needed.

Food additive petition 7M2056: A petition submitted by the Army for the gamma processing of canned hams. This was received on July 11, and filed on July 26. It is still undergoing evaluation. Early indications are that additional data may be required.

Representative PRICE. What is the difference between received and filed?

Mr. KIRK. Filing is an informal operation. We look at the petition. If it appears to be complete, that is, each section has some material in it, then we notify the applicant that his petition is filed, and we put a notice in the Federal Register to that effect. In a sense that starts the clock running.

Senator AIKEN. Do they have petitions under active review? You don't use the term "under active review," do you?

Mr. KIRK. We don't use that, but when a petition has been filed the law says we shall get it done within a specified period of time.

Senator AIKEN. "Under active review" usually means we are going to wait a few weeks or months before we do anything. I am glad one agency does not use that term.

PETITION ON IRRADIATED HAM

Mr. KIRK. We don't like terms that mean you are not doing your job.

In this food additive petition for the hams, so far as we have gone on it, it looks like we are going to have to call for some more information.

Representative PRICE. Which one is this?

Mr. KIRK. That is 7M2056, the ham.

LABELING STATEMENTS

As you no doubt know, FDA published in the Federal Register on July 13, 1966, amendments to several of the radiation regulations which set forth certain labeling statements as "processed (or treated) by ionizing radiation" and in the case of bulk shipments the words "do not irradiate again." These amendments to the regulations followed publication of an initial proposal by the Office of the Commissioner on February 26, 1966, and the evaluation of nine comments which were filed thereon.

Sixteen communications have been received since the amended regulations were published. Most of these reflect a concern that labeling foods as process or treated by "ionizing radiation" will cause the consumer to be afraid of the commodity. A few of the letters received have asked for a public hearing. The letters are currently being evaluated to see if a hearing can be granted and if any information is provided which would require further action.

It is our aim to process all petitions in this area promptly, but we cannot issue any authorizing regulations unless and until our scientists can certify that there is clear evidence of safety of this process.

We shall be glad to provide such further information concerning the FDA activities in this field that the committee may desire.

ECONOMICS OF IRRADIATION

And I recall we already have one question which you forwarded from Mr. Bates. That dealt with the matter of economics. The Food and Drug Administration does not have a staff to look into the economics of processes which are proposed under the food additives amendment. We do not believe this is really our affair. We are concerned to see that the process or the additive in the case of other food additives is safe, that it will do the job it is supposed to do, that you don't use any more of it than is needed to do that job, and that there is no adulteration or misbranding or deception of the consumer in the proposal.

Representative PRICE. I think the reason Mr. Bates wanted to propound these questions is that he felt you were doing this and it bothered him a little.

Mr. KIRK. May I assure you, sir, that we do not do that.

Representative PRICE. Your concern is that it is safe and the effectiveness of it will do what it is claimed it will do?

Mr. KIRK. With no more than necessary. In other words, if 10,000 will do it, we don't want to authorize 20,000.

Representative PRICE. Senator Aiken.

WHY RADIATION TREATED AS FOOD ADDITIVE

Senator AIKEN. I was just wondering why radiation was referred to as a food additive.

Mr. KIRK. That is a specific section of the Food Additives Amendment of 1958.

Senator AIKEN. You mean it is in the law?

Mr. KIRK. It is in the basic law.

Senator AIKEN. Do you suppose it should be a separate category? I can't think of it the same as I would benzoate of soda.

Mr. KIRK. It really is not the same, but the same procedure which is a preclearance operation is required here as in the case of all of these other food additives. So the same types of handling are involved. I think that is as good a place as any to have it.

IRRADIATION OF POTATOES

Senator AIKEN. The only other question I have is why was approval given to irradiation of potatoes, and not to beets, carrots, and other vegetables of similar texture? Was it because there was no application for the others?

Mr. KIRK. So far as I know there has been none. Keep in mind that this was strictly an antisprouting order, that is for the whole potato.

Senator AIKEN. A laborsaving device.

Mr. KIRK. You lose a lot of good in potatoes if you let them sprout.

Representative PRICE. How much does it extend the shelf life, or would you know that, by delaying or preventing sprouting?

Mr. KIRK. I don't know as I would want to try to plant any potatoes that had been so treated.

Representative PRICE. Senator Aiken would probably know as much about that as anybody.

Senator AIKEN. I don't know. I know sprouts start growing the last of January and they grow awfully fast if you don't pick them off and they don't make a good seed if they are sprouting.

The other question which I asked the previous witness, the wrong witness, is this: Do you give approval to dehydration of all vegetables?

APPROVAL FOR OTHER PRESERVATION METHODS

Mr. KIRK. No, sir. There is no formal approval. However, you must do it in conformity with the requirements of the law, and when someone comes up with a new process, it is quite often that they will come to Food and Drug and outline what they have done, what they propose to do, and ask our views as to whether or not we believe they have done enough background work and whether what they are doing will be in accord with the requirements of the law. We encourage that.

Senator AIKEN. Did you give approval to the atmospheric control process of extending the usable life of fruits; for example, apples? Most apples now in my country are stored in storage houses where the oxygen is pumped out leaving only the nitrogen. That means that a fall apple is as good in May as it was in November. Did you approve that?

Mr. KIRK. We didn't have to. We were asked about it. But because the nitrogen gas is inert, there was no opportunity to be concerned about toxic substances and so forth.

Senator AIKEN. I store my Golden Delicious apples in laundry bags. Otherwise they will shrivel by New Year's. But if they are tied up tight in a laundry bag, they will keep until May. Do you think I should get approval for that process?

Mr. KIRK. No, sir.

Senator AIKEN. If it will work for that, it will work for others. It is a very cheap process which costs about 10 cents a bushel.

Mr. KIRK. You do not need our approval, sir.

ACTION ON FISH FILLETS

Representative PRICE. Is there any way you could give us any indication of when the petition on the fish fillet might be acted on?

Mr. SPIHER. We are awaiting the receipt of the material that we expect to get regarding the shipping and testing that is being conducted right now. We don't know when they expect to get it in. We would not expect our evaluation to take a great deal of time after it has been received.

FDA PROCEDURES AND STAFF

Representative PRICE. Does the Food and Drug Administration independently make physical or chemical analyses to determine that there is no induced radioactivity or chemically toxic substances in food processed by irradiation?

Mr. KIRK. Before the petition is filed, normally we would not do it, but I understand in a few cases our people have tried it out. You see, under the law the burden is on the petitioner to supply us with all of this information. While we do occasionally do a little checking, it is not required that we do so where we believe the data is adequate.

Representative PRICE. You indicate that all petitions are processed promptly, but you cannot issue authorizing regulations unless and until your scientists can certify that there is clear evidence of the safety of this process. How many scientists in FDA devote themselves only to irradiated food or food packaging material, and how many additional scientists are available for this purpose?

Mr. KIRK. Currently we have five who work on this directly, but that is not really a good answer because when you have questions like this one involving whether or not *Clostridium botulinus* may be involved, then that material will go to another division, the Division of Mircobiology, and they will work on this, although ordinarily they are not concerned with the radiation processing of food. This *Clostridium botulinus*, as you know, is a very, very potent food poisoning organism, and is one with which we are most concerned.

You mentioned Salmonellae. We are concerned about that, but, of course, that is a little bit lower on the scale.

Representative PRICE. How do Food and Drug scientists establish clear evidence of the safety of a process?

Mr. KIRK. Basically by review of what has been done, the results, and whether or not the data answers the scientific questions which come to them as they are reviewing the process and the results of the studies in the light of their past experience and so forth.

I should add, Mr. Chairman, that we have an arrangement with the Radiological Health Group in the Public Health Service, and our people work very closely with them. We do not release a petition for a regulation until they have had a look at it, too.

Representative PRICE. In general do you feel that you have enough scientists assigned to this food irradiation program?

Mr. KIRK. I seriously doubt that we do, sir, but these people are in very short supply. They are hard to get.

Representative PRICE. Do you have a backlog in the handling of petitions of all types of food processing?

Mr. KIRK. Yes, sir.

Representative PRICE. How serious is it?

Mr. KIRK. It is a serious backlog. Dr. Goddard has just arranged for some people who ordinarily do only research work to be taken off those jobs to look at these petitions which we are a little behind on. Actually we have a situation, Mr. Chairman, where the law says we have 90 days after filing which may be extended another 90 days. It has been the exception rather than the rule to get one out in the first 90 days. Dr. Goddard has made no bones of the fact that he is not at all satisfied with that kind of timing and he believes that when a gentleman submits a petition which is a good petition, justifies what the man wants, he ought to get real good service, particularly within the first 90 days specified in the statute.

PREPARING PETITION FOR FDA

Representative PRICE. I was going to ask whether or not the petitioner could give you any assistance in this matter. Do you normally go to the petitioner?

Mr. KIRK. Well, they can give us assistance if they will sit down and write out and organize the kind of petition that makes it easy for our people to follow through precisely what has been done. Unfortunately, we don't always get that kind of petition. We get petitions with lots of enclosures and references here and references there and the scientist who reviews it has to be jumping back and forth.

If he gets a question which is a logical question that ought to be answered right there, he finds it is over on page 92 instead of where he is.

Representative PRICE. Do you encourage informal discussions with the petitioners before the actual filing of petitions?

Mr. KIRK. By all means, we have encouraged that for years. If someone knows precisely what he has to do, he is more likely to do a better job in presenting his evidence.

IONIZING RADIATION AND OTHER TERMS

Representative PRICE. Could you explain to us what is conveyed to you by the term "ionizing radiation"? This is one you indicated you have problems with in connection with your packaging petition.

Mr. KIRK. Yes, sir. I don't think I am the man to say what the average consumer, if there is such a person, would think. But to us it means a radiation processing operation which has done a job. As I mentioned, there is a lot of concern that this statement is going to scare the customer. We believe firmly the customer is entitled to know that this new process has been employed.

As we indicated in the statement, we have these 16 communications which are by and large very thoughtful communications. They discuss why they don't like this. There are a few of them that say you

should not have anything on the label; but by and large there is a general agreement that the customer is entitled to know.

Now perhaps this is not the best term. We are not going to rush the matter of making a quick decision that, "Well, we have said this and we are going to stand on it." Rather than that, we are trying out these various ideas which were proposed to us.

The next question for us to determine is, Should we change this or should we say, "All right, people have asked for a public hearing as is provided in the statute, and let us have a hearing"? Certainly there should be no hearing if any of these have convinced the Commissioner that what he has done should be changed. Dr. Goddard does not have the benefit of staff review of the 16 communications as yet.

QUESTION OF LABELING AND RE-IRRADIATION

Representative PRICE. There are a number of different types of radiations.

Mr. KIRK. That is true.

Representative PRICE. Would you comment on the advisability of labeling according to the method of radiation? Say this is gamma radiation treated or processed, X-ray processed, electron processed, or whatever specific method is used?

Mr. KIRK. My personal opinion, sir, is that that would not be a good idea, that you would just compound confusion. Certainly you don't want to create an illusion that one type is better than another so far as the consumer is concerned, when they are all safe.

Mr. CONWAY. It would be more specific than the very general term that you have originally gone forward with. To an educated layman it may mean a lot more.

Mr. KIRK. I agree.

Mr. CONWAY. It might not have a connotation that the other words have tended to develop over the years. It would give more specific information.

Mr. KIRK. This suggestion was offered in some of the communications. As I say, the Commissioner has made no decision on it. My personal view is against it.

Representative PRICE. Since you cannot by law irradiate food for sale to the public unless the Food and Drug Administration regulations are followed, what is the significance of the Food and Drug Administration requirement as pointed out in your statement that bulk shipments be labeled with the words, "Do not irradiate again"?

Do you require such labeling in connection with other processes? For example, since refreezing after thaw may be of concern both to health and wholesomeness, do you require a label saying, "Do not refreeze"?

Mr. KIRK. We do not so require. However, we are currently trying to work out with a lot of people a method by which a quick indicator of thawing can be placed on a package so that if it is supposed to be red and it turns blue, there will be an indication there that this has been thawed somewhere along the line.

We have not required such labeling, although, frankly, most frozen food people do use that. It is from a quality standpoint.

Mr. CONWAY. You do the same with irradiated products. You put on certain monitoring devices that becomes discolored which indicate that it has been irradiated. If you put that on a bulk package thereafter and it was reirradiated, it would show.

Mr. KIRK. One thing I think of in this area, sir, is the carload of wheat which is a bulk shipment of wheat. There we would call for that statement on the invoice. Now, we have provided for a limit as to the irradiation which may be applied to that wheat. Now, if it is going to be irradiated in Minneapolis, shipped to Chicago, and somebody says we had better irradiate this wheat, he does it again and it gets to New York and he does it again, you are way outside the regulation by then. The whole idea was to get across to the next man what has been done.

Mr. CONWAY. I think the concern is whether or not you are setting up special rules and regulations that are outside the normal methods you have in other food processes and particularly where they also might have some problems.

Mr. KIRK. We are thinking here of safety. In other words you have a regulation that permits you to do something.

Mr. CONWAY. I am thinking also of food products. As the chairman brought out, if you have something frozen and the ultimate consumer goes into the market and buys what he thinks is frozen food and that has been thawed and refrozen and thawed and refrozen all along the chain without his knowledge, he may be getting some food with some real health hazards built in.

Mr. KIRK. That is true.

Mr. CONWAY. Again what we are trying to suggest is that if you are going to have rules and regulations, can you apply it evenly to the various processes and not necessarily penalize one versus another?

Mr. KIRK. Of course as far as retail packages are concerned, we were not proposing this "Do not irradiate again." We did have in mind this large-scale operation, particularly where there is a bulk operation. As far as the carload of wheat is concerned, very frankly, "Do not irradiate again," on the invoice would not have any bad effect on anybody that I can see.

Representative PRICE. The reference then is to the invoices more than to the package, itself?

Mr. KIRK. On that bulk shipment operation, yes. There we are talking about things where the people who might treat it again really ought to know, they have a right to know, they have an obligation to know.

Representative PRICE. I think they should know. It is important that they know.

Mr. KIRK. Yes, sir.

Representative PRICE. Thank you very much, Mr. Kirk. The committee will recess until 2 o'clock this afternoon.

AFTERNOON SESSION

The subcommittee reconvened at 2 p.m., Representative Melvin Price, chairman of the subcommittee, presiding.

Representative PRICE. The committee will be in order.

This is a continuation of the hearing being held by the Subcommittee on Research and Development on the Food Irradiation Program.

The first witness this afternoon will be Mr. Joseph Slavin, Acting Assistant Director for Industrial Research, Bureau of Commercial Fisheries. He will be accompanied by Mr. Louis J. Ronsivalli, Project Director of the Gloucester Marine Pilot Plant Irradiator. Will you gentlemen proceed, please?

STATEMENT OF JOSEPH W. SLAVIN, ACTING ASSISTANT DIRECTOR FOR INDUSTRIAL RESEARCH, BUREAU OF COMMERCIAL FISHERIES, U.S. DEPARTMENT OF THE INTERIOR; ACCOMPANIED BY LOUIS RONSIVALLI, PROGRAM LEADER FOR TECHNICAL IRRADIATION STUDIES, GLOUCESTER TECHNOLOGICAL LABORATORY; AND JOHN KAYLOR, OPERATOR AND SUPERVISOR OF THE AEC'S MARINE PRODUCTS DEVELOPMENT IRRADIATOR (MPDI)

Mr. SLAVIN. Thank you, Mr. Chairman.

I will attempt to be brief, as I realize that the committee is pressed for time. I have on my right, Mr. Ronsivalli, head of fishery irradiation research program, and Mr. John Kaylor, who is head of our Marine Products Development Irradiator (MPDI).

I have several technical reports that I would like to submit for the record.

Representative PRICE. Without objection, they will be accepted.

Mr. SLAVIN. One is a report of a meeting held at Karlsruhe, Germany, last June, in which a comprehensive paper was given on the technical aspects of fishery products irradiation. I also have a statement by Mr. Ronsivalli on recent technical developments in the program (see appendixes, 3 and 4, pp. 124 and 126.)

I will attempt to briefly review some of the highlights of the program and try to answer some of the questions that you may raise concerning industry participation and industry interest in the program.

ADVANTAGES OF IRRADIATION FOR SEAFOOD

Last year you perhaps will recall when I appeared before this committee I expressed some optimism in regard to commercialization of irradiation in the seafood industry. Today I am pleased to report that our work using the marine products development irradiator has been very encouraging.

Also, as Commissioner Ramey mentioned, a petition has been submitted to the Food and Drug Administration for approval of irradiated fish fillets.

I would like to cite for the record a specific example on exactly how irradiation can be applied in the seafood industry and what its value is both to the fishermen and to the processor.

ECONOMICS OF FISH IRRADIATION

For example, in 1964 some 39 million pounds of haddock fillets representing about 100 million pounds of fish exvessel were distributed in this country. Contrary to expectation, only 13 million pounds of fillets were frozen. Over 26 million pounds were shipped fresh and unfrozen. Largely this was to the restaurants and institutional trade.

The demand for such fish on the part of buyers representing these food outlets was such as to drive the price up to 80 to 90 cents per pound of fillets, representing a return to our fisherman of about 20 cents per pound at the dock. This contrasts sharply with the 5 to 7 cents per pound commonly recived by fishermen in the early 1950's.

This development is significant in terms of the program that we discuss here today in that today's fresh fish markets out of Boston extend only as far west as Chicago and except in very special cases only as far south as Washington, D.C., and Kentucky.

The use of gamma radiations to preserve fish fillets in a form identical with that of the natural fish fillet will enable the industry to extend its market distribution throughout the Nation. The consequent prospects for an economic revitalization of this industry and for a return of capital and labor to it, modernization of vessels and increased productivity alone justify Government interest and support for the radiation preservation program.

I would like to make the point here that industry is interested in radiation only because they feel it will be profitable for them. They see radiation as a means of selling more of their product in a fresh condition, thereby getting a higher price and as a means of eliminating and reducing waste.

I would like to point out, too, that with radiation pasteurization you produce a fresh fillet that compares equally with the nonirradiated fresh fillet.

I have only mentioned one species of fish and one major fishing port, but as I mentioned last year, we have worked on something like 18 different species of fish and shellfish, and when we take a look at these products and the many diversified uses we find for them in the fresh form, I think that you can see the potential that radiation may have in our fishing industry.

Against this background, I would like to discuss our efforts utilizing the pilot plant irradiator, the MPDI, and the shipboard irradiator.

As you know the MPDI is a semicommercial seafood irradiator experimental prototype of some of the irradiators we hope soon will be found all over the country. It contains 250,000 curies of cobalt 60 and has a capacity of approximately a ton of fish per hour at a low dose of 250,000 rads.

During the past year over 152 separate and distinct radiation assignments have been performed in the MPDI. We have handled something like 42,000 pounds of products. While by far the greatest part of our production has been concerned with fishery products, we have also pasteurized fruits, meats, chickens, and some nonfood items. We have taken a look at beer and also done some work on gypsy moth.

In our program we have cooperated quite actively with Dr. Josephson's group at the Army laboratories at Natick and also with the USDA. We find through these cooperative efforts we have been able to harmoniously work together and get quite a bit done for the overall objective of the program.

As far as commercialization goes, we in the laboratory have conducted many storage life studies. In fact, this information is reflected in the petition on fish fillets that has been made available to the Food and Drug Administration. This information does substantiate what can be realized by applying radiation to fish fillets.

Generally speaking it means a shelf-life extension of from 12 to around 30 days. But we have also, as Commissioner Ramey mentioned, made products available to the industry. We have made these fillets available to two groups in the industry, to processors in the industry so that they can take the products into their plants and evaluate them, and also to large chainstore operators.

Specifically, we have cooperated with five major processors, and we have furnished them haddock and flounder fillets and they have confirmed our laboratory findings with regard to the quality extension that can be realized and with regard to the fact that there is no difference between fresh fish and irradiated fish. By no difference, I mean there is no difference in the normal characteristics of the product.

CHAINSTORE INTEREST IN IRRADIATED FISH

We have also made irradiated fillets available to large chainstore operators who handle a large number of different food items. In this case I would like to point out that these chainstore operators again are interested in making a dollar and they are also interested in being able to provide a food that the consumer desires.

These buyers, as you know, are not laboratory experimenters. They are shrewd businessmen with discriminating sensitivity for success and success means profit in business. We have received favorable replies from eight food chains. Some of them have stores from coast to coast. Others have concentrated in certain regions with their supermarkets. The number of stores per chain varies from as few as 75 up to the thousands. The chains which have cooperated with us so far have a total of 8,886 stores at the last count. This I would like to submit is a substantial number of stores.

What do the chainstore operators see in irradiation? They see means of providing a fresh product which is in demand. You probably realize in some of the supermarkets there is a great emphasis on marketing fresh food and thus a lot of the chainstores are interested in marketing more fresh fish because they can get a higher price for it than they can in the frozen form or in other forms.

They also see reduction of waste.

Our industry contacts to date have been on a selective basis. This has been done to permit us to perfect our distribution techniques and to insure beyond all doubt that no irradiated products reach the consumer. We are now ready to take the next step. We are ready to contact and elicit the cooperation of additional chainstore

organizations and of the independent distributors of fish who service the thousands of individual restaurants, hotels, institutions, and grocery stores.

OTHER STUDIES; SHIPBOARD IRRADIATION

We are also ready to make relatively large shipments under strictly controlled conditions through complex distribution channels, to Bureau laboratories in all parts of the country.

This work has been required because of questions raised in connection with clearance procedures, as to efficacy and need for the process and as to consumer attitudes. The latter can be conclusively resolved, of course, only through clearances and commercial adoption, but our studies during fiscal year 1967 will yield information on the attitudes of the persons most responsive and sensitive to probable consumer reactions, the buyers and distributors who serve the consumer.

I would like, also, to point out in response to the point raised by Dr. Kirk, of Food and Drug, that we are in a position to draw some of our data together and present it to Food and Drug to answer the question of efficacy which was raised this morning.

We also have two shipboard irradiators that have been constructed by the AEC. One has been placed aboard the Bureau's exploratory vessel *Delaware* operating out of Gloucester and a second will shortly be placed on the Bureau's exploratory vessel *Oregon* which operates out of the gulf.

We expect that by the close of fiscal 1967 we will have some very definitive evidence on the operational feasibility and benefits to be gained by irradiation of fish at sea immediately after capture.

I have attempted to go through the statement rather fast because of time. I do have the complete statement which I will submit for the record.

(The statement follows:)

ECONOMIC IMPLICATIONS AND COOPERATIVE INDUSTRY-GOVERNMENT IMPLEMENTATION OF THE RADIATION-PROCESSED FOOD DEVELOPMENT PROGRAM

Thank you, Mr. Chairman.

It is a privilege to appear again before this Committee to discuss the fisheries aspects of the AEC food-irradiation research and development program.

I have with me from our Gloucester laboratory, Mr. Louis Ronsivalli, Program Leader for technical irradiation studies, and Mr. John Kaylor, operator and supervisor of the AEC's Marine Products Development Irradiator (MPDI) who will assist me in answering any questions that may be raised. My comments, largely an extension of my statement during last year's hearings before this Committee, will cover the implications of this program for the domestic fisheries and its supporting industries, as well as our activities in encouraging and facilitating early commercialization of the process.

Last year, I expressed optimism in respect to the possibility of industry's early participation in the fisheries program. Today, I am pleased to report our results are very encouraging after one-year's operation of the MPDI as a vehicle for industry-Government testing of the market-acceptance and feasibility of the process. Further, the submission to the Food and Drug Administration during 1966 of food additive petitions covering, among other products, six different fish commodities (haddock, cod, sole, flounder, pollock, and ocean perch), gave further incentive to industry's interest. We are hopeful that these clearances will be given at an early date.

The interest of the Department of the Interior and of its Bureau of Commercial Fisheries in the food-irradiation program stems from several sources: (1) the greater susceptibility of fresh, unfrozen fish to spoilage than is the case with other animal-protein foods—and the consequent large annual losses to the domestic industry from this fact, and (2) the growing demand on the part of our society for certain highly valuable species of fish and shellfish in a sea-fresh state—and the inability of the industry, under present processing technology, to satisfy this demand throughout the nation. Also I would like to point out that in spite of its widespread reputation as a conservative industry, the domestic fishery industry is an innovator, recognizing a good thing when it appears—it pioneered in the development of today's great frozen-food industry—contributed greatly to the development of our canned foods industry and, today,—is in the forefront of industry participation in the food-irradiation research program.

I'd like to cite a specific example to show how the American public will spend more money for higher quality fresh fish, such as would be supplied by irradiation. In 1964, some 39 million pounds of haddock fillets, representing about 100 million pounds of fish, ex-vessel, were distributed. Contrary to expectations only 13 million pounds of fillets were frozen; over 26 million pounds were shipped fresh and unfrozen, largely to the hotel and restaurant trade. The demand for such fish, on the part of buyers representing these food outlets, was such as to drive the price up to 80 to 90 cents per pound of fillets, representing a return to our fishermen of about 20 cents per pound at the dock. This contrasts sharply with the five to seven cents per pound commonly received by fishermen in the early 1950's. This development is significant, in terms of the program being discussed here today—in that today's fresh fish markets out of Boston extend only as far west as Chicago and, except in very special cases, only as far south as Washington, D.C., and Kentucky. The use of gamma radiations to preserve fish fillets in a form identical with that of the natural fish fillet will enable the industry to extend its market distribution throughout the length and breadth of the nation. The consequent prospects for an economic revitalization of this industry—for a return of capital and labor to it—for the modernization and increased productivity of its vessels, fishing gear and crews, alone would justify interest and support for the radiation-preservation program. Stress why industry should be interested.

I have mentioned merely one species of fish and one major fishing port. We confidently expect the same benefits for the crabmeat industries of Alaska, Washington, Oregon, Maryland, and the southeastern and Gulf States. Similar demand exists for swordfish, scallops, oysters, and clams. In a nutshell, with respect to the hotel and restaurant trade and during certain fast-days and fasting-seasons (such as Lent), fishery products enjoy what our economists tell us is an inelastic demand; no other protein-food may be wholly substituted for fish or shellfish if the latter is available in good quality at any reasonable price. Both the fishing industry and Government see this new processing development as aiding the rebirth of a new basic food industry.

Against this background, I wish to discuss our efforts, utilizing the pilot-food irradiator (MPDI) and the shipboard irradiator, to encourage industry participation in the program, to permit analyses by dispassionate businessmen of the feasibility and market value of the process and to study the quality characteristics of irradiated foods as against non-irradiated foods during long distribution and storage intervals. The MPDI is a semicommercial seafood irradiator, an experimental prototype of the irradiators we hope will soon be found all over the country. It contains 250,000 curies of cobalt 60—and has a design capacity, for radiation-pasteurization dosages of 250,000 rads of energy, to handle 2000 pounds of food products per hour. Under an experimental license granted by the Food and Drug Administration, we have been furnishing technical advice and food-radiation services to all responsible parties, in industry, in research and in Government, upon request. During the past year, over 152 separate and distinct irradiation assignments, totalling over 42,000 pounds of product, have been completed. While, by far the greatest part of the production involved fishery products, we have also pasteurized fruits, meats, chickens, and non-food products. We have actively cooperated with several Army corps, the Dept. of the Army and U.S.D.A. in irradiating these products. Table 1 includes a summary of the type and scope of the services rendered.

During this last fiscal year, the MPDI performed the following irradiation services:

TABLE 1.—*Operations of the marine products development irradiator*

Product	Number of jobs	Unit	Purpose
Beer	1	2 cases	Industry pasteurization.
Clams (shucked)	16	9,680 pounds	Research pasteurization.
Clams (sea)	1	25 pounds	Do.
Clams (live)	11	37 bags	Do.
Crabmeat, blue	2	84 pounds	Do.
Crabmeat, Dungeness	1	20 pounds	Do.
Crabmeat, king	2	21 pounds	Do.
Culture medium, microbiological	1	Samples	Research sterilization.
Cod	12	793 pounds	Research pasteurization.
Chicken	1	80 pounds	Do.
Haddock	27	2,340 pounds	Do.
Do	14	1,945 pounds	Industry evaluation.
Ham	3	930 pounds	Research sterilization.
Film bags	4	600 pounds	Do.
Fish extract	1	7 tubes	Research pasteurization.
Fish oil	2	9 vials	Research sterilization.
Flounder	2	60 pounds	Research pasteurization.
Do	2	540 pounds	Industry evaluation.
Glassware	1	Assorted	Research pasteurization.
Oysters (shucked)	2	26 pounds	Do.
Oysters (live)	2	118 pounds	Do.
Perch, ocean	1	20 pounds	Do.
Perch, yellow	1	25 pounds	Do.
Do	1	10 pounds	Industry evaluation.
Pike	1	do	Do.
Scallops	1	165 pounds	Do.
Do	2	100 pounds	Research pasteurization.
Seawater	4	4 samples	Do.
Shrimp	2	11 pounds	Industry evaluation.
Do	1	20 pounds	Research pasteurization.
Fish special	1	5 each	Do.
Insects	2	2,571 pupae	Research-sexual sterility
Wood plastic compound	2	Various	Research industry.
Viruses, etc	1	Tubes	Research pasteurization.
Do	1	Oysters, live	Do.
Papayas	1	3,500 pounds	Research deinfestation.
Mangos	1	4,000 pounds	Do.

MPDI activities in this period, other than operation, have emphasized the commercial potential of fresh seafood distribution to determine just how irradiated seafoods will fit into the picture when they are finally cleared for general sale. We have conducted many storage-life and product-quality studies utilizing current commercial conditions of handling, processing, and transporting fish fillets from the fish pier to the fish peddler. Some of the shipments were to warehouses as far as 1500 miles from Gloucester. These were all commercial-size shipments which, in some cases, belonged to industry and not to us. All travel was ICC regulated common carriers. In no sense can they be regarded as laboratory experiments. We find that irradiated fillets, travelling in the same carriers under identical conditions, will outlast the nonirradiated fillets by ten or more days.

We used the above method of commercial transportation to send shipments of irradiated and non-irradiated haddock fillets to interested processors, chain-store seafood buyers and other industry members located hundreds of miles away from our irradiator. Such samples were, of course, controlled. None entered the retail outlets and the samples were destroyed at the end of the testing period. These experienced people tested the fillets in their laboratory over an extended period of time. They reported that the irradiated fillets outlasted the non-irradiated fillets from six to fourteen days. Specifically, we have cooperated with 5 major processors, haddock and flounder fish fillets. They have confirmed our laboratory findings on quality extensions that can be obtained over that of fresh fish. We have also made irradiated fillets available to large chain store operators who handle a large number of different food items.

These buyers are not laboratory experimenters. They are shrewd businessmen with a discriminating sensitivity for success, and success means profits in business. To date, we have received favorable replies from eight chain stores. Some of them have stores from coast to coast. Others have concentrated in certain regions with their supermarkets. The number of stores per chain varies from as few as seventy-five up to the thousands. The chains which have

cooperated with us so far have a total of 8,886 stores at the last count. We have concentrated our efforts in the regions of heavy population, that extends from Boston to below Washington. These outlets are all successful merchandisers, and they sense the potential of irradiation of fresh seafoods. They are eager for irradiation because it will reduce waste, increase profits and enable them to pass along savings to consumers.

Our industry contacts, to date, have been on a selective basis. This was done to permit us to perfect our distribution techniques and to ensure, beyond all doubt, that no irradiated products reached the consumer. We are now ready to take the next steps: (1), to contact and elicit the cooperation of additional chain-store organizations and of the independent distributors of fish who service the thousands of individual restaurants, hotels, institutions, and grocery stores, and (2) to make relatively large shipments, under strictly controlled conditions, through complex distribution channels to Bureau stations in all parts of the country. Bureau experts will test and evaluate the shipments as to quality and condition when received and as to comparative shelf-life remaining, upon arrival, of the irradiated fish and non-irradiated controls. This work has also been required because of questions raised, in connection with clearance procedures, as to efficacy and need for the process and as to consumer attitudes. The latter can be conclusively resolved, of course, only through clearance and commercial adoption but our studies during fiscal 1967 will yield information on the attitudes of the persons most responsive and sensitive to probable consumer reactions—the buyers and distributors who serve the consumer.

During the past year, construction of two prototype shipboard irradiators was completed. One has now been placed aboard the Bureau's exploratory vessel *R/V Delaware*, operating out of Gloucester. A second will shortly be placed on the Bureau's exploratory vessel, *R/V Oregon*, operating out of Brunswick, Georgia, and Pascagoula, Mississippi. Initial operational tests, on sea clams, have been completed on the *Delaware* irradiator. We expect that by the close of fiscal 1967, we will have definitive evidence of the operational feasibility and benefits, to be gained by irradiation of fish at sea immediately after capture.

This concludes my statement. We have discussed commercialization, like putting the cart before the horse.

(1) Government has committed itself to peaceful application of food research.

(2) Industry is not in a position to support this kind of research, but once research is completed and FDA approval is obtained, industry will apply.

NEED FOR FDA CLEARANCE

Mr. SLAVIN. In listening to the committee questions this morning and some of the discussions, it seemed that the committee was raising the points as to how about commercialization, what is industry's interest in this?

I would like to submit that in some cases it is kind of like putting the cart before the horse. This radiation program has been in effect now since 1960. We have been discussing the program with industry members continually, and there has been quite a bit of interest. But the lack of any FDA approval for the process is really a deterrent at the present time. I think that after FDA approval is obtained on more items, that you will see more action in the industry and you will definitely see application in the fishing industry.

Furthermore, the question was raised as to why should the Government undertake this research. Although I can't put an exact figure on it, a large number of dollars have been spent to date, to get sufficient data for FDA approval, I would like to submit it would be very difficult for any industry firm to undertake this very costly research.

So, if the Government then is dedicated to peaceful application of atomic energy, I think the food industry, which is one of the biggest industries in the United States, is certainly a potential for this. I

think it will take time, it is going to take research, but I think the end results will be very beneficial to all. Thank you very much.

Chairman HOLIFIELD. Thank you, Mr. Slavin.

You know how hard this committee has fought to keep this irradiation program going. Your statement is quite encouraging.

As you know, we do have some items already cleared by the FDA. Do they give any technical reasons why they are slow in clearing the fish? They have cleared bacon and some other foodstuffs.

Mr. SLAVIN. I think on the fish we do have to come back to FDA with some more data as to the efficacy of the process—efficacy meaning perhaps some of the benefits that can be realized commercially, whether the shelflife extensions that were realized in the lab can be realized commercially. We have this now. I think when we can come back to Food and Drug with this information, then we will see where we stand.

Chairman HOLIFIELD. When do you plan to make your next appearance before them?

Mr. SLAVIN. This will be up to the AEC, but we are gathering the data together now to have AEC submit it to Food and Drug.

Chairman HOLIFIELD. Do you think it will be this year?

Mr. SLAVIN. I would hope so certainly. In fact I would hope it would be fairly soon.

Chairman HOLIFIELD. Senator Hickenlooper, do you have any questions?

HISTORY OF FISH IRRADIATION

Senator HICKENLOOPER. How long have you been experimenting with fish products, Mr. Slavin?

Mr. SLAVIN. Since 1960, sir.

Senator HICKENLOOPER. What has been the nature of those experiments with regard to the efficacy of the program?

Mr. SLAVIN. The experiments started off first of all on an exploratory nature to determine what products were more susceptible to irradiation, which products we could get shelflife extension in. As far as efficacy, this work has been conducted only during the past year. This has been mainly concerned with the shipping and distribution studies, and industry's evaluation of the products.

Senator HICKENLOOPER. When you started the investigation, in addition to testing the feasibility of irradiation for preservation, did you also test the shelflife beginning at that time?

Mr. SLAVIN. Yes, sir.

Senator HICKENLOOPER. And the storage and the ease with which it could be stored or the success with which it could be stored?

Mr. SLAVIN. Yes.

Senator HICKENLOOPER. It has been going on all that time?

Mr. SLAVIN. Since 1960.

Senator HICKENLOOPER. Has the Food and Drug Administration known about this all this time?

Mr. SLAVIN. I think they do because the AEC has annual contractors' meetings and usually there is a representative from the Food and Drug Administration which attends these meetings.

Senator HICKENLOOPER. It has not been reported to them or do they just have to pick it up at a meeting someplace?

Mr. SLAVIN. I am not aware of the formal reports which have been made available to Food and Drug.

Senator HICKENLOOPER. I was wondering about the long delay. You have been working at this thing for 6 years and they have not approved it yet. What is the reason for it?

Mr. SLAVIN. We had to get quite a bit of information to prepare the petition. The petition was only submitted just about a year ago, a little more than a year ago. So, we did have to acquire quite a bit of scientific information for the petition on fish fillets.

Senator HICKENLOOPER. That is all, Mr. Chairman.

PRIOR CONSULTATION WITH FDA ON PETITIONS DESIRABLE

Mr. CONWAY. I might make mention, Mr. Chairman, in this morning's testimony representatives from FDA mentioned delays having been caused by the necessity of getting additional data. But in response to queries from members of the committee, the representatives from FDA indicated that they would encourage and try to encourage informal discussions prior to the formal submission of the petition. It would seem that this is where some of these delays might be eliminated.

If in the formal meeting they could lay out exactly what is expected from the petitioners and the petitioners in turn would know how to proceed and how to formalize a petition, a great deal of time might subsequently be saved.

They indicated they would be receptive to that and would attempt to encourage it.

Mr. SLAVIN. This is a very good point. As you recognize, this research is quite costly. If we can get an agreed-upon protocol early in the game, then I think we can complete the necessary research and fill in the missing spots and provide the necessary answers. But if you have to keep going back and going back and going back, it can be a very long and costly process.

Senator HICKENLOOPER. Has that not been one of the things that bureaucracy is accused of, going back for more data and submit that data and this is not sufficient and go back and submit some more and it goes on ad infinitum?

Mr. SLAVIN. Yes; definitely. In fact, I have just moved up from Gloucester, from the head of the lab, to Washington. I am becoming more of a bureaucrat. But you are quite right, sir. This is what happens.

Chairman HOLIFIELD. We hope you will bring some of your frustration and impatience from the lab to Washington and push this along.

Mr. SLAVIN. I intend to do that.

SHIPBOARD IRRADIATORS

Chairman HOLIFIELD. Do you think it is feasible to have shipboard irradiators for fish preservation on the ships where they catch them?

Mr. SLAVIN. Yes, I do. Of course, this is a program we are just getting into, but logically it is a very good program because when fish

are landed on the vessel, they are pretty near sterile. If we can just irradiate them at low levels, we can get high through-puts of amounts of fish and extend shelf life on the vessel to permit landing a fresh product which one can do a lot more to.

Chairman HOLIFIELD. This would involve cleaning and packaging them on the ship, would it not?

Mr. SLAVIN. Yes, sir. It would involve different concepts than the way we handle them now. On the other hand, we are building new and advanced fishing vessels. As you probably know, the Russians have some very large factory vessels where the products are frozen on board and then later thawed and refrozen ashore. In this case we are providing fresh products with irradiation.

SOVIET UNION INTEREST IN FOOD IRRADIATION

Chairman HOLIFIELD. Do we have any information as to whether the Soviets are using irradiation yet?

Mr. SLAVIN. Over at the meeting in Karlsruhe, in June, the Soviet delegation in its statement indicated that Russia is applying irradiation to meat and vegetable products. Also, they are working on a sterilzed fish product. Apparently the Russians are quite interested in irradiation; they see a place for it in their economy, and they said by the time of the next meeting they expect to have several cleared fish items, including caviar.

PACKAGING OF IRRADIATED FISH

Chairman HOLIFIELD. Does the problem of maintaining the integrity of the packaging seal have anything to do with the delay on the part of the FDA?

Mr. SLAVIN. No; not that I know of.

Chairman HOLIFIELD. As I understand it, after the fish is irradiated, it has to be put into a container that is also sterile and usually thought of as being a plastic container of some kind. I am just wondering if in the shipping of plastic containers, if you have the problem of perforation which would cause bacteria to get into the package and cause fish spoilage, that might cause some trouble.

Mr. SLAVIN. This has not been a problem at all. You see, the fish fillets, or whatever the product, are irradiated in the package. Let us say this package is opened subsequently and then the product is just put out on the retail counter, that product will spoil in the normal manner. This is kind of like a safeguard. No vacuum packaging or anything is required.

Chairman HOLIFIELD. Could you explain the advantages or disadvantages of frozen fish versus freeze dried and compare them with fish preserved by irradiation?

Mr. SLAVIN. Well, irradiated fish, for example, produce a product that compares with the fresh product. It is essentially the same as the fresh product with a longer shelf life. On freezing, of course, you change the product and you get a product which goes through a distribution chain and on which in many cases you don't know what the history is. It spoils in a different way than the fresh product, over a longer period of time. With freeze drying you remove the

moisture from the product and produce a product that can be stored without refrigeration. The cost, you see, in irradiation is perhaps 2 to 3 cents a pound, where in freezing it is about 1 cent a pound, and in freeze drying, it is around 8 cents a pound of wet product. So the added cost for irradiation, when you produce the product in the fresh form is very little.

Representative PRICE. Senator, do you have any questions?

Senator HICKENLOOPER. Thank you.

Representative PRICE. Thank you very much, Mr. Slavin.

Mr. SLAVIN. Thank you, sir.

Representative PRICE. The next witness will be Mr. Charles L. Poor, Deputy Assistance Secretary of the Army for Research and Development, and Dr. Edward S. Josephson, Associate Director for Food Radiation.

Mr. Poor, will you give your statement first?

STATEMENTS OF HON. CHARLES L. POOR, DEPUTY ASSISTANT SECRETARY OF THE ARMY (RESEARCH AND DEVELOPMENT), AND DR. EDWARD S. JOSEPHSON, ASSOCIATE DIRECTOR FOR FOOD RADIATION; ACCOMPANIED BY COL. IRVIN C. PLOUGH, CHIEF, RESEARCH DIVISION, OFFICE OF THE SURGEON GENERAL; AND VERNON T. GILPIN, FOOD SERVICE OFFICER, OFFICE OF THE CHIEF OF SUPPORT SERVICES

Mr. POOR. Thank you, Mr. Chairman. The Army especially welcomes the opportunity to review our activities and accomplishments in the food radiation program since the last meeting we held here in June 1965.

Because of his long experience and detailed knowledge of the Army program, I have asked Dr. Edward S. Josephson, Associate Director for Food Radiation, Food Division, the Natick Laboratories, to describe the current status of our program and to discuss concepts for future utilization of irradiated foods by the Army. Before Dr. Josephson's presentation, I would like to introduce supporting witnesses to the committee. They are Col. Irvin C. Plough, Chief, Research Division, Office of The Surgeon General, and Mr. Vernon T. Gilpin, Food Service Officer, Office of the Chief of Support Services.

We welcome questions at any time during the presentation on aspects not covered to your satisfaction. With your permission, I would like to ask Dr. Josephson to continue the Army presentation.

Representative PRICE. Dr. Josephson, you have quite a lengthy statement. I suggest that we consider the whole statement as though read and you pick up what you consider to be the vital and most important part of the statement which I understand is on page 12 of one copy and on page 13 of the copy I have in front of me, "Future Utilization Concepts."

Dr. JOSEPHSON. The first 12 pages, sir, list a series of accomplishments since the last hearings. They are summarized in the table in front of you and you will have the expanded details go into the record.

(The first part of the statement follows.)

STATEMENT BY DR. EDWARD S. JOSEPHSON,[1] ASSOCIATE DIRECTOR FOR FOOD RADIATION, FOOD DIVISION, THE NATICK LABORATORIES, DEPARTMENT OF THE ARMY

Mr. Chairman and Members of the Joint Committee: It is a pleasure to appear before you again to review activities and accomplishments of the Army Food Irradiation Program during the period since the last Hearings in June 1965. With your permission, I also would like to describe some future utilization concepts as they have evolved over the past 15 months.

CURRENT STATUS

The Army program has followed the plan presented to you at the June 1965 Hearings. I am pleased to report that progress has been excellent. To present the details of this progress, I have grouped accomplishments into three general categories.

Turning attention first to actions related to the Food and Drug Administration (FDA) and the Department of Agriculture (USDA), much has been achieved through the superb cooperation of these two agencies with the Army.

(1) The experimental work in support of petitions to FDA and USDA for irradiation sterlized ham has been completed. The petition was submitted to both agencies on July 11, 1966 and accepted for filing by FDA on August 15, 1966. The petition requests approval of shelf-stable canned ham treated with cobalt^{60} or cesium^{137} in the dose range from 3.5 to 5.6 megarads for unlimited public consumption and use in interstate or foreign commerce.

(2) All the experimental work on irradiation sterilized pork has been completed and the petition is in the final stages of preparation. The pork petition will be submitted to FDA and USDA within the next 60 days, and will request approval of shelf-stable canned pork preserved by gamma energy from cobalt^{60} or cesium^{137} in the dose range from 4.0 to 5.6 megarads.

(3) Research and testing of ham and pork irradiated in the frozen state at $-30°C \pm 10°C$ have progressed to the point that petitions for these two products will be submitted to FDA and USDA in the fall of 1967. Their quality, i.e., their appearance, texture and acceptability, is much improved when compared with products irradiated at room temperature. In addition, vitamin losses, particularly vitamin B_1, are decreased by this low temperature processing. The final long-term studies of microbiological safety are under way and will be completed in the summer of 1967.

(4) On 13 July 1965, FDA accepted for filing the Army's petition for the following four films as food contactants for irradiation sterilization processing of prepackaged foods: (a) polyethylene, (b) poly(ethylene terephthalate), (c) poly(vinyl chloride-vinyl acetate), and (d) Nylon 6.

(5) In addition, experimental work on five more plastic films has been completed. These are: (a) polystyrene, (b) poly(vinylidene chloride-vinyl chloride), (c) Nylon 11, (d) high density polyethylene, and (e) poly(ethylene terephthalate-isophthalate). The petition to FDA for these plastics with improved radioresistance will be submitted during the second quarter of FY 67.

(6) From studies over the past 3 years on quality improvements by irradiation at low temperatures from 0°C to —160°C, it has been possible to eliminate studies

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[1] Dr. Edward S. Josephson is Associate Director for Food Radiation, Food Division, and Director, U.S. Army Radiation Laboratory, the Natick Laboratories, Natick, Mass.

A noted biochemist, Dr. Josephson has been active in Government research since 1944. Before coming to Natick in 1954, he worked in Washington with the Office of the Quartermaster General, Research and Development Division; the Office of the Chief Chemical Officer, R&D Division; and the U.S. Public Health Service, National Institutes of Health.

One of three Department of the Army civilians selected in 1961 to attend the Industrial College for the Armed Forces, Dr. Josephson received three commendations for his outstanding contributions and achievements at the end of the 1-year resident course. He was 1 of 8 students in a class of 162 whose thesis, "Food Research and Development: Freedom From Want," was selected for outside publication, including a White House request for 200 copies.

He was also cited by the Office of Scientific Research and Development in 1945 for his participation in the Nation's World War II malaria research program.

Born in Boston in 1915, Dr. Josephson is a graduate of Boston Latin School, Harvard College, and Massachusetts Institute of Technology where he received his Ph. D. degree with distinction in 1940.

He has published over 60 articles in scientific journals on food, science, chemotherapy of malaria and amebiasis, nutritional biochemistry, endocrinology, enzymes, and related subjects.

on beef, chicken and shrimp irradiated at room temperature, and to proceed directly with studies on these food products irradiated in the frozen state. Petitions for approval of beef, chicken and shrimp irradiated at low temperatures will be ready for submission to FDA and USDA by the fall of 1967.

(7) Based on the results of extensive studies of microbiological safety, a petition to FDA and USDA is now in preparation to request approval of a reduction in the minimal radiation dose for shelf-stable bacon from the presently approved level of 4.5 megarads down to 3.0 megarads. This petition will be submitted during the second quarter of FY 67. If approved, the lower dose will reduce the cost of production and result in an even better product.

(8) In July 1965 a petition was submitted jointly by the Army and the Atomic Energy Commission (AEC) to FDA requesting approval of six irradiation pasteurized fish—haddock, codfish, sole, flounder, pollock and ocean perch. This petition was accepted for filing by FDA in September 1965.

(9) On November 9, 1965, FDA approved the Army's petition requesting an increase in the maximum permissible dose for irradiating potatoes from 10,000 to 15,000 rads. The higher dose permits more economical irradiation on a commercial scale with reduced handling and bruising of the potatoes.

(10) On February 26, 1966, FDA approved the use of electron beams for insect deinfestation of wheat and wheat products. Using an energy level of 5 million electron volts, the permissible dose is 20,000 to 50,000 rads. The Army contributed the major portion of the data submitted by the petitioner, the High Voltage Engineering Corporation.

We are delighted with this collaboration with FDA and USDA regarding the submission and subsequent consideration of our petitions, and anticipate that this momentum will be maintained over the next few years. With your permission, I would like to submit for the record updated tabulations of items approved and pending before the FDA (Appendices 1 and 2) and an updated planning schedule for submission of future petitions (Appendix 3).

This progress has led to the following actions to procure irradiated food items for the Armed Forces:

(1) Thirty thousand pounds of bacon sterilized with cobalt^{60} were procured in July 1966 for use by the Army and the Air Force. This bacon has now entered our subsistence supply channels and will be used for troop acceptance testing and logistical evaluation. You will recall from the June 1965 Hearings that our first effort to obtain responsive bids on this bacon procurement from private industry was unsuccessful. Subsequently, the March 1965, procurement document was revised and recoordinated with industry. Two responsive bids were accepted and the procurement made.

(2) A procurement document for potatoes irradiated to inhibit spoilage losses from sprouting has been completed and submitted to the Defense Supply Agency. This document will be used this fall as the procurement instrument for 400,000 pounds of potatoes to be divided among the Armed Forces. These potatoes will be placed into our subsistence supply channels for test and evaluation.

(3) A procurement document for irradiated wheat flour is in the final stages of preparation. In a manner similar to the potato procurement, 200,000 pounds of irradiated flour will be procured during FY 1967 and divided among the Armed Forces. The flour will be irradiated in 35-pound rectangular cans for introduction into overseas subsistence supply channels for test and evaluation.

I would like now to describe ten research and testing advances accomplished during the past 15 months.

(1) Irradiation of products in the frozen state has proven to be an excellent technique for improving quality of most meats, poultry and seafood products. The earliest observations were made using the extreme cold of —196°C provided by liquid nitrogen. We have now been able to demonstrate that such extreme cold is not required. For most products, irradiation at —30°C±10°C is providing the desired increase in quality. Certain cuts of beef, however, require the lower temperature of —80°C±10°C. Use of these moderately cold temperatures eliminates the great industrial problems which would have been involved if it had been necessary to irradiate at liquid nitrogen temperatures. Although the principle of the use of cold is now well established, we are continuing to accumulate further data to obtain the optimum temperature for each individual product and to study the applicability of different radiation sources to processing in the cold.

(2) Dehydrated foods are playing an increasingly important role in military feeding. For some dehydrated products, particularly those used in combat rations, a persistent problem is the length of time required for rehydration, especially in cold water. Investigators in private industry have made the observation that irradiation of certain dehydrated products markedly decreases rehydration time. The Army has studied the effects of irradiation temperature and dose on the rehydration characteristics of potatoes and vegetables. A patent application has been submitted recently by the Army on a technique for irradiating dehydrated potatoes at doses of 4 to 8 megarads at temperatures of —80° to —160° C. The irradiated product rehydrates in 5 minutes in hot water without loss of color or flavor contrasted with a 20-minute rehydration time for the non-irradiated control. Similar results have been obtained with other vegetables and a second patent application has been filed for low temperature radiation of these dehydrated vegetables to shorten rehydration time.

(3) As you will recall from the 1965 Hearings, we placed considerable emphasis on the military need for flexible packaging of irradiation sterilized foods. Although rapid progress is being made by industry in the flexible packaging, we have not yet succeeded in providing packaging which will meet the stringent requirements necessitated by military operational circumstances. However, we are now studying two laminated materials which show promise. One consists of an outside layer of paper, a middle layer of aluminum foil and an inside food contactant layer of polyester-medium density polyethylene. The second laminate consists of an outside layer of Mylar, a middle layer of aluminum foil and an inside food contactant layer of Nylon 11. Enzyme-inactivated bacon, ham, pork and chicken vacuum packed in these flexible laminates have retained good degrees of acceptability after irradiation and non-refrigerated storage at high humidities for 12 to 20 months. These laminates have also shown improved integrity in their protective characteristics for the foods. I wish to stress that we plan to continue accelerated work on flexible packaging until a family of materials has been developed meeting the specific military needs.

(4) In research supported by Army contract, the Danish Meat Research Institute has reported that the use of very high radiation dose rates with the electron linear accelerator provides significant improvement in retention of flavor and texture of meats. These investigators used dose rates of $2x10^8$ to $2x10^{10}$ rads per second in contrast to the more conventional and much lower dose rates of 10^4 to 10^5 rads per second. Using our linear accelerator, we are studying the precise effects of these high dose rates.

(5) In our search for techniques to provide the best quality products, preliminary findings indicate that partial dehydration of fresh meat before irradiation coupled with heat treatment after irradiation improves retention of red meat color and flavor. The actual technique includes partial dehydration of fresh meat to remove 15 to 30 percent of moisture which is equivalent to the moisture lost during cooking. This is followed by canning and irradiation in the frozen state. The final step is the usual heat inactivation of proteolytic enzymes.

(6) Under Army contract, a very sensitive and rapid method has been developed for measuring residual proteolytic enzyme activity in meats after irradiation. The method is based upon tagging a representative sample of food being processed with a tracer compound labelled with carbon[14]. Previous chemico-analytical methods for measuring proteolytic activity were relatively crude and often months of storage were required before sufficient proteolytic breakdown had occurred to permit measurement. The new method now being applied in our laboratories allows changes in proteolytic activity to be recognized early in the storage life of the product. Hence, experimental techniques for inactivating enzymes can be evaluated much more promptly and the ability to predict non-refrigerated shelf life of irradiated foods has been greatly improved.

(7) Within the collaborative program with the AEC and the Atomic Energy of Canada, Limited on irradiation pasteurization of chicken, it has been determined that frozen chicken irradiated at a dose of one megarad to eliminate *Salmonellae* has resulted in a product equivalent in acceptability to the non-irradiated control as determined by taste panel evaluations.

(8) Under Army contract, a survey of meat and poultry processing plants in five regions of the United States and two regions of Canada to determine the natural prevalence of *Clostridium botulinum* Types A and B has been completed recently. The survey revealed that the presence of botulinal spores is a rare event in the plants studied. In addition to providing the Army and the Ameri-

can food industry with the most comprehensive data available to date on risk of contamination, this survey also provides a major input into the source material under study by the Task Group on Microbiological Safety for Radiosterilized Foods established by the National Academy of Sciences-National Research Council.

(9) Using shrimp as a model for shell fish, we have succeded in extending shelf life from 6 months to 12 months. This was accomplished by selection of very fresh raw material, the use of flavor and odor scavengers, and irradiation of the shrimp in the frozen state.

(10) As we modify and improve processing techniques for each food item, troop feeding tests for acceptability continue to be conducted at Fort Lee, Virginia. Since the June 1965 Hearings, the following items have been tested and found acceptable: irradiation sterilized bacon, chicken, ham, pork, beef and codfish cakes, and irradiation pasteurized chicken, codfish, haddock, shrimp and oranges.

With your permission, I would like to submit for the record a tabulation of the 30 contracts, project orders and no-cost agreements in effect since the June 1965 Hearings in support of the Army Food Irradiation Program (Appendix 4).

In spite of this excellent research progress, significant problems remain to be solved. As you will recall, these problems were discussed in some detail in the June 1965 Hearings, and presently include:

(1) The fundamental mechanisms underlying the radioresistance of spore-forming organisms, particularly *Clostridium botulinum*, with the ultimate goal of developing methods to decrease this radioresistance.

(2) More rapid means of establishing minimum safe radiation doses for irradiation sterilized foods; our present procedure of inoculating thousands of cans of food with the most radioresistant strains of *Clostridium botulinum* and incubating for 6 months is cubersome, extremely time-consuming and very expensive.

(3) The fundamental biochemistry and physical chemistry of off-odors, off-flavors, off-colors and undesirable textural changes in irradiation sterilized foods.

(4) Non-thermal means of achieving enzyme inactivation to permit irradiation of products as close to the raw state as possible.

(5) Improved means of dosimetric monitoring, particularly a system which would be dose rate independent over a wide dose range and sensitive up to dose rate of 10^{11} megarads per second; the possibilities of biodosimeters are being explored.

I would like now to mention briefly some of the other activities of the Army Food Irradiation Program during the past 15 months.

As you have heard from the Department of Commerce, the Army provided a member for the Interagency Pilot Plant Meat Irradiator Task Force to discuss with industry the possibilities of construction of a pilot plant for processing irradiation sterilized meat and poultry products. The excellent relationships established with the food industry, manufacturers of radiation sources and state and local government groups interested in the potential value of irradiation sterilized foods will have a profound stimulating effect on ultimate commercialization.

As you know, interest in food irradiation is accelerating rapidly in the world-wide scientific community. Since the June 1965 Hearings, there have been three symposia in which the Army participated devoted entirely to food irradiation and a fourth meeting in which the subject constituted a significant portion of the program. The Army had the privilege of co-chairing the Symposium on Radiation Preservation of Foods held under the auspices of the American Chemical Society in September 1965. In October 1965, a Symposium on the Status of the National Food Irradiation Program was held at the Natick Laboratories under the auspices of Research and Development Associates. Five of the eight papers given were by the Army. In May 1966, six papers on irradiated food were presented by Army scientists at the 26th Annual Meeting of the Institute of Food Technologists. Among the 71 papers presented at the June 1966 International Symposium on Food Irradiation Program was held at the Natick Laboratories under the auspices and four were on work supported by Army contracts. Later this month, on September 21, 1966, the American Institute for Chemical Engineers is sponsoring a Symposium on Food Radiation. The Army will have the privilege of co-chairing

this symposium and three papers will be presented on the Army program. With your permission, I would like to submit for the record a tabulation of the 50 scientific publications and 27 scientific presentations of the Army Food Irradiation Program for the period June 1965 through August 1966 (Appendix 5).

There has been considerable international activity within the Army program during the past 15 months. Staff members of the Natick Laboratories and the Army Medical Service have provided consultative assistance to a working party from the United Kingdom which has now recommended legislation to the British Government to establish mechanisms for approval of irradiated foods for public consumption. In reply to inquiries, advice on many facets of radiation preservation of foods has been extended to the governments of Canada, the United Kingdom, France, the Federal Republic of Germany, Italy, Turkey, Israel, Nigeria, Pakistan, India, Australia, New Zealand, Japan, Venezuela, Peru, Nicaragua, and Argentina. In addition, one staff member of the Natick Laboratories has served as a consultant on irradiated food legislation to the Food and Agriculture Organization of the United Nations.

FUTURE UTILIZATION CONCEPTS

Dr. JOSEPHSON. Earlier in this presentation I have described procurement actions and testing activities within the Armed Forces for irradiated bacon, potatoes, and flour. Army plans for future tests are in accordance with publicly announced requirements for 150,000 pounds of irradiation sterilized meats each year for a period of 3 years, subject to approval of petitions by FDA and USDA for unlimited human consumption of those food items. In addition, the Air Force, Navy, and Marine Corps have now stated their test requirements for irradiation sterilized meats for fiscal year 1968 which total approximately 150,000 pounds. Concurrent with processing of petitions by FDA and USDA, the Army prepares procurement instruments so that the Defense Supply Agency (DSA) will be in a position to issue to industry notices of intent to purchase shortly after the foods are cleared.

For example, based upon submission of petitions in fiscal year 1966 and fiscal year 1967, it is anticipated that irradiation sterilized ham and pork and six irradiation pasteurized fish items will be cleared by fiscal year 1968. This makes it possible for the DSA to forecast procurement and production testing of these foods in fiscal year 1968.

In addition to testing the adequacy of the procurement instrument and obtaining cost data, the foods procured will be subjected to troop acceptance tests and logistical evaluation. Only after these actions have been successfully accomplished can true troop acceptability and cost comparison data be obtained.

IRRADIATED HAM FOR THE ARMY

Although commitments to utilize sizable quantities of irradiated products over an extended period must be deferred until after adequate testing, the Department of the Army has a firm and pressing need for the potential advantages of certain irradiation sterilized foods and an interest in pasteurized and other forms of irradiated products. The Army's major interest is in the area of irradiation sterilized foods for potential use in the A ration to replace or partially replace frozen or heat processed counterparts, and in the B

ration to replace certain less desirable heat-processed and dehydrated items. There is also a need for the potential advantages of irradiation sterilized food items in ready-to-eat packaged operational rations. In addition, the Army has an interest in irradiation pasteurized items wherein the shelf life of a fresh product held at ambient or refrigeration temperatures is extended. The immediate need is for those irradiated products that will replace the items currently in the supply system that cannot be processed satisfactorily, from an acceptability standpoint, by freezing and/or canning, or which have limited storage stability.

An example of an A ration item in this category is heat-pasteurized canned ham. The canned ham requires refrigeration, has a short shelf life, has decreased acceptability when frozen, and has required very careful monitoring by the Armed Forces to avoid health hazards. The present heat-sterilized canned ham chunks or frozen boneless product are not satisfactory replacements in either the A or B rations. After FDA and USDA clearances are obtained for the irradiation sterilized product and if production and user tests provide satisfactory results, the Army could phase irradiation sterilized ham into the troop feeding system in fiscal year 1969. The estimated maximum quantities for phasing in this item based upon present feeding strengths and the planned servings as scheduled in the fiscal year 1967 annual food plan are as follows:

Fiscal year	Forecast maximum annual needs (pounds)	Primary use [1]
1969	3,500,000	To replace canned ham overseas.
1970	5,900,000	To replace canned and frozen ham overseas.
1971	15,735,000	To replace canned and frozen ham worldwide.

[1] CONUS consumption assumes competitive costs.

OTHER IRRADIATED MEAT FOR ARMY NEEDS

Other specific examples of forecasted Army needs for irradiation sterilized meats include:

Product:	*Forecast maximum annual needs* *Pounds*
Frankfurters	7,418,000
Luncheon meats (all varieties)	4,140,000

In addition to irradiation sterilized ham and processed meats, Army needs exist for certain types and cuts of pork, beef, and chicken. Unquestionably, further needs will become evident as the research, development, and testing program progresses.

The Army has a great deal invested in the concept of irradiation sterilization of foods. Fourteen years of time, personnel, and supporting funds have brought the Army research program close to the goal of establishing a family of irradiation sterilized foods which are safe,

nutritious, and highly acceptable. A 5-year Army research program was presented to the committee at the June 1965 hearings. We have outlined the Army's firm requirements for meat products for the specific purpose of conducting large-scale tests, and the much larger quantities needed for introduction into the troop feeding system, particularly for overseas use.

TASK FORCE: PILOT PLANT MEAT IRRADIATOR

Because of these firm requirements and forecast needs, we were extremely pleased when the Department of Commerce formed the pilot plant meat irradiator task force and invited Army and AEC participation to explore commercialization with industry.

In support of the recommendations of the task force, the Natick Laboratories will provide scientific backup for problems which might arise during the first 5 years of pilot plant operations. In addition, the Natick Laboratories will provide technical liaison services to the operating staff of the pilot plant whereby individuals may observe and collaborate with Army scientists to gain experience and solve specific production problems.

Even though introduction of food items into the civilian and military dietary must await FDA and USDA approvals, we strongly endorse the timely efforts of the Department of Commerce to encourage industry to commercialize irradiation sterilization. The Army looks forward to providing the Department of Commerce with all possible technical assistance. We have every anticipation that achievement of the ultimate goal of a national production base for irradiation sterilized meats, poultry, and seafood products will result in further improvement and diversification of the dietary of our national population. Such a base will allow the Armed Forces to procure food items to meet the specific military needs.

CLOSINGS REMARKS

In conclusion, Mr. Chairman, I would like to express our appreciation to you and the members of the committee for this opportunity to review the events of the past 15 months of the Army food irradiation program. Your comments and guidance will be most helpful. I would like to emphasize our continuing appreciation to the AEC for their daily collaboration and assistance, and also wish to thank the advisory committees of the National Academy of Sciences-National Research Council and of the Surgeon General for their continuing counsel. Finally, I wish to pay tribute to the late Mr. Morris Simon, my former deputy, who played a major role in the Army program almost from its inception. Although he passed away on December 30, 1964, his ideas and contributions are very much alive today. I will be happy to answer any further questions you may have or refer them to the supporting witnesses. Thank you.

(The appendixes accompanying the statement follow:)

APPENDIX 1

Items from the food irradiation program approved by the Food and Drug Administration (FDA) as of August 1966

Product and purpose of irradiation	Radiation source	Dose (permissible range) (megarad)	Petitioner	Date of FDA approval	FAP No.[1]	21 CFR[1] reference
Bacon, sterilization	Cobalt 60	4.5 to 5.6	Army	Feb. 8, 1963	890	121.3002
	Electron beam (5 Mev)[1]	do	General Electric Co.[2]	Aug. 23, 1963	1139	121.3004
	Cesium 137	do	AEC[2]	Jan. 30, 1964	1226	121.3002
	X-rays from electron beam (5 Mev)[1]	do	Radiation Dynamics, Inc.[2]	Dec. 15, 1964	4M1433	121.3005
	Electron beam (10 Mev)[1]	do	Army	Apr. 15, 1965	1205	121.3004
Wheat and wheat products, insect deinfestation	Cobalt 60	0.02 to 0.05	Private citizens[2,3]	Aug. 21, 1963	941	121.3003
	Cesium 137	do	AEC[2]	Oct. 2, 1964	5M1509	121.3003
	Electron beam (5 Mev)[1]	do	High Voltage Engineering Corp.[2]	Feb. 18, 1966	4M1276	121.3003
White potatoes, sprout inhibition	Cobalt 60	0.005 to 0.010	Army	June 30, 1964	1132	121.3003
	Cesium 137	do	AEC[2]	Oct. 2, 1964	5M1509	121.3003
	Cobalt 60 and cesium 137	0.005 to 0.015	Army	Nov. 1, 1965	5M1644	121.3003
Packaging materials,[4] food contactants for use in radiation preservation of prepackaged foods.	Gamma emitters	1 maximum	AEC	Aug. 10, 1964	1297	121.2543
Vegetable parchment paper, food contactants for use in radiation preservation of prepackaged foods.	Cobalt 60	6 maximum	Army	Mar. 8, 1965	5M1622	121.2543
	Cesium 137	do	do	do	5M1622	121.3002
	X-rays from electron beam (5 Mev)[1]	do	do	do	5M1622	121.3005

[1] Mev—Million electron volts; FAP No.—FDA food additive petition number; CFR—Code of Federal Regulations.

[2] The Army contributed the major proportion of the data submitted by the petitioner.

[3] Dr. L. E. Brownell, University of Michigan; Mr. T. Horne, Curtiss-Wright Co.; Mr. W. J. Kretlow, University of Michigan.

[4] 9 classes of materials: nitrocellulose-coated cellophanes; glassine papers; wax-coated paperboards; polypropylene films; ethylene-alkene-1 copolymer films; polyethylene films; polystyrene films; rubber hydrochloride films; vinylidene chloride-vinyl chloride copolymer films.

APPENDIX 2

Items from the food irradiation program pending before the Food and Drug Administration (FDA) as of August 1966

Product and purpose of irradiation	Radiation source	Dose (recommended range) (megarad)	Petitioner	Date of notice of FDA filing	FAP No.[1]
Oranges, inhibition of surface and subsurface micro-organisms.	Cobalt 60 and cesium 137.	0.075 to 0.200.	Joint Army/AEC.	Dec. 11, 1963	1233
Packaging materials,[2] food contactants for use in radiation preservation of prepackaged foods.	do	6 maximum.	Army	July 13, 1965	5B1645
Do.[3]	do	1 maximum.	AEC	July 26, 1965	5B1674
Nylon film, food contactant for use with prepackaged foods.	do	do	AEC	Aug. 31, 1965	6M1820
Fish,[4] shelf-life extension.	Cobalt 60, cesium 137, electron beam (5 Mev),[1] X-rays from electron beam (5 Mev).[1]	0.10 to 0.20	Joint Army/AEC.	Sept. 8, 1965	6M1815
Strawberries, reduce spoilage, shelf-life extension.	Cobalt 60 and cesium 137.	0.10 to 0.25	AEC	May 11, 1966	6M2024
Ham, sterilization	do	3.5 to 5.6	Army	Aug. 15, 1966	7M2056

[1] Mev, million electron volts; FAP No., FDA food additive petition number.
[2] 4 plastic materials: polyethylene; poly(ethylene terephthalate); poly(vinyl chloride-vinyl acetate); and nylon 6.
[3] 2 groups of plastic materials: (1) vinylidene chloride copolymer-coated or polyethylene-coated polyethylene terephthalate film; (2) vinylidene chloride copolymer-coated polypropylene film.
[4] Fillet of haddock, codfish, sole, flounder, pollock, and ocean perch.

APPENDIX 3

Planning schedule for submission of future petitions to the Food and Drug Administration (FDA), from the Army food irradiation program[1]

Product	Purpose	Petitioner	Planned time of submission (fiscal year)
Pork	Sterilization	Army	2d quarter, 1967.
Chicken	do	do	1st quarter, 1968.
Beef	do	do	Do.
Shrimp	do	do	Do.
Hamburger	do	do	1968.
Corned beef	do	do	1968.
Pork sausage	do	do	1968.
Codfish cakes	do	do	1968.
Turkey	do	do	1969.
Frankfurters	do	do	1969.
Barbecued beef, chicken, and pork	do	do	1969.
Luncheon meats	do	do	1970.
Lamb	do	do	1970.
Salmon cakes	do	do	1970.
Baked fish	do	do	1970.
Duck	do	do	1970.
Clams	Pasteurization	Joint Army/AEC	1968.
Crab	do	do	1968.
Shrimp	do	do	1968.
Chicken	do	do.[2]	1968.
Oysters	do	do	1969.
Fresh water fish	do	do	1970.
Halibut	do	do	1970.
Hake	do	do	1970.
Prunes	do	do	1970.
Apricots	do	do	1970.
Nectarines	do	do	1970.
Peaches	do	do	([3]).
Pineapples	do	do	([3]).

[1] Petitions for meat and poultry items will, in addition, be submitted on the same schedule to the Department of Agriculture (USDA).
[2] Data accumulated through collaborative efforts by the Army, the AEC, and Atomic Energy of Canada, Ltd.
[3] Not yet scheduled.

APPENDIX 4

Technical contracts and project orders active during the period June 30, 1965–Aug. 31, 1966 (excludes all supply and service contracts)

Contractor and contract No.	Period	Total	Subject
Swift & Co., DA19-129-AMC-161.	July 22, 1963, to Dec. 1, 1965.	$58,571	Incidence of *Clostridium botulinum* in raw meats.
Continental Can Co., DA19-129-AMC-162.	June 25, 1963, to Nov. 30, 1965.	106,444	Study of extractable substances and microbial penetration of polymeric packaging materials to develop flexible containers for radiation sterilized foods.
Swift and Co., DA19-129-AMC-164.	June 25, 1963, to Jan. 21, 1966.	34,521	Study the effects of irradiation temperature on the chemical and physical properties of irradiated meats.
American Can Co., DA19-129-AMC-119.	June 26, 1963, to Sept. 9, 1966.	41,114	Studies on irradiation-induced headspace gases in packaged radiation-sterilized foods.
Agricultural Research Council, DA91-591-EUC-2900.	Apr. 1, 1963, to May 31, 1967.	27,320	Studies on the chemistry of radiation-induced changes in protein.
Danish Meat Research Institute, DA91-591-EUC-3342.	July 1, 1964, to June 30, 1965.	14,450	Investigation of the use of very high dose rates for the radiation preservation of protein food.
Iowa State University, DA19-129-AMC-227.	Feb. 28, 1964, to Mar. 14, 1966.	24,747	Development of cooking procedures and recipes for using irradiation-sterilized meats.
National Bureau of Standards, AMXREC 64-69.	Jan. 31, 1964, to June 30, 1967.	66,655	Calculation of the transport of energy by fast electrons and associated gamma radiation.
Department of Commerce, AMXREC 64-76.	June 19, 1964, to Sept. 30, 1967.	110,000	Economic analysis and user cost-benefit study of the use of radiation-sterilized foods for troop feeding.
Continental Can Co., DA19-129-AMC-362.	July 8, 1964, to July 7, 1965.	1,000	Preparation of petition to Food and Drug Administration for packaging materials for radiation-sterilized foods.
U.S. Army Medical R. & D. Command, AMXREC 65-56.	July 1, 1964, to June 30, 1966.	50,000	Nutrition research studies and other controlled metabolic studies in human volunteers (subcontracted with the University of Colorado).
Taft Sanitary Engineering Center, USPHA, AMXREC 65-62 and 66-63.	Oct. 8, 1964 to Oct. 31, 1966.	20,150	Kinetics of viral radioresistance.
Atomic Energy Commission, AMXREC 65-87.	Mar. 18, 1965 to Aug. 31, 1966.	215,000	Provide 400 units of cobalt 60 slugs with specific activities.
AEC (Hazelton Labs), AMXREC 65-83.	Feb. 25, 1965 to Sept. 30, 1965.	12,000	Evaluate the effects of radiation on packaging materials.
Atomic Energy Commission, AMXREC 65-86.	Mar. 18, 1965 to Mar. 31, 1967.	43,000	Microbiological study of radiation-pasteurized chicken.
University of Connecticut, DA19-129-AMC-594.	May 11, 1965 to Oct. 10, 1966.	14,867	Establishment of a rapid method for determining proteolytic enzyme activity in irradiated meats.
U.S.A. Medical R. & D. Command, AMXREC 66-55.	July 1, 1965 to June 30, 1967.	9,000	Subcontract with the University of Massachusetts, subject: "Publication of an Annotated Bibliography of the Wholesomeness of Irradiated Foods."
U.S.A. Medical R. & D. Command, AMXREC 67-58.	July 1, 1965 to June 30, 1967.	31,000	Subcontract with the University of Oklahoma, subject: "On the Nutritive Value of the Major Nutrients of Irradiated Foods."
Arthur D. Little, Inc., DA19-129-AMC-806.	Sept. 27, 1965 to Sept. 26, 1966.	39,980	Effect of irradiation temperature on volatile flavor compounds in meat.
Oregon State University, DA19-129-AMC-853.	Dec. 27, 1965 to June 26, 1967.	25,000	Storage stability studies on radiation-sterilized fish items.
Swift & Co., DA19-129-AMC-858.	Dec. 14, 1965 to June 13, 1968.	29,966	Study process criteria to develop radiation-sterilized beefsteaks.
Department of the Interior, AMXREC 66-88.	Mar. 17, 1966 to Mar. 31, 1968.	50,000	Radiation sterilization of fish and seafood items.

No-cost agreements active during the period beginning June 30, 1965

Contract and agreement No.	Period	Subject
Swift & Co., QMR & E 172	Mar. 1, 1962, to Mar. 1, 1967.	Investigate methods for controlling changes in sensory characteristics of irradiated meats.
Campbell Soup Co., NLABS 211	June 1, 1964, to May 31, 1966.	Study effects of irradiation on the canning stability of cereal products.
Illinois Institute of Technology, NLABS 212.	June 2, 1964, to June 1, 1969.	Study kinetics and effect of temperature on destruction by irradiation of *Clostridium botulinum* spores.
Polo Food Products, NLABS 227	Feb. 15, 1965, to Feb. 14, 1967.	Investigate effects of irradiation on processed poultry products.
Quaker Oats Co., NLABS 224	Feb. 1, 1965, to Jan. 31, 1970.	Study resistance to irradiation of micro-organisms found in perishable refrigerated foods.
Wilson & Co., NLABS 237	Oct. 1, 1965, to Mar. 31, 1968.	Study process criteria to develop irradiated hams.
New England Deaconess Hospital, NLABS 239.	Nov. 1, 1965, to Jan. 31, 1968.	Study ionizing radiation effects upon pigmentation in plants.
California Vegetable Concentrates, NLABS 243.	June 15, 1966, to June 14, 1967.	Investigate effects of irradiation on rehydration time of dried vegetables.

APPENDIX 5

LIST OF SCIENTIFIC PUBLICATIONS AND PRESENTATIONS OF THE ARMY FOOD IRRADIATION PROGRAM—JUNE 65 TO AUGUST 66

A. BOOK CONTRIBUTIONS

El-Bisi HM: Principles of microbiological safety and stability of radiation-sterilized foods. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 223–232, 1965

Goresline HE: Need for international cooperation. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 17–21, 1965

Harlan JW, Kauffman FL, Heiligman F: The effects of irradiation temperature on organoleptic, physical and chemical properties of beef. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Hembree HW, Burt TB: Troop-acceptance testing of irradiated foods. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 108–19, 1965

Holm NW, Jarrett RD: An evaluation of dosimetry procedures applicable for use in food irradiation. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 361–82, 1965

Jarrett RD: Radiation dosimetry in relation to high intensity radiation sources. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Johnson BC: Stability of amino acids in foods to gamma-ray and electron beam irradiation. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Josephson ES: Department of the Army food irradiation program. Hearings before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy, Congress of the United States. Radiation Processing of Foods, Appendix 12 Attachment B: 668–73, 9 & 10 Jun 65

Josephson ES: Foreward. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Josephson ES: Statement of, Hearings before the Subcommittee on Research, Development, and Radiation of the Joint Committee on Atomic Energy, Congress of the United States. Radiation Processing of Foods: 90–100, 9 & 10 Jun 65

Josephson ES: Summary and concluding remarks. Symposium Radiation Preservation of Foods. Inst Food Technol, Kansas City, Missouri, May 65. USAEC Publ (in press)

Josephson ES, Shea KG: Food preservation. (Large Scale Production and Applications of Radioisotopes) Proc Amer Nuc Soc DP–1066, 1:IV 3–25, May 66

Massey LM: Some radiation induced changes in fresh fruits and vegetables. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Merritt C, Angelini P: Volatile compounds induced by irradiation in basic food substances. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Mulvey PF, Cardarelli JA, Meyer RA, Cooper RD, Burrows BA: Sensitivity in Bremsstrahlung activation analysis for iodine determination. Proc IAEA: Radioisotope Sample Measurement Techniques in Medicine and Biology, Vienna, Austria, 249–58, 1965

Raica N: Data on wholesomeness studies. A progress report. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 185–90, 1965

Siu RGH: Summary and trends. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 277–80, 1965

Southern EM, Rhodes DN: Radiation induced changes in polyamino acids. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Wisk, EL, Murray E, Mizutani J, Koshika M: Radiation flavor and the volatile components of beef. Symposium Radiation Preservation of Foods: Chemistry and Design Technology, Sept 65. Amer Chem Soc: Advances in Chemistry Series (in press)

Wierbicki E, Simon M, Josephson ES: Preservation of meats by sterilizing doses of ionizing radiation. Proc Int Conf Radiat Pres Foods NAS–NRC Publ 1273: 383–409, 1965

B. JOURNAL ARTICLES

Heiligman F: Storage stability of irradiated meats. Food Technol 19: 114–16, 1965

Heiligman F, Phillips CE: Acceptance of irradiated foods. R&D Associates Activities Report 17: 114–19, Fall 1965

Josephson ES: Recent progress in applying high doses of ionizing radiations to achieve shelf-stable foods. R&D Associates Activities Report 17: 95–102, Fall 1965

Meyer A: Induced radioactivity in food and electron sterilization. Health Phys. 12: 1027–39, 1966

Murphy PJ, Cooper RD, Meyer RA: Servo systems for automatic dose control. Proc IEEE NS–12: 725–27, 1965

Previte, JJ, El–Bisi HM: Biological properties of irradiated endotoxin. Bact Proc 17: 50, 1966

Rowley DB, Leinvson HS: Changes of spores *of Bacillus magaterium* treated with thioglycolate. Bact proc 17: 17, 1966

Thompson SW, Hunt RD, Ferrell J. Jenkins ED, Monsen H: Histopathology of mice fed irradiated foods. J Nutr 87: 274–84, 1965

Wadsworth CK, Shults GW: Low temperature irradiation of meat. R&D Associates Activities Report 18: 13–17, Spring 1966

Wierbicki E. Killoran JJ: Packaging for radiation-sterilized foods: Present status. R&D Associates Activities Report 18: 18–29, Spring 1966

C. ARMY AND CONTRACTOR REPORTS

Anderson AW: Resistance of microorganisms to ionizing radiation applied to foods. Oregon State Univ, Corvallis, Oregon, Contract DA19–129–QM–2035: Techn Rep FD–24, Sep 65

Burt TB: Final report of research test of irradiated chicken, ham, and haddock. US Army GETA, Fort Lee, Virginia, May 65

Burt TB: Final report of research test of irradiated codfish and oranges. US Army GETA, Fort Lee, Virginia, Sep 65

Burt TB: Final report of research test of irradiated bacon. US Army GETA, Fort Lee, Virginia, Oct 65

Burt TB: Final report of research test of irradiated shrimp, beef, chicken, and ham. US Army GETA, Fort Lee, Virginia, May 66

Burt TB: Final report of research test of irradiated ham, pork, chicken, and clams. US Army GETA, Fort Lee, Virginia, Jul 66

Greenberg RA, Bladell BO, Zingelmann WJ: Determination of equivalents between radiation sterilization process and commercial thermal process for cured

meats. Swift & Co, Chicago, Illinois, Contract DA19–129–QM–2008: Techn Rep FD–28, Oct 65

Hansen, PE, Ellemann G, Pedersen AJ: Investigation of the use of very high dose rates for the radiation preservation of protein food. Danish Meat Research Inst, Roskilde, Denmark, Contract DA91–591–EUC–3342: OI–452–4472, 13 Aug 65

Johnson BC: Nutritive value of the major nutrients of irradiated foods. Amino acid destruction in beef by high energy electron beam irradiation. Univ Illinois, Urbana, Illinois, Contract DA49–193–MD–2572: Final Report 17 Aug 66

Kertesz ZI, Massey LM: A study of the radiation-induced softening of plant tissues. Cornell Univ, Ithaca, New York, Contract DA19–129–QM–1584: Techn Rep FD–27, Oct 65

Landmann WA: A study of chemical changes produced by heat and by irradiation of meat and meat fractions. Amer Meat Inst Foundation, Chicago, Illinois, Contract DA19–129–QM–1972: Techn Rep FD–2, Sep 65

Landman WA, Batzer OF, Santoro AT: Flavor precursors in meat. Amer Meat Inst Foundation, Chicago, Illinois, Contract DA19–129–AMC–2114(X): Techn Rep FD–21, Sep 65

Landmann WA: Studies on means of controlling or inhibiting beef tissue enzyme systems. Amer Meat Inst Foundation, Chicago Illinois, Contract DA19–129–AMC–87(N): Techn Rep FD–23, Sep 65

Martin TG: Calculated internal radiation dose from ingestion of meat sterilized by electron irradiation. USANLABS Natick, Mass: Techn Rep FD–38, Apr 66

Nelson S: Effects of radio-frequency irradiation on the enzymes of beef muscle tissue. Melpar Inc, Falls Church, Virginia, Contract DA19–129–AMC–262(N): Techn Rep FD–33, Dec. 65

Schultz HW, Sinnhuber RO, Yu TC, Landers M: Development of irradiation sterilized shelf-stable fish and seafood products. Oregon Stat Univ, Corvallis, Oregon, Contract DA19–129–QM–1356: Techn Rep FD–16, Aug 65

Sinnhuber RO: Development of radiation sterilized fish items for armed forces feeding. Oregon State Univ, Corvallis, Oregon, Contract DA19–129–AMC–155(N): Techn Rep FD–15, Aug 65

Tompkin RB: Incidence of *Clostridium botulinum* in raw meats. Swift & Co. Chicago, Illinois, Contract DA19–129–AMC–161(N): Techn Rep FD–50, Jun 66

Watson DF, Libke KG, Smibert RM, Engel RW: Feeding of dogs, rabbits and hamsters with irradiated shrimp and its effect upon thyroid activity (phase 1). Effect on resistance to infection (phase 2). Virginia Polytechnic Inst, Blacksburg, Virginia, Contract DA49–007–MD–784: Final Rept 15 Sept 65

Wick EL: Studies of beef irradiation flavor using a concurrent radiation-distillation technique. Mass Inst Technol, Cambridge, Mass, Contract DA19–129–AMC–99(N): Techn Rep FD–32, Dec 65

D. PRESENTATIONS

Auerbach E, Wadsworth CK: Irradiation-pasteurization of further processed poultry. Inst Food Technol, Portland, Oregon, 25 May 66

El-Bisi HM: Microbiological aspects of food irradiation. Ak-Sar-Ben Chapter Inst Food Technol, Omaha, Nebraska, 14 Apr 66

El-Bisi HM: Progress in botulism research. Interagency Botulism Research Coordinating Committee, Robt A Taft Engr Ctr, Cncinnati, Ohio, 31 Mar 66

Gardner DS, Wadsworth CK, MacQueen KF: The effect of low temperature gamma irradiation on the cooking time of dehydrated diced and sliced potatoes. Inst Food Technol, Portland, Oregon, 25 May 66

Gardner DS, Wadsworth CK, MacQueen KF: The effect of low temperature gamma irradiation on the cooking time of dehydrated diced and sliced potatoes. Inst Food Technol (Canada), Toronto, Ontario, Jun 66

Heiligman F., Wadsworth CK: Radiation sterilization processing of chicken. Inst Food Technol, Kansas City, Missouri, May 65

Heiligman F, Wierbicki E: Preservation of foods by ionizing radiation. National Association of Sanitarians, Cranston, Rhode Island, 17 Sep 65

Josephson ES: Physical aspects of food radiation technology. Boston Medical Physics Group New England Chapter Amer Assoc Physicists in Medicine, US Army Radiation Laboratory, Natick, Mass, 7 Dec 65

Josephson ES: Simplified procedures for obtaining clearances of foods preserved by ionizing radiation. IAEA/FAO UN Int Sympos Food Irradiation, Karlsruhe, Germany, Jun 66

Josephson ES: Thoughts for food. Maryland District of Columbia-Delaware Hospital Association, Wash DC, 10 Nov 65
Killoran JJ: The US Army food irradiation program with emphasis on packaging. Inst Food Technol Blue Grass Sec, Louisville, Kentucky, 23 Sep 65
Killoran JJ, Breyer JD, Wierbicki E: Development of flexible containers for irradiated foods. I. Screening of commercially available plastic laminates. Inst Food Technol, Portland, Oregon, 25 May 66
Mehrlich FP: The US Army food irradiation program. IAEA/FAO UN Int Sympos Food Irradiation, Karlsruhe, Germany, June 66
Mehrlich FP, Snyder OP, Shults GW: Cryogenics in food irradiation, Amer Inst Chem Engrs, Minneapolis, Minnesota, 29 Sep 65
Merritt C: Chemical changes induced by irradiation in meats and meat components. IAEA/FAO UN Int Sympos Food Irradiation, Karlsruhe, Germany, Jun 66
Pratt GB, Kneeland LE, Heiligman F, Killoran JJ: Irradiation induced gases in packaged foods. I. Identification and measurements. Inst Food Technol, Portland, Oregon, 25 May 66.
Previte JJ: Biological effects of irradiated endotoxin. Pioneering Research Division Biology Seminar USANLABS, Natick, Mass, Apr 66
Previte JJ: Biological properties of irradiated endotoxins. Leo F. Rettger Society, Univ Mass, Amherst, Mass, Apr 66
Previte JJ, El-Bisi HM: Biological properties of irradiated endotoxins. Amer Soc Microbiol, Los Angeles, California, May 66
Raica N, Howie DL: Review of US Army wholesomeness of irradiated food program (1955–1966). IAEA/FAO UN Int Sympos Food Irradiation, Karlsruhe, Germany, Jun 66
Shults GW, Wadsworth CK, Wierbicki E: Development of irradiated beef. II. Effect of irradiation temperature on sensory quality and consumer preference. Inst Food Technol, Portland, Oregon, 25 May 66
Sinnhuber RO, Landers MK, Yu TC, Simon M, Heiligman F: The development of radiation sterilized seafood products. I. Enzyme inactivated cod and halibut patties. IAEA/FAO UN Int Sympos Food Irradiation, Karlsruhe, Germany, Jun 66
Snyder OP: Food radiation 1966: The process engineering challenge. Amer Soc Agric Engrs, Amherst, Mass, Jun 66
Wadsworth CK, Wierbicki E, Josephson ES: Pilot meat and poultry irradiator. I. Food technology requirements pertinent to design. Inst Food Technol, Portland, Oregon, 25 May 66
Wierbicki E: Bacon in the atomic age. Meat Sci Inst, Rutgers Univ, New Brunswick, New Jersey, Aug 66
Wierbicki E: Radiation preservation processing of foods. Sympos Changing Trends in Meat Marketing, FMC American Viscose Division, Lansing, Michigan, 13 Apr 66
Wierbicki E, Warnecke MO, Phillips CE, Giddings GG: Development of radiation-sterilized hams. Inst Food Technol, Kansas City, Missouri, May 65

ARMY'S IRRADIATION RESEARCH AND DEVELOPMENT PROGRAM

Representative PRICE. Thank you, Dr. Josephson, for a fine statement. The committee has been impressed with the very good and productive research work which has gone on in the Army's food irradiation program. I might say the committee has followed it very closely with the Army, on numerous occasions since the inception of this program. You have brought this program of feasibility research to the threshold of full-scale development.

I notice in your statement, however, that you refer to a 5-year Army research program but make no mention of development. Is there any significance in the omission of the word "development"?

Dr. JOSEPHSON. Not exactly, sir. The Army has been pulling together an overall 5-year program for subsistence of which development of irradiated food items is a part. This 5-year subsistence program is being prepared now by the Natick Laboratories and is due at our

higher headquarters, Army Materiel Command, on the 15th of October, 1966.

Representative PRICE. Will you please explain to the committee the Army's plan for the development phase of the food irradiation program?

Dr. JOSEPHSON. We, of course, do not have an official Army approved plan. We only have a local plan at this time, sir. I cannot speak for the Army on that subject.

Representative PRICE. I wonder if you can give us some idea of what exactly is going on as far as development is concerned?

Dr. JOSEPHSON. Of course we see the need for bringing these irradiated food components all the way into operational rations. Getting approval from FDA and USDA in our position merely establishes a technical feasibility, and we have to do the testing and evaluation of these products under the regular Army service testing and engineer testing procedures. We also have to determine the shape of the particular food item: that is, its configuration, whether it will be in slices or chunks, and how it will be put together as a component of the overall combat ration system. This is what we refer to as development. We also in this part have to make sure of the long-range storage capability so that the irradiated food component would have the same storage as the other items in the operational ration which may not be irradiated. These are the types of activities which have to be carried on after the food has passed the acid test of approval by FDA and USDA.

Representative PRICE. Wasn't one of the early phases of the Army program conducted at Stockton?

Dr. JOSEPHSON. There was no program as such at Stockton. Stockton was a site.

Representative PRICE. Weren't you building an irradiator there at one time?

Dr. JOSEPHSON. Yes. It was proposed that there be an irradiator at Stockton built by the Army and operated by industry under contract with the Army to carry out some of the aspects I have just outlined.

Representative PRICE. Now your main operations are at Natick?

Dr. JOSEPHSON. Yes.

Representative PRICE. When you moved, what you planned to have at Stockton to Natick, did you drop the idea then of the irradiator?

Dr. JOSEPHSON. Natick became a research facility, not a production facility. Stockton was conceived before the 1958 amendment to the basic Food, Drug, and Cosmetic Act was adopted. Therefore, one could plan in the early days, in the early or mid-1950's, for a facility without an FDA clearance. But since 1958, one requires an FDA clearance. Therefore, the program was recast in 1960 and Natick was built as a research facility to bring the products to the point where successful petitioners could go to the Food and Drug Administration and in the case of meat and poultry items, to the Department of Agriculture as well.

We are now talking about the next step, scaling up from laboratory through pilot plant to commercializiation. This is a step beyond the research program.

EXPEDITING THE PILOT PLANT MEAT IRRADIATOR

Chairman HOLIFIELD. What do you think we can do, Mr. Poor, to move ahead faster with the next phase, which is the cooperative Government-industry pilot plant meat irradiator?

Mr. POOR. I think you will perhaps find a considerably more encouraging view of what we could do to move ahead faster when you listen to the industry witnesses who I believe are going to follow us. As a businessman I suppose you would ask yourself a question: "If I were to invest in a plant to make foods of this sort, what is the prospect that I will get my bait back?" The numbers in the statement in front of you suggest that the possibility of getting bait back on certain limited products, canned ham, for instance, is extremely good, given FDA clearance.

You have heard today a good deal of material showing that the food industry and nuclear processors in general are getting more and more excited about this program. The key, of course, is FDA clearance and in the case of the Army, adequate testing to make sure that their packaged products will be in a form that can safely be shipped overseas and maintained in the field.

I think we are very near there, and I think continuing with the present program is the wisest thing we can do. It is enormously better looking than it was 15 months ago when you last heard from us.

Chairman HOLIFIELD. Do you think it is possible for us to move ahead with a pilot plant without getting the Government to commit itself to a load of operation?

Mr. POOR. I have struggled with this problem a bit, and in this morning's testimony you heard of a meeting that the Department of Commerce, AEC, and the Army had on precisely this subject. It seems to me that it would be improper for the Army to commit itself to a baseload in the absence of FDA clearance and in the absence of evidence that the product produced by the plant would be suitable for feeding to the troops. Thus, we have made a commitment subject to FDA clearances for relatively modest amounts.

Incidentally, some of the industry people may even think these are sufficient to encourage them to take the first steps on a small plant which total about 300,000 pounds per year amongst the three services.

(NOTE: This sentence was rewritten by the Department of the Army editor to read as follows:

Incidentally, some of the industry people may even think these amounts, which total about 300,000 pounds for FY '68 amongst the three services, are sufficient to encourage them to take the first steps on a small plant.

This proposed change by the Army was the subject of the following correspondence:)

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
Washington, D.C., October 21, 1966.

Hon. CHARLES L. POOR,
Deputy Assistant Secretary of the Army (R. & D.),
Department of the Army, Washington, D.C.

DEAR MR. POOR: I have recently reviewed the transcript of the September 12 hearings on Food Irradiation by the Subcommittee on Research, Development, and Radiation.

I note that on page 113 of the transcript the editor for the Department of the Army has corrected your statement relative to the commitment of the Services to purchase irradiated food from the proposed pilot plant meat irradiator. (Copy of "corrected" transcript page 113 is enclosed.)

The change concerns the original statement in the transcript of "300,000 pounds per year" which the Committee believed to be a commitment for more than one year and, in the context of other statements made at this hearing, for at least three years. The "corrected" version speaks of "300,000 pounds *for FY '68.*" (emphasis supplied)

It appears that this is a substantive change and should therefore be accompanied, in accordance with Committee policy (as pointed out in the transmittal of transcript for correction), by a letter stating the reasons why the changes are considered necessary. It would also appear that, even under the best of circumstances, the proposed pilot plant meat irradiator could just barely be available during the latter part of FY 1968 and thus not be able to furnish any irradiated meat during FY 1968.

Thank you for your cooperation in this matter.

Sincerely yours,

JOHN T. CONWAY, *Executive Director.*

OCTOBER 28, 1966.

Mr. JOHN T. CONWAY,
Executive Director, Joint Atomic Energy Committee,
Congress of the United States.

DEAR MR. CONWAY: The Army testimony of 12 September before the Subcommittee on Research, Development, and Radiation, has been examined as you suggested in your letter of 21 October.

Plans of the Army for the purchase of irradiated meats are as stated on pages 13–14 of the statement given to the Subcommittee by Dr. Edward S. Josephson. Pertinent portions of the statements indicate that the "Army plans for future tests are in accordance with publicly announced requirements for 150,000 pounds of irradiation sterilized meats each year for a period of 3 years, subject to approval of petitions by FDA and USDA for unlimited human consumption of those food items. In addition, the Air Force, Navy, and Marine Corps have now stated their test requirements for irradiation sterilized meats for FY 68 which total approximately 150,000 pounds".

The transcript (page 113) which you provided was changed to reflect the testimony as outlined in Dr. Josephson's statement. The corrected statement on page 113 of the transcript now reflects that a total of 300,000 pounds will be required by the three services for FY 68. That portion of the corrected transcript is correct. The Air Force, Navy, and Marine Corps have made a formal, written commitment to the Defense Supply Agency only through FY 68. Because no written commitment beyond FY 68 has been provided to the Defense Supply Agency by the other services, it would not be proper for the Army to commit the other services to procurement of irradiation sterilized meats beyond FY 68. However, we do anticipate, based on previous informal agreements, that the other services' requirements, when combined with the Army requirements, will total 300,000 pounds per year for three years.

I trust that the above information will clarify the overall procurement plans for irradiation sterilized meats.

Very sincerely yours,

CHARLES L. POOR,
Deputy Assistant Secretary of the Army (R. & D.).

POTENTIAL MARKET FOR IRRADIATED MEAT

Mr. POOR (continuing). The carrot in front of the entrepreneur is obviously the potential market.

I, therefore, urged the Army supply people and logistics people to generate data on the potential market. The potential market is presumably larger than that which is indicated in the Army statement because this is limited to very few types of foods which may quite soon be approved.

Chairman HOLIFIELD. You are talking of millions of pounds there?

Mr. POOR. Yes, sir.

Chairman HOLIFIELD. Within the next 4 or 5 years?

Mr. POOR. Yes, sir. But it would not be prudent to turn these numbers now into a commitment. They are no more than statements that

if things work as we hope they will work, we would have a very real need for amounts like those expressed in the Army statement.

Chairman HOLIFIELD. Dr. Josephson spoke about acceptability. How is the Army going to test acceptability unless we have commercial production which is enough to really test this matter? It is a kind of chicken-and-egg question, I know.

Dr. JOSEPHSON. We start off rather modestly even before we submit petitions to FDA. We do acceptance testing at Natick, both among our own experts and with another division at Natick. Then if the foods pass these acceptance tests, we go down to Fort Lee and run tests with perhaps 600 troops under garrison-type feeding conditions.

Chairman HOLIFIELD. Have you already done this, or is this something you are planning?

Dr. JOSEPHSON. This is something we have been doing all along, sir.

Chairman HOLIFIELD. Do you obtain volunteer participation on the part of the troops?

Dr. JOSEPHSON. Yes.

Senator HICKENLOOPER. You did that during World War II, didn't you?

Dr. JOSEPHSON. Not with food irradiation. We started testing irradiated products at Fort Lee in 1958. Then we had a hiatus of several years and picked it up again in 1963. We have been continuing with tests every quarter since 1963. These tests, which are prior to FDA clearance, are under artificial conditions where the material is closely scrutinized by the Surgeon General of the Army and the health and medical records of the volunteers are checked into. This creates perhaps an aura of mystery or mysticism about the product.

After an FDA clearance is obtained, then the product can go out into the field and be tested under different environmental conditions, in the Arctic, in the tropics, in the temperate regions, in the desert and overseas.

The foods tested in this fashion can be associated with long-term storage studies running in parallel. We can have many more troop servings under the circumstances. These tests account for the 150,000 pounds that the Army talks about for engineer testing and service testing.

After the foods pass these tests, we can talk about phasing them in full scale into the feeding system. As the table (p. 66) shows, for example, irradiated ham would first replace quantities of canned ham and frozen ham overseas. Then later, as production increases, the costs could come down to where irradiated food costs would be competitive with costs for nonirradiated counterparts in the continental United States and even larger quantities could be procured.

IRRADIATED BACON

Mr. CONWAY. Bacon you have already had approved by FDA and you had 22,000 pounds irradiated at Brookhaven. Hasn't that been sent out to the field?

Dr. JOSEPHSON. Actually, sir, 30,000 pounds have been irradiated. These quantities are now being readied for release into the field for larger scale testing. We have never tested before anything of the order of 30,000 pounds of one food.

Chairman HOLIFIELD. Are we testing any of that bacon in Vietnam?

Dr. JOSEPHSON. Some of it went over to Vietnam, very limited quantities, about a month ago. I have not heard how it was received. The bulk of the bacon will be tested by the Army in the 3d Army area centered around Atlanta. The Army procurement people have said that after we find out how well this bacon is accepted in continental United States, then they will consider procurement for oversea testing.

IRRADIATION OF FROZEN MEATS

Chairman HOLIFIELD. Dr. Josephson, on page 2 you talk about irradiating ham in the frozen state and that a petition for frozen ham and pork will be submitted to FDA sometime in the fall of 1967. Is it your understanding that the proposed pilot plant meat irradiator, if built, could be utilized for both room- and below-zero-temperature irradiation of meat?

Dr. JOSEPHSON. I would like to see it so designed because if one irradiates in a frozen state, one gets a substantially improved quality item for all products except bacon. For bacon, it does not seem to matter.

Chairman HOLIFIELD. I did not get the point.

Dr. JOSEPHSON. I would like to see the facility designed so that irradiation of food could be accomplished in both the frozen state and at room-temperature because the next generation of items will provide for irradiation in the frozen state. In the frozen state a significantly superior commodity is obtained.

Chairman HOLIFIELD. Why is that?

Dr. JOSEPHSON. We would like to have the answer to this question. Evidently by irradiation in the frozen state we minimize formation of compounds that are associated with off-flavor or off-odors. We observe less destruction of certain nutrients like vitamin B_1 and we have less undesirable changes in texture.

Chairman HOLIFIELD. Is this just true in the case of meats?

Dr. JOSEPHSON. No. We find this across the board. For example, when we irradiate dehydrated vegetables to make them rehydrate faster, we find a better quality product when we irradiate in the frozen state.

Mr. CONWAY. Are you talking solely in the sterilization area?

Dr. JOSEPHSON. Yes, we are just talking about sterilizing doses. In the case of the irradiating of the dehydrated vegetables, we are in the doses that we consider in the sterilizing range. The purpose is not sterility.

Senator HICKENLOOPER. I understood from the testimony a moment ago that fish was not so good in the frozen state.

Dr. JOSEPHSON. Mr. Slavin was talking about pasteurizing doses. This is a horse of a different color. We are talking about sterilizing doses which are perhaps 20 times as high as the pasteurizing doses.

Mr. CONWAY. In pasteurization you are only interested in extending the shelf life for a limited period of time. The Army has a different problem. You may have long period of storage. This is to what you are directing your efforts?

Dr. JOSEPHSON. That is right. We shoot now for 2 years. We would like to get even longer periods of storage without refrigeration.

IRRADIATION OF FRANKFURTERS, LUNCHEON MEATS, AND CHICKEN

Chairman HOLIFIELD. Is it necessary for you to have more experimentation in the field of frankfurters and luncheon meats or could this come under the Army's food irradiation program now?

Dr. JOSEPHSON. We are actively engaged in studying the effects of irradiation on these commodities now. They are, of course, not as far along as are basic commodities such as chicken, beef, ham, pork, and shrimp. We have to get the basic things through first. Then the formulated products come along after that.

Chairman HOLIFIELD. What success have you had in the irradiation of chicken?

Dr. JOSEPHSON. We have had very good success with irradiation of chicken.

Chairman HOLIFIELD. Is that pasteurization or sterilization?

Dr. JOSEPHSON. Both. I would like to expand on the subject of pasteurization of chicken. It is the only commodity for which we now have an on-going program in the low-dose area. This is a cooperative program with our own Atomic Energy Commission and Atomic Energy of Canada, Ltd. We find that with pasteurizing doses we can get a product that tastes just as well as the nonirradiated product. We are pretty sure that we have eliminated Salmonellae, a problem which was discussed this morning.

In the high dose area where we are looking for a product that will keep on the shelf without refrigeration, we do get excellent chicken. The only thing holding us back from submitting a petition to FDA and USDA right now is the need to determine what is the required irradiation dose to eliminate *Clostridium botulinum*. We will have these data next spring or summer and should then proceed, with a petition next fall, assuming the data fall in place.

Senator HICKENLOOPER. Could you explain the difference, whether it is a matter of taste or what it is, between the irradiated foods and the canned foods that we buy off the shelf today? They will stay there for a long time.

VIRTUES OF IRRADIATION PRESERVATION

Dr. JOSEPHSON. The canned foods have to be heated at high temperatures and pressures to destroy the microorganisms that either cause spoilage or could cause disease, such as *Clostridium botulinum*. To get the right conditions, for penetration of the heat into the food in the center of the can, we have to use temperatures as high as 250° Fahrenheit and pressure. As a result, the thermally processed canned food must be so overworked that it does not taste at all like the fresh food. With radiation, the temperature of the food does not rise significantly, at most perhaps 10° Centigrade. Because radiation is a cold sterilization process, the irradiated food on the plate of the consumer is almost

undistinguishable from food prepared from fresh food. On the other hand, a thermally canned product tastes nothing like the fresh product. That is the big virtue of ionizing energy for food preservation.

Senator HICKENLOOPER. What about the problem of discoloration that came up at least earlier in some of the experiments with certain meats, especially pork?

Dr. JOSEPHSON. Some discoloration occurs but we find that this is minimized in low-temperature irradiation. We also find that discoloration occurs around the bone. The Army does not propose to ship the bones overseas. We would bone out the chicken or bone out the beef. We do not run into the discoloration problem from both points of view because (1) we have eliminated the bone, and (2) we have gone to low temperature.

Chairman HOLIFIELD. Mr. Hosmer.

ARMY RATION STRENGTH

Representative HOSMER. On those figures of maximum annual needs, for instance, frankfurters, 7,418,000 pounds, that is not the total number of frankfurters that the Army needs, is it?

Mr. POOR. I will ask Mr. Gilpin to answer that if he can.

Mr. GILPIN. Yes, sir; that is the total Army requirement for a given year based on a ration strength of 690,000 people.

Mr. POOR. That is current feeding strength.

Representative HOSMER. How many?

Mr. GILPIN. Ration strength of 690,000.

Representative HOSMER. You must be planning to end up the war with pretty major reductions, aren't you?

Mr. GILPIN. Sir?

Representative HOSMER. We have a lot more people in the Army than that, do we not?

Mr. GILPIN. We speak of total strength and we speak of ration strength, sir, because in the United States, for example, approximately 60 percent of our soldiers will eat in the messhall. The other 40 percent are either on leave or on separate rations or something like that. So, you can't compare ration strength to total strength.

Senator HICKENLOOPER. It looks like a stepping up in 1971.

Representative HOSMER. This is a total replacement basis?

Mr. GILPIN. Yes, sir.

Representative HOSMER. What minimums are you working on, or are these figures more or less illustrative?

Mr. GILPIN. These are just illustrative.

Mr. POOR. I think a realistic minimum is zero.

Representative HOSMER. Well, if peace swoops down upon us I suppose.

Mr. POOR. I tried to get the kind of thing you are asking for, for example, a cost curve estimate for ham, to answer the question of how much premium we would be willing to pay for total replacement for everything and how much premium we would pay for only oversea shipments. It is a very difficult question to get answered well.

Representative HOSMER. Did you get it answered well?

Mr. POOR. No.

Representative HOSMER. You don't really know?

COST FACTORS

Mr. POOR. In a qualitative sense I think you can say this much. There are current logistics studies going on that show a very substantial extra cost added to canned ham shipped overseas for the necessary storage in transit, refrigeration, and so on. These overall costs exceed our estimates of the premium that would be required for radiation sterilization even in a moderately efficient plant. I don't think we ought to put dollar amounts on this because the dollar amounts will really depend on what kinds of bids we get in from the new plant as developed.

For the domestic replacement, that is, the 15-million-pound level in 1971, the premiums for irradiation sterilization clearly could not be very large because now the product has to ride only on the extra cost of refrigeration in the United States.

Representative HOSMER. Maybe we are not so much talking about the elimination of grousing in the messhall as we are the cost factor.

Mr. POOR. Cost is very important in this. There is enough cost advantage for the oversea shipment case to make it a very desirable thing.

Representative HOSMER. As to the point about increasing the boys' morale, that is not really there, is it?

Mr. POOR. I think it is there. The canned ham products, as I understand it, are good enough so that they will help substantially to eliminate grousing in the messhall as compared, for example, to heat-processed canned ham.

Representative HOSMER. The trouble with taking away the messhall as a place to grouse in is that they will grouse someplace else. So I guess it has a lot of applications.

Thank you, Mr. Chairman.

5-YEAR DEVELOPMENT PROGRAM

Chairman HOLIFIELD. Dr. Josephson, will you submit to the committee if you can by October 15 your 5-year development program?

Mr. POOR. I think it is due in the Department of the Army about then. As soon as the Army staff has had a chance to review it, we will be very happy to provide it to the committee for the record. (See app. 13, p. 323.)

Mr. CONWAY. There is a provision of the law that requires DOD to keep the committee fully and currently advised.

Mr. POOR. We will do that, surely. We are very proud of the program and we would like as much publicity as we can possibly get.

Representative PRICE. Thank you very much, Mr. Poor and Dr. Josephson.

Mr. POOR. Thank you, Mr. Chairman.

Representative PRICE. The next witness will be Dr. Richard R. Konicek, research director of the Iowa Development Commission.

STATEMENT OF RICHARD R. KONICEK, DIRECTOR OF RESEARCH, IOWA DEVELOPMENT COMMISSION

Mr. KONICEK. I appreciate what I presume to be the conferring of an honorary degree.

For the record I would like to state I do not hold a doctor of philosophy degree.

I am the director of research at the Iowa Development Commission. I am here to represent along with Senator Hickenlooper, the State of Iowa, our Governor, Hon. Harold Hughes, and the Iowa Development Commission.

I want to thank you for the privilege of appearing before the committee.

Representative PRICE. This is a State commission?

Mr. KONICEK. Yes, sir.

Radiation preservation of food promises many unique benefits to producers, processors, and consumers in the form of reduced waste, reduced process costs, reduced storage costs, opportunities for new convenience-type consumer products, opportunities for geographic market expansion, and, ultimately, in lower real costs to consumers.

Most of the credit for the progress in this field, thus far, must be attributed to the farsighted, pioneering efforts of the various Federal agencies through support from the U.S. Congress.

The research conducted thus far has been culminated in a number of food products which have gained approval by the Food and Drug Administration as well as those products which are scheduled for submission of approval.

To this date, most of the Federal Government-sponsored effort in meat products has been directed toward "radiation sterilization" or the complete destruction of decay-causing bacteria which permit the indefinite or long-term storage of these products at room temperature.

The results of these efforts have been extremely encouraging and should have particular beneficial application in military procurement programs and in the development of commercial markets in which lack of refrigeration and long-term storage are critical marketing factors.

Significant opportunities exist for the development of new convenience food mixes which include nonrefrigerated meat components.

RADIATION PASTEURIZATION OF MEATS

Prospective benefits from "radiation pasteurization" of meats offer other and perhaps even a broader and more direct range of opportunities to the meat industry and consumers as well.

Radiation pasteurization, utilizing relatively low-dose radiation, destroys the major portion of decay-causing bacteria found in meat products and extends shelf life of fresh meats for an additional 5 to 14 days.

The principal advantages of radiation-pasteurized meats appear to be:

1. Relatively low process costs.
2. Utilization of existing, basic distribution channels and marketing systems.
3. Improved overall meat processing efficiency through greater specialization of labor, equipment, and marketing efforts.
4. Protection from short-term meat price variations.

5. The opportunity to capitalize more effectively upon regional and local preferences for specific retail meat cuts.

6. Public health benefits through the elimination of disease-causing organisms, for example trichinae, salmonellae, et cetera.

Radiation pasteurization affords a relatively low-cost method for extension of shelf life of fresh meats. It is estimated by industry and Government sources that radiation pasteurization could be accomplished at up to one-twentieth of the cost of completely sterilized products.

There already appears to be a development in meat processing and marketing practices within the meat industry to which radiation pasteurization could make a significant contribution. This is in the area of centralized processing of fresh meat cuts.

The advantages of centralized processing of fresh meat cuts for retail stores have already been established. Basically, this consists of processing retail cuts of fresh meats in a central plant for redistribution to a group of retail stores in a given metropolitan market at a considerable reduction of overall processing costs.

The savings which result from this type of an operation have been estimated to represent approximately one-half of the operating costs, compared to those of a firm processing an equivalent volume of meat in conventional store meat backrooms.

Benefits from this type of a centralized operation are quite likely to be shared by consumers through lower prices at retail and products through higher prices for livestock as its use becomes more widespread throughout our competitive economy.

Under existing practices, shelf life of fresh-meat retail cuts is limited to 2 to 5 days. Despite strict adherence to rigidly controlled conditions of refrigeration and sanitation, the adoption of centralized processing of retail cuts is limited because of spoilage problems.

The technique of centralized processing continues the existing practice of shipment of carcass meats to the consuming markets, which also involves the accumulation of 12 to 14 percent byproduct of the carcass weight in the form of bone, fat, and scraps for which there is little demand in most consumer market areas.

Radiation pasteurization and the extension of refrigerated shelf life of centrally processed meat products could serve to accelerate this trend, with attendant benefits to the industry and to the consumer alike.

Ultimately, it is expected that effective shelf life extension, through radiation pasteurization, would permit centralized meat processing to be extended to the primary slaughtering areas, with benefits to be derived through the reduction of spoilage, which must eventually be absorbed at retail, reduction of shipping costs, the concentration and effective utilization of waste byproducts, and would open new opportunities to meat processors to capitalize more effectively upon regional market preferences for specific retail meat cuts.

In many respects, radiation pasteurization of meat products would not cause a significant alteration of existing meat industry structure, that is, existing distribution systems are readily adaptable to accept the marketing of pasteurized products.

Radiation pasteurization, in our opinion, represents an extremely practical application of the radiation process which the meat industry can readily accept.

A comprehensive program is needed to develop radiation pasteurization of fresh meats, including beef, pork, chicken, turkey, and lamb products, subsequently leading to Food and Drug Administration and the U.S. Department of Agriculture approval.

While there is significant interest on the part of the meat industry to develop petitions and to submit these for FDA and USDA approval, it is our opinion that the proposed radiation-pasteurization effort is too costly to be undertaken by a single company for final submission to the FDA and USDA, and particularly when considering that little opportunity would accrue in the way of proprietary advantages to an individual company as the result of FDA and USDA approval of such petitions.

Therefore, we respectfully request that the Joint Committee on Atomic Energy give consideration to the funding of research efforts to be administered by appropriate Federal agencies leading to the above-stated goals.

It is our belief that, if successful, such an effort would materially contribute to commercialization of radiation-preserved meats, with widespread benefit to the entire Nation.

SELECTED REFERENCES

"Radiation Processing of Foods, Hearings Before the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy," Congress of the United States, 89th Congress, 1st session, June 9 and 10, 1965, U.S. Government Printing Office, Washington, D.C., 1965.

Marvin D. Volz and James A. Marsden, "Centralized Processing of Fresh Meat for Retail Stores, Marketing Research Report No. 628," U.S. Department of Agriculture, Agricultural Marketing Services, Washington, D.C., 1963. (See app. 8, p. 189.)

"Current Status and Commercial Prospects for Radiation Preservation of Food," U.S. Department of Commerce, BDSA, Washington, D.C., 1965. (See pp. 285 to 466, in JCAE 1965 hearings on food irradiation.)

Representative PRICE. Thank you very much, Mr. Konicek.

Senator Hickenlooper, do you have any questions?

Senator HICKENLOOPER. I might ask a question or two to bring out the situation here.

I am familiar with what Mr. Konicek is suggesting, and the ambitions of the people out there to do something about this, because we have a great center of the meat industry in the State of Iowa. The Animal Disease Laboratory is located there, and we have a great agricultural school at Ames. We feel that we have a specialized interest in the development and advancement of the meat industry.

I think he is pointing out that it can be advanced through this method. I expect if he were pushed, he would say it could be done better in Iowa than any other place in the Union.

Mr. KONICEK. That is right, sir. I would not even have to be pushed.

Senator HICKENLOOPER. He is research director for the Iowa Development Commission.

I do not know that I have any particular questions, unless there is something else you want to add, Mr. Konicek, in addition to your statement here.

RESEARCH SUPPORT BY THE FOOD INDUSTRY

Mr. KONICEK. There was some comment this morning regarding the amount of interest by the meat industry in this particular phase of the radiation program.

I would like to state that when we talk about research and development funds, that the food industry is a very basic industry to the Nation. This is a foregone conclusion.

The food industry as a whole has not generally had the reputation of being very aggressive in research and development efforts. I have some data which has been compiled by the National Science Foundation for 1962 which describes some of the research and development funds expended by various industries.

Significantly, the food and kindred products industry has the lowest amount of money funded for research and development.

Senator HICKENLOOPER. Do you have a table there showing that?

Mr. KONICEK. Yes, sir.

Senator HICKENLOOPER. Do you want to put that in the record?

Mr. KONICEK. Yes, sir.

Representative PRICE. Without objection, it will be accepted for the record.

(The table referred to follows:)

Funds for performance of total industrial research and development, by industry and source of funds, United States, 1962 [1]

[In millions of dollars]

Industry	Total funds	Federal funds	Private industry funds	Percent of total funds		Percent distribution of Federal funds
				Federal	Private	
Total	11,544	6,524	5,020	56.5	43.5	100.0
Food and kindred products	127	5	121	5.7	95.3	.1
Chemicals and allied products	1,184	260	924	22.0	78.0	4.0
Petroleum refining and extracts	305	20	285	6.6	93.4	.3
Rubber products	133	30	103	22.6	77.4	.5
Primary metals	178	13	164	7.3	92.1	.2
Fabricated metal products	149	29	120	19.5	80.5	.4
Machinery	921	280	641	30.4	69.6	4.3
Electrical equipment and communications	2,381	1,051	880	63.0	37.0	23.0
Motor vehicles and transport	1,011	280	731	27.7	72.3	4.3
Aircraft and missiles	4,140	3,676	463	88.8	11.2	56.3
Professional and scientific instruments	450	208	241	46.2	53.6	3.2
Other [2]	564	222	342	39.4	60.6	3.4

[1] Includes basic research, applied research and development.
[2] Includes textiles, lumber, paper, stone, clay, and glass, and other industries.

NOTE.—Detail does not necessarily agree with total because of independent rounding of figures.

Source: Statistical Abstract of the United States, 1965.

Funds for performance of total industrial research and development, by industry and source of funds, 1960 to 1963

[In millions of dollars. Includes Alaska and Hawaii. See headnote, table 760]

Industry	Total funds [1]				Federal funds				Private industry funds			
	1960	1961	1962	1963 [2]	1960	1961	1962	1963 [2]	1960	1961	1962	1963 [2]
Total	10,509	10,908	11,544	12,723	6,081	6,240	6,524	7,345	4,428	4,668	5,020	5,378
Food and kindred products	102	122	127	135	9	5	5	[3]	93	117	121	[3]
Textiles and apparel	38	30	32	34	[3]	[3]	[3]	2	29	[3]	[3]	32
Lumber, wood products, and furniture	10	10	10	[3]	[3]	[3]	[3]	[3]	9	[3]	[3]	[3]
Paper and allied products	56	59	65	71	[3]	[3]	0	0	[3]	[3]	65	71
Chemicals and allied products	986	1,109	1,184	1,253	182	232	260	264	804	877	924	989
Petroleum refining and extraction [4]	290	295	305	315	16	19	20	20	274	276	285	295
Rubber products	120	136	133	146	37	39	30	39	83	97	103	107
Stone, clay, and glass products	96	99	113	122	[3]	[3]	[3]	[3]	[3]	88	101	[3]
Primary metals	176	175	178	191	15	18	13	12	161	157	164	179
Fabricated metal products	144	135	149	162	36	38	29	29	108	97	120	133
Machinery	932	864	921	977	377	281	280	264	555	583	641	713
Electrical equipment and communication [5]	2,406	2,297	2,381	2,483	1,594	1,465	1,501	1,562	812	832	880	921
Motor vehicles and other transportation equipment	890	944	1,011	1,103	217	226	280	289	673	718	731	814
Aircraft and missiles	3,558	3,904	4,140	4,835	3,180	3,490	3,676	4,371	378	414	463	464
Professional and scientific instruments	396	382	450	497	202	175	208	232	194	207	241	265
Other industries [6]	309	346	344	399	216	252	222	261	255	205	181	395

[1] Includes basic research, applied research, and development.
[2] Preliminary.
[3] Not available.
[4] Excludes geological and geophysical exploration activities of petroleum companies.
[5] These 2 industries have been combined because of the similarity of their research and development activities.
[6] Includes data for all other manufacturing and nonmanufacturing industries not specifically listed and industry data specified as not available.

Source: National Science Foundation; annual report, "Research and Development in Industry."

Mr. KONICEK. Now, it is significant that of the total funds expended for research and development by the food industry, 95.3 percent of the total funds are supplied by the private industry, in contrast to the remainder of the industries that are represented there.

Representative HOSMER. Will you say that again?

Mr. KONICEK. 95.3 percent of the total research and development funds that are devoted to food and kindred products industry are supplied by private funds, in contrast to the rather significant contribution by the Federal Government to the other industries.

Senator HICKENLOOPER. If you would point out that 4.7 percent was provided by the Federal Government, 95.3 percent is provided by private industry and private funds; that is what you were saying a minute ago?

Mr. KONICEK. Yes, sir.

Senator HICKENLOOPER. Give us some comparisons on the table you have.

Mr. KONICEK. For the total funds, including kindred products, for 1962, a total of $127 million was spent in food and kindred products industry, of which the bulk was provided by private funds.

In contrast, in the aircraft and missile industry, $4 billion was expended in research and development, of which only 11 percent was provided by private funds.

Senator HICKENLOOPER. And the rest by public funds?

Mr. KONICEK. By Federal funds, according to this table.

In the primary metals industry, private funds were substantially in evidence. Nevertheless, I think this table does point out in the total distribution of Federal funds that about one-tenth of 1 percent of the total Federal funds for R. & D. were devoted to the food and kindred products industry.

So what we are saying is that we think that our request is a rather modest one, in terms of the significance of the industries to the Nation.

Representative PRICE. What is the source of these figures?

Mr. KONICEK. I got these figures from the Statistical Abstract of the United States. I assume that they are from the National Science Foundation, which would no doubt have more recent data than these.

Senator HICKENLOOPER. This is for 1965?

Mr. KONICEK. That is 1962.

Senator HICKENLOOPER. It says 1965, here.

Mr. KONICEK. That is the 1965 edition of the Statistical Abstract.

Representative HOSMER. Mr. Chairman, I suggest that rather than this table that either the witness or staff obtain updated tables. (See app. 10, p. 272.)

I think the significant additions to the table would be the volume, total volume of business of all these categories, and the breakdown between Government business and private business, since in the case of aircraft and missiles there is a high proportion of Government business which can be supported by Government R. & D. money.

Senator HICKENLOOPER. I think this does that, Mr. Hosmer. This refers to the total amount in each industry, and then gives the percentage in each industry that is contributed by Government and by private industry.

Representative HOSMER. The $121 million that the food industry spends for R. & D., they spend such a small fraction of the total of their

funds on R. & D. compared with these other industries that it is almost insignificant.

It is essentially the only industry in the country that carries on practically no R. & D. in modern terms.

Mr. KONICEK. Are you referring to the food industry, sir?

Representative HOSMER. Yes, food and kindred products category.

Mr. KONICEK. I would say that is generally true. There are a number of reasons for this, from my point of view.

I would say that the food industry, the National Commission on Food Marketing notwithstanding, has done a marvelous job in providing an extremely low-cost and abundant supply of food in this Nation.

By virtue of its competitiveness, it is very difficult for these industries to allocate a significant amount of money for R. & D. because it is a highly competitive industry throughout, from the producer to the processor to the marketer.

The meat industry, for example, has an extremely low profit margin. When you start committing research and development funds on the basis of that low profit margin, it seriously affects your return.

Representative HOSMER. It is more profitable to put funds in buying than in R. & D.

Mr. KONICEK. The meat industry is more production-oriented than they are marketing-oriented, by virtue of their position.

Representative HOSMER. In addition to that, the Government puts tremendous amounts into the raw product that they buy; for example the amount of money which the Government spends on agricultural improvement and agricultural programs, and everything else.

Mr. KONICEK. It is a very wise investment.

Representative HOSMER. If you blanketed that in this thing, you would find probably there was almost a reverse of the proportion of Government funds in the total food package.

Senator HICKENLOOPER. Just like the Government buying airplanes.

Mr. KONICEK. In my estimation, it is a very wise investment, Mr. Hosmer, the fact, notwithstanding, that the total consumer budget for food products in this Nation is very low in contrast to other nations.

I think that the entire food industry from the producer all the way through the marketer illustrates this fact. For example, the Common Market countries have seen fit to introduce variable levies in the Common Market into the movement of American commodities there.

This is a very commendable gesture on their part. It recognizes the high degree of efficiency that we have achieved.

Representative HOSMER. I would like you to talk to my wife and convince her how well off she is.

Mr. KONICEK. The fact is that we are finally reaching the stage where we are in a supply-and-demand balance.

CORRESPONDENCE ON PILOT PLANT MEAT IRRADIATOR

Chairman HOLIFIELD. Mr. Chairman, at the conclusion of the interchange between Mr. Konicek and the committee members, I would like to introduce seven letters; five of which are from Iowa from different meat companies; one is from the Governor of Iowa and one is from a meatpacking company in Los Angeles.

All of them are in favor of a program of this kind, and all of them stress the fact that they feel that the AEC should do it. They stress the fact that there is a very narrow profit in this particular industry, and therefore they feel that this type of effort should be done by the Atomic Energy Commission.

I would like to have them included in the record at the proper point.

Representative PRICE. Without objection, it is so ordered.

Thank you very much, Mr. Konicek.

Mr. KONICEK. I have some original letters I will present to Chairman Holifield.

Representative PRICE. If they are not duplicates, without objection, they will be included in the record.

Mr. KONICEK. These are originals.

(The letters referred to by Representative Holifield follow:)

KING MEAT PACKING CO.,
Los Angeles, Calif., September 9, 1966.

JOINT COMMITTEE ON ATOMIC ENERGY,
Congress of the United States,
Washington, D.C.

GENTLEMEN: In regard to the proposed meat irradiation pilot plant, the following information is presented on behalf of the King Meat Company in Los Angeles, a locally owned and operated firm founded eighteen years ago. Currently King Meat employs eighty people, processing in excess of 50 million pounds of beef annually for distribution to retail and institutional outlets.

In attempting to determine the value of meat irradiation on a commercial basis, we have discussed marketing aspects of beef and pork with many of the major retail chains and some of the largest institutional purveyors in the Southern California area. These people have the daily task of understanding the buying habits of over three million consumers. We have used our knowledge of sales and distribution and the technical assistance and guidance of the Nuclear Division of the engineering firm Holmes & Narver, Inc. to present as clear a picture of meat irradiation as possible to these people.

From the retail chains we received enthusiasm in regard to pasteurized beef and pork in wholesale sizes. This enthusiasm stems from experience with advanced production and distribution methods now employed, such as vacuum packaging, central warehousing, and centralized production where labor productivity may be fully maximized. These advances require the extension of the fresh shelf life of beef and pork. Their negative reaction pertained to the required labeling. The required labeling was not found to be detrimental at the wholesale level, but objectionable at the retail level. The example cited was the compete failure of the "acronizing" process used on chickens. What was expected to be a sales asset by labeling the chickens as "acronized" turned out to be a rejection by the public. It presented the connotation that the chickens were less than pure or wholesome. Retail sentiment on sterilized beef or pork was negative due to obvious lack of eye appeal and the necessity to change a housewife's method of meal preparation.

At the institutional purveyor level our findings were approximately the same, a definite affirmation on pasteurized fresh beef and pork; and, in addition, an interest in a limited usage of sterilized product, e.g., in hospitals, penal institutions, and other mass feeding operations.

Summarizing the commercial aspects of meat irradiation, we have found a definitely affirmative attitude toward pasteurization of fresh beef and pork (provided labeling as such is not carried to the retail level) with a limited response to sterilization.

Turning to industry participation in the construction and operation of a meat irradiation plant, we recognize the value that such a plant would have in demonstrating the use of radiation in the processing of meat products. We visualize that accompanying the utilization of the irradiation facility would be a marketing study and a certain amount of experimentation with such problems as product

acceptability. Again, however, we must submit the results of our own experiences. By being a small business we must view any capital expenditure very severely with respect to the return and risk factors. After determining the sales potential we approached organizations in related fields to form a joint team to increase the potential for utilization of the facility and of course to lessen the individual risk. We met with principals of cold storage firms, pork processors, chicken processors, and industrial developers. These organizations, almost without exception, felt the cart was before the horse. Namely, to submit a proposal to products a pasteurized product that from a commercial viewpoint has not been approved by the Food and Drug Administration (FDA) and the Department of Agriculture would present an unreasonable risk. Sterilized beef and pork being a specialized item, in our estimation, with a value to the Department of Defense (DOD) almost exclusively would require a firmer declaration of intent from DOD—perhaps not so much in pounds, but in percentages of total purchases of beef and pork. (This should stimulate construction of industrial facilities to compete from the business.) In particular, we can justify a financial commitment to construct and operate a meat irradiator providing (1) FDA approval of the proposed meat products is assured, and (2) DOD makes a firm commitment for a major portion of the product including an intent to increase product procurement over a reasonable period of time.

Respectfully submitted.

WILLIAM HUGHES,
Vice President.

STATE OF IOWA,
OFFICE OF THE GOVERNOR,
Des Moines, September 9, 1966.

Hon. CHET HOLIFIELD,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress, Washington, D.C.

DEAR CHAIRMAN HOLIFIELD: The State of Iowa and the entire Midwest enjoys an eminent position in the meat industry. The continued growth of this industry will likely be influenced by its ability to find and cultivate new markets at home and abroad. New products based on new preservation techniques will materially contribute the industry in achieving these objectives.

I should like to commend the Joint Committee's past accomplishments in the field of radiation preservation of foods and urge you to give consideration toward a continued, broadened effort in radiation-preservation of meat products.

I would specifically urge your consideration of the request for additional effort by the Joint Committee toward the development of acceptable standards for radiation-pasteurized meats and meat products leading to the necessary approval by the Food and Drug Administration and the U.S. Department of Agriculture.

Very truly yours,

HAROLD E. HUGHES.

CENTRAL COOPERATIVE TURKEY PRODUCERS,
Ellsworth, Iowa, August 29, 1966.

Hon. CHET HOLIFIELD,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress, Washington, D.C.

DEAR CHAIRMAN HOLIFIELD: As a processor of poultry meats, and one who has had an opportunity to observe the handling of this and other perishable meats in many market places, both in this and several foreign countries, I am very much interested in seeing research efforts continued toward the development of radiation-pasteurization of meat products.

Much progress in this field has been accomplished to-date, and with the great amount of potential advantages already recognized, to further the availability and keeping qualities of a product so important to the diet of most peoples around the world, I wholeheartedly recommend that your committee give urgent support to this program.

Respectfully,

HOWARD H. RICHEY, *Manager.*

ELSHEIMER'S MEAT PRODUCTS,
West Union, Iowa, August 30, 1966.

JOINT COMMITTEE ON ATOMIC ENERGY,
U.S. Congress,
Washington, D.C.
(Attention Hon. Chet Holifield).

SIR: It is our contention that the development of radiation-pasteurization of meat products and their subsequent approval by the Food and Drug Administration and the U.S. Department of Agriculture, is urgent and necessary for safe and efficient distribution of fresh meat products.

Radiation-pasteurization, in our humble opinion, can be one of the most important technological advances to be made in the meat industry to meet the challenge of a growing population, demanding a variety of products and the storage made necessary through modern distribution methods.

Up to date packaging combined with radiation-pasteurization is an opportunity to look at intensively and support.

Respectfully,

T. G. DOSCHER.
C. H. BIERMAN.

ID PACKING CO., INC.,
Des Moines, Iowa, August 30, 1966.

Hon. CHET HOLIFIELD,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress,
Washington, D.C.

DEAR CONGRESSMAN HOLIFIELD: We should like to add our support to the request for additional Federal efforts toward developing acceptable standards of radiation-pasteurized meat and meat products.

Radiation-preservation of meat offers significant potential benefits to the processor, the farmer and the consumer alike. As a relatively small firm in a highly competitive industry, we feel that such an effort would impose an undue burden uupon firms such as ours if the effort were to be borne by private industry. Firms such as ours are unable to justify sufficient budget to develop and promote radiation-processed meats until acceptable standards have been developed and approved.

We would like to commend your past efforts in meat irradiation technology and respectfully urge you to consider further efforts toward radiation-pasteurization of meat and meat products.

Sincerely,

E. HOWARD HILL, *Chairman.*

OSCAR MAYER & CO.,
Madison, Wis., September 2, 1960.

Hon. CHET HOLIFIELD,
Chairman, Joint Committee of Atomic Energy,
U.S. Congress,
Washington, D.C.

DEAR MR. HOLIFIELD: As a packer and processor of both fresh and processed meats, we request that favorable consideration be given to the proposal prepared by the Iowa Development Commission with regard to additional and accelerated efforts toward the development of radiation-pasteurization of meat products.

We concur with their opinion that development and approval of radiation-pasteurized meats would offer too little proprietary benefit to an individual company to justify private research. However, this program could result in significant economic benefits to both consumers and agricultural business in general by reducing the perishability and resulting waste due to spoilage of refrigerated meats both in the home and throughout the distribution system from the packer to the consumer.

Yours very truly,

HAROLD T. JAEKE,
Executive Vice President.

FLOYD VALLEY PACKING CO.,
Sioux City, Iowa, September 3, 1966.

HON. CHET HOLIFIELD,
Chairman, Joint Committee on Atomic Energy,
U.S. Congress, Washington, D.C.

MY DEAR CONGRESSMAN: After seeing firsthand the Radiation Processing of meat and fish products at Natick, Massachusetts, by Cobalt application, I realize the tremendous technical advances and cost reduction of this method over direct generated methods of just a short time ago.

Such accelerated rates of advancement in this field is hard to grasp even with a 30-year background in electronics, and an interest in its preservation of fruits and meats.

The wide diversity of scientific knowledge in food products and electronics makes impractical research by private industry. The Atomic Energy Joint Committee should see it as their duty to the nation to press forward with their contribution toward research that could reasonably forsee commericalization of this process with mutual advantages to all citizens of our country.

Respectfully yours,

R. A. KENNEDY, *President.*

Representative PRICE. The next witnesses are Mr. William A. Loeb, president of Iso Nuclear, and Dr. William L. Brown, vice president for research, John Morrell Co.

You may proceed in any way you care to divide the time.

STATEMENT OF WILLIAM A. LOEB, PRESIDENT, ISO NUCLEAR

Mr. LOEB. Thank you, Mr. Chairman.

Mr. Chairman and members of the committee, I am William Loeb, president of Iso Nuclear Corp. With me is Dr. Brown, of the John Morrell Co. He is vice president of research, and he will add to my remarks the point of view of an established meat processing company.

Iso Nuclear's business is the manufacture and sale of products made with nuclear radiation. We will build and operate a gamma processing production plant suitable for the pilot meat procurement program now under consideration. We have just delivered to the Department of Defense 22,000 pounds of gamma preserved bacon.

I would like to tell you of our experience in this first procurement, accomplished by private industry, but using Brookhaven's irradiation facility. I would also like to tell you Iso Nuclear's views on the proposed pilot meat procurement program.

DOD BACON PROCUREMENT

Iso Nuclear, together with John Morrell & Co., produced 22,000 pounds of gamma processed bacon in late June of this year. The bacon was packed in 1-pound cans, 12 cans to a cardboard container. I have with me a complete box, just as it came from the irradiator.

Dr. Brown has two of the cans that are typical of the ones that are inside the box.

The irradiation was performed with the cans already assembled in the cardboard box. The bacon was processed, canned, and packed by Morrell at the Ottumwa, Iowa, plant. It was then shipped by refrigerator truck to Brookhaven National Laboratory, where prior arrangements had been made to gamma process it, using BNL's High Intensity Radiation Development Laboratory.

Processing was done on a round-the-clock, three-shift basis, over a period of 5 days. The bacon was kept refrigerated until a few minutes before it was to enter the irradiator. After processing, it was handled at room temperature and was shipped by unrefrigerated truck to the delivery depots.

The entire process was performed in accordance with a 30-page, detailed DOD specification.

I have here the specifications, just so that you can get some idea of how complete looking it was.

Throughout the processing, careful and detailed inspection was performed, and detailed records were maintained.

During the month before the bacon arrived, the Natick Laboratory personnel, with the cooperation of the Brookhaven staff and ourselves, checked the uniformity of the dose that the BNL cobalt 60 source would deliver. The source itself was adjusted until Natick was satisfied that they could qualify the source for use on this procurement.

At the same time, the BNL and Iso Nuclear staffs prepared a set of written procedures, inspection methods, and data recording forms, which were used throughout the processing.

I have here again the written instructions to the operators, which were the procedures that were used in processing the bacon.

Representative PRICE. Did you get that up to 30 pages, too?

Mr. LOEB. I didn't count.

Also, so that you will get some idea of the care that went into inspection, I have here the record that was made of all the data as it was taken during the processing for quality control.

Iso Nuclear obtained a temporary Department of Agriculture license as meat processing establishment No. 1928. To keep this in perspective Morrell is No. 17.

Throughout this undertaking, I have been particularly impressed with the great interest and helpfulness of the personnel of the many Government agencies involved. Brookhaven, Natick, and AEC's Division of Isotopes Development were, of course, directly interested.

The Defense Supply Agency, Chicago and Philadelphia, were extremely helpful, and their contracting officer was present throughout the actual processing.

The Department of Agriculture issued our meat establishment license, and followed up by supplying a meat inspector together with a scientific adviser from their Beltsville laboratory.

Observers from the Philadelphia and New York offices were present during the production, and the New York office ran the final product acceptance incubation test.

What have we learned from this production?

First: Commercial firms can produce a good product in accordance with the specification as it is written. It is a good model on which to base future specs for additional meat products.

Second: A production plant is needed if the gamma processed meat program is to maintain its momentum.

In the course of seeking a suitable facility for this production, we surveyed all existing irradiation facilities. The only facility in the country that could reasonably handle this level of production is Brookhaven's HIRDL.

But HIRDL is a research facility in which a great deal of needed basic work in going on. We should not, therefore, expect to be able to interrupt that program in any extensive way. A production plant is needed.

Third: I feel reassured on the processing techniques involved. Our yield on product processed was 99 percent. Counting product purposely sampled for quality control testing, the yield was 99.3 percent. The remaining 166 pounds of product was lost when the automatic indexing mechanism stuck for a few minutes on one occasion. This was detected as it occurred, and the product was rejected on the spot as being out of spec.

I think that we have confirmed that for unrefrigerated irradiation, there are no major technical surprises awaiting us.

PILOT PLANT MEAT IRRADIATOR

Iso Nuclear is planning to build a large gamma processing plant near Buffalo, N.Y. Our investment in this plant will be $1,300,000. It will be able to process 2 million pounds of meat per year.

We will bid on the pilot invitation with John Morrell, as we did on the bacon. The meatpacking will be done at Morrell's new plant in Philadelphia, accessible by truck from Buffalo.

It is our expectation that the pilot procurement will utilize only a portion of our plant's large production capability. I am confident that over the first few years of operation we can develop commercial production uses for the remaining capacity—for instance meat, as FDA approvals come into effect, wood, plastics, sterilized medical products, and specialty chemicals.

Morrell will undertake the market development for commercial meat sales for this plant.

To accomplish this program, I believe the AEC's offer of cobalt and design aid is desirable. This would be in addition to our $1,300,000 that I already mentioned.

When the cobalt is needed for products other than meat, Iso Nuclear will pay a reasonable use charge to the Government.

The quantity of meat to be procured annually is an important and difficult consideration. I feel that a production level of at least one shift, half time, would give reliable data on the realities of plant operation. For Iso Nuclear's plant, that would call for 300,000 pounds a year.

This production level will not, however, reflect per pound costs which are commercially attractive. Higher production levels are desirable if the per pound cost is to be brought into the realm of practicality.

Nevertheless, Iso Nuclear will bid at the 300,000-pound-per-year level in the expectation that future Department of Defense requirements will be higher, and that sufficient other business may be obtained to justify our plant investment. Assurance of the 3-year firm procurement that has been discussed is also important in the program.

The other major area to be checked is the military effectiveness and utility of the product.

I am not experienced in this area, so I can have no meaningful judgment of a proper amount. I do think the Department of De-

fense should purchase an amount which it judges will allow a clear assessment of field use. I suspect that this may require more than 300,000 pounds a year. If so, Iso Nuclear would be pleased to bid on this amount.

We have just heard from the Army that they feel this is a sufficient amount, of course. If so, Iso Nuclear would be pleased to bid on this amount.

We would also plan to give priority to later Government meat purchases up to our plant's full capacity.

Why a pilot meat procurement?

It is clear that a major technical achievement has been brought about by the present DOD–AEC development program. There are many applications for this new food preservation tool, most of them things that cannot now be accomplished in any other way, all of them holding promise of benefit to the consumer.

The obvious first goal is the needs of the Department of Defense, which in 1965 purchased over $400 million worth of meat alone. If only 10 percent of this amount is benefited by radiation preservation, the program would appear worthwhile.

In the consumer area, the 500 million pounds of canned ham consumed annually in the United States represents a fine target, especially since today's large canned hams all have to be refrigerated.

It takes nearly 2 years to build such a plant. Two years from now, there should be a number of additional FDA approvals. But if we wait till then to start a plant, we will have moved production out 4 years from today.

I am sure that to maintain the momentum already gained, construction of a production plant should start now. Then, with FDA approvals, things can roll. That will be the breakthrough that moves this program from technique into technology.

This concludes Iso Nuclear's portion of our presentation. I would like to pass the baton now to Dr. Brown of John Morrell & Co.

Representative PRICE. Dr. Brown, will you proceed with your statement?

STATEMENT OF DR. WILLIAM L. BROWN, VICE PRESIDENT FOR RESEARCH, JOHN MORRELL & CO.

Dr. BROWN. Mr. Chairman, members of the committee, I am William L. Brown, Research Director of John Morrell & Co., Ottumwa, Iowa.

John Morrell & Co., is the fourth largest meatpacker in the United States, and has an agreement with Iso Nuclear Corp., to bid jointly for the pilot meat procurement proposed by the Federal agencies.

We have been interested in the meat irradiation program since initiation of research with the Quartermaster Corps in 1957. We have published several scientific papers as a result of our meat irradiation research program.

In June we produced the first commercial shipment of irradiated bacon for the Army at our Ottumwa, Iowa, plant. We appreciated the help and guidance from Natick, Department of the Army, Defense Supply Agency, and the inspectors from the Army and Meat Inspection Division.

The procurement specification was generally satisfactory, and resulted in product of excellent quality. We have suggested a few small changes to Natick.

The bacon was irradiated by Iso Nuclear Corp., at Brookhaven National Laboratory. We made bacteriological analysis of the bacon before and after shipment and found the product sterile after irradiation.

We hope to be able to explore the commercial possibility of irradiated meat, if additional FDA approvals are obtained, and we are successful in our bid for the pilot procurement.

We are especially interested in products that cannot now be produced.

NEW PRODUCT TESTING

To acquaint you with our plans, our normal new product testing procedure is as follows:

Laboratory development: We have suggestions from our marketing and sales people for products they are interested in having developed.

After we get past the laboratory stage, we go into consumer panels. These are made up of housewives. This testing is conducted by a firm other than Morrell. Then if we have a successful product through the consumer panels, we go into a market research program.

We plan to put the irradiated products through the same program. Products that we are interested in testing are items difficult or impossible to produce using conventional heat sterilization. For instance:

1. A large shelf-stable canned ham is not presently produced commercially because of the excessive juice released in the can during heat processing. Using irradiation, it may be possible to produce and merchandise this type of ham.

2. We are very interested in flexible packages, rather than in metal cans. Natick is developing these packages for Army use. We will be particularly interested in "see through" packages for the consumer, even though it may not be necessary for the Army.

Sliced hams are currently being sold in flexible plastic pouches and kept under refrigeration. Perhaps we can develop a sterile irradiation processed sliced ham.

3. There are several vending machine items that are attractive, if they can be successfully produced.

4. We may be able to use a plastic material to dip the products into, such as smoked ham, then irradiate to form a film and sterilize the surface of the product in one operation.

In conclusion, this program merits increased support if we are to explore the commercial possibilities for radiation processing of foods.

BASE LOAD FOR PILOT PLANT MEAT IRRADIATOR

Representative PRICE. Thank you, Dr. Brown.

Mr. Loeb, you say that you will build and operate a gamma processing production plant suitable for the pilot plant meat procurement. Do you mean that you will build such a facility whether or not a base procurement load is guaranteed

Mr. LOEB. Iso Nuclear is in the business of manufacturing, using radiation as a tool in that manufacturing.

Our plans at the present time, and for a considerable length of time, now that we have been laying these plans, are based on the assumption that there is going to be a meat procurement of the sort that we have been discussing today.

If there is not such a procurement, we would rethink our plans, and our course of action. I don't know what the result of that rethinking would be, offhand.

I would hope that we would still go ahead and build a plant that would have the same capability, but I also doubt that the justification from a financial point of view would really allow us to do that in the same sense that we are talking of here today.

Representative PRICE. You are going to look, then, for the availability of that base load before you go ahead with your plans to build?

Mr. LOEB. Yes. I think under the present set of plans we are looking at it that way.

Representative PRICE. Do you see this in private industry, or are you looking to the military for the baseload that will be necessary to justify your investment in such a plant?

Mr. LOEB. From the meat point of view, the only identifiable, realistic market in the next 5 years, or perhaps 3 years, is the military demand. With FDA approvals, there will be a need on the part of the Army, and we have heard today of the kind of numbers that they are looking forward to.

In the area of commercial meat sales, even with FDA approval, there will still be a considerable amount of question as to the applicability of these higher priced products, even though they are specialty products, and as to the consumer acceptance of these products after they are available on the market.

So that I think the only prudent market that we can look to in the financial sense is the Army market, at the present time.

My own belief is that the Army demands are very real, and even in the cost effectiveness sense will be very real, as Secretary Poor described.

I fed into our plans my own optimism in that regard. But I think for the near term, the Army demands, both for the testing purposes that have been described, and for at least the initial larger base production, will be the only market available for sterilized meat.

Representative PRICE. At the same time, would you not be looking for civilian consumption of bacon that you could handle in this pilot plant?

Mr. LOEB. Well, if we proceed, and have some sort of baseload from the military side, we will pursue with Morrell the commercialization that grows out of that.

I hope, and really expect, that we will succeed. But there are considerable uncertainties associated with that.

IRRADIATED BACON

As to bacon specifically, I think perhaps Dr. Brown can speak for that particular product.

Representative PRICE. Dr. Brown, has any of the Morrell bacon been sold on the civilian market, or tested for future civilian marketing?

Dr. BROWN. No, sir; we have not.

Representative PRICE. You have not made any attempt to test the marketing of it anyplace?

Dr. BROWN. No, sir; we have not.

Representative PRICE. In the pilot plant, Mr. Loeb, that you propose to build, will it be possible to irradiate meats in the frozen condition, as well as at room temperature?

Mr. LOEB. Yes, sir. Our plans involve frozen while irradiated capability. That is the kind of capability that is required for good product, as the Natick people have described, and we fully anticipate including that in the plant.

Representative HOSMER. What temperature are you talking about?

Mr. LOEB. These would be temperatures as low as minus 80°—80° below zero.

Representative HOSMER. Have you done any experimentation on what temperature range may be advantageous for the preparation of the irradiation process?

Mr. LOEB. No, sir; we have not. Natick has been carrying on that development work.

Representative HOSMER. How long does the irradiation process take?

Mr. LOEB. The bacon is perhaps our best experience. It took 2 hours total time for a box of bacon to go through the irradiator.

Representative HOSMER. What kind of temperature rise did the product experience during that period?

Mr. LOEB. The product went into the irradiator at 25° F. After 2 hours it came out of the irradiator and measurement of the temperature within 10 minutes after coming out of the irradiator indicated temperatures below 80° F.

This 2-hour period including warming up just from the cell being at room temperature plus any heat that was deposited in the meat.

The specification called for the temperature not to exceed 80° F. within 10 minutes after coming out of the irradiator, and it never did. It was always below that.

Representative HOSMER. With the minus 80° you mentioned, you get a better product?

Mr. LOEB. Excuse me. For all of the meats except bacon, the low temperature, frozen during irradiation, gives a much better product. For bacon, that is unnecessary.

Dr. Josephson, perhaps, knows the details of the variation with temperature better than any of us. But for bacon it was not frozen; need not have been frozen during irradiation. It happened to be slightly frozen at the time it went into the irradiator.

Mr. CONWAY. You don't want to leave the impression it took 2 hours per dozen cans. You put in more than a dozen at one time?

Mr. LOEB. I am sorry. We had in the irradiator at any one time on a continuing processing basis 42 boxes times 12, which is about 650 cans at any one moment.

One of these boxes came out of the irradiator every 20 minutes; excuse me, seven boxes came out of the irradiator every 20 minutes.

Senator HICKENLOOPER. Can you give that to us in simple language, now? How long did it take to irradiate that can?

Mr. LOEB. If you were riding on one of the cans, it would take 2 hours, sir. If you were standing outside the facility watching the

cans go by, a batch of them, seven of these boxes would come by every 20 minutes.

Senator HICKENLOOPER. What I am trying to find out is what elapsed time is it from the time you turn on the irradiation until it is irridiated, and you accomplish its purpose? Is it 2 hours? or 20 minutes? or what?

Representative PRICE. In other words, how long is a can exposed to irradiation?

Mr. LOEB. The can is exposed to irradiation for 2 hours.

I think our confusion is that this was not handled as a batch process, where we put these boxes in and then turned it on and turned it off and took them out. The source was on from the beginning of the first day, and then these cans were fed in continually.

Chairman HOLIFIELD. On a conveyor belt?

Mr. LOEB. On an overhead conveyor, in on one side, and they went out continuously on the other. That went on for 5 days, with no interruption during the time bacon was going through.

Senator HICKENLOOPER. It takes about 2 hours' exposure?

Mr. LOEB. Two hours' exposure.

Senator HICKENLOOPER. This has to be exposed for 2 hours from the original fresh meat before it reaches the point of sufficient sterilization?

Mr. LOEB. That is correct.

RATE OF IRRADIATION EFFECTS

Representative HOSMER. You are talking about this particular operation up at Brookhaven, and the geometric configurations of the particular thing you ran it through. When it first went into the portal, it was far from the source, and then she gradually got closer, and she got a good hot shot. Maybe she was around the source for a few minutes, and then she went away again.

This brings up the question: Can you hot-shot this and run it fast past a source, and speed up your time to 20 minutes for the whole process, instead of an hour?

What are all the things you are thinking about? Are there any tricks up your sleeve?

Mr. LOEB. I don't know about tricks, but the time required for processing is certainly dependent on the design of the facility.

The Brookhaven facility was designed initially for experimental developmental work, and therefore it was not aimed particularly at high throughputs. The efficiency of use of the source that is there at Brookhaven is therefore considerably lower than it would be in a production plant.

If Brookhaven's facility had been meant to be a production plant, and had been aimed at the optimum throughput for the source that they have, the throughput would have been about three times as high as it actually was in this case, or, instead of 2 hours, it would have been about 40 minutes travel time for a can of bacon.

Representative HOSMER. You gave this 4.5 to 5.6 megarads?

Mr. LOEB. Yes, sir. That is the specification, the actual dose.

Representative HOSMER. Conceivably, with a hot enough source, you could put that in for a few seconds, or a few minutes. Is that right?

Mr. LOEB. Yes, you could.

Representative HOSMER. Would it make any difference as to the preservation quality?

Mr. LOEB. No. The rate of putting the dose into the meat has no detectable effect on the quality.

Representative HOSMER. Would it make any difference as to the quality of the product from other standpoints?

Mr. LOEB. No, it would not.

Representative HOSMER. I assume that this plant design that you are conceiving will attempt to have the irradiation input accomplished as quickly as possible in relation to the price of the amount of radiation source you can afford.

Incidentally, are you going to use an isotopic source, or are you going to use accelerators?

Mr. LOEB. We are planning to use cobalt-60 at the present time.

Representative HOSMER. On the basis that you get it on loan for part of the time?

Mr. LOEB. Yes, sir. We are also using it not only for that reason. We are using it because we feel that that is the appropriate source to use at this stage of development for this kind of product.

The gamma rays have the penetrating qualities required to do large pieces of meat, and cobalt is a well understood, available, and cost-known source of gamma rays.

Representative HOSMER. Is Iso Nuclear a subsidiary of Morrell, or is it a joint venture?

Mr. LOEB. Iso Nuclear is a corporation, and is in no way associated with any other large corporation in an ownership or interlocking way.

Representative HOSMER. In other words, this is a joint venture or partnership, or something between you and Morrell?

Mr. LOEB. That is correct.

Chairman HOLIFIELD. Mr. Chairman, I am unsatisfied with one of the answers, and I want to be sure that I understand it.

It has been my understanding that different doses of irradiation do have different effects upon the taste of foods. Now, I am not sure that it would have on bacon, but I gather from Mr. Hosmer's question, that if, instead of having 4.5 megarads you had 50 megarads, that you would do the job quicker.

Representative HOSMER. I was talking about the exposure rate, rather than the exposure dose.

Mr. LOEB. Yes, I think I misled you in the way I answered. The total dose that is put in certainly makes the effect that you are referring to. The rate at which it is put in for the same total amount has no apparent effect.

Chairman HOLIFIELD. Then you can take a stronger source and in a shorter time get the same dose; that is 4.5 megarads?

Mr. LOEB. Yes, we can put the same dose in in less time, and still get the same product.

Chairman HOLIFIELD. If you were working commercially, you would become very much more efficient, because you could process much faster than you were at the Brookhaven Laboratory, which had a makeshift experimental facility, as I understand it.

Mr. LOEB. Yes. Also, in the Brookhaven facility, I should point out that when you pass the product through, 60 percent of the dose

that is put in, even to this bacon, is accomplished in about 40 minutes of the total time that it is in there. The rest of the time, as Mr. Hosmer pointed out, is in outside layers, which are put in there so that we can use the radiation that comes all the way through the bacon, instead of just letting it go off and disappear.

If we didn't want to use that, we could speed things up just by using one layer in close, but we would lose some radiation in the process.

Chairman HOLIFIELD. In a regular facility made for the purpose, you could control the intensity and direction of your radiation beam to the point where you could do it much faster?

Mr. LOEB. You could if you so desired. I think in all likelihood the best combination will be a mix of speed and mutiple layers to absorb all of the radiation that is worth catching.

Senator HICKENLOOPER. You evidently have given this a lot of thought. Do you have a projection as to what you would do with the type of machinery that you would design for a commercial operation, and how long it would take to do it?

It would seem to me that if you had to run this through for 2 hours to get the necessary effect, it would be quite costly.

Can you reduce that cost, as far as the cost to the public is concerned? Do you have any data on that, or any speculation worth anything?

Mr. LOEB. The 2-hour number corresponded to the Brookhaven source. We will have faster throughput times in our facility, so that to some extent we have already taken into account what you are referring to.

In addition, if one has a plant investment, then until such time as you have reached the capacity of that plant, the speed of going through is relatively unimportant in the cost.

The labor is not very great, in other words. Once we reach capacity, then it has a direct effect in bringing down cost.

Senator HICKENLOOPER. Once you reach capacity, I suppose the size of the plant has something to do with it, too.

Mr. LOEB. Yes, it does.

ECONOMICS OF IRRADIATED BACON

Senator HICKENLOOPER. It would seem to me that we ought to have some at least speculative figures as to the economics of this thing.

Mr. LOEB. I don't have any for you today. We of course have put together figures on how we would operate, on what we might accomplish for our own contribution, in deciding that we should do this.

The essence of what we have in mind is that we can afford to operate a plant at less than a major fraction of capacity, because we think that we can find and develop other business for the remaining capacity of the plant, and this will make it unnecessary for us to charge as though the only product from the plant were the one production meat contract that we are discussing today.

Representative PRICE. Could you explain to us why so far the bacon is put up in cans? Is this strictly for military orders?

Dr. BROWN. Yes, sir.

Representative PRICE. Or is this because this is the only container that has been cleared at this time by FDA?

Dr. BROWN. It is both. It is specified by the military, and this is the only container approved by FDA.

Representative PRICE. If you wanted, you could not package it in any other way?

Dr. BROWN. We could not.

Representative HOSMER. I would like to follow up on Senator Hickenlooper's question on the economics a bit.

Mr. Loeb, in this thinking you have been doing about this 300,000 pounds annually in this plant you are going to build, you are going to have to make some bids in competition with somebody else, and the AEC is going to take all those bids. What do you think the range of bids could reasonably be, high and low, in terms of per pound of bacon, for this plant?

Mr. LOEB. I would think that the cost per pound from these invited bids for the add-on for irradiation processing could be as high as a dollar a pound, which I think is too high to be encouraging in the commercial sense of the word. It may be worth that to the Army.

Representative HOSMER. How, what is a pound of bacon selling for in the food stores around here today?

Dr. BROWN. Generally less than a dollar per pound, sir.

Representative PRICE. A pound of bacon in a food store?

Dr. BROWN. Yes, sir.

Representative PRICE. I don't think so. It is $1.19 a pound.

Dr. BROWN. Right now we are in a high market situation. Normally bacon sells at less than a dollar a pound.

Representative PRICE. It has been a long time since it has.

Representative HOSMER. Let us assume it sells for a dollar a pound on the market. On the same basis, what would this irradiated bacon sell for over in the same market?

Dr. BROWN. Mr. Hosmer, I think it would depend upon packaging, first of all.

Let us assume we package it the same as we do now. The cost would be slightly higher than regular bacon through our handling process, and then the cost of the irradiation.

Representative HOSMER. Would it be a dollar and a quarter a pound?

Dr. BROWN. Let us assume we are processing the bacon at about a dollar per pound. Presently maybe a 20-percent increase, because of special requirements in the selection of the bacon, and in the processing, would be a good figure.

Representative HOSMER. $1.20 a pound to put it on the shelf?

Dr. BROWN. No. This is up to the radiation processing cost.

Representative HOSMER. What I am trying to get is what a customer would pay for a can of irradiated bacon versus the regular bacon he buys out of this new plant.

Dr. BROWN. If Mr. Loeb indicates the costs are going to be a dollar a pound, and our production cost is $1.20, this would be $2.20 a pound.

Mr. LOEB. I would like to be careful. You asked about the maximum cost from this invitation.

Representative HOSMER. I thought you were trying to avoid me on the minimum, so I didn't press you.

Mr. LOEB. Thank you.

I think, though, that that is going to come down rapidly, as volume goes up.

If the plant were turning out a million pounds a year, instead of 300,000, the cost would be way down from $1 a pound.

Representative HOSMER. What does that mean, "way down"?

Mr. LOEB. I would think in terms of something like a factor of three, right off the bat, that kind of level change.

Representative HOSMER. You mean about 33 cents a pound?

Mr. LOEB. That is one-third of a dollar, yes.

Representative HOSMER. You would throw away the third of the penny.

Senator HICKENLOOPER. A little less than one-third.

Representative HOSMER. Thank you.

Chairman HOLIFIELD. Of course, if this is your ultimate in cost reduction for irradiation, why, you are not going to be able to get this accepted with such a tremendous difference on the commercial market.

Mr. LOEB. No, sir.

What I really meant to say when I began to add to my statement was that as the volume goes up, the cost is going to come down.

We have a number of projections of ultimate processing cost from people at the Department of Commerce, and from the Army personnel, which brings it down into the cents-per-pound region, which is the ultimate volume kind of cost which will be involved in commercialization eventually.

REDUCING COSTS OF IRRADIATED BACON AND HAM

Chairman HOLIFIELD. This kind of packaging, of course, is to be shipped all over the world. I would say it is fairly high cost packaging, but if you were using bacon like we buy in the supermarkets, I don't see any reason why it could not be placed in plastic bags, which would be bacteria proof and processed for, let us say, short-time use, a month or 2 months, something like that, without refrigeration, at a much lower cost.

Is that not true?

Dr. BROWN. Yes, sir; that is correct.

Chairman HOLIFIELD. If it is not true, we have too expensive a process to be commercially acceptable.

Dr. BROWN. That is true, sir.

Representative HOSMER. That is the difference between pasteurization and sterilization, again. Is that right?

Dr. BROWN. Right; that is part of the difference.

Mr. LOEB. Pasteurization with much lower doses will be cheaper.

Chairman HOLIFIELD. If you pasteurize in cellophane-type packages, 1-pound packages, something like we buy in the supermarket, you could do it much cheaper, could you not, than doing it this way? This is wrapped carefully in paper, and rolled, you might say, inside the can?

Dr. BROWN. Yes, sir.

Chairman HOLIFIELD. Which involves, I would suppose, some hand labor, a lot of hand labor, before it is even put in the can.

Mr. LOEB. Yes.

Chairman HOLIFIELD. It would seem to me that we would get the wrong impression if we would think that it is going to cost $1.30 a pound to protect a pound of bacon from spoilage.

Representative PRICE. The figures you are talking about as of now are with the minimum amount of research that you are doing on it, and the amount that you are canning?

Mr. LOEB. Yes, sir. These are figures which are based on our understanding of sterilized shelf-stable product, canned ham, that will last I don't know how many years, sort of forever.

Representative HOSMER. But you were talking about some commercial business. That is why we perked up our interest on the cost.

Mr. LOEB. All the area we are describing is centered around the sterilized product, which is the Army's major interest at this time, and things that would grow in a commercial sense out of those FDA-approved products.

For pasteurized product, there would be a very different story. Costs would be much lower. It is almost a different area of the business.

Representative HOSMER. What is the commercial potential on it, either pasteurized or sterilized?

Dr. BROWN. I think, Mr. Hosmer, that probably the best bet would be in the area of new product development. Items that are not presently being sold would be the best commercial possibility.

Representative HOSMER. You are getting out of the bacon category?

Dr. BROWN. Yes, sir. I don't believe anybody would be interested in selling this particular product.

Representative HOSMER. Would it be a delicatessen type of stuff, or for maybe Christmas packages, or what?

Dr. BROWN. There is a pretty good product on the market now, produced in Denmark, and heat-sterilized, that you would be in direct competition with.

Representative HOSMER. Bacon?

Dr. BROWN. Yes, sir; canned bacon.

Representative HOSMER. You are still talking about bacon?

Dr. BROWN. Yes, sir.

Representative HOSMER. Who is going to use that, a fellow that owns a yacht or something, who does not have an icebox? Who is going to buy it?

Dr. BROWN. Campers; a housewife might have one on the shelf just in case she gets some unexpected company.

Senator HICKENLOOPER. It is on the shelves of the supermarket now, is it not?

Dr. BROWN. Yes, sir; it is being sold commercially, canned specialty bacon.

Representative PRICE. The price is lower than the domestic bacon.

Dr. BROWN. Yes, sir; at the present price level.

RESEARCH AND DEVELOPMENT INVESTMENT BY FOOD INDUSTRY

Representative PRICE. Dr. Brown, could you tell us about how much money John Morrell & Co. puts into research and development a year, and how much financial effort they put into this food irradiation program?

Dr. BROWN. Mr. Chairman, I have some industry figures that were released by the Food Marketing Commission.

The four major packers, according to the information available for 1964, put 0.33 percent of each sales dollar into new product de-

velopment. Packers in size 5 through 8 put 0.09 percent of the sales dollar into new product development.

We spend less than that. We are not up to industry average in this regard.

Representative PRICE. What about the amount? What you do spend, what amount of that goes into this irradiation program you are interested in?

Dr. BROWN. Over the years, we have had one person in our laboratory primarily interested in the irradiation work. I suppose we have spent maybe four or five man-years, total.

This, to you people, I am sure is a small amount, but this, to us, as far as our total budget is concerned, is a significant research effort.

Representative PRICE. Could you put it in terms of dollars? You gave the percentage on the industry, and so forth. Could you tell us what percent of the money that Morrell spends on research and development, what percent of that goes into the irradiation work?

Dr. BROWN. Yes, sir; I could give it to you percentagewise. It would be between 5 and 10 percent.

Representative PRICE. Are there any further questions?

Thank you very much, gentlemen.

I want to also congratulate Iso Nuclear for the contribution of putting $1,300,000 into a pilot plant, $1,300,000 of your own money, in this plant.

Representative HOSMER. They have not done it yet.

Representative PRICE. No; but they are considering it. We seldom have that situation.

The next witness will be Mr. William D. Keith, director of the Industrial Development Council.

Mr. Keith.

Mr. Keith, your organization is located at Carroll, Iowa?

STATEMENT OF WILLIAM D. KEITH, DIRECTOR, INDUSTRIAL DEVELOPMENT COUNCIL

Mr. KEITH. That is correct, Mr. Chairman.

Mr. Chairman and members of the committee, I very much appreciate the committee's invitation to report on the work which the Carroll Industrial Development Council has been doing in order to establish in our community the first expandable pilot plant meat irradiator.

ADVANTAGES OF CARROLL, IOWA, FOR IRRADIATOR FACILITY

We have been working intensively since early spring, in conjunction with Nuclear Materials and Equipment Corp.—NUMEC—of Apollo, Pa., to arrange for the construction in Carroll of an irradiation facility based on a unique philosophy: this irradiator would be operated with the participation of a cooperating group of meat and poultry packers, processors, and distributors, so as to provide the widest possible dissemination of experience and technology over as broad a sampling of the food industry as may be interested in participating in this project.

Carroll is in midwestern Iowa, close to the geographical center of the United States. As you know, Iowa is the Nation's leading State in terms of numbers of cattle and hogs slaughtered each year, and is also one of the leaders in chicken and turkey processing.

We in Carroll are surrounded by over a hundred independent commercial meat and poultry packers, processors, and distributors. We are ideally situated to act as a service center for this area.

In terms of transportation, for instance, over 50 million pounds of meat flow through Carroll each month by rail alone, and considerably more by truck.

We are about an hour from Iowa State University and its outstanding food technology department.

And we can deal impartially with all our neighbors who might wish to participate in this project, since they are all around us, but none of them is in Carroll itself. This permits us to work with them all without any questions of favoritism to any individual concern.

It therefore seemed to us, when discussions concerning the meat irradiator project arose following the Industry-Government Conference of September 24, 1965, that we could help bring to Iowa a development of great ultimate interest to our food industry, and do it in such a way that the benefits of the program would be widely disseminated throughout the industry, rather than concentrated for the advantage primarily of any individual company.

We accordingly undertook a series of visits all over the country last March to inform ourselves about this program. Senator Hickenlooper and his staff were particularly helpful in arranging interviews for us in Washington, as were Senator Miller and Congressman Hansen and their staffs.

We met at that time with the staff of this committee, particularly Mr. Conway and Mr. Graham, with Army officials at the Pentagon, and representatives of the Department of Commerce, with Dr. Josephson and his enthusiastic staff at the Natick, Mass., Army Radiation Laboratory.

We were received especially hospitably on a Saturday afternoon by Mr. Kaylor at the Bureau of Commercial Fisheries Radiation Laboratory at Gloucester, Mass., and we also visited a number of private and educational facilities outside Iowa, including NUMEC and the department of food science of Michigan State University.

We found that NUMEC was already conducting a survey of over 1,000 meat and poultry processors throughout the country in order to establish interest in a pilot plant meat irradiator to be operated on the basis which I outlined above.

We undertook to arrange a broadly based meeting in Iowa, with NUMEC participating, to demonstrate the advantages of locating such a plant in Iowa, among the greatest possible concentration of packers and processors.

With the help of the Iowa Development Commission and Iowa State University, we therefore sponsored a 2-day information conference on April 14 and 15 at Iowa State University on the irradiator project.

In addition to these organizations and NUMEC, the Iowa Department of Agriculture and the Iowa meat and poultry industry were also represented.

We received encouragement in the form of telegrams and letters from Senators Hickenlooper and Miller and Governor Hughes, and were honored by the attendance of Congressman Hansen, who spoke briefly at one of our sessions.

The general consensus of the discussions was that there was an interesting future for irradiated meat and poultry, but that much more work

remained to be done, and that this work could best be done in a place such as Iowa, where there is an abundance of the product and of product processors, as well as an active State university and State departments of agriculture and commerce interested in marketing development and the development of new agricultural processes.

Our next step was to make personal visits to representative Iowa meat and poultry packers, processors, and distributors.

NUMEC PROPOSAL FOR PILOT PLANT MEAT IRRADIATOR

NUMEC prepared for us a special brochure on the meat irradiator program, a copy of which I have here. (See app. 9, p. 265.)

We asked these firms to study this brochure and to send representatives, as our guests, on a visit to Natick and Gloucester to learn about the present status of the irradiation program at first hand.

The first such visit was made on June 21 and 22. In addition to representatives of the Carroll Industrial Development Council, NUMEC, the Northern Natural Gas Co., Iowa Public Service Co., and the Des Moines Register and Tribune, we had officials of 11 packing, poultry, and supply firms on the tour.

A visit by a second group, of between 15 and 20, which was scheduled soon afterward but postponed because of the airline strike, is now rescheduled for September 22 and 23.

The results of our discussions to date are encouraging in a number of respects. Most of the meat and poultry people who made the first trip were enthusiastic about the ultimate potential of radioprocessing.

To the best of my knowledge, this is among the first expressions of concrete interest by a varied industry group in this area.

There was, however, considerable doubt as to when radioprocessing would become widespread. Most thought it would be a matter of 10 years or so.

Accordingly, the general attitude was that it would be premature to make an extensive financial commitment in an irradiator, but that a shared facility would be of interest, depending on developments in the FDA and USDA clearance of additional foods, and on the availability of a sufficient baseload of initial orders for the military.

A great part of the interest centered on radiopasteurization, rather than sterilization, of commercial meat products.

We recognize that the basic work necessary for approval of radiopasteurized meat products is yet to be done, and hope that provision will be made for such development work.

If our proposal for the pilot plant is successful, and if the pasteurization development work has not been completed by the time the irradiator is built, we would be particularly interested in having such work contracted to the pilot plant, where it could be carried out with widespread cooperation of Iowa industry and, I am sure, of Iowa educational institutions.

FDA APPROVAL AND LABELING REQUIREMENTS

In order to continue to develop interest among commercial processors, it would be very helpful if the pace at which additional food products are cleared for public consumption could be accelerated.

I realize, of course, that complex investigations and careful evaluation are essential for such clearance. To the extent, however, that the agencies concerned could be encouraged in the priority with which the clearances are expedited, a serious obstacle to the development of commercial interest would be overcome.

It would, similarly, be most desirable that labeling requirements not be designed to discourage the use of products which have been cleared for public consumption. When a gamma or electron processed product has been determined to be safe, I would hope that it could be labeled in such a way as to avoid suggesting that the food itself is radioactive.

I have found considerable concern among food people that the word "radiation" misleadingly suggests "radioactivity" to the layman, and I would hope that other ways could be devised to meet labeling requirements without giving rise to such misunderstandings.

In the meantime, our community remains intensely interested in having the first pilot plant irradiator located in Carroll, and we shall continue to work with the local meat and poultry people to assemble a group for this purpose when the terms of the baseload military procurement have been established.

In conclusion, I would like to express for the record the deep and favorable impression that we have received as to the dedication which has been brought to the food irradiation program by the personnel of the AEC, Army, Interior, and Commerce Departments and other agencies of the Government which have been concerned with the development of this process.

We in Iowa are just beginning to appreciate the long-term benefits to the public which can come about in the future because of the work which has been done in this area. We know that much of the credit for this work is due to the impetus brought to the program by this committee, and I believe that appreciation for this should be expressed to the committee on behalf of the public as a whole, as well as ourselves.

Thank you again for the opportunity of testifying before you today.

Representative PRICE. Thank you, Mr. Keith.

Since this is Iowa Day in the committee, the chairman recognizes the Senator from Iowa.

Senator HICKENLOOPER. Well, let us get out the flag and start marching.

BASELOAD REQUIREMENTS FOR MEAT IRRADIATOR

Mr. Keith, you are proposing to build a pilot plant in Carroll. What are the real requirements? You have to have money, and it has to run, it has to operate. Do you expect Government contracts, Government participation? What is that phase of the economics of this thing?

Mr. KEITH. Yes, Senator Hickenlooper, I believe at the outset of this particular irradiator there is going to have to be a baseload established by the various defense departments, by the Army and so forth.

What this baseload or procurement should be, or has to be, seems to be way up in the air.

Senator HICKENLOOPER. I know. You said that in your statement.

Do you expect that to be determined before you start building the plant, or before you put your money in it, or what is the proposal?

Mr. KEITH. I would say it would absolutely have to be determined

before we could begin the construction of the plant, not the construction of it, but before we could begin the assembling of the financing of it.

Senator HICKENLOOPER. When the baseload is determined—do you mean the baseload for the entire country, or the amount that the Army or the Federal Government or its agencies would be willing to contract for with the plant that you are constructing?

Mr. KEITH. It would be the latter, sir, the baseload that the Army or whatever Federal agency it might be would be willing to contract for, or give a letter of intent for, whatever the legal procedure would be.

Senator HICKENLOOPER. Are you planning that this plant will be devoted entirely to this, or would you expect that it would have to operate at capacity?

PILOT PLANT TO ENCOURAGE SMALL MEAT PACKERS; INDICATED INTEREST

Mr. KEITH. This is where we feel we have the answer to the program. Whatever the Government did not place a procurement or contract for, we would then have a group of some 20 to 30 meatpackers, processors, who would be able to do research in this pilot plant.

These are not large meatpackers. They are not large processors. They are small, medium-sized ones.

Sometimes I think the breakthrough for a new process, a new product, a new idea, does not always come from General Motors, but sometimes comes—well, as Senator Aiken said this morning, Mr. Birdseye was one we never heard of, yet he came up with a phenomenal way of marketing frozen foods.

This is why we feel this pilot plant should be available to everyone, so that maybe there is another "Mr. Birdseye" out in the Amana Co. in Iowa. Maybe all he is making is sausage today.

Senator HICKENLOOPER. They are making pretty good bacon.

Mr. KEITH. Right. Maybe he will be the one to come up with that one breakthrough, that one marketing idea that will put this thing on the road.

If we have 20 or 30 of them—in fact, the plant would be open to the whole United States, but we know that we have these people interested—we feel that the breakthrough would come through much quicker, and it would be competitive.

Senator HICKENLOOPER. Would you contemplate that eventually this irradiated food or product, whatever it might be, would be available for sale to the general public?

Mr. KEITH. I would say that one of these people is going to have enough initiative, have the idea to put on the market a product that will be irradiated. Otherwise, he would not be interested in putting some of his money in the pilot plant.

Senator HICKENLOOPER. As I understand it your program would be that the processors of the meat, that is, the original processors, the packers or others, would send the meat to this pilot plant to be irradiate. Is that correct?

Mr. KEITH. Yes, sir. It would be a custom or consortium type of plant.

Senator HICKENLOOPER. The Government would buy that from the original packer, and your plant would get a fee for the irradiation? Is that correct?

Mr. KEITH. Yes, sir.

Senator HICKENLOOPER. You say that there has been interest expressed by packers or processors. Have you had interest expressed by some of the larger packers, as well as the smaller one?

Mr. KEITH. I would like, if I may, to read the list of the ones who have expressed an interest. I would let you decide whether they are large or small.

Bookey Packing Co., Des Moines, Iowa; I. D. Packing Co., Des Moines, Iowa; Rich Foods, Inc., West Liberty, Iowa; the Elsheimeier Meat Products, West Union, Iowa; the Table Supply Meat, Inc., Omaha, Nebr.; Sioux Quality Packers, Inc., Sioux City, Iowa; Gus Glaser Meats, Fort Dodge, Iowa; Spencer Packing Co., Spencer, Iowa; Nissen and Sons Packing, Webster City, Iowa.

That was on the first trip. Our second trip includes:

Iowa Beef Packers, Denison, Iowa, and Dakota City, Nebr.; Amend Packing Co., Des Moines, Iowa; Amana Society Meat, Amana, Iowa; Needham Packing Co., Sioux City, Iowa; Stoller Fisheries, Spirit Lake, Iowa; Blue Star Foods, Council Bluffs, Iowa; Vilas and Co. Storm Lake, Iowa; Dubuque Packing Co., Dubuque, Iowa.

And that would be the second list.

Plus I have a letter from the Marshall Packing Co. of Marshalltown, Iowa. Blue Ribbon Packing Co., Mason City, Iowa.

Senator HICKENLOOPER. That would be the business really of the people who want to build this plant, from the standpoint of investment, but none of these really comes right down to put its name on the dotted line, has it?

Mr. KEITH. We have not. We have had a verbal expression that they would like to be stockholders in this pilot plant, and serve on the board of directors.

This is not from all of them, but from some of them.

Senator HICKENLOOPER. I take it the same thing is true of the people who are hoping to build this plant. It has not come to fruition yet, to the point of really selling stock, or getting the money put up.

Mr. KEITH. The NUMEC Company is the one that has proposed to build the plant. They would be owners, with it, along with the meat packers, and with the community of Carroll, Iowa.

CURRENT ECONOMICS IN SELLING MEAT—POSSIBLE REVERSAL

Senator HICKENLOOPER. What about the housewife and the consumer here, in connection with this operation?

Mr. KEITH. To me, Senator Hickenlooper, irradiation can open or turn about the retail or the marketing of fresh meat products. It is exactly the reverse now of all retailing.

Now the farmer takes his critter to the market, and he does not say, "I want so much for this critter." The packer says, "I will give you so much," and the packer goes to the retailer, and the packer does not say, "I want so much for this." The retailer says, "I will give you so much for this." The same way with the consumer.

So it has been a price situation all the way through.

I believe with irradiation, where you can give the housewife a quality control type of product, with a name brand on it, so that she can go in day in and day out and buy the same name brand and get the same quality, and be assured of it, because of the extensive shelf life, that you will then be doing her a great service.

She will be willing to pay for this service, the packer will be willing to pay the farmer more for his product, and this will maybe eliminate some of these large subsidies that Mr. Hosmer indicated the farmers were receiving.

Senator HICKENLOOPER. Of course there are two sides to that question, you know.

Mr. KEITH. But I do think it could reverse the situation to where meat could be actually promoted, and retailed like any other product, instead of always being a price item or a loss leader.

Senator HICKENLOOPER. Thank you very much.

Representative PRICE. Mr. Holifield.

Chairman HOLIFIELD. No questions.

Representative PRICE. Mr. Hosmer.

CARROLL DEVELOPMENT COUNCIL

Representative HOSMER. Mr. Keith, this Carroll Industrial Development Council, is that a kind of chamber of commerce outfit, or is it a city office, or what?

Mr. KEITH. It is a group of businessmen in the city of Carroll.

Representative HOSMER. Now, your objective is to get this processing pilot plant in your community? It that it?

Mr. KEITH. That is our selfish objective. We will be very happy if it ends up in Iowa.

Representative HOSMER. I think it is a good objective. It shows progress and foresight.

Mr. KEITH. Thank you.

METHOD OF FINANCING PILOT PLANT

Representative HOSMER. Now, to implement the objective, there is going to have to be some kind of corporation set up, I suppose, to build the plant.

Mr. KEITH. Yes. This would be NUMEC.

Representative HOSMER. You said the meat companies were going to be stockholders, and the city was going to be a stockholder, and NUMEC was going to be a stockholder. Let us get this clarified.

The city is not going to put up any money as a stockholder?

Mr. KEITH. The present plan is for a municipal bond issue to build the facility.

Representative HOSMER. Then you will lease the facility?

Mr. KEITH. We will lease the facility back to the corporation.

Representative HOSMER. Then NUMEC would form a new corporation along with the other stockholders that you mentioned?

Mr. KEITH. It has not been decided whether it would be a new corporation, or whether it would be a division of NUMEC.

Representative HOSMER. Then if it were, in either event, I presume there would have to be some contracts in addition to this Government

contract from the various meat producers of Iowa, in order to justify the building of the plant.

Mr. KEITH. The meat producers are going to be stockholders, so I would assume they would have good intentions of using their own facility.

Representative HOSMER. I would presume, myself, that it would go further than that. You would actually have to have some contracts in your hands to make it worthwhile.

Mr. KEITH. I would like to clarify, Congressman Hosmer, that we do not feel that this plant can be feasible without a sufficient baseload from the Army.

This baseload is going to have to be in the proportion of possibly a break-even point.

I am talking about possibly 75 to 80 percent of the actual production would have to be procured by the Army.

Representative HOSMER. You do not know when they are going to possibly put this out for bid, or anything?

Mr. KEITH. I have no idea. We have been told May, June, July, and now I don't know when.

Representative HOSMER. You are going to have to get your organization together so that you have a bidding entity, I suppose, rather rapidly.

Mr. KEITH. We have the entity together, sir. We are simply waiting for the proposal.

Representative HOSMER. Is NUMEC going to make the bid?

Mr. KEITH. The bid will be made by NUMEC; yes, sir.

Representative HOSMER. Thank you.

GOVERNMENT REQUEST FOR BIDS ON PILOT PLANT MEAT IRRADIATOR

Representative PRICE. Mr. Keith, the committee has long been interested in a pilot plant. Personally, I would hope that with the Joint AEC and the Department of the Army pilot plant, the baseload concept will move ahead without too much delay. I would like to see th AEC and Army go out for bids soon. (See apps. 14 and 15, pp. 326 and 339.)

These bids could be held up, of course, depending on the FDA approval. But if we wait for FDA approval before you go out with a proposal, that would result in considerable delay.

If you get the bids in on the proposal, at least they would be held in abeyance, but would be ready to move as soon as the FDA gave approval.

If there are no further questions, we will bring to a close our 1966 hearings on the food irradiation program.

Several reports have been requested, and the record will remain open for statements to be considered to be put into the printed record.

The subcommittee is now adjourned.

(Whereupon, at 4:30 p.m., Monday, September 12, 1966, the subcommittee adjourned.)

APPENDIXES

Appendix 1

Remarks on Food Irradiation by Representatives Price and Bates in Congressional Record, July 12, 1966

FOOD IRRADIATION PROGRAM

Mr. Price. Mr. Speaker, on several occasions in the past I and other members of the Joint Committee on Atomic Energy furnished to this body our views on the national food irradiation program. We have provided reports on progress in the program being made by both the Department of the Army in the sterilization of food by irradiation and by the AEC in its program which involves the pasteurization of food by the irradiation process.

In June of 1965 the Joint Committee on Atomic Energy Subcommittee on Research, Development, and Radiation, of which I am chairman, held hearings on the radiation processing of foods. During these hearings there was clear evidence that significant progress was being made on many of the items under study. It was noted, however, that the Food and Drug Administration up to that time had approved for public consumption only irradiated bacon, irradiated wheat products, and irradiated potatoes. This is still the case.

I have been concerned that the review and approvals of petitions by the Food and Drug Administration has not kept pace with the development work. Please understand that I recognize the need for careful study to insure that the product that is being approved is highly nutritious, palatable, and will have no untoward side effects an ony segment of our population. I was concerned that an apparent delay in the handling of petitions might have been in part attributable to a lack of appreciation of the work that has been done and of the potential benefits that can result from the adoption of this new technique for the preservation of certain food products. I expressed this concern in a letter dated June 2, 1966, to Chairman Seaborg of the Atomic Energy Commission. He has responded in a letter dated June 17, 1966. Mr. Speaker, I would like to make copies of these letters a part of the Record.

I am very much encouraged by Dr. Seaborg's response and I am hopeful that his enthusiasm will be reflected throughout both the developmental and the regulatory programs. I do not think we should delude ourselves by assuming that in this day and age a program can always succeed on the basis of its own merit. Programs that are small in terms of dollars or expenditure of scientific manpower run the risk of being overlooked. There is a continual struggle for the research dollar. There is the competition for the time and attention of top management. In the Army and in the AEC as well, items that directly affect the national security are given the highest priority. I believe that it is at times necessary to draw special attention to programs that, though they be relatively small in magnitude, are well conceived, well executed, and hold promise of widespread application. They can represent the dedicated efforts of competent scientists and may well hold the promise of great benefit to mankind. This food preservation program is, in my mind, such a program.

I have taken personal interest in both the AEC's and Army's food irradiation program because I believe they are worthwhile programs and should go forward. It is, of course, an ultimate goal that private industry will take over the main effort of this program when a commercial application can be identified and the necessary approvals have been received. During the aforementioned hearings by the Joint Committee a number of representatives of private industry told of their interest in the program and their hopes for commercial application in the future. The Department of Commerce, the Atomic Energy Commission, and the Department of Army have been holding discussions with private industry

in an attempt to find the necessary support so that a cooperative Government-private industry food irradiation plant can be designed, constructed and operated. The Government would plan to make a significant contribution to the initial costs of this plant. In addition it would guarantee a certain throughput so that, in effect, during the early years of this first-of-a-kind plant the operating costs of the plant would be shared.

I have been informed that discussions with the principal meatpackers of this country have made it clear that the amount of meat products proposed to be purchased by the Government was not considered sufficient by industry representatives. They believe that in order for an agreement to be reached the Government should offer to take a larger portion of the plant's output. There is some indication that some of the Government participants are not yet convinced of the desirability of increasing the Government's commitments during initial years of operation for the purpose of assuring that the project will get underway.

I should say that the intent here is to get a plant into operation for the purpose of learning the problems and techniques associated with the operation of a food irradiation facility of this type. It is all very well to do research on food products where the volumes are low and each package of food is, in effect, handled by a technician in a very special way. We have proceeded beyond that stage, and we are now ready on a number of products to have trained but non-technical personnel handle large volumes of meat products in a manner similar to that used in the meatpacking industry. The Army, I understand, is prepared to use fairly large quantities of irradiated meat products in order to get additional information on acceptability for inclusion in the diet of our fighting men.

A year or more will be required for the design and construction of this proposed plant. As I indicated earlier, the Food and Drug Administration has already approved public consumption of irradiated bacon, and I have been informed that the Army yesterday has fully documented and submitted to the Food and Drug Administration a petition for the approval of irradiated ham. I think it is important that the construction of facilities for the food irradiation program proceed on an orderly schedule so that when the facilities are needed they are available and can be put to use. I think it is equally important that at as early a stage as possible we bring private industry into this program, because it is clear that the know-how of industry is a necessary ingredient for a successful overall program.

Therefore, I would like to again say that I shall encourage the Army and other Government agencies involved to make every effort to reach an agreement with those representatives of private industry who recognizes the potential of this program and are willing to commit some of their own funds for the building and operation of facilities because of the possible long-range benefits and profits which may accrue.

The letters mentioned before follow:

JOINT COMMITTEE ON ATOMIC ENERGY,
CONGRESS OF THE UNITED STATES,
June 2, 1966.

HON. GLENN T. SEABORG,
Chairman, U.S. Atomic Energy Commission,
Washington, D.C.

DEAR MR. SEABORG: As you know, the Atomic Energy Commission's research and development program is exceedingly broad in scope and includes a wide range of projects extending from those vital to the common defense and security of this country, to those which might be described as incidental benefits deriving from peaceful uses of atomic energy. With such a broad program involving many scientific disciplines, it is understandably difficult for the Commissioners to find the time to give detailed attention to what might be described as major development projects; let alone time for close study and management of the smaller programs.

I am writing because of a continuing interest that I have had in the AEC's Food Irradiation Program, a program which is small in terms of funds and scientific manpower in relation to many other Commission efforts. I believe, however, that the program has far-reaching significance in terms of the benefits which it holds out for mankind. We are living in a time when world food supplies are inadequate to meet the demands of the present population. Predictions for the future envision even a more dismal picture than the present

one. A large fraction of the world's food supplies is continuously being lost through bacterial spoilage as the result of improper or inadequate refrigeration. In addition, large quantities of vital grain products are ruined by insect infestation.

Radiation processing of food has demonstrated its capability to sterilize, pasteurize, and disinfect food products effectively. A great deal of scientific data concerning this program have been gathered, and for the most part they are favorable. As an example of a feasible application of radiation processing to a food product, it has been demonstrated that radiation treatment of poultry and poultry products is an effective means of preventing the spread of salmonella infection. The significance of preventing the spread of this infection was highlighted by President Johnson in the January 1966 Economic Report of the President as follows:

"Foodborne diseases are being increasingly recognized as a leading cause of acute sickness in this country and probably account for more illness than all other environmental elements combined. Salmonellosis—the most serious such disease—now is much more widespread than it was 15 years ago because of inadequate controls in new methods of food production and processing."

As you know, to date, the Food and Drug Administration has approved for general consumption only irradiated bacon, grain products, and potatoes. Other petitions for irradiated foods have been before the FDA for some time, and an increasing number are in preparation for submission in the near future.

As I have already indicated I have taken a personal interest in the Food Irradiation Program throughout the years, and a similar concern had been displayed by other members of the Joint Committee. I am disappointed that I have not seen evidence of an equally strong interest in this program on the part of the Commission. In my opinion, if you as Chairman of the AEC, were to display such an interest this would have a salutary impact, particularly with respect to encouraging the prompt, as well as thorough, review of petitions submitted for radiation processed foods.

I was very pleased—and I am sure that you were too—to see the invigorating effect on the Food Irradiation Program that resulted from the Food and Drug Administration's approval, in the spring of 1963, of irradiated bacon for consumption by the general public. I am growing concerned that we may have lost the momentum which resulted from this approval, and the subsequent favorable action on grain products and potatoes. Accordingly, I urge that you devote special attention to the needs of this program in order to help assure that the pace of progress, as measured by FDA clearance of specific petitions, be commensurate with the rate of accumulation of scientific data in this new and promising field.

I would appreciate receiving any comments you may have on the views which I have expressed.

Sincerely yours,

MELVIN PRICE,
Chairman, Subcommittee on Research, Development and Radiation.

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., June 17, 1966.

Hon. MELVIN PRICE,
Chairman, Subcommittee on Research, Development and Radiation, Joint Committee on Atomic Energy, Congress of the United States.

DEAR MEL: I am sympathetic to the views you have expressed on the AEC's Radiation Preservation of Foods Program, and I know that the other Commissioners join me in assuring you of our enthusiasm for this promising new technology. We have every intention of continuing to support the program vigorously. In fact, I and my colleagues have stated publicly on several occasions that we look forward to the time when the benefits of this process will become available to the consumer throughout the world. Yet, we recognize the complexities our scientists face in proving beyond reasonable doubt that radiation processing of foods does not adversely effect their quality and wholesomeness.

Procedures for obtaining clearances to permit unlimited public consumption of radiation-processed foods are both laborious and expensive to carry out, particularly because each class of food product is considered independently of

other classes. Thus each petition for clearance represents a new approach usually without precedent. Our concern over this protracted matter resulted in an intensive review of the status of the program about a year ago, prior to the hearings held on the same subject by the Joint Committee. Since that time we have had occasion to review the program specifically again as part of our general review of the AEC's budget submittal to Congress. For planning purposes, we have authorized extension of the program beyond FY 1967, subject to approval by the Bureau of the Budget and Congress. We fully appreciate the situation where the exhaustive detail required to assure process efficacy and wholesomeness could not have been anticipated in the earlier years, since no ground rules for the granting of clearances had been laid down at the inception of the program. In fact, the ground rules continue to change as we progress with the technology.

More recently—in fact, two weeks ago—the Commission began making arrangements to meet with Commissioner James Goddard of the Food and Drug Administration to discuss the objectives of the AEC program and then to explore with him any means by which the granting of clearances for irradiated foods could be expedited. This is not a matter of academic interest on our part. We know that many food processors are interested in one or more facets of the program and will not commit themselves further until the clearances are obtained. At this juncture, we are unable to anticipate the outcome of the meeting with Commissioner Goddard. I will be happy to advise you of the outcome.

From the operational side, several important advances have been made recently: (1) our large mobile irradiator has been delivered to California and will soon be in operation there, processing field crops in cooperation with the farming industry; (2) ground breaking for the large Hawaii Development Irradiator is planned for July 18; (3) a solicitation of proposals for a contract to operate our fourth portable food irradiator has been made, and upon completion of the irradiator in October, it will be put into service on a cooperative basis with several industrial firms in succession. One or more of these are particularly interested in the control of Salmonellae—a point mentioned in your letter; (4) the world's first grain irradiator will be put into operation this summer, at Savannah, Georgia, and will be made available to the grain and flour industry; (5) the petition to FDA for clearance of strawberries was submitted in April.

In still another direction, our study on the cost-benefit relationships of selected parts of the food program is progressing well, and we expect that our contractor will soon be able to begin the consumer attitude survey which is in an integral part of the study.

In general, the program is progressing according to plan, and the granting of more clearances would be a most timely reward for the efforts that have been expended by you, the Joint Committee, the AEC, and its contractors.

Let me say in conclusion that your letter is a further stimulus to us to accomplish our objectives in the most expeditious manner possible and that your continued support of the Radiation Preservation of Foods Program will be welcomed wholeheartedly.

Cordially,

GLENN,
Chairman.

(Mr. BATES (at the request of Mr. PRICE) was given permission to extend his remarks at this point in the RECORD and to include extraneous matter.)

Mr. BATES. Mr. Speaker, I rise to express my strong endorsement of the statement made by my colleague, the gentleman from Illinois, Congressman PRICE. We on the Joint Committee on Atomic Energy have from the inception of the program followed closely the research and development progress on the use of ionizing radiation as a means of preserving food products.

A large portion of this program is carried out in my home State of Massachusetts. In Gloucester, at the Marine Products Development Irradiator, designed and constructed by the Atomic Energy Commission, the Bureau of Commercial Fisheries is carrying out a program on the radiation preservation of marine products. There, at the Development Irradiator, large quantities of fresh fish fillets and similar marine products are packaged and irradiated in order that we may study at near commercial scale this new technique of food preservation. I am happy to say that the work is progressing satisfactorily and there is every indication that this new means of preservation will have widespread application for fishery products.

It has been shown that the use of irradiation as a pasteurization technique permits substantial increase in the shelf life of these products without undesirable side effects. It will be possible therefore to reach wider markets, including the Midwest and other portions of our Nation not accustomed to a plentiful supply of fresh seafood.

In another part of Massachusetts, at Natick, the principal portion of the Army's food irradiation program is being carried out. The emphasis in the Army's program is on the sterilization of food products. The research has shown that bacon—already approved by the Food and Drug Administration—ham, beef, and other products, respond favorably to the irradiation process and we are hopeful that in the near future a number of these products will be available for use in our Armed Forces. In addition, there is promise of commercial application for the process.

I have mentioned the work at Natick and at Gloucester. In addition, the Atomic Energy Commission is supporting research at universities and research institutes in the preservation of fruits and vegetables by pasteurizing doses of irradiation. Certain of these products have been shown to respond favorably to radiation treatment.

The process also has application in disinfestation of fruits and may open up special markets. For example, fruits grown in Hawaii and treated by this process may some day be imported to the mainland in large quantities.

There are a number of experimental facilities that are in operation as a part of the national food irradiation program. We have reached the stage of development where larger facilities are needed, those which would more closely approximate the size which could be utilized in industry. Preliminary meetings have been held between Government representatives and representatives of the meat packing industry. There has been tentative agreement on the size and scope of activities and a sharing of costs for a pilot plant meat irradiator.

As my colleague has said, it is very important that work of this sort go forward and I am very hopeful that agreement can soon be reached, that commitments can be met, and that the special knowledge and expertise of private industry can be brought to bear on this program.

Throughout the years I have spoken out on the merits of the food irradiation program. This is in part because of special interest I have taken in the program and in part because I share the view that programs small in terms of dollar amounts and technical manpower may be brushed aside in our rush to achieve progress in other fields such as national defense, space, high energy physics, and so forth. I have on a number of occasions visited the research laboratories involved in the food irradiation program. I have talked to the scientists and engineers and I am convinced that the program is a good one with reasonable short-term and long-term objectives and having the merit of achieving goals which can be important both to our military program and ultimately for the benefit of mankind. We must find a way to deal with the tremendous spoilage that occurs in foodstuffs throughout the world. People are often concerned over the shortage of food which occurs in many nations. This is only in part caused by underproduction. We must not overlook the fact that a sizable fraction of what is produced is never available for distribution to the consumer.

I do not wish to be misunderstood. I am not saying that irradiation of food is a panacea; it will not solve all of our problems. It must compete with the other techniques of food preservation already developed and it must be able to pay its own way in the marketplace. Again, however, I urge that this work be allowed to continue at an appropriate level so that the worth of this new technique can be properly assessed.

Appendix 2

Status of Irradiated Food Petitions to U.S. Food and Drug Administration, U.S. Department of Agriculture, July 1966

Foreword

This is a status report on irradiated food petitions to Federal regulatory agencies from the U.S. Army Natick Laboratories, U.S. Atomic Energy Commission (AEC) and others. It lists those items which have been approved and which are pending approval by the Food and Drug Administration (FDA) and by the

Technical Services Division (formerly the Meat Inspection and Poultry Inspection Divisions) of the U.S. Department of Agriculture (USDA). It also shows items which are scheduled to be submitted to these agencies for approvals.

The FDA regulates radiation processed foods under the Food Additives Amendment of 1958 to the Food, Drug, and Cosmetic Act. To conform with the regulations, a petition for approval to irradiate a food must be submitted to FDA. The petition must contain detailed evidence that the irradiated food is safe for human consumption, the desired effect is accomplished, the radiation dose is no higher than needed, no measurable induced radiation is present, and the process is safe and efficacious under simulated commercial conditions with no significant adverse effects on flavor, odor, texture, or appearance.

Irradiated meat and poultry products shipped in interstate or foreign commerce must also be approved by USDA under the Federal Meat Inspection Act and the Poultry Products Inspection Act of 1957. Requests to USDA for approvals of irradiated meats and poultry must include data similar to that submitted to FDA on wholesomeness, microbiological safety, absence of toxicity, nutritional adequacy, processing control, labeling, and benefits. In effect, identical petitions can be submitted to both Governmental agencies.

Acknowledgment is made to Dr. E. S. Josephson, U.S. Army Natick Laboratories, and Dr. Kevin G. Shea, Division of Isotopes Development, AEC, for their contribution to the data in this report.

This report was prepared by Jerome Deitch under the direction of Jack W. Osburn, Jr., Food Industries Division.

FORREST D. HOCKERSMITH,
Acting Administrator, Business and Defense Services Administration.

TABLE 1.—*Irradiated foods and packaging materials approved by the Food and Drug Administration*

Products	Purpose of irradiation	Petitioner	Radiation source	Dose range (megarad)	Notice of FDA filing; date published in Federal Register	FDA approval; date published in Federal Register	Food additive petition (FAP) No.	Code of Federal Regulations (CFR)
Bacon	Sterilization	Army	Cobalt 60	4.5 to 5.6	Aug. 17, 1962	Feb. 15, 1963	3M890	121.3002
		General Electric Co.[1]	Electron beam, 5 Mev.	4.5 to 5.6	June 5, 1963	Aug. 30, 1963	3M1139	121.3004
		Army	Electron beam, 10 Mev.	4.5 to 5.6	Aug. 23, 1963	Apr. 21, 1965	4M1205	121.3004
		AEC [1]	Cesium 137	4.5 to 5.6	Nov. 5, 1963	Apr. 1, 1964	4M1226	121.3002
		Radiation Dynamics, Inc.[1]	X-rays from electron beam, 5 Mev.	4.5 to 5.6	July 23, 1964	Dec. 19, 1964	4M1433	121.3005
Wheat and wheat flour [2]	Insect deinfestation	Brownell, Horne, Kretlow.[1 3]	Cobalt 60	0.02 to 0.05	Oct. 4, 1962	Aug. 21, 1963	3M941	121.3003
		AEC [1]	Cesium 137	0.02 to 0.05	Sept. 1, 1964	Oct. 10, 1964	5M1509	121.3003
		High voltage engineering.[1]	Electron beam, 5 Mev.	0.02 to 0.05	Dec. 18, 1963	Feb. 26, 1966	4M1276	121.3003
White potatoes	Sprout inhibition	Army	Cobalt 60	0.005 to 0.010	June 6, 1963	July 8, 1964	3M1132	121.3003
		AEC [1]	Cesium 137	0.005 to 0.010	Sept. 1, 1964	Oct. 10, 1964	5M1509	121.3003
		Army	Cobalt 60 and cesium 137.	0.005 to 0.015	Jan. 30, 1965	Nov. 9, 1965	5M1644	121.3003
Packaging materials [4]	Food contactants for use with prepackaged foods.	AEC	Cobalt 60 and cesium 137.	1.0 maximum	Feb. 8, 1964	Aug. 14, 1964	4M1297	121.2543
Vegetable parchment paper	Food contactant for use with prepackaged food.	Army	Cobalt 60 and cesium 137.					121.2543
			X-rays from electron beam, 5 Mev.	6.0 maximum	Jan. 15, 1965	Mar. 12, 1965	5M1622	121.3002 121.3005

[1] U.S. Army Natick Laboratories, Food Division, contributed the major portion of data submitted.

[2] FDA ruled that "wheat and wheat products" is too broad and indefinite and that that the existing regulation be restricted to "wheat and wheat flour"—Federal Register, Mar. 4, 1966.

[3] Dr. L. E. Brownell, University of Michigan; Mr. T. Horne, Curtiss-Wright Co.; Mr. W. J. Kretlow, University of Michigan.

[4] 9 classes of materials: (1) nitrocellulose-coated or vinylidene chloride copolymer-coated cellophane (as amended F.R. June 11, 1965; FAP-5B1670); (2) glassine paper; (3) wax-coated paperboard; (4) polypropylene film; (5) ethylene-alkene-1 copolymer film; (6) polyethylene film; (7) polystyrene film; (8) rubber hydrochloride film; (9) vinylidene chloride-vinyl chloride copolymer film.

NOTE.—Mev=1,000,000 electron volts.

TABLE 2.—*Irradiated foods and packaging materials pending approval by Food and Drug Administration*

Product	Purpose of irradiation	Radiation source	Dose range (megarad)	Petitioner	Notice of FDA filing; date published in Federal Register	Food additive petition (FAP) No.
Oranges	Reduce spoilage, shelf-life extension.	Cobalt 60 and cesium 137	0.075 to 0.20	Joint AEC/Army	Dec. 18, 1963 [1]	4M1233
Packaging materials [2]	Food contactants for use with prepackaged foods.	do	6 maximum	Army	July 21, 1965	5M1645
Do [3]	do	do	1 maximum	AEC	July 30, 1965	5B1674
Nylon film	do	do	do	do	Sept. 8, 1965	6M1820
Dehydrated vegetables	Soften and reduce cooking time	Gamma or electron emitters	0.3 to 4	Thomas J. Lipton, Inc.	[4]	6M1833
Fish [5]	Shelf-life extension	Cobalt 60, cesium 137, electrons (10 Mev), and X-rays from electron beam (5 Mev).	0.10 to 0.20	Joint AEC/Army	Sept. 15, 1965	6M1815
Strawberries	Reduce spoilage, shelf-life extension.	Cobalt 60 and cesium 137	0.10 to 0.25	AEC	May 18, 1966	6M2024
Ham	Sterilization	do	3.5 to 5.6	Army	Submitted July 11, 1966.	

[1] The original petition submitted included oranges and lemons. A substantive amendment deleting lemons was submitted which FDA gave a new filing date of May 17, 1965. Another substantive amendment was filed Oct. 18, 1965. The petition is now awaiting additional information from AEC.

[2] 4 classes of plastic materials: Polyethylene; polyethylene terephthalate; vinyl chloride-vinyl acetate copolymers; nylon 6 resins complying with specifications prescribed in the table in 121.2502(b), item 6.1.

[3] Includes 2 groups of plastic materials: (1) Vinylidene chloride copolymer-coated or polyethylene-coated polyethylene terephthalate film; (2) vinylidene chloride copolymer-coated polypropylene film.

[4] Original submission of Aug. 2, 1965, and resubmissions of Aug. 27 and Nov. 16, 1965, have been turned down. FDA has requested additional information which the company has indicated it will submit.

[5] Fillet of haddock, codfish, sole, flounder, pollock, and ocean perch.

TABLE 3.—*Schedule for proposed irradiated food petition submissions to the Food and Drug Administration*

Product	Purpose	Petitioner
Proposed submission August 1966:		
Pork	Sterilization	Army.
Proposed submission during fiscal year ending June 30, 1967:		
Onions	Sprout inhibition	AEC.
Proposed submission during fiscal year ending June 30, 1968:		
Chicken	Sterilization	Army.
Beef	do	Do.
Shrimp	do	Do.
Corned beef	do	Do.
Hamburger	do	Do.
Pork sausage	do	Do.
Codfish cakes	do	Do.
Clams	Shelf-life extension	Joint Army/AEC.
Crab	do	Do.
Shrimp	do	Do.
Chicken	Shelf-life extension and salmonellae control.	Do.[1]
Papayas	Deinfestation and shelf-life extension	AEC.
Mangoes	Deinfestation	Do.
Proposed submission during fiscal year ending June 30, 1969:		
Turkey	Sterilization	Army.
Frankfurters	do	Do.
Barbecued beef, chicken, and pork	do	Do.
Bananas	Delayed maturation	AEC.
Figs	Deinfestation	Do.
Oysters	Shelf-life extension	Joint Army/AEC.
Proposed submission during fiscal year ending June 30, 1970:		
Luncheon meats	Sterilization	Army.
Lamb	do	Do.
Salmon cakes	do	Do.
Baked fish	do	Do.
Duck	do	Do.
Fresh water fish	Shelf-life extension	Joint Army/AEC.
Sweet cherries	Reduce spoilage	AEC.
Prunes	do	Joint Army/AEC.
Nectarines	do	Do.
Apricots	do	Do.
Halibut	Shelf-life extension	Do.
Hake	do	Do.

[1] Data being accumulated through the collaboration of the U.S. Army Natick Laboratories, U.S. Atomic Energy Commission, and the Atomic Energy of Canada, Ltd.

TABLE 4.—*Irradiated foods approved by the U.S. Department of Agriculture*

Products	Purpose of irradiation	Petitioner	Radiation source	Dose range (megarad)
Bacon	Sterilization	Army	Cobalt 60,[1] cesium 137,[1] X-ray from electron beam–5 Mev.[2]	4.5 to 5.6

TABLE 5.—*Irradiated foods pending approval by U.S. Department of Agriculture*

Products	Purpose of irradiation	Petitioner	Radiation source	Dose range (megarad)
Ham	Sterilization	Army	Cobalt 60, cesium 137	3.5 to 5.6.

[1] Federal Register, Nov. 26, 1964.
[2] Federal Register, Nov. 27, 1965.

TABLE 6.—*Schedule for proposed irradiated meat and poultry petition submissions to the U.S. Department of Agriculture*

Product	Purpose	Petitioner
Proposed submission, August 1966: Pork.	Sterilization	Army.
Proposed submission during fiscal year ending June 1968:		
Beef	do	Do.
Chicken	do	Do.
Corned beef	do	Do.
Hamburger	do	Do.
Pork sausage	do	Do.
Chicken	Shelf-life extension and salmonellae control.	Joint Army/AEC.[1]
Proposed submission during fiscal year ending June 30, 1969:		
Turkey	Sterilization	Army.
Frankfurters	do	Do.
Barbecued beef, chicken, and pork	do	Do.
Proposed submission during fiscal year ending June 30, 1970:		
Luncheon meats	do	Do.
Lamb	do	Do.
Duck	do	Do.

[1] Data being accumulated through the collaboration of the U.S. Army Natick Laboratories, U.S. Atomic Energy Commission, and the Atomic Energy of Canada, Ltd.

APPENDIX 3

RADIOPASTEURIZATION OF FOODS—TECHNOLOGICAL STATEMENT OF L. J. RONSIVALLI

BUREAU OF COMMERCIAL FISHERIES,
TECHNOLOGICAL LABORATORY,
Gloucester, Mass., September 9, 1966.

Introduction

One of the missions of each of three of the Technological Laboratories of the Bureau of Commercial Fisheries (BCF) has been to investigate the important aspects of the feasibility of radiopasteurizing the economically important fisheries of the United States. This work, supported and coordinated by the U.S. Atomic Energy Commission (AEC), is part of a nationwide effort which includes private industry, universities, and other agencies.

It is well established that different species of fish in general require individual study because of inherent physical and chemical differences. The concept of parallel studies at different research institutions working on different species thus has yielded a maximum amount of information in a minimum of time.

The accomplishments, now a matter of record, were ably described by Joseph Slavin of the BCF in his testimony before this body in June of 1965.

I would like to take this opportunity to bring you up to date on the accomplishments made since last year. Although I report on the Gloucester Technological Laboratory, I wish to assure you that equally productive work has been conducted at the other laboratories of the BCF.

We have always considered that the definition of feasibility is a comprehensive one, and as this testimony unfolds, I hope to create this impression. I am going to try to present our work according to the outline described by Director Fowler of the AEC, Division of Isotopes Development, during his testimony at the 1965 Hearings.

Studies to determine optimum dose

Over the past year, we have established that blue crab meat and scallops are extremely amenable to preservation by radiation at levels of 250–450 kilorads. Irradiated blue crab compared well with heat-pasteurized blue crab, both products having an unusual shelf life of at least six months at 33°F. Scallops appear to tolerate as much as 1 megarad.

Microbiology and applied chemistry studies

Microbiological data obtained over this period continues to show that when we irradiate fish fillets at 0.15–0.25 megarads we destroy about 99–99.9% of the bacteria. This is the essence of the application of irradiation as a preservative. By coincidence, if you look into the literature, you will find that about the same degree of bacterial destruction takes place in the heat pasteurization of milk. Thus, while we apply two different energies to two different foods, the overall results are the same since bacteria are responsible for spoilage of both these foods.

The role of bacteria in fish spoilage is well documented, and in our applied chemistry studies we are finding evidence to further support this. We are concerned here with specific organoleptic effects which might be attributable to bacteria as well as to processing variables, and we find, for example, that only minimal amounts of volatile compounds are present in sterile fish.

Study to determine the effect of preirradiation quality on postirradiation quality and shelf life

Since by the 1958 Delaney Amendment to the Food and Drug Administration (FDA) regulations, irradiation is defined as a food additive, it is incumbent upon us to show the applicability and commercial usefulness of the process. Essentially we need to show that nearly all, if not all, the presently marketable fresh fish can be irradiated to advantage. The fact of the matter is that while radiation does not enhance the product quality, it definitely prolongs its shelf life, no matter how old the fish is. Over the past year, we showed that clam meats can be irradiated to advantage even after they have been shucked for as long as seven days.

Packaging studies

During this period, we completed a study to determine the suitability of plastic films for packaging radiopasteurized fish. We obtained evidence to show that nearly every FDA-approved film was suitable. Although plastic films are not as reliable as metal cans, we nevertheless obtained good results with a large percentage of our packs. The product shelf life of pasteurized fish is, however, inversely related to the gas permeability of the container since many spoilage organisms which survive the pasteurization process are aerobic. Thus, with polyvinylidene chloride, polyester, aluminum laminates, and other gas barrier films, the product shelf life was longer than with gas-permeable films like polyethylene, polypropylene, and others. It was during this work that we became curious about the changes which take place within a hermetically sealed container with special concern for the oxygen concentration. By actual experimentation, we found that this value was reduced from the initial amount in air which is $\sim$ 21% to $\sim$ 1% within 30 days. Recognizing the implication of the role of oxygen in fish spoilage, we undertook cooperative experiments with Massachusetts Institute of Technology (M.I.T.) bacteriologists to study the effects of hermetic sealing on the microflora in radiopasteurized fish. The experimental results proved that a significant change in oxygen level does, in fact, alter the microflora composition. During this study, we found, as did other experimenters, that low levels of irradiation also created drastic changes in the composition of the microflora.

Bulk-packed experiments

Until this year, we normally packed all samples in individual containers to minimize experimental variables. However, it became necessary to advance the packaging to bulk-sized containers since much of the fresh fish of this area is shipped in 10-, 20-, and 30-pound fillet tins. The results of these tests, while not exactly the same as those obtained in small containers, nevertheless showed the distinct advantage of radiation to preserve fish. Fillets irradiated and stored in bulk form were evaluated by U.S. Army troops at Fort Lee, Virginia, and these products were found as acceptable as were the fresh frozen control samples.

Marine products development irradiator (MPDI) studies

The new MPDI facility was used to scale up the processing and distribution of radiopasteurized fish. Actual temperature studies to check present commercial handling methods from points of landing to points of consumption, as

far as 1500 miles apart, indicated the present fresh fish handling methods are excellent from a temperature standpoint. Certainly there need be no drastic change for handling irradiated fish. Actual distribution experiments using Interstate Commerce Commission regulated common carriers indicated that radiopasteurized fillets had a shelf life of ten or more days in excess of the shelf life of nonirradiated fillets which were sent in the same shipment. Many of the experiments were carried out in cooperation with personnel of many national food chains. Irradiated fish were compared by company personnel and thus far their comments corroborated our laboratory findings.

Shipboard irradiator studies

The important role of bacteria and their enzymes in fish spoilage was further illustrated in recent simulated shipboard irradiation experiments where live fish taken from a laboratory holding tank were slaughtered and immediately packaged and irradiated at the MPDI. In this case, the fish flesh was sterile and free from bacterial enzymes. The organoleptic results indicated the samples were superior to those which had been held for a day or more between the time of slaughter and the time of packaging and irradiation. The shipboard irradiator discussed at last year's meetings is now a reality sitting in the hold of the BCF Research Ship M. V. *DELAWARE*. Initial trial runs were performed, and from the standpoint of performance and safety, the irradiator is a testimonial to the ingenuity and capabilities of our colleagues at Brookhaven National Laboratories and at Nuclear Materials and Equipment Corporation. Our schedule calls for further irradiation at sea during this month and in the following two months, and we are hopeful that meaningful data should be accumulated within the next several months.

Unscheduled research

In addition to carrying out our scheduled developmental studies, we have cooperated with other researchers in a nationwide attempt to resolve the question as to whether there is a botulism hazard with radiopasteurized foods. For some time now, we have been engaged in a study which we feel will contribute in large measure to resolve this question. Our role in this vital program is to determine the absolute maximum shelf life of nonirradiated fish and fish irradiated at different pasteurization levels. At the same time, cooperating microbiologists will determine minimum toxin outbreak times for similarly treated samples and a comparison of both data will yield meaningful information. Our results thus far for haddock fillets irradiated at 0.2 megarad indicate absolute maximum shelf life times of 10, 12, 21, and 55 days at storage temperatures of 60, 55, 46, and 40°F., respectively. It must be remembered that these unusually long shelf life times at this and other dose levels (0, 0.05, 0.1 megarads) are obtained by our definition of maximum shelf life which is the unanimous rejection of samples by a trained panel (about eight members), a mixed panel (about 20 members), and a consumer-type panel (about 10–20 members). When rejected, the products are in advanced stages of spoilage (e.g., putrid, ammoniacal, etc.).

Appendix 4

Radiopasteurization of Fish

Status of Research and Developmental Studies on Radiation Pasteurization of Fish and Shellfish in the United States

(By Joseph W. Slavin, Louis J. Ronsivalli, and Thomas J. Conners, U.S. Bureau of Commercial Fisheries Technological Laboratory, Gloucester, Massachusetts)

I. Introduction

The U.S. Atomic Energy Commission's program on radiopasteurization of fish and shellfish formally began in 1960 with a feasibility study by Proctor *et al.* [1] followed by specific outlines of project proposals dealing with wholesomeness, quality, and economics by Nickerson *et al.* [2].

Proceedings of the International Conference on Radiation Preservation of Foods [3] and the report of the U.S. Congressional Subcommittee on Atomic Energy [4] provide a comprehensive review of progress in the U.S. food irradia-

tion program, including seafoods, up to June 1965. Recently these reports were supplemented by other reviews on radiation pasteurization of fish and shellfish [5, 6, 7].

Since these are rather complete reviews, we will limit our discussions to an evaluation of technical progress and development toward commercialization of radiopasteurized seafoods.

II. QUALITY CONSIDERATIONS

A summary of recent data on 19 radiation-pasteurized fish and shellfish is contained in Table I. Although the literature is replete with information attesting to the effectiveness of low levels of gamma radiation for the preservation of seafood, only limited data are available to permit a penetrating analysis of the factors that influence the quality and shelf life of the product. In this section we will discuss quality changes in irradiated fish and shellfish and attempt to analyze some of the factors affecting quality.

Quality Changes in Radiation-Pasteurized Fish

Information presented in Table II shows that the microbial flora of certain species of fish and shellfish is influenced by radiation level, processing method, packaging, and temperature of storage. When aerobically packed dover sole fillets were subjected to doses of 0.1 megarad to 0.3 megarad and stored at 43° F, pseudomonad species were eliminated and achromobacter species predominated at spoilage [8]. According to other researchers [9, 10, 11, 12], pseudomonads grew back in irradiated haddock and flounder fillets held at 33–43° F. The spoilage flora of aerobically packed irradiated dover sole consisted of achromobacter and yeasts, whereas the vacuum-packed irradiated samples contained mainly lactic acid bacteria [12]. Interestingly enough, radiation induced changes in microbial flora of clam meats were different from those in haddock fillets [11]. Changes in microbial flora as a result of irradiation are no more spectacular than changes resulting from other environmental factors such as temperature, gas composition, salts, etc. Although total plate counts are reduced with increased radiation dose (Figure 1), they achieve a higher level than in nonirradiated fish at the end of the product shelf life. Ratios of total plate counts (TPC) for a given quality level (Q) at the end of the product shelf life have been calculated from some recent studies and are reported in Table III. Indications are that TPC/Q for irradiated fish is several to 100 times greater than it is for nonirradiated fish. This might indicate that the bacteria remaining after irradiation are not as active biochemically as those normally found in fresh fish, thus greater numbers of surviving bacteria are needed to produce the same effect as a small amount of the more potent spoilage bacteria.

Goldblith and Nickerson [13] reported that air-packed haddock fillets irradiated at 0.15 and 0.35 megarad and held at temperatures of 33–45° have a putrid ammoniacal oder when total plate counts approximate 1×10^8 per gram. Dassow and Miyauchi [14] reported that vacuum-packed king crab meat irradiated at 0.2 megarad was of unacceptable quality when total plate counts approximated this same level. An assessment of organoleptic quality of irradiated and nonirradiated cod fillets stored at different temperatures (Table IV) shows that in samples irradiated at a dose level of 0.15 megarad spoilage manifestations are somewhat similar to those of the non-irradiated product. It is thus evident that the type as well as rate of quality change in the irradiated product can be controlled by dose level to produce organoleptic indicators of spoilage as recognizable as those in the nonirradiated product. This is illustrated in Figure 2. Note that as the dose level decreases the rates of quality loss for vacuum-packed products approaches that of the aerobically packed samples.

Factors Influencing Quality

Little is known about the factors that influence the quality of radiation-pasteurized seafoods. Although it is generally recognized that type and/or amount of lipids and, in the case of salmon, carotenoid pigments may limit acceptability, more penetrating studies are needed to determine the effect of the basic biochemical properties of the product on tolerance to irradiation.

Some very recent preliminary studies conducted at this laboratory indicate that state of rigor may influence quality of the irradiated product. The results of one experiment (Figure 3) show that cod fillets irradiated in a pre-rigor

condition kept longer and at a higher quality level than those irradiated post-rigor.

Quality of raw material used for irradiation directly influences the quality and shelf life of the irradiated product. In Figure 4 it can be seen that as the preirradiation iced storage time is increased the rate of shelf life reduction is increased.

Methods of processing, handling, packaging, and storage also affect the quality of radiation-pasteurized fish and shellfish. The level of radiation significantly influences shelf life. In Figure 5 it can be seen that temperature of storage has a very pronounced effect on shelf life of the irradiated product, closely approximating $Q_{10}=3$ reported by Spencer and Baines for fresh fish [15]. As storage temperature increases, the rate of quality loss in the aerobically packed irraditaed product more closely approximates that of the fresh control.

The influence of packaging must not be overlooked. Vacuum packaging minimizes oxidative reactions which is beneficial in some of the fatty species—i.e., petrale sole and halibut—but is of little value for lean fish. It is generally true that with radiation-pasteurized fish the onset of spoilage is less rapid in a vacuum pack than in an aerobic pack. Fish fillets aerobically packed in 20- to 30-pound tins in bulk spoil faster than those packed in sealed cans, but still have a significant extension in shelf life over nontreated samples (Figure 6).

Synergistic, or complementary, effects to further extend shelf life occur when using radiation in combination with heat [16, 17] or additives—i.e., sodium benzoate, potassium sorbate, and sodium salts of methyl and propyl esters of para-hydroxybenzoic acids [18]. These complementary effects must, however, be fully appraised with regards to product spoilage pattern, total shelf life, and outgrowth of *Clostridium botulinum* Type E.

III. WHOLESOMENESS CONSIDERATIONS

A complete report of the wholesomeness and nutritive value of radiopasteurized marine products can be found in the proceedings of the hearings before the Joint Congressional Committee on Atomic Energy [4] and in the petition submitted to the U.S. Food and Drug Administration for clearance of irradiated marine products [19].

Since no abnormal responses were found in animals fed at high dietary levels with codfish, salmon, haddock, whitefish, and tunafish irradiated at 2.79 to 5.58 megarads, it is logical to conclude that ingestion of fish irradiated at these and pasteurization levels does not induce formation of toxic substances. Protein utilization studies with fish treated at sterilizing and pasteurizing doses show that protein quality is not adversely affected by irradiation. Also, with the exception of thiamine, no significant changes occurred in the water-soluble vitamins of haddock fillets and clam meats subjected to pasteurizing doses of radiation.

The 1963 incidences involving *Clostridium botulinum* Type E in smoked fish and lack of information on the presence of this organism in the product and on the factors contributing to its growth in fish raised concern about the likelihood of toxin development in fish treated with substerilizing doses of radiation. Evidence accumulated by Nickerson, however, indicates that haddock fillets are a poor substrate for growth of *Clostridium botulinum* Type E [13]. No toxin was found in haddock fillets that had been inculated with $1x10^2$ spores per gram, irradiated at .15, .25, or .35 megarads, and held at 45° F. for three times the product shelf life. Similarly treated haddock fillets inoculated with $1x10^4$ spores per gram became toxic at two times the shelf life at 45° F. and fillets inoculated with $1x10^6$ spores per gram became toxic at the maximum shelf life at 5° F. It is interesting to note that Nickerson and his co-workers found the level of contamination in fish fillets to be not more than 0.17 clostridia per gram, an amount about 100,000 times less than required to produce toxin at 45° F.

We feel that the role of *Clostridium botulinum* should be appraised in a manner which will permit an accurate and objective evaluation of any possible public health hazard. Some recent studies, which indicate that toxin can be produced in inoculated packs, have little significance because of the high inoculation levels used and failure to consider the safety gap between the period of recognizable spoilage and toxin development in nonirradiated as well as in radiopasteurized fish.

The factors influencing the safety of radiation-pasteurized fish can be graphically presented as shown in Figure 7. This example, which is intended to demonstrate the concept, shows how the difference between rejection time of spoilage and toxin development time can be related as a function of temperature, radiation dose, and inoculation level. We feel this kind of data would be valuable for evaluating the role of *Clostridium botulinum* in marine products, or in any food, and suggest that workers in the field give it serious consideration. Although these are merely preliminary data shown in Figure 7, the implication that these data are essential should be obvious.

As expected, the samples inoculated at the higher levels developed toxin first and, as ponited out earlier, samples inoculated with 10^2 spores per gram of Type E *Clostridium botulinum* did not develop toxin at all and are omitted in the graph. The data further suggest that the toxin outbreak time, as well as product shelf life, is increased as a function of applied irradiation dose.

Present indications are that haddock and cod fillets inoculated with up to 10^4 spores per gram will undergo spoilage and be rejected by consumers well in advance of toxin development. The time elements in samples inoculated with 10^6 spores per gram are still vague, and more work is required before conclusions can be made.

IV. COMMERCIALIZATION

Public Health clearance, market acceptability, and economics are essential considerations in evlauating application of radiation pasteurization in the fishing industry.

Public Health Clearance

Approval by the U.S. Food and Drug Administration is, of course, a necessary prerequisite to commercial development of the process. A petition for approval of radiation-pasteurized fish fillets of haddock, cod, flounder and sole, pollock, and ocean perch was submitted to the Food and Drug Administration on July 7, 1965; and formal comments have been received requesting information on commercial shipping tests. This petition specifies radiation levels of 0.2 megarads or less and packaging and handling in the usual conventional manner using well-established refrigeration practices.

Feeding studies are being conducted in preparation for a petition on soft shell clam meats. We anticipate that in the future petitions will be prepared for oysters, scallops, shrimp, and king crab, all products of high acceptability and value.

Market Acceptability

Quality evaluations by about 15 U.S. fishing firms substantiate laboratory findings and indicate that the irradiated product keeps over a week longer than fresh controls [20]. These findings are similar to those obtained in other acceptability tests conducted at Fort Lee, Virginia, in cooperation with the U.S. Army Natick laboratories, and by other voluntary industry groups (Tables V and VI).

In the U.S., the three distinct and separate market outlets can be classified as (1) restaurant or institutional, (2) supermarket, or (3) reprocessing into frozen or prepared foods. In the absence of specific market test data, it is not possible to accurately estimate consumer demand for radiation-pasteurized fish. We do feel, however, that the restaurant outlet might be best because in the U.S. fresh fish is enjoying a very healthy demand in eating establishments, and radiation-pasteurized fish might help fulfill this demand. We would rank supermarkets next because of their somewhat limited use of fresh fish in these outlets and difficulty in predicting consumer reaction to irradiation. Reprocessing into frozen or prepared foods may be very useful, particularly if quality and economic requirements can be satisfied. It will be necessary at the appropriate time to conduct a comprehensive test marketing and consumer evaluation program.

Ecomonics

Accurate information on the economics of producing radiation-pasteurized fish is not available. A report on the Marine Products Development Irradiator [21] indicates that radiation costs may approximate two cents per pound of product, with a production of one ton per hour for 24 hours daily for 50 weeks a year. With variations in supply we could conservatively estimate a cost of

not more than four cents per pound. Packaging costs would be less than one cent per pound; thus, since shipping and handling costs would be the same for fresh fish, the increase should not exceed five cents per pound of irradiated product. The reduction of product waste due to spoilage and shrinkage through use of radiation pasteurization might amount to over 3% [22] thus approximating a net increase of one to two cents per pound.

Another consideration is the amount of high-quality raw material available for radiation pasteurization. Some surveys of quality of haddock landed at Boston indicate that over 85% of the fish being landed is of a quality suitable for irradiation. Thus, we would estimate that in the New England area, annually, probably 50% of the haddock, cod, flounder, and pollock landed would be of quality sufficient for radiation pasteurization. If half of the fillets from these fish are marketed in local areas without treatment, about 140 million pounds [23] would be left for distribution in the irradiated condition annually.

V. CONCLUSIONS

Since 1960 considerable technical progress has been made in the U.S. in research on radiation pasteurization of fish and shellfish.

The refrigerated shelf life of about 19 different species of fish and shellfish can be significantly increased with low doses of gamma radiation, without introduction of irradiation odors or flavors.

Storage time for a particular species is a function of preirradiation quality, dose level, packaging, and storage temperature. At radiation doses of .15 megarads or lower spoilage in fish fillets manifests itself organoleptically in a manner similar to that of nonirradiated products.

The role of *Clostridium botulinum* can be accurately evaluated by appraising the difierence between spoilage rejection time and time for toxin development as a function of level of contamination, radiation dose, and storage temperature. Haddock fillets are a very poor substrate for growth of *Clostridium botulinum*.

Radiation pasteurization has significant economic potential for the fishing industry in the U.S. in reducing waste and extending markets.

Greater attention must be directed toward obtaining FDA clearance of radiation-pasteurized seafood.

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TABLE I.—*Shelf life of radiation pasteurized fish and shellfish*

[Key: A—U.S. Bureau of Commercial Fisheries Technological Laboratory, Ann Arbor, Mich.; G—U.S. Bureau of Commercial Fisheries Technological Laboratory, Gloucester, Mass.; S—U.S. Bureau of Commercial Fisheries Technological Laboratory, Seattle, Wash.; L—Louisiana State University, Baton Rouge, La.; M—Massachusetts Institute of Technology, Cambridge, Mass.; O—Oregon State University, Corvallis, Oreg.]

Product	Source	Package		Head space		Dose (megarads)	Average storage temperature (° F.)	Average total shelf life [1] (days)	Spoilage criteria
		Can	Pouch	Air	Vacuum				
SHELLFISH									
Lobster meat (cooked)	M	X		X		0.125	38	10	Total plate count.
Do	M	X		X		[2].125	38	>60	Do.
Do	M	X		X		.25	38	10	Do.
Do	M	X		X		[2].25	38	>60	Do.
Do	G	X		X		.15	33	>30	Organoleptic and total plate count.
Crab meat (cooked):									
King	S	X		X		[3].20	33	28–42	Organoleptic.
Do	S	X		X		.20	42	14	Do.
Dungeness	S	X		X		[3] 0.10–.20	33	14–56	Do.
Do	S	X		X		.10–.20	42	14–21	Do.
Do	O	[4]		X		.10	43	7	Total plate count (limit 1×10^6).
Do	O	[4]		X		.40	43	15	Do.
Blue	G	X		X		.35	33	>159	Organoleptic and total plate count.
Soft shell clam meats	G	X		X		[3].45	33	>30	Organoleptic.
Do	G	X		X		.45	42	20	Do.
Do	G	X			X	[3].35	33	>30	Do.
Do	G	X			X	.35	42	20	Do.
Shrimp	L		X	X		[3].20	33	21–28	Total plate count, trimethylamine nitrogen, and organoleptic.
Oysters:									
Southern	L	X		X		.20	33	20–21	Do.
Pacific	O	[4]		X		.10	43	8	Total plate count (limit 1×10^6).
Do	O	[4]		X		.40	43	20	Do.
FISH									
Fish fillets:									
Sole:									
Petrale	S	X			X	.10–.15	33	20–25	Odor.
Do	S	X			X	.10–.15	42	3–8	Do.
Do	S	X			X	[3].20–.30	33	21–42	Do.
Do	S	X			X	.20–.30	42	12–18	Do.

English	S	X			X	.10	33	14–21	Organoleptic.
Do	S	X			X	[3].20	33	21–28	Do.
Dover	O	([4])		X		.10	43	5	Total plate count. (limit 1×10^6).
Do	O	([4])		X		[3].20	43	7	Do.
Do	O	([4])		X		.30	43	10	Do.
Do	O	([4])		X		.40	43	13	Do.
Do	O	([4])		X		.50	43	25	Do.
Ocean perch:									
Atlantic	G	X		X		[3].25	33	30	Organoleptic.
Do	G	X		X		.25	42	20	Do.
Do	G	X			X	.15	33	40	Do.
Do	G	X			X	[3].25	33	40	Do.
Pacific	S	X			X	.15–.20	33	25–28	Do.
Haddock	G	X		X		[3].25	33	>30	Do.
Do	G	X		X		.25	42	20	Do.
Do	G	X			X	[3].15	33	>30	Do.
Do	G	X			X	.15	42	20	Do.
Cod	G	X		X		[3].15	33	34	Do.
Do	G	X		X		.15	37	13	Do.
Do	G	X		X		.15	42	10	Do.
Do	G	X		X		.15	47	10	Do.
Do	G		X	X		[3].15	33	34	Do.
Do	G		X	X		.15	37	13	Do.
Do	G		X	X		.15	42	10	Do.
Do	G		X	X		.15	47	10	Do.
Pollock	G	X		X		[3].15	33	30	Do.
Do	G	X		X		.15	42	10	Do.
Do	G	X			X	[3].15	33	30	Do.
Do	G	X			X	.15	42	20	Do.
Yellow perch	A		X	X		.30	33	40–47	Total plate count and organoleptic.
Do	A		X	X		.30	42	15	Do.
Do	A		X	X		.60	33	51–61	Do.
Do	A		X	X		.60	42	20	Do.
Tinker mackerel	G	X		X		.25	34	50	Organoleptic.
Fish steaks:									
Pacific halibut	S	X			X	[3].20	33	21–56	Do.
Do	S	X			X	.20	42	14–21	Do.

[1] Shelf life—That point at which the product is considered unmarketable.
[2] 140° F.
[3] Optimum dose is that dose which provides a significant shelf life extension without altering product acceptability.
[4] Glass.

A—U.S. Bureau of Commercial Fisheries Technological Laboratory, Ann Arbor, Mich.
G—U.S. Bureau of Commercial Fisheries Technological Laboratory, Gloucester, Mass.
S—U.S. Bureau of Commercial Fisheries Technological Laboratory, Seattle, Wash.
L—Louisiana State University, Baton Rouge, La.
M—Massachusetts Institute of Technology, Cambridge, Mass.
O—Oregon State University, Corvallis, Oreg.

TABLE II.—*Survey of recently published data on the effects of different treatments on the composition of the microflora in fish and shellfish*

Species and treatment	Storage temperature	Storage time (days)	Package head space	Reference	Composition of microflora (percent)																	
					Pseudomonas	Achromobacter	Flavobacteria	Corynebacteria	Micrococci	Lactobacilli	Staphylococci	Sarcina	Yeasts	Vibrio	Miscellaneous	Paracolobacteria	Mycoplana aeromonas	Enterobacteri	Brevibacteria	Bacilli	E. coli	Proteus
Yellow perch fillets:																						
None	33° F	(1)	Not specified	[24]	41	12	2	3	17	10	----	3	----	----	----	----	----	----	13	5	1	2
Irradiated, 0.3 megarad	33° F	(1)	do		---	83	----	----	----	----	----	----	15	----	----	----	----	----	2	----	----	----
Irradiated, 0.6 megarad	33° F	(1)	do		---	77	----	----	----	----	----	----	15	----	----	----	----	----	8	----	----	----
None	42° F	(1)	do		36	12	----	8	20	----	----	8	4	----	----	----	----	----	4	8	----	----
Irradiated, 0.3 megarad	42° F	(1)	do		22	72	----	----	----	----	----	----	----	----	----	----	----	----	----	6	----	----
Irradiated, 0.6 megarad	42° F	(1)	do		--	100	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Dover sole fillets:																						
Nonirradiated	43° F	2	do	[25]	90	----	----	----	----	----	----	----	10	----	----	----	----	----	----	----	----	----
Nonirradiated + MPB	43° F	1	do		81	----	----	----	----	----	----	----	----	----	19	----	----	----	----	----	----	----
Nonirradiated + PPB	43° F	1	do		90	----	----	----	----	----	----	----	----	----	10	----	----	----	----	----	----	----
Irradiated, 0.3 megarad	43° F	2	do		---	----	----	----	----	----	----	----	100	----	----	----	----	----	----	----	----	----
		4	do		---	80	----	----	----	----	----	----	----	----	20	----	----	----	----	----	----	----
		6	do		---	69	----	----	----	----	----	----	----	----	11	----	----	----	----	----	----	----
Irradiated 0.3 megarad, MPB added before irradiation.	43° F	7	do		---	14	----	----	----	----	----	----	62	----	24	----	----	----	----	----	----	----
		11	do		5	5	----	----	----	----	----	----	89	----	1	----	----	----	----	----	----	----
		13	do		---	72	----	----	----	----	----	----	14	----	14	----	----	----	----	----	----	----
		15	do		---	81	----	----	----	----	----	----	19	----	----	----	----	----	----	----	----	----
Irradiated, 0.3 megarad, PPB added before irradiation.	43° F	7	do		---	19	----	----	----	----	----	----	10	----	71	----	----	----	----	----	----	----
		11	do		---	25	----	----	----	----	----	----	56	----	19	----	----	----	----	----	----	----
		13	do		---	----	----	----	----	----	----	----	100	----	----	----	----	----	----	----	----	----
		15	do		---	19	----	----	----	----	----	----	81	----	----	----	----	----	----	----	----	----
		18	do		---	79	----	----	----	----	----	----	10	----	11	----	----	----	----	----	----	----
Irradiated, 0.3 megarad, MPB added after irradiation.	43° F	4	do		---	65	----	----	----	----	----	----	20	----	15	----	----	----	----	----	----	----
		6	do		---	58	----	----	----	----	----	----	37	----	5	----	----	----	----	----	----	----
		9	do		---	100	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
		11	do		---	86	----	----	----	----	----	----	----	----	14	----	----	----	----	----	----	----

Irradiated, 0.3 megarad, PPB added after irradiation.	43° F	1	do			57							43																		
		4	do			43									57																
		6	do			38									62																
		9	do			100																									
		11	do												100																
		13	do			76							24																		
		15	do			94							6																		
Petrale sole fillets:																															
Nonirradiated control	33° F	0	Vacuum		10	19	6	31	22	12.0																					
		4	do		61	24		3	4	4.0			2										2								
		7	do		94	1				5.0																					
Irradiated, 0.1 megarad	33° F	0	do			31		12	43	10.0			1										3								
		7	do		30	2		14	18	35.0			1																		
		14	do		30				3	67.0																					
Irradiated, 0.2 megarad	33° F	0	do			7		2	71				3										17								
		14	do		8	44		1	5	42.0																					
		28	do							100.0																					
Irradiated, 0.3 megarad	33° F	0	do			5		6	53				5										31								
		21	do	[26]		1				99.0																					
		49	do							100.0																					
Irradiated, 0.4 megarad	33° F	0	do				2	2	38				6										52								
		28	do			54				46.0																					
		56	do							100.0																					
Nonirradiated control	33° F	0	Air		6	31	10	35	13	5.0																					
		5	do		38	36	1	14	2													8		1							
Irradiated, 0.1 megarad	33° F	11	do		24	54		2	2				15									2		1							
		0	do		2	30		5	61															2							
		5	do			65		3	29	3.0																					
		11	do			98				2.0																					
		15	do		2	85		7		6.0																					
Irradiated, 0.15 megarad	33° F	0	do			11		16	68														5								
		7	do			92			3	3.0													2								
Irradiated, 0.2 megarad	33° F	18	do			46		26		27.0			1																		
		0	do			20		2	76														2								
		4	do			23			73	3.0			1																		
		18	do		3	94		3																							
		22	do			93				7.0																					
Irradiated, 0.3 megarad	33° F	0	do			41			59																						
		7	do		1	92			3				4																		
		15	do		1	56							43																		
		27	do			78		6					16																		
Irradiated, 0.4 megarad	33° F	0	do			30		10	50				10																		
		15	do			100																									
		27	do			10							90																		

See footnote at end of table.

TABLE II.—*Survey of recently published data on the effects of different treatments on the composition of the microflora in fish and shellfish*—Con.

Species and treatment	Storage temperature	Storage time (days)	Package head space	Reference	Composition of microflora (percent)																	
					Pseudomonas	Achromobacter	Flavobacteria	Corynebacteria	Micrococci	Lactobacilli	Staphylococci	Sarcina	Yeasts	Vibrio	Miscellaneous	Paracolobacteria	Mycoplana aeromonas	Enterobacteria	Brevibacteria	Bacilli	E. coli	Proteus
Haddock fillets:																						
Fresh control	35° F	1	All	[27]	17	10	34	34						5								
		13	do		99			0.4		0.6												
		13	Vacuum		92			4		4.0												
		19	do		87					13.0												
Irradiated, 0.15 megarad	35° F	1	Air			62		14			14	7	3									
		31	do			95				5.0												
Irradiated, 0.15 megarad	35° F	1	Vacuum			63					35		2									
		31	do							100.0												
		48	do							100.0												
Nonirradiated	38° F	19	Air		84	8	4								4							
Do	38° F	19	Vacuum	(28)	65	22									13							
Do	38° F	19	Air		48	20	4		4							24						
Irradiated, 0.15 megarad	38° F	19	do		5	44	29		4		17				1							
Do	38° F	19	Vacuum			40	18		28						10	4						
Do	38° F	19	Air		4	62			9		21					4						
Nonirradiated		0	do	(11)	13	15	19	10	12	1.0			3	2	10		5	1	1	8		
Irradiated, 0.05 to 0.3 megarad		0	do		1	11	6	12	34	2.0			8	1	11		1			13		
	6° C	6	do		9	10	5	10	26				7	1	3		4		4	21		
	0° C	6	do		3	8	7	6	27				9		6				1	33		
	6° C	9	do		19	4	11	4	15	1.0			16	10	2		3		2	13		
	0° C	9	do		4	8	5	6	32				11	2	2		1			29		
	6° C	15	do		26	6	6	5	17	2.0			16	7	3		2			10		
	0° C	15	do		18	5	7	3	21				18	3				2	1	22		
Nonirradiated		0	Air		12	16	18	9	11	2.0			4	3	10		6		2	7		
Irradiated, 0.4 to 0.6 megarad	0 to 6° C	0	do			3	2	7	44				17		8				1	18		
		14	do		4	7	4	5	33				21		12					14		
		30	do		4	12	1	12	24	1.0			28		6		1		2	9		
		60	do		23	8	7	7	17				13	2	3		2			18		
Nonirradiated	0 to 6° C	0	do		19	17	15	8	9	3.0			6	6	6		6		1	4		
		7	do		29	27	3	3	2	10.0			4	11	5		2		2	2		
		14	do		32	18	5	5	5	2.0			2	12	3		7	4	1	4		
Irradiated, 0.65 to 0.8 megarad	0 to 6° C	30	do		2	11	2	6	29				34		4				2	10		

Cod:																									
Irradiated, 0.5 megarad	0° C	1	do	[10]	5	40	3	5	7				3		37										
		13	do		52	47		1																	
		20	do		100																				
Irradiated, 0.25 megarad	0° C	1	do		3	63	8	6	20																
		13	do		7	93																			
		21	do		99										1										
Ungutted, unwashed	Newly caught.	0	Not specified		63	22	5	6	2						2										
Gutted, washed	2 to 3 hours, iced.	0	do		44	13	10	24	5						4										
Iced	Ice	5	do		45	46	3	3							3										
		12	do		50	27	23																		
		21	do		89	7	3	1																	
Gutted	Newly caught, uniced.	0	do		84	13		1							2										
Iced	Ice	8	do		90	4	6																		
		13	do		92	4	4																		
		19	do	[29]	80	8									12										
Ice+5 p.p.m. CTC	0° C	8	do		12	12	7	10					27		32										
		13	do		57	10		6					25		2										
		19	do		79	15		6																	
Filleted	0° C	1	do		40	30	11	6	1						12										
		16	do		55	40	1	2							2										
		23	do		72	14		1							13										
Dipped 30 minutes in 20 p.p.m. CTC	0° C	1	do		32	35	5	12	5				1		10										
		9	do		5	16	11	18	38				2		10										
		16	do		7	9	4	3	15				55		7										
		23	do		7	6	1	8	2				67		9										
Dipped 30 minutes in 20 p.p.m. CTC	0° C	6	do		2	2			2				92		2										
Irradiated 0.25 megarad		15	do		89	11																			
		20	do		97								1		2										
Soft shell clam meats:																									
Nonirradiated		0	Air		9	12	3	20	26				3	4	4		2			17					
Irradiated, 0.05 to 0.35 megarad		0	do		1	5	2	12	28				15		5		1			31					
	6° C	6	do		6	5	4	9	37	2.0			6	1	1		2		1	26					
	0° C	6	do		2	6	1	8	41				11		8					23					
	6° C	9	do		12	9	6	6	30				7		12		3			15					
	0° C	9	do		3	6	2	8	38				7		9					27					
	6° C	15	do		17	5	4	10	24	1.0			13	2	3		2			19					
	0° C	15	do		8	4	4	9	29				7	3	10		1		1	24					
Nonirradiated		0	do	[11]	10	11	3	20	25	1.0			2	4	5		1	1	1	16					
Irradiated, 0.4 to 0.6 megarad		0	do			4	3	11	29	1.0			17		3					32					
	0 to 6° C	14	do		6	3	2	17	18				26		11		1		2	14					
		30	do		9	6	2	6	15				33	2	7			1		19					
		60	do		21	9	5	16	13	3.0			12	3	2		4		1	11					
Nonirradiated		0	do		14	12	7	21	8	5.0			5	5	4		2	2	1	14					
Irradiated, 0.65 to 0.8 megarad		0	do			1	3	10	28				14		3				1	40					
	0 to 6° C	30	do		12	9	4	4	11				46	3	2				2	7					
		60	do		47	13	5	10	5				7	4	3				2	4					
		90	do		23	6	3	8	9				31	1	9				1	9					

See footnote at end of table.

TABLE II.—*Survey of recently published data on the effects of different treatments on the composition of the microflora in fish and shellfish.*—Con.

Species and treatment	Storage temperature	Storage time (days)	Package head space	Reference	Composition of microflora (percent)																	
					Pseudomonas	Achromobacter	Flavobacteria	Corynebacteria	Micrococci	Lactobacilli	Staphylococci	Sarcina	Yeasts	Vibrio	Miscellaneous	Paracolobacteria	Mycoplana aeromonas	Enterobacteria	Brevibacteria	Bacilli	E. coli	Proteus
Oyster meats:																						
Untreated	43° F	0	Not specified	[30]	17	2	5	14	----	57.0	2	----	----	----	----	----	----	----	----	3	----	----
		2	do		36	----	----	2	----	58.0	2	----	----	----	----	----	----	----	----	2	----	----
		4	do		56	----	----	----	----	42.0	2	----	----	----	----	----	----	----	----	----	----	----
		7	do		79	1	----	----	----	18.0	2	----	----	----	----	----	----	----	----	----	----	----
Treated with 0.1 percent sodium benzoate.	43° F	0	do		17	2	5	8	----	65.0	----	----	----	----	----	----	----	----	----	3	----	----
		2	do		49	7	4	8	----	30.0	1	----	----	----	----	----	----	----	----	1	----	----
		4	do		92	2	----	----	----	6.0	----	----	----	----	----	----	----	----	----	----	----	----
		7	do		95	2	----	----	----	2.0	----	----	----	----	----	----	----	----	----	1	----	----
Irradiated, 0.1 megarad	43° F	0	do		----	6	2	8	----	71.0	8	----	----	----	----	----	----	----	----	5	----	----
		2	do		----	----	----	12	----	58.0	10	----	----	----	----	----	----	----	----	20	----	----
		4	do		----	5	3	9	----	65.0	13	----	----	----	----	----	----	----	----	5	----	----
		8	do		----	5	----	----	----	95.0	----	----	----	----	----	----	----	----	----	----	----	----
		11	do		----	----	----	2	----	97.0	1	----	----	----	----	----	----	----	----	----	----	----
		14	do		----	2	----	----	----	95.0	3	----	----	----	----	----	----	----	----	----	----	----
Treated with 0.1 percent sodium benzoate.	43° F	0	do		----	3	2	8	----	73.0	8	----	2	----	----	----	----	----	----	4	----	----
		2	do		----	8	4	8	----	42.0	23	----	4	----	----	----	----	----	----	11	----	----
		4	do		----	6	5	34	----	33.0	9	----	----	----	----	----	----	----	----	13	----	----
		8	do		----	----	4	18	----	32.0	35	----	----	----	----	----	----	----	----	11	----	----
Irradiated, 0.1 megarad	----	11	do		----	7	7	18	----	25.0	24	----	12	----	----	----	----	----	----	7	----	----

[1] Not specified.

TABLE III.—*Total plate counts (TPC) of irradiated and nonirradiated fillets at time when quality of fish reaches borderline level*

Product	Dose level (megarad)	TPC/g of nonirradiated samples (n)	TPC/g of irradiated samples (i)	Ratio, i/n	Source of information
Cod	0.15	2.1×10^7	1.5×10^8	7/1	BCF Technological Laboratory, Gloucester, Mass.
Petrale sole	.25	1×10^7	1×10^8	10/1	BCF Technological Laboratory, Seattle, Wash.
King crab	.20	1×10^6	1×10^9	100/1	Do.

Q=Borderline quality by taste panel.

TABLE IV.—*Spoilage characteristics and shelf life of irradiated (150,000 rads) and nonirradiated cod fillets stored at different temperatures*

Sample	Storage temperature (° F)	Shelf life of product served steamed (days)	Panelists' comments	
			Cooked evaluation at end of shelf life	Raw evaluation at end of shelf life
Irradiated in air-packed cans.	33	36	Off odor, musty, old	Persistent fishy odor, slight discoloration.
	37	15	Ammonia, bitterness	Opaque, defects, discolored, fishy odor.
	42	12	Irradiation taste, bitter, burnt taste.	Slight irradiation odor, slight fishy odor.
	47	12	Ammonia, putrid, inedible	Defects and discoloration, slight irradiation odor, fishy odor.
Irradiated in bulk-packed 30-pound tins.	33	36	Spoiled, irradiation odor, irradiation flavor, ammonia.	Slight discoloration, slight fishy odor, slight irradiation odor.
	37	15	Putrid, ammonia, irradiation odor.	Defects and discolored, fishy odor.
	42	12	Musty, rancid	Slight fishy odor.
	47	12	Ammonia, stale odor	Defects, discoloration, irradiation odor, decomposition odors.
Nonirradiated, bulk-packed in 30-pound tins.	33	15	Ammonia, putrid, sour, inedible.	Defects and discolored, persistent fishy odor.
	37	12	Ammonia, inedible, putrid	Defects and discolored.
	42	12	Ammonia, putrid, rancid, sour, bad.	Defects, discolored, decomposition odors.
	47	5	Ammonia	Decomposition odors.

TABLE V.—*Acceptability tests on radiopasteurized seafood (U.S. Army Test and Evaluation Command, Fort Lee, Va.)*

Product	Number of panelists	Dose (megarads)	Storage temperature (° F.)	Storage period (days)	Average taste scores [1]	
					Irradiated	Nonirradiated frozen controls
Haddock fillets [2]	314	0.25	33	15	5.76	6.13
				29	5.80	6.17
Petrale sole fillets [2]	333	.20	32-35	16	5.90	6.43
				28	6.52	6.57
Haddock fillets [3]	693	.15	33	7	6.19	5.90
				14	5.99	6.19
Cod fillets [3]	588	.15	33	17	6.59	6.54
				24	6.31	6.23

[1] Based on hedonic scale where: 9=like extremely; 8=like very much; 7=like moderately; 6=like slightly 5=neither like nor dislike; 4=dislike slightly; 3=dislike moderately; 2=dislike very much; 1=dislike extremely.

[2] Packed in air hermetically sealed cans.

[3] Packed in 30-pound fillet tins to approximate commercial conditions.

TABLE VI.—*Acceptability scores*[1] *by different panels of radiopasteurized seafoods held at 33° F. for about 2 weeks*

Panel	Number in panel	Fried haddock	Lobster salad	Clam chowder	Cod fillets
Gloucester (trained)	14	7.4	8.4	7.7	6.0
Consumer type	278	7.2	7.7	6.4	(2)
Natick (trained)	8	(2)	(2)	(2)	6.5
Natick (consumer type)	36	(2)	(2)	(2)	6.9

[1] Based on hedonic scale where: 9=like extremely; 8=like very much; 7=like moderately; 6=like slightly; 5=neither like nor dislike; 4=dislike slightly; 3=dislike moderately; 2=dislike very much; 1=dislike extremely.
[2] No test.

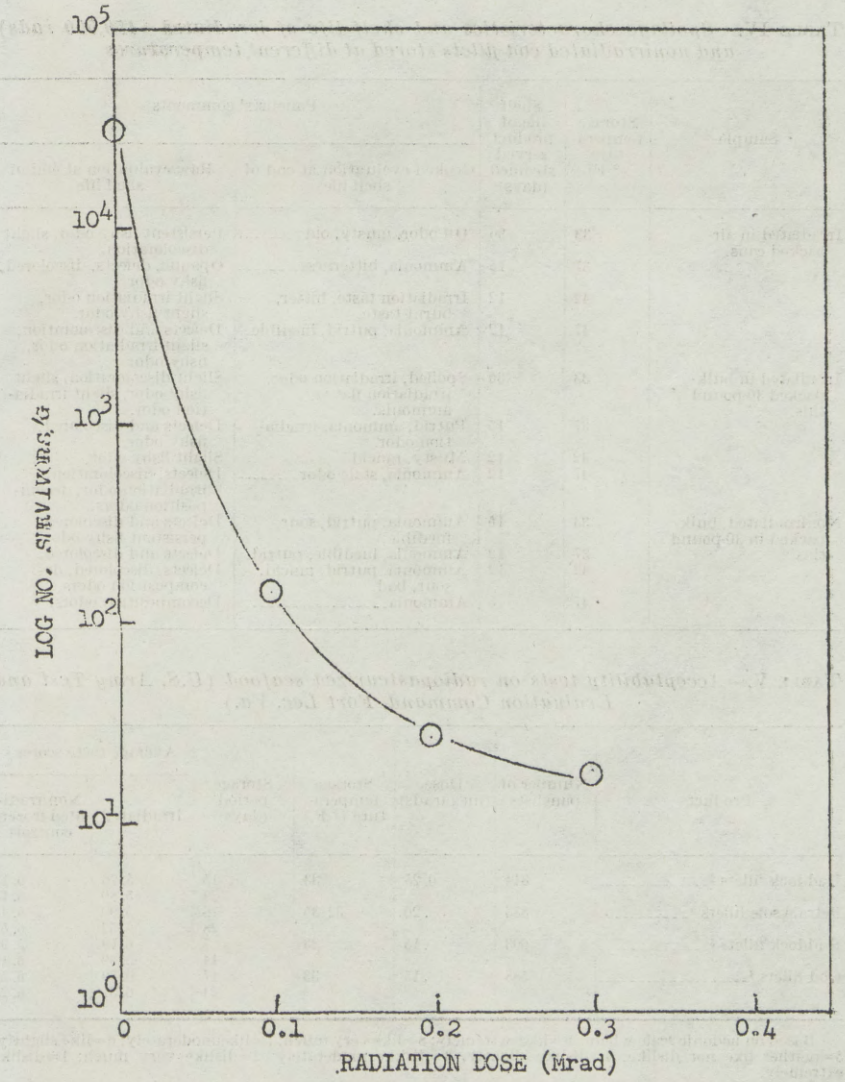


Fig. 1. Effect of different pasteurizing radiation doses on the total plate count in dover sole [25].

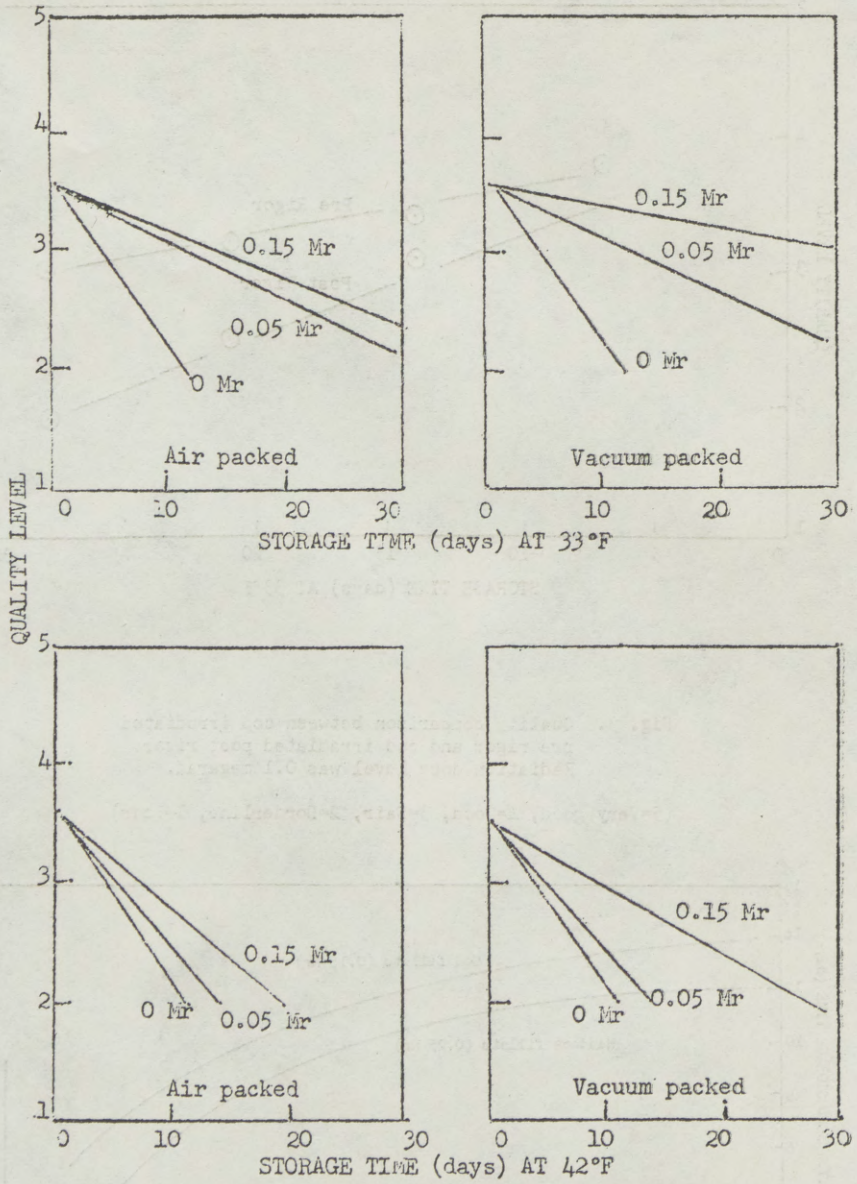


Fig. 2. Effect of different radiation doses on quality degradation rates of air and vacuum packed haddock fillets stored at 33° and 42°F.

(5=Excellent, 4=Very good, 3=Good, 2=Fair, 1=Poor)

70-905—67——10

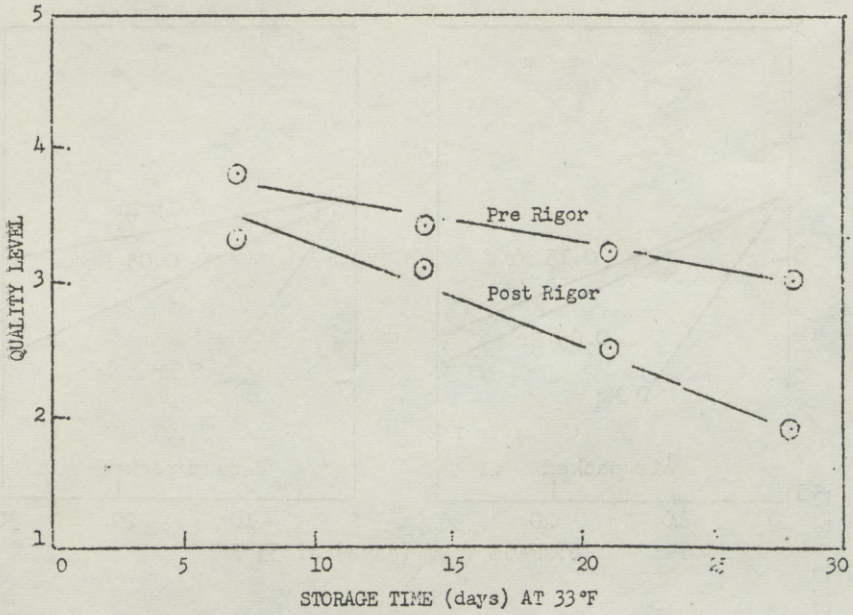


Fig. 3. Quality comparison between cod irradiated pre rigor and cod irradiated post rigor. Radiation dose level was 0.1 megarad.

(5=Very good, 4=Good, 3=Fair, 2=Borderline, 1=Poor)

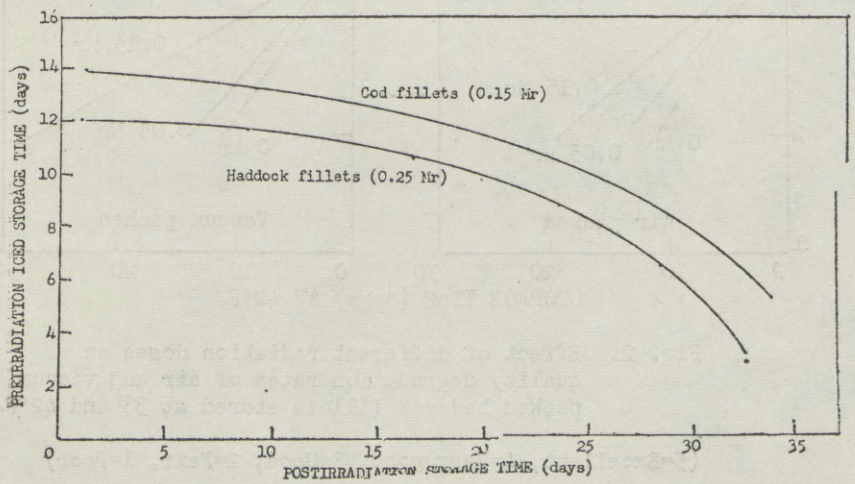


Fig. 4. Effect of preirradiation quality of iced eviscerated fish on the postirradiation shelf life of the fillets stored at 33°F.

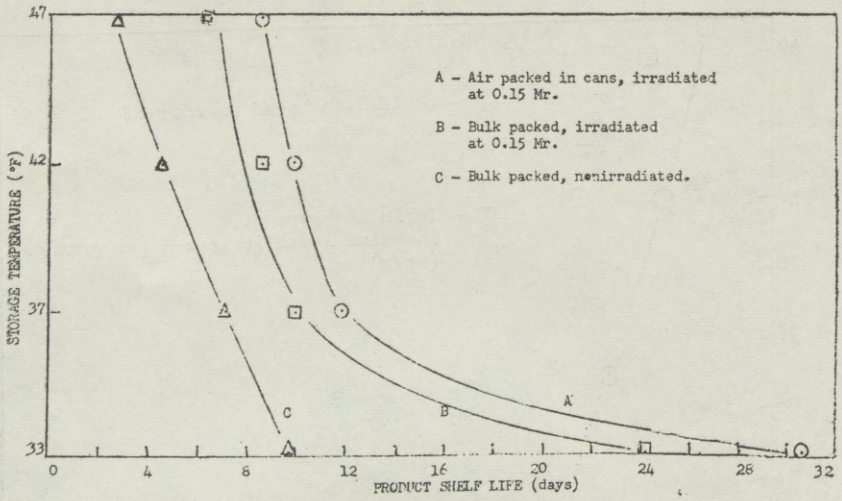


Fig. 5. Effect of storage temperature, packaging, and irradiation at 0.15 Mr on the shelf life of cod fillets.

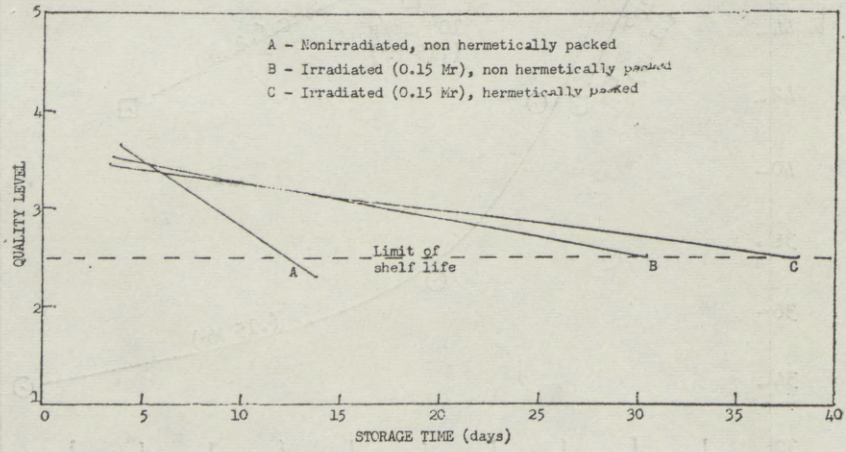
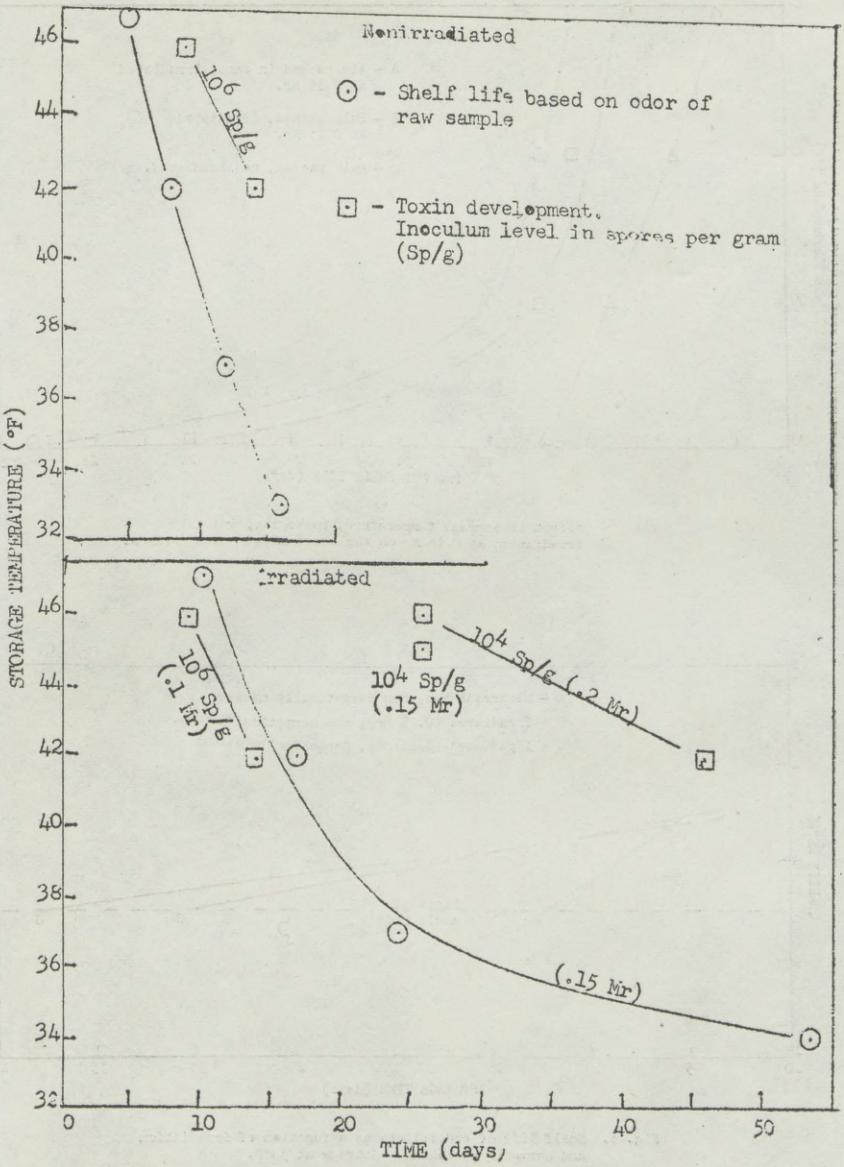


Fig. 6. Shelf life of cod fillets as a function of irradiation and hermetic packaging. Storage at 33°F.

(5=Very good, 4=Good, 3=Fair, 2=Borderline, 1=Poor)



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Appendix 5

AEC Reports on Food Irradiation Studies

Reports Submitted For Hearings on Food Irradiation of the Joint Committee on Atomic Energy

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Application of Radiation-Pasteurization Processes to Pacific Coast Fishery Products AT(49-11)-2058

(By M. Steinberg, D. Miyauchi, J. Spinelli, and G. Pelroy)

Products (AT(49-11)-2058

Our research work has been continued in those areas where additional information is needed to: (1) further define the radiation-process parameters in order to assure the marketing of fishery products of high quality; (2) demonstrate the commerical potential of the radiation process through the use of retail food chains, fish processors, and fish distributors who test, evaluate, and report to us on the attributes of irradiated fishery products; and (3) support with experimental findings the petitions to the Food and Drug Administration for clearance of radiation-pasteurized fishery products.

In completed work, Dungeness and king crab meats, halibut steaks, and fillets of petrale sole, English sole, and Pacific ocean perch were packed in consumer-size packages of about 1 pound and irradiated. We have found that these irradiated products could be held under refrigeration at a high level of acceptability for 2 to 5 times as long as corresponding nonirradiated control samples. We are also investigating the feasibility of repacking fillets into consumer-size containers after they have been irradiated in bulk wholesale packages and held in refrigerated storage for up to 2 weeks. We have found that the repackaged fillets are acceptable for an additional week. One week is the normal shelf life for nonirradiated control fillets. Thus, in this application of the radiation process, a shelf-life extension of up to 2 additional weeks was gained. Fish distributors and buyers are attracted by the advantages of potential high quality and longer shelf life offered by radiation processing.

The longer shelf life obtained by radiation-pasteurization of fish fillets can result in considerable weight loss from drip during refrigerated storage. Dipping Pacific ocean perch fillets for 15 seconds in 7.5 percent sodium tripolyphosphate (an FDA-approved food additive) containing 2 percent salt resulted in fillets that had practically no drip loss even after 28 days of storage. These fillets were superior in color and texture to untreated irradiated fillets stored for the same length of time.

In the process of obtaining experimental data to support petitions to the FDA we have found that the post-irradiation storage conditions have a strong influence on the composition of the microflora. The spoilage flora of irradiated fillets stored in oxygen-permeable films consisted of aerobic bacteria and yeasts; whereas, the spoilage flora of vacuum-packed fillets were predominantly *Lactobacillus*, a microorganism that requires only very small amounts of oxygen for growth. We are continuing this study to determine whether favoring the growth of certain spoilage microorganisms, such as *Lactobacillus*, by the selection of packaging materials can be used to control the pattern of spoilage of irradiated fishery products. We have also found that fish fillets irradiated in oxygen-impermeable films at low pasteurization doses and stored at various temperatures ranging from 33° to 72° F. spoil similarly to corresponding nonirradiated control samples in time and type of spoilage.

Study of Irradiated-Pasteurized Fishery Products

(By Louis J. Ronsivalli[1])

PROGRESS REPORT SINCE JUNE 1965

This continuing research is conducted in two concurrent phases. Phase I is concerned with laboratory-scale studies into the feasibility of radio-pasteurizing economically important fish of the Northwest Atlantic Ocean.

Phase I.—In the feasibility studies, our main interest is to determine whether the shelf life of unfrozen fish can be significantly extended by treatment with gamma radiation and we are, of course, interested in the chemical, bacterial, and wholesomeness aspects of the process. In a comprehensive experiment, we found that blue crab meat had a shelf life of about six months at 33° F. after receiving radiation treatment at levels of 0.25–0.45 Mrads. This compared well with heat-pasteurized crab meat although the irradiated crab meat had better

[1] Program leader of phase I research.

color retention and received slightly higher scores. Scallops also responded favorably to radio-pasteurization; this product might tolerate even higher radiation dose levels (up to 1 Mrad).

We are presently studying the feasibility of irradiating frozen fillets which are normally sold as thawed fresh fish. This represents a sizable area for the application of radiation preservation methods.

In another part of our study we found that clam meats can be irradiated with good results even after they have been shucked for as long as one week. For example, one-week-old clam meats irradiated at 0.45 Mrad lasted 22 days at 33° F. This represents approximately 2–3 times the expected shelf life of seven-day-old untreated clam meats. This type data supports the usefulness and applicability of radiation as a food additive under the 1958 amendment to the Food and Drug Administration regulations.

In cooperation with U.S. Army researchers, we conducted large-scale acceptance tests at Fort Lee, Virginia, where several hundred soldiers rated irradiated (0.15 Mrad) three- and four-week-old (at 33° F.) cod fillets as highly as they did fresh frozen, top quality cod fillets. These results, as did those of earlier large-scale experiments, attest to the acceptance of irradiated fillets.

For some time now, we have been engaged in a study which we feel will contribute in large measure to resolve the problem of whether there exists a botulism hazard with radiopasteurized foods. The experimental design, conceived in this Laboratory, has been groomed into a nation-wide effort with the cooperation of Government, Academic, and Industrial Laboratories. Our role in this vital program to bolster the U.S. Atomic Energy Commission petition for radiopasteurized seafoods is to determine the absolute maximum shelf life of nonirradiated fish and fish irradiated at different pasteurization levels. At the same time, cooperating microbiologists will determine minimum toxin outbreak times for similarly treated samples and a comparison of both data will yield meaningful information. Our results thus far for haddock fillets irradiated at 0.2 Mrad indicate absolute maximum shelf life times of 10, 12, 21, and 55 days at storage temperatures of 60°, 55°, 46°, and 40° F., respectively. It must be remembered that these unusually long shelf life times at this and other dose levels (0, 0.05, 0.1 Mrads) are obtained by our definition of maximum shelf life which is the unanimous rejection of samples by a trained panel (about eight members), a mixed panel (about 20 members), and a consumer-type panel, (about 10–20 members). When rejected, the products are in advanced stages of spoilage (e.g., putrid, ammoniacal, etc.).

Microbiological data obtained over this period continues to show that when we irradiate fish fillets at 0.15–0.25 Mrads we destroy 99–99.9% of the bacteria. The bacteria are, of course, responsible for fish spoilage, and this is borne out in our latest chemistry research where we determined that a significant amount of volatile chemical compounds in fish might be attributable to the bacteria which normally contaminate them. This is apparent by the larger number and higher concentrations of volatile compounds in contaminated flesh than in sterile flesh.

Finally, the important role of bacteria and their enzymes in fish spoilage was further illustrated indirectly in simulated shipboard experiments where fish were irradiated immediately after slaughter, resulting in the production of superior quality products. In this case, the fillets were initially sterile and, therefore, free of bacterial enzymes. Our shipboard irradiation study, under a separate U.S. Atomic Energy Commission contract, is now underway with a portable cobalt-60 irradiator installed in the hold of the MV *Delaware*, a Bureau of Commercial Fisheries research vessel.

Study of Irradiated-Pasteurized Fishery Products

(By John D. Kaylor[1])

PROGRESS REPORT SINCE JUNE 1965

This continuing research is conducted in two concurrent phases. Phase II is concerned with operations of the Marine Products Development Irradiator and exploration of the commercial potential of irradiated seafoods.

Phase II.—The MPDI has shown that its basic design is excellent for large scale production. Its production capacity in enormous (a ton an hour) when compared with the amount it has irradiated. Obviously, where no fishery prod-

[1] Program leader of phase II research.

ucts have yet been cleared for sale, there is no point in irradiating more than can be justified. However, in the period from June 1965 to the end of August 1966, it has completed 152 separate and distinct irradiation jobs for a total of over 42,000 pounds of products. These jobs consist of fishery products for the greater part but also include fruits, meats, chicken, non-food products and even several very precise sexual sterilization jobs of several thousand made Gypsy Moths.

MPDI activities in this period, other than operation, have emphasized the commercial potential of fresh seafood distribution to determine just how irradiated seafoods will fit into the picture when they are finally cleared for general sale. We have conducted many temperature studies which reveal current commercial conditions of handling, processing and transporting fish fillets from fish pier to fish peddler as far as 1500 miles away. Without exception, the temperatures of all common carrier shipments are reduced substantially by the time of arrival at destination with some of them at or below the freezing point. These are all genuine commercial size shipments which, in some cases, belong to industry and not to us. They all travel by ICC regulated common carriers and are in no sense to be regarded as laboratory experiments. We find that irradiated fillets travelling in the same carrier under identical conditions will outlast the nonirradiated fillets by ten or more days.

We used the above method of commercial transportation to send shipments of irradiated and non-irradiated haddock fillets to interested chain-store head seafood buyers and other industry members located hundreds of miles away from our irradiator. These experienced people tested the fillets over a period of time and have reported that the irradiated fillets outlasted the nonirradiated ones from six to fourteen days. It is interesting to note that when we start to speak to the buyers about the market potential of irradiated seafoods, they interrupt to tell us just what irradiated seafoods can do for them. Invariably, they want to know when seafoods will be cleared for sale. They have even offered us a whole chain of supermarkets to do any testing we need to get answers at the consumer level, because this is where success or failure will ultimately lie. This is the usual and sensible way of finding consumer attitudes, reactions and, most importantly, volume of repeat sales.

These buyers are not laboratory experimenters. They are shrewd businessmen with a discriminating sense for success, and success means profits in business. To date, we have received favorable replies from eight chain stores. Some of them have stores from coast to coast. Others have concentrated in certain regions with their supermarkets. The number of stores per chain varies from as few as seventy-five up to the thousands. The chains which have cooperated with us so far have a total of 8,886 stores at the last count. We have concentrated our efforts in the regions of heavy population, chiefly that megapolis that extends from Boston to below Washington. These outlets are all successful merchandisers, and they sense the potential of irradiation of fresh seafoods. They are eager for irradiation because it will reduce waste, increase profits and enable them to pass along savings to consumers.

AT(49-11)-2954 "Irradiation Preservation of Freshwater Fish"

(By J. A. Emerson, N. Kazanas, R. H. Gnaedinger, R. A. Krzeczkowski, and H. L. Seagran)

PROGRESS REPORT SINCE JUNE 1965

The current contract was initiated April 15, 1963, between the Bureau of Commercial Fisheries Technological Laboratory, Ann Arbor, Michigan, and the Institute of Science and Technology, The University of Michigan. The objective of the study was to investigate the application of cobalt-60 gamma rays at substerilization doses to the extension of the refrigerated shelf life of commercially significant Great Lakes fishery products, i.e., freshwater fish species. The potential usefulness of gamma radiation for controlling the activity of the enzymatic antimetabolite of whole fish and fishery products was also studied.

This report summarizes the results obtained on: (1) the shelf life extension of the freshwater species yellow perch, channel catfish, lake trout, whitefish, and lake herring; (2) environmental studies on yellow perch microbiology at the net, vessel, and plant levels; and (3) investigations of the effect of gamma radiation on the antimetabolite thiaminase.

Shelf life extension of yellow perch fillets irradiated to 0.1 and 0.2 Mrad and stored at 33° F. appeared to increase this product's shelf life approximately 2-fold. The level of 0.2 Mrad provided only a slightly greater extension of shelf life than did the level of 0.1 Mrad. *Pseudomonas*, and to a lesser degree *Achromobacter*, were the predominant organisms at the time that nonirradiated fillets were spoiled. *Pseudomonas* was eliminated at both dose levels (0.1 and 0.2 Mrad) and the *Achromobacter* group mostly comprised the residual flora.

The shelf life extension of commercial-scale packs of yellow perch fillets irradiated to 0.3 Mrad and stored at 36° F. was extended by approximately 2.5-fold. The unusually righ initial microbial load (10^7) and, possibly the milt (spawning season) on the fillets contributed to the relatively early unacceptability of the irradiated and nonirradiated fillets.

Organoleptic evaluations of lake herring irradiated to 0.3 Mrad and refrigerated at 33° F. showed that blandness of this product rather than spoilage was the cause of relatively early fillet unacceptability. Chemical treatment of fillets prior to irradiation might help control blandness and render a more suitable irradiated product.

Shelf life of lake trout and whitefish irradiated to 0.2 and 0.3 Mrad was extended by approximately 2- and 3-fold, respectively.

Warm-water fish farming in the U.S. has achieved new status and recognition with the rapid increase in channel catfish farming. An estimated 15 million pounds were harvested in 1965 as compared to only a few thousand pounds in 1963. There is a good indication that the production of farm-raised catfish will double in the next year or two. Because of this trend, catfish could also be a species which would lend itself to radio-pasteurization. Shelf life studies on irradiated channel catfish were conducted. Organoleptic evaluations or irradiated (0.2 and 0.3 Mrad) and refrigerated (33° F.) channel catfish indicated the usual shelf life extension for freshwater fish (2- and 3-fold).

In all fish species tested the irradiated residual flora consisted essentially of the *Achromobacter* group and, in a lesser degree, yeasts. Environmental studies of yellow perch microbiology has shown that the normal flora of fresh, yellow perch fillets on harvesting was increased by as much as 270-fold and the small number of *Pseudomonas* was increased markedly by commercial handling procedures. The predominant organisms on fillets at the plant level were proteolytic. Yeasts and molds were picked up at the plant level. Good sanitation and handling practices could contribute materially to minimizing the irradiation dosage necessary to achieve commercially significant extension of shelf life.

The radiosensitivity of the enzyme thiaminase in whole fish is dependent on many physical and chemical conditions. Thiaminase sensitivity is directly dependent upon sample temperature (durng irradiation) and irradiation dosage. Source of thiaminase (species of fish), chemical inhibitors, and the amount of water present during irradiation influence thiaminase sensitivity to gamma rays.

The Effect of Gamma Rays on Haddock and Clams Inoculated With Clostridum Botulinum Type E

(By Samuel A. Goldblith and John T. R. Nickerson)

PROGRESS REPORT SINCE JUNE 1965

The ability of *Cl. botulinum* type E to grow and produce toxin in radiopasteurized haddock fillets depends upon the initial concentration of spores, the irradiation dose, and the temperature of storage.

Haddock inoculated with 100 spores per gram, irradiated with 150, 250 or 350 kilo rad and then held at 33° F., 35° F., 40° F., or 45° F. did not become toxic even after three times the expected storage life of the irradiated fillets at these temperatures.

When the initial spore concentration was ten thousand per gram, the irradiated haddock did not become toxic after three times the expected storage life at 33° F., 35° F., or 40° F., but did become toxic after three but not two times the expected storage life at 45° F.

With an initial spore concentration of one million per gram, the irradiated haddock did not become toxic after three times the expected storage life at 33° F., 35° F., or 40° F. but did become toxic during the expected storage life at 45° F.

In a survey to determine the natural level of contamination of commercially produced haddock fillets with type E *Cl. botulinum*, samples were taken from

five different plants. About 23% of the fillets were found to contain type E *Cl. botulinum* and the highest concentration of this organism found in any of the contaminated fillets was 17 per 100 grams.

The spores of type E *Cl. botulinum* were cultured at 45° F., aerobically or anaerobically, in sterile haddock flesh together with the cells of some other bacterial species to determine if a condition of symbiosis might occur which would promote toxin production. Under aerobic conditions, inoculation with *Strept. lactis*, *Strept. faecolis*, *Lactobacillus viridescens* and *Cl. sporogenes* did not support growth of type E *botulinum* or toxin formation. In the presence of *Pseudomonas fluorescens* or *Pseudomonas fragi*, type E *botulinum* grew and produced toxin.

When these same bacterial species were each inoculated with type E *botulinum* under anaerobic conditions, there was neither outgrowth of type E *botulinum* nor toxin production.

The results of this investigation indicate that irradiation-pasteurization of haddock presents no particular public health hazard from botulism because—

(*a*) haddock fillets are infrequently contaminated with the spores of type E *botulinum* and when present, the concentration is low.

(*b*) even with unnaturally high concentrations of the spores, there was no growth or toxin production in the radio-pasteurized fillets held up to 40° F. At higher storage temperatures (45° F.) when well beyond their expected storage life.

(*c*) it has been found that the type of bacteria which causes spoilage of fresh fish enhances growth and toxin production of type E *Cl. botulinum* in fish. These bacteria are mostly destroyed by irradiation-pasteurization treatment of haddock.

Inoculated pack studies with irradiated ocean perch (a fatty fish) have indicated that this fish is a better growth medium for type E *Cl. botulinum* than haddock (a lean fish) since toxin production at the various storage temperatures occurred sooner in ocean perch than in haddock.

Simultaneous Radiation-Heating Treatment of Precooked Marine Products

(By Samuel A. Goldblith and John T. R. Nickerson)

PROGRESS REPORT SINCE JUNE 1965

Treatment of precooked fish sticks or scallops with a pasteurizing dose of gamma radiation at a temperature of 150° F. was found to be an effective method, from a bacteriological standpoint, for extending the refrigerated shelf life. However, these products underwent a chemical type deterioration during storage, and this precluded the use of simultaneous radiation-heating as a semi-preservation treatment for this type product.

The results obtained with lobster meat or crab meat were more encouraging. Very good refrigerated storage life extension of these two items, moderately contaminated with bacteria, was obtained by irradiating at 125,000 rad while holding at 140° F.

With very low bacterial count lobster or crab meat, irradiation at 125,000 rad while holding at 32° F. was a good method of extending the refrigerated storage life. No advantage was gained in this situation by irradiating at the higher temperature.

Organoleptic tests indicated that irradiation of lobster or crab meat at 125,000 rad, either while holding at 32° F. or 140° F., had little effect on the taste of these products, at the start or after refrigerated storage.

Also, from an organoleptic standpoint, vacuum-packed samples were judged higher than air-packed samples.

Radiation Pasteurization of Shrimp and Oysters

(By Arthur F. Novak and Joseph A. Liuzzo)

PROGRESS REPORT SINCE JUNE 1965

Results of chemical, bacteriological, physical and organoleptic tests show that gamma radiation at dose levels of 0.15 to 0.20 megarad increases the iced storage life of Gulf shrimp for 2 to 3 weeks longer than non-irradiated shrimp from the same catch.

Organoleptic field tests conducted in coastal and inland cities with oysters show that irradiation (0.2 Mrad) successfully extends the storage life of oysters

from 1 to 2 weeks. In each case the panelists, who ranged from low to high income, social, and educational backgrounds, rated the irradiated product as superior to the non-irradiated oysters. Similar results were obtained in a test conducted at the National Fisheries Institute Meeting in Houston, Texas. These panel participants were scientists, packers, and executives of the oyster industry and they accepted a 29-day-old irradiated oyster sample as being "relatively fresh." This panel also judged a 25-day-old irradiated shrimp sample as being less than 10 days old.

Irradiation of oysters at 0.2 Mrad did not result in a drastic destruction of the B-vitamins. The only vitamins adversely affected were thiamine, niacin, pyridoxine, biotin, and vitamin B_{12}, and losses for these vitamins did not exceed those experienced by other means of food processing employing some sort of energy. Available riboflavin, pantothenic acid, and folic acid actually increased after irradiation, suggesting a release of bound forms of the vitamins.

Metabolic studies with bacteria resistant to radiation of oysters show that their by-products, formed during ice storage, are not contributory to spoilage of the product. This indicates the value of irradiation in eliminating bacteria most responsible for destruction of oyster nutrients and for the production of products which enhance spoilage. In many instances irradation stopped or lowered the production of these by-products by the radiation-resistant bacteria.

A search has been initiated for acceptable food additives to employ as an adjunct to radiation to lower the bacterial counts by greater numbers than by irradiation alone. Since low level radiation must be employed with oysters and shrimp, other means of bacterial destruction could be used to obtain longer storage periods. Sodium benzoate was effective in reducing the numbers of bacteria during storage when irradiation was employed.

Many oysters harvested from Gulf waters cannot presently meet the standards for total and coliform counts. Consequently, they are rejected by Louisiana and other states. A project was initiated to test the effect of irradiation on the reduction of coliforms. This investigation, conducted in cooperation with the Alabama State Board of Health, has shown that coliform counts can be significantly lowered when the oysters are irradiated. In most cases, non-irradiated oysters stored for 15 days could not meet the standards in coliform counts, whereas the irradiated samples were acceptable.

Plans have been completed for commercial radiation of shellfish with an on-shipboard irradiator. Procedures employed successfully for small scale production will be applied to the shipboard investigations.

Effect of Irradiation on the Microbial Flora Surviving Irradiation Pasteurization of Seafoods

(By R. O. Sinnhuber and J. S. Lee)

PROGRESS REPORT SINCE JUNE 1965

The storage-life of Dover sole, Ocean perch, Dungeness crabmeat and Pacific oysters was increased threefold over that of the control, when irradiated at 0.1 Mrad and stored at 43° F. Increasing radiation dose, however, did not proportionally increase the storage-life. When the above seafoods were irradiated at 0.4 to 0.5 Mrad, the resulting storage-life did not increase more than tenfold.

The 0.1 Mrad inactivated 90 to 99% of the microorganims originally found in the fresh seafoods. Notably affected by irradiation were the *Pseudomonas* species which have been regarded as the potent spoilage organisms. Radiation doses of 0.1 Mrad or more successively eliminated this group from the above seafoods. The microorganisms most frequently found in irradiated seafoods were *Achromobacter* species.

Achromobacter species have been investigated in detail. They were characterized by biochemical inactivity, slower growth than *Pseudomonas* and a wide range of radiation sensitivity among species. Investigation into the role of *Achromobacter* in fish spoilage is now in progress.

The effect of Chlortetracycline (CTC) treatment was investigated in comparison to that of irradiation on the microbial population of fish. Microorganisms isolated from CTC-treated fish were more resistant to CTC. The degree of selection in favor of resistant species was proportional to the concentration of CTC. On the other hand, *Achromobacter* species isolated from fish irradiated at 0.4 Mrad were not necessarily more radiation resistant than those isolated from the 0.1 Mrad sample.

The radiation resistance of *Salmonella* species was determined in oysters with that of the natural flora. The degree of resistance shown by *S. typhimurium* was within the level of other microorganisms present in oysters. It was more sensitive to radiation than *Micrococcus*, yeasts, *Lactobacillus* and *Achromobacter*. It was more resistant than *Pseudomonas* and *Flavobacterium*.

Our results to date did not uncover any unduly radiation resistant or pathogenic species from irradiated seafoods.

Irradiation of Fruits and Vegetables

(By P. Markakis, R. C. Nicholas and B. S. Schweigert)

PROGRESS REPORT SINCE JUNE 1965

Studies conducted during this period have confirmed and extended our previous studies indicating that irradiation pasteurization can significantly extend and refrigerated storage life of inland fruits and vegetables. The major findings are as follows:

(1) *Strawberries.*—It was shown that 200 krad of either gamma rays or 0.6 Mev electrons delayed the appearance of mold growth on Michigan-grown strawberries of the Robinson and Sparkle varieties by 4 to 8 days if the fruit was stored at 33° F. after irradiation.

(2) *Potatoes.*—In confirmation of results obtained in 1964, it was shown that Michigan-grown potatoes of the varieties Arenac and Ontario are inhibited from sprouting by 7.5 krad of gamma irradiation.

(3) *Prunes.*—Prunes of the variety Stanley were dehydrated more rapidly if they had received 200 krad of gamma irradiation and still faster if they had received 400 krad. The weight loss during freeze-drying indicates that irradiation (400 krad) and blanching (200° F., 30 sec.) significantly accelerates the freeze-drying of prunes. The rehydration rate was also enhanced. This phenomenon was also demonstrated with irradiated dried beans.

(4) *Apple juice.*—The bottled juice was exposed to 0, 150, and 300 krad of gamma rays and subsequently stored at 38° F. After 93 days the 300 krad nitrogen pack still represented a good apple juice.

(5) *Mushrooms.*—In a recent experiment this year it was shown that as low a gamma radiation dose as 12.5 krad prevented to the opening of the veils of edible mushrooms practically completely and preserved their fresh-looking appearance for 1 2days at 38° F., while non-irradiated mushroom showed 100% veil opening and considerable aging at the end of the same period. No undesirable taste effect was observed as a result of this irradiation.

It was also evident that extension of the refrigerated storage life of fruits and vegetables by radiation pasteurization yields the best results when these products are gently handled under sanitary conditions throughout all stages of harvesting, processing, storage and transportation.

Studies were initiated this summer to ascertain if low levels of irradiation significantly inhibited the undesirable maturation of other vegetables after harvest (asparagus and sweet corn). While these studies are still under way, delay in maturation which would maintain the quality and thereby the marketing period for such products may be a general phenomenon for several fruits and vegetables. This may provide a most promising and unique application of irradiation technology. This observation is consistent with findings obtained in other laboratories (for example, with bananas by Dr. Maxie of the University of California at Davis).

Radiation Technology in Conjunction With Postharvest Procedures as a Means of Extending the Shelf Life of Fruits and Vegetables, Contract No. AT(11-1)-34, Project Agreement No. 80

(By E. C. Maxie, N. F. Sommer, and F. P. Guerrero)

PROGRESS REPORT SINCE JUNE 1965

Major accomplishments on this project during this season are:

1. Gamma irradiation in combination with heat at levels which hold promise as fungicidal treatment does not reduce the level of ascorbic acid in nectarines and peaches.

2. Combinations of heat and irradiation as described in number 1 do not result in significant adverse effects on acceptability of nectarines and peaches as determined by an expert taste panel.

3. Combinations of heat and irradiation as described in number 1 do not significantly alter the texture of nectarines and peaches as compared to irradiation alone. With some varieties, fruits subjected to combination treatments are more firm than those subjected to irradiation alone.

4. Heat suppresses the radiation-induced ethylene production in nectarines and peaches.

Considering 1, 2, 3, and 4, combination treatments of heat and irradiation are not more detrimental to the quality of nectarines and peaches than either treatment applied alone. This may provide a means of effectively irradiating these fruits without excessive textural damage.

5. Cantaloupes held at 68° F. show no adverse flavor response to high levels (100–900 Krad) of gamma rays. Whether these high doses will significantly affect shelf life of the fruits is now under study.

6. Extensive studies with bananas, strawberries, nectarines and peaches indicate that losses in ascorbic acid will not be a problem at doses the fruits can tolerate.

7. Tomatoes irradiated at the pink stage to 300 Krad then subjected to simulated transit showed an increased amount of injury as compared to unirradiated lots. However, as the fruit ripened, the differences in injury symptoms become minor.

8. Mechanical injury to bananas prior to irradiation substantially reduces the capability of the treatment to retard ripening. This may account for negative results by some workers with this species.

9. Ripe bananas can tolerate much higher doses of gamma rays than unripe fruits. However, this has little practical significance because of the difficulties in shipping ripe bananas. This explains the differences between our results and those of the Canadian workers.

10. The Mobile Gamma Irradiator (MGI) has finally been made operational and the dosimetry determinations have begun preparatory to conducting test shipments with strawberries and other fruits.

Effects of Low Level Irradiation Upon the Preservation of Food Products

(By R. A. Dennison, Margaret S. Merkley, E. M. Ahmed, and G. D. Kuhn)

PROGRESS REPORT SINCE JUNE 1965

The objectives were twofold: the determination of biochemical changes in irradiated citrus and peaches, and the development of irradiation processing technology of oranges, strawberries and peaches.

Pineapple oranges and Duncan grapefruit were treated with 200 krad of irradiation. Using uniform juice extraction conditions the juice yield from irradiated fruit was 1 to 3% greater than from control fruit. Juice from irradiated fruit had a higher viscosity. Peel injury was examined on irradiated (100, 200, and 300 krad) and control Valencia and Temple oranges stored up to 21 days at 35°, 50°, and 65° F. While peel injury was negligible on fruit stored at 35° F., it increased with higher irradiation doses and longer storage intervals. In a similar experiment, control and irradiated Valencia oranges were transported to Hazelton Laboratories and examined after storage. The pattern of peel injury was unchanged. Marked reduction of spoilage occurred on irradiated fruit stored 39 days at 35° F. Control of spoilage was less discernible in irradiated treatments stored for a 9-day storage interval or at 62° F. storage temperature. No significant differences were evident in pH, reduced ascorbic acid or organoleptic evaluations.

Irradiation (200 krad) of peaches significantly reduced the incidence and severity of brown rot on stored peaches. The time interval between inoculation of peaches with brown rot and irradiation treatment was important. Only 10% of the inoculations formed lesions when the fruit were irradiated within 24 hours after inoculation. Delaying irradiation until 36, 48 and 60 hours after inoculation resulted in 60, 80, 90% lesions on fruits, respectively. Taste panel acceptability of peaches was not significantly lowered by irradiation provided the fruits were irradiated at the firm-ripe maturity, pressure of 4 to 6 pounds by the Magness-Taylor fruit tester.

Spoilage of irradiated strawberries was markedly retarded without producing deleterious effects. Irradiation (200 krad) responses to maturity, post-harvest delay of irradiation, packaging, season, variety and long-term, low-temperature storage were studied on Daybreak and Florida 90 strawberries. Irradiation of less mature (white shoulder to pink) berries resulted in a higher retention of sound berries than irradiation of more mature (red) berries. For maximum retention of sound fruit held at 55° F., irradiation of white shoulder berries immediately after harvest was not vital; percentages of sound fruit in treatment sets irradiated at 12-hour intervals during a 72-hour period after harvest were not significantly different. After 10 days storage of irradiated berries packaged in lidded cups and open baskets, examination revealed a higher retention of sound fruit, less weight loss, and a better appearance of berries packaged in cups. In studies of berries harvested and irradiated at five weekly intervals, analyses of variance revealed no significant interactions between irradiation, harvest date and cultural practices; only irradiation significantly influenced retention of sound fruit. No varietal difference, attributable to irradiation was observed. Significantly higher percentages of sound fruit were retained in irradiated treatments stored 21 days at 35° F.; at shorter storage intervals, irradiation exhibited no effect. However for shorter storage intervals at 55° F., irradiation significantly reduced spoilage.

Dosimetry, Tolerance, and Shelf Life Extension Related to Disinfestation of Fruits and Vegetables by Gamma Irradiation

(By Edward Ross, James L. Brewbaker, and James H. Moy)

PROGRESS REPORT SINCE JUNE 1965

The Food Irradiation Research Program at the University of Hawaii has been oriented to phases of research projected to commercial handling and irradiation processing of Hawaii-grown fresh produce. Major attention has been directed to papaya, mango and pineapple, with research emphasis on factors relating to quality and shelf-life, FDA clearance, economics, packaging, and production handling.

Irradiation studies with a Co–60 source on Solo papayas have shown that 33 krad disinfests papaya of the Oriental fruit fly. 75 krad, combined with hot water treatment, induced optimal shelf-life extension of 3–5 days, a 100% increase over non-irradiated fruits. Sensory evaluations by trained panelists revealed no significant differences between unirradiated papayas and papayas treated up to 100 krad. Vitamin C was not lost at any stage of ripeness of papayas irradiated up to 75 krad. Sensory data on papayas shipped to California under quasi-commercial conditions were similar to those collected in Hawaii.

Sensory evaluations of irradiated Haden mangoes showed no adverse quality changes up to 75 krad. Sweetness, protein contents, Vitamin C were retained following 75 and 100 krad doses which disinfest the mango and sterilized the seed weevil; sterilization of the weevil actually occurred at doses of 33 krad and above.

Post-irradiation changes in the Smooth Cayenne pineapple were studied following different storage periods, over a dose range of 50 to 100 krad. On irradiated ripe fruit stored for 8 days, no change was found in the sugar and acid levels, but a 30% protein reduction was found at 500 krad. On mature-green pineapples irradiated at 50–100 krad and stored for 8 days, total sugars were up while acids dropped sharply, indicating improvement.

On miscellaneous commodities, treatments exceeding 2 krad inhibited sprouting in ginger with no evident detrimental effects. Irradiated sweet potatoes failed to sprout at doses of 10 krad and above. Lychees irradiated at 50–100 krad retained their taste qualities for at least two weeks. Tangerines and avocadoes appeared to be highly sensitive to irradiation, with conspicuous discoloration and/or off-flavors developing at 20–40 krad.

Research results obtained for papaya, mango and pineapple attest to the biological feasibility of gamma irradiation for insect disinfestation. The USDA Hawaii Fruit Fly Investigation Laboratory at Honolulu has officially requested plant quarantine approval for irradiated papaya, eggplant and sweet peppers. Clearance is expected in the near future, although this will be limited to shipments for experimental purposes until FDA approval has been obtained.

Present plant quarantine regulations require chemical fumigation of Hawaii papaya for shipment to the U.S. Mainland. Over four million pounds of fumi-

gated papaya are air-shipped to the mainland annually. Return to the farmer on total production is over a million dollars per year. With papaya acreage in Hawaii doubled in the last decade, outshipment of papaya from Hawaii may reach twenty million pounds annually by 1970, particularly with shelf-life extension and improved quality by irradiation, and development of a potential Japanese market.

Radiation Preservation of Tropical Foods

(By Drs. Robert A. Luse and Horace D. Graham, Puerto Rico Nuclear Center)

"PROGRESS REPORT SINCE JUNE 1965"

This project has as its purpose to determine feasibility of radiation preservation for bananas and mangoes, with initial emphasis on two aspects of the general problem. The first is to determine those factors of pre-irradiation condition, radiation dose, and post-irradiation treatment which produce maximal delay of ripening and extension of shelf-life. Here, criteria of ripening include visual observation, firmness and taste of fruits. Chemical analysis of tissue for starch, sugars and acidity is used to supplement the ripening observations. The second aspect is to evaluate the effect of radiation treatment on food quality, through measurement of changes of various nutritional factors, particularly carotenoids and vitamin C, which result from the radiation pasteurization.

In the first nine months of the project (October, 1965 through June, 1966) over 3,000 bananas of known age and variety (Montecristo) have been irradiated with from 10 to 50 Kilorad gamma doses and the effects of this radiation treatment on the ripening and food quality determined. On the basis of daily observations for ripening and weekly biochemical determinations on irradiated and control fruit, the following general conclusions for this banana variety may be drawn.

(1) Ripening is not consistently retarded by 10 to 40 Kr doses at 68° and 75° F. storage; irradiation at 40 Kr and storage at 80° F. results in a definite delay in ripening of up to six days.

(2) Radiation doses of 10 to 40 Kr have no significant influence on the carbohydrate and carotenoid content of bananas; with irradiation, titratable acid nearly doubles while ascorbic acid decreases by 10 to 25 percent.

(3) During fruit ripening, their content of carbohydrate, carotenoid, and acidity increases, while ascorbic acid content decreases, which decrease is accelerated at 80° F. storage.

In addition to the experiments with bananas, experiments have been done with several mango varieties of importance in the tropics. Mango fruits of ten varieties were irradiated with gamma doses of from 100 to 300 Kilorad.

The ripe stage was studied in the ten varieties at both 50° and 70° F. storage temperatures. Results indicated that spoilage caused by microbial infections was reduced by the use of these low levels of gamma radiation. The fungal-free period was sharply increased at the lower storage temperature.

Irradiation treatments of 150–200 Krads increased the shelf-life of the varieties studied, although it varied with the varietal radiosensitivity. Two varieties exhibited shelf-life extensions of 18 and 12 days, respectively; the other varieties averaged 8 days extension. The major adverse effect of radiation in the ripe stage was softening of the fruits, which constitutes the limiting factor in the extension of the shelf-life by irradiation treatments. In view of the long shelf-life extension noted, this fruit holds considerable promise for radiation preservation.

Cost-Benefit Analysis of Low Dose Radiation Preservation of Foods Program

(By Daniel Yankelovich, Inc.)

PROGRESS REPORT SINCE JUNE 1965

Study objective.—The purpose of this study is to assess the level and duration of AEC investment required—and the public and private benefits attendant thereto—to achieve commercialization of the low-dose radiation process of preserving foods. The study will present projections covering the period 1967–1980. The specific scope of work includes assessment of radiation processing's commercial prospects in three product categories (East coast fin fish, West coast

crab and tropical fruits). To the extent practical, conclusions based on these products are to be extrapolated to other foods.

Current status.—The project was initiated in February, 1966, and is scheduled for completion in October, 1966. The schedule is being maintained.

To this point the following have been completed: statistical information on production, prices, demand and the composition of each of the food industries included in the scope of work have been assembled from government and private sources; AEC contractors working in each food covered by the scope of the study have been interviewed and their reports reviewed; major equipment designers and manufacturers in the radiation processing field have been interviewed; commercial food firms through the entire chain of production and distribution have been contacted. In each food category, an intimate relationship with leading processors and marketers has been established which has yielded basic economic and attitudinal data. Surveys of cross-sections of other firms in each category are providing supplementary detailed information. These firms include fruit growers and importers, fishing companies, processors, packers, wholesalers, retailers and institutions. In addition, the field work for a survey of consumers has been completed and is now in the tabulation and analysis phase. This survey will establish consumer interest in irradiated foods, resistance to the concept of radiation processed foods, and consumer attitudes toward labelling of irradiated foods.

Preliminary conclusions.—Among the products included in the scope of this study, "the prospects for commercialization of irradiation processing can be arrayed as follows: best prospects, East coast fin fish and papaya; middling prospects, Dungeness crab and mango; poor prospects, king crab and banana."

This array is based on consideration of processing and distribution economics, the commercial need for radiation processing as indicated by opportunities for market expansion or cost economies over present or alternative processes, attitudes toward innovation in irradiation processing, and firms' financial ability and managerial willingness to enter radiation processing.

The study team will in the month of September complete the analysis and summarize findings for presentation in October.

While general awareness and interest in irradiation processing at present is widespread in the food industry, much of this interest is at the "curiosity" level. Important commercial interest does exist, however, among a small number of small number of firms with ability to invest in radiation processing. Broader interest is contingent on FDA approval of several products. If the AEC program is terminated in FY 1967, it is our judgment that the momentum underlying the program among commercial firms is insignificant for the process to achieve commercialization. Indications are that a sound public strategy would involve narrowing the scope of AEC support to those products which have the best commercial potential, notably fin fish and Hawaiian and other fruits. Inclusive in this strategy is the need to continue AEC developmenal and demonstration support for a number of years beyond 1967 if necessary commercial interest is to be attracted.

Irradiation Studies With Insects Infesting Bulk Grain and Packaged Commodities

(By H. Laudani, E. W. Tilton, J. H. Bower, and R. R. Cogburn, Stored-Product Insects Research and Development Laboratory, USDA, Savannah, Georgia)

PROGRESS REPORT SINCE JUNE 1965

Construction of the bulk-grain and packaged-commodity irradiator being built by AEC at the Stored-Product Insects Research and Development Laboratory is about complete after numerous delays. The 25,000 curies of Co^{60} to operate the irradiator is expected daily.

During construction of the above facility, studies have been conducted on the radiosensitivity of each stage of the major stored-products pests using the Mark III irradiator at the University of Florida. Ninety individuals of each stage were treated with 0, 10, 20, 30, 50, or 100 krads, and subsequent effects observed and recorded.

The results indicate a radiation exposure of 20–25 krads will upset the development of the stored-product insects sufficiently to control infestations in grain. Moth species are more resistant than beetles, with species of the latter

appearing to have about the same degree of susceptibility to radiation. Of the comparative sensitivity of the various stages, the egg is the most susceptible, followed in order by the larva, pupa, and adult. With the exception of the adult, the older the insect is within a stage, the greater its resistance to gamma irradiation. Minimum lethal dosages to eggs and young larvae usually produce sterility in the more advanced forms of a particular species.

Studies were also conducted to determine the effect of gamma radiation on the effectiveness of malathion when present on grain as a protective treatment. Chemical and bioassay analyses of the treated grain during 6 months of storage indicate that 25- and 100-krad treatments produced no noticeable degradation of the malathion residue.

A preliminary experiment in which three species of insects were fed on whole wheat, flour, wheat, or raisins radiated at dosages as high as 4,300 krads indicated that radiated diets do not appreciably change the fecundity or development time of the insects.

At present there is no evidence to indicate that treating several successive generations with substerilizing doses of gamma radiation produces any increase in radioresistance of the insect.

Extraction Studies of Packaging Materials To Be Used With Irradiated Foods and Preparation of Petitions on Irradiated Foods

(By Edward A. Garlock and Dr. John M. Barnes)

PROGRESS REPORT SINCE JUNE 1965

The irradiated marine products petition was submitted on July 6, 1965 and accepted for filing by the FDA on September 15, 1965 in accordance with the provisions of the Food Additives Regulations. The final revision of the irradiated strawberry petition was submitted on April 29, 1966 and accepted for filing on May 17, 1966. These petitions are now being critically reviewed by the scientific and administrative staffs of the FDA. A rough draft of the petition for the irradiation of onions as a means of preventing sprouting has been prepared. It is expected that this petition will be ready for submission within a few months. In response to specific requests from the FDA, supplemental data have been recently submitted in support of the irradiated strawberry petition. No significant action has been taken on any of the other petitions on file with the FDA during this contract period.

A set of guidelines to aid research workers in designing and reporting experiments on irradiated foods was prepared and submitted to Dr. Shea for distribution. These guidelines were prepared in order to familiarize AEC research contractors with FDA food additive petition requirements.

Dr. Barnes reviewed contractors' reports and other documents pertinent to the AEC food irradiation program and as a result of his efforts a card index file of over 800 cross references has been established. This has greatly simplified the collection and review of data relevant to any food item for which a petition is being drafted. These references also serve as the basis for the status chart on the experimental phases of the food irradiation program. This chart, designed to permit ranking of irradiated food items on the basis of the completed or projected completion of pertinent studies, will be constantly updated in order to serve as a current guide for petition preparation for the various food items.

Extraction studies were continued on various flexible packaging materials as part of the Quartermaster food irradiation program. Data from these studies were submitted to support petitions to FDA requesting approval for use of these packaging materials with irradiated foods.

We participated in designing and conducting shipping, storage and acceptability studies in cooperation with the University of Florida. Irradiated oranges were shipped to our laboratory where they were stored at different temperatures. They were examined regularly during storage for spoilage, radiation injury and other physical changes. After storage the orange juice was analyzed and evaluated for organoleptic attributes by a taste test panel of Hazleton personnel. The results of this experiment, together with other relevant data, were submitted to the FDA as a supplement to the irradiated orange petition.

Mr. Garlock visited AEC research contractors at the University of Florida and Louisiana State University for the purpose of reviewing and collecting data in

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support of irradiated food petitions. He accompanied AEC personnel on numerous occasions to the FDA for the purpose of discussing protocol for studies designed to demonstrate safety and efficacy and to discuss questions of policy such as labeling statements and petition requirements for irradiated foods. Mr. Garlock also participated in the discussions on irradiated marine products which took place during the AIBS Advisory Committee-AEC staff meeting at Gloucester on March 17–18, 1966.

Effects of Gamma Radiation and Chemical Treatment on Quality of Potatoes for Fresh Market and Processing Usage

(By Dr. Eugene V. Kwiat, the Pillsbury Co.)

PROGRESS SINCE NOVEMBER 1965

The purpose of this study is to critically evaluate the potential role of radiation treatment of potatoes for long-term commercial storage. Limitations on the storageability of potatoes currently force a reduction in operation or shutdown of potato facilities for 3–4 months of the year. Information derived from this study will allow the potato industry to be in better position to serve the American public in providing year around supplies of fresh and processed products.

The scope of work entails comparisons of the effect of ionizing radiation and two chemical treatments—CIPC (Chloro-N-Isopropyl-Phenyl Carbamate) and MH (Maleic Hydrazide) on quality, especially sprout inhibition, of potatoes stored in pallet boxes (one ton per box) for processing usage and fresh market. A check or untreated group of potatoes is also included.

Approximately 72 tons of potatoes from the Pontiac and Kennebec varieties of the Red River Valley are involved in this project, being stored in The Pillsbury Company Potato Plant, Grand Forks, North Dakota. After thorough suberization, the potatoes were randomly allocated to treatments for sprout inhibition by radiation, CIPC, and untreated. The MH treatment is applied as a spray in the field prior to harvesting. The radiation phase of this work was performed in November, 1965, by Nuclear Materials and Equipment Corporation in collaboration with The Pillsbury Company.

Potatoes for irradiation were transferred from the pallet boxes to reinforced cardboard containers holding 32 pounds of potatoes. This container was then placed on roller conveyors for passage through the irradiator where a dose of 7,500 to 15,000 rads was applied using Cobalt-60. After transfer back to pallet boxes, the potatoes were held at approximately 55° F. and 90% relative humidity with sufficient air flow to maintain optimum quality. The radiation treatment was conducted in a manner simulating a production facility in which potatoes were moved in a dry handling facility with a minimum of damage.

The CIPC sprout inhibition treatment was applied four weeks later, employing a commercially used fogging dosage. Special precautions were taken to insure satisfactory administration of all treatments.

On specific request of the Army Natick Laboratories, quantities of Russet Burbank potatoes were included in the radiation and untreated aspects of this investigation. The East Grand Forks U.S. Department of Agriculture Laboratories also collaborated in the study by storing and evaluating treated potatoes held at various storage conditions.

Potatoes were removed periodically from storage for evaluation over approximately 11 months. Both chemical and physical tests were employed to compare treatment variables. The Pillsbury Company evaluated potatoes for production of flakes and dice, etc.; Old Dutch Foods of Minneapolis for use as potato chips; Jiffy Fry Corporation of Grand Forks, N.D. for frozen french fried potatoes; and Ryan Potato Company of East Grand Forks, Minnesota for evaluation as table stock potatoes.

We are currently evaluating the seventh withdrawal of potatoes. Over-all it appears that the radiation and CIPC treatments result in similar quality for the Pontiac variety. In the Kennebec series it appears that the CIPC treated potatoes are holding up slightly better than the irradiated although the differences may be marginal. Kennebecs of the 1965 crop are holding up better than Pontiacs.

The MH treated potatoes from both varieties evidenced rosette-type sprouting about 4-5 months after harvest. No sprouting is observed in either irradiated

or CIPC potatoes although loss of quality due to desiccation is apparent. The control potatoes from both varieties were removed from the study in June, 1966, because of extreme sprouting and loss of quality.

We are currently using mechanical refrigeration to keep the potatoes at as close to 55° F. as practicable. Withdrawals will continue every month until termination of the study.

Our collaborative work with the East Grand Forks USDA Laboratory has yielded very interesting results regarding the effects of storage temperatures of 45° F., 50° F., and 65° F. on the irradiated, MH, and control potatoes. The 65° F. storage yielded extremely poorer potatoes from both varieties. The differences between 45° and 50° F. were noticeable but not exceptional. Even the control potatoes at these temperatures looked satisfactory for certain processing uses although some sprouting was observed.

Preliminary conclusions of this study indicate that generally potato sprout inhibition by radiation or CIPC treatment is satisfactory for the Pontiac and Kennebec varieties. The major factors controlling quality of commercially stored potatoes treated by these means are:

1. Initial quality of potatoes.
2. Adequate sprout inhibition treatment.
3. Temperature, relative humidity, and air flow control during storage.

This study is continuing and above conclusions are subject to change based on final analyses of information.

Comparative economic data for the various treatments will be presented in the final report.

Electron and X- and Gamma-Ray Research for Radiation Processing

(By William L. McLaughlin, Physicist, Radiation Physics Division, National Bureau of Standards)

Progess Report, 1965–66

The main purpose of this project throughout the past year has been to develop a chemical dosimetry system suitable for industrial applications in the radiation processing of foodstuffs, plastics, medical supplies, etc. Such a system would have the following desirable characteristics:

1. A linear response between optical transmittance density and radiation dose in the range 10^3 to 10^7 rads.
2. A low dependence on temperature, and on energy and intensity of the radiation.
3. A high reproducibility and stability factor, and good spatial resolution.
4. Be simple and convenient to prepare and use, and be useful in a wide range of industrial applications.

Results of tests using radiation sources similar to those which would be used in industry (electron beams and ^{137}Cs and ^{60}Co gamma-ray sources) show that certain colorless dye precursors, which may be used in a variety of forms such as thin films, gel blocks, and liquid cells, take on deep colors upon irradiation. Dose response upon irradiation is determined by relating the radiation dose to the corresponding increase in optical density measured at a given wavelength of light. The system thus far developed meets the following of the above guidelines:

Linearity and dose range.—Thin film coatings of pararosaniline-derivative solutions in gelatin, plastic, and other solid media show a linear response between optical transmittance density and radiation dose in the range 10^5 to 10^7 rads. Thick gel and liquid cell solutions show a linear response over an even wider range, 10^2 to 10^7 rads. Different portions of this range are covered by varying the thickness, concentration, and type of dye progenitor used.

Exposure variables.—Preliminary studies show that response is relatively independent of temperature, having a small temperature coefficient in the range −90° C to + 60° C.

The dose response has a low wavelength dependence and can be precisely controlled to achieve plastic, water, or tissue equivalence by controlling the ratios of the constituents. Energy dependence, for electron beams, can be controlled by adjusting the geometry and stopping power of the dosimeter so it simulates a given material.

Rate dependence has been found to be absent up to dose rates of 10^4 rad/second. Present experiments will extend this study to a dose rate of 10^7 rads/second.

Reproducibility, stability, and resolution.—Precision limits of the thin film dosimeter at 4 x 10^5 rads (a radition dose of interest in food processing) have been found to be ± 2.2 percent. This is an improvement over other practical dosimetry systems having the same response range. The reproducibility of liquid systems is now being studied in the hope of developing a standard dosimeter.

Pararosaniline nitrile in acidified gelatine, and liquid solutions of various dyes in methyl cellosolve and isopropanol have proven to be stable before irradiation. After irradiation its color remains unchanged when stored for several weeks.

Due to the very thin films used, and the low molecular weight of the solutes, extremely high spatial resolution is possible. This is essential in studying the microscopic distribution of dose, for example, near the boundary between a foodstuff and its container.

Usefulness.—The chemical dye dosimetry system developed at NBS shows promise of being a highly versatile, reliable and easy-to-use radiation processing dosimeter. This system can be made up with reagent grade chemicals in thin-film, gel, or liquid cell forms, or may be used to impregnate paper for use as a go-no-go system in the 10^5 to 10^7 rad range. It can be used to measure dose distribution grossly or microscopically in radiation fields in different media. The dye dosimeter is insensitive to room light and can be used without change in response in a vacuum or oxygen environment.

Plans for future studies include further investigations of temperature dependence, rate dependence (up to 10^{11} rads/second), dose distribution measurements, pulse radiolysis, and molecular yield measurements. Other investigations planned will include response to heavy particle radiation, and the development of a liquid cell standard dosimeter for the 10^2 to 10^7 rad range.

In addition to the dosimetry studies, techniques for energy measurement of monoenergetic electron beams are underway. Supplementary work includes coordination with other NBS projects (for example, the Berger-Seltzer computations of photon and energy dissipation) and keeping selected representatives of concerned manufacturers of radiation processing equipment informed of related NBS activities.

Commercial Prospects for Select Irradiated Foods, Contract No. AT(49–11)–2797

(By Jack W. Osburn, Jr., Food Industries Division, Office of Chemicals and Consumer Products, Department of Commerce)

Objective

The objective of this study is threefold:

1. To analyze and evaluate the commercial prospects of select irradiated foods by intensive study of the pertinent economic, marketing, and production factors related to each food;
2. To present the findings in a report designed for wide dissemination to food industry management; and
3. To recommend courses of action helpful in expediting commercialization of those products for which the outlook is favorable.

Scope

The scope of this study is limited to radiation pasteurized poultry and marine products; radiation sterilized meat, including beef, pork, and poultry; radiation improvement of dehydrated vegetables; and the use of radiation to inhibit ripening of bananas.

Progress

Battelle Memorial Institute was awarded a subcontract for the major portion of this work. Battelle completed their first draft using personal interviews with about 50 operating food companies as the prime source of information. This draft has been reviewed and is now being revised extensively prior to its final submission to BDSA. BDSA expects to submit the final draft for AEC approval in December 1966.

APPENDIX 6

REPORTS SUBMITTED FOR HEARINGS ON FOOD IRRADIATION OF THE JOINT COMMITTEE ON ATOMIC ENERGY BY THE DIVISION OF BIOLOGY AND MEDICINE, U.S. ATOMIC ENERGY COMMISSION

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Institution: University of Massachusetts.
Investigator: Elwood F. Reber.
Title: "The Wholesomeness Evaluation of Radiation Sub-Sterilized Food Products".
Contract No.: AT(30–1)3461.

The protein efficiency ratio (PER) and the protein quality of radiation pasteurized flounder, haddock, crab, clams and shrimp have been determined. There appears to be no differences between the protein quality of raw, non-radiated, freeze-dehydrated and raw, radiated, freeze-dehydrated samples of each of the sea foods listed above.

The wholesomeness of radiated (400,000 and 800,000 rad) pasteurized clams has been evaluated by feeding the clams as 35% of the total solids in a complete ration to three generations of rats over a two year period. Growth, reproduction, longevity, hematological, enzyme, gross pathological and histopathological data have been obtained. Statistical analysis of the data is being performed. Under the conditions of this experimental work an analysis and evaluation of the data leads to the conclusion that radiation pasteurized clams (400,000 and 800,000 rad) are as wholesome as nonradiated clams.

Institution: AME Associates.
Investigator: Karl L. Gabriel.
Title: "Short-Term Subacute Animal Feeding Studies on Radiation-Pasteurized Foods".
Contract No. AT(30–1)3422.

Subacute animal feeding studies were undertaken with radiation pasteurized sweet cherries, apricots, prune-plums and onions. Irradiated and nonirradiated foods were fed to both rats and Beagle dogs for a 90 day period. For sweet cherries, apricots and prune-plums, 35% dry weight of each fruit was incorporated into the experimental diets. For onions, 10% dry weight was incorporated into the experimental diets. All foods studied were dehydrated by freeze drying after being irradiated.

Final reports covering this contract have been submitted to the Atomic Energy Commission. The first report covering sweet cherries, apricots and prune-plums was dated January 31, 1966. The second report covering the work on onions was dated February 28, 1966. Both studies were subjected to extensive statistical analysis.

The conclusion reached in both reports was that irradiation of the test foods did not produce any deleterious effects in the test animals. With regard to

onions, there was no evidence that irradiation of onions contributed any deleterious effects over and above the known toxicity of onions.

Institution: AME Associates
Investigator: Karl L. Gabriel.
Title: "Chronic Animal Feeding Studies on Radiation-Pasteurized Clams".
Contract No.: AT(30–1)3573.

Chronic (two year) animal feeding studies were undertaken with radiation-pasteurized soft shelled clams (*Mya arenaria*) using Beagle dogs and White Leghorn chickens as the test animals. The test clams are being irradiated at 800,000 rads and at 400,000 rads. Control groups fed nonirradiated clams are also being employed. All test animals are now being fed diets containing 35% dry weight of clams. There were some problems in feeding chickens at this level but this was overcome by supplying thiamine daily in the drinking water to overcome any residual thiaminase remaining in the clams after completion of cooking.

The studies with chickens are progressing satisfactorily. We have completed the first breeding cycle and have been feeding the offspring the clam diets for almost three months. All of the offspring appear normal and are eating well. The hematology values of both parents and offspring are within normal limits. Weight gain has been uniformly good. A few birds have died but necropsy revealed lesions which might have been responsible which were unrelated to experimental procedure. We are preparing for the next breeding cycle involving the offspring of the F_0 generation. We anticipate no problems in completing this part of the project.

The studies with dogs are also progressing satisfactorily. All of the dogs are eating the diets and are gaining weight. Hematologic values are within normal limits. We are in the process of breeding the females during their second heat period. Again we anticipate no problems in completing this part of the project.

We have already made three procurements of clams and have utilized the Gloucester Irradiator each time for processing. This has worked out very well. The people at Gloucester have been most cooperative in helping us carry out this part of the project.

To sum up, this entire project is proceeding on schedule with no adverse effects due to the irradiated clams observed in either chickens or dogs. It is estimated that the study will be completed within the date specified in the contract.

Institution: Food and Drug Research Laboratories, Inc.
Investigator: Kenneth Morgareidge.
Title: "Chronic Toxicity Studies on Low-Dose Irradiated Bananas".
Contract No.: AT(30–1)3734.

A contract for the determination of effects of administration of low-dose irradiated bananas to rats and dogs was negotiated between these Laboratories and the Atomic Energy Commission on June 20, 1966. Preliminary studies have been undertaken to determine the effects of feeding the required synthetic diets in which banana powder constitutes 35 per cent of the food solids, to weanling rats and 3-month old dogs. During this 4-week trial, the dogs accepted the diets and normal growth patterns ensued.

Significant differences were noted, however, between the male rats receiving the control diet (containing 35 per cent dextrin solids) and those of the same sex receiving the banana-containing diet. There were no such differences among the females. Clinical laboratory analyses of blood and urine from these animals have shown no difference in either sex. Analyses of the diets have shown them to be comparable in protein or caloric levels. Thus, the differences in male growth rates have not yet been explained. Modifications of the dietary composition are being studied before the 2-year is initiated.

A design for the full-scale study has been prepared by the consultant biometrician, Dr. John E. Silson, in which the guiding principle is stratified randomization of animals as to disposition within batteries, time of feeding, initial weight, etc. The basic outline has been selected to yield valid comparisons of effects of irradiated versus non-irradiated bananas.

Institution: Continental Can Company, Inc.
Investigator: Wayne P. Segner.
Title: "Growth Characteristics of Type E *Clostridium botulinum* in the Temperature Range of 34°F. to 50°F."
Contract No.: AT(11–1)1183.

Until recently all inoculated pack work has been conducted with Type E spores products at 85F. It has appeared desirable also to conduct tests with spores produced at lower temperatures, which might be more representative of those formed in nature. At 60F and 50F spore yields in TPG medium used for producing spore crops at 85F have been very low. However, modifying the medium by the addition of 1% Yeast Extract has resulted in good spore yields at 60 and 50F. In once instance, a satisfactory spore yield was also obtained at 46F, although this could not be reproduced in further experiments. Spore crops have been produced in this modified medium at 50F in two other laboratories (Seattle BCF and MIT) and are currently being used for inoculated packs. Comparative tests for outgrowth time in steamed ground haddock at 42, 40 and 38F of spores of the Beluga strain produced at 85, 50, and 46F show somewhat more rapid outgrowth of the 50 and 46F spores at 40F, but not at 38 or 42F. The overall results suggest the desirability of using spores produced at 50F in inoculated pack work, but are not sufficiently great to seriously invalidate previous results obtained with spores produced at 85F.

Until recently all tests for outgrowth of Type E spores in marine products have been conducted in this laboratory in homogenates or ground fish in tubes under an anaerobic seal. This does not correspond to the conditions under which irradiated fish fillets would be commercially handled. A revised procedure has been developed using a 1¾ x 1½ inch screw cap jar, having a capacity of 70 ml which can be handled in our irradiation facility at ITT. A press and stainless steel die has been constructed to cut plugs from fish fillets to fit in the jar. Jars will be filled with 40–45 gm of fish, leaving 25–30 ml air in the sealed container. These conditions resemble much more closely those under which irradiated fish will be handled commercially.

Meetings were held with Messrs. Slavin and Ronsivalli of the BCF Gloucester Laboratory in which a program was developed to determine the absolute maximum shelf life of fish fillets at various temperatures with and without irradiation based upon rejection by both trained and untrained panels, and to parallel this work in our laboratory with inoculated packs of fresh fish, using the jar method to determine the toxin outbreak time. Our first experiment of this cooperative work on haddock is now in progress.

In the detection of Type E toxin using trypsin digestion, the standard procedure has been to dilute the blended fish with an equal part of pH 6.2 phosphate buffer, add 0.5% tryspin, and digest one hour at 98F. A modified test has been devised in which the blended fish is diluted with an equal quantity of 0.5M acetate buffer pH 5.5 and held overnight at 38F. Then 0.5% trypsin is added and digestion conducted at 98F for three hours. Rather extensive comparison of the two procedures on samples of ground fish inoculated with Type E spores and incubated at various temperatures suggests that the modified acetate buffer procedure provides a more sensitive test for the presence of Type E toxin.

Institution: U.S. Department of Interior, Bureau of Commercial Fisheries.
Investigator: Melvin W. Eklund.
Title: "The significance of *Clostridium botulinum* Type E in the application Of Radiation-Pasteurization Process to Pacific Crab Meat and Flounder."
Contract No.: AT(49–7)2442.

The purpose of our microbiology studies has been to assure that the commercial use of pasteurization doses of ionizing radiation for the purpose of preserving fishery products is a safe process and precludes any public health hazard from the bacteria *Clostridium botulinum*.

To accomplish this end, we have studied the following phases: (1) determination of the incidence and concentration of *Cl. botulinum* Type E cells in the marine environment; (2) determination of the characteristics of new types of Cl. botulinum isolated by our laboratory from the Pacific Ocean off the North American coast; and (3) determination of the outgrowth of *Cl. botulinum* Type E in nonirradiated and irradiated fishery products packaged and stored under conditions simulating those found in commercial operations.

In our completed work, we have shown that Type E is very prevalent in the marine sediments collected from the Pacific Coast of the United States to 36° North Latitude. However, we have been unable to demonstrate Type E south of this point, but we could demonstrate the presence of Types A, B, and F.

The concentration of Type E cells in the marine sediments varied from 28 to 3200 per 100 grams of sediment.

The physiological and biochemical characteristics of strains of *Cl. botulinum* Types B and F isolated from the Pacific Coast of the United States has shown that these types have many of the same characteristics as Type E. Type F has been shown to grow and produce toxin at 38°F and Type B has been shown to grow and produce toxin at 40°F in cooked meat medium. This characteristic of growth and toxin production at 38°F is also possessed by Type E. The data collected thus far, however, do not indicate that the outgrowth time of Type B and F at refrigerated temperatures are of any greater public health signifiicance than that of Type E.

Preliminary studies have been completed to determine the outgrowth of Type E in irradiated petrale sole fillets stored at refrigerated temperatures. We have shown that toxin production does not occur in irradiated petrale sole fillets within a 72-day storage period at 38°F. This is over 4 times the maximum storage life of irradiated petrale sole fillets at 38°F.

Toxin production did occur in irradiated petrale sole fillets which had been inoculated with 100 and 10,000 spores per gram of fish and stored at 42°F. Spoilage, however, occurred from 13 to 19 days prior to detection of the botulinum toxin in the 0.1- and 0.15-megarad samples. More detailed experiments are currently in progress to provide completely reliable evaluation of the degree of safety that exists in irradiated fishery products with respect to *Cl. botulinum*.

Institution: Louisiana State University.
Investigator: Robert M. Grodner.
Title: "Examination of Gamma Irradiated Gulf Shrimp for *Clostridium botulinum* and Type E Toxin".
Contract No.: AT(40–1)3265.

The survey for the presence of *C. botulinum*, type E in both fresh and commercial frozen, deveined and breaded samples of Gulf shrimp and oysters has continued. Even though more and larger samples are being analyzed, to date *C. botulinum*, type E has not been found in any samples of Gulf shrimp or oysters tested, besides there has been an absence of *Salmonella sp.* and/or low acceptable counts for fecal *E. coli* and other Coliforms.

Toxin production by *C. botulinum*, type E spore inocula (10^3, 10^4, and 10^5 spores/g.) in gamma irradiated fresh Gulf shrimp and oysters as affected by dosage (0, .15, .20, .30 and .50 Mrads), storage temperature 32–34°F and storage time (0, 7, 14, 21 and 30 days) have been studied.

In fresh Gulf shrimp, no toxin was produced when stored at 32–34°F up to 30 days after being inoculated with a mixed *C. botulinum*, type E spore suspension and exposed to Co^{60} radiation from .15 to .50 Mrads respectively. After storage at 40°F toxin production was noted after 7 days in all cases, except at 500 Krads, but toxin was produced after 30 days storage.

In fresh Gulf oysters, no toxin was produced when stored at 32–34° up to 30 days after being inoculated with a mixed *C. botulinum*, type E spore suspension and exposed to Co^{60} radiation from .15 to .50 Mrads respectively. After storage at 40°F toxin production was noted only after 30 days in all cases.

Presently our survey for *C. botulinum*, type E in shrimp and oysters are continuing, as well as our inoculation studies with individual cultures of the "rugged" Beluga and/or 8E strains of *C. botulinum*, type E.

Institution: U.S. Department of Interior, Bureau of Commercial Fisheries.
Investigator: Benjamin Q. Ward.
Title: "Survey of the Gulf Coast for the Presence of *Clostridium botulinum*, Type E".
Contract No.: AT(49–7)2777.

This agreement between the AEC and BCF was finalized April 1, 1965, and was extended for one additional year (on April 1, 1966) in order that the Atlantic Coast from Staten Island to South Florida might be surveyed for the

presence of *Clostridium botulinum* in the same manner as the Gulf Coast had been investigated under the original agreement. Results of the Gulf Coast survey are presently being prepared for publiation in a recognized scientific journal, and this presentation, if approved by the AEC, should constitute the final complete report for 1965–66, progress reports having been made during the year at periodic contractor's meetings. Collecting from the Atlantic area continues. Analyses of cool-weather samples are nearing completion, and a second sweep of that entire area to collect warm weather samples is scheduled for early September.

A total of 1414 samples of bottom sediments and animal life (predominantly fish, of nearly 40 species) were collected in estuarine and inshore waters of the Gulf of Mexico. Collecting trips were conducted in both warm weather and wintry seasons. In both sediments and animals collected in warmer months between Key West, Fla., and Brownsville, Texas, *C. botulinum*, predominantly type E, as was demonstrable by generally accepted laboratory techniques. Incidence was higher in the Eastern Gulf (arbitarily setting the Mississippi River mouths as the point of East-West division), but the organism was present to the Southmost geographic limits of both Texas and Florida. No bottom type, nor any single species, was clearly more or less apt to harbor the organism. Neither type A nor type F was ever detected.

In samples collected during cold weather, the East-West incidence differential previously mentioned was no longer observed, the overall incidence declined well below that of the Summer collections, all types were found (A–F), and type E no longer predominated. Such results suggest a need for more research in the area of microbial ecology. The presence of the organism throughout the Gulf region, although admittedly of low incidence (5 percent maximum), is nevertheless, a fact to be accorded due consideration by Gulf fisheries in the future.

Attempts to apply fluorescent antibody techniques to the problem of rapid detection of the organism in raw samples and crude cultures were unsuccessful. Existing antisera were found to lack the breadth of composition essential to any useful diagnostic application, but the techniques could, if improved, still be valuable in the future. These results were presented at the International Botulism Symposium, Moscow, and will appear in the report of that meeting.

Institution: Massachusetts Institute of Technology.
Investigator: Samuel A. Goldblith and John T. R. Nickerson.
Title: "The Effect of Gamma Rays on Haddock and Clams Inoculated With *Clostridium botulinum* Type E".
Contract No.: At(30–1)3325.

Some researchers are of the opinion that radio-pasteurized fish may present a possible health hazard from toxin production by *C. botulinum* Type E. This report is of a study to determine if Type E botulinum toxin would be adequately destroyed in radio-pasteurized haddock during the normal course of cooking, that is, if the toxin were initially present.

Type E botulinum toxin was suspended in a haddock substrate and the thermal inactivation times for the toxin were determined at various temperatures. From these data a thermal inactivation time curve was constructed. Next, the rate of heat penetration into haddock fillets of different thickness was determined either during deep fat frying or during pan frying. With this information at hand the theoretical cooking times required to destroy the toxin in the different sized fillets were calculated.

However, these theoretical cooking times were based on the destruction of a particular concentration of the toxin and they probably would not be adequate for higher concentrations of the toxin. This latter supposition proved to be correct for a study of the effect of toxin concentration on the thermal inactivation time revealed that for a tenfold increase in toxin concentration the thermal inactivation time increased by a factor of 5.5.

Therefore, it became of the utmost importance to determine the amount of toxin that could be produced by Type E botulinum in haddock. An experiment with this objective was undertaken and it was found that when spoilage was evident, there was just a small amount of toxin present.

Another variable which had to be investigated was the effect of pH on thermal inactivation time, since in the earlier study the thermal inactivation times were

determined at a fixed pH value. It was found that the toxin was more heat sensitive in an alkaline pH in an acid pH. It was also demonstrated that when radio-pasteurized haddock fillets spoiled bacteriologically, the pH was alkaline.

To determine the validity of the theoretical cooking times required, inoculated haddock fillets were allowed to proceed to an advanced stage of spoilage so as to accumulate the maximum amount of toxin. These fillets were then cooked for different times and assayed for toxicity. It was shown that if the fillets were cooked in accordance with standard recommended practice, the toxin would be inactivated.

On the basis of these results and others not included here, it is concluded that Type E botulinum would not constitute a public health hazard in radio-pasteurized haddock provided the fish is cooked for consumption.

Institution: Massachusetts Institute of Technology.
Investigator: John T. R. Nickerson and Samuel A. Goldblith.
Title: "The Effect of Repeated Treatment with Gamma Rays on the Radio-Resistance, Virulence and Cultural Characteristics of Certain Pathogenic and Related Bacteria."
Contract No.: AT(30–1)3325.

Broth cultures of *S. newport* were irradiated with various doses of gamma rays to about 0.0001 percent survival. Colonies from cells which survived the maximum radiation treatment were subcultured in broth and then irradiated again. For the control cells the decimal reduction dose (90% destruction) ranged from 30,000 to 40,000 rad with an average value of 36,000. For cells which had previously survived one irradiation treatment, the decimal reduction dose ranged 28,000 to 44,000 rad with an average value of 39,000 rad.

The decimal reduction for *S. typhimurium* was found to be greater than that for *S. newport*, with values ranging from 60,000 to 70,000 rad.

Cells of *S. typhimurium* which had survived an irradiation dose of 500,000 rad were subcultured in broth for 24 hours and then given an irradiation dose of 300,000 rad. For 15 different cultures treated as above the average value for survival was 0.33% and this figure is to be compared with an average survival value of 0.01% for 15 different control cultures after receiving the same dose.

This experiment was repeated with another set of 15 cultures which had previously survived an irradiation dose of 500,000 and this time the average value for survival following the 300,000 rad treatment was 0.08%.

These preliminary results with the two salmonella serotypes seem to indicate that the survivors of a high irradiation dose are more radio-resistant than the parent strain. However, throughout the course of the preliminary study some variability in radio-resistance was noted even within the stock culture.

Therefore, before proceeding any further along these same experimental lines. it was decided to study the factors which might influence radio-sensitivity of salmonella so as to be able to control experimental conditions more closely in future studies. The experimental protocol which had been followed was to incubate broth cultures for 24 hours, oxygenate, irradiate at 33°F, plate out survivors and incubate at 97°F.

An earlier study had shown that oxygenated broth cultures were less radio-resistant than non-oxygenated broth cultures, and cultures were more resistant to radiation at 33°F than at room temperature. Thus, an additional study was conducted to determine the effect of growth stage and also incubation temperature on radiation resistance. Growth curves for the two salmonella serotypes were determined at 97°F. Broth cultures were irradiated with various doses after 8 hours growth (logarithmic phase), 14 hours (late logarithmic), 24 hours (early stationary phase) and 32 hours (late stationary phase). Both serotypes were least radiation resistant in the logarithmic growth phase. *S. newport* was most resistant to radiation after 24 hours growth, whereas *S. typhimurium* exhibited about the same resistance after 14, 24, or 32 hours growth.

Incubation temperature was found to influence recovery of survivors particularly at the high irradiation doses. Maximum recovery of survivors occurred at an incubation temperature of 68°F for *S. newport* and 97°F for *S. typhimurium*.

Institution: Oregon State University.
Investigator: A. W. Anderson.
Title: "Deriving Methods of Differentiation and Identification, and Improving Cultural Methods of Detecting *Cl. botulinum* in Foods and Natural Substances."
Contract No.: AT(45–1)1930.

Identification of the genus Clostridium is currently based on morphological, biochemical and serological data. Among the clostridia many strains are encountered which are indistinguishable from one or other except for toxin production. The taxonomy of these organisms is not clear at present. Furthermore, a number of investigators have suggested that non-toxic mutants of *Cl. botulinum* may be common and these would be indistinguishable from other non-toxic or toxic clostridia.

In the present investigation the technique of electrophoresis, selective media, and lipid component analysis has been used to find differences which can be exploited in studying the relationships between strains of *Cl. botulinum* and non-toxic clostridia or non-toxic botulinum mutants. This report presents some preliminary findings which may be used to study these organisms.

Extracts were prepared from *Cl. botulinum* types. Using the disc method of electrophoresis as suggested by Ornstein and Davies for separation of various protein. It was found that all types of *Cl. botulinum* examined (A, B, C, E, F) gave protein patterns characteristic for the strain, though some minor differences occurred between different strains. Thus one can differentiate the types on the bases of protein patterns. Most of the non-toxic clostridia gave patterns different from the toxic strains. However, certain non-toxic strains of clostridia which are similar to the type E, with the exception of toxicity produced electrophoresis pattern characteristic of type E. These could be type E mutants.

Protein-laden gels of strains of *Cl. botulinum* A, B, and E have been electrophoresed and then exposed to modified enzyme stains with surprising results. *Clostridium botulinum* strains all have single or multimolecular enzyme forms of the dehydrogenases of isocitric, succinic malic, and lactic. On these bases the toxic types E, C and F can be separated from non-toxic and from the types A and B.

All types of *Cl. botulinum* show multimolecular forms of the alkaline phosphatases. At the present time these have not been evaluated sufficient for identification purposes.

All types of *Cl. botulinum* show multimolecular forms of the esterases. Investigations are still in progress.

A method for identifying iron binding proteins has been used in locating single and multiple bands on the protein gels. Although information is lacking as to the exact nature of these proteins, it is believed that they are either ferridoxin, ferridoxin-like compounds, or a species of cytochrome. Recently an iron binding compound has been isolated from type E using the method suggested for ferridoxin. Spectrum analysis shows an absorption band at 258 mμ in the oxidized state. Our results indicate strongly that this protein is a type of ferridoxin. These bands vary with the strains and they thus have possibilities for identification purposes.

To the best of our knowledge this is the first time that the dehydrogenases alkaline phosphatase, and esterase have been reported in the clostridia, and the first time that an iron binding compound, possibly ferridoxin, has been reported *Clostridium botulinum*. Further investigations may prove that any of the above have a potential for identification purposes.

Another objective of this research project was to find a selective media for the isolation and identification of the Clostridia. A comparative study was run on strains of A, B, E, and non-toxic types using liver-veal egg-yolk media and trypticase sucrose egg-yolk with neutral red as an indicator, and plain trypticase egg-yolk media. The distinguishing characteristics were noted for each strain such as the development of the pearly layer, opalescence fermentative ability, and the ability to form starch or lipids as end product. The liver-veal media proved to be the most inconsistent and so was discarded.

The results on trypticase sucrose egg-yolk media indicated that (1) strains of A and B produce a very strong pearly layer, do not utilize sucrose and are starch negative. (2) Toxic E types ferment sucrose, which shows up nicely as a bright pink color in the media around the colonies; is starch positive as indicated by simply flooding the plate with iodine and is inconsistent on pearly layer development. In some cases both pearly and non-pearly colonies are found. (3) Some non-toxic strains ferment sucrose, some are starch positive and in most cases produce a pearly layer. There seems to be a correlation between the fermentation of sucrose in the media and the ability to produce a pearly layer.

Further research is being conducted on the effect of different temperatures and the possible differentiation of pearly and non-pearly colonies through isolation, toxicity and other tests.

In addition to the above methods of characterization, a study was begun on the fatty acids of the vegetative cells of *Clostridium botulinum* types A, B and E (33A, 115B and VHE respectively) as the first step in an investigation of the possible relationship between the fatty acid composition of this organism and related strains.

Cell cultures were grown at 30° C for 72 hours. Free and bound lipids were extracted from lyophilized cells. The free fatty acids were separated by column chromatography. Methyl esters of the free fatty acids and the fatty acids from the standard lipids were prepared. These methyl ester derivatives were characterized using gas-lipid chromatography. Identification was based on comparison of the chromatograms with those of known fatty acid methyl ester samples and on reaction to hydrogenation. The lipids samples were separated into classes using thin-layer chromatography.

The results indicate that these organisms possess fatty acids ranging in chain length from C_9 to C_{20} with the exception of C_{19}. The composition of the free fatty acid and total fatty acid fractions is very similar with the exception of type E. The great majority of fatty acids present are normal saturates or normal monounsaturates. Myristic and palmitic acids are the most abundant. There is evidence that small amounts of cyclopropane acids are present. The lipid classes include hydrocarbon, glycerides, free fatty acids, and phospholipids. Our observation would indicate that type E can be separated from types A and B on the bases of free fatty acids.

Institution: Georgia Institute of Technology.
Investigator: Nancy W. Walls.
Title: "Physiological Studies on *Clostridium botulinum*, Type F".
Contract No.: AT(40–1)3347.

Six sub-strains of the F immunologic type of *Clostridium botulinum* are being used to study the ability of this organism to grow, sporulate, and produce toxin at temperatures between 4 C and 40 C with particular attention to the 4 C to 10 C range, the temperatures encountered in refrigerated storage of food products.

The effect of the pH of the growth medium on growth and toxin production has been studied in the range of pH 5.2 to pH 7.9. Attainment of maximum growth of cultures is slower at pH 5.2 than at pH 6.4 to 7.9 but the highest toxin titers are found in the cultures grown at the lower pHs. In studies on the effects of media composition, the concentrations of enzymatic digests of protein, carbohydrate source, and yeast extract are varied in a liquid trypticase medium and a type C toxin medium and the cultures incubated at various temperatures from 4 C to 40 C. Toxin production is good in cultures incubated at all temperatures between 25 C and 40 C and the toxin persists in the medium for several days. The spores of type F are capable of germination, growth, and toxin production at temperatures between 4 C and 10 C, also, although the maximum level of toxicity of low temperature cultures is less than in cultures incubated at higher temperatures. Growth has been obtained at 4 C with as few as 3 spores per ml initial inoculum but the total amount of growth is a function of the strain of the organism being used. An increase in the total number of spores present in a culture incubated at 4 C has also been noted. The percentage of sporulation of a culture is sharply increased by a short incubation at temperatures in the 37 to 40 C range, followed by continued incubation at a lower temperature.

Studies of resistance of *C. botulinum*, type F spores to cesium-137 gamma irradiation show that the strain of the organism, the type of medium used during irradiation, and the recovery medium used affect the survival ratios. A minimum of 600,000 rads of gamma radiation is necessary to effect a 90 per cent kill even in the least protective of the media tested.

Institution: Hazleton Laboratories, Inc.
Investigator: Gilbert V. Levin.
Title: "Microbial Aspects of Radiopasteurized Chicken."
Contract No.: AT(30–1)3733.

Since initiation of this project on June 20, 1966, four principal requirements have been met. There are:

1. Culture collection

All the cultures required, except *Clostridium botulinum*, Type E, have been received. These include:

a. non-fecal coliforms
   5 from Communicable Disease Center (CDC)
   1 from Robert A Taft Santiary Engineering Center (TSEC)
b. fecal coliforms
   5 from CDC
   2 from TSEC
c. fecal streptococci
   5 from TSEC
d. Salmonella
   14 from CDC
e. enterotoxingenic stapyhylococci
   11 from Food and Drug Administration (FDA)
   7 from TSEC

Arrangements have been made with Dr. Clarence Schmidt of Continental Can Company to obtain the clostridial cultures.

The psychotrophic flora is currently being isolated and identified. Samples of chicken were permitted to spoil at 5° C. Homogenates of these samples are currently being assessed for the generic identification of the microorganisms responsible for spoilage.

Samples of all cultures are being lyophilized for shipment to the United States Army Natick Laboratories as well as for storage within Hazleton Laboratories.

2. Source of chicken

A site visit of Holly Farms, Richmond, Virginia, has been made. During this visit, a satisfactory procedure for obtaining prepackaged chicken was arranged. Holly Farms will randomly select our requirements and deliver their chill-pack selection to a retail store in Herndon, Virginia, less than five miles from the laboratory from which Hazleton Laboratories' personnel may obtain such material.

3. Packaging material

Polyethylene No. 309–T–1, the recommended packaging material, is being obtained from the Dow Chemical Company and we should receive this material in early September. This material has been used in previous food irradiation programs and was selected in order to maintain a uniformity with other programs. Furthermore, the use of other materials would only introduce another variable yet to be studied.

4. Irradiator

A Gamma Cell 220 which has sample chamber dimensions of 6 inches diameter and 8⅛ inches height and provides a dose rate of 1×10^6 rads per hour is available for use at Isotopes, Inc., Westwood, New Jersey.

The first scheduled date for irradiation of chicken is September 6. At this time chicken pieces will be sterilized for use within this program. In addition, detailed information about the type of dosimetry that is to be used, its position in the source and the type of container it will be in will be obtained.

Institution: Massachusetts Institute of Technology.
Investigators: S. A. Goldblith and J. T. R. Nickerson.
Title: "Treatment of Poultry with Ionizing Radiation to Destroy Salmonellae."
Contract No.: AT(30–1)3727.

This study was recently initiated to investigate several important questions in regard to irradiation pasteurization of frozen poultry. The aims of this proposal are: (1) To determine the D_{90} value for *Salmonella typhimurium* in chicken meat; (2) To determine the degree of increase of small numbers of Salmonellae surviving irradiation treatment of poultry when the product is mishandled; (3) To determine the level of Salmonellae contamination of commercially processed poultry or to examine a significant number of chickens (finished plant product) for Salmonellae contamination and numbers of organisms present. Procedures include a combination of irradiation, then freezing of products (or vice versa), followed by storage at 0° F. for 30 and 60 days.

Institution: University of Washington.
Investigator: Alexander M. Dollar.
Title: "A Study of the Basic Biochemical and Microbiological Factors Involved in the Irradiation Preservation of Marine Products".
Contract No.: AT(45–1)1730.

The general scope of the studies relates to the effects of radiation upon bacteria and tissues to improve storage life of fresh fisheries products. Considerable emphasis is given to studies of the effects of radiation on bacteria, both saprophytic (normal bacterial flora) and potentially hazardous, and the biochemical and chemical changes in fish tissues.

Microbiology and biochemistry

The natural flora present on fish at the time of processing is heterogenous. Changes take place in this commensal flora during storage depending to some extent on storage conditions. The biochemical capabilities and products from the action of this commensal flora will also change as the flora changes. The total numbers of organisms increased progressively as iced storage time increases. This is true for fillets stored in pouches as it is for whole fish stored in ice. The radiation dose reduces a total count in fillets prepared from fish immediately after catching to a level below accurate detection. This reduction is true to a lesser degree for samples taken from fish held in ice storage for up to 12 days. It is important to note that the storage life of fish irradiated in an absolutely fresh condition is greatly in excess of fish irradiated after ice storage for even as short a period of 4 days, hence the value of two stage combination of shipboard and shoreside treatment.

Studies have shown that salmonellae and potential pathogens increase in numbers very rapidly in crabmeat and English sole fillets held at 22°C. When lower temperatures are used, i.e., 8°C, these organisms can grow out on English sole fillets but not on crabmeat. When inoculated in high numbers, salmonellae are able to complete more effectively with the saprophytes. These data point out the potential hazard that exists when samples containing salmonellae are permitted to warm up to 8°C or higher. These results will presumably apply to non-seafood items as well as seafoods.

Irradiation largely eliminates organisms producing high amounts of total volatile base (TVB). Changing the environment such as the type of packaging and the degree of vacuum produced alters the biochemical processes during storage at 34°F. Incidence of bacteria reducing TMAO or yielding TVB is consistently low in irradiated fish. Since these biochemical activities yield products typical of spoiled fish, their repression provides a partial explanation for the extension of shelf life that results from the irradiated treatment.

Vapor phase studies:

Studies clearly show that packing in helium, or complete evacuation of the product, prevents development of rancidity and oxidation of fish products while in contrast, an atmosphere of nitrogen or air encourages the development of rancidity. This rancidity developes even when the nitrogen and the product are

kept in separate containers and combined only after exposure to radiation. These results confirm the necessity of irradiating fisheries products in an evacuated container to insure the best quality.

Indicators of radiation:

The studies with model systems and tissues demonstrated that radiation of glucose and other sugars, with phosphate buffers, yields products that will brown when heated. Free phosphate ions are essential for this discoloration during storage of heating. Here again, the studies indicate that fish tissues must be irradiated as soon after death as is possible to achieve the best quality and the greatest shelflife.

Catalase, an enzyme in tissues that destroys peroxides, is inactivated when irradiated (less than 100 Krads) in simple model systems and is partially protected in tissues. It is probable that catalase can serve to indicate that animal and fish tissues have been exposed to radiation.

Catalase is essential to protect the fish tissues from oxidative damage due to peroxides. Heating fish tissue before radiation inactivates the catalase and peroxides formed in the product are not destroyed. Unless the catalase activity is adequate to destroy peroxides, even very small concentrations of air result in the formation of significant concentrations of peroxides which can react with fish tissues. Hence the good results are observed when the very fresh products are irradiated and since cooking destroys catalase, more care is necessary in the irradiation pasteurization of cooked shellfish such as crab.

Institution: University of Wisconsin.
Investigator: Dean O. Cliver.
Title: "Mutagenesis of Enteroviruses by Gamma Rays".
Contract No.: AT(11–1)1645.

Viruses contaminating foods have been responsible for outbreaks of human disease. Polioviruses are thought to have been transmitted in foods, and it seems likely that other enteroviruses might be spread in the same fashion. Enteroviruses are among the smallest agents known to infect man and are not likely to be completely inactivated by "pasteurizing" doses (0.1 to 0.5 megarad) of gamma rays now being used in pilot-plant studies of food irradiation. Work by others indicates that 0.5 megarad, the upper limit of these dosages, is near the D value for enteroviruses.

The present study is intended to determine whether enteroviruses which have withstood these levels of irradiation are genetically typical of the input population. Model suspensions of laboratory strains of poliovirus type 1, Coxsackie virus types A9 and B2, and ECHO virus type 6 will be irradiated at dosages of 0.25 and 0.5 megarad and the residual virus tested for genetic variants. Mutations effecting genetic markers said to be correlated with virulence, host range, tissue tropism, and antigenic specificity will be sought. The findings are expected to give some preliminary indication of the possible consequences of radiation pasteurization of virus-contaminated foods.

Institution: University of California.
Investigator: Noel F. Sommer.
Title: "The Radiation Physiology and Microbiology of Fruit Deterioration".
Contract No.: AT(11–1)34, No. 73.

Objectives of this project have been divided between the immediate need to determine the practicability of a fruit irradiation technology, and the long-ranged need to obtain basic information about the normal and radiation-affected physiology and cytology of the important fruit pathogenic fungi and their hosts.

Toward the first objective, the results that have been obtained suggest that irradiation may be used as a therapeutic fungicidal treatment for certain fresh commodities. The result will be added time to permit transportation to more distant markets or less deterioration at present market sites. The most hopeful

of the results have come from tests which have demonstrated synergistic effects from combined heat and irradiation. Commodities once considered too sensitive to withstand irradiation, such as peaches and nectarines, have yielded excellent results with combined treatments. Heat sensitization permits use of a relatively low irradiation dose. Irradiation injury to the host is thereby minimized while the fungicidal effect is enhanced. This finding that, in fungi, the synergism between heat and irradiation may be large is clearly of great practical significance. Even strawberries, which receive an important benefit from irradiation alone, may possibly receive added benefits if the gray mold fungus, *Botrytis cinerea*, is sensitized by heat.

The response of fruits and vegetables to combined heat-radiation treatment must be further tested. Ripening, texture changes, and vitamin content are of particular importance in this regard. Results to date suggest that host injury is not synergistically increased by the combined treatment. Instead, adverse responses have been more typical of the effects of individual components of the treatment when applied alone.

With respect to the second objective, studies of the normal and radiation biology of fruits and their pathogenic fungi have produced results leading to these conclusions:

(1) Spores from different groups of fungi differ widely in their sensitivity to gamma radiation. Differences in sensitivity also exist among the various structures (hyphae, sclerotia, conidia) of the same organism. Besides these differences, the population size is important in determining what dose will be required to inactivate any fungus lesion; as the number of fungal reproductive units increases so must the dose be increased.

(2) A striking recovery from potentially lethal radiation damage is possible for spores of several species of *Rhizopus*, including *R. stolonifer*, *R. oryzae*, and two strains of *R. arrhizus*. Prevention of growth is necessary for recovery, but conditions otherwise favorable for growth must prevail. If aerated spores are suspended in water, or in anoxic suspensions containing glucose, recovery occurs. If recovery conditions are favorable, virtually all repairable spores are restored within 48 hours. A number of substrates other than glucose can sustain recovery inoxia; among the effective sugars are D-ribose, D-fructose, D-galactose, D-mannose, maltose, sucrose, and lactose. D-arabinose and celliobiose are ineffective. Certain inhibitors of protein synthesis (chloramphenicol, dihydrostreptomycin, 8-azaguanine, puromycin) were shown to prevent repair. Protection by cysteamine and repair of potentially lethal injuries are not independent and additive processes according to tests conducted with *R. stolonifer* sporangiospores. Evidently the types of lesions that can be prevented by the presence of cysteamine are also capable, if inflicted, of being restored by repair processes. The nutritional background of sporulating colonies was shown to have an effect on the radiation resistance and recovery ability of spores; spores from colonies grown on a rich medium were more resistant and showed greater recovery than these from colonies grown on a nutritionally deficient medium.

(3) Fine structure studies have begun to expand our meager knowledge of the subcellular organizations of fungal spores. They have permitted comparisons between structures of dormant and germinating cells as well as between irradiated and normal ones. It is believed that continuing these studies can contribute to a better understanding of the metabolic processes involved in radiation responses and in recovery.

(4) Certain irradiated food substances have been reported to induce toxic effects or mutations in various organisms. In some cases the reports appear to be questionable, particularly some of those concerning irradiated sucrose. In view of the potential use of irradiation as a fungicidal treatment for some food items containing sucrose, intensive investigation of the effects of irradiated sucrose is now under way, with chromosome aberrations in anaphase configurations of *Vicia faba* root tips serving as the criterion of possible undesirable effects.

The evidence obtained in preliminary work indicates that sucrose irradiated with doses up to 800 Krads from ^{60}Co caused very little chromosome damage.

Institution: University of California.
Investigator: Roger J. Romani.
Title: "Radiation Biochemistry of Fruit."
Contract No.: AT(11–1)34, No. 112.

Promise of a fruit irradiation technology lies in widening the disparity in radiation tolerance between senescent fruit cells and the cells of proliferating pathogens. Toward this end there is a need to understand the radiobiology of fruit tissues and especially their behaviour following massive irradiation.

In the past year substantial evidence has been uncovered for the presence of cytoplasmic repair in fruit cells receiving massive (250 to 1000 K rad) doses of ionizing radiation. This evidence includes the presence of a suppression and recovery in the respiratory control function of mitochondria and in the capacity of mitachondria to incorporate amino acids into protein, *in vivo*. In addition, evidence has been accumulated via electron microscopy, examination of various membrane characteristics, and sucrose density gradient centrifugation for the presence of radiation resistance among the intracellular organelles of fruit tissues.

Studies of more immediate and direct concern to fruit irradiation have been completed. These include the demonstration that direct gas-chromatographic sampling of fruit volatiles can be useful in discerning the effects of radiation on fruit ripening and volatiles (flavor) development. A paper is also to appear soon in *Radiation Botany* giving evidence for the presence of electron spin resonances (ESR) in irradiated fruit tissues. The ESR signals, requiring doses of approximately 1 megarad for detection decay to background noise levels in 15 to 30 minutes after exposure to a radiation flux of ca. 300 K rad per hour.

In keeping with the general objective of this contract two reviews have been prepared that emphasize the relevance of radiobiological information to research toward the development of a fresh food irradiation technology. The first of these reviews has appeared in *Radiation Botany*. The second entitled "Radiobiological Parameters in Food Irradiation" is to appear in the forthcoming issue of the *Advances in Food Research*.

Institution: Cornell University.
Investigator: Louis M. Massey, Jr.
Title: "Biochemistry and Physiology of Irradiated Fruits and Vegetables."
Contract No.: AT(30–1)3274.

The purpose of this project is to define the response of fresh fruits and vegetables to ionizing radiations, and to explain them in terms of biochemical and physiological reactions. To this end, an investigation of the intermediary metabolism of irradiated tissues for the biochemical cause of the previously reported respirational stimulation continues to be emphasized. It has been determined that, although acetate catabolism through the tricarboxylic acid cycle is stimulated by irradiation in a manner identical to that of overall respiration, both acetate anabolism and succinate anabolism and catabolism are inhibited. A solution to this anamoly is presently being searched for. The presence of a radiation-resistant shunt around the radiation-sensitive succinic dehydrogenase enzyme system is postulated.

In non-irradiated carrot tissue, the radiation degradation products of both glucose and sucrose have no discernable effect upon the direction or magnitude of either carbohydrate and tricarboxylic acid metabolism. In no instance has any response suggesting either a duplication of or an explanation for the adverse effects of these products reported by others, been obtained.

Another aspect of tissue response to ionizing radiation which has been investigated is that of texture. Radiation-induced softening in carrot tissues has been defined in detail by means of the Instron Universal Testing Machine in terms of the General Foods Texture Profile. The softening threshold of most components appears to be essentially similar. The quality of "hardness" appears to be the most significant single factor of radiation response. Additional investigation has indicated that the initial loss in hardness at doses around and slightly above the threshold is due to causes of physiological origin such as wilting. This

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is followed at higher doses by softening due to the radiation degradation of pectin and cellulose. The effect of radiation upon the permeability of cells to water and to both organic and inorganic compounds of biological significance is being pressed.

Institution: University of California.
Investigator: William D. Brown.
Title: "Radiation of Heme Proteins."
Contract No.: AT(11–1)34, No. 95.

Gamma irradiation (500 krads) of purified myoglobins and hemoglobins (the pigments found in meats and most fish) alters spectral properties, slightly changes the shape of the molecules, lowers the pH of the solutions irradiated, but does not change the ability of these proteins to oxygenate.

In connection with the change in pH of irradiated solutions, we have investigated the effect of pH on oxidation of these heme proteins, since such oxidation may occur in some food products. The findings show that the rate of oxidation of oxymyoglobins and oxyhemoglobins is directly dependent upon H+ ion concentration, i.e., the rate of oxidation is doubled when the concentration of H+ is doubled. This may indicate a direct involvement of H+ in the oxidation mechanism.

We have studied the production of malonaldehyde from these proteins and from amino acids following irradiation, since such production had been reported by others. The results indicate that a malonaldehyde-like substance produced from irradiation of amino acids is derived from contaminants and is not formed from the amino acids *per se*. No malonaldehyde was produced from irradiation of solutions of myoglobins and hemoglobins. These proteins will, however, bind small amounts of malonaldehyde (as will other proteins) so that if malonaldehyde were produced in irradiated foods, there would probably be some reaction with the heme proteins. As a "spinoff" finding from these studies, we have found that many lipid solvents of commercial purity are contaminated with malonaldehyde-like materials which may cause erroneous results in studies of lipid oxidation unless they are carefully purified.

Radiation of heme proteins at 0° C. rather than at ambient temperature of the source (24–26° C.) results in less damage. There is also some preliminary evidence that different myoglobins from the same animal source (the so-called "multiple" myoglobins) may show different susceptibility to radiation. These findings await confirmation.

Institution: University of Massachusetts.
Investigator: Wassef W. Nawar.
Title: "Stability of Food Lipids to Ionizing Radiation."
Contract: AT (30–1) 3499.

This project was initiated to investigate in detail the effects of ionizing radiation on food lipids with emphasis on trace changes which could be significant from the standpoints of both flavor quality and wholesomeness. Pork fat, beef fat and fish oil were irradiated in vacuum at doses varying from 0.4 to 5.0 megarads and their volatiles examined by gas chromatography.

Significant changes were found to be induced by the irradiation of beef and pork fat; in both cases the major components formed consisted of a series of saturated and unsaturated hydrocarbons. On the other hand, the effect of irradiation on the volatile composition of fish oil appeared to be of a different character. "Mackerel" was chosen as a representative of fish species with high fat content. The fresh unirradiated oil gave a complex but reproducible gas chromatographic pattern of volatiles. Irradiation at 5 megarads caused the destruction of certain volatile components and the formation of others. At lower doses the same trends could be observed but the magnitude of changes was smaller, with those at 0.4 megarad barely detectable. A gas chromatographic-mass spectrometer system has been installed and is now being used for the identification of these compounds.

Since the organoleptic implications of such hydrocarbons as found in irradiated foods have not as yet been established, a study is in progress to elucidate this aspect of flavor chemistry.

In addition, the effect of irradiation on the susceptibility of fish oil to oxidation is being determined by oxygen absorption and other conventional methods. Model systems will be used to aid in explaining the mechanism of changes induced in polyunsaturated fats by ionizing radiation.

Institution: Bureau of Commercial Fisheries, Gloucester, Massachusetts.
Investigator: Joseph W. Slavin.
Title: "Study of Radiation-Pasteurized Fishery Products—Fundamental Radiation Chemistry Studies".
Contract No.: AT(49–7)2443.

INTRODUCTION

The overall objective of these studies is to find a solution for those technological problems in which a fundamental knowledge of the radiation chemistry of fishery products is the most efficient approach in doing the research. Since the last Congressional hearing, the specific objectives of this research effort covered four important areas:

(1) Development of analytical methods and instrumentation.
(2) Study of effects of irradiating seafood products in inert or reducing atmospheres.
(3) Study of enzyme inactivation techniques.
(4) Study of penetration gradients of bacteriostatic salts.

Development of analytical methods and instrumentation

Most of our studies in analytical methods are designed to improve our knowledge of the chemistry of seafood odor and flavor. To collect the significant components from seafoods, we have developed two techniques—high-vacuum, low-temperature distillation (for odor components) and solvent extraction (for flavor components). To identify these components, we have employed gas chromatography and mass spectrometry. If the mixture contains many components, they can be identified more accurately if they are separated first into chemical classes according to their functional groups. We have developed specific techniques to separate carbonyls (using Girard-T reagent) and amines (using an ion exchange resin) from mixtures of volatile compounds. These techniques will be used to identify the components of volatiles obtained from radiopasteurized seafood. The analytical results will be compared with organoleptic evaluations to determine which of the identified compounds are significant.

Study of effects of irradiating seafood products in inert or reducing atmospheres

We are studying the effect of radiopasteurizing fillets in the presence of inert or reducing gases to determine (1) if these gases could complement the bactericidal effects of irradiation, and (2) that they might minimize damage to product quality due to radiation-induced oxidative reactions. Preliminary experiments have been conducted in cooperation with Massachusetts Institute of Technology. The bacteriological results suggested that hydrocarbon gases acted as synergists since irradiation in either gas instead of air doubled the bactericidal effect of radiopasteurization. The organoleptic results indicated that these gases adversely affected quality of the product. Since the bacteriological results are promising, more work is planned to develop a suitable process which does not impair product quality.

Study of enzyme inactivation techniques

The synergistic effect of irradiation followed by heat has been demonstrated by a number of researchers. One important implication of this finding is that lower radiation doses might be used for radiopasteurization to achieve lower processing costs and least quality damage to the product. Radiopasteurization is effective in reducing the number of viable spoilage bacteria in the product but is is much less effective than heat in reducing the activity of bacterial and autolytic enzymes. Therefore, we plan to study which enzymes limit product storage life and the effectiveness of synergistic processing (irradiation followed by heat) in extending storage life of the product.

Study of penetration gradients of bacteriostatic salts

We are presently studying the penetrability of the disodium salt of ethylene diaminetetraacetic acid (Na_2 • EDTA) into haddock flesh since Continental

Can Company researchers have found that Na_2 • EDTA inhibits growth of *Clostridium botulinum* Type in minced haddock flesh. The Food and Drug Administration has not yet established a maximum allowable concentration for Na_2 • EDTA in all points of the dipped fillet are almost the same.

Since Na_2 • EDTA is a sequestering agent, its inhibiting activity against *Clostridium botulinum* may be due to this property. Our studies indicate that haddock flesh possesses sequestering properties of its own. These findings suggests a need to determine the magnitude of variations in the sequestering capability of the other species of seafoods for which radiopasteurization is being considered. They also suggest that a lower concentration of Na_2 • EDTA may inhibit botulism if a method were found to prevent any of the added Na_2 • EDTA from sequestering normal constituents of the flesh instead of *Clostridium botulinum*.

Appendix 7

Discussion of Radiopasteurization of Meats

Michigan State University,
College of Agriculture,
Department of Food Science,
East Lansing, Mich., February 25, 1966.

Dr. Kevin Shea,
Chief, Radiation Processed Foods Section,
Radiation Applications Branch,
Division of Isotopes Development,
U.S. Atomic Energy Commission,
Washington, D.C.

Dear Dr. Shea: This is in response to your letter of February 17 regarding the use of radiation to extend the shelf life of meats.

I am enclosing a reprint of an article, "Radiation Preservation of Fresh Meat and Poultry," which I presented at the International Conference on Radiation Preservation of Foods in Boston, September, 1964. On page 89 of this reprint there is a section dealing with pasteurization. I call your attention to the first full paragraph of page 90. This paragraph, I believe, summarizes the situation and the use of radiation in pasteurizing doses for preserving fresh meats and poultry under refrigeration.

As you know, there are basically two types of meats: fresh, typified by steaks and chops; and cured, typified by ham and certain sausages such as bologna. Vacuum packaging has been applied effectively to the protection of cured meats. The exclusion of oxygen protects the color and gives very significant product life extension. In my judgment vacuum packaging of such meats makes it unnecesary to consider the use of radiation in their preservation through normal refrigerated channels. Fresh meats on the other hand are not amenable to vacuum packaging without seriously affecting color. The fresh meat pigment requires oxygen to be available in order that the color be the typical bright red of such meats. Some work I have done has indicated that vacuum packaging applied to fresh meats without regard to color will delay microbial spoilage very much as it does for cured meats. The question of the effect of vacuum packaging on the color of fresh meats is primarily in the field of marketing. So far, the view point has been that the dark color experienced with vacuum packaging is unacceptable.

There is an increasing interest in finding ways to accomplish centralized cutting of fresh meats. Currently because of the extreme perishabiltiy of fresh meat, fabricated into retail cuts, this operation is done at the retail outlet. Since microbial spoilage is one factor preventing this, it would appear that radiation could be helpful. However, as the reprint I cited above indicates, there are other factors of spoilage which are not controlled by the radiation and which are very important in the merchandising of the product.

I trust that the above will be of help to you in connection with your inquiry.

Yours very truly,

Walter M. Urbain,
Professor, Food Science.

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RADIATION PRESERVATION OF FRESH MEAT AND POULTRY

WALTER M. URBAIN
Swift & Company
Chicago, Illinois

The Effects of Ionizing Radiation on Fresh Meats and Poultry

Ionizing radiation can destroy spoilage microorganisms regardless of the state of the meat or poultry, that is, whether raw or cooked, frozen or unfrozen. Generally speaking, radiation does not alter the state of the meat, and, largely for this reason, the radiation preservation of fresh meats and poultry has been a matter of great interest from the date of the earliest observations (Proctor, Van de Graaff, and Fram, 1942). Some effects other than the destruction of spoilage microorganisms do occur, however. These include:

(1) Color changes: The red pigments of raw meats and poultry become brownish. Cooked meats and poultry in the absence of oxygen turn pink. The magnitude of the color changes is somewhat dependent on the dose.

(2) Texture: A softening of the lean tissue can occur, the degree of this effect being related to the dose (Bailey and Rhodes, 1964).

(3) Fats: Oxidation with concomitant development of a rancid flavor can be caused; access to oxygen during or after irradiation increases the amount of rancidity. This effect is likewise related to the dose.

(4) An odor and/or flavor change may occur. This most important change, generally regarded as undesirable, is characteristic and resembles a kind of scorching. Within limits the amount of irradiation-flavor development is dependent on the dose. There is, however, a species variation in the effect. The following is the generally accepted order of increasing sensitivity to flavor development:

1. Pork, Chicken
2. Lamb, Veal
3. Beef

No adequate explanation for the relation of this effect to species has been obtained. The order of increasing sensitivity is roughly the same as the order of increasing myoglobin content of the skeletal muscle tissue. It might be useful to extend the knowledge of this sensitivity to more species to learn if correlation can be made with some specific characteristic.

Within a species, it appears that the flavor or odor sensitivity is not related to the fat content of the tissue (Whitehair, Bray, Weckel, Evans, and Heiligman, 1964). While fat *per se* can undergo flavor changes upon irradiation, the characteristic irradiated flavor of meats and poultry has been associated with the protein portion. Many substances have been identified as

occurring in irradiated meats, but no specific definition of the flavor has been secured.

Flavor and odor changes due to irradiation can be reduced by three general approaches:

(1) Exclusion of atmospheric oxygen during and after irradiation (Brasch and Huber, 1948).

(2) Addition of substances referred to as free radical acceptors (Proctor, Goldblith, Bates, and Hammerle, 1952).

(3) Irradiation at low temperatures (Brasch and Huber, 1948; Coleby, Ingram, Shepherd, Thornley, and Wilson, 1961).

Of these, (1) and (2) have only a relatively small effect. Irradiation at very low temperatures, on the other hand, can virtually eliminate flavor changes in the most sensitive of meats, namely, beef. The rationale for these measures appears to be on a sound basis. All are related to controlling the indirect effect of radiation. Elimination of atmospheric oxygen removes the possibility of the radiation-producing ozone or other chemically active forms of oxygen. Such forms of oxygen can cause flavor changes. Free radical acceptors preferentially react with free radicals present in the meat as a result of the action of radiation on tissue water, fats, etc., and in this way remove them before they can cause flavor changes. Only a few such substances have been found, among which the most effective is ascorbic acid. Low temperatures during irradiation immobilize water molecules and any free radicals generated by the action of radiation on them. This limits reaction with other constitutents and thereby controls off-flavor development. Apparently the degree of mobility and the character of the free radicals are a matter of how low the temperature is; simple freezing does not maximize the effect.

Data obtained in our laboratory by Kauffman and co-workers are shown in Table 1. At −196° C the amount of irradiated flavor produced in beef at 6.0 megarads is such that only critical evaluation by a "trained" panel is likely to detect it. At higher temperatures more flavor can be detected, the amount increasing with the temperature of irradiation. The

Table 1

Effect of Irradiation Temperature on Beefsteak Flavor (6.0 megarads)

Irradiation temperature	*Flavor score* [a]
25° C	5.07 [b]
−25	4.37 [b]
−80	4.08 [b]
−140	3.52 [b]
−196	2.35 [b]

[a] Six-point scale: 1 no irradiated flavor, 6 very much.
[b] 95 per cent confidence level ±0.35.
Data of Kauffman, Harlan, and Rasmussen, Ref. A.

amount of flavor inhibition at −169° C is such as to make beef irradiated at 4.5 megarads probably acceptable to the public.

Other means of reducing flavor effects have been tried but with little or only moderate success. These have included adsorbents; storage of irradiated meats at moderately high temperatures (room or higher); and the use of flavorings, spices, and other ingredients such as tomato to mask the irradiated flavor.

One might expect that changes other than those listed also occur. It is known that some constituents such as vitamins are partially destroyed. Such changes are generally considered as having no large significance and are of the type associated with any processing, as for example thermal processing.

Use of the Irradiation Process on Fresh Meats and Poultry

The proposed uses of radiation in preserving fresh meats and poultry vary according to objectives. Two broad objectives have been advanced:

(1) To extend in a limited way the life of meats and poultry when handled with refrigeration (pasteurization).

(2) To obtain indefinite product life without refrigeration or other preservative agent (sterilization).

PASTEURIZATION

The purpose is to kill enough microbes to effectively delay the appearance of a microbial population large enough to constitute spoilage. It is expected that spoilage could eventually occur, but only after a time period long enough to permit distribution and consumption of the food. The initial microbial population and the desired or tolerable population after irradiation establishes the dose requirement. The desired or tolerable population after irradiation in turn is related to the storage conditions and the product-life-extension requirement.

For fresh meats and poultry in the United States, storage conditions probably will be 2–12° C. Packaging will be in moisture-proof but oxygen-permeable transparent flexible films. Product life would need to be one to three weeks.

A dosage of 100,000 to 250,000 rads probably would be required to provide such product life. At the higher level, beef irradiated at conventional temperatures exhibits a noticeable irradiation flavor. For meat from other species, including chicken, this level probably would have acceptable flavor.

The usual spoilage bacteria of fresh meat are primarily of the genus *Pseudomonas*. These organisms are easily killed by radiation. Growth of the more resistant *Microbacterium* species tends to become the cause of spoilage of irradiated fresh meats. The *Microbacterium* species, on the other hand, are quite sensitive to certain antibiotics such as the tetracyclines

(Niven and Chesbro, 1956). When meat is treated with both radiation and a tetracycline, bacterial spoilage at 2° C is delayed significantly. In fact, the

Table 2

Treatment	*Days for tenfold population increase*	
	Yeasts & Molds	*Bacteria*
None	>20	2–5.5
Irradiation (10^5 rep)	3.5–9.0	4–6
Oxytetracycline (10 ppm)	3	7–8
Sorbic acid (0.1%)	>20	3–5
Irradiation plus oxytetracycline	4	14
Irradiation plus sorbic acid	8–17	8–17
Irradiation plus sorbic acid—plus oxytetracycline	15–23	16–33

Data of Niven and Chesbro 1956–57.

surviving microorganisms now are yeasts and molds. These in turn are subject to control by sorbic acid. The data of Table 2 show the effects of combinations of treatments in beef.

Despite the possibilities of control of microbial spoilage through radiation combined with other agents such as antibiotics and sorbic acid, there remain other problems to solve before a product of satisfactory consumer acceptability can be had. These problems are (1) the slow changes in the meat pigments through action of atmospheric oxygen (which is needed to produce and maintain the initial bright red color) and (2) the collection of serum liquid (drip) in the package. These and other appearance changes not related to microbial action are important in making fresh meats and poultry unacceptable in time and, until controlled, are a deterrent to the application of pasteurizing doses of radiation for meats and poultry (Urbain, 1955; Coleby, Ingram, and Shepherd, 1960).

STERILIZATION

This process requires destruction or inactivation of all microbial life. It also requires isolation of the product from all new sources of microbial life; that is, there must be effective packaging in sealed containers.

Since fresh meat and poultry are nonacid low-salt foods capable of supporting the growth of the toxin-producing anaerobe *Clostridium botulinum*, the radiation dose applied must accomplish destruction of this organism. The dose required to do this is considered to be 4.5 megarads. This amount of radiation is sufficient to destroy all other microorganisms (with apparently one exception, a micrococcus not commonly encountered and of no public health significance (Anderson, Nordan, Cain, Parrish, and Duggan, 1956)). The large size of the dose required for sterility has been the reason for efforts to find ways to obtain the same result with less radiation. One such effort

led to the discovery that radiation sensitized spores to heat (Morgan and Reed, 1954). It was found that *C. botulinum* in beef irradiated with 1.2 to 1.5 megarads required about one fourth the heat process (measured by F_0) as unirradiated beef for complete destruction. Unfortunately the reverse process does not show the same result; a pretreatment with heat does not reduce the radiation requirements (Kempe, 1955). Recently it has been reported that the radiation sensitivity of *Salmonella typhimurium* suspended in egg yolk increased as a function of irradiation temperature from 0° C to 55° C (Licciardello, 1964). Also recently, an ultrasonic treatment prior to irradiation has been shown to sensitize to radiation *Micrococcus radiodurans* and *Streptococcus faecalis* suspended in buffer solution (Dharkar, 1964). These new observations may point to methods for dose reduction of *C. botulinum.*

The principal problem with sterilized meats is the flavor change. For pork and chicken even at 4.5 megarads this does not appear serious. But for beef the amount of flavor development from irradiation at the 4.5-megarads level at ordinary temperatures is sufficient to make it unacceptable. By carrying out the irradiation at liquid-nitrogen temperatures (approximately —196° C), as stated earlier, virtually all irradiated-flavor development is prevented, and beef of acceptable taste can be prepared. The data of Kauffman and co-workers, also referred to earlier, indicate an inhibition effect inversely proportional to the temperature of irradiation. Whether it is necessary to go as low as liquid-nitrogen temperatures depends on what level of irradiated flavor is considered acceptable. Only consumer testing can provide data for determining what is acceptable.

It is generally accepted that the lethal action of radiation on microbes is a combination of the direct and indirect effects. Consequently irradiation at low temperatures would be expected to have some effect on the dose required for sterility. The results of various workers indicate that there is some additional amount of radiation required, of the order of 15 per cent at —75° C over 0° C (Ingram, Coleby, Thornley, and Wilson, 1959. See Figure 1). It appears that even with such a penalty the gain in off-flavor reduction is sufficient to warrant the use of low temperatures.

Since raw meat and poultry contain native enzymes, it would be expected that their inactivation is necessary for product stability. At the dose levels adequate to destroy microbial life, radiation does not cause such enzyme inactivation. Bitter flavors that have been observed to occur when irradiated meats are stored have been correlated with the presence of tyrosine (and likely with other amino acids). Likewise, texture alteration has been noted (Kirn, Urbain, and Czarnecki, 1956). Since radiation at the dose levels likely to be used does not inactivate the native enzymes, some other means of accomplishing this must be used. To date only heat has been an effective and practical agent for this. Inactivation of enzymes involves both time and temperature. Data for beef and pork are shown in Figure 2 (data of Chiambalero, Johnson, and Drake). As a consequence, radiation-sterilized meats cannot be raw but must be moderately well cooked. This in itself is

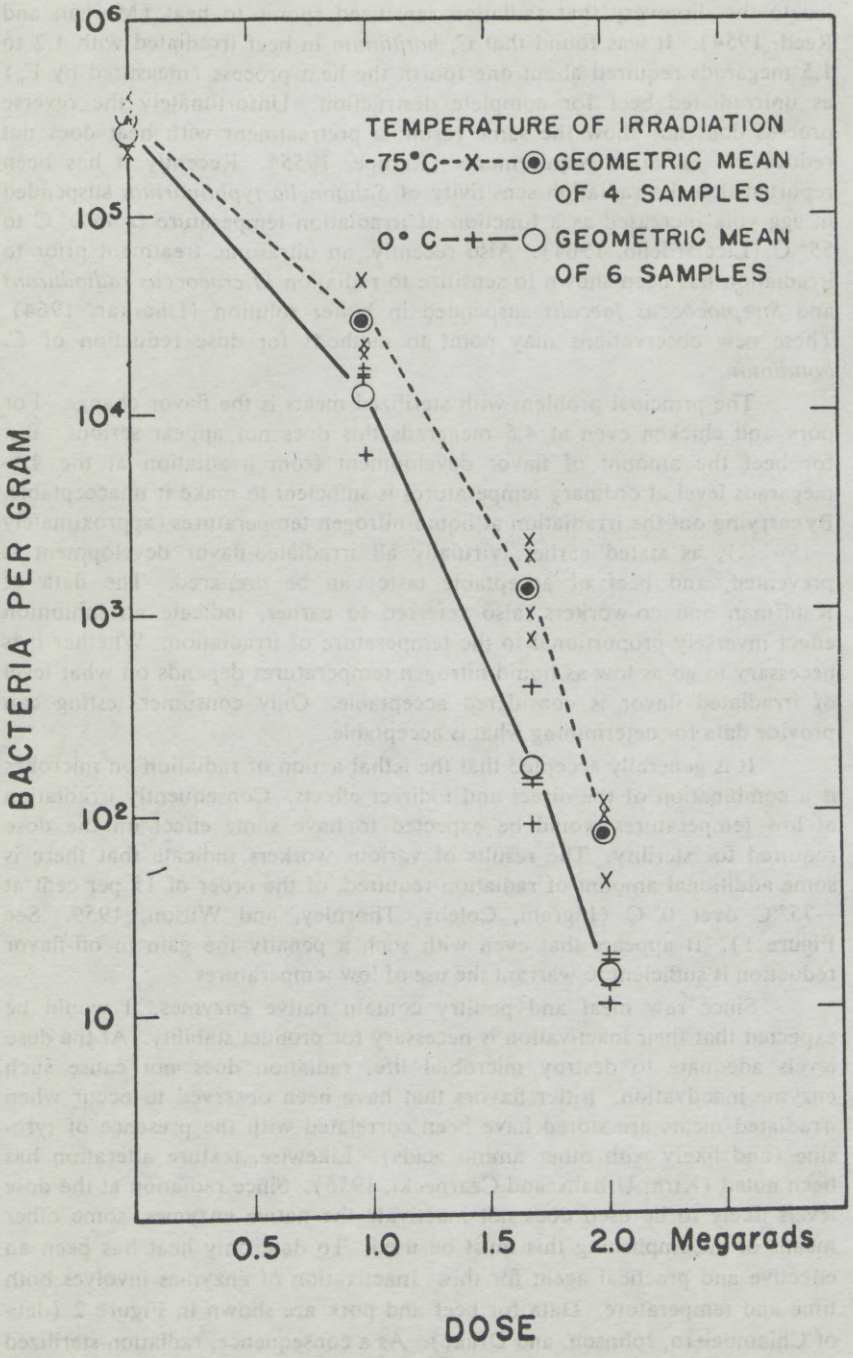

Figure 1. Irradiation of *Clostridium botulinum* spores in raw minced pork at different temperatures.

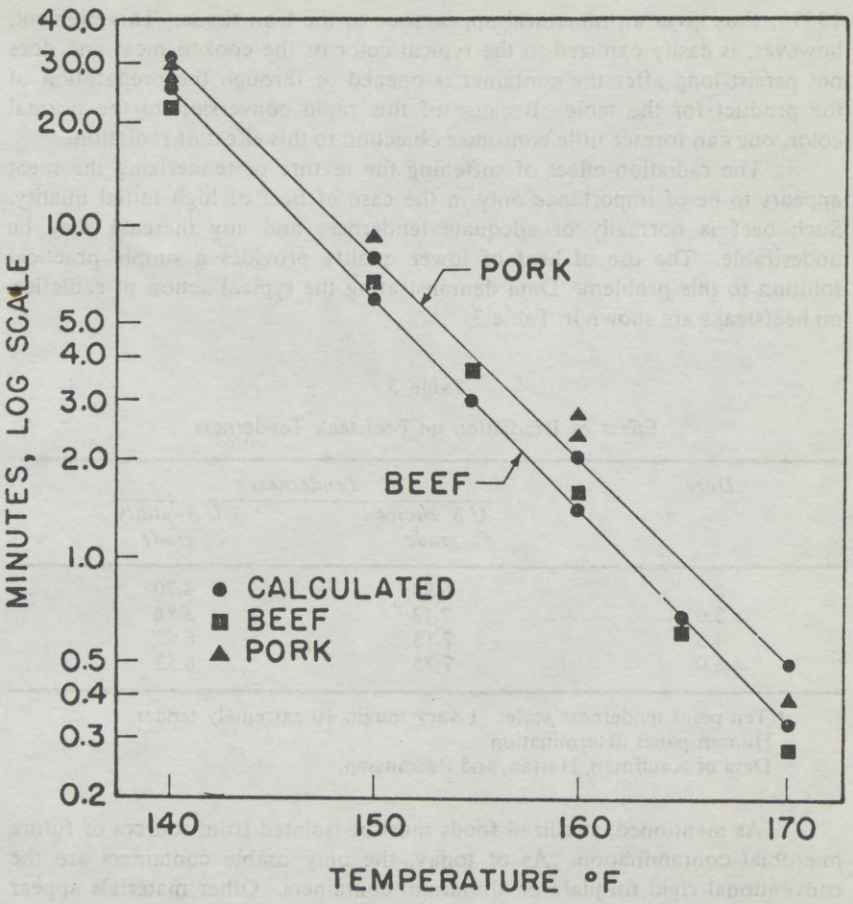

Figure 2. Time vs. temperature plot of regression lines for enzyme inactivation in irradiated beef and pork.

not a very important factor in acceptance, since meats need cooking before consumption. Cooked meats, however, have a characteristic flavor when rewarmed which, while generally not objectionable, does not have the appeal of freshly prepared meats. In addition there can be a dryness that is undesirable. The chef may have the opportunity to use his skills to overcome these deficiencies of flavor and texture.

Because of the heating to inactivate the native enzymes, the color of meats and poultry is changed from red or pink to brown or grey (the color of cooked meats). As mentioned earlier, the effect of radiation, in the absence of oxygen, on the cooked meat pigments is to turn them pink. The pink pigment, which has been identified as mychemochromogen (Tappel,

1957), thus gives an unnatural appearance to the lean tissue. This pigment, however, is easily oxidized to the typical color of the cooked meat and does not persist long after the container is opened or through the preparation of the product for the table. Because of this rapid conversion to the normal color, one can foresee little consumer objection to this effect of radiation.

The radiation effect of softening the texture or tenderizing the meat appears to be of importance only in the case of beef of high initial quality. Such beef is normally of adequate tenderness and any increase may be undesirable. The use of beef of lower quality provides a simple practical solution to this problem. Data demonstrating the typical action of radiation on beefsteaks are shown in Table 3.

Table 3

Effect of Irradiation on Beefsteak Tenderness

Dose	*Tenderness* [a]	
	U.S. choice grade	*U.S. utility grade*
0	6.94	4.70
3.0	7.13	5.86
4.5	7.13	6.62
6.0	7.75	6.53

[a] Ten-point tenderness scale: 1 very tough, 10 extremely tender.
Human panel determination.
Data of Kauffman, Harlan, and Rasmussen.

As mentioned, sterilized foods must be isolated from sources of future microbial contamination. As of today, the only usable containers are the conventional rigid tin-plate or aluminum containers. Other materials appear to suffer radiation damage that renders them unsuitable.

Cost

It appears, therefore, that the major technical problems in the preparation of shelf-stable irradiated meats and poultry either have been solved or can easily be coped with. Since wholesomeness will be the subject of another paper, we will pass it simply with a note that we are encouraged to expect governmental approval for fresh meats and poultry when all the data now being gathered become available.

There remains then the question of cost. With only laboratory-scale experience as a basis, can we give some answer to this question? A number of estimates have been given previously and perhaps there is not too much value in additional attempts at this time. It may be of interest, however, to present the approach of a commercial organization, which to date appears not to have been done.

An estimate of costs involves (1) capital costs incurred in setting up the facility and (2) operating costs. These are shown in Tables 4, 5, and 6.

Table 4

Sterilization Plant

Capital Costs		
1. Source: 3×10^6 curie Co-60		
@ 30¢/curie	$900,000	
Transportation	30,000	
Sub-Total		$930,000
2. Building, etc.		880,000
3. Liquid N facility		750,000
Total		$2,560,000

Table 5

Sterilization Plant

Operating Costs	
1. Labor	$ .70/cwt
2. Source maintenance	.68
3. Liquid N	.85
4. Mechanical refrg.	.05
5. Repairs & utilities	.08
6. Taxes & insurance	.45
	2.81/cwt

Table 6

Sterilization Plant

Capital Costs	
Plant $2,560,000	
Capacity at 26% efficiency—17,000,000 lb/year	
50% rate of return	$14.33/cwt
25% " " "	$ 7.15/cwt
Operating Costs	$ 2.81/cwt
Total Costs	
50% rate of return	$17.14/cwt
25% " " "	$ 9.96/cwt

Considering the source 26 per cent efficient, it should treat 17,000,000 lbs of product per year at 4.5 megarads. To provide a rate of return of 50 per cent after taxes on the invested capital (using a basis of a 10 year economic life for the facility and straight line depreciation) would require $14.33/cwt over operating costs or a total of $17.14/cwt. With the same

conditions, a 25 per cent return on invested capital would require $7.15/cwt over operating costs or a total of $9.96/cwt. It should be noted that the capital costs expressed in relation to a rate of return must be considered in the economic appraisal, since no capital money is likely to be made available unless adequate return is anticipated. The rates of return used in these estimates, namely, 50 per cent or 25 per cent, are fairly typical for the kind of business venture involved with irradiated foods. (A 50 per cent rate of return approximates a one year payoff of investment; 25 per cent, a two year.) The rate-of-return requirement for a particular business venture, however, is not a fixed matter, but is subject to a management decision.

From these figures, it can be seen that capital costs for sterilized products are the major costs, but have the potential for being reduced. The following specific factors appear particularly promising:

Sources: It will be noted that a cost of 30¢ per curie has been used. This figure might be lowered under some circumstances. A 26 per cent efficiency in the use of the source has been used in the calculation. Better design of the facility or possibly the use of other sources might improve this.

Dose: Reduction in the amount of radiation required can reduce capital cost or increase capacity.

All these factors relating to source or dose could reduce capital costs.

The use of liquid-nitrogen temperatures may be debatable, even for beef. As the cost estimate shows, it accounts for about one third of the capital and operating costs. From a cost viewpoint, its elimination is obviously desirable.

Whether costs such as shown, or others that might be obtained, can fit in with commercial opportunities can hardly be known without the test of experience. Obviously the estimated high capital costs presented are a deterrent, at least until marketing experience provides a basis for confidence that an adequate return will be obtained. At present, the best way to proceed appears to be through pilot planting by which practical operating knowledge, cost determination, and marketing experience can be had. Pilot planting should:

(1) Confirm the basic process as defined through laboratory studies, or point to the need of modification.

(2) Enable the working out of practical requirements for handling, reliability, efficiency, etc.

(3) Supply the product in limited quantities so that additional information on consumer acceptance can be obtained. This can include limited market testing.

(4) Establish process-cost information.

(5) Provide design data for full-scale operation.

Encouraging results at the pilot-plant scale will lead to full-scale operation. With full-scale operation available, the future depends on adequate consumer acceptance of irradiated products in competition with the many other food products of the market place.

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Appendix 8

Centralized Processing of Fresh Meat for Retail Stores

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CENTRALIZED PROCESSING OF FRESH MEAT FOR RETAIL STORES

An Interim Report

By Marvin D. Volz and James A. Marsden, industrial engineers, Wholesaling and Retailing Research Branch, Transportation and Facilities Research Division, Agricultural Marketing Service

SUMMARY

Processing retail cuts of fresh meat in a central plant for a group of retail stores can save thousands of dollars annually in construction, equipment, and labor costs--as much, for example, as $650,000 for a group of 40 stores with a yearly meat volume of $13,000,000. Benefits from such reductions in marketing costs are likely to be shared by consumers through lower prices at retail and by producers through higher prices for livestock.

These savings were projected from results obtained by research in smaller central plants. The savings represent approximately half of the operating costs, compared to those of a firm processing an equivalent volume of meat in conventional-store meat backrooms.

Central meat processing offers additional opportunities for savings due to: (1) Better distribution of meat cuts according to market preferences, (2) more uniform and efficient cutting methods, (3) better control of overhead costs, (4) advantages of quantity purchases, and (5) a better market for carcass byproducts.

Central processing of fresh meats has been attempted in this country by a number of firms, but, except in a few cases, has not been successful. The primary difficulties encountered by these concerns appeared to be over-ordering or under-ordering, due to poor production planning and control; and lack of shelf life, due to improper sanitation and temperature control. Because of the limited shelf life of fresh meat, quantities on display and production must be carefully controlled.

A system was developed by the researchers to provide industry with procedures for: (1) Determining how much and when to produce, (2) maintaining uniform workloads for men and equipment, (3) scheduling work to men and equipment, and (4) scheduling store deliveries.

Specially designed equipment and efficient work procedures can greatly increase productivity, thereby reducing the total operating costs by a substantial amount. Equipment and operational procedures recommended are:

1. The central plant should schedule the major part of the week's supply of meat products for delivery during the first part of the week, so that work schedules can be better balanced. The coolers should be designed with ample storage facilities to allow the central plant to receive on the basis of a limited number of shipments per week. This also permits shipment of full loads of product to the plant.

2. Blocking of carcass beef into primal cuts should be done well in advance of retail cutting. The blocking operation preferably should be done in the cooler by crews equipped with portable power saws which can easily be moved to the product.

3. To increase production at the cutting stations, two- or three-man crews should be used during peak periods. Meat rails should feed the primal cuts to the individual cutting stations.

4. Automatic wrapping machines, scales, label printers, and handwrapping stations designed for efficiency should be used in the packaging and pricing operation.

5. The selection cooler should contain enough fixed slot racks and gravity-flow conveyors to store all the peak day's production.

6. Shipping containers should have the following features: (a) Size and weight that permits easy handling, (b) a shape so they can be nested when empty, (c) ability of material to withstand rough handling and cleaning methods.

7. Delivery trucks should be equipped with self-contained refrigeration units.

8. All power equipment and cutting blocks should be thoroughly cleaned at least once a day, and perhaps even more often, to obtain at least 2 to 5 days of shelf life for fresh red meats.

9. The recommended temperature levels for the various storage and processing areas are as follows:

a. Storage cooler, 30° to 33° F.
b. Processing area, 32° to 40° F.
c. Selection cooler, 30° to 33° F.
d. Refrigerated truck, 28° to 31° F.
e. Store cooler, 32° to 34° F.
f. Retail display cases, 29° to 32° F.

Retail stores should be staffed with enough personnel to handle adequately the special order requests of the customers, to police and stock the display cases, to price mark and display prepackaged luncheon meats, and to take daily inventories of the meat display cases. It was also found that the retail-store meat backroom area could be reduced by over 50 percent when retail cuts of meat were supplied by a central plant.

Layout designs for central plants of low, medium, and high volume have been developed as a guide to the industry. These layouts permit a straight-through flow of the products, from receiving area to carcass storage area, to blocking area, to primal-cut storage area, to cutting area, to wrapping and pricing area, to line unloading area, to order-selection area, to bill-out area, and finally to shipping area.

The research results presented in this report will be revised and refined as more experience and information are obtained.

BACKGROUND

The meat department sales of retail food stores represented about one-fourth of the total annual food store sales of $54 billion in 1961.[1] Handling costs in the meat department are more than 1/4 of total store expenses because of the extra refrigerated equipment, supplies, and labor required. At present, most supermarket companies are processing fresh meat at each individual store into retail cuts that are weighed, priced, and packaged, ready for sale from self-service refrigerated display cases.

Considerable work has been done in the past 12 years by the U.S. Department of Agriculture and other researchers to improve the efficiency of self-service meat departments through development of improved methods, materials, equipment, and layouts. Dollar sales per man-hour in meat departments have moved steadily upward from about $20 in 1950 to $40 in 1962. Substantial further operational efficiencies appear to be limited in processing in the backroom of retail stores. Improvements in food-handling practices have led to reexamination of the feasibility of central handling and packaging of fresh meats.

Luncheon meats, produce, and bakery items are, in many cases, being packaged and priced for retail sale at central processing plants. Several large corporate chains and voluntary group wholesalers have centralized such operations as carcass blocking, boning

[1]Facts in Grocery Distribution, 1962 Edition, Progressive Grocer Magazine.

of rough cuts, and the ground meat operation. Ground meat is being packaged in bulk and in retail-size packages in central plants. Central processing plants are also packaging portion-control meat (each package containing portions of about equal size), both in frozen and fresh form, for institutional use and for limited sale in retail stores. Plants in producing areas are cutting up and packaging poultry in consumer units.

Central packaging and distribution of retail meat cuts is being extensively practiced in Europe, some plants serving as many as 100 stores up to distances of 100 miles. They do not use meat preservatives. One plant has been successfully supplying 30 stores with 100,000 packages a week, and was planning to expand within the next year.

In 1955, USDA researchers made a survey and analyzed the distribution practices of packers of prepackaged frozen meats (1).[1] It was concluded that freezing was not essential for the success of a central meat operation. Many frozen meat cuts were not well accepted by consumers. Handling costs for frozen meat were high.

Starting in 1959, studies were made of firms in this country which were packaging and distributing retail cuts of fresh meat from central processing plants. The majority of these firms were supplying retail stores that sold too low a volume to prepackage fresh meat profitably in the store.

Each of these central plants was processing for 3 to as many as 25 retail stores whose fresh meat sales varied from $200 to $1,500 a week. However, several of the concerns studied were processing all the retail packages for stores with weekly meat sales as high as $10,000 to $12,000. Usually, no more than a few stores of this size were being supplied by the central plant.

An over- or under-supply of retail cuts, short shelf life, and discoloration were the greatest difficulties encountered in central meat plant operations. No effective procedures were in use to predict sales or to control inventories, and frequently many packages of meat in unsalable condition were found in the retail stores.

During the past several years, researchers from both industry and government have been trying to extend the shelf life of meat. Findings in research with preservatives, radiation, and special packaging materials give indications of success; but there are many problems which limit their immediate application in the retail trade.

Preliminary research shows that costs of central packaging of fresh meat can be reduced materially by better utilization of labor and by the use of more efficient machinery, equipment, and layout of processing lines.

USDA researchers designed and installed improved operational procedures, inventory control systems, scheduling systems, and layouts in three central plants. Standard industrial engineering procedures and marketing research techniques were employed to develop and project operational systems which can be used in the design and operation of larger volume central meat plants.

The objective of this report is to aid the food industry in evaluating central fresh meat processing operations, and to provide fundamental guidelines for those who plan to build such central plants. Data presented in this report will be revised and refined when more experience and information are obtained from larger scale operations as they come into existence.

The labor times used in this report are developed for budgeting purposes and are not intended for use as labor standards. Equipment costs were obtained on a single-unit purchase basis. They do not reflect price differences in different regions of the country.

[1]Underlined figures in parentheses refer to items in Literature Cited, p. 54.

PLANT LAYOUT

A central meat-packaging plant's operation involves ordering, processing, order selecting, billing out store orders, and delivery scheduling. Central fresh meat processing is now being done either in a backroom of an individual retail food store (servicing several stores), or in a separate building devoted to processing.

The total volume of meat distributed to retail stores by a central plant may be insufficient to justify the costs of a separate building. Instead of constructing a separate building, it may be more feasible to package the meat in an existing retail store or in one that is to be built.

A central packaging operation in a retail store is, in most cases, not as efficient as one in a separate structure, because of inherent physical limitations. It is difficult to design a supermarket layout which includes the meat processing, storage, selection, bill-out, and shipping areas so as to provide a smooth, continuous flow of the product from the receiving area to the shipping area. Needs of other supermarket departments for space impose serious limitations on an attempt to integrate a central fresh meat plant into a store.

The design of a small central meat-packaging plant built in conjunction with a retail store is shown in figure 1. Most store meat backrooms are long and narrow, which limits the plant to a straight-line flow layout. A disadvantage of the layout is the distance separating the receiving and shipping operations, making it more difficult for the plant manager to keep close watch on these two important areas.

Constructing a central plant for fresh meat packaging as a separate building has the following advantages over a plant in the backroom of a retail store:

1. The plant can be more centrally located in relation to the retail stores that it is to service.

2. The layout can be designed more easily for the best arrangement of work areas.

3. Equipment can be used more efficiently.

4. It is easier to expand the plant.

5. It is more economical in land costs.

A large-volume central-plant layout, shown in figure 2 (in the center spread, page 38), is designed to handle production volume valued at $130,000 to $250,000, based on an 8-hour shift and a 40-hour workweek. A peak production volume of $35,000 to $60,000 would occur on the Wednesday or Thursday shift, and the plant was designed to handle that peak in a regular 8-hour shift without overtime.

Receiving Area

When the volume of the central plant is small, all shipments can be received at one door. Meat rails extend to the door to facilitate the receiving of beef. The floor level of the receiving area is at truckbed height.

In a large-volume central plant, as shown in figure 2, two receiving doors are advisable, to minimize the time spent in receiving. Meat rails with scales are installed at both doors to permit simultaneous receiving of beef from two trucks. A 10-foot overhanging roof is provided for protection in inclement weather. Backup pads are permanently installed on receiving doors to aid in maintaining the temperature in refrigerated trucks.

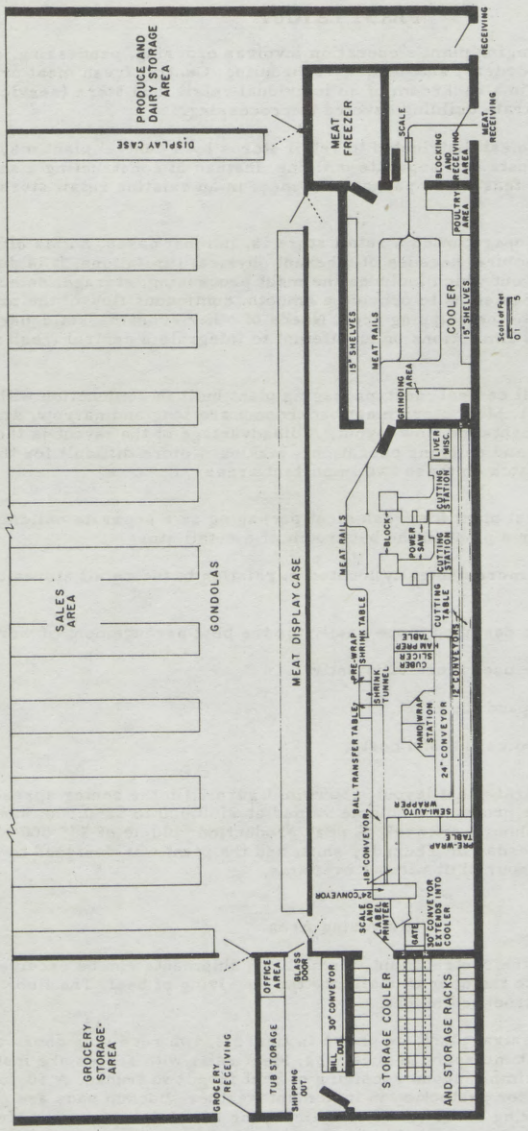

Figure 1.--A small-volume central meat-packaging plant built in conjunction with a retail store.

An unloading ramp extends from the shipping area into the meat receiving area. If necessary, this ramp can be used to receive prepackaged luncheon items which are stored in the order-selection cooler. Also, there may be times when it would be used for shipping purposes.

Meat Storage Cooler

In a medium-volume central plant, as shown in figure 3, the cooler is equipped with 100 feet of rails, which is enough space for hanging 80 sides of beef.

In a large-volume central plant, as shown in figure 2, the meat cooler has 252 feet of actual storage rail and allows ample space for hanging over 200 sides of beef at one time. The poultry storage area is near the receiving and processing area. Storage racks are along both walls, running the length of the cooler, with 3 1/2 feet of aisle space between the racks and the meat rails. The aisle width is sufficient for easy movement of dollies and handtrucks from one end of the cooler to the other. The ground meat processing area is at the far end of the cooler, as shown in figure 2. Ground meat is moved to the automatic wrapping machine through a pass-through window on 30-inch skate-wheel gravity conveyors.

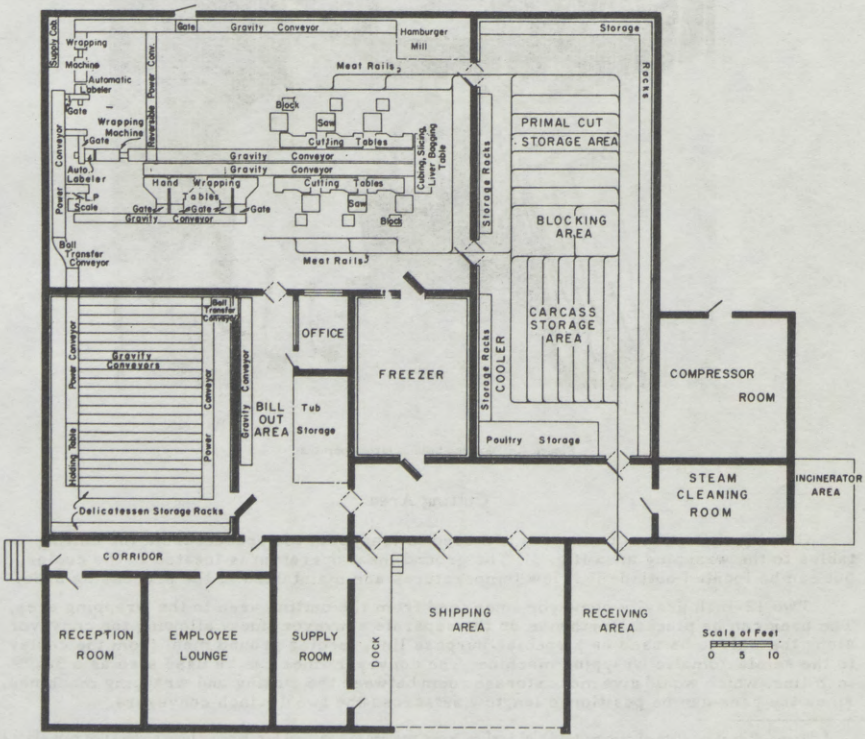

Figure 3.--A medium-volume central meat-packaging plant.

Blocking Area

In a central plant at a retail store, the blocking is done in the receiving area after all shipments have been received. (2) Beef is then brought out from the storage cooler as needed and cut into primal cuts, treed,[3] and returned to the meat storage cooler.

In a central plant in a separate building, the blocking area should be located approximately in the center of the meat cooler, as shown in figure 4, to eliminate backtracking and to insure that the product is used on a first-in, first-out basis.



BN-19256

Figure 4.--Blocking area in large operation.

Cutting Area

Gravity skate wheel conveyors are used to transport the product from the cutting tables to the wrapping area (fig. 5). The ground meat operation is located in the cooler, but can be located outside it if low temperatures are maintained in the processing area.

Two 12-inch gravity conveyor lines feed from the cutting area to the wrapping area. The pans can be placed lengthwise on the separate conveyor lines, allowing the conveyor along the wall to be used as a special-purpose line, feeding ground meat from the cooler to the semiautomatic wrapping machine. The conveyor lines can be used also as a 30-inch line, which would give more storage room between the cutting and wrapping machines, since the pans can be positioned lengthwise across the two 12-inch conveyors.

[3] "Treeing" beef consists of placing blocks of beef on hooks attached to a vertical bar, hanging from a wheel that runs along a meat rail.

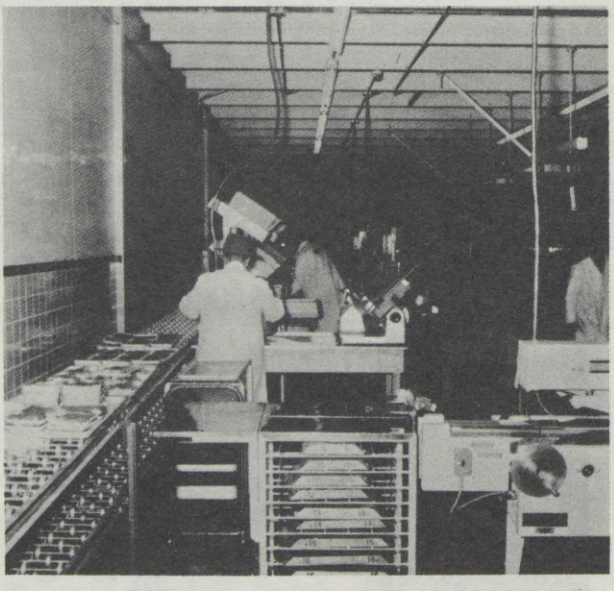

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Figure 5.--Cutting area.

Wrapping Area

As shown in figure 3, in a medium-volume plant both conveyors feed to the semi-automatic wrapping machine. Packages that cannot be wrapped on the machines are placed by the machine operator on a 24-inch conveyor line which feeds to two right-angle handwrapping stations. Wrapped packages from both the machine and handwrapping stations are fed by conveyors to the pricing station.

In a larger volume plant, as shown in figure 2, two parallel 24-inch gravity conveyors bring the product from the cutting area into the wrapping area. One of the conveyor lines feeds the product toward the automatic wrapping machines, while the adjoining line moves products to be handwrapped at the handwrapping station. Each machine wrapper feeds the product into an automatic labeler, where it is weighed, priced, labeled, and transported by power conveyor to the selection cooler. Handwrapped items move from the wrapping tables on a skate-wheel gravity conveyor which feeds the product to the automatic scales and label printers. The weighed and priced packages are moved from the scales to the selection cooler by power conveyors.

Selection and Bill-Out Area

Each wrapped, weighed, and priced package moves by means of a small power belt conveyor from the automatic labeler onto a main power belt conveyor and is transported into the selection cooler.

In the central plants shown in figures 2 and 3, gravity-flow conveyors are provided for storing the fast-moving items. Slow-moving items are stored in fixed selection slots.

The product moves by conveyor to selection area to bill-out area, and by handtruck to the delivery truck.

Shipping Area

The floor of the shipping dock should be at truckbed level to facilitate loading. After the store orders have been billed out, they are either stored in the cooler or loaded directly into the delivery truck. The shipping door should be lined with backup pads, as shown in figure 6, to maintain a low temperature within the truck during loading.

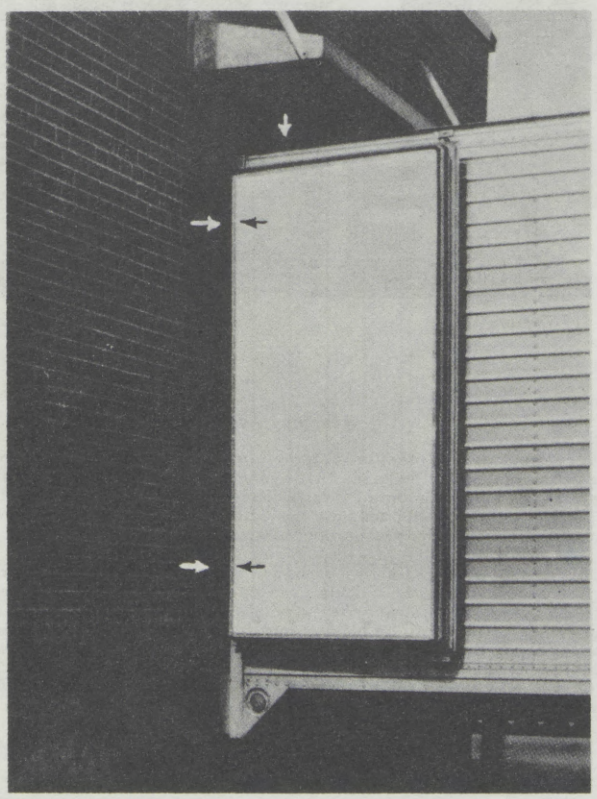

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Figure 6.--Trailer backed against foam rubber (indicated by arrows) at loading door.

The shipping area is entirely enclosed to facilitate the loading operation during inclement weather. The shipping docks are long enough to load three delivery trucks at a time. The loading dock is located near the storage area, to minimize travel distances. This area can be used also for receiving prepackaged delicatessen and processing supplies.

Office Area

The office should be so located that the plant manager can see all the major processing areas from his desk. As shown in figure 7, there should be large windows in the walls of the office, so the plant manager can view the receiving, blocking, boning, cutting, wrapping, pricing, bill-out, and shipping operations from the office.

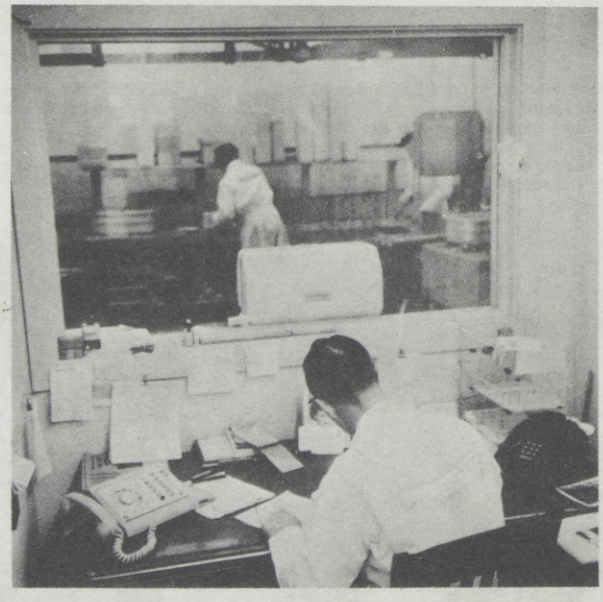

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Figure 7.--Office located in central meat plant.

ANALYSIS OF EQUIPMENT AND WORK PROCEDURES

In a central meat-packaging plant, it is economically feasible to use specially designed equipment, and work methods to reduce total operating costs substantially.

Receiving, Storage, and Blocking

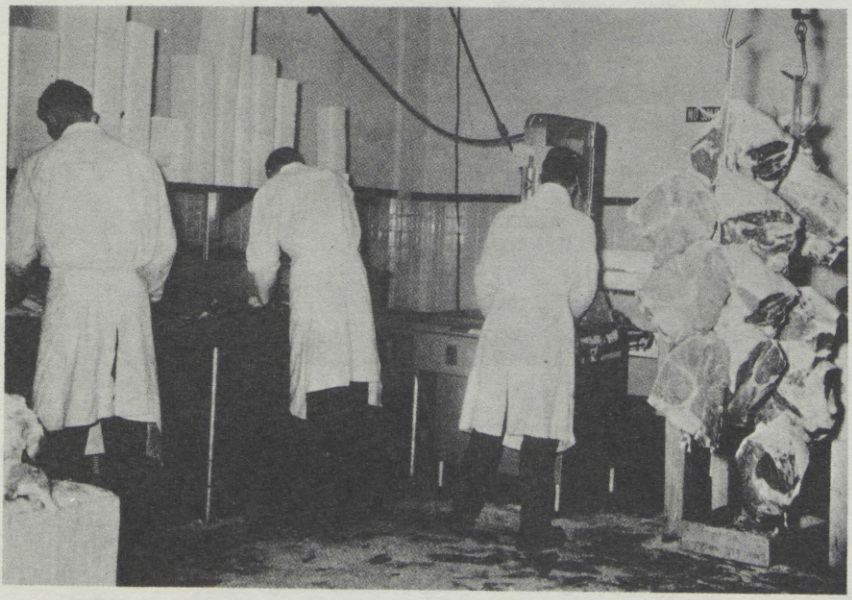
Preferably, all meat products that are to be processed and distributed by a central plant should be received during the first part of the week. This permits a minimum number of orders and full delivery loads from the packers, and makes work scheduling easier

for the plant manager. Coolers should, therefore, be designed with ample storage facilities, allowing the central plant to receive only one or two shipments per week.

Since approximately 60 to 70 percent of the weekly sales occur on Thursday, Friday, and Saturday, most of the blocking operation should be completed by Wednesday. Two or more two-man blocking crews can be used. For speed, blocking should be done on the meat rail with ceiling-suspended power saws (2). One man on the crew should operate the power saw, while the second man trees the primal cuts according to type of cut. Also, the second man of the crew pushes each multiple rail hook (tree hook) of primal cuts to the appropriate storage meat rail and sees that an ample supply of empty meat trees is always on hand. A two-man crew could switch jobs after some specified amount of work, in order to reduce fatigue.

Cutting

Each cutting station should be designed to accommodate either a two- or three-man crew (fig. 8). In large operations, team cutting is usually more productive and provides a better balanced processing line. The size of the cutting crew depends upon the volume of product required during a particular 8-hour shift. Probably a two-man crew would be scheduled for the first part of the week, and a three-man crew for the heavy-volume production later in the week.



BN-19262

Figure 8.--Cutting and traying station.

Each cutting station should have enough rail space for storing up to four trees of primal cuts, thus reducing trips to the cooler (fig. 9). Also, a holding area should be provided at each cutting station to help in keeping like items together. When a substantial amount of similar items has been accumulated, they can then be passed on to the wrapping stations.

Packaging and Pricing

Wrapping machines combined with automatic scales and labelers should be used to the maximum, because of their high production capacity (fig. 10). In a high-volume central plant, conveyor lines, with switches, can be set up so that the product can be diverted from one automatic wrapper to another in order to balance the work load properly. Enough storage area should be provided at each automatic wrapper so that the machine operator can bypass some of the product in order to wrap like items in one batch. This arrangement makes for less adjusting of the automatic wrapper.

Handwrapping stations should be designed with all supplies and wrapping tools easily accessible to the wrapper. (3) The USDA wrapping table shown in figure 11 is an example of an efficient handwrap station. A bypass storage area also should be provided at each handwrapping station to help in keeping like items together. One automatic scale can usually handle the volume of product from four or five well-designed handwrapping stations.



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Figure 9.--Meat rails extending to each cutting station.

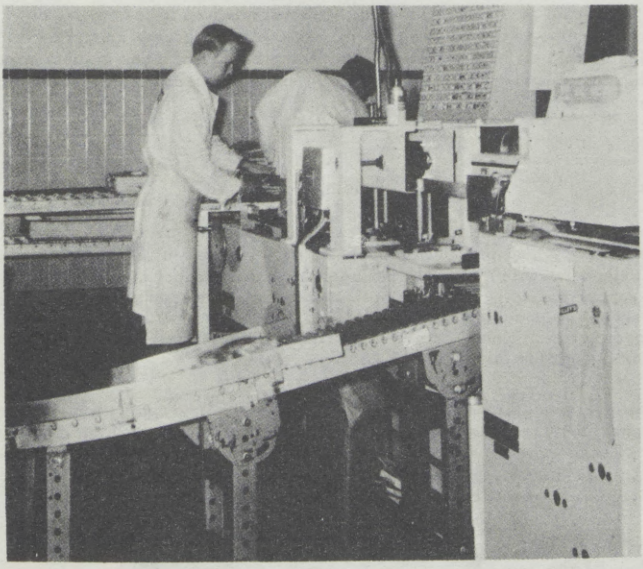

Figure 10.--Wrapping machine combined with automatic scale.

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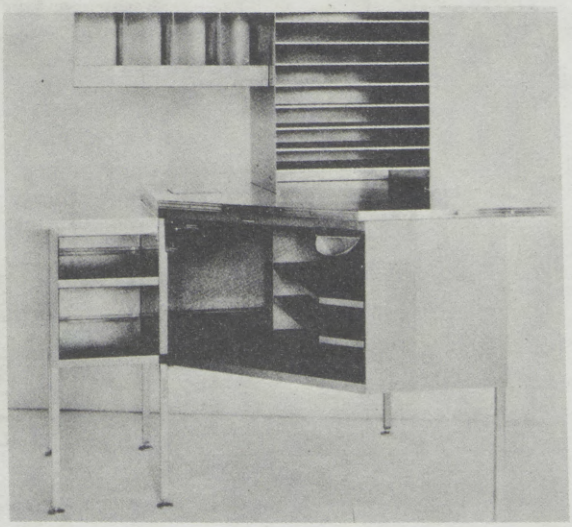

Figure 11.--USDA-designed handwrapping table.

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Selection and Bill-Out

The selection cooler should contain enough fixed slot racks for storing all of the peak day's production. Items should be placed in the slots and selected according to the sequence of their listing on the store order forms. A special crew is used in the selection area to take the product from the conveyor and store it in the proper slots (fig. 12).

In a large-volume central plant, gravity-flow conveyor lines can be provided for storing the fast-moving items. The gravity-flow conveyors are stocked from the rear, and the selection is done from the front, as shown in figure 13. This system assures that the product will be selected on a first-in, first-out basis. Slow-moving items are stored in fixed selection slots.

Team work may be used also in selecting store orders. For instance, one man may select the high-volume items while a second man selects the slow-moving items. The selecting is done for one store at a time and, as the order is being selected, it moves by power and gravity conveyors into the bill-out room. Several types of bill-out systems can be used, but, regardless of the system, this operation can be a major bottleneck in a central-plant operation.

In a small-volume plant doing $15,000 to $30,000 weekly volume in fresh red meats and supplying from three to six retail stores, the bill-out operation can be performed effectively by using electric adding machines.



BN-19258

Figure 12.--Stocking gravity-flow conveyors from rear (4).



BN-19261

Figure 13.--Selecting store orders from gravity-flow conveyors (4).

As the volume of the central plant and the number of stores serviced increase, use of an electric adding machine in the bill-out system becomes more and more inefficient, and other methods of billing the stores must be used to speed up the operation.

The few concerns in the country that are packaging retail cuts of fresh meat from a central plant bill the stores for each package at regular retail price. A percentage discount is then given to each store based on management's policy. In a high-volume operation, it might prove feasible to bill out all the high-volume movers by the bulk method. As an example, all ground meat packages being shipped to the store could be weighed at one time and charged to the store on the basis of the total retail price.

After all the orders have been billed out, the tape is sent to the office, where each store's total is entered in the store ledger journal. The type of layout for the bill-out area would depend on the volume and the number of stores involved. When a central plant is servicing many retail stores, it is necessary to have several separate bill-out lines in order to handle the volume efficiently (fig. 14).

A bill-out line could be set up for the high-volume movers and another for the low-volume movers. To balance the bill-out operation with the low-volume line, it might be necessary to place two bill-out stations in the high-volume line. After the store's order has been billed out, it is placed in the delivery truck for shipment to the store.

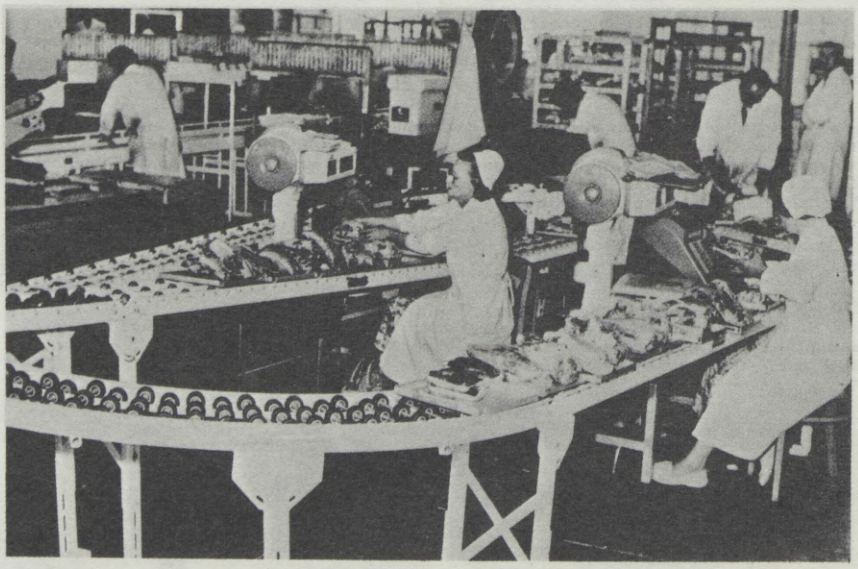

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Figure 14.--Bill-out station, showing two billing lines (4).

Shipping Containers

The container needed for shipping and storage of the processed retail cuts should have the following attributes: (1) Convenient in size; (2) lightweight but extremely durable; (3) designed for nesting; and (4) made of material that can stand rough handling and cleaning methods.

One of the first decisions to be made is determination of the size and type of container to use. The maximum number and weight of the packages that can be handled reasonably by one man without causing undue fatigue is probably the major factor in determining the size of container to use. It was decided by researchers that a man should not be asked to handle over 50 pounds in a shipping tub. Using this assumption, the size of the container was determined by considering the following factors: (1) Size of trays in which the majority of the products are packed; (2) average weight of packages; and (3) damage due to weight of packages in container.

In most cases, the highest percentages of the product will be packed in 2S and 4S trays. The 2S tray is 5 1/2 inches wide by 8 inches long. One layer of 10 2S trays will fit in a container having inside dimensions of 18 inches by 28 inches. The number of layers that a container can hold depends on the height and weight of the product. For example, club steaks packaged in 2S trays take up about three-fourths of an inch for each layer; therefore, a container 8 inches deep will hold 8 layers, or 80 packages.

Another factor to be considered is the effect that the weight of the product in the container has on the bottom packages, in relation to package or product damage. On some items, it may be necessary to place cardboard dividers between the layers in order to protect the product from being damaged in shipment.

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It probably would be necessary for most firms to use two sizes of containers, varying in depth for different products, since some items, such as cut-up chicken and roasts, range in height from 3 to 7 inches (fig. 15). These items would require a shipping container at least 8 inches deep to get two layers of the product into the container.

Material used in construction of the shipping container must be extremely durable and able to withstand rough handling without being damaged. Also, the containers probably would be cleaned by a high-pressure steam or hot-water system, so it is necessary that the material used in them be capable of withstanding high temperatures. To facilitate handling and to conserve storage space, the containers should be designed for nesting.

Delivery Trucks

In medium- and large-volume operations, it is probably most economical, in servicing the stores, to use a refrigerated "bobtail" truck with a truckbed length of about 18 feet and inside width of about 6 1/2 feet.

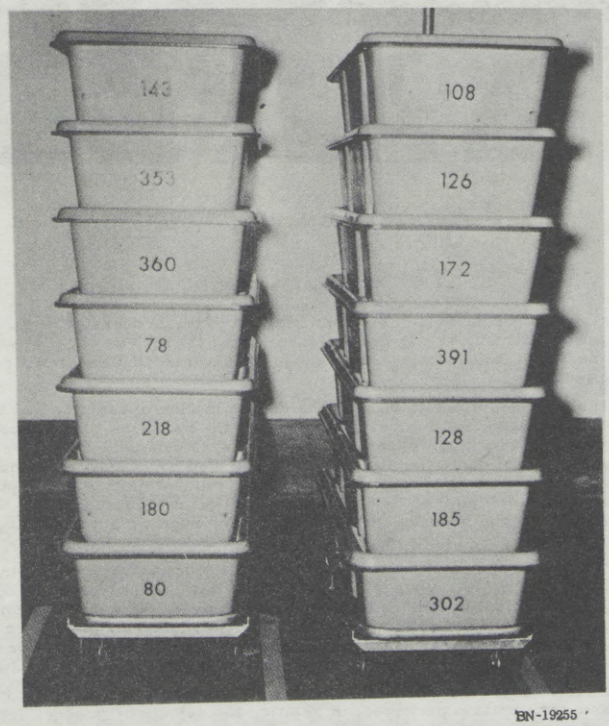

Figure 15.--Shipping containers for prepackaged meat.

A "bobtail" truck has the capacity for holding a reasonably large order while still being fairly maneuverable in city and suburban traffic. However, it might be more economical to use a semitrailer truck, especially if 20 or more stores are to be serviced.

It is possible that both semitrailer and "bobtail" trucks would be used in a given operation, if the volume of the stores serviced varied widely and if the stores were in urban and suburban areas (fig. 16). In any case, the size and number of trucks should be based on the total volume of the stores to be serviced, along with the number of delivery runs to each store that a truck is required to make during the day of peak production.

Unloading methods at the stores depend upon the type of truck, type of shipping containers, and facilities available at the retail stores. Some of the retail stores may not have truckbed-height docks; therefore, the order could be unloaded by either conveyors, chutes, or a truck equipped with a hydraulic-type tailgate. The orders can be transported into the stores' holding coolers by pallet jacks, handtrucks, four-wheel dollies, or conveyors, depending upon equipment and operating conditions.

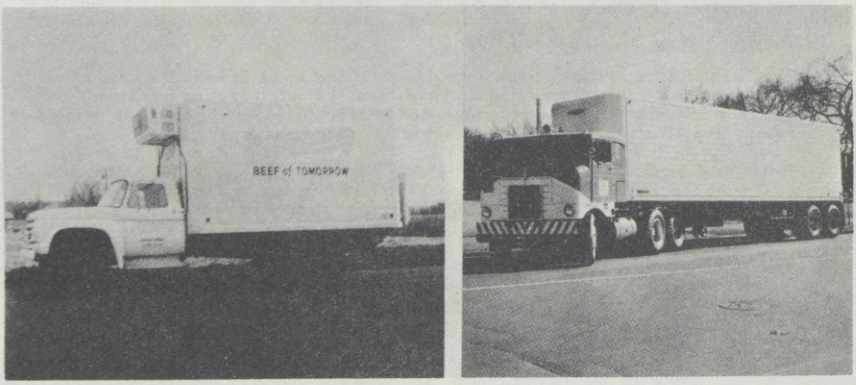

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Figure 16.--Two types of delivery trucks: "Bobtail" (left) and semitrailer.

Sanitation and Refrigeration

It is entirely feasible to package retail cuts of fresh meat at a central plant when a shelf life of 2 to 5 days is realized. The work done thus far in centralized operations indicates that by using proper sanitation and by holding temperatures near the freezing point, a shelf life of 2 to 5 days can be attained on most meat cuts, with ground meat being limited to approximately 2 days.[4] Research is continuing in order to determine more precisely the sanitation, refrigeration, and other procedures that should be followed in order to attain maximum shelf life.

A concentrated effort by management is needed to teach employees to use good sanitation procedures. Cutters and wrappers should clean their work stations after each operation. All power equipment and cutting blocks should be thoroughly cleaned. A portable steam unit is an effective method to use for cleaning the equipment and the cutting

[4]Unpublished research conducted by the University of Missouri and W. R. Grace & Co., Cryovac Division, substantiates these findings.

blocks, although some researchers suggest that hot water under pressure is even more effective than steam.

Floors should be kept clean. Trash cans or bins should be in convenient locations throughout the plant, and employees trained to use them. Increasing production by combining modern equipment with the best practical layout cannot be attained when "sloppy" work methods and poor housekeeping principles are permitted in a central plant.

Good sanitation can drastically reduce the bacteria count, thereby adding to the shelf life of fresh red meats; but another factor, equally or more important, is temperature. Bacteria become less active as the temperature is lowered; therefore, low temperatures are extremely important in extending the shelf life of fresh meats. Recommended temperature levels for the various storage and processing areas are:

1. Carcass meat, 30° to 33° F. in storage cooler.
2. Processing area, 32° to 40° F.
3. Selection cooler, 30° to 33° F.
4. Refrigerated truck, 28° to 31° F.
5. Store cooler, 31° to 34° F.
6. Retail display cases, 29° to 32° F.

The temperature of the coolers should be held low so as to keep the product as cold as possible without actually freezing it. Therefore, the refrigeration equipment should be capable of maintaining these recommended temperatures during the peak periods of processing when the cooler doors are frequently opened and closed.

Refrigeration in the delivery trucks should have the capacity to consistently hold the meat near the 32° F. level. This temperature is affected by the number of times the doors are opened and by the outside temperature, so it may be necessary to set the thermostat lower than 32°.

The store's display cases should be adjusted within the range of 29° to 32° F. Defrost cycles of the display cases should occur in the early morning before the delivery is scheduled to arrive. Holding the display case at 29° does not ordinarily freeze the product, even though it may remain in the case for 3 days, provided covers are not placed over the case at night.

RETAIL MEAT DEPARTMENT OPERATIONS

The meat department of a retail store should have adequate personnel (1) to maintain personal contact with the customer; (2) to service orders that require special handling; (3) to keep the meat in the case properly displayed; (4) to rewrap or remove damaged packages; and (5) to take daily inventories.

In a department that receives its meat from a central processing center, those responsibilities should be assigned to a meat cutter. He should have a pleasing personality and have the ability to help customers with problems relative to meat preparation, cooking, and serving.

The backrooms of retail stores supplied by a central plant are smaller because of the elimination of most of the processing and because fewer personnel are required. Shown in figure 17 is the processing backroom of a meat department for a store with a weekly meat volume of 15 to 20 thousand dollars. The processing area may, of course, vary slightly from store to store, but the size of this backroom was determined according to good layout and flow arrangements using modern equipment and an efficient materials-handling system. (5)

Figure 18 shows a meat department designed by the researchers for a retail store where processing at the store level is eliminated. The cooler area has been reduced to about 60 percent of the size needed in the conventional backroom. The only items that will be placed in the cooler when the store is being serviced from a central plant will be

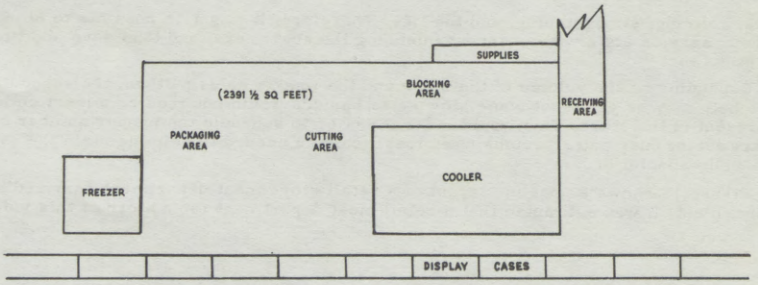

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Figure 17.--Conventional meat backroom area for a medium-volume retail store.

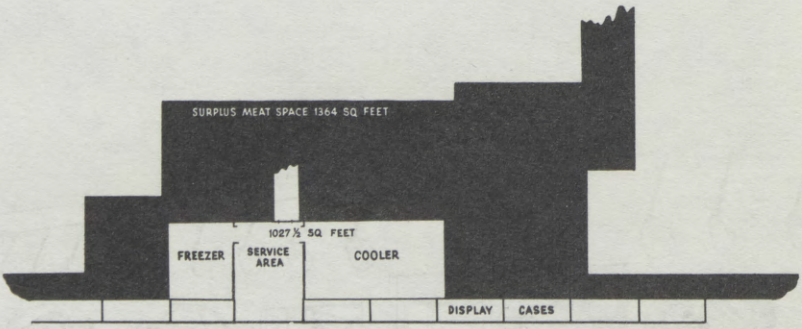

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Figure 18.--Illustration of savings in meat backroom space for a store with volume of $15,000 to $20,000 when the retail store is serviced by a central meat plant.

a few primal cuts which are used to take care of special orders, and for temporary storage of part of the store's orders that are received daily from the plant.

The freezer probably would remain the same size, since about the same amount of products would be stored there with either method of operation.

Customers need to be assured that quality meat is always available, and, if necessary, that it can be cut to their special requirements. To help demonstrate activity and service in the meat department, the processing area can be open to the customer's view. A window might be located in the cooler wall so the primal cuts can be seen from the sales area. Only a minimum of inexpensive equipment is needed in an operation of this type. The butcher would be provided with a block or small cutting table and some hand-cutting tools for handling special orders and for reworking some of the meat packages. Also provided would be some sheet film and hand irons, a few labels, a small mill, a slicer, and a cuber for special orders and rewraps. These work areas would also be used for pricing some delicatessen items and for other jobs related to servicing the meat displays.

Stocking of cases usually would be done early in the day, and the only work needed at the cases during busy sales periods would be some restocking of a few fast-moving

items, policing, straightening, and the like. Therefore, it might be possible to eliminate the rear service aisle without inconveniencing the customers, and thus save additional space.

Depending on the volume of the store and the weekly sales pattern, the scheduling of store help may be such that some slow sales periods would not require a meat cutter to be present in the store. This would make it easier to schedule the proper number of cutters during busy sales periods when they would be needed to help maintain the case and handle special orders.

Figure 19 shows a possible layout of a retail store meat department serviced by a central plant. It was estimated that a retail meat department for a store of this volume

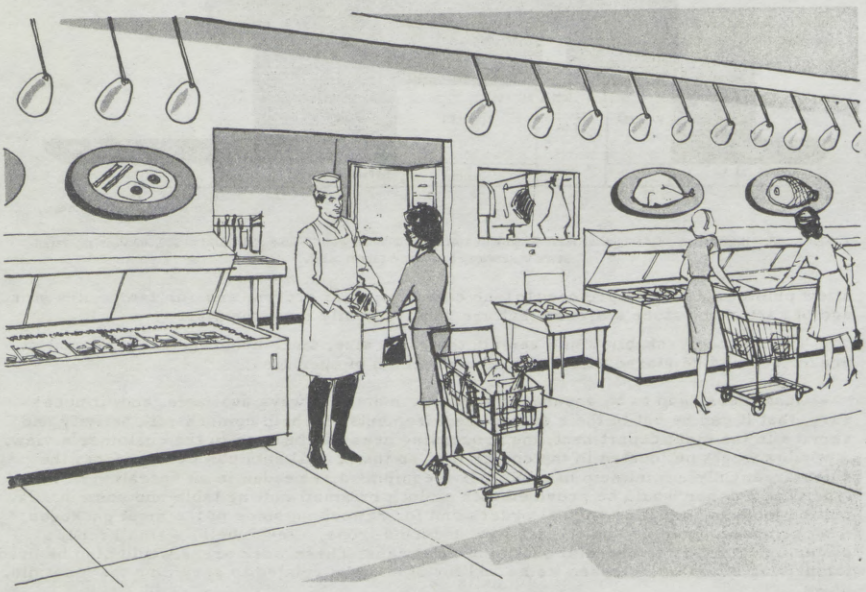

Figure 19.--Layout of a retail store meat department when serviced by a central plant.

($6,250 weekly) would require about 2,390 square feet of floor space. A meat department of the same volume, supplied by a central processing plant, would require only about 1,030 square feet, a saving in floor space of over 50 percent. (6)

COSTS OF CENTRALLY PROCESSING FRESH MEATS

Several factors tend to favor centralized meat processing; however, some of them are difficult to evaluate because of variations in conditions under which food firms operate. These factors are discussed here under the general headings of construction, equipment, labor, and special cost considerations.

Potential direct savings from processing fresh meat products at a central plant rather than at the retail store can be predetermined fairly accurately. The following factors should be considered in a cost evaluation of central fresh meat processing:

1. The equipment presently used in retail stores is often not used to capacity, and must necessarily consist of small-volume units. Centralized processing eliminates the need for most of the present equipment in retail outlets, provides for more efficient use of the equipment due to the higher volume, and permits the use of highly specialized or high-volume production machines that are not economical in a retail store.

2. Elimination of processing space at the retail store by the concentration of these facilities into one plant can reduce floor space requirements considerably.

3. Land and building costs can be lower for the centralized operation. Central plants can be constructed on less costly land and with less costly construction than retail stores located in high-cost shopping centers.

4. Layout and arrangement of work areas in central plants, designed for production only, can often be made more efficient than those in a retail store.

5. Efficient labor scheduling is one of the chief advantages of centralized operations. Specialization is possible, and less changing of jobs and less make-ready and put-away time are required. Also, specialization of personnel is increased by putting sales-oriented people in the retail store and production-oriented people in the central plant.

Many of the costs shown in this section are projections beyond the volume level of existing plants, and, therefore, are tentative, for use in comparisons of the two systems and not as a definite cost analysis of central meat plant operations. Labor, equipment, and construction costs vary in different regions and for different operating methods, and should be modified in line with local conditions when applied to specific operations.

Costs used in this analysis are based on the assumption that both equipment and construction are new. However, most construction and equipment costs for a central meat plant will normally be additional costs, because most of the stores are already in existence and have been processing meat in their own backrooms. Even so, equipment now in the retail stores can often be used by the central plant. In addition, much of the space occupied by the conventional meat backrooms can be allotted to other departments. The cooler, freezer, and processing area in some older stores may be inadequate for retail-level processing, but may be adequate for stores serviced by a central plant.

In this report, construction, equipment, and labor costs were determined for central-plant operations designed to produce $37,500, $75,000, and $250,000 in total retail meat sales per week. These volumes include luncheon meats and other packaged meats which would be handled and distributed by the plant but not packaged and processed there. Layouts of plants with these volumes are found in the plant layout section of this report.

Construction Costs

The following calculation should be used only as a guide in comparing total construction costs for operations of the three different volumes:

A. Construction costs for a central meat plant with a $75,000 weekly volume:

		Dollars
1. Cost of building (shell):		
12,774 sq. ft. x $8.00 per sq. ft.		102,192
2. Cost of coolers (meat and selection coolers):		
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080	
Remaining 28,390 cu. ft. x $.74 per cu. ft.	21,008	
Total cost for 31,190 cu. ft. of cooler area		24,088
3. Cost of refrigerating the processing and bill-out area:		
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080	
Remaining 32,360 cu. ft. x $.74 per cu. ft.	23,946	
Total cost for 35,160 cu. ft. of processing and bill-out areas		27,026
4. Cost of freezer:		
First 2,240 cu. ft. x $1.63 per cu. ft.	3,977	
Remaining 5,360 cu. ft. x $1.09 per cu. ft.	5,842	
Total cost for 7,600 cu. ft. of freezer area		9,819
Total construction costs of central plant		163,125

B. Construction costs for a $6,250 weekly volume retail store meat backroom when serviced by a central meat plant:

1. Cost of backroom (shell):		
332 sq. ft. x $8.00 per sq. ft.	2,656	
2. Cost of cooler:		
960 cu. ft. x $1.10 per cu. ft.	1,056	
3. Cost of freezer:		
640 cu. ft. x $1.63 per cu. ft.	1,043	
Construction costs for one backroom	4,755	
4. Construction costs of backrooms for 12 retail stores with total weekly volume of $75,000	57,060	
Total construction cost of central plant plus retail stores served		220,185

C. Construction costs for retail store meat department with $6,250 weekly volume when served from conventional backroom:

1. Cost of backroom (shell):		
1,080 sq. ft. x $8.00 per sq. ft.	8,640	
2. Cost of cooler:		
2,400 cu. ft. x $1.10 per cu. ft.	2,640	
3. Cost of freezer:		
640 cu. ft. x $1.63 per cu. ft.	1,043	
Construction costs for one backroom	12,323	
4. Construction costs of backrooms for 12 retail stores with total weekly volume of $75,000:		
$12,323 x 12 stores		147,876

Construction costs for a central plant to service retail stores with an average weekly volume in meats of $6,250, are shown graphically in figure 20. The size of the central operation, as shown in the chart, ranges from $37,500 to $250,000 a week. Construction costs for any volume within this range can be interpolated from this graph.

To use the chart, assume a central plant is to service 12 stores with an anticipated total weekly volume of $75,000. To find the estimated construction costs, refer to figure 20 and follow the $75,000 line vertically until it intersects the sloped line titled "conventional method." At this point, the total construction cost of $147,876 is read on the vertical axis. Second, follow the $75,000-volume line vertically until it intersects the sloped line titled "central plant method." At this point, the central plant construction cost of $220,185, which also includes the construction costs of the retail stores, can be read from the vertical axis. Therefore, in a $75,000 weekly volume operation the construction cost for a central operation would be $72,309 greater than it would if the processing had been done at the retail stores in conventional backrooms.

Calculations of construction costs for all other weekly volume levels discussed in this report can be found on pages 56 through 59 of the appendix.

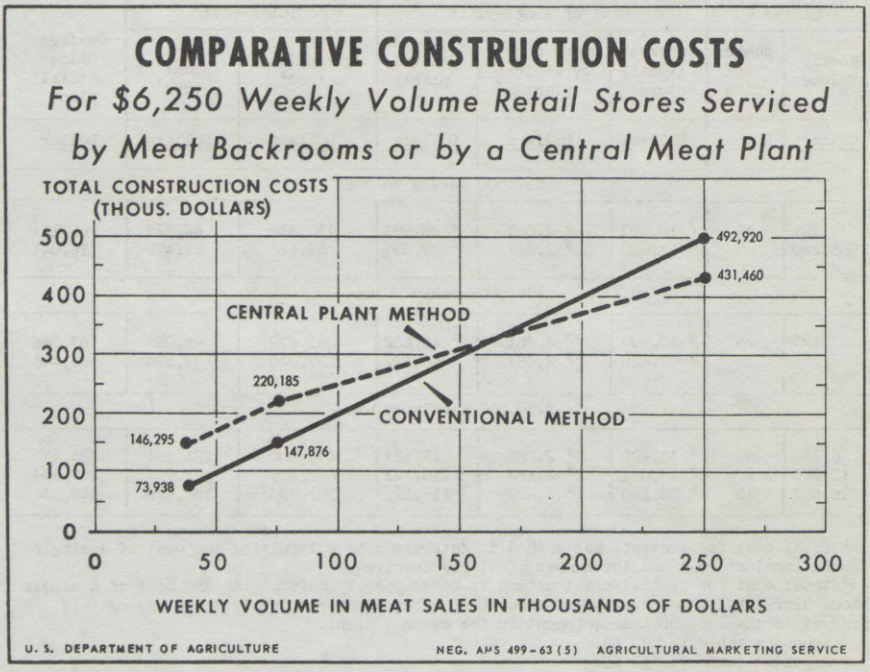

Figure 20.

Equipment Costs

The total cost of equipping central plants is shown in table 1, including the cost of equipment needed at the stores.

Table 1 shows that a central plant designed to handle $75,000 a week in retail meat sales would cost about $73,600 to equip. This includes the amount of equipment needed at the 12 retail stores when the average weekly meat sales are $6,250 per store. The equipment costs would amount to about $137,000 for the 12 stores when the processing was done from efficiently operated individual meat backrooms. A central operation would, therefore, save as much as $64,000 in equipment costs.

A detailed breakdown of equipment requirements and costs for all three volumes of operation can be found on pages 60 through 66 of the appendix.

Table 1.--Equipment costs for meat departments serviced by conventional meat backrooms and by central plants

Stores		Cost of single unit			Total cost		Savings using central plant
Weekly volume	Number of units	Conventional store	Store served by central plant	Central plant	Conventional method[1]	Central plant method[2]	
Dollars	Number	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
$37,500 weekly volume							
3,125	12	[3] 10,903	[3] 2,061	[4] 39,993	130,836	64,725	66,111
6,250	6	[5] 11,420	[5] 2,081	[4] 39,993	68,520	52,479	16,041
$75,000 weekly volume							
3,125	24	[3] 10,903	[3] 2,061	[6] 48,622	261,672	98,086	163,586
6,250	12	[5] 11,420	[5] 2,081	[6] 48,622	137,040	73,594	63,446
$250,000 weekly volume							
6,250	40	[5] 11,420	[5] 2,081	[7] 118,121	456,800	201,361	225,439
10,000	25	[8] 17,691	[8] 2,192	[7] 118,121	442,275	172,921	269,354
16,667	15	[9] 20,260	[9] 2,429	[7] 118,121	303,900	154,556	149,344

[1] Total cost for conventional method is determined by multiplying the cost of a single conventional store times the number of stores involved.
[2] Total cost for central-plant method is determined by multiplying the cost of a single store served by the central plant times the number of stores involved and adding this product to the cost of the equipment in the central plant.
[3] Appendix table 12, p. 63.
[4] Appendix table 9, p. 60.
[5] Appendix table 13, p. 64.
[6] Appendix table 10, p. 61.
[7] Appendix table 11, p. 62.
[8] Appendix table 14, p. 65.
[9] Appendix table 15, p. 66.

Figure 21 is a graphic representation of total equipment cost for either type of operation between weekly volumes of $37,500 and $250,000.

Labor Costs

In a retail store serviced by a central plant, one or two skilled butchers are needed to service the displays and to provide special orders for customer convenience. Efficient work methods and operating procedures were used in this study for conventional and central plant operations in determining the amount of labor required.

Table 2 shows that a central plant with a weekly volume of $75,000 would have an annual labor cost of about $217,000. Included in this figure is the labor force that would be needed in the stores' retail meat departments. The labor costs when processing at the retail stores in the conventional manner would amount to about $373,000 a year. Therefore, a central plant operation of this volume could save as much as $156,000 a year in labor costs. A detailed breakdown of labor costs for both methods of operation at other weekly volume levels appears in the appendix, pages 66 through 68.

The graph in figure 22 represents the total annual labor costs required in either method of operation for weekly volumes ranging from $37,500 to $250,000.

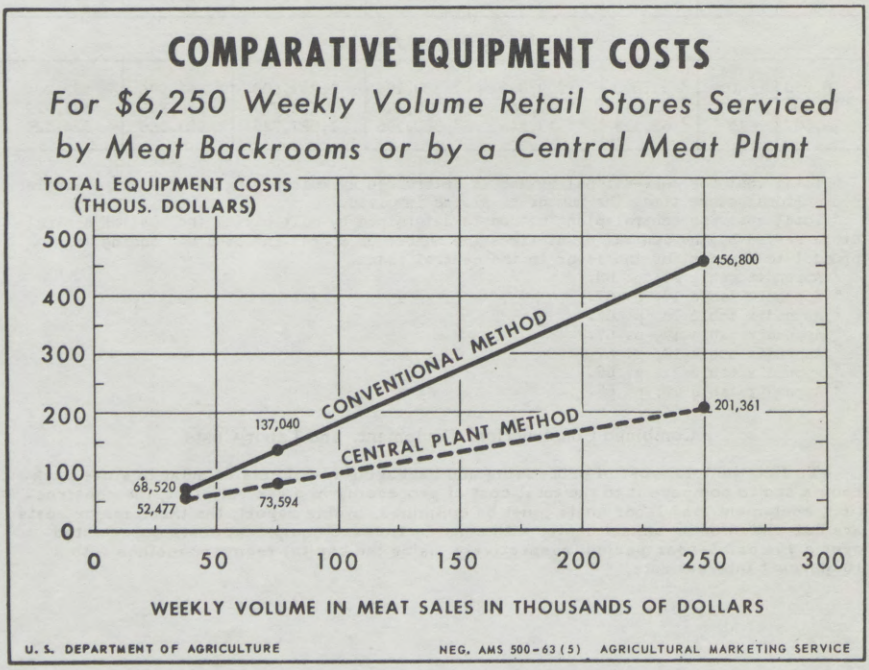

Figure 21.

Table 2.--Labor cost for conventional backroom operation compared to labor cost of a central-plant operation

Stores		Cost of single unit			Total cost		Savings using central plant
Weekly volume	Number of units	Conventional store	Store served by central plant	Central plant	Conventional method[1]	Central plant method[2]	
Dollars	Number	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
$37,500 weekly volume							
3,125	12	[3] 21,057	[4] 9,030	[5] 77,701	252,684	186,069	66,615
6,250	6	[3] 31,090	[4] 9,030	[5] 77,701	186,540	131,885	54,655
$75,000 weekly volume							
3,125	24	[3] 21,057	[6] 9,030	[7] 108,748	505,368	325,484	179,884
6,250	12	[3] 31,090	[7] 9,030	[7] 108,748	373,080	217,116	155,964
$250,000 weekly volume							
6,250	40	[3] 31,090	[8] 9,030	[9] 300,196	1,243,600	661,396	582,204
10,000	25	[3] 46,911	[8] 13,546	[9] 300,196	1,172,775	638,846	533,929
16,667	15	[3] 68,515	[8] 13,546	[9] 300,196	1,027,725	503,386	524,329

[1] Total cost for conventional method is determined by multiplying the cost of a single conventional store times the number of stores involved.

[2] Total cost for central-plant method is determined by multiplying the cost of a single store served by the central plant times the number of stores involved and adding this product to the cost of the labor in the central plant.

[3] Appendix table 22, p. 68.

[4] Appendix table 17, p. 67.

[5] Appendix table 16, p. 66.

[6] Appendix table 19, p. 67.

[7] Appendix table 18, p. 67.

[8] Appendix table 21, p. 68.

[9] Appendix table 20, p. 68.

Combined Construction, Equipment, and Labor Costs

To find the total cost of processing and packaging retail cuts of meat in store backrooms and to compare it to the total cost of processing in a central plant, the construction, equipment, and labor costs must be combined. In this report, the three major costs are calculated on an annual basis, with construction and equipment costs depreciated over a 10- and 5-year period, respectively, using the capital recovery method with a 10-percent interest rate.

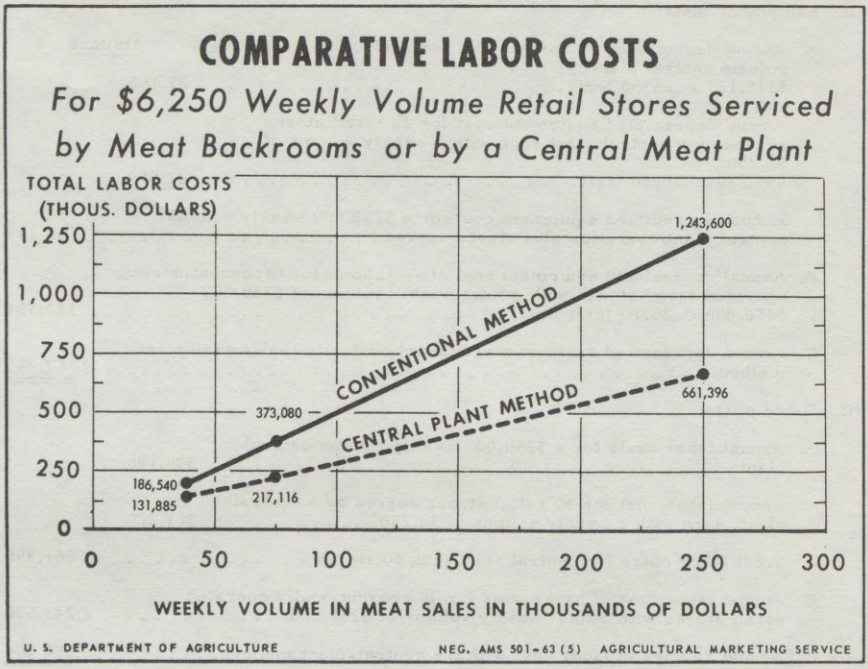

Figure 22.

Calculations for an operation with a $250,000 weekly volume, for both the central-plant and the conventional backroom methods, were made as follows:

		Dollars	
I.	Construction costs:		
	A. Annual depreciated construction cost for a $250,000 weekly volume central plant $241,260 x .16275 (crf)[5]	39,265	
	Annual depreciated construction cost for 40 retail stores served by a central plant, each with a weekly volume of $6,250 $190,200 x .16275 (crf)	30,955	
	Total annual depreciated construction cost for a $250,000 weekly volume central plant operation plus stores served		70,220
	B. Annual depreciated construction cost of backrooms for 40 conventionally operated retail stores with a total weekly volume of $250,000 $492,920 x .16275 (crf)		80,223
	C. Annual depreciated savings in construction cost with central-plant method		10,003

[5]Crf is a factor which, when multiplied by the initial investment, will give the uniform annual end-of-year payment necessary to repay the debt in a specified number of years at a given interest rate.

		Dollars
II.	Equipment costs:	
	A. Annual depreciated equipment cost for a $250,000 weekly volume central plant $118,121 x .26380 (crf)	31,160
	Annual depreciated equipment cost for 40 retail stores served by a central plant each with a weekly volume of $6,250 $83,240 x .26380 (crf)	21,959
	Annual depreciated equipment cost for a $250,000 weekly volume central plant operation plus stores served	53,119
	B. Annual depreciated equipment cost of backrooms for 40 conventionally operated retail stores with a total weekly volume of $250,000 $456,800 x .26380 (crf)	120,504
	C. Annual depreciated savings in equipment cost with the central-plant method	67,385
III.	Labor costs:	
	A. Annual labor costs for a $250,000 weekly volume central plant	300,196
	Annual labor cost for 40 retail stores served by a central plant, each with a weekly volume of $6,250	361,200
	Total labor costs for central plant plus 40 stores	661,396
	B. Annual labor cost of backrooms for 40 conventionally operated retail stores with a total weekly volume of $250,000	1,243,600
	C. Annual savings in labor cost with the central-plant method	582,204
IV.	Total annual savings in a $250,000 weekly volume central-plant operation compared to conventionally operated retail stores with their own backroom:	
	Annual depreciated construction savings	10,003
	Annual depreciated equipment savings	67,385
	Annual labor savings	582,204
	Total annual savings	659,592

The graph in figure 23 can be used for estimating the annual savings of a central meat operation compared to conventional meat backrooms for total weekly volumes up to $250,000.

A summary of the overall costs for processing retail cuts of fresh meat for other store volumes appears in table 23 (p. 73). The number of stores serviced by the central plant varies from 6 to 40, depending upon the average volume of the stores involved and the capacity of the central plant itself.

Special Cost Considerations

Central processing of fresh meats appears to offer a number of possibilities for reducing the costs of and promoting the sale of meat products. Many of these possibilities will develop only after the number of plants and their volume increases beyond the

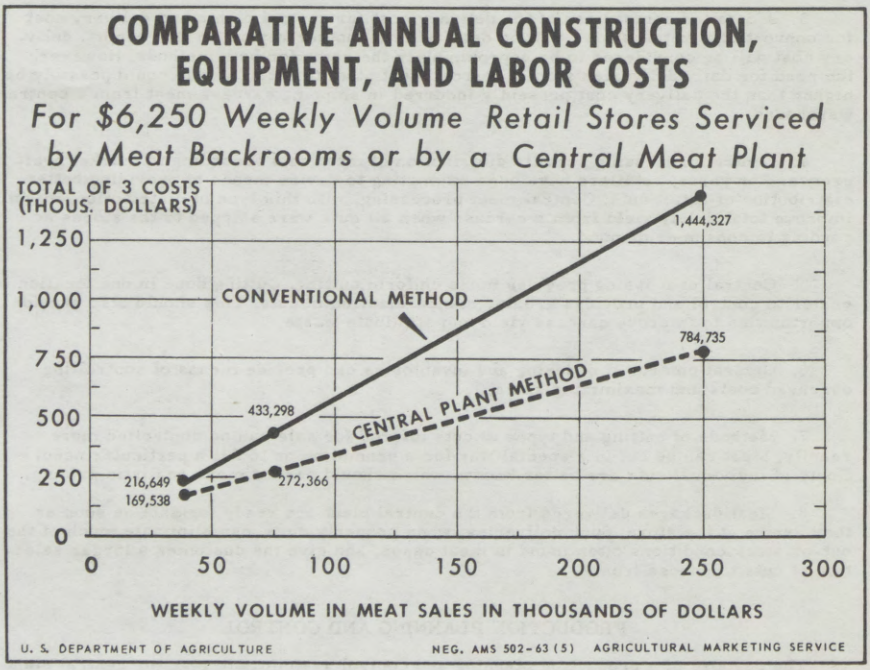

Figure 23.

present levels in the United States. Possible advantages are pointed out here, but no attempt is made to place a monetary value on them:

1. Better discounts from packers and packaging suppliers can often be obtained because deliveries can be fewer and larger. Opportunities exist for bulk handling, using such handling methods as pallet shipment. Individual retailer savings are hard to estimate, because they are reflected in reductions in the price, quality, competition between alternate sources of supply, and lack of knowledge about the suppliers' own delivery costs. Retailers' estimates of savings varied considerably, but ranged from 0.5 to 2 cents per pound for meat carcasses and from 2 to 4 cents per pound on packaged or processed meat products.

2. Another factor affecting costs is the prices obtained for byproducts. Prices received for bones and meat scraps are usually low at the retail store because of the high cost of collecting them. Centralizing the retail meat processing operation makes it possible to collect sizable quantities of scrap and bone which, in some areas, are sold at prices ranging from 1 to 2 cents per pound higher than the price received in retail stores. The average retailer accumulated 12 to 14 percent of carcass weight in these byproducts. A central plant processing for $75,000 of retail meat sales per week might save from $4,000 to $5,000 per year on this factor, based on the price differential mentioned.

3. A detailed comparison of the delivery cost for central plants and delivery cost for conventional retail stores will be dealt with in another report. In this report, delivery cost will be considered to be approximately the same for both methods. However, the need for daily deliveries from a central meat plant to retail stores could possibly be higher than the delivery cost presently incurred in shipping carcass meat from a central warehouse.

4. Central processing permits distribution of meat cuts according to market preference. For years, retailers have been attempting to devise means of providing better distribution of retail cuts. Central meat processing, with this type of distribution, might improve total dollar yield from a carcass when all cuts were shipped to the stores according to consumer demand.

5. Central processing provides more uniform cutting. Cutting done in one location is easier to control and provides greater standardization in cuts. This should also provide opportunities to improve carcass yield and eliminate waste.

6. Central control of ordering and inventories can provide means of controlling overhead costs and maximizing sales.

7. Methods of cutting and types of cuts offered for sale can be controlled more readily. Meat can be cut in a special way for a promotion or to fill a particular need. Costs of individual cuts are better known, which should permit more realistic pricing.

8. Meat packages delivered from the central plant are ready for sale as soon as they arrive at the store. Such deliveries, when properly done, can eliminate much of the out-of-stock conditions often found in meat cases, and give the customer a larger selection of cuts to choose from.

PRODUCTION PLANNING AND CONTROL

The purpose of a production planning and control system is to give the central plant manager an accurate method for determining the amount of production needed during any given period. Shortages and overages can be held to a minimum, the workload of the crew kept in better balance, and efficient scheduling of deliveries to the stores facilitated.

For effective production control, all the planning and control work should be done by specialists on a supervisory level and should not be the responsibility of the operational personnel. Some of the specific objectives of this function are: (7)

1. Inventory methods that are adequate, but simple.

2. Centralized planning.

3. Maintenance of uniform workloads.

4. Information that will enable the plant manager to anticipate difficulties.

5. Accurate current information regarding the progress of all orders, and provision for corrective action with respect to delays.

6. Advance provision for material and packaging supplies to prevent delays and idle time.

7. Accumulation of information that will improve the accuracy of future planning and reduce the work involved.

The production planning and control function in a central plant represents a specialized area of administrative activity. The plant manager should have administrative ability as well as operational knowledge. In setting up a production control system, all conditions and situations should be covered without an undue number of "special" forms or other improvised procedures (7).

In a central meat-packaging plant, the flow control method of production is probably the best. The control points in a central plant are the specific processing centers, such as cutting, wrapping, and pricing. A given amount of work is scheduled for each of these centers in a given period of time. The planning function consists primarily of establishing hourly, daily, weekly, and monthly production quantities. The main job of plant supervision then becomes one of control, to see that schedules are kept.

Design and Use of Forms

To obtain reasonable accuracy in estimating the amount to produce, each individual store order should be based on daily store inventories, past sales, and any other special considerations which may affect sales. An efficient inventory control system is a basic requisite for the successful operation of a central meat plant. It is imperative that the central plant be able to supply each store with the required amount and quality of the desired items.

The design and type of forms used in the inventory control system vary according to volume, the number of stores serviced, and, to some extent, company preference. In most cases, two types of forms are needed in a central-plant operation to aid in determining the amount to produce. One form is designed for obtaining data on each store, while the second form is designed for production information needed for the efficient operation of the central plant.

Form "A," called "Meat Prepack Inventory and Order Sheet," should contain columns for the following information:

1. Inventory.
2. Number of packages ordered.
3. Number of packages shipped out.
4. Number of damaged packages "pulled" from the display case.
5. Number of packages actually on display at the store after returns have been deducted.
6. Number of packages sold.

Form "B" can be titled "Daily Production Form," and should contain columns for the following information:

1. Primal cuts.
2. Inventory of selection cooler.
3. Amount ordered for each store.
4. Total amount of each item ordered for the stores.
5. Amount to produce.

As the volume and the number of stores serviced become greater, it may be more feasible to process the information with data processing equipment, but the same basic information would still be needed.

The two forms shown in this report were developed by AMS researchers for a central fresh meat packaging plant in the eastern section of the country. They are used in this report as an illustration of the production planning and control system. The central plant using these forms in the manner described in this report is servicing three stores located within a 3-mile radius. The stores are doing a total meat retail volume of $10,000 to $15,000 per week.

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The design of form A, Meat Prepack Inventory and Order Sheet, is shown in figure 24. Each store phones in its daily inventory of individual meat packages, and the person handling the records at the plant fills in the inventory column. These records may be kept by the central plant manager or his assistant, in a small plant, or by a production control department or accounting office in a larger operation. The "Package Order" column is filled out by the production control department, using daily sales records of the past movement of each individual store.

The assembling of Thursday's inventory and order sheets for 4 weeks is shown in figure 25. Records are kept, for each day of the week on all stores, by the production control department. Upon completion, each week's Thursday inventory and order form is positioned under the previous Thursday's, allowing only the "Number Sold" column to show. The oldest Thursday is removed to maintain the 4-week record.

As illustrated in figure 26, the record of sales for the past 4 weeks for a given day of the week, in this case Thursday, is used to prepare the individual store order. The new inventory and order form, with only the inventory column filled in, is positioned under that store's records of past 4 weeks of sales for that particular day. The amount of an item to order for a store is determined by using the last 4 weeks of sales as an indicator of sales, and then allowing for the amount in inventory plus or minus an additional amount to adjust for special considerations. The number of items to ship is placed in the store's packaged order column.

MEAT PREPACK INVENTORY AND ORDER SHEET

Store #1 (Form A) Day - Thurs. Date 6/20

Item	Inv.	Pkg. ord.	Shipped	Ret.	On hand	No. sold
BEEF	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX
Tenderloin steak	2	9	5-4	1	10	5
Rump steak, sh. cut	0	4	4	0	4	3
N.Y. sirloin stk.	1	10	5-5	1	10	9
Thin sh. cut steak	0	3	3	0	3	3
XXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX
Porterhouse stk. D.P.	0	6	3-3	0	6	5
Porterhouse steak	2	18	8-10	1	19	15
T-bone steak	1	10	4-6	0	11	8

Figure 24.--A meat prepack inventory and order form for a retail store served by a central plant.

MEAT PREPACK INVENTORY AND ORDER SHEET

Store #1 (Form A) Day: Thurs. Date: 6/20

Item	Inv.	Pkg. ord.	Shipped	Ret.	On hand	No. sold	Thurs. 6/27 No. sold	Thurs. 7/4 No. sold	Thurs. 7/11 No. sold
BEEF	XXXX

MEAT PREPACK INVENTORY AND ORDER SHEET

Store #1 (Form A) Day: Thurs. Date: 6/20

Item	Inv.	Pkg. ord.	Shipped	Ret.	On hand	No. sold	Thurs. 6/27 No. sold	Thurs. 7/4 No. sold	Thurs. 7/11 No. sold
BEEF	XXXX

MEAT PREPACK INVENTORY AND ORDER SHEET

(Form "A")

Store #1

Item	Inv.	Pkg. ord.	Shipped	Ret.	On hand	Day: Mon. Date: 6/10 No. sold	Tues. 6/11 No. sold	Wed. 6/12 No. sold	Thurs. 6/13 No. sold	Fri. 6/14 No. sold	Sat. 6/15 No. sold	Weekly sales ledger for all stores Store #1 No. sold	Store #2 No. sold
BEEF	XXXX

DAILY PRODUCTION SHEET--MEAT DEPARTMENT

Day Thursday (Form B) Date 7/18/60

Item		Prim.	Inv. coolr.	Packgs. ordered			Total ordered	Amount to produce
				Store #1	Store #2	Store #3		
BEEF	XXXX

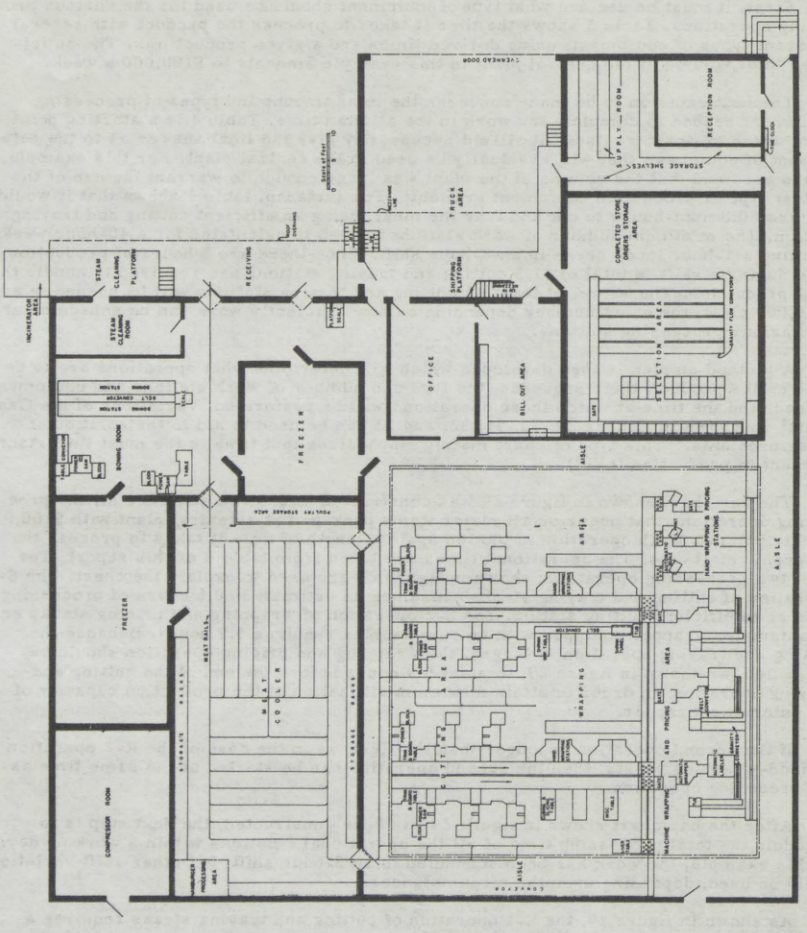


Figure 2.--A large-volume central meat plant.

First, it must be decided what type of equipment should be used for the various processing operations. Table 3 shows the time it takes to process the product with several different types of equipment, using derived times and a given product mix. The anticipated total volume of the central plant in this example amounts to $100,000 a week.

The next decision to be made concerns the total amount and types of processing equipment needed to complete the work in the allotted time. Table 4 is a starting point from which to work; by itself, it will not necessarily give the final answer as to the actual amount of equipment that will eventually be used in the central plant. For this example, it was assumed that the volume of the plant was large enough to warrant the use of the fastest type of production equipment available. For instance, table 4 shows that it would require 80.8 man-hours to cut and tray the meat, using an efficient cutting and traying station. The minimum number of work stations needed is calculated for a 40-hour week, allowing a 1-hour lunch break in an 8-hour shift. Since there are 7 hours of production time during a shift, a total of 11.5 cutting and traying stations are required to handle the total production. Therefore, at least 12 cutting and traying stations will be needed in a $100,000 plant, the exact number depending on how efficiently work can be scheduled at the various processing stations.

A method or plan is then developed which will determine what operations are to be done on the product, their sequence, the type and number of work stations and equipment needed, and the time at which these operations will be performed. Variations of the Gantt chart[6] as shown in figures 29, 30, 31, 32, and 33 can be used to aid in the solution of these problems.[7] This type of chart mainly emphasizes that time is the most important element in production (6) (7).

The bar chart shown in figure 29 was constructed to show in sequence all the processing operations that occur on all major items packaged at a central plant with $100,000 weekly volume. Each operation is plotted against length of time it takes to process the different retail cuts. The operational times are taken from table 4 of this report. The first two processing operations shown in figure 29 are used to explain the chart. The S-1 operation of cutting and traying steaks consumes an estimated 20.6 hours of processing time at an efficient cutting station. The S-2 operation of wrapping and pricing steaks on an automatic wrapper equipped with an auto-labeler requires 5.9 hours. Because the cutting and traying operation is longer, the wrapping and pricing operation should be scheduled, as shown in figure 29, to start 5.9 hours before the end of the cutting and traying operation, in order to attain maximum utilization of the production capacity of the automatic wrapper.

If the second operation is longer than the first, as in the case of the R-2 operation of hand-wrapping roasts, then the second operation can be started at the same time as the preceding operation.

After the bar chart shown in figure 29 has been constructed, the next step is to schedule the total processing time of all the operational functions within a working day. In this example, the work has been scheduled to an 8-hour shift, but other shift variations could be used, depending upon the circumstances.

As shown in figure 29, the S-1 operation of cutting and traying steaks requires a total processing time of 20.6 hours. Therefore, completion of the total processing in the S-1 operation, within the 7 hours of actual production time available, requires that the work be scheduled to three work stations, as illustrated in figure 30. The S-2 operation can be satisfactorily handled by one automatic wrapping machine and automatic labeler, since the function of wrapping and pricing with this equipment requires 5.9 hours. The S-2 operation should be scheduled to start 5.9 hours before the end of the S-1 operation, for maximum utilization of the production capacity of this equipment. All the other processing operations are scheduled similarly.

[6] A method developed by Henry L. Gantt for plotting plans on progress of operations in relation to time.
[7] Gantt chart vertical axis lists the jobs to be done, horizontal axis represents time to do the work.

Table 3.--Production time for processing at a central meat prepackaging plant with a weekly volume of $100,000 in fresh red meats

Item	Pkgs. per week[1]	Maximum pkgs. per day[2]	Cutting and traying time per unit[3]	Total cutting and traying time	Wrapping and/or pricing time per unit	Total wrapping and/or pricing time	Type of equipment
	Number	Number	Minutes	Hours	Minutes	Hours	
					.108	11.8	Semiautomatic wrapper and automatic scale and labeler
Steaks	24,226	6,541	.189	20.6	.054	5.9	Automatic wrapper and automatic scale and labeler
					.385	19.9	Hand-wrap stations
Roasts	5,638	3,099	.217	11.2	.108	5.6	Conventional scale
Ground meat	10,881	3,409	.152	8.6	.054	3.1	Automatic wrapper and automatic scale and labeler
					.054	1.0	Automatic wrapper and automatic scale and labeler
Misc. beef	3,518	799	[4] .511	6.8	.108	1.9	Semiautomatic wrapper and automatic scale and labeler
					.054	2.2	Automatic wrapper and automatic scale and labeler
Pork	7,918	2,423	.172	6.9	.108	4.4	Semiautomatic wrapper and automatic scale labeler
Lamb legs	258	113	.246	.5	.534	1.0	Hand-wrap stations
					.054	.20	Automatic wrapper and automatic scale labeler
Lamb	518	225	.131	.5	.108	.4	Semiautomatic wrapper and automatic scale labeler
		4207 W	.147	10.3	.108	7.6	Hand-wrap stations
Poultry	22,500	4208 C	.220	15.4	.054	3.8	Automatic wrapper and automatic scale labeler
					.444	18.3	Hand-wrap stations
Ham	7,889	2,422	.213	8.6	.108	4.4	Conventional scale

[1] Based on production of $100,000 in fresh red meats.
[2] Estimated maximum daily production.
[3] Cutting times based on standards taken from MRR No. 41 and supporting data.
[4] Estimated cutting and traying times.

Table 4.--Hours of operating time at each station required for equipment in a $100,000-a-week central fresh meat processing plant

Processing operation and work station numbers	Cutting and traying station	Ground meat and traying station	Automatic wrapping and pricing station	Hand wrapping station	Shrink tunnel	Conventional automatic weighing and pricing station
	Hours	Hours	Hours	Hours	Hours	Hours
S--1	20.6					
S--2			5.9			
R--1	11.2					
R--2				19.9		
R--3						5.6
GM-1		8.6				
GM-2			3.1			
MB-1	6.8					
MB-2			1.0			
P--1	6.9					
P--2			2.2			
LL-1	.5					
LL-2				1.0		
LL-3						.2
LC-1	.5					
LC-2			.6			
PW-1	10.3					
PW-2						7.6
PC-1	15.4					
PC-2			3.8			
H--1	8.6					
H--2					18.3	
H--3						4.4
Total hours	80.8	8.6	16.6	22.4	18.3	22.8
Decimal station req.	11.54	1.23	2.37	3.20	2.61	3.25
Actual no. stations req.	12	2	3	4	3	3

LEGEND

S--Steak
R--Roast
GM--Ground meat
MB--Miscellaneous beef
P--Pork
LL--Leg of lamb
LC--Lamb chops
PW--Poultry (whole)
PC--Poultry (cut up)
H--Ham

Operations

1--Cutting, traying, grinding, or bagging
2--Automatic wrapping and pricing or hand wrapping
3--Conventional pricing

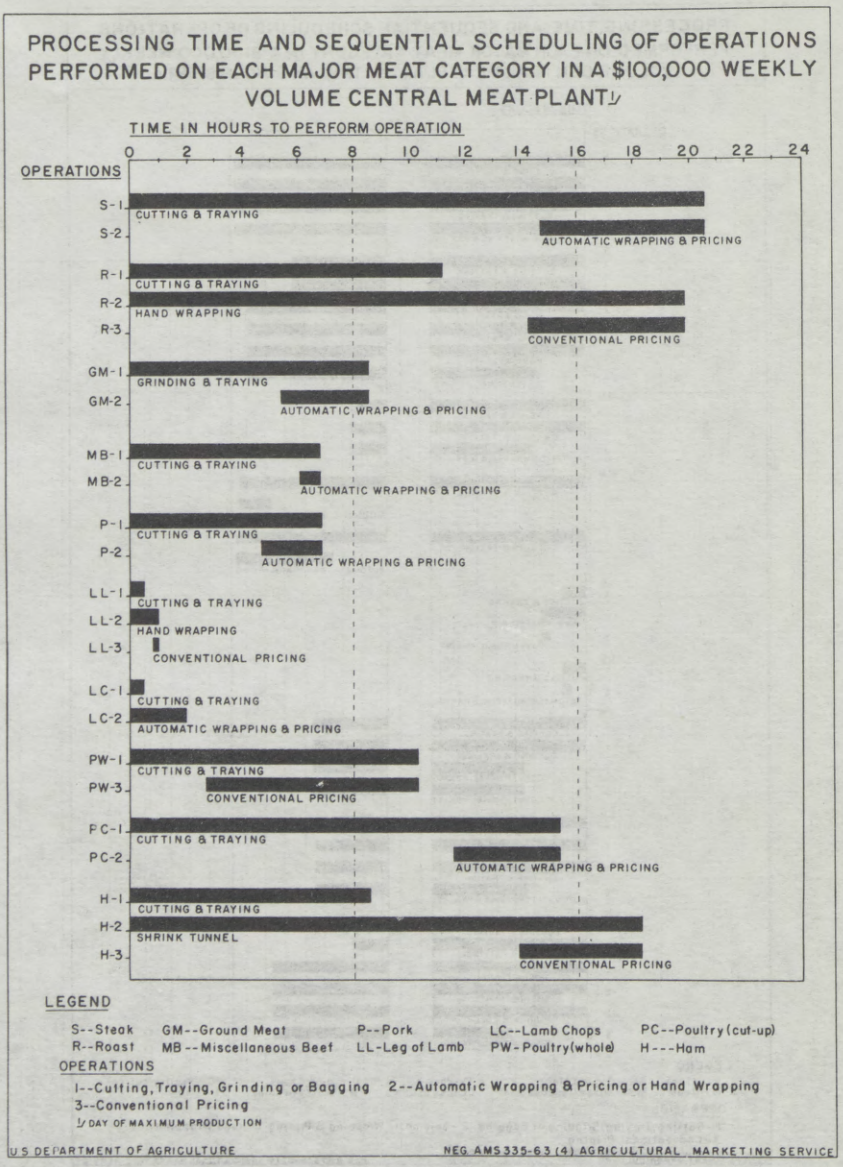
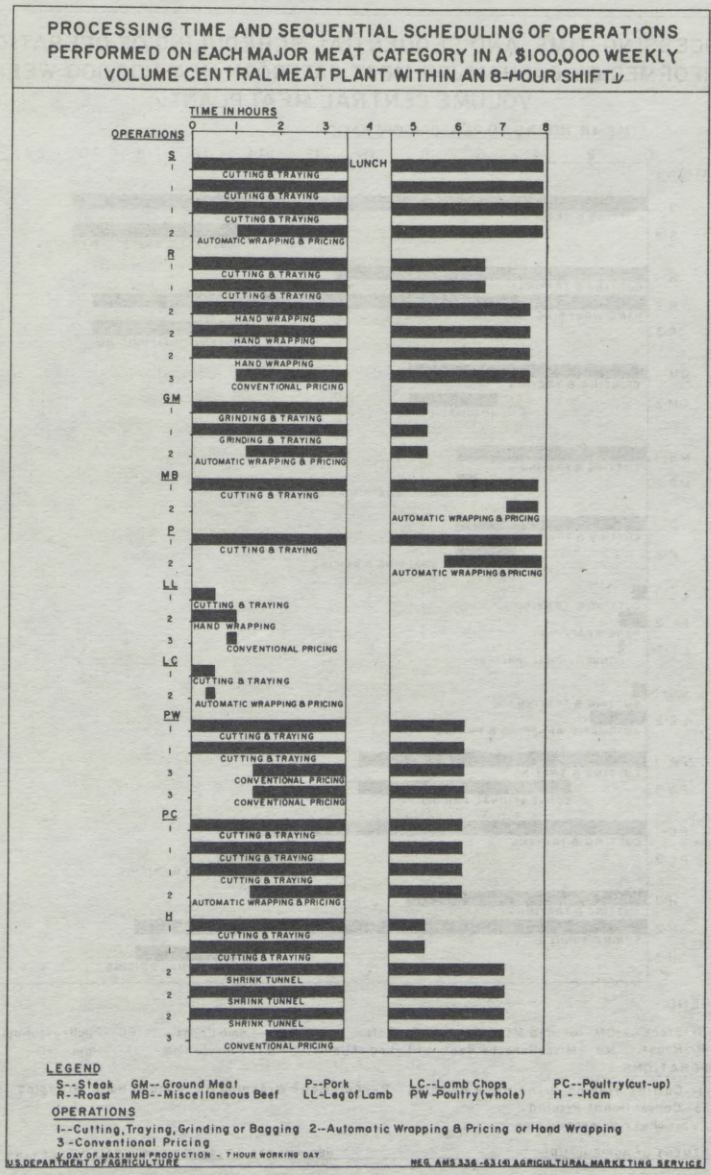

PROCESSING TIME AND SEQUENTIAL SCHEDULING OF OPERATIONS PERFORMED ON EACH MAJOR MEAT CATEGORY IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT 1/
TIME IN HOURS TO PERFORM OPERATION
0 2 4 6 8 10 12 14 16 18 20 22 24
OPERATIONS
S-1 CUTTING & TRAYING
S-2 AUTOMATIC WRAPPING & PRICING
R-1 CUTTING & TRAYING
R-2 HAND WRAPPING
R-3 CONVENTIONAL PRICING
GM-1 GRINDING & TRAYING
GM-2 AUTOMATIC WRAPPING & PRICING
MB-1 CUTTING & TRAYING
MB-2 AUTOMATIC WRAPPING & PRICING
P-1 CUTTING & TRAYING
P-2 AUTOMATIC WRAPPING & PRICING
LL-1 CUTTING & TRAYING
LL-2 HAND WRAPPING
LL-3 CONVENTIONAL PRICING
LC-1 CUTTING & TRAYING
LC-2 AUTOMATIC WRAPPING & PRICING
PW-1 CUTTING & TRAYING
PW-3 CONVENTIONAL PRICING
PC-1 CUTTING & TRAYING
PC-2 AUTOMATIC WRAPPING & PRICING
H-1 CUTTING & TRAYING
H-2 SHRINK TUNNEL
H-3 CONVENTIONAL PRICING
LEGEND
S--Steak GM--Ground Meat P--Pork LC--Lamb Chops PC--Poultry (cut-up)
R--Roast MB--Miscellaneous Beef LL-Leg of Lamb PW-Poultry (whole) H---Ham
OPERATIONS
1--Cutting, Traying, Grinding or Bagging 2--Automatic Wrapping & Pricing or Hand Wrapping
3--Conventional Pricing
1/ DAY OF MAXIMUM PRODUCTION
U.S. DEPARTMENT OF AGRICULTURE
NEG. AMS 335-63 (4) AGRICULTURAL MARKETING SERVICE

Figure 29.


PROCESSING TIME AND SEQUENTIAL SCHEDULING OF OPERATIONS PERFORMED ON EACH MAJOR MEAT CATEGORY IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT WITHIN AN 8-HOUR SHIFT1/
TIME IN HOURS
0 1 2 3 4 5 6 7 8
OPERATIONS
LUNCH
S
CUTTING & TRAYING
CUTTING & TRAYING
CUTTING & TRAYING
AUTOMATIC WRAPPING & PRICING
R
CUTTING & TRAYING
CUTTING & TRAYING
HAND WRAPPING
HAND WRAPPING
HAND WRAPPING
CONVENTIONAL PRICING
GM
GRINDING & TRAYING
GRINDING & TRAYING
AUTOMATIC WRAPPING & PRICING
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CUTTING & TRAYING
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LL
CUTTING & TRAYING
HAND WRAPPING
CONVENTIONAL PRICING
LC
CUTTING & TRAYING
AUTOMATIC WRAPPING & PRICING
PW
CUTTING & TRAYING
CUTTING & TRAYING
CONVENTIONAL PRICING
CONVENTIONAL PRICING
PC
CUTTING & TRAYING
CUTTING & TRAYING
CUTTING & TRAYING
AUTOMATIC WRAPPING & PRICING
H
CUTTING & TRAYING
CUTTING & TRAYING
SHRINK TUNNEL
SHRINK TUNNEL
SHRINK TUNNEL
CONVENTIONAL PRICING
LEGEND
S--Steak GM--Ground Meat P--Pork LC--Lamb Chops PC--Poultry(cut-up)
R--Roast MB--Miscellaneous Beef LL-Leg of Lamb PW-Poultry(whole) H--Ham
OPERATIONS
1--Cutting, Traying, Grinding or Bagging 2--Automatic Wrapping & Pricing or Hand Wrapping
3-Conventional Pricing
1/ DAY OF MAXIMUM PRODUCTION - 7 HOUR WORKING DAY
U.S. DEPARTMENT OF AGRICULTURE
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Figure 30.

PROCESSING TIME OF OPERATIONS PERFORMED ON EACH MAJOR MEAT CATEGORY SCHEDULED AT SPECIFIC WORK STATIONS IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT BASED ON ONE DAILY SET-UP1/

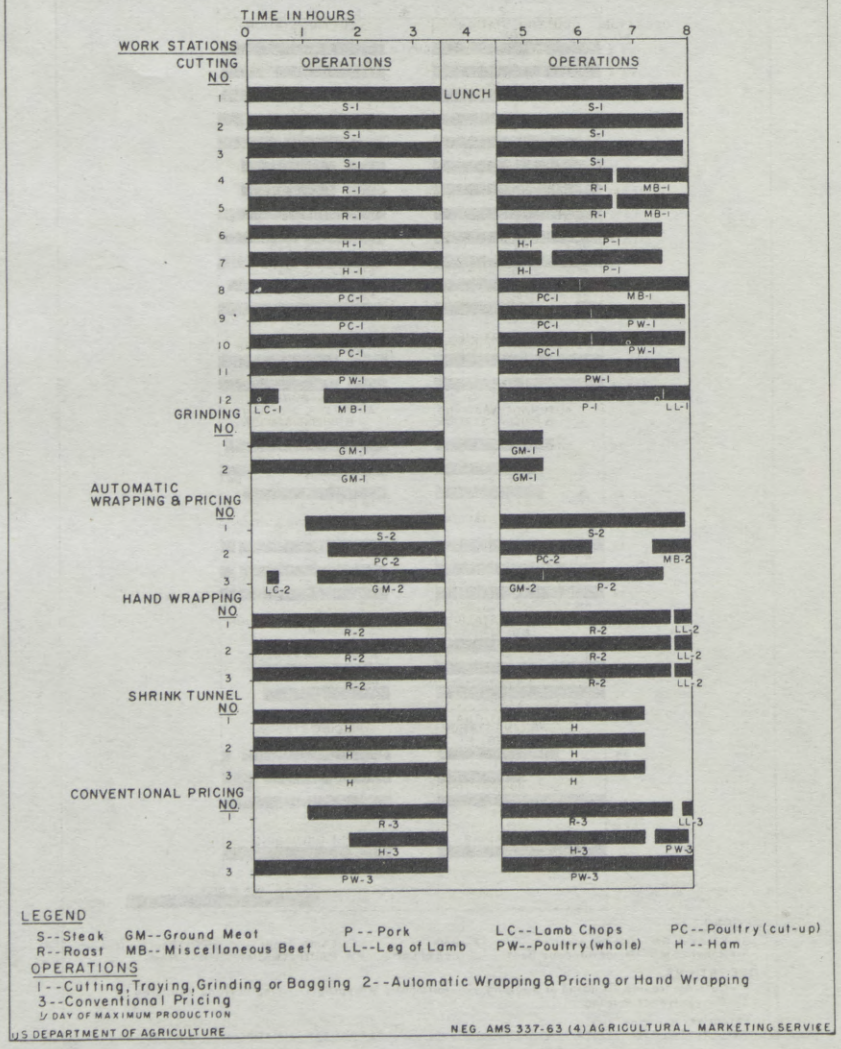

Figure 31.

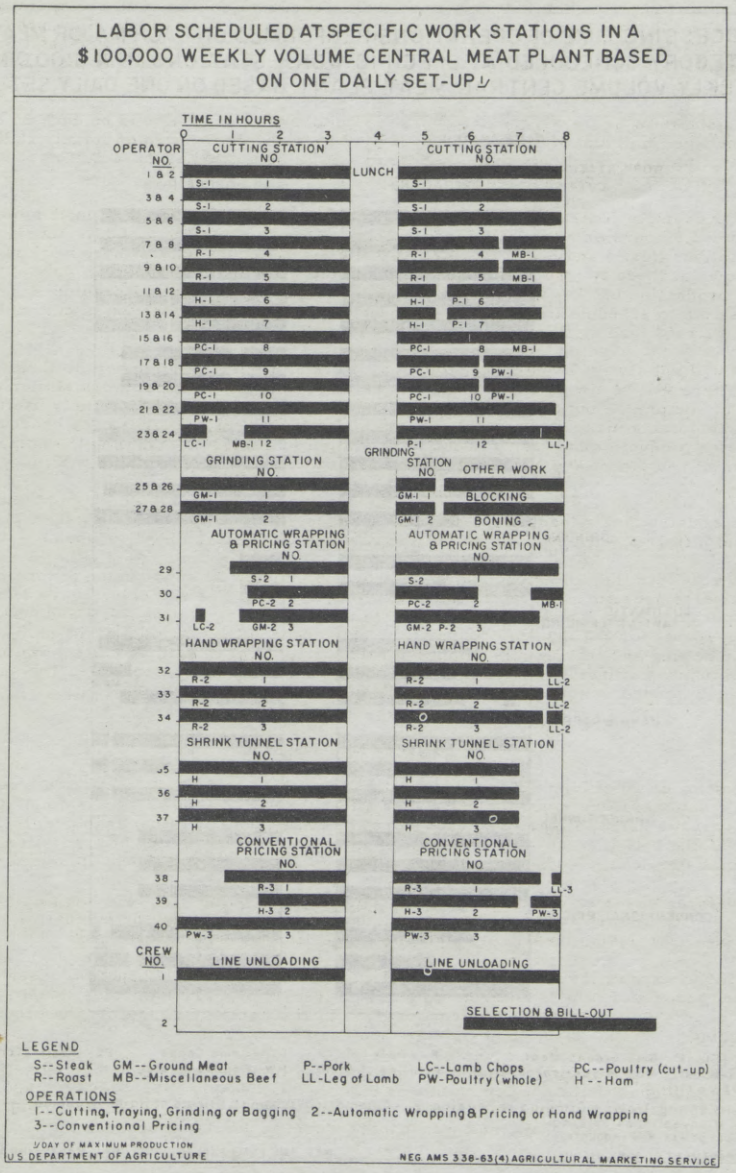
LABOR SCHEDULED AT SPECIFIC WORK STATIONS IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT BASED ON ONE DAILY SET-UP 1/
TIME IN HOURS
0 1 2 3 4 5 6 7 8
OPERATOR NO.
CUTTING STATION NO.
LUNCH
GRINDING STATION NO.
OTHER WORK
AUTOMATIC WRAPPING & PRICING STATION NO.
HAND WRAPPING STATION NO.
SHRINK TUNNEL STATION NO.
CONVENTIONAL PRICING STATION NO.
CREW NO.
LINE UNLOADING
SELECTION & BILL-OUT
BLOCKING
BONING
LEGEND
S--Steak GM--Ground Meat P--Pork LC--Lamb Chops PC--Poultry (cut-up)
R--Roast MB--Miscellaneous Beef LL-Leg of Lamb PW-Poultry (whole) H--Ham
OPERATIONS
1--Cutting, Traying, Grinding or Bagging 2--Automatic Wrapping & Pricing or Hand Wrapping
3--Conventional Pricing
1/ DAY OF MAXIMUM PRODUCTION
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Figure 32.

The next phase of scheduling is to allot the processing times of all the operations in a central meat plant to a number of specific work stations. This should allow production to be completed within a normal 8-hour shift with maximum loading of work stations and equipment. It is necessary to use table 4 and figure 30 when constructing the chart shown in figure 31.

As shown in figure 31, the S-1 operation on steaks is scheduled to be done on cutting stations Nos. 1, 2, and 3, utilizing them for 6.9 hours of the 7 hours of actual production time available. It is unlikely that other items can be scheduled at these cutting stations, because they are being used to near capacity.

For example, roasts are scheduled on cutting stations Nos. 4 and 5, loading each of them for 5.6 hours or a total processing time for the R-1 operation of 11.2 hours. Cutting stations Nos. 4 and 5 will therefore be idle for 1.4 hours unless more work is scheduled at these two work stations. To load stations 4 and 5 to capacity, part of the MB-1 production has been scheduled to them. As the chart is further developed, it will be possible to schedule the remaining production of the MB-1 operation to cutting station No. 8, thereby loading this work station to capacity.

It will not always be possible to load all work stations and equipment to their capacities. There will be times when no work is being done on a particular work station or piece of equipment, but a loading chart as shown in figure 31 is an extremely useful device in obtaining maximum possible utilization of equipment and labor. The chart aids in balancing production between various work stations, besides determining the actual amount of equipment and work stations needed to produce a given volume within an 8-hour shift.

In constructing a loading chart of this type, the various operations must be placed at several different work stations before the best combination can be developed.

A chart similar to the one shown in figure 31 can now be constructed for the purpose of assigning operators to specific work stations and jobs. For example, figure 32 shows that operators Nos. 7 and 8 are scheduled to work at cutting station No. 4 and will be cutting roasts for the first 5.6 hours of the shift. During the last part of the shift, they will be cutting and traying miscellaneous beef for 1.3 hours. Loading cutting station No. 4 in this manner utilizes it for 6.9 hours of the 7 production hours available. The same technique is used in scheduling labor to the remaining equipment and jobs.

Delivery Scheduling

Setting up an efficient delivery operation is another important function in a central fresh meat operation, since the deliveries affect the entire scheduling system. For instance, if two daily deliveries to each store are contemplated, rather than one, the scheduling of the entire processing operation is affected. The scheduling of production and labor for two deliveries a day is shown in figures 34 and 35 (pp. 75 and 76, appendix).

Before deliveries can be scheduled accurately, the number and volume of stores serviced, the length of delivery routes, the number of trucks, and the number of shipping containers for use on the day of maximum production must be determined.

Table 5 shows the number of shipping containers, 18 by 28 1/2 inches, required to service three stores with different volumes on the day of maximum sales. Meat sales were broken down into eight major categories in an attempt to segregate the products according to weight, size, and height as much as possible.

The following example is used to show how the total delivery time can be estimated. This central plant is to service 16 stores doing a total weekly volume of $100,000 with an average volume per store of $6,250. The round-trip distance from the central plant to the stores is 68 miles. This means that there would be 17 stops, because the last stop at

Table 5.--Shipping container requirements on peak volume days for stores of different volumes

	Sales, pkgs. weekly[1]	Sales, pkgs. peak day	Pkg./tub[2]	Tubs required on peak day
	$6,250 volume store			
	Number	Number	Number	Number
Steaks	476	143	50	3
Roasts	200	60	20	3
Ground meat	687	206	75	3
Misc. beef	346	104	50	3
Veal	66	20	55	1
Pork	546	164	30	6
Poultry	890	267	36	8
Lamb	6	2	5	1
			Total tubs	28
	$10,000 volume store			
Steaks	793	238	50	5
Roasts	335	100	20	5
Ground meat	1,145	343	75	5
Misc. beef	576	173	50	4
Veal	110	33	55	1
Pork	910	273	30	10
Poultry	1,482	445	36	12
Lamb	10	3	5	1
			Total tubs	43
	$16,667 volume store			
Steaks	1,319	395	50	8
Roasts	558	167	20	9
Ground meat	1,907	572	75	8
Misc. beef	960	288	50	6
Veal	184	55	55	1
Pork	1,519	451	30	15
Poultry	2,477	740	36	21
Lamb	16	5	5	1
			Total tubs	69

[1] Used product mix based on movement studies from 5 stores located in different areas of the country.
[2] Using a container size of 18" X 28" X 6".

the central plant would have to be included. The average distance between stops would be 4 miles. In this example, it was assumed that the most economical type of delivery truck was a self-contained refrigerated "bobtail" unit with inside dimensions 6 feet 10 inches wide by 18 feet long by 6 feet high.

Table 5 shows that each store with an average weekly volume of $6,250 would require 28 containers to fill the order on the day of maximum production. Therefore, to supply all 16 stores would require a total of 448 containers. The maximum number of shipping containers that can be loaded into the truck used in this example is 225, stacked 5 high; therefore, since 448 containers must be delivered, at least 2 trucks would be required when each truck made 1 daily delivery trip. The actual number of delivery trucks required is specified in the latter part of this section, which deals with overall scheduling of all phases of a central meat-processing operation.

An estimate of the total time required for delivery to a given number of stores may be obtained by calculating the actual driving time to the stores, time required to service the stores, time required to unload and check the orders, and normal stop times which occur during the delivery operations. To find the actual amount of driving time required, in the above example, use table 6 in the following manner:

1. Read vertically down the "Total miles" column until the line is reached which contains the total distance of 68 miles.

2. Follow this line horizontally across the table until a column is reached which contains the average distance of 4.0 miles per stop.

3. Read the figure appearing at the junction point, 234 minutes.

After the driving time has been arrived at, the next step is to find the length of time required to unload and check the order at the 16 stores being serviced. The times in tables 6, 7, and 8 were established for wholesale groceries, but have been checked for retail meat deliveries and found to be consistent.

Using table 7, the total unloading and checking time can be read from the table as follows:

1. Read vertically down the "Total pieces" column until a line is reached which contains 225 containers.

2. Read horizontally across the table until a column is reached which contains the average number of pieces per order (28).

3. Read the number of minutes used, appearing at the junction point (101).

The last operation in computing total time required on a delivery run is to find the normal stop times during the run. As used here, stop times are considered to be the small amounts of time that are not included in either unloading and checking time or travel time. This time includes such activities as preparing to unload the truck, receiving instructions from the retailer, and filling out information on the delivery manifest. Also included is unavoidable delay time at each delivery stop, such as waiting for dock space and waiting for the retailer to open the receiving door and sign the invoice. (6) These times were found to be consistent for all types of store deliveries.

Normal stop times on urban delivery trips can be found in table 8 as follows:

1. Read vertically down the "Total delivery stops" column until the number of stops is reached; in this case, it is 16.

2. Read horizontally along line 16 until the column is reached which includes the average containers per order, which is 28.

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Table 6.--Normal driving times on urban delivery trips by wholesale grocers[1]

Total miles	Average distance per stop				
	Over 4 miles	3.1 to 4.0 miles	2.1 to 3.0 miles	1.6 to 2.0 miles	Under 1.5 miles
	Min.	Min.	Min.	Min.	Min.
4 to 6.....	17	18	20	24	35
6.1 to 8.....	24	24	28	34	49
8.1 to 10.....	31	32	36	43	63
10.1 to 12.....	37	38	44	53	77
12.1 to 14.....	44	46	52	62	91
14.1 to 16.....	51	52	60	72	105
16.1 to 18.....	58	60	68	82	119
18.1 to 20.....	65	66	76	91	133
20.1 to 22.....	71	74	84	101	149
22.1 to 24.....	78	80	92	110	161
24.1 to 26.....	85	88	100	120	175
26.1 to 28.....	92	92	108	130	189
28.1 to 30.....	99	100	116	139	203
30.1 to 32.....	105	106	124	149	217
32.1 to 34.....	112	114	132	158	231
34.1 to 36.....	119	120	140	169	245
36.1 to 38.....	126	128	148	178	259
38.1 to 40.....	133	134	156	187	273
40.1 to 42.....	139	142	164	197	
42.1 to 44.....	146	150	172	206	
44.1 to 46.....	153	156	180	216	
46.1 to 48.....	160	164	188	226	
48.1 to 50.....	167	172	196	235	
50.1 to 52.....	173	180	204		
52.1 to 54.....	180	186	212		
54.1 to 56.....	187	194	220		
56.1 to 58.....	194	200	228		
58.1 to 60.....	201	208	236		
60.1 to 62.....	207	214	244		
62.1 to 64.....	214	220	252		
64.1 to 66.....	221	228	260		
66.1 to 68.....	228	234			
68.1 to 70.....	235	242			

[1] See p. 17 of reference (8).

Table 7.--Normal unloading and checking times on urban delivery trips by wholesale grocers[1]

Total pieces (containers)	Average pieces per order											
	451 to 650 pcs.	351 to 450 pcs.	251 to 350 pcs.	151 to 250 pcs.	101 to 150 pcs.	71 to 100 pcs.	50 to 70 pcs.	31 to 50 pcs.	26 to 30 pcs.	21 to 25 pcs.	16 to 20 pcs.	15 pieces or under
	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
200 to 225....				43	52	62	71	87	101	112	138	160
226 to 250....				48	58	69	80	98	113	125	155	178
251 to 275....			43	53	64	76	88	108	125	138	171	197
276 to 300....			47	58	71	84	96	118	137	151	187	216
301 to 325....			48	63	77	91	105	128	149	164	203	235
326 to 350....			52	68	83	98	113	138	160	177	220	254
351 to 375....		54	60	73	89	105	122	149	172	190	236	272
376 to 400....		58	64	78	95	112	130	159	184	203	252	291
401 to 425....		62	68	83	101	120	138	169	196	216	268	
426 to 450....		66	72	88	107	127	147	180	208	230	285	
451 to 475....	57	69	76	93	113	134	155	190	220	243	301	
476 to 500....	61	73	81	98	120	141	163	200	232	256	317	
501 to 525....	64	77	85	103	126	149	172	210	244	269	333	
526 to 550....	67	81	89	108	132	156	180	220	256	282		
551 to 575....	70	84	93	113	138	163	189	231	267	296		
576 to 600....	74	88	97	118	144	171	197	241	279	307		

[1] See p. 18 of reference (8).

For this set of circumstances, a total stop time of 96 minutes is indicated.

The total delivery time can be arrived at by adding together the three variables:

	Minutes
Normal travel time	234
Normal unloading and checking time	101
Normal stop time	96
Normal total delivery time	431

It takes approximately 7.2 hours to make a delivery run to 8 stores with 1 truck, or a total of slightly over 14 hours for servicing all 16 stores. Therefore, it is impractical to consider using one delivery truck.

Overall Scheduling of Operations

Management must have a method for determining when each of the major functions should be scheduled in relation to the others. In the chart in figure 33, the functions of processing orders for 16 stores, selecting and filling the orders, loading the delivery truck or trucks, and delivering the orders to the stores, are plotted with respect to total time in hours. The scheduling timetable at the bottom of the chart can be used to find the time the central plant should begin production.

Table 8.--Normal stop times on urban delivery trips by wholesale grocers[1]

Total delivery stops	Average pieces per order								
	151 to 250 pieces	101 to 150 pieces	71 to 100 pieces	51 to 70 pieces	31 to 50 pieces	26 to 30 pieces	21 to 25 pieces	16 to 20 pieces	Under 16 pieces
	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.	Min.
1	17	16	12	9	7	6	5	4	3
2	34	32	24	18	14	12	10	8	6
3	51	48	36	27	21	18	15	12	9
4	68	54	48	36	28	24	20	16	12
5	85	70	60	45	35	30	25	20	15
6	102	86	72	54	42	36	30	24	18
7	119	112	84	63	49	42	35	28	21
8	136	128	96	72	56	48	40	32	24
9		144	108	81	63	54	45	36	27
10		160	120	90	70	60	50	40	30
11		176	132	99	77	66	55	44	33
12		192	144	108	84	72	60	48	36
13		208	156	117	91	78	65	52	39
14		224	168	126	98	84	70	56	42
15		240	180	135	105	90	75	60	45
16			192	144	112	96	80	64	48
17			204	153	119	102	85	68	51
18			216	162	126	108	90	72	54
19				171	133	114	95	76	57
20				180	140	120	100	80	60
21				189	147	126	105	84	63
22				198	154	132	110	83	66
23				207	161	138	115	92	69
24				216	168	144	120	96	70
25				225	175	150	125	100	73
26					182	156	130	104	76

[1] See p. 20 in reference (8).

Suppose management decides that the last store serviced should receive its order no later than 2 p.m. First, assume that all processing for the 16 stores will be done with 1 setup and the delivery made with 2 trucks. Using the upper portion of the chart, locate the bars on the chart representing delivery time with two trucks. A dotted line runs vertically from the end of the bars through the scheduling table. Follow the dotted line until it reaches a line containing 2 p.m. To find when the central plant must start processing, follow the 2 p.m. line horizontally until it intersects the beginning of the bar titled "Processing orders." The time of 8 p.m. is read at this intersection point. Therefore, for the last store on the delivery run to receive its order by 2 p.m., the central plant will have to commence processing the orders by 8 p.m., which is nearly 18 hours before the order is to arrive at the last store. If opening the central plant at 8 p.m. is

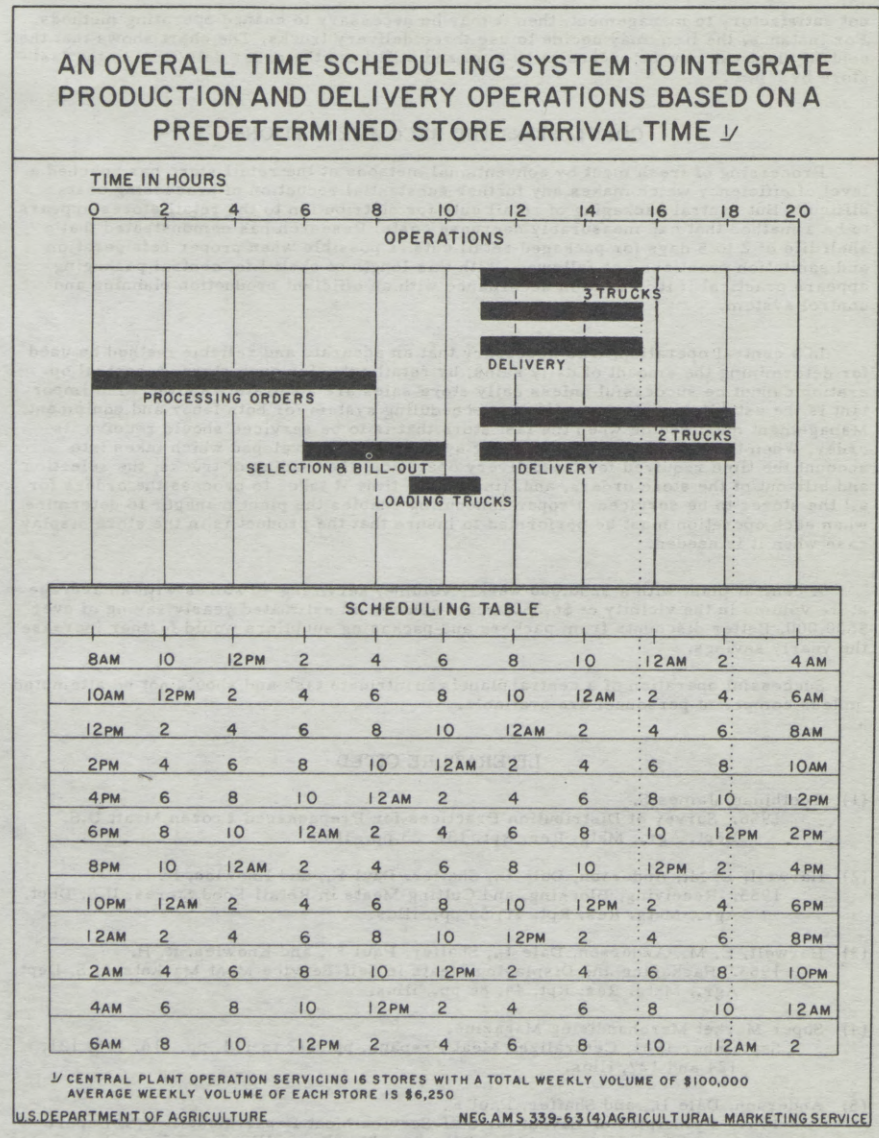
AN OVERALL TIME SCHEDULING SYSTEM TO INTEGRATE PRODUCTION AND DELIVERY OPERATIONS BASED ON A PREDETERMINED STORE ARRIVAL TIME 1/
TIME IN HOURS
0 2 4 6 8 10 12 14 16 18 20
OPERATIONS
3 TRUCKS
DELIVERY
PROCESSING ORDERS
2 TRUCKS
SELECTION & BILL-OUT
DELIVERY
LOADING TRUCKS
SCHEDULING TABLE
8AM 10 12PM 2 4 6 8 10 12AM 2 4AM
10AM 12PM 2 4 6 8 10 12AM 2 4 6AM
12PM 2 4 6 8 10 12AM 2 4 6 8AM
2PM 4 6 8 10 12AM 2 4 6 8 10AM
4PM 6 8 10 12AM 2 4 6 8 10 12PM
6PM 8 10 12AM 2 4 6 8 10 12PM 2PM
8PM 10 12AM 2 4 6 8 10 12PM 2 4PM
10PM 12AM 2 4 6 8 10 12PM 2 4 6PM
12AM 2 4 6 8 10 12PM 2 4 6 8PM
2AM 4 6 8 10 12PM 2 4 6 8 10PM
4AM 6 8 10 12PM 2 4 6 8 10 12AM
6AM 8 10 12PM 2 4 6 8 10 12AM 2
1/ CENTRAL PLANT OPERATION SERVICING 16 STORES WITH A TOTAL WEEKLY VOLUME OF $100,000
AVERAGE WEEKLY VOLUME OF EACH STORE IS $6,250
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Figure 33.

not satisfactory to management, then it may be necessary to change operating methods. For instance, the firm may decide to use three delivery trucks. The chart shows that the central plant can now be opened at 10 p.m. and still have the order delivered to the last store by 2 p.m.

CONCLUSIONS AND RECOMMENDATIONS

Processing of fresh meat by conventional methods at the retail store has reached a level of efficiency which makes any further substantial reduction of processing costs difficult. But central packaging of retail cuts for distribution to the retail stores appears to be a method that can measurably decrease costs. Research has demonstrated that a shelf life of 2 to 5 days for packaged retail cuts is possible when proper refrigeration and sanitation practices are followed. With this length of shelf life, central packaging appears practical if it is done in accordance with an efficient production planning and control system.

In a central operation, it is necessary that an accurate and reliable method be used for determining the amount of daily sales, by retail cuts, for each store. A central operation cannot be successful unless daily store sales are accurately known. Also important is the establishment of an effective scheduling system for both labor and equipment. Management must decide when the last store that is to be serviced should receive its order. When this is decided, a scheduling system can be developed which takes into account the time required for the delivery operation, the loading of trucks, the selection and bill-out of the store orders, and, finally, the time it takes to process the orders for all the stores to be serviced. Proper scheduling enables the plant manager to determine when each operation must be performed to insure that the product is in the store display case when it is needed.

A central plant with a $250,000 weekly volume, servicing 40 stores with an average store volume in the vicinity of $6,250, could achieve an estimated yearly saving of over $600,000. Better discounts from packers and packaging suppliers would further increase the yearly savings.

Successful operation of a central plant is an intricate task and should not be attempted unless competent personnel are available.

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APPENDIX

Methodology

Researchers visited and studied the operations of several small central meat-processing plants in the United States. Observations were made of the methods and equipment used. Motion and time studies and flow process charts were made of each operation. Studies were made of product movement, inventories, sales space allocation, rewraps, ordering and scheduling techniques, and processing procedures. Operating expenses and other business records were analyzed.

Reports were made to management recommending changes in the operations based on the studies completed and on previous research in retail meat operations. These recommended changes in plant layout, equipment, work methods, scheduling, ordering, delivery, and store operations were made, and the results analyzed.

The methods, procedures, equipment, and layouts developed for these small plants were projected through budgeting techniques to larger scale operations. Equipment and construction cost estimates were obtained from the retail firms and from suppliers on a single-unit cost basis. Labor costs used were median for the firms studied.

The larger plants are described and pictured in this report. At least one of these plants and several stores have been completed, and construction and equipment cost estimates checked. Other recommendations regarding operation of these plants are being and will be continually developed and checked for accuracy as additional facilities are built.

Two new plants have been constructed according to floor plan layouts developed by the researchers, and one older plant has been remodeled. All architectural design work was done by local firms. Visits were made to at least six other firms, and much additional information was analyzed from other types of large meat-processing plants in this country and abroad. The recommendations and findings of the report also have been reviewed and checked for accuracy by a group of leading industry personnel, such as meat packers, retail chain store operators, suppliers, and university researchers.

Results obtained thus far are published to aid the industry in making evaluations of central fresh meat processing operations and to serve as guidelines for firms who plan to build central plants and distribute meat by this method.

Cost Data

Construction, equipment and labor estimates were calculated in the following manner:

I. Construction Costs for Central Meat Plants

A. $37,500 weekly volume central plant

1. Cost of building (shell):	
9,500 sq. ft. x $8.00 per sq. ft.	$76,000
2. Cost of cooler (meat and selection cooler):	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 20,340 cu. ft. x $.74 per cu. ft.	15,052
Total cost for 23,140 cu. ft. of cooler area	18,132
3. Cost of refrigerating the processing and bill-out area:	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 17,840 cu. ft. x $.74 per cu. ft.	13,202
Total cost for 20,640 cu. ft. of processing and bill-out areas	16,282
4. Cost of freezer:	
First 2,234 cu. ft. x $1.78 per cu. ft.	3,977
Remaining 3,095 cu. ft. x $1.09 per cu. ft.	3,374
Total cost for 5,329 cu. ft. of freezer area	7,351
Total construction cost	117,765

B. $75,000 weekly volume central plant

1. Cost of building (shell):	
12,774 sq. ft. x $8.00 per sq. ft.	102,192
2. Cost of cooler (meat and selection cooler):	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 28,389 cu. ft. x $.74 per cu. ft.	21,008
Total cost for 31,189 cu. ft. of cooler area	24,088
3. Cost of refrigerating the processing and bill-out area:	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 32,360 cu. ft. x $.74 per cu. ft.	23,946
Total cost for 35,160 cu. ft. of processing and bill-out areas	27,026
4. Cost of freezer:	
First 2,234 cu. ft. x $1.78 per cu. ft.	3,977
Remaining 5,360 cu. ft. x $1.09 per cu. ft.	5,842
Total cost for 7,594 cu. ft. of freezer area	9,819
Total construction cost	163,125

C. $250,000 weekly volume central plant

1. Cost of building (shell):	
17,650 sq. ft. x $8.00 per sq. ft.	$141,200
2. Cost of cooler (meat and selection cooler):	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 33,880 cu. ft. x $.74 per cu. ft.	25,071
Total cost for 36,680 cu. ft. of cooler area.	28,151
3. Cost of refrigerating the processing and bill-out areas:	
First 2,800 cu. ft. x $1.10 per cu. ft.	3,080
Remaining 61,360 cu. ft. x $.74 per cu. ft.	45,406
Total cost for 64,160 cu. ft. of processing and bill-out areas.	48,486
4. Cost of freezer:	
First 2,234 cu. ft. x $1.78 per cu. ft.	3,977
Remaining 17,840 cu. ft. x $1.09 per cu. ft.	19,446
Total cost 20,074 cu. ft. of freezer area	23,423
Total construction cost.	241,260

II. Construction Costs for Retail Store Meat Backrooms When Served by Central Plant

A. $3,125 weekly volume retail store

1. Cost of backroom (shell):	
332 sq. ft. x $8.00 per sq. ft.	2,656
2. Cost of cooler:	
960 cu. ft. x $1.10 per cu. ft.	1,056
3. Cost of freezer:	
640 cu. ft. x $1.63 per cu. ft.	1,043
Construction costs of one backroom	4,755
4. Construction costs of backrooms for 12 retail stores with total weekly volume of $37,500:	
$4,755 x 12 stores	57,060
5. Construction cost of backrooms for 24 retail stores with total weekly volume of $75,000:	
$4,755 x 24 stores	114,120

B. One $6,250 weekly volume retail store

1. Cost of backroom (shell):	
332 sq. ft. x $8.00 per sq. ft.	2,656
2. Cost of cooler:	
960 cu. ft. x $1.10 per cu. ft.	1,056
3. Cost of freezer:	
640 cu. ft. x $1.63 per cu. ft.	1,043
Construction costs for one backroom	4,755

4. Construction costs of backrooms for 6 retail stores with total weekly volume of $37,500:
$4,755 x 6 stores $28,530

5. Construction costs of backrooms for 12 retail stores with total weekly volume of $75,000:
$4,755 x 12 stores 57,060

6. Construction costs of backrooms for 40 retail stores with total weekly volume of $250,000:
$4,755 x 40 stores 190,200

C. One $10,000 weekly volume retail store

1. Cost of backroom (shell):
372 sq. ft. x $8.00 per sq. ft. 2,976

2. Cost of cooler:
1,280 cu. ft. x $1.10 per cu. ft. 1,408

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 5,427

4. Construction costs of backrooms for 25 retail stores with total weekly volume of $250,000:
$5,427 x 25 stores 135,675

D. One $16,667 weekly volume retail store

1. Cost of backroom (shell):
492 sq. ft. x $8.00 per sq. ft. 3,936

2. Cost of cooler:
2,240 cu. ft. x $1.10 per cu. ft. 2,464

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 7,443

4. Construction costs of backrooms for 15 retail stores with total weekly volume of $250,000:
$7,443 x 15. 111,645

III. Construction Costs for Retail Store Meat Departments When Served from Conventional Backrooms

A. One $3,125 weekly volume retail store

1. Cost of backroom (shell):
805 sq. ft. x $8.00 per sq. ft. $6,440

2. Cost of cooler:
1,800 cu. ft. x $1.10 per cu. ft. 1,980

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 9,463

4. Construction costs for one backroom for 12 retail stores with total weekly volume of $37,500:
$9,463 x 12 stores 113,556

5. Construction costs of backrooms for 24 retail stores with total weekly volume of $75,000:
$9,463 x 24 stores $227,112

B. One $6,250 weekly volume retail store

1. Cost of backroom (shell):
1,080 sq. ft. x $8.00 per sq. ft. 8,640

2. Cost of cooler:
2,400 cu. ft. x $1.10 per cu. ft. 2,640

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 12,323

4. Construction costs of backrooms for 6 retail stores with total weekly volume of $37,500:
$12,323 x 6 stores 73,938

5. Construction costs of backrooms for 12 retail stores with total weekly volume of $75,000:
$12,323 x 12 stores 147,876

6. Construction costs of backrooms for 40 retail stores with total weekly volume of $250,000:
$12,323 x 40 stores 492,920

C. One $10,000 weekly volume retail store

1. Cost of backroom (shell):
1,480 sq. ft. x $8.00 per sq. ft. 11,840

2. Cost of cooler:
First 2,800 cu. ft. x $1.10 per cu. ft. 3,080
Remaining 400 cu. ft. x $.74 per cu. ft. 296

Total cost for 3,200 cu. ft. of cooler area 3,376

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 16,259

4. Construction costs of backrooms for 25 retail stores with weekly volume of $250,000:
$16,259 x 25 stores 406,475

D. One $16,667 weekly volume retail store

1. Cost of backroom (shell):
1,980 sq. ft. x $8.00 per sq. ft. 15,840

2. Cost of cooler:
First 2,800 cu. ft. x $1.10 per cu. ft. 3,080
Remaining 2,800 cu. ft. x $.74 per cu. ft. 2,072

Total cost for 5,600 cu. ft. of cooler area 5,152

3. Cost of freezer:
640 cu. ft. x $1.63 per cu. ft. 1,043

Construction costs for one backroom 22,035

4. Construction costs of backrooms for 15 retail stores with total weekly volume of $250,000:
$22,035 x 15 stores 330,525

Table 9.--Equipment requirements and costs for a $37,500 weekly volume central meat plant

Equipment	Pieces required	Unit cost	Total cost
	Number	Dollars	Dollars
Cutting tables	3	100.00	300
Cutting tools	3	40.00/station	120
Chopper	2	702.50	1,405
Meat block	3	65.00	195
Power saw	3	840.00	2,520
Liver table and loader	1	65.00	65
Cuber, slicer table, and equipment	1	910.00	910
Hand-wrap station	2	375.00	750
Automatic scale and label printer	1	4,700.00	4,700
Auto wrap machine	1	6,400.00	6,400
Transfer and labeling machine	1	2,500.00	2,500
Shrink tunnel	1	500.00	500
Prewrap shrink table	1	237.00	237
Misc. table	1	57.00	57
Ball transfer table	1	23.00	23
24" skate wheel conveyor	61 ft.	8.73/ft.	533
18" skate wheel conveyor	32 ft.	7.25/ft.	232
Office equipment--desks and 2 chairs	2	100.00	200
Freezer racks	8	248.00	1,984
Storage racks--main cooler	9	248.00	2,232
Portable tray rack	2	50.00	100
Utility lugs	35	12.00	420
Lug racks	5	42.00	210
Tubs--main cooler	150	6.00	900
Tubs--freezer	100	6.00	600
Holding racks (selection)	30	55.00	1,650
Tubs for holding racks (selection)	700	6.00	4,200
Adding machine	2	300.00	600
Meat rail	439 ft.	5.10/ft.	2,239
Lounge equipment	1	100.00	100
Time clock	1	150.00	150
File cabinet	3	50.00	150
Meat rail scale	1	2,000.00	2,000
Meat pans	200	3.25	650
Dolly and galvanized drum	3	35.00	105
Handtrucks	3	18.75	56
Totals			39,993

Table 10.--Equipment requirements and costs for a $75,000 weekly volume central meat plant

Equipment	Pieces required	Unit cost	Total cost
	Number	Dollars	Dollars
Chopper	2	702.50	1,405
Automatic scale and label printer	1	4,700.00	4,700
Transfer and labeling machine	1	2,500.00	2,500
Wrap tables	3	375.00	1,125
24" gravity conveyor	19 ft.	8.73/ft.	166
24" power conveyor	25 ft.	11.00/ft.	275
24" gravity conveyor	5 ft.	8.73/ft.	44
18" gravity conveyor	20 ft.	7.25/ft.	145
18" belt conveyor	14 ft.	24.20/ft.	339
18" gravity conveyor	23 ft.	7.25/ft.	167
24" gravity conveyor	10 ft.	8.73/ft.	87
Ball transfer table	6 ft.	7.00/ft.	42
24" gravity conveyor	60 ft.	8.73/ft.	524
12" roller conveyor	4 ft.	9.70/ft.	39
Meat rail scale	1	2,000.00	2,000
Platform scale	1	105.00	105
Meat saw	5	840.00	4,200
Auto wrap machine	1	6,400.00	6,400
Meat pans	400	3.25	1,300
Meat block	5	65.00	325
Dolly and galvanized drum	6	35.00	210
Slicer and cuber	1	810.00	810
Cutting tables	5	100.00	500
Cutting tools	5	40.00	200
Portable tray rack	2	50.00	100
Utility lug	45	12.00	540
Lug racks	7	42.00	294
Meat rail	527 ft.	5.10/ft.	2,688
Storage racks (cooler)	10	248.00	2,480
Liver table	1	57.00	57
Shrink tunnel	1	500.00	500
Shrink prewrap table	1	237.00	237
Storage racks, freezer	8	248.00	1,984
Desk and chair	3	100.00	300
Lounge equipment		300.00	300
Tubs (cooler)	254	6.00	1,524
Slicer table	1	100.00	100
Holding racks (selection)	42	55.00	2,310
Time clock	1	150.00	150
Adding machine	2	300.00	600
File cabinet	5	50.00	250
Tubs for holding racks	1,100	6.00	6,600
Total equipment			48,622

Table.11.--Equipment requirements and cost for a $250,000 weekly volume central meat plant

Equipment	Pieces required	Unit cost	Total cost
	Number	Dollars	Dollars
24" gravity flow conveyor	1,183 ft.	8.73/ft.	10,328
24" power conveyor	97 ft.	11.00/ft.	1,067
24" belt conveyor	29 ft.	25.30/ft.	734
18" gravity flow conveyor	63 ft.	7.25/ft.	457
18" belt conveyor	26 ft.	24.20/ft.	629
15" belt conveyor	35 ft.	23.10/ft.	809
12" belt conveyor	21 ft.	21.00/ft.	441
12" roller conveyor	18 ft.	9.70/ft.	175
Ball transfer tables	15 ft.	7.00/ft.	105
Meat rail scale	2	2,000	4,000
Hamburger mill	2	800	1,600
Platform scale	1	250	250
Scale (boning operation)	1	80	80
Steam cleaner	4	555	2,220
Storage racks (freezer)	12	248	2,976
Storage racks (cooler)	11	248	2,728
Tubs (cooler)	164	15	2,460
Boning table	2	334	668
Misc. table (blocking)	4	82	328
Misc. table (boning)	1	58	58
Meat pans	1,438	3	4,314
Cuber-slicer with table	2	900	1,800
Liver table	1	58	58
Shrink wrap table	3	237	711
Shrink tunnel	1	500	500
USDA handwrap table	8	375	3,000
Misc. table	1	60	60
Auto wrap machine	3	6,400	19,200
Automatic scale and label printer	3	4,700	14,100
Transfer and labeling machine	3	2,500	7,500
Meat cutting tables	14	100	1,400
Meat blocks	14	65	910
Power saws	14	840	11,760
Meat rail	884 ft.	5/ft.	4,420
Cutting tools	14	40/station	560
Holding racks (selection)	40	54	2,160
Tubs for racks	757	15	11,355
Lounge equipment		400	400
Time clock	1	200	200
Electric adding machine	2	300	600
Desk and chairs	5	100	500
File cabinet	10	50	500
Total			118,121

Table 12.--Comparative equipment costs for a store ($3,125 weekly volume) serviced by conventional methods and by a central meat plant

Equipment	Store serviced conventionally	Store serviced by central plant
	Dollars	Dollars
Meat chopper	295	295
Automatic scale and label printer	4,700	
Small scale		195
Miscellaneous table		72
USDA handwrap table	375	
Conveyor 24" skate wheel	175	
Meat saw	840	
Hand irons		23
Cutting tools	80	40
Meat pans	244	33
Meat block	65	40
Cutting tables	200	
Dolly and galvanized drum	70	35
Slicer, cuber, and table	900	900
Meat rail scale	2,000	
Boning table	227	
Portable tray rack	50	
Meat rail	200	
Utility lugs	72	12
Lug racks	42	
Galvanized shelf	248	248
Tray racks	120	30
Shipping containers		120
Handcart		18
TOTALS	10,903	2,061

Table 13.--Comparative equipment costs for a store ($6,250 weekly volume) serviced by conventional methods and by a central meat plant

Equipment	Store serviced conventionally	Store serviced by central plant
	Dollars	Dollars
Meat chopper	295	295
Automatic scale and label printer	4,700	
Small scale		195
Miscellaneous table		72
USDA handwrap table	750	
Conveyor	104	
Meat saw	840	
Hand irons		23
Meat pans	325	49
Small meat block		40
Meat block	65	
Dolly and galvanized drum	70	35
Slicer and cuber	810	810
Cutting tables	200	
Cutting tools (set)	80	40
Meat rail scale	2,000	
Boning table	227	
Dolly tray rack	50	
Meat rail	302	
Handtruck		18
Utility lugs (small)		16
Utility lugs (large)	120	
Lug racks	84	
Shipping containers		180
Galvanized shelf	248	248
Tray racks	150	60
TOTALS	11,420	2,081

Table 14.--Comparative equipment costs for a store ($10,000 weekly volume) serviced by conventional methods and by a central meat plant

Equipment	Store serviced conventionally	Store serviced by central plant
	Dollars	Dollars
Meat chopper	586	295
Dolly tray rack	50	
Dolly and galvanized drum	105	35
Automatic scale and label printer	4,700	
Small scale		185
Tray racks (12' section)		40
Tray racks (10' section)	275	
Miscellaneous table		72
USDA handwrap table	750	
Galvanized shelves	496	248
Conveyor	130	
Lugs	216	16
Handtrucks		18
Conveyor	104	
Boning table	273	
Meat power saws	840	
Hand irons		23
Wrapping machine	4,500	
Lug racks (small)		30
Lug racks (large)	126	
Meat pans	650	70
Meat rail	530	
Meat block	130	40
Cutting table	300	
Meat rail scale	2,000	
Slicer and cuber	810	810
Cutting tools	120	40
Shipping containers		270
TOTALS	17,691	2,192

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Table 15.--Comparative equipment costs for a store ($16,667 weekly volume) serviced by conventional methods and by a central meat plant

Equipment	Store serviced conventionally	Store serviced by central plant
	Dollars	Dollars
Meat chopper	705	295
Automatic scale and label printer	4,700	195
USDA handwrap table	1,125	72
Conveyor	261	
Meat saw	1,680	
Wrapping machine	4,500	23
Meat pans	975	130
Meat block	195	40
Dolly and galvanized drum	140	35
Slicer and cuber	810	810
Cutting tables	400	
Cutting tools	160	40
Meat rail scale	2,000	
Boning table	334	
Portable tray rack	50	
Meat rail	663	
Utility lugs	300	16
Lug racks	168	30
Galvanized shelf	744	248
Tray racks	350	75
Shipping containers		420
TOTALS	20,260	2,429

Table 16.--Labor force at a $37,500 weekly volume central meat plant (40-hour week)

Personnel	Job description	Weekly wage rate	Total yearly wages
Number		Dollars	Dollars
1	Plant manager	175.00	9,100
1	Clerk-typist (part-time)	62.58	3,254
1	Bill-out man	81.72	4,249
1	Delivery man	87.44	4,547
1	Head meat cutter	111.25	5,785
1	Meat cutter (2nd man)	111.25	5,785
2	Meat cutter	111.25	11,570
1	Mill man	111.25	5,785
1	Blocker	111.25	5,785
1	Apprentice	87.44	4,547
1	Cleanup man	87.44	4,547
1	Wrapper (machine)	81.72	4,249
1	Wrapper (H. W.)	81.72	4,249
1	Scale girl	81.72	4,249
15			77,701

Table 17.--Total labor expenditure for stores served by a $37,500 weekly volume central meat plant

Volume of stores	Stores	Men/store	Total men all stores	Weekly wage rate per man	Yearly wage/man	Total yearly wages for all stores
Dollars	Number	Number	Number	Dollars	Dollars	Dollars
3,125	12	1 1/3	16	130.25	6,773	108,368
6,250	6	1 1/3	8	130.25	6,773	54,184

Table 18.--Labor force at a $75,000 weekly volume central meat plant (40-hour week)

Personnel	Job description	Weekly wage rate	Total yearly wages
Number		Dollars	Dollars
1	Plant manager.....	175.00	9,100
1	Order selector.....	87.44	4,547
1	Bill-out man.....	81.72	4,249
4	Cutters.....	111.25	23,140
1	Delivery man.....	87.44	4,547
2	Trimmers and boarders.....	111.25	11,570
2	Boners.....	87.44	9,094
1	Blocker.....	111.25	5,785
3	Hand wrappers.....	81.72	12,748
1	Machine wrapper.....	81.72	4,249
1	Hobart 2,000 operator.....	81.72	4,249
2	Mill operators.....	111.25	11,570
1	Clerk-typist.....	75.00	3,900
21			$108,748

Table 19.--Total labor expenditure for stores served by a $75,000 weekly volume central meat plant

Volume of stores	Stores	Men/store	Total men all stores	Weekly wage rate per man	Yearly wage/man	Total yearly wages for all stores
Dollars	Number	Number	Number	Dollars	Dollars	Dollars
3,125	24	1 1/3	32	130.25	6,773	216,736
6,250	12	1 1/3	16	130.25	6,773	108,368
10,000	8	2	16	130.25	6,773	108,368

Table 20.--Labor force at a $250,000 weekly volume central meat plant (40-hour week)

Personnel	Job description	Weekly wage rate	Total yearly wages
Number		Dollars	Dollars
1	Plant manager	225.00	11,700
1	Assistant manager	175.00	9,100
10	Cutters	111.25	57,850
10	Trimmers and boarders	111.25	57,850
4	Mill operator	111.25	23,140
8	Hand operator	81.72	33,995
3	Auto. wrapper	81.72	12,748
3	Automatic scale operator	81.72	12,748
2	Blockers	111.25	11,570
4	Boners	111.25	23,140
1	Clerk-typist	76.23	3,964
2	Clerk	75.00	7,800
2	Order selector	87.44	9,094
6	Bill-out	81.72	25,497
57			300,196

Table 21.--Total labor expenditure for stores served by a $250,000 weekly volume central meat plant

Volume	Stores	Average of men/store	Total men all stores	Weekly wage rate per man	Yearly wage/man	Total yearly wages for all stores
Dollars	Number	Number	Number	Dollars	Dollars	Dollars
6,250	40	1 1/3	53 1/3	130.25	6,773	361,200
10,000	25	2	50	130.25	6,773	338,650
16,667	15	2	30	130.25	6,773	203,190

Table 22.--Labor requirements for conventional-type meat backrooms of different volumes

Job description	Weekly wage rate	Labor force used in $3,125 volume store	Total yearly wages	Labor force used in $6,250 volume store	Total yearly wages	Labor force used in $10,000 volume store	Total yearly wages	Labor force used in $16,667 volume store	Total yearly wages
	Dollars		Dollars		Dollars		Dollars		Dollars
Meat manager	130.25	1	6,773	1	6,773	1	6,773	1	6,773
Assistant meat manager	111.25							1	5,785
Cutters	111.25	1	5,785	2	11,570	3	17,356	5	28,926
Mill operator	111.25					1	5,785	1	5,785
Wrappers	81.72	1	4,249	2	8,498	3	12,748	4	16,997
Scale operator	81.72	1	4,249	1	4,249	1	4,249	1	4,249
Total		4	21,057	6	31,090	9	46,911	13	68,515

COMBINED CONSTRUCTION, EQUIPMENT, AND LABOR COST OF CENTRAL PLANT OPERATIONS AND CONVENTIONAL BACKROOM OPERATIONS

I. Annual depreciated construction costs		
A. $37,500 weekly volume operation		
1. Central plant: $117,765 x .16275 (crf)	$19,166	
2. 6 stores served by central plant: $28,530 x .16275 (crf)	4,643	
3. 12 stores served by central plant: $57,060 x .16275 (crf)	9,287	
4. Central plant plus 6 stores		$23,809
5. Central plant plus 12 stores		28,453
6. 6 stores served by own backrooms: $73,938 x .16275 (crf)		12,033
7. 12 stores served by own backrooms: $113,556 x .16275 (crf)		18,481
B. A $75,000 weekly volume operation		
1. Central plant: $163,125 x .16275 (crf)	26,549	
2. 12 stores served by central plant: $57,060 x .16275 (crf)	9,287	
3. 24 stores served by central plant: $114,120 x .16275 (crf)	18,573	
4. Central plant plus 12 stores		35,836
5. Central plant plus 24 stores		45,122
6. 12 stores served by own backrooms: $147,876 x .16275 (crf)		24,067
7. 24 stores served by own backrooms: $227,112 x .16275 (crf)		36,962
C. A $250,00 weekly volume operation		
1. Central plant: $241,260 x .16275 (crf)	39,265	
2. 15 stores served by central plant: $111,645 x .16275 (crf)	18,170	
3. 25 stores served by central plant: $135,675 x .16275 (crf)	22,081	
4. 40 stores served by central plant: $190,200 x .16275 (crf)	30,955	
5. Central plant plus 15 stores		57,435

6. Central plant plus 25 stores		$61,346
7. Central plant plus 40 stores		70,220
8. 15 stores served by own backrooms: $330,525 x .16275 (crf)		53,793
9. 25 stores served by own backrooms: $406,475 x .16275 (crf)		66,154
10. 40 stores served by own backrooms: $492,920 x .16275 (crf)		80,223

II. Annual depreciated equipment costs

A. $37,500 weekly volume operation

1. Central plant: $39,993 x .26380 (crf)	$10,550	
2. 6 stores served by central plant: $12,486 x .26380 (crf)	3,294	
3. 12 stores served by central plant: $24,732 x .26380 (crf)	6,524	
4. Central plant plus 6 stores		13,844
5. Central plant plus 12 stores		17,074
6. 6 stores served by own backrooms: $68,520 x .26380 (crf)		18,076
7. 12 stores served by own backrooms: $130,836 x .26380 (crf)		34,515

B. A $75,000 weekly volume operation

1. Central plant: $48,622 x .26380 (crf)	12,826	
2. 12 stores served by central plant: $24,972 x .26380 (crf)	6,588	
3. 24 stores served by central plant: $49,464 x .26380 (crf)	13,048	
4. Central plant plus 12 stores		19,414
5. Central plant plus 24 stores		25,874
6. 12 stores served by own backrooms: $137,040 x .26380 (crf)		36,151
7. 24 stores served by own backrooms: $261,672 x .26380 (crf)		69,029

C. A $250,000 weekly volume operation

1. Central plant: $118,121 x .26380 (crf)	$31,160	
2. 15 stores served by central plant: $36,435 x .26380 (crf)	9,612	
3. 25 stores served by central plant: $54,800 x .26380 (crf)	14,456	
4. 40 stores served by central plant: $83,250 x .26380 (crf)	21,959	
5. Central plant plus 15 stores		$40,772
6. Central plant plus 25 stores		45,616
7. Central plant plus 40 stores		53,119
8. 15 stores served by own backrooms: $303,900 x .26380 (crf)		80,169
9. 25 stores served by own backrooms: $442,275 x .26380 (crf)		116,672
10. 40 stores served by own backrooms: $456,800 x .26380 (crf)		120,504

III. Annual labor cost

A. A $37,500 weekly volume operation

1. Central plant	77,701	
2. 6 stores served by central plant	54,184	
3. 12 stores served by central plant	108,368	
4. Central plant plus 6 stores		131,885
5. Central plant plus 12 stores		186,069
6. 6 stores served by own backrooms		186,540
7. 12 stores served by own backrooms		252,684

B. A $75,000 weekly volume operation

1. Central plant	108,748	
2. 12 stores served by central plant	108,368	
3. 24 stores served by central plant	216,736	
4. Central plant plus 12 stores		217,116
5. Central plant plus 24 stores		325,484
6. 12 stores served by own backrooms		373,080
7. 24 stores served by own backrooms		505,368

C. A $250,000 weekly volume operation

1. Central plant	$300,196	
2. 15 stores served by central plant	203,190	
3. 25 stores served by central plant	338,650	
4. 40 stores served by central plant	361,200	
5. Central plant plus 15 stores		$503,386
6. Central plant plus 25 stores		638,846
7. Central plant plus 40 stores		661,396
8. 15 stores served by own backrooms		1,027,725
9. 25 stores served by own backrooms		1,172,775
10. 40 stores served by own backrooms		1,243,600

Table 23.--Summary of overall costs and other operational information for central plants of different volumes supplying small-, medium-, and high-volume retail stores

Description of overall costs and other operational information	Store with own backroom				Store served by central plant				Individual central plant			$37,500 weekly volume			
												6 stores, average volume $6,250		12 stores, average volume $3,125	
	$3,125 wk. vol.	$6,250 wk. vol.	$10,000 wk. vol.	$16,667 wk. vol.	$3,125 wk. vol.	$6,250 wk. vol.	$10,000 wk. vol.	$16,667 wk. vol.	$37,500 wk. vol.	$75,000 wk. vol.	$250,000 wk. vol.	With own backrooms	Served by central plant	With own backrooms	Served by central plant
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Capital costs:															
Construction costs	9,463	12,323	16,259	22,035	4,755	4,755	5,427	7,443	117,765	163,125	241,240	73,938	146,295	113,556	174,825
Equipment costs	10,903	11,420	17,691	20,260	2,061	2,081	2,192	2,429	39,993	48,622	118,121	68,520	52,479	130,836	64,725
Annual depreciated costs of construction and equipment									29,716	39,375	70,425	30,109	37,653	52,996	45,527
Annual labor costs	21,057	31,090	46,911	68,515	9,030	9,030	13,546	13,546	77,701	108,748	300,196	186,540	131,885	252,684	186,069
Total annual cost of operation									107,417	148,123	370,621	216,649	169,538	305,680	231,596
Total annual savings in central plant operation													47,111		74,084
Percent savings in annual costs with central plant operation													Percent 21.7		Percent 24.2
Supplemental information:															
Total number personnel	4	6	9	13	1 1/3	1 1/3	2	2	15	21	57	36	20	48	28
Man-hours per week	160	240	360	520	53	53	80	80	600	840	2,280	1,440	800	1,920	1,120
Sales per man-hour (dollars)									62.50	89.29	109.65	26.04	46.88	19.53	33.48
Labor as a percentage of gross sales									4.0	2.8	2.3	9.6	6.8	13.0	9.5

Description of overall costs and other operational information	$75,000 weekly volume				$250,000 weekly volume					
	12 stores, average volume $6,250		24 stores, average volume $3,125		15 stores, average volume $16,667		25 stores, average volume $10,000		40 stores, average volume $6,250	
	With own backrooms	Served by central plant	With own backrooms	Served by central plant	With own backrooms	Served by central plant	With own backrooms	Served by central plant	With own backrooms	Served by central plant
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Capital costs:										
Construction costs	147,876	220,185	227,112	277,247	330,525	352,905	406,475	376,935	492,920	431,460
Equipment costs	137,040	73,594	261,672	98,086	303,900	154,556	442,275	172,921	456,800	201,361
Annual depreciated costs of construction and equipment	60,218	55,250	105,991	70,996	133,962	98,207	182,826	106,962	200,727	123,339
Annual labor costs	373,080	217,116	505,368	325,484	1,027,725	503,386	1,172,775	638,846	1,243,600	661,396
Total annual cost of operation	433,298	272,366	611,359	396,480	1,161,687	601,593	1,355,601	745,808	1,444,327	784,735
Total annual savings in central plant operation		160,932		214,879		560,094		609,793		659,592
Percent savings in annual costs with central plant operation		Percent 37.1		Percent 35.1		Percent 48.1		Percent 45.0		Percent 45.7
Supplemental information:										
Total number personnel	72	37	96	53	195	87	225	107	240	110
Man-hours per week	2,880	1,480	3,840	2,120	7,800	3,480	9,000	4,280	9,600	4,400
Sales per man-hour (dollars)	26.04	50.68	19.53	35.38	32.05	71.84	27.78	58.41	26.04	56.82
Labor as a percentage of gross sales	9.6	5.6	13.0	8.3	7.9	3.9	9.0	4.9	9.6	5.1

Note: Fringe benefits not included. Labor requirements and wage rates, construction requirements and costs, equipment requirements and costs, and combined construction, equipment, and labor costs are shown in other portions of the appendix.

Table 24.--Sales breakdown by major categories of central plant processing $100,000 in fresh meats

Category	Proportion of meat sold[1]	Sales
	Percent	Dollars
Beef steaks	23.5	23,500
Beef roasts	9.8	9,800
Ground meat	12.2	12,200
Misc. beef	1.9	1,900
Veal	1.5	1,500
Pork, fresh	7.6	7,600
Lamb	2.4	2,400
Poultry	22.4	22,400
Hams	18.7	18,700
Total	100.0	100,000

[1] Percentage of product sold is an average figure of sales by retail food stores observed in the eastern and midwestern sections of the country.

Table 25.--Derived cutting time for steaks

Item	Retail cuts	Time per pkg.[1]	Total time
	Number	Minutes	Minutes
Sirloins	90	.127	11.430
T-bones	192	.078	14.976
Top round	217	.186	40.362
Bottom round	230	.187	43.010
Rib steaks	179	.219	39.201
Total	908		148.979

[1] These are estimated cutting times based on standard times from MRR No. 41. Because of production-line layout of central plant, certain irregular elements have been eliminated in calculating the cutting times appearing in this table. Calculations: Normal time $\frac{148.979}{908}$ = .164 min./pkg. Standard time .164 x 115 = .189 min./pkg.

Table 26.--Derived cutting time for roasts.

Item	Retail cuts	Time per pkg.[1]	Total time
	Number	Minutes	Minutes
Pork loin roast	21	.101	2.121
Rib end roasts	2	.246	.492
Jiffys	10	.223	2.230
Spareribs	10	.254	2.540
Backbone	10	.262	2.620
Total	53		10.003

[1] Calculations: Normal time $\frac{10.003}{53}$ = .189 min./pkg. Standard time per package .189 x 115 = .217 min./pkg.

PROCESSING TIME OF OPERATIONS PERFORMED ON EACH MAJOR MEAT CATEGORY SCHEDULED AT SPECIFIC WORK STATIONS IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT BASED ON TWO DAILY SET-UPS 1/

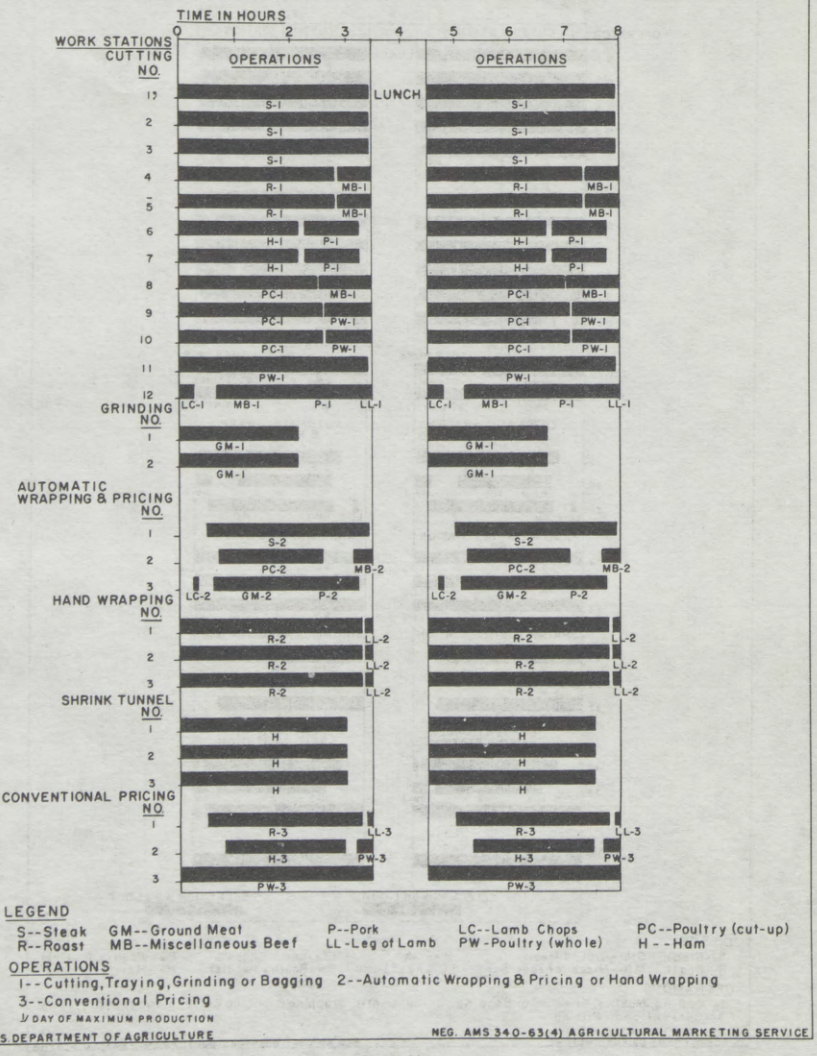

Figure 34.

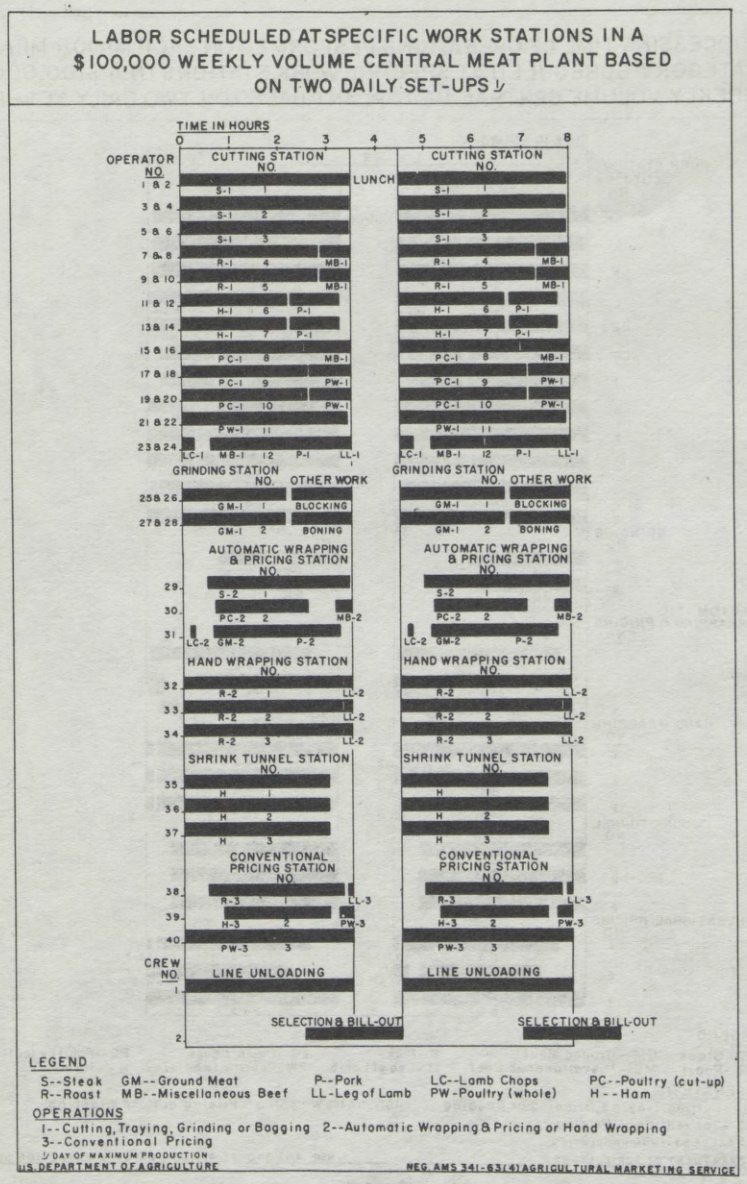
LABOR SCHEDULED AT SPECIFIC WORK STATIONS IN A $100,000 WEEKLY VOLUME CENTRAL MEAT PLANT BASED ON TWO DAILY SET-UPS 1/
TIME IN HOURS
0 1 2 3 4 5 6 7 8
OPERATOR NO.
CUTTING STATION NO.
LUNCH
GRINDING STATION NO.
OTHER WORK
BLOCKING
BONING
AUTOMATIC WRAPPING & PRICING STATION NO.
HAND WRAPPING STATION NO.
SHRINK TUNNEL STATION NO.
CONVENTIONAL PRICING STATION NO.
CREW NO.
LINE UNLOADING
SELECTION & BILL-OUT
LEGEND
S--Steak GM--Ground Meat P--Pork LC--Lamb Chops PC--Poultry (cut-up)
R--Roast MB--Miscellaneous Beef LL-Leg of Lamb PW-Poultry (whole) H--Ham
OPERATIONS
1--Cutting, Traying, Grinding or Bagging 2--Automatic Wrapping & Pricing or Hand Wrapping
3--Conventional Pricing
1/ DAY OF MAXIMUM PRODUCTION
U.S. DEPARTMENT OF AGRICULTURE
NEG. AMS 341-63(4) AGRICULTURAL MARKETING SERVICE

Figure 35.

APPENDIX 9

THE MARKET FOR RADIOPROCESSING OF MEATS

(Prepared by Nuclear Materials & Equipment Corp.)

FOR THE MEAT INDUSTRY—YOUR INVITATION TO INVESTIGATE RADIOPROCESSING, A PLACE, MEANS AND OPPORTUNITY

CONTENTS

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Preliminary designs of the NUMEC facility.
Capacity of NUMEC plant.

THE MARKET FOR RADIOPROCESSED MEAT

Within the next few years, the world's soaring population will create an unprecedented demand for poultry, meat and meat products. This vast, new and rapidly expanding market will create problems in storage, distribution and marketing.

With the use of radioprocessing, however, the meat industry will be able to increase profits and reduce costs while serving the needs of both the domestic and world-wide markets for poultry, meat and meat products.

Radioprocessing will create new opportunities for improving profit margins throughout the meat industry. Consider just a few of the potentials and what they might mean to the industry.

Beef slaughterers, breakers or cutters could exploit centralized meat cutting.

Canned ham producers could market consumer acceptable, shelf stable canned hams.

Poultry processors could gain an extra week or two of shelf-life for fresh chickens or market shelf stable, cooked chicken and turkey parts.

Speciality canners could produce charbroiled canned meats.

Processed meat operators could reduce packaging costs and spoilage as well as extend the shelf-life of luncheon meats, sausages or frankfurters.

The entire industry could benefit from the potentially large military market for radiosterilized meat and poultry products.

Further, a large new market awaits radiosterilized meats in the protein hungry parts of the globe. These areas lack the refrigeration and quick transport necessary for the fresh or frozen product. In Europe, where refrigeration capability exists, radiopasteurization will open vast new markets for fresh meats. Because of the limited appeal of frozen meats and the high cost of keeping meat frozen during long transportation periods, only small quantities are now exported.

The Armed Forces, already purchasing radiosterilized bacon for its troops, and test feeding other meats as well, expect to include many radioprocessed meats in their rations by 1969. The Army will not irradiate meats at its research facility in Natick, Massachusetts, but plans to buy them commercially. By 1969, the Government's purchases of radiosterilized meats for garrison feeding and, in some cases, field rations will be stepped up and ultimately grow to large levels.

Radiosterilization will also pay dividends in new civlian markets. It will bring to every American table a new generation of "heat and eat" and "brown and serve" convenience foods—none of which will require any refrigeration.

Radiopasteurization, a technique in which interest is just now beginning to generate, may open up totally new and profitable marketing practices for the meat industry. A modest shelf-life extension of perhaps two to three weeks would allow the meat industry to make much wider use of centralized meat-cutting—a very profitable marketing innovation already being explored.

The catalogue of new products, new markets and new opportunities for profit in the meat industry is impressive. Yet only a few companies have begun to investigate radioprocessing. Why? Because development work on this process requires a large capital investment in irradiation faciilties and the resources of a specially recruited and trained radiation staff—a major road block which will now be removed.

Key Definitions

Radiosterilization

Destruction of spoilage organisms by radiation to the point that unrefrigerated shelf-life is possible for several years. Requires a relatively high exposure.

Radiopasteurization

Reduction in spoilage organisms by radiation so that the fresh shelf-life is extended and disease-causing organisms are destroyed. Refrigeration is required to realize the fullest potential. Requires a relatively low exposure.

NUMEC Proposes an Industry Facility

The pilot plant meat irradiator, planned by the Nuclear Materials and Equipment Corporation of Apollo, Pennsylvania, would, for the first time, make it possible for any meat processing company to engage in its own research and market development program on a cost-controlled basis. NUMEC plans to build and operate a radioprocessing facility initially capable of sterilizing a million pounds of meat a year. Because radiopasteurization requires such low radiation absorption compared with radiosterilization, this facility will be initially capable of pasteurizing twenty million pounds of meat per year. The facility would be designed and constructed to permit a ten fold expansion of its initial capabilities.

Each participating company could establish a firm budget for its own development, production and market evaluation program, using the irradiation facility for only as long as needed. Charges would be made on a "time and materials" basis. Any participating company would thus be assured of its competitive position in the new markets that will be created by radioprocessing without having to make a capital investment or support an irradiation development staff.

The NUMEC Proposal for an Expandable Pilot Plant Meat Irradiator

1. NUMEC will design, build and make available to the meat industry a flexible research and pilot plant facility for the irradiation of meat and meat products.
2. NUMEC will offer a variety of services such as: Plant operation, dosimetry, training, product evaluation, program planning, marketing assistance, and consumer education.
3. The meat processor can conduct an individually tailored, cost-controlled research program.

Meat processor pays only for the time used and services selected.

No capital investment by the meat processor.

4. Full protection of proprietary interest of the individual meat processor.

The Radioprocessing Technique

Quickly and safely, without raising internal temperature by more than a few degrees, ionizing radiation can preserve food by either inhibiting or destroying bacteria and other microorganisms.

The food suffers no harmful effects. It does not become radioactive and there is very little alteration of its protein or vitamin content. In some cases there is less loss than in canning, freezing or dehydrating.

No food processing method in use today has been as thoroughly studied as radiation. Experiments have been performed since the discovery of natural radioactivity and X-Ray. Work has been considerably accelerated during the past 15 to 20 years since Co–60 became relatively abundant and practical electron accelerators became available.

Approximately 4,000 animals have been used in the Army's long-term feeding program alone to establish the wholesomeness of irradiated foods, many of them meats and poultry. Feeding programs with Army personnel have also confirmed the wholesomeness and acceptability of radioprocessed foods.

The source of ionizing radiation can be gamma rays from a material such as cobalt-60 or cesium-137 or electrons from an accelerator or X-rays.

The amount of radiation utilized depends upon the food being processed and the purpose, i.e., pasteurization, sterilization, etc. For instance, 20,000 to 30,000 rads can inhibit the development of trichinella spiralis nematode in infected pork. . . . 750,000 rads will destroy all known types of salmonellae in broken eggs, chicken, turkey and animal feed.

Radiation can disinfest grain and kill insect larvae such as those which are present inside some tropical fruits at 20,000 to 100,000 rads. In general, "pasteurization" at 100,000 to 500,000 rads can be used to suppress deterioration and prolong refrigerated storage life. If the goal is to "sterilize" food for long term storage without refrigeration, about 3,000,000 to 5,000,000 rads (3 to 5 megarads) is usually required.

Early History of Radioprocessing of Foods

1896: Discovery of Natural Radioactivity—Becquerel.
1896: Discovery of X-Rays—Roentgen.
1898: Observation of Radiation Effects In Microbes—Pacronotti and Procelli.
1904: Report of Radiation Effects on Pathogenic Organisms—Prescott.
1916: Swedish Evaluate Radioprocessing of Strawberries.
1930: Patent Issued on Use of Ionizing Radiation to Preserve Food (France)—Wust.

Common Units Used in Measuring Radiation

Curies

The term used in measuring the quantity of radiation emitted by a gamma source. One curie is equivalent to 37 billion atomic disintegrations per second.

Kilowatt

A measurement of an accelerator's capability to produce radiation. 1 kw is equivalent to 68,000 curies.

Rad

A unit of measure of radiation is equal to that quantity of ionizing radiation which results in the absorption of 100 ergs of energy per gram of irradiated material.

Meat Irradiation Progress

STERILIZATION

It is in the sterilization range that the U.S. Army has done most of its meat irradiation.

Beef

Recent developments have indicated that the irradiation of beef at very low temperatures (between −40°C and −100°C) practically eliminates the slight off-taste or color that was detected in the initial experiments. In addition, pre-irradiation heating inactivates enzymes and permits the prolonged storage of

sterilized beef at room temperature in sealed containers. Such heating provides the opportunity for the elimination of off-tastes and odors as the food is processed into pre-cooked convenience food items. These are the products that are capturing larger and larger shares of the consumer market. The Army plans to submit a petition to the FDA for the approval of sterilized beef in 1967.

Ham

The potential of a shelf stable, sterilized canned ham has encouraged considerable work by the U.S. Army, the Danish Meat Institute and a major domestic meat packer. The results have been most promising. Wholesomeness studies are complete and submission of a petition to the FDA is anticipated by the end of June. Field feeding studies have indicated acceptability for standard Army rations.

Since the amount of radiation necessary for destruction of trichina is much less than that for sterilization, a radiosterilized ham is automatically free of trichina. In addition, low radiation could be used for the destruction of trichina in fresh hams.

Pork

Radio processed, grilled pork chops received an almost identical rating to the fresh product from a taste panel of over 1000 servicemen. Pork loin roasts, irradiated at five megarads and stored in sealed containers at room temperature for nine months, also rated near their fresh counterparts. The Army expects to submit a petition to the FDA for the approval of radiosterilized pork within the next few months.

Poultry

Irradiated at five million rads, held for five months at room temperature in sealed containers and then served in a variety of recipes such as fried, southern fried, and barbecued, chicken was rated highly in large-scale, soldier-consumer tests. Radiosterilized cooked chicken parts and pieces have qualities similar to cooked and frozen chickens, but do not deteriorate during shipment, distribution and storage due to temperature changes. The Army expects to submit a petition to the FDA in fiiscal year 1968 for the approval of radiosterilized chicken.

Bacon

The FDA clearance of bacon in 1963 was the first obtained for a radiosterilized food. Radiosterilized bacon is virtually indistinguishable from fresh bacon for at least two years after packaging and sterilization. Bacon has been found to be acceptable for troop feeding and is the first radioprocessed meat purchased in quantity by the Department of Defense.

Processed meats

The U.S. Army has completed preliminary experiments with various processed meats. Based on these results, they have scheduled submissions to the FDA on radiosterilized canned beef and pork sausage in fiscal year 1969. This will be followed by radiosterilized frankfurters, barbecued beef and luncheon meats. Because of the wide variation in commercial formulations, additional work on sterilized and pasteurized processed meat provides a potentially fruitful area of evaluation by individual processors.

PASTEURIZATION

Utilizing relatively low radiation, radiopasteurization can extend by a few weeks the refrigerated shelf-life of fresh beef, pork and poultry. They would be fresh . . . would retain their original appearance and would be handled and sold in exactly the same manner as their non-pastuerized counterparts. As a result, much less market development would be required to exploit the vast commercial potential of radiopasteurized meat. The benefits of radiopasteurization to the meat industry include not only the extension of markets for fresh meat but also reduction in spoilage and the ability to reduce distribution costs by centralized and automated final breaking and cutting operations.

Centralization of these steps would also permit the direct marketing of fresh meat products in the meat packers' name and return to him a much larger share of the consumer's dollar. Pasteurization will also provide the fresh shelf-life extension required to protect the meat industry from short term price fluctuations.

In the case of chicken, radiopasteurization at 100,000 rads permits an extension of the shelf-life of the fresh product for about 12 additional days. This shelf-life extension will provide the processor with additional flexibility in marketing, enabling him to minimize the problems of periodic market glut.

Although much work remains to be done before radiopasteurization can be exploited commercially, the technique holds the promise of revolutionizing the economics of the meat industry.

NOTE.—For additional information on progress in the field of food irradiation, see the excellent and authoritative compilations which have been prepared by the Joint Congressional Committee on Atomic Energy, particularly the following:

"Radiation Processing of Foods", Hearings, June 9–10, 1965.

"Review of the Army Food Irradiation Program", Hearing, May 13, 1963.

"Review of AEC and Army Food Irradiation Program", Hearings March 6–7, 1962.

"National Food Irradiation Research Program", Hearings Jan. 14–15, March 31, 1960.

Benefits of Radioprocessing of Meats

Minimize public health hazards.
Reduce storage and handling costs.
Extend market.
Reduce spoilage.
Protect against price fluctuations.
Market in meat packer's name.
Greater portion of consumer dollar to meat packer.
New products.
Improved canned meats.

FDA CLEARANCE

Since radiation is considered a food additive, radioprocessed food must be approved by the Food and Drug Administration. The first radioprocessed food approved by FDA for general consumption was sterilized bacon which was cleared on February 8, 1963. Since then, wheat, wheat products, potatoes and a number of packaging materials have also been approved for general use.

The timetable on which the Army is asking the Food and Drug Administration for additional approvals anticipates the Army's large scale purchase of radioprocessed beef, ham, pork, bacon and chicken beginning in 1968. FDA approval is the last step to full exploitation of radioprocessing in the food industry. The scheduled completion of NUMEC's Pilot Plant meat irradiator is timed to coincide with the start of the Government's large-scale purchasing program and the granting of broad FDA clearances.

Modern Development in Radioprocessing of Foods

1943: U.S. Army Quartermaster Corps support program at MIT.
1950: USAEC begins support of food preservation research.
1954: U.S. Army Quartermaster Corps begin support of food preservation research.
1959: Army decision to concentrate on high dose radiosterilization.
1960: USAEC assumes responsibility for radiopasteurization.
1962: U.S. Army Natick Laboratory begins operation.
1963: FDA clearance of bacon. FDA clearance of wheat and wheat products.
1964: FDA clearance of potatoes.
1965–66: Army–AEC commence proposal for Pilot Plant Meat Irradiator.

NUMEC'S PROGRESS IN RADIOPROCESSING

Though lacking any ties to the meat processing industry, NUMEC has been active in the field of radioprocessing for several years. Its participation, examples of which are described below, extends to virtually every phase of irradiation processing.

70-905 O—67——18

Architect-engineering

Under an architect-engineering contract to the Atomic Energy Commission, NUMEC is now designing and will supervise the construction of the Hawaiian Development Irradiator, a facility capable of handling over two tons of fruit per hour. Hawaii plans to use the radiation facility primarily for irradiating mangoes to kill the weevil deeply imbedded in the seed and for killing fruit fly larvae imbedded in the skin of papayas which now keep much of the fruit quarantined and ineligible for export. As a bonus, the radiation will also slightly extend the fruits' storage life.

Equipment design and fabrication

Under contract to the United States Atomic Energy Commission, NUMEC built the first two shipboard irradiators. Initially these will be mounted on fishing trawlers. One will operate from the port of Gloucester, Massachusetts; the other off the coast of Louisiana. Each of these irradiators, containing a 30,000 curie radioactive cobalt source, will be used to give a quick, on-the-spot 100,000 rads to freshly caught seafood. This will extend the refrigerated storage life of fresh North Atlantic fish and Louisiana shrimp by at least two weeks.

If given a later sterilizing, the shrimp can be stored at room temperature for many months. They are often included in experimental meals of irradiated food served to guests at the Army's Radiation Laboratory Natick, Massachusetts. Haddock and other fish processed on the Gloucester trawler will subsequently receive additional exposure in the range of 500,000 to 600,000 rads at a landbased facility to increase their refrigerated (not frozen) storage life by almost a month. Since both irradiators are portable, they may ultimately be truck mounted and driven into the fields to radiopasteurize crops of small fruits such as strawberries and cherries to inhibit decay.

Process development and product evaluation

NUMEC is participating in a cooperative project with the Pillsbury Company and the Atomic Energy Commission to study the relative merits of radiation and chemical processing to suppress sprouting so as to increase the storage life of potatoes under normal commercial conditions. At its Grand Forks, North Dakota, plant, Pillsbury annually processes large quantities of potatoes into convenience forms such as instant mashed, au gratin and hashed brown potatoes. The company is vitally interested in increasing the storagability of potatoes. NUMEC has irradiated 19 tons of potatoes which will be evaluated, during a twelve month storage period, along with chemically treated potatoes.

Facility operation

In Israel, Isotopes and Radiation Enterprises Ltd., a company formed jointly by NUMEC and the Government of Israel, is using a 30,000 curie source of radioactive cobalt for pasteurization of citrus fruits, sterilization of medical supplies and eradication of fruit flies.

Source encapsulation

NUMEC encapsulates cobalt-60 sources used in irradiators at its hot cell facilities, located near its main offices in the greater Pittsburgh area. Therefore, NUMEC would be able to assure the continued supply of cobalt to the pilot plant meat irradiator.

A Need and an Opportunity

The Federal Government in encouraging commercial participation in radioprocessing of meat and meat products. In September, 1965, a meeting was held at the Department of Commerce in Washington to elicit the commercial interest in the construction and operation of a pilot plant for meat irradiation. To stimulate interest, government representatives offered a number of incentives such as: assurance that a portion of the plant's capacity would be utilized on a continuing basis for a supply of radioprocessed meats to the Department of Defense; some financial assistance toward the design of the facility; and the radioactive cobalt source free of charge—or funds toward the construction of an accelerator, in the event the latter is the designer's choice.

To answer the need and provide the opportunity, NUMEC plans to build and operate an expandable pilot plant meat irradiator. The facilities and services will be made available to the meat processing industry.

In this facility individual meat processors will be able to conduct their radioprocessing programs with complete assurance that NUMEC will respect and pro-

tect the confidential nature of their activities and results. On request, NUMEC is prepared to conduct training programs for a participating company's employees, to assist in the planning of experiments and to provide the services of its expert dosimetry staff.

Schedule of NUMEC's Expandable Pilot Plant Meat Irradiator

Nov. 1965–June 1966: Discussions with meat industry.
July 1966–August 1966: Preparation of proposal to Government.
Sept. 1966–Dec. 1966: Development of Contracts.
Jan. 1967–June 1967: Plant Design.
July 1967–June 1968: Plant Construction.
July 1968: Begin plant operation.

Preliminary Designs of the NUMEC Facility

Refrigerated storage area for incoming meat and meat products, poultry and poultry products.
Facilities for enzyme inactivation.[1]
Quick freezing Unit.[1]
Cryogenic unit to bring certain meats far below freezing temperatures.[1]
Radiation processing unit utilizing Cobalt-60.
Test kitchen.
Dining area.
Final storage area.

Capacity of NUMEC Plant

Initially

Sterilization: 1,000,000 pounds/year, 150 pounds/hour.
Pasteurization: 200,000,000 pounds/year, 30,000 pounds/hour.

Expanded

Sterilization: 10,000,000 pounds/year, 1,500 pounds/hour.
Pasteurization: 200,000,000 pounds/year, 30,000 pounds/hour.

ECONOMICS OF RADIOPROCESSING MEATS

Considering the large savings, extensions of markets and new products that would be made possible as a result of radioprocessing of meat, the costs are quite nominal. At a throughput of 100,000,000 pounds per year (equivalent to the output from about 500 cattle per day) pasteurization costs only about a penny and a half per pound. At the same throughput, most meats can be sterilized for less than three cents per pound—slightly higher for beef.

COST OF NUMEC'S EXPANDABLE PILOT PLANT MEAT IRRADIATOR

NUMEC's expandable pilot plant meat irradiator is expected to cost about $1.1 million. The portion of operating time not required to process the government's base load will be offered to the meat packing industry. All services of the NUMEC's facility will be made available at a charge of approximately $85.00 per hour.

Considering the advanced state of research in radioprocessing meat, the Government's obvious desire for industrial participation and the potential markets to be realized by the meat processing industry, we believe the time is right for meat processors to investigate actively the field of radioprocessing. We would be pleased to hear of your interest in the plan we have outlined and would welcome the opportunity to discuss it with you. Please direct your inquiries to:

Marketing Division
Nuclear Materials and Equipment Corporation
Apollo, Pennsylvania 15613
Telephone: (Area Code 412) GRover 2–8411
TWX 412/584–5212 Cable NUMEC Apollo

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[1] To be used only for sterilizing not for pasteurizing.

APPENDIX 10

NATIONAL SCIENCE FOUNDATION TABLES ON BASIC RESEARCH, APPLIED RESEARCH, AND DEVELOPMENT IN INDUSTRY, 1964

TABLE 2.—*Funds for R. & D. performance, by industry and size of company, 1956–64*

[In millions of dollars]

Industry and size of company	1964	1963	1962	1961	1960	1959	1958	1957	1956
DISTRIBUTION BY INDUSTRY									
Total	13,353	12,630	11,464	10,908	10,509	9,618	8,389	7,731	6,605
Food and kindred products	135	125	117	122	102	90	83	74	64
Textiles and apparel	32	30	28	30	38	30	26	15	(1)
Lumber, wood products, and furniture	11	11	10	10	10	12	12	14	(1)
Paper and allied products	73	69	65	59	56	49	42	35	36
Chemicals and allied products	1,284	1,263	1,190	1,109	986	891	792	705	641
Industrial chemicals	856	827	748	709	666	599	553	503	460
Drugs and medicines	235	218	197	181	163	154	128	104	94
Other chemicals	193	217	245	218	157	139	111	98	87
Petroleum refining and extraction	337	311	305	295	290	276	246	211	182
Rubber products	150	150	135	136	120	115	89	107	(1)
Stone, clay, and glass products	133	123	113	99	96	[2] 84	[2] 75	[2] 69	[2] 60
Primary metals	191	180	169	175	176	152	131	108	90
Primary ferrous products	113	106	96	98	102	84	80	64	(1)
Nonferrous and other metal products	78	75	72	78	74	68	51	44	(1)
Fabricated metal products	152	154	145	135	144	137	162	135	116
Machinery	1,028	948	911	864	932	927	781	669	543
Electrical equipment and communication	2,635	2,496	2,346	2,297	2,406	2,270	1,969	1,804	1,516
Communication equipment and electronic components	1,480	1,375	1,277	1,202	1,190	1,102	868	748	(1)
Other electrical equipment	1,154	1,121	1,069	1,096	1,216	1,168	1,101	1,056	(1)
Motor vehicles and other transportation equipment	1,189	1,106	1,011	944	890	870	856	707	688
Aircraft and missiles	5,097	4,826	4,147	3,904	3,558	3,110	2,609	2,574	2,138
Professional and scientific instruments	483	473	439	382	396	339	294	249	200
Scientific and mechanical measuring instruments	210	221	206	188	215	184	156	139	97
Optical, surgical, photographic, and other instruments	273	252	232	194	181	154	138	110	103
Other manufacturing industries	96	90	95	158	149	130	105	93	(1)
Nonmanufacturing industries	328	277	239	188	160	136	117	(1)	(1)
DISTRIBUTION BY SIZE OF COMPANY (BASED ON NUMBER OF EMPLOYEES)									
Less than 1,000	656	619	633	612	581	546	532	542	369
1,000 to 4,999	1,093	1,022	990	949	892	740	642	[2] 632	[2] 550
5,000 or more	11,605	10,989	9,840	9,347	9,036	8,332	7,215	[2] 6,557	[2] 5,686

[1] Not separately available but included in total.
[2] Estimated by the National Science Foundation.

TABLE 11.—*Company funds for R. & D. performance, by industry and size of company, 1957–64* [1]

[In millions of dollars]

Industry and size of company	1964	1963	1962	1961 [2]	1960	1959	1958	1957
DISTRIBUTION BY INDUSTRY								
Total	5,753	5,360	5,029	4,668	4,428	3,983	3,630	3,396
Food and kindred products	(3)	(3)	114	117	93	85	77	74
Textiles and apparel	30	28	(3)	(3)	29	23	20	14
Lumber, wood products, and furniture	(3)	(3)	(3)	(3)	9	10	12	14
Paper and allied products	73	69	65	(3)	(3)	49	42	35
Chemicals and allied products	1,054	997	933	877	804	739	666	616
Industrial chemicals	684	649	588	569	538	485	443	423
Drugs and medicines	224	209	193	178	159	151	126	104
Other chemicals	146	138	152	128	107	105	97	89
Petroleum refining and extraction	310	290	284	276	274	251	234	200
Rubber products	124	110	104	97	83	76	68	70
Stone, clay, and glass products	124	115	106	88	(3)	(3)	(3)	(3)
Primary metals	182	170	157	157	161	140	117	103
Primary ferrous products	111	104	94	94	99	83	78	63
Nonferrous and other metal products	72	66	63	64	62	57	39	40
Fabricated metal products	133	127	119	97	108	94	105	97
Machinery	770	693	636	583	555	514	438	397
Electrical equipment and communication	1,007	929	877	832	812	673	632	608
Communication equipment and electronic components	507	469	437	407	340	292	253	230
Other electrical equipment	499	460	441	425	472	381	379	378
Motor vehicles and other transportation equipment	865	814	729	718	673	648	560	517
Aircraft and missiles	489	476	472	414	378	341	333	299
Professional and scientific instruments	276	254	241	207	194	173	157	140
Scientific and mechanical measuring instruments	90	86	91	80	76	68	63	59
Optical, surgical, photographic and other instruments	185	168	150	127	117	104	94	81
Other manufacturing industries	74	68	73	54	53	36	39	(3)
Nonmanufacturing industries	98	89	82	(3)	57	47	55	(3)
DISTRIBUTION BY SIZE OF COMPANY (BASED ON NUMBER OF EMPLOYEES)								
Less than 1,000	443	425	421	(3)	(3)	(3)	299	375
1,000 to 4,999	640	596	599	590	545	477	[2] 440	[2] 406
5,000 or more	4,669	4,338	4,009	3,767	3,595	3,241	[2] 2,891	[2] 2,615

[1] Company funds include all funds for industrial research and development performed within company facilities except funds provided by the Federal Government. The data do not include company financed research and development contracted to educational institutions, commercial laboratories, nonprofit research institutions, or other recipient organizations. In 1964, industrial firms contracted $157,000,000 in company financed R. & D. projects to outside organizations.

[2] Estimated by the National Science Foundation.

[3] Not separately available but included in total.

TABLE 12.—*Company funds for R. & D. performance, by industry and size of company, 1964 and 1963* [1]

[In millions of dollars]

Industry	1964				1963			
	Company funds	Companies with total employment of—			Company funds	Companies with total employment of—		
		Less than 1,000	1,000 to 4,999	5,000 or more		Less than 1,000	1,000 to 4,999	5,000 or more
Total	5,753	443	640	4,669	5,360	425	596	4,338
Food and kindred products	(1)	(2)	(2)	101	(2)	(2)	(2)	(2)
Textiles and apparel	30	(2)	10	17	28	(2)	10	15
Lumber, wood products, and furniture	(2)	(2)	2	5	(2)	(2)	2	4
Paper and allied products	73	(2)	17	51	69	(2)	15	48
Chemicals and allied products	1,054	(2)	165	784	997	(2)	154	743
Industrial chemicals	684	(2)	(2)	578	649	(2)	(2)	551
Drugs and medicines	224	(2)	(2)	(2)	209	(2)	(2)	(2)
Other chemicals	146	(2)	42	(2)	138	(2)	41	(2)
Petroleum refining and extraction	310	(2)	3	(2)	290	(2)	2	273
Rubber products	124	(2)	10	(2)	110	(2)	9	(2)
Stone, clay, and glass products	124	(2)	9	105	115	(2)	(2)	(2)
Primary metals	182	(2)	31	145	170	(2)	(2)	138
Primary ferrous products	111	(2)	7	98	104	(2)	(2)	93
Nonferrous, other metal products	72	(2)	24	47	66	(2)	21	45
Fabricated metal products	133	(2)	(2)	71	127	30	31	66
Machinery	770	74	111	585	693	68	103	522
Electrical equipment and communication	1,007	77	100	829	929	79	91	759
Communication equipment and electronic components	507	37	35	435	469	39	31	399
Other electrical equipment	499	41	65	394	460	39	60	361
Motor vehicles and other transportation equipment	865	(2)	(1)	852	814	(2)	(2)	803
Aircraft and missiles	489	8	25	456	476	10	27	439
Professional and scientific instruments	276	28	51	197	254	27	48	180
Scientific and mechanical measuring instruments	90	18	(2)	(2)	86	17	(2)	(2)
Optical, surgical, photographic, and other instruments	185	10	(2)	(2)	168	9	(2)	(2)
Other manufacturing industries	74	(2)	(2)	(2)	68	(2)	(2)	(2)
Nonmanufacturing industries	98	(2)	24	(2)	89	33	(2)	(2)

[1] See table 11, footnote 1.
[2] Not separately available but included in total.

TABLE 70.—*Funds for basic research performance, by industry and field of science, 1964*

[In millions of dollars]

Industry	Total	Life sciences	Physical and mathematical sciences	Engineering sciences	Other sciences
Total	582	57	355	125	44
Food and kindred products	12	2	7	2	1
Textiles and apparel	1	----	(1)	(2)	(2)
Lumber, wood products, and furniture	----	----	----	----	----
Paper and allied products	2	(2)	1	(1)	(2)
Chemicals and allied products	161	44	110	7	(1)
Industrial chemicals	109	15	88	(2)	(2)
Drugs and medicines	37	26	10	(2)	(2)
Other chemicals	(2)	(2)	(2)	(2)	(2)
Petroleum refining and extraction	52	(2)	29	6	(2)
Rubber products	10	(2)	(2)	(2)	(2)
Stone, clay, and glass products	7	----	6	(2)	(2)
Primary metals	11	(2)	9	2	(2)
Primary ferrous products	8	(2)	7	1	(2)
Nonferrous and other metal products	3	----	2	(1)	----
Fabricated metal products	4	(2)	3	1	(2)
Machinery	24	(2)	16	7	(2)
Electrical equipment and communication	143	(2)	(2)	(2)	(2)
Communication equipment and electronic components	116	(2)	(2)	(2)	(2)
Other electrical equipment	27	(2)	20	5	(2)
Motor vehicles and other transportation equipment	38	(2)	(2)	(2)	(2)
Aircraft and missiles	59	3	25	20	12
Professional and scientific instruments	(2)	(2)	(2)	(2)	(2)
Scientific and mechanical measuring instruments	6	(1)	3	(2)	(2)
Optical, surgical, photographic, and other instruments	(2)	(2)	(2)	(2)	(2)
Other manufacturing industries	5	(2)	3	1	(2)
Nonmanufacturing industries	34	1	17	7	9

[1] Less than $500,000.
[2] Not separately available but included in total.

TABLE 76.—*Funds for applied research and development performance, by industry and product field, 1964*

[In millions of dollars]

Industry	Total	Product field																
		Aircraft and parts	Atomic energy devices	Chemicals, except drugs and medicines	Drugs and medicines	Electrical equipment, except communications	Communication equipment and electronic components	Fabricated metal products	Food and kindred products	Guided missiles and spacecraft	Machinery	Motor vehicles and other transportation equipment	Petroleum refining and extraction	Primary metals	Professional and scientific instruments	Rubber products	Stone, clay, and glass products	Other product fields
Total	12,771	1,392	627	928	238	301	2,279	145	119	3,409	983	683	193	164	317	98	79	819
Food and kindred products	123	-------	(1)	(1)	(1)	(1)	-------	(1)	(1)	-------	(1)	-------	-------	(1)	(1)	-------	(1)	(1)
Textiles and apparel	31	-------	-------	4	(1)	(1)	-------	(1)	(1)	-------	1	-------	(1)	-------	(1)	1	-------	24
Lumber, wood products, and furniture	(1)	(1)	-------	(1)	-------	(1)	(1)	(1)	-------	-------	(1)	(1)	-------	-------	(1)	-------	-------	(1)
Paper and allied products	17	-------	-------	5	-------	(1)	(1)	(1)	(1)	-------	7	(1)	(1)	(1)	(2)	1	-------	57
Chemicals and allied products	1,123	(1)	78	634	218	5	3	7	23	6	18	(1)	11	13	3	6	3	33
Industrial chemicals	747	(1)	78	517	43	(1)	(1)	(1)	5	6	17	(1)	(1)	13	2	6	1	27
Drugs and medicines	199	-------	-------	23	166	-------	-------	-------	6	-------	(1)	-------	-------	-------	(1)	(1)	(1)	1
Other chemicals	177	(1)	-------	93	9	(1)	(1)	(1)	12	-------	(1)	-------	(1)	-------	(1)	(1)	(1)	4
Petroleum refining and extraction	285	(1)	(1)	92	(1)	(1)	(1)	(1)	-------	(1)	1	(1)	176	2	3	(1)	1	7
Rubber products	140	(1)	(1)	(1)	(1)	-------	(1)	(1)	(1)	(1)	(1)	(1)	-------	(1)	-------	(1)	-------	(1)

Stone, clay, and glass products	126	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Primary metals	180	2	1	13	--------	2	2	15	(1)	1	10	3	(1)	115	2	1	(1)	11	
Primary ferrous products	(1)	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	
Nonferrous and other metal products	75	(1)	(1)	5	--------	2	(1)	6	(1)	(1)	7	3	(1)	35	(1)	(1)	(1)	9	
Fabricated metal products	147	1	22	13	(1)	4	5	43	2	(2)	25	2	1	5	4	2	3	17	
Machinery	1,004	16	3	11	(1)	16	195	17	(1)	53	598	23	1	3	6	(1)	1	60	
Electrical equipment and communication	2,492	142	317	17	(1)	180	250	17	(2)	231	142	4	(1)	8	71	1	3	106	
Communication equipment and electronic components	1,364	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	(1)	
Other electrical equipment	1,128	142	(1)	16	(1)	174	273	10	(1)	141	50	4	(1)	5	51	(1)	(1)	40	
Motor vehicles and other transportation equipment	1,150	59	2	8	(1)	52	184	23	(1)	87	82	616	1	9	3	5	(2)	19	
Aircraft and missiles	5,038	1,081	137	28	--------	14	442	7	(1)	2,928	27	20	(1)	4	10	8	1	330	
Professional and scientific instruments	464	5	2	11	(1)	16	107	6	(1)	50	22	(2)	(1)	(1)	163	2	1	65	
Scientific and mechanical measuring instruments	204	(1)	1	1	(1)	8	84	3	--------	22	14	(2)	(1)	(1)	43	(1)	(1)	25	
Optical, surgical, photographic, and other instruments	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	(1)	
Other manufacturing industries	91	(1)	(1)	(1)	--------	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	--------	(1)	
Nonmanufacturing industries	294	(1)	59	11	3	4	49	1	2	23	21	1	2	3	48	(1)	(2)	44	

[1] Not separately available but included in total. [2] Less than $500,000.

APPENDIX 11

UNITED STATES PROGRAM FOR RADIATION PRESERVATION OF FOOD

REMARKS BY E. E. FOWLER, DIRECTOR, DIVISION OF ISOTOPES DEVELOPMENT, U.S. ATOMIC ENERGY COMMISSION, BEFORE THE 48TH ANNUAL CONVENTION OF THE NATIONAL ASSOCIATION OF STATE DEPARTMENTS OF AGRICULTURE, HONOLULU, HAWAII, NOVEMBER 14, 1966

Let me begin by expressing my personal appreciation in being invited to participate in this year's proceedings of the National Association of State Departments of Agriculture. I would be less than candid if I did not acknowledge also my extreme pleasure in again having the opportunity to come to this beautiful State of Hawaii.

I have been invited here today to tell you about work which we are engaged in to use ionizing radiation to preserve foods. As a consequence, I would hope we could stimulate your interest and direct participation in the tasks which lie ahead before this technology can be commercialized.

In the United States this work has been focused upon two specific objectives: first, to develop a technology whereby radiation can be used to sterilize foodstuffs, such as meats, for long-term storage without refrigeration; and second, to develop a technology whereby radiation can be used to extend the marketing time for perishables, such as fresh fruits and marine products, under refrigerated conditions.

The overall management of these research and development programs resides in the first instance with the United States Department of Army and in the second with th United States Atomic Energy Commission. The goal of the Army's program is to provide improved rations and logistic advantages for troop feedings under field conditions. The goal of AEC's program is to provide a new processing method for fresh foods having important consumer and commercial value.

As all of you know, food deteriorates in many ways: through physical, chemical and enzymatic changes, and by activity of microorganisms and insects.

Fresh, untreated foods are generally subject to spoilage by all the mechanisms just mentioned. Physical, chemical and enzymatic changes are of major concern in long-term storage and they can be retarded by refrigeration. On the other hand, spoilage by microorganisms is often the prime cause of rapid deterioration of perishable foods. While refrigeration is helpful, it often will not do the job alone. Thus, the use of radiation to control microbiological spoilage and extend refrigerated shelf life of fresh food products becomes a most important goal. Insect destruction of foodstuffs such as grain or processed flour continues to be a major problem in many parts of the world. Radiation is a potent means of killing or sterilizing insects and, accordingly, offers a method whereby destruction of foodstuffs by such pests can be controlled.

A large part of our effort has been directed to radiation processing of fresh marine products, such as finfish and shellfish. Large-scale shipping and storage tests involving many tons of processed products have demonstrated the ability to extend marketing times of marine products under refrigerated conditions for several weeks instead of a few days.

We are also experiencing highly encouraging results with selected fruits and vegetables such as papayas, bananas, strawberries and tomatoes. In the case of bananas, our interest has been in using radiation to delay the ripening process thereby increasing marketing time and reducing spoilage. While technically this appears to be fully achievable, progress in developing new varieties of bananas has also been moving apace. The Valeriee variety, which is replacing the Gros Michel variety, shows improved stability against deterioration in marketing. Therefore, a good question now exists with respect to use of radiation commercially for processing of bananas for mainland distribution. Nevertheless, we remain hopeful that radiation processing of bananas will find important application in other market areas around the world.

Results of work which we are sponsoring here at the University of Hawaii indicates a 3 to 4 dav shelf-life extension in papayas when subjected to radiation processing coupled with the standard hot water treatment.

We are working toward extending the shelf life to 6 to 8 days which would permit surface shipment as opposed to current air shipment.

You may be interested in the fact that we have recently completed a cost-benefit analysis of selected products in the food irradiation program. Papaya was one of the products evaluated, with some of the more interesting conclusions as follows:

Assuming the mainland market expands at a rate equal to the present, demand will increase from 5.0 million to 45 million pounds for papaya by 1980.

If a 6 to 8 day shelf-life extension can be obtained through the use of radiation, shipping costs by surface vessel rather than air can result in transportation savings of 8.5 cents per pound. Chemical disinfestation costs also will be eliminated.

Adding the net yearly bneefits between 1970–1980, and discounting these at a 10 percent rate, the sum of the annual benefits is nearly $9 million (present worth).

If one were to assume that the growth of the papaya industry parallels that of avocado and fresh pineapple in their first 15 to 20 years, the papaya market would reach 70 million pounds by 1980. In this case, the sum of the annual values, discounted at 10 percent would be $22 million. The estimates are based on an FDA approval of papaya by late 1967.

Results of two years of work at the University of California with tomatoes irradiated at the "pink" to "full-ripe" stage demonstrate a shelf-life extension of 8 to 15 days. This may mean an extended radius of marketing from central warehouses as well as an extended retail period. The results have special significance when it is recognized that the present trend in the United States is to pick tomatoes in the "pink" stage.

As all of you know, the U.S. Department of Agriculture regulates the quarantine of agricultural products suspected of carrying pests into the United States. It has given clearance for importation, from the State of Hawaii to the United States' mainland, of experimental lots of papaya, eggplant and pepper fruits processed with radiation for control of Hawaiian fruit fly infestation. Disinfestation, under current practice, is carried out using chemical fumigation treatment. This is a significant development from two points of view; it will further the objectives of the program being carried out in Hawaii directed to radiation processing of tropical fruits; and it is a tentative recognition by U.S. quarantine officials that low-dose radiation processing is an adequate means of controlling the fruit fly. It is likely that similar approval will be granted for importation of mango fruits processed with radiation for control of the mango seed weevil.

This gives you but a glimpse of the technical side of work in progress. However, hopefully, I have been able to bring out the fact that from a technical standpoint, we see no untoward reasons why radiation processing cannot be reduced to commercial practice during the period between now and the early 1970's.

Let us look next to the question of "value added" as a consequence of commercializing radiation processing. The gains in economic efficiency from extending, through radiation processing, the time available for marketing fresh foods take a number of forms. For example:

1. By reducing retail costs attributable to actual or impending food spoilage which result in reduced-price "clearance" sales, actual throwaways, and revneue foregone as a result of short buying of perishables.

2. By making available a superior product to regional markets which cannot now be reached from distant producing points; that is, a product with a greater value added (or more consumer utility) than the products it will logically displace (fresh fish for frozen, for example).

3. By making possible use of more efficient (less costly) modes of shipping (surface vessels for air freight, for example).

Other values include:

1. Benefits related to the world food problem. The United States has clearly indicated its commitment to assisting other nations to alleviate food shortages. The best single example might be the Food for Peace Program. Clearly, irradiation could by preventing spoliage, etc., help to make such programs more effective.

2. Benefits related to public health issues. Irradiation preservation of foods has a distinct promise in the areas of food sanitation and public health. For example, irradiation is an alternative methods to traditional means of control of salmonellae in processing poultry and other foods. It is also an alternative to use of chemical fumigants and preservatives in some foods. The costs of using radiation processing as a complementary or substitute

method of sanitation control can be reasonably estimated but not the benefits. Neither were, nor are, the public health benefits of pasteurization of milk measurable to suggest a relevant analogy.

3. Benefits related to consumer choice. Irradiation can expand the variety of foods available to consumers by making new foods available (e.g., Hawaiian mango) or new forms of foods available (fresh fish in inland markets).

4. Benefits related to World Trade policy. From the viewpoint of domestic shippers, expansion of international trade as a result of being able to ship perishables longer distances is a tangible benefit that is likely to result from commercialization of irradiation processing for some products. The advantages of developing new technology which can be also used by foreign shippers is unknown, but is cited as an intangible.

The next question to which we are directing increasing attention is the mechanisms for commercialization of the first new food processing method in 150 years. Commercialization has to be looked at from the veiwpoint of those on whom commercialization depends—that is, the growers and fisheries' groups, processors and distributors whose costs, revenues, and net incomes are at issue.

Some roadblocks must be overcome to permit commercialization. These include:

1. *Commercialization will not take place until a sufficient number of food clearances have been issued.*—Food and Drug Administration approval of the process has been obtained for only a few specific food products, specifically bacon, wheat and wheat flour and white potatoes. Approval for additional food products is required if commercialization of radiation processing of foods is to be achieved. The FDA is currently evaluating other petitions for oranges, strawberries, six species of East Coast finfish, and ham.

2. *The economic relationship of costs versus benefits for radiation pasteurized food is as yet not sufficiently well defined.*—Reasonably reliable estimates are available of radiation pasteurization costs, and activities in progress will provide increasing accurate information. Data on the economic value of benefits conferred by radiation pasteurization has been developed for only a few products, for example papayas.

3. *The extent, if any, of consumer resistance to consumption of radiation pasteurized foods has yet to be fully established.*—It should be noted that the actual existence of consumer resistance in fact has not been substantiated. Results of a limited consumer attitude survey which we have just completed indicated a surprising degree of consumer acceptance of radiation processed foods.

These problems tend to inhibit commercial enthusiasm for the process. Our responsibility is to overcome them. It is here that you, through the agricultural community which you represent, can lend a welcome and helping hand.

Today, we are taking specific steps to overcome these roadblocks. For example:

1. We are increasing our emphasis on completing work necessary to obtain FDA clearances and hope to submit at least five new petitions to FDA over the next 12 months.

2. We are planning to undertake limited consumer education and information activities to overcome any apprehensions in this quarter. We would hope other interested Government agencies and private industry would supplement our activities in this area.

3. We have been and propose to continue to use our large-scale food irradiators, such as the Hawaiian Development Irradiator, for cooperative large-scale shipping and acceptability tests with industry.

4. Finally, we are prepared to engage in jointly financed programs with industry for the construction and operation of pilot plants to demonstrate the radiation processing of foods on a near-commercial scale.

APPENDIX 12

CORRESPONDENCE AND EXTRACTS FROM REPORT TO AEC ON COST-BENEFIT STUDY OF SELECTED PRODUCTS IN LOW DOSE FOOD IRRADIATION PROGRAM

U.S. ATOMIC ENERGY COMMISSION,
Washington, D.C., November 22, 1966.

MR. JOHN T. CONWAY,
Executive Director, Joint Committee on Atomic Energy, Congress of the United States.

DEAR MR. CONWAY: The cost-benefit analysis conducted on selected foods within our Radiation Preservation of Foods Program has been completed. I am pleased to forward a copy of the draft report on this study for the Committee's information. We will provide to you shortly our programmatic evaluation of the total food irradiation program as based on this study plus other reviews.

Sincerely yours,

S. G. ENGLISH,
Assistant General Manager for Research and Development.

COST-BENEFIT STUDY OF SELECTED PRODUCTS IN ATOMIC ENERGY COMMISSION'S LOW-DOSE FOOD IRRADIATION PROGRAM

(Prepared for Division of Isotopes Development, U.S. Atomic Energy Commission, October 1966)

I. Foreword

This report presents findings and conclusions from a study of prospective costs and benefits of the Atomic Energy Commission's low-dose food irradiation program. The objectives of the study were to estimate the tangible and intangible benefits likely to accrue as a result of commercialization food irradiation taking into account:

1. The value added by the process;
2. The expenditure of Government funds required to achieve commercialization; and
3. The costs to be incurred by private industry in establishing and operating the process.

The imponderables which the study faced are formidable. Nevertheless, the Atomic Energy Commission and the Bureau of the Budget must make basic policy decisions about the food irradiation program. In short, the justification for this study rests on its ability to narrow the degree of uncertainty relative to the continued extension of the program, in terms of time and dollars.

If the program is to continue, the questions are at what level, for how long, and in what manner?

CRITERION FOR MISSION FULFILLMENT

This study differs from the usual cost-benefit analyses of public investment programs in a very fundamental way. Cost-benefit studies usually involve appraisal of missions about which decisions to go ahead or not, or about which of a number of alternatives to choose, are made within the province of government; i.e., decisions concerning water resource investments, airport developments, military procurement, etc.

The mission of AEC's research and development program in food processing is to commercialize the low-dose irradiation process of preserving foods. Success of the program is contingent on a series of interrelated decisions to be made, not by government, but by business firms throughout the producing, processing and distribution segments of the food industry and ultimately by consumers. These are decisions the AEC can influence but cannot make; in the final analysis, commercialization requires private, profit-motivated decisions that investment in this field represents an attractive venture.

WHOSE VIEWPOINT?

Thus, the study had to come to grips with two fundamental questions: first, can the *public* benefits associated with AEC's investment in research and development

of radiation processing of foods cover the public costs; and, second, given a favorable answer to that question, what is the likelihood that members of industry and consumers will behave in a way that will actually result in commercialization.

This study looks at the first question from the viewpoint of the "American taxpayer." At this level the tangible economic benefits from commercialization of the food irradiation process have to be found in gains in national economic efficiency.

These are gains that underlie improvement in economic well-being for the citizenry as a whole. If gains from AEC's investment in radiation processing will accrue only to specific industries or segments of consumers *at the expense of other groups*, then the government's participation is called into question.

Radiation processing is a method of preserving foods, or put another way, of extending the time available between harvest and consumption of perishable foods. The measurable tangible benefits from extending the time available for marketing fresh foods, which *may* yield gains in economic efficiency, potentially take a number of forms, for example:

1. By reducing retail costs attributable to actual or impending food spoilage which result in reduced-price "clearance" sales, actual throwaways, and revenue foregone as a result of short buying of perishables.
2. By making available a superior product to regional markets which cannot now be reached from distant producing points; that is, a product with a greater value added (or more consumer utility) than the products it will logically displace (fresh fish for frozen, for example).
3. By making possible use of more efficient (less costly) modes of shipping (surface vessels for air freight, for example).

The second question, as to the likelihood of commercialization, has to be looked at from the viewpoint of those on whom commercialization depends—that is, at the growers and fisheries, processors, and distributors whose costs, revenues and net incomes are at issue.

Favorable answers to either one of the two questions do not assure a favorable answer to the other. Thus, considerations which may make investment in irridiation facilities attractive from a food processor's viewpoint may, from the public viewpoint, simply improve one processing segment's market position vis-a-vis other processors—for example, if consumers substitute fish meals for meat. This will have no effect (at least no clear-cut tangible effect) on national well-being as reflected in economic efficiency.

On the other hand, realization of gains in national economic efficiency, say through reductions in food spoilage losses, may not constitute commercial incentive for investment in radiation processing facilities, even if benefits exceed costs. This can be the case when the facilities investment is made at one stage in food production, processing, and distribution and the benefits accrue at another stage. This is not an unrealistic possibility. Irradiation facilities must be near harvest points, yet gains in marketing-time will often be taken at retail in the form of extended shelf-life. Costs of radiation processing might be passed along by processors to retailers in higher prices; but this is unlikely in the short run because the initial effect of reduced spoilage is reduced market demand for growers and processors, requiring either lower prices to clear the market or reductions in production to maintain prices. The processor's revenue is reduced as a result of his investment and the fact that the economy as a whole benefits can be seen as quite immaterial from his point of view.

DEALING WITH INTANGIBLES

This study emphasizes the tangible economic costs and benefits attributable to AEC's food irradiation program. These are the factors that will play the compelling role in *commercialization* of the food radiation process.

The worth of intangibles, by definition, can only be appraised subjectively. And while there may be a consensus that the desire to realize prospective intangible benefits justifies public support, the amount of conjecture and uncertainty involved in the questions of "how much support" and "at the expense of what" are clearly much less if concrete commercial benefits can be reasonably expected also.

Attention is nevertheless called to categories of intangible benefits which public support of the food irradiation program might produce:

1. Benefits related to the world food problem. The United States has clearly indicated its commitment to assisting other nations to alleviate food shortages.

The best single example might be the Food for Peace Program. Clearly, irradiation could by preventing spoilage, etc., help to make such programs more effective.

2. Benefits related to public health issues. Irradiation preservation of foods has a distinct promise in the areas of food sanitation and public health. For example, irradiation is an alternative method to traditional means of control of salmonellae in processing poultry and other foods.[1] It is also an alternative to use of chemical fumigants and preservatives in some foods. The costs of using radiation processing as a complementary or substitute method of sanitation control can be reasonably estimated but not the benefits. Neither were, or are, the public health benefits of pasteurization of milk measurable to suggest a relevant analogy.

3. Benefits related to consumer choice. Irradiation can expand the variety of foods available to consumers by making new foods available (e.g., Hawaiian mango) or new forms of foods available (fresh fish in inland markets).

4. Benefits related to World Trade policy. From the viewpoint of domestic shippers, expansion of international trade as a result of being able to ship perishables longer distances is a tangible benefit that is likely to result from commercialization of irradiation processing for some products, the advantages of developing new technology which can be also used by foreign shippers is unknown, but cited as an intangible.

5. The Army Food Sterilization Program. Several foods have been approved by the Surgeon General for troop feeding. The army, however, will not as a matter of policy and logistics take advantage of this opportunity until after FDA approval of these foods. This is partly because many civilians are fed at army installations and partly because of possible public relations implications. Therefore, the AEC program which is contributing to FDA approval procedures is an intangible in development of the army's radiation-sterilized foods program.

PRODUCT SCOPE

In commissioning the study, AEC specified the key products to be covered and provided assumptions regarding certain key inputs. Specifically, the study was limited to the following products:

1. East Coast finfish (Cod, Haddock, Sole and Flounder).
2. West Coast Dungeness crab.
3. Alaskan king crab.
4. Bananas.
5. Hawaiian papayas.
6. Tropical mangos.

The AEC program is concentrating on a limited number of research and development projects in food irradiation. Table 1 summarizes the status of projects in fruits and vegetables which are in addition to work being done on marine products.

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[1] See, for example, Arthur D. Little, Inc., "Study of the Economics of Controlling Salmonellae in Foods by the Use of Ionizing Radiation," April, 1965. Reprinted in *Radiation Processing of Foods*, Hearings before the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy, June 9 and 10, 1965.

TABLE 1.—*Product status, fruits and vegetables*

[Legend: RS, reduced spoilage; SLE, storage life extension; SI, sprout inhibition; DIS, disinfestation; DM, delayed maturation]

Product	Desired end point	State of technology	Technological outlook [1]	State of wholesomeness	Completion of wholesomeness (fiscal year)	Petition submission date [2] (clearance expected 12 to 18 months later) (fiscal year)
Strawberries	RS, SLE	Advanced	Excellent	Near completion	1966	1966
Sweet cherries	RS	Relatively new	Fair	do	1966	1967
Pears	RS, DM	Advanced	Poor	do	1966	(?)
Plums	RS	New	Fair	do	1966	(?)
Prunes	RS	do	Good	do	1966	1967
Peaches	RS	Advanced	Uncertain [3]	Completed		(?)
Apricots	RS	New	Poor	Near completion	1966	1967
Nectarines	RS	Advanced	Good	Completed		1967
Apples	DIS	New	Fair	Near completion	1966	(?)
Oranges	RS	Advanced	Good	Completed		(4)
Lemons	RS	Dropped	Poor			
Grapes	RS	do	do			
Tomatoes (ripe)	RS, DM	New	Fair	Not initiated	(?)	(?)
Bananas [5]	DM	do	Excellent	do	1967	1969
Papayas	DIS, SLE	Relatively new	do	do	1967	1969
Mangoes	DIS	do	do	do	1967	1969
Pineapples	DIS	New	Good	Partly completed	(?)	(?)
Figs	DIS	do	do	Not initiated	1967	1969
Onions	SI	Near completion	do	Near completion	1966	1967
Potatoes	SI	Completed	do	Completed		(6)
Wheat and wheat products	DIS	do	Excellent	do		(6)

[1] Economic aspects not considered.
[2] Approval normally requires 12 to 18 months, and may require additional work during that period.
[3] Improving due to promising combination treatment with heat.
[4] Pending FDA action.
[5] Main variety studied to date (Gros Michel variety).
[6] FDA approval.

Source: U.S. Atomic Energy Commission, "Radiation Processing of Foods Program" SM 73/29, June 6–10, 1966.

During the course of this study, we have been asked many times by business respondents, researchers, consumers and officials in other agencies of government why the particular group of six products was selected. AEC's criteria in this selection were essentially two: products were selected on which the state of technology was relatively well-advanced and for which the technological outlook was considered good. Strawberries which also meet these criteria were not included because previous marketing studies have indicated a favorable economic and marketing outlook for the irradiated product.[2]

A third consideration in AEC's selection of the products for this study was their "representativeness" of the full-scope of AEC's research and development program. The six products do represent East Coast and West Coast marine products, a large, established tropical fruit (bananas) and two exotic, specialty fruits (papaya and mango).

At this point, the issue of "representativeness" must be considered carefully. We want to emphasize our conviction that the results of the study based on these six products can *not* be extrapolated to the program as a whole. This is true because benefits from irradiation of each product are unique to each product and to each's own marketing problems and opportunities. In short, this "study" is in fact six case studies. Knowledge about one product's irradiation opportunities and problems has not been generalizable to other products, except in the very broadest of terms. It can be noted that this has tended to be true of the AEC's technological research also. Results of research on one fruit, for example, have not been reproducible for similar fruits or even different varieties of the same fruit.

There are two reasons for dwelling on this point. One is the possible use of the six-product study as a basis for judging the entire program; and the second is the desire to make the study maximally helpful to AEC in screening products other than the six. We have concluded that radiation processing is most likely to find commercial application—given technological feasibility—when the products meet the following criteria:

1. The product is a large volume, staple perishable so that success in commercializing radiation processing on a large scale is not first contingent on developing a market—i.e., on changing consumer eating and food buying habits—for the product.
2. The product is subject to spoilage losses that are sufficiently high to create widespread, overtly recognized problems.
3. The product is relatively high priced so that the costs of spoilage losses constitute a more than adequate incentive to incur the relatively modest costs of radiation processing.

There are other criteria underlying success in commercialization but the foregoing are cited as *a priori* criteria to be applied as a first cut in deciding which among alternative products to support.

As discussed in subsequent sections of this report, none of the six products included in this study fully satisfy all three of the criteria just cited. But AEC's research program includes products which do—for example, strawberries, peaches and tomatoes. The first of these was excluded from this study, as noted, because of the favorable outlook indicated by other studies. Research progress made since this study was started has materially improved the technological outlook for peaches and tomatoes from "uncertain" or "fair" to "good."

We have concluded that among the six products studied here the public benefits and commercial prospects for two of them—finfish and papaya—are sufficiently good to support a recommendation for continued AEC support. What should be recognized, however, is that even if *none* of the six were felt to justify continued support, we would be hard pressed to conclude the program should be terminated, because of the nonrepresentativeness of the sample of six products and the *a priori* promise in others (e.g., strawberries, peaches, tomatoes).

TIMING ASSUMPTIONS: FDA APPROVAL CRUCIAL

The planning horizon for the estimation of costs and benefits from commercialization of radiation processing was specified by AEC as the fifteen-year period 1966–1980.

[2] Southern Interstate Nuclear Board, "Applicability of Radiation Pasteurization Oranges, Grapefruit, Tomatoes, Peaches, Strawberries in the Southern Region," September 15, 1964; United States Department of Agriculture, "Economic Feasibility of Radiation-Pasteurizing," August 1963; United States Department of Agriculture, "Radiation-Pasteurizing Fresh Strawberries and Other Fresh Fruits and Vegetables: Estimates of Costs and Benefits," March 1965.

Fifteen years is a "long" time from the viewpoint of the reliability of predictions. But it is not necessarily "long" from the viewpoint of sequentially unfolding all of the events that appear to lie between the present state of development and utlimate commercialization of radiation processing of foods.

The first event in this sequence is approval by the Food and Drug Administration of petitions to market irradiated foods. The timing of approval is the most crucial and in a number of respects most uncertain of all the events required to reach commercialization. For purposes of this study, the Food and Drug Administration's approval of petitions for these products were assumed to be forthcoming on the following schedule:

1. East Coast finfish: Mid 1967.
2. West Coast crab: Late 1967.
3. Bananas: Mid 1968 to early 1969.
4. Papayas and mangos: Late 1967.

FDA approval on these dates, which were given to us by AEC, are taken as facts for this study. All of the study's projections and conclusions about timing stand or fall on these dates and, of course, the program as a whole stands on FDA approval sooner or later.

At the present time, a petition has been submitted to FDA for one of the six products, finfish. Once a petition is submitted, FDA has, as we understand it, 180 days to approve, reject or return it to the petitioner for more information. Four petitions relating to food irradiation have been submitted to FDA. Three have been approved (bacon, wheat and wheat flour for disinfestation, and potatoes for sprout inhibition). All others have been returned to petitioners for additional data. FDA officials responsible for recommending approval cannot assess the reasonableness of the timetable shown above for three fundamental reasons:

1. Petitions have not been received for five of the products.
2. No basis exists for predicting whether petitions will be judged complete or will require additional data; nor, if the latter, can the timetable on which the required data will come forth, be predicted.
3. Information concerning the efficiency and safety of radiation-processed foods have come from many quarters, the significance of which FDA is charged with evaluating. In some cases the methodology for such evaluation has not been developed.

Among our recommendations, is that AEC's food irradiation program be extended into the early 1970's. What must be stressed, however, is that in fact we are recommending that the program be extended at least three to four years beyond FDA approval of several important products.

INDUSTRY ASSISTANCE

On the issue of uncertainties and probabilities, a fact of life which transcends all but two of the products included in the scope of this study is that very little commercial awareness exists about radiation processing. The exceptions to this are finfish and bananas. In the absence of FDA approval of petitions, companies who would be the logical investors in radiation processing, indicate little familiarity with the process, research findings, process economics, or possible applications in their industries. It should also be noted that a majority of the trade and institutions' executives consider themselves ill-informed about food irradiation. In the product categories where advanced thinking has been done by key companies in the two industries referred to—bananas and New England finfish—there is less uncertainty about the prospects for commercialization. (The outlook for bananas is poor, for finfish relatively good.)

In the other product categories, it is necessary to leap frog FDA approval and ask whether conditions in each industry are amenable to irradiation investment or not. The following criteria were brought to bear in appraising the opportunity from the viewpoint of the potential investor:

1. Is production adequate in a *single location* to justify an irradiation facility?
2. Is production and demand sufficiently stable throughout the year to permit efficient utilization of a facility?
3. Is there an economic justification and need for extended marketing time for the product which cannot be met by a lower cost or otherwise more effective alternative to radiation processing?

4. Are there companies or organizations in the industry which have both the financial strength and an historical record (or managerial attitude) that implies receptivity to innovation in new processes?

Specific study findings for each product are tested against these criteria in relevant sections that follow.

STUDY METHODOLOGY

The study was conducted in three phases:

1. *Qualitative, Discovery Phase.*—In this phase, AEC research contractors were interviewed and their reports reviewed; the work of researchers in government agencies who have conducted marketing and economic studies in this area was reviewed; leading firms involved in producing, processing and marketing each product were interviewed and in many instances relevant, though confidential, company data was made available. Finally, an opening wave of qualitative group conferences and individual personal interviews with consumers was conducted.

The objective in this first phase was to identify the overall dimensions of the problem; to determine how effectively the prospective technical benefits of radiation processing addressed themselves to industry needs; to understand the degree to which key firms or organizations, particularly at the processing level for each product, were aware of, interested in, and enthusiastic about the prospects of radiation processing of foods; and, at the consumer level, to develop some early insights into consumer attitudes toward the concept of irradiated foods.

2. *Quantitative, Survey Phase.*—The second phase of the undertaking extended the data-gathering effort to a broader base. Surveys were conducted among seven populations of interest including consumers. The objectives and scope of these surveys are summarized in Table 2. At the same time, an engineering study of facilities investment and operating costs was undertaken under subcontract to Jackson and Moreland, Inc. This study used as inputs a range of thruput assumptions and practical production considerations for each product that emerged from Phase 1.

TABLE 2.—*Summary of surveys conducted: Phase II, food irradiation cost-benefit study*

Respondents	Number of interviews	Number of organizations	Sampling universe
Consumers	627	----------	Total household in the United States.
National headquarters of largest supermarket chains.[1]	37	20	25 largest supermarket chains, based on annual sales of over $150,000 and/or over 90 stores.
Local units of the largest supermarket chains.[1]	60	34	All local stores of top 25 supermarket chains.
Local units of all other supermarkets.[1]	45	23	All other supermarkets having a minimum of 2 stores.
Individual food stores [1]	41	21	All other general food stores with a minimun of $150,000 annual sales. Includes fruit and fish specialty stores.
Subtotal local stores	146	78	
Restaurants	87	87	All restaurants (register of members of National Restaurant Association).
Institutions	40	40	Largest 225 institutions in the United States.

[1] Fruit and fish buyers.

3. *The Analytical Phase.*—This final phase addressed itself to quantifying the prospective streams of economic benefits and costs that could result between now and 1980 from commercialization of radiation processing of foods under a number of assumptions. This analytical exercise must necessarily be subject to differing points of view. Accordingly, in order to evaluate the effect of uncertainty about crucial assumptions, we have relied heavily on sensitivity analysis. That is, the sensitivity of conclusions—specifically the sensitivity of the present worth of net benefits attributable to AEC's research and development expenditures—was tested by calculating net benefits from a range of values for key

variables. The most important of the variables subjected to sensitivity analysis included radiation processing costs, market demand, and economic benefits attributable to radiation processing, e.g., the proportion of total current spoilage losses in each fruit that can be avoided in the future by extending total marketing time or retail shelf-life.

In addition, in the analytical phase some conclusions had to be reached concerning, on the one hand, the probabilities that a large number of interdependent decisions by independent companies and groups would be made in favor of radiation processing of foods, and on the other hand the probabilities attendant to realization of the many assumptions made in the course of estimating prospective costs and benefits.

OUTLINE OF THE REPORT

An overview of the major study findings, their implications and program recommendations follows this Foreword. The two sections of the report immediately following the summary, address themselves to issues that transcend specific product considerations: Section III presents the results of the consumer studies of attitudes toward the concept, consumption and labeling of irradiated foods; Section IV presents corresponding attitudes expressed by commercial food servers—restaurants and institutions—and food retailers; Section V through VIII present in turn salient findings that relate specifically to the products examined (V. Finfish, VI. Tropical Hawaiian fruits, VII. West Coast Crab, and VIII. Bananas). The final section of the report presents the detailed cost-benefit tables and constitutes a detailed summary of the study as a whole.

II. Overview

CONSUMER ATTITUDES

Intensive interviewing of consumers supplemented by a national survey of homemakers' attitudes permits three broad conclusions:

1. The level of informed awareness concerning preservation of foods by radiation is low (24% of consumers claim some awareness; and only 6% grasp the concept correctly).
2. Consumers' initial response to the concept of irradiated foods without further information or explanation shows a surprising degree of acceptance. Thus, 11 per cent flatly state that they would not buy, 36 per cent state that they don't know how they would react and more than half (53%) state that they would buy foods preserved by radiation.
3. After information about the process and reassurance is provided, about four fifths of consumers (82%) appear to be accepting the concept. Some of these would have sufficient confidence to buy such foods immediately and others would wait for a while, but feel that eventually they would buy such foods. Only about 1 out of 5 can be considered negative—they state that even after receiving reassurance and more accurate information they would probably or definitely not buy irradiated foods.

The overall picture is thus one of acceptance tempered with reservations. The intensive interviews with consumers show that radiation effects in the abstract are mysterious and somewhat frightening. They lose much of their anxiety-provoking character, however, when radiation is considered in connection with food preservation. Most of the remaining anxieties are then effectively countered when the fact is made known that irradiated foods will not be offered to consumers without prior FDA approval.

In our judgment, therefore, there will be quick acceptance of irradiated foods by a minority of consumers (possibly one third) followed by gradually increasing acceptance by the large majority (the findings indicate that this will go up to four fifths of consumers), and the balance will continue to hold out.

The fact that there may be active opposition and widespread misinformation, however, could mobilize the anxieties the people have about radiation in general. To minimize this danger, it will be important to have a program of accurate information and reassurance.

TRADE ATTITUDES

A majority of the trade and institutional executives are receptive to the idea of irradiation of food. This majority is made up of a relatively small group (8%) which unequivocally favors the process, another 46 per cent which will

buy, sell and use irradiated fish if the FDA has approved it, another 37 per cent who do not consider safety a problem and apparently have no opinion or attitude toward irradiation of food, as yet. Finally, there are a small group—9 per cent—who are determined in their opposition to the irradiation of foods.

A majority of the executives interviewed reveal a lack of knowledge about irradiation. Most of them have little hesitation in admitting this limitation and explain that they must rely upon the government for protection with respect to the safety of food processing methods of all kinds. It should also be noted that those executives who have experience with or knowledge of irradiation (typically associated with larger food selling or using organizations) are among the most favorable toward expanded radiation processing of food. Simply stated, therefore, the more knowledge the trade has about the process the more likely they are to recognize its benefits and favor its use.

Finally, a preponderant majority of the executives emphasize their belief that the consumers will accept and buy foods processed with irradiation under FDA standards.

PRODUCT-BY-PRODUCT HIGHLIGHTS

The following paragraphs review the major factors influencing the commercial prospects for irradiation processing of the six foods included in the scope of this study, along with our appraisal of the public costs and benefits that can be reasonably associated with commercialization.

PROSPECTS FOR THE SIX PRODUCTS

In summary, among the six products, positive net benefits and commercial incentives to innovate with radiation processing appear most promising for two products—New England *finfish* and Hawaiian *papaya*. Within the planning period for this study, the magnitude of the net benefits are estimated to be notably larger and to occur sooner for *finfish* than *papaya*.

The need for the technical benefits of radiation processing of Hawaiian *mango* (disinfestation) and *Dungeness crab* (extension of marketing life) are clear. There are, however, market supply, and industry considerations which rule out any possibility of early adoption of radiation processing for these products.

In the case of the two remaining products—*bananas* and *king crab*—the technical advantages of radiation processing of *bananas* provides insufficient commercial justification to incur the (low) processing costs. The *king crab* industry is wholly based on canning and freezing. The probability that a fresh market for this food will be developed within the next fifteen years is judged to be extremely slight.

NEW ENGLAND FINFISH

Irradiation of finfish extends marketing life by two to three weeks over that of the unirradiated product. The benefits from this extension can take one or more of three forms:

1. *Market expansion.*—The additional marketing time will make inland markets practically accessible from coastal fish landing ports. Based on consumer surveys, trade opinions, and trend projections, an inland market for irradiated New England haddock, cod, flounder and sole on the order of 6 to 11 million pounds per year can be developed by 1980.

Consumer research findings suggest that increased purchases of (irradiated) fresh fish come at the expense of frozen products, most of which are currently imported. The value added by substitution of fresh for frozen fish is approximately 10 cents per pound. This benefit compares with cost of radiation processing estimated at 1.6 cents per pound. Shipping costs of fresh fish are approximately twice those for frozen because of the weight of ice and containers. This is equivalent to about .3 cents per pound to Chicago. While some retailers would have to invest in new storage equipment and hire additional personnel to handle irradiated fresh fish, most report the product could be handled with existing facilities and labor. Thus, the net gain from sale of irradiated fish inland would approximately 5 cents per pound.

2. *Reduced spoilage loss.*—Retail throwaways of fresh fish because of spoilage is comparatively modest. Most retailers report no losses from throwaways. This experience is attributable to two practices in retailing of fresh fish: freezing of fish prior to its reaching crucial spoilage points and short buying of fish so that normal demand exhausts supply before Friday or Saturday store closings.

Nevertheless, enough stores do report spoilage losses and reveal that they con-

sider them a serious problem. For our sample fish product managers at the headquarters of 20 major supermarket chains, representing more than 14,000 stores, the overall loss of fresh fish at retail from spoilage is projected at 5 per cent of poundage. Since the retail sales value of fresh fish is high, typically 69–79 cents per pound in Eastern markets for the New England species of concern, avoiding even a small portion of this loss by shelf-life extension has a high economic benefit.

3. *Reducing revenue foregone as a result of short buying.*—Approximately 69 per cent of all retail stores report that they buy conservatively to avoid fresh fish carryovers from Friday or Saturday until Monday. The retail value of the revenue (or intangible value of consumer satisfaction) foregone as a result of this practice is unknown. Based on retailers' opinions and conservative assumptions, the nominal retail value is placed at 10 per cent of fresh fish marketings. Shelf-life extension obtainable from low-dose radiation preservation of fish can sharply reduce this practice.

The net benefits calculated from the foregoing sources are compared with AEC development costs at the end of this Overview.

Irradiation pocessing of fresh fish is economically feasible based on engineering assumptions worked out with the assistance of Boston fish processors. For example, a 21 million pound radiation facility located on the Boston fish pier could cover estimated capital amortization, operating costs, and realize an attractive return on investment at less than 2 cents per pound, under practical operating assumptions.

Most significantly, and in contrast to most other product categories, major commercial firms in fish processing and retailing have appraised costs of entry, their opportunity, the risks and expected return from innovation in radiation processing of fish and are enthusiastically awaiting FDA approval of petitions. These firms are few in number but have in our judgment the financial strength and demonstrated marketing and technical knowhow to optimize their chances for success. This conclusion is buttressed by the fact that the Snead Report for AEC (January, 1966), a detailed study of the outlook for radiation processing in the fish industry, states unequivocally that—"the majority of dealers at all market levels agreed that commercial adoption of radiation pasteurization would serve the best interests of the domestic fishing industry" (p. 79).

Thus, in terms of commercial incentives, prevailing attitudes, and projected public net benefits, we conclude that New England finfish is likely to represent the first, large volume radiation preserved product to reach consumers.

Approval of an already filed FDA petition, which has been returned for additional data, is assumed for mid-1967. Commercial interest is sufficiently advanced (largely as a result of the efforts of the United States Bureau of Commercial Fisheries' commercial development work conducted at Gloucester) to permit a prediction that an investment decision, construction of a facility, an initial marketing can take place by 1969 or 1970. This sequence of events presumes, in addition to timely FDA approval, that an effective informational program will have been initiated up to twelve months prior to product marketing.

HAWAIIAN PAPAYA

Irradiation of papaya at 75 krads extends shelf-life approximately three days. The primary benefit of the shelf-life extension is expected to take the form of retail cost reductions now attributable to spoilage. Losses attributable to impending or actual spoilage are estimated from a survey of retailers at 11½ per cent of the value of the fruit. Approximately half of this loss results from reduced price sales to clear retailers' shelves of ripe papaya and half from actual throwaways.

Hawaiian papaya destined for the mainland currently undergoes fumigation treatment to meet USDA quarantine restrictions to control for fruit flies. Radiation at a dosage of 75 krads is a more than adequate disinfestation procedure. The costs of present fumigation treatments, which would be displaced by radiation processing, is about .25 to .50 cent per pound.

The net benefits from irradiation processing of papaya which results in shelf-life extension of three days are marginal. The value of the potential retail saving is estimated at 1.7 cents per pound of fruit. Irradiation costs are estimated at 2.8 cents per pound in the early years of commercial operations and decline to about 1 cent later as the scale of operations expands. This cost is partially offset by displacement of fumigation costs. On balance, the present worth of benefits from retail cost reductions attributable to radiation processing of papaya

are about equal to estimated radiation processing costs and AEC development costs. if the three-day extension of marketing time cannot be improved upon.

Prospective benefits will be magnified substantially however if an extension of six to eight days in marketing time can be achieved by radiation processing alone or in combination with other distributional or processing technology. Six to eight days would make practical shipment of papaya by surface vessel instead of air freight as at present. A net economic incentive from shifting to surface from air shipments on the order of 5–8 cents per pound of fruit would exist after retail markup. This constitutes 15–25 per cent of the typical retail price of Hawaiian papaya to consumers.

Unlike the New England finfish industry, commercial papaya interests are not now attuned to the possible opportunities from radiation processing. Leading growers have attended University of Hawaii seminars, but interest in radiation processing is, at best, at the curiosity level. Similarly, the two West Coast importing firms who account for practically all of Hawaiian papaya sold on the mainland have not given radiation processing serious consideration. The presence of the Hawaii Development Irradiator, to be completed early next year, will however focus its commercial demonstrations on papaya and particularly on the feasibility of the surface shipping option. If feasibility can be demonstrated—and this seems highly likely—commercial interest in a facility will be aroused.

The current lack of overt interest in radiation processing of papaya on the part of commercial firms can be attributed largely to its remoteness. There is a perceived need in the industry to find, as soon as possible, a way of reducing papaya marketing costs.

Papaya marketers have been quite successful in developing the West Coast market for this fruit in the past five years. Currently, the marketing program is being extended to mid-Western and Eastern markets. The major hurdle to repeating the West Coast success across the country is papaya's high cost. Accordingly, surface shipment, if made possible by radiation processing will tap into an unmet need in the industry.

Sources of capital for a commercial facility are available in Hawaii and managerial attitudes held by the mainland importing organizations are such that one or the other of these organizations can be expected to provide leadership in moving ahead with a facility, if the existence of an incentive is demonstrated.

Irradiation processing of Hawaiian papaya is economically feasible based on engineering estimates. The fruit is grown year round, mostly on the Big Island of Hawaii. Thus a single facility located in Hilo could be used efficiently. Processing costs are estimated at 1–3 cents per pound depending on thruput, less .25 to .50 cents for present fumigation procedures which would be displaced by radiation processing.

It should be recognized that there are competitive alternatives to radiation processing by which the need to reduce costs might be met. One is the possibility of lower air freight costs. Air freight costs will be 3 cents lower than now if direct service is instituted from Hilo, Hawaii, thereby eliminating the present cost of trans-shipment from Hilo to Honolulu. Major airlines have new route petitions pending with FAA now. Except for this change, no major reduction in Eastbound air freight rates is predicted. These rates are already materially below Westbound rates reflecting much heavier air freight traffic Westbound than Eastbound. A second competing alternative to radiation processing which might make surface shipment of papaya practical is controlled atmosphere technology. This technology, however, is in an early state of development also.

In summary, considerable uncertainty surrounds the prospects for commercialization of radiation processing of papaya. Nevertheless, the commercial need, technological benefits, industry climate, the growing season, and concentration of the crop largely in one location are all in the right direction for adoption of the process. Moreover, from the viewpoint of public benefits, conservative assumptions suggest a breakeven return to AEC's investment if the process is commercialized. More optimistic assumption, which depends on extending marketing time to permit surface shipment, suggests the possibility of considerably higher net benefits relative to public development costs.

HAWAIIAN MANGO

If radiation processing of papaya is commercialized, a spillover benefit can take the form of development of export markets for mangos.

The interest in radiation processing of mangos stems from two facts. First. Hawaiian mangos are felt by many experts to be superior to Mexican, Florida and

South American varieties. In all probability, a mainland market of significant magnitude could be developed, if appropriate marketing support were forthcoming. The taste of mango is described as a cross between melon and peach and is quite appealing to those familiar with it, based on our consumer survey. Second, radiation processing is the only known means of disinfesting Hawaiian mangos for seed weevils. The seed weevil is peculiar to the Hawaiian fruit.

Despite these favorable considerations, it is highly unlikely that public investment in development of radiation processing of mango can produce significant positive benefits within the planning period of this study (to 1980), for the following reasons:

1. There is no commercial mango crop in Hawaii at present, beyond one or two small operations (10 to 20 acres).
2. Decisions to develop a commercial crop cannot be expected until after the seed weevil problem is solved. The payback to commercial development would be long in coming, since approximately seven years is required for mango trees to mature.
3. The harvest season lasts only two to three months so that an irradiation facility installed just for mango could not be used economically.
4. If commercial mango farms were developed, they would probably not be located on the Big Island where papaya is grown—and where a papaya irradiator would most likely be located—because mango requires considerably more rainfall than papaya.

The incremental costs of radiation research for mango, given that the emphasis is on papaya, are quite small and probably justified by the very long-term outlook. Without papaya, however, the prospects for commercializing radiation processing of Hawaiian mangos are altogether too remote to be given serious consideration.

WEST COAST DUNGENESS CRAB

Dungeness crab is a delicacy favored by many on the West Coast. A substantial portion of landings is sold to consumers and institutions in its fresh form and the remainder in frozen form. The product in fresh form has a shelf-life of about four days. The quality of the fresh product is acknowledged to be substantially superior to that of the frozen, which deteriorates month-by-month after freezing. Irradiation can extend the marketing time of the fresh product, thereby making it feasible to reach a broader market than at present.

This probability that radiation processing of fresh Dungeness crab can be commercialized, however, is considered by industry people to be quite low, for the following reasons:

1. Supplies of Dungeness crab in West Coast fishing market are not large and have tended to decline in recent years for unknown biological reasons (15–20 million pounds).
2. The catch is landed at many ports along the West Coast; concentration of production at a single location is insufficient to justify a large-scale irradiation operation.
3. More important, the crab season lasts only about six months, making economic use of a facility impossible (unless the facility was based mainly on processing of other marine products).
4. The Dungeness crab industry consists mainly of small fisheries. Dungeness crab firms with the financial and capable ability to innovate in a process such as radiation are located in Alaska where their operations are based on canning and freezing, rather than on fresh crab.

Thus, while the Dungeness crab industry could conceivably benefit from shelf-life extension, limitations on supply, particularly, but also the structure of the industry, the seasonal problem, and dispersion of landings along the coast indicate the prospects for developing commercialized radiation processing within the time period of this study are poor and that virtually no public benefits can reasonably be foreseen from development of this product.

KING CRAB

The prospects for radiation processing of Alaskan king crab are at present nil. The factors underlying this conclusion are, however, completely different from those relevant to Dungeness crab. In contrast to Dungeness crab, no

commercial market for fresh king crab exists. The industry sees neither a need nor basis for developing one. Rather the king crab industry is based entirely on canning or freezing. The frozen product is of high quality and quality is maintained well with freezing and canning for as long as a year.

The center of the king crab industry is Kodiak, Alaska. Industry people point out that even if a basis for developing a fresh market existed, it would have to rely on air freight. The detectable differences in taste between fresh and frozen king crab would not, in their opinion, justify the additional transportation costs.

BANANAS

The prospects for the commercialization of irradiation processing of bananas destined for sale in the United States and Canada are, in our judgment, very poor. The reasons for this outlook are:

1. The reduction in "ripes and turnings" afforded by irradiation is not important to the grower or importer because losses due to these factors are very small with the Varieties replacement of the Gros Michel as the principal type of banana exported.
2. The reduction in shrinkage offered as a benefit to the retailer is not considered sufficient to spur his interest in irradiation because shrinkage is only 10 per cent of total potential sales and there are alternative packaging solutions which are cheaper and less difficult than irradiation.

The cost-benefit tables, at the end of the report, extrapolate to 1980 the detailed comparison of irradiation processing costs as against potential benefits to be realized by importers, retailers, and consumers. These tables show costs of irradiation to be significantly higher than the measurable benefits that may be derived therefrom.

SUMMARY COST-BENEFIT ESTIMATES

Detailed cost-benefit tables were developed for New England finfish, papaya and bananas. Tables were not prepared for mangos, Dungeness crab and king crab because of the near certainty that radiation processing cannot be brought to commercialization in these products, under presently practical assumptions. For the three products for which tables were prepared, net benefits were calculated from a range of assumptions covering key variables.

The table below compares estimates of the present worth of net benefits based on "best bet" estimates for the three products. Detailed considerations underlying these estimates are described in the sections of the report dealing with each product. In preparing the estimates, every effort has been made to avoid double-counting and transfers. Annual values have been discounted to present worth at a 10 per cent rate. Results of discounting AEC development costs at 5 and 15 per cent did not change basic conclusions.

As the table indicates, net benefits from commercializing radiation processing of New England finfish promise to be considerable. These mainly reflect reduction of spoilage losses and loss of revenue attributable to short buying. The benefits attributed to sale of fresh fish inland are more modest under our assumptions—in part because of offsetting transfers between fresh and frozen fish. The benefits shown are after deduction of radiation processing costs and higher costs of shipping fresh (rather than frozen) fish.

The AEC costs assumed for 1967 and 1968 to develop commercialization of finfish are modest in comparison with benefits. It is assumed New England finfish can be commercialized by 1969.

In the case of papaya, benefits represented in the table are entirely attributable to cost reductions at retail from a three-day shelf-life extension (lower losses from throwaways and reduced-price sales). In contrast to finfish, for which the bulk of development costs were incurred in earlier years (1960–1966), papaya development expense lie mainly in the years ahead (1967–1970). Thus, net benefits are estimated to about equal AEC development costs. Commercialization is assumed for 1970. If, as noted, further shelf-life extension can be demonstrated, the surface shipment option would yield greater net savings (benefits) and produce a more attractive benefit-cost ratio.

For bananas, the estimated cost of irradiation processing exceed the potential savings estimated from reduction of retail throwaways and reduced-price sales.

Present worth of net benefits, 1967–80

	Market expansion	Cost reduction (millions)	AEC development costs
New England finfish	2.3	$18–$22.0	0.4 (1967–68).
Papaya		.8	0.7 (1967–70).
Bananas		[1] −50.0	Nominal.

[1] Processing costs exceed benefits.

PROGRAM RECOMMENDATIONS

This section has two parts:

1. A brief one page summary which outlines our key recommendations;
2. The remainder of the section which elaborates upon the recommendations and spells out the reasoning upon which they are based.

Key recommendations

1. The AEC food irradiation program should be continued because it appears likely that commercialization can be achieved on selected products with benefits to the United States taxpayer which will exceed costs of the government activity. For the finfish and papaya, for example, the net benefits exceed costs by approximately $20 million in the 1967–1980 period.

2. The commercialization objective should be narrowly defined. We believe that many companies in many industries will adopt radiation processing as soon as a very few companies in a few industries have shown that it is profitable and practical. This means, as we see it, that AEC can work on relatively few products to provide the "seeding" necessary.

3. The relatively few products to be included in the AEC program should be those for which well-defined markets now exist. We are suggesting that the market needs play a considerably more important role than product research interest in the program's emphasis.

4. The funding of the program should be at a lower rate than fiscal 1967 because fewer products would be included and also because of the limited definition of commercialization. We suggest that the AEC discontinue its program efforts on Dungeness crab, king crab, and bananas (3 of the 6 products studied) because of the negative cost/benefit relationships revealed. We are not able to provide similarly specific recommendations with respect to products in the AEC program which were not studied. Therefore, we are not able to specify an exact funding level.

5. The studies among consumers, the trade and the industries affected by the AEC program reveal clearly a need for a government sponsored information program limited in scope. The need for the information program results from the fact that most people will buy or sell irradiated foods only if they are assured of their safety by the government.

Discussion

AEC requested that program implications of three funding assumptions be examined: (1) phasing out the food irradiation program in fiscal year 1967; (2) continuation at approximately current levels; and (3) continuation at a higher level.

The most crucial consideration underlying this budget recommendation concerns the definition of the "commercialization" objective. Commercialization can be taken to mean one private organization has adopted the process. At this point, we do not know the extent to which a single firm's decision would be emulated by competitors and by companies in noncompeting product areas.

Nevertheless AEC's objective of commercialization radiation processing of foods is obtuse unless the concept of "commercialization" is brought down to the realities of the industries who are considered prospective users of radiation technology.

During the course of the study, the logical and likely investors in radiation processing in each of the six product categories studied were identified. On a product-by-product basis, radiation processing would be "commercial" if the following numbers of firms were to decide to adopt the process for all or part of their shipments to their customers:

1. *New England finfish.*—One major Boston processor and shipper whose decision would be watched and probably emulated in other fishing ports.
2. *Papaya and mango.*—One or two fruit cooperatives and importers who account for virtually all of the mainland sales of Hawaiian papaya.
3. *Dungeness and king crab.*—One or two leading packers of primarily king crab, who also pack and market Dungeness crab. There are many small king crab packers, but only the leading three are judged capable of successfully adapting a process like radiation treatment.
4. *Bananas.*—At least one of the two major importers.

As to funding level, the present degree of commercial interest is too tenuous to suggest commercialization will follow if AEC's program is terminated in fiscal year 1967. The few concerns who have evaluation programs of their own are not likely to continue them if AEC does not see products of interest to them through FDA approval.

On the other hand, this study suggests no basis for expanding the food irradiation program. On the contrary, the six-product review indicates a need to narrow the scope of AEC's program to those products for which clear commercial needs can be demonstrated for the benefits of radiation preservation. Accordingly, we recommend serious consideration be given to instituting several procedures for screening presently supported products with a view to dropping work on the least promising ones. The same procedures are recommended for any new products considered for AEC's program.

The implication of this recommendation is that the program can be scaled back without reducing the net public benefits that can accrue ultimately from commercialization of the food irradiation process. For the six products included in this study, this recommendation would involve abandonment of the crab and banana programs and minimal support of mango. Work on strawberries, finfish, papaya and dehydrated soups [3] should continue. If only these four are brought to commercialization in the next five years, it would be our view that AEC's objectives have been realized. Since many unknowns still surround these products, and will until FDA approval is received and commercial investment decisions have been made, it would be prudent also to continue to support a few of the more promising other products in AEC's current program which satisfy the criteria described in the Overview section of this report.

Publicity program

A program to familiarize food editors of newspapers, magazines and other media with the nature and benefits of food irradiation should be prepared. The emphasis should not be defensive, but rather simply factual. The facts of greatest interest to consumers are (1) that FDA approval of radiation processed foods is required before they can be offered for sale to consumers, (2) that radiation preservation is not unlike other forms of radiation treatment with which consumers are familiar (the bacteria reducing effect of heat radiation—cooking—for example, can be called to attention), and (3) that radiation processed foods are stored and prepared just like fresh foods.

Whatever publicity is released should be prepared in light of the fact that most consumers do not now have a set for or against radiation processing of foods. Most have little awareness or concern over how their foods are processed or preserved, except as reflected in appearance and taste. They do have confidence in governmental food control procedures and in the integrity of food retailers and brands. Accordingly, the role of the publicity program should be to provide a hedge against a *potential* flair-up of apprehension based on misconceptions. Otherwise the best strategy in marketing irradiated foods to consumers, based on present attitudes, appears to us to involve simply offering the foods with appropriate labels. The survey findings with respect to labeling favor use of a phrase which includes the familiar word "Pasteurized" e.g., "Pasteurized with ionizing energy" or "Pasteurized with ionizing radiation."

Product screening

Thus far, AEC's food irradiation program has had a stronger research orientation than market orientation. At this juncture it is recommended that emphasis be shifted toward specific, existing product needs.

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[3] Dehydrated soups were not a subject of this study, but in the course of our conversations with industry people we became convinced that the benefits and commercial interest in radiation processing of these products justify a conclusion that radiation processing is likely to be commercialized here.

The commercial opportunity for irradiated foods was found to vary materially among the six products included in this study. At one extreme, the opportunity for finfish is seen as relatively good because of both market-expansion and cost-reduction possibilities. At the other extreme, Hawaiian mango opportunities are remote for lack of commercial farms and king crab opportunities are remote for lack of a fresh market.

Now that the general kind of benefits from irradiation are known, it should be possible to prescreen products and determine those products having the more severe needs for marketing-time extension and other benefits from radiation preservation. For example, a major opportunity for papaya cost reduction would result from being able to ship by surface rather than air. This requires a six to eight day extension in marketing time and represents a clear-cut goal towards which research can be directed.

The market research effort required to develop product-need specifications is relatively small and inexpensive. The type of information sought can usually be obtained from three or four large processors and a similar number of large supermarket chains.

Accordingly, if the *a priori* screening criteria cited previously are brought to bear along with limited market research studies, a hierarchy of products based on the commercial prospects for application of radiation processing could be developed.

In terms of the six products studied here, it is recommended that research on finfish and papaya be continued, that the crab products and bananas be dropped, and that Hawaiian mangos be supported by a minimal program run in conjunction with the papaya. A hierarchy developed for other products may suggest a different emphasis on the products presently being supported, and that some products should be added and others removed from the number now receiving AEC support.

III. Consumer Attitudes

This chapter presents the study findings with respect to consumer knowledge of and attitudes toward radiation processed food; the findings on consumer response to alternate methods of labeling irradiated food are also included.

In brief, the research among consumers reveals that:

1. Knowledgeability about radiation processed foods is at a relatively low level at the present time. About 6 per cent of consumers now understand what the process is and can do; an additional 18 per cent are familiar with the term but are either uninformed as to its meaning or are misinformed.
2. There is little evidence of widespread resistance to the concept of radiation processing. Taking all the data into account, it would appear that only between 15 per cent and 20 per cent of consumers reveal real hesitation about trying irradiated foods (after a brief explanation). Resistance is concentrated among older, lower income, less well-educated women.
3. FDA approval, signifying the approval of the government, appears to be a vital element in reassuring consumers about radiation processing.
4. Assuming FDA approval, a low key education program, replicating the content of the briefing given during the survey, would appear to be all that is required to reassure consumers.
5. The label phrase "Pasteurized with ionizing energy" appears to represent an optimum approach to being both descriptive and reassuring. "Pasteurized" and "energy" are both words with essentially positive connotations. "Irradiated" and "radiation," as words, appear to stimulate latent fears and concerns.

RESEARCH METHOD

The work among consumers involved three different research methods:

1. *Qualitative research*, utilizing both individual in-depth case histories and focused group discussions in a number of different regions of the country. The qualitative research was carried out in two "waves," the second wave drawing upon the insights derived initially. In this way, a full exploration of consumer knowledge of, attitudes towards and concerns about radiation processing was accomplished.
2. *A quantitative survey*, among 627 randomly selected homemakers, representative of all United States households.

The survey sample employed the following design elements:

a. The United States was divided into three basic regions reflecting fish availability considerations:

1. "Coastal East"—including the following five Census regions: New England, Middle Atlantic, South Atlantic, East South Central and West South Central.

2. "Midwest" (Inland)—including the East North Central and West North Central Census regions.

3. "West" (Pacific Coast)—including the Mountain and Pacific Census regions.

b. The consumer sample was divided equally among the three basic regions. This was done to maximize the sample sizes of the West (Pacific Coast) and Midwest (inland) subsamples, within the framework of the agreed-upon sample size. The interviews were statistically weighted to bring the regional samples into proper balance.

c. Within each basic region, the particular cluster frames in which interviewing was conducted were based on the Daniel Yankelovich, Inc. national probability sample frame, updated in 1965.

d. Nonresponse was handled through weighting according to not-at-homeness data (random time weighting).

e. The survey data are based on 2,939 cases—reflecting the geographic and not-at-home weighting—and are reflective of the total United States household population.

The line of inquiry dealing with radiation processing included: awareness of the process; knowledge of the process; attitudes toward the process, both before and after communication of specific information about radiation processing to the respondents; and, consumer reaction to seven alternate "labels."

3. *An Experimental Study*, among over 100 consumers, designed to assess consumer response to labels under conditions, similar to a retail store. This experiment was carried out at the Daniel Yankelovich, Inc. Communications Research Clinic in Upper Montclair, New Jersey which includes a supermarket replica as one of its facilities.

In this supermarket replica, displays were built of foods labeled with seven alternate ways of presenting radiation processed foods. Consumers were exposed to the displays and were asked about their reactions in the context of a simulated store situation.

The findings developed through the three research methods have been integrated in the discussion that follows.

DETAILED FINDINGS

Consumer knowledge about radiation processing of foods

1. About 1 in 4 (24%) of the consumers interviewed in the national survey stated that they had heard of radiation processed food. Better educated women and those with higher incomes reportedly were more familiar with the term than those in the lower socioeconomic stratum. (See Table 1.)

2. Further questioning revealed that the majority (44%) of those who claimed familiarity with radiation processing of food, in fact, had no real understanding of the process. Only a little more than a quarter of those familiar with the term had any real perception of what it means. (This amounts of 6 per cent of all United States housewives.) And, another fourth of those who reported familiarity with the term, radiation processed foods, revealed misunderstanding in their efforts to explain it. (See Table 2.)

3. Understanding of the process was most frequently expressed in terms of "a method of preserving food." Lack of understanding was related to confusion both about process (ideas about chemicals, fumigants, etc.) and about results (ideas about tenderizing, dehydration, etc.). In addition, about 5 percent included in their discussion of the term, radiation processed foods, the belief that the process was poisonous or harmful. (See Table 3.)

4. Television, magazines and newspapers were the most frequently named sources of awareness of radiation processed foods. Of those familiar with the term,

33 per cent said they had heard about it on television.
25 per cent named magazines.
16 per cent named newspapers.
5 per cent said they had heard about it from friends and relatives.
4 per cent named radio.
3 per cent named schools and universities.

Attitudes toward radiation processed foods

5. Those consumers who reported in the survey that they had heard of radiation processed foods (24%) were asked if they would eat foods processed in this way. More than half (53%) said they would—only 1 in 10 expressed a negative attitude. This reaction should be considered in the light of the fact that only a small proportion familiar with the term radiation processing knew anything about what the term means. Receptivity appears to be relatively greater in the West (known to marketers as a precursor area) and among the better educated groups. (See Table 4.)

6. This survey evidence of general receptivity to the idea of radiation processed food confirms the qualitative research findings. Of about 60 women interviewed in depth—about 6 out of 10 stated that they approved of this new process after a very brief explanation of the term was provided to them. Interestingly, the qualitative work revealed greatest resistance to this processing innovation among women over 55 years of age, and—like the survey—greater acceptance of the new process among the better educated segment.

7. The depth interviews and focused group discussions conducted in the qualitative research step provided an unlimited opportunity for respondents to voice their concerns and questions about radiation processed foods. The most prevalent concern revolved around the possibility of harm and injury to health, with cancer being overtly named by a minority. Interestingly, the second most frequently mentioned concern was that radiation processed foods might possibly be more expensive. Some women also wanted to know if the vitamin content and/or general nutritional content of the foods would be adversely affected.

8. The national survey data confirm the finding that fear about possible health hazards is a major deterrent among those women who did not say "yes" to the question "Would you *eat* radiation processed foods?" (About half—47%—either said no or expressed uncertainty.) In addition, a substantial proportion of this group reported that their resistance was based on insufficient information. (See Table 5.)

9. On the positive side—the qualitative research revealed that the major consumer benefits associated with radiation processing are:

Lower prices.

Greater availability of new foods and year-round availability of seasonal foods.

Longer life in the home, reducing frequency of marketing and danger of spoilage. Some women also mentioned the possibility of freeing up refrigerator space in this connection.

10. After the initial determination of attitudes had been made, the consumers interviewed in the survey were provided with the following information, and then asked once again whether or not they would eat radiation processed foods.

"1. *For approval.*—All of these products must receive FDA approval before they can be marketed to the consumer. This approval will be granted only after extensive studies which include feeding tests to animals, taste tests, nutritional evaluations, residual radiation level tests, etc.

"2. *Safety.*—Gamma rays pass through the food but are not retained. Radiation processed food is *not* radioactive.

"3. *Taste.*—Radiation processed foods do not differ in flavor or appearance from fresh foods.

"4. *Preparation and storage.*—You prepare radiation processed foods just like fresh foods—no special preparation or handling is necessary. They can be frozen or refrigerated like fresh foods.

"5. *Availability.*—These products will not be available for three or four years.

"6. *Public information.*—Programs will be undertaken to inform the public on the safety and benefits of utilizing radiation processed foods.

"7. *Consumer benefits.*—Radiation processed foods may make possible shipment of a larger variety of certain fresh foods to parts of the country that are now too distant from growing or fishing areas."

After absorbing this information, about 57 per cent stated that they would eat radiation processed foods—a receptivity level very close to the 53 per cent who had said "Yes, they would eat radiation processed food." Among those who initially said they had heard of the term, radiation processing.

[In percent]

	Those initially familiar with term, radiation processing (24 percent)	Total sample, after exposure to some facts about radiation processing (100 percent)
Total	100	100
Yes, would eat	53	57
No, would not eat	11	17
Not sure	36	26

The above table suggests that exposure to detailed information will reduce the group "on the fence, "—probably in the direction of increased acceptance of the process among key consumer groups. Again, there is evidence that resistance will be concentrated among older, less well-educated, less affluent women. (See Table 6.)

11. Those respondents who,—after exposure to some facts about radiation processing (as described earlier),—said that they would eat foods processed in this way were asked to name the information that had been most important. Approval by FDA, reassurances about safety, and parallels with fresh foods (flavor, storage, preparation) were cited as the most compelling facts. (See Table 7.)

12. The survey evidence about the importance of FDA approval confirms findings emergent from the qualitative research. The depth interviews and group discussions revealed that FDA approval—as representing assurance by the government—would be a particularly reassuring element. FDA approval appears to connote extensive testing and high standards and criteria— both connotations operating to reduce generalized anxiety and concern about innovations in general and radiation processed food in particular.

13. Even after the briefing (as described earlier), however, fear about health hazards and the expressed need for still more information were the major deterrents to a positive statement about radiation processed food among the 43 per cent who said that they would not eat radiation processed food, or who were not sure one way or the other. (See Table 8.)

14. As the final question in the series after the briefing, the survey respondents were asked to choose among four statements, summarizing attitudes toward radiation processed foods. The four statements presented as alternatives were:

"When radiation processed foods become available:

"1. I would try them without hesitation.

"2. It would take awhile to convince me radiation processed foods were safe, but I'd probably try them eventually.

"3. I would probably never be convinced radiation processed foods were safe enough for me to use. It's doubtful that I would try them.

"4. I absolutely would not try radiation processed foods."

About 3 out of 10 women said they would try radiation processed foods without hesitation and an additional 53 per cent acknowledged that they would eventually try them. Only 6 per cent stated that they definitely would not try them. Such resistance as was reported was again most noteworthy among the less well-educated, lower income, older women. (See Table 9.)

Attitudes and reactions toward labeling

The research, specifically, assessed consumer reaction to seven possible label phrases:

1. "Treated with ionizing radiation."
2. "Treated with ionizing energy."
3. "Processed with ionizing radiation."
4. "Processed with ionizing energy."
5. "Irradiated."
6. "Pasteurized with ionizing radiation."
7. "Pasteurized with ionizing energy."

As described earlier in this chapter, two separate research methods were used to evaluate these label phrases: an experimental study among 106 women, using displays in a store replica and a series of questions in the national survey.

15. Insights into the connotations of key words used in the label phrases were derived from women's free responses during the experimental study. In brief, the key words were thought of as follows:

"Treated"—"Processed"—The women agreed that these were words which frequently appeared on labels of produce currently found on their grocer's shelves. Precisely what either word meant nobody could say. There was general agreement however that both words in this particular context implied tampering in some way with food. Several women were more definitive and claimed that *treated* was a method by which undesirable food was made more desirable.

"Pasteurized"—Pasteurized was a safe, acceptable word familiar to the milk-buying respondents. As understood by them it means heating, sterilizing or purifying.

"Energy" though obviously a preferred word, according to the respondents had only some obscure association with vitamins, health or the sun's rays.

"Ionizing"—Of the total collections of words, this was the one which was virtually unknown. Most women stated that they had no idea what the word meant. Several women got confused with the iodizing process, but a couple of the women were able to make a feeble connection between it and atomic energy and/or the world of science.

"Radiation"—Without question, this word produced the greatest amount of agitation and apprehension. Whereas the other words mentioned were only provocative, this was frightening. The women verbalized thoughts of the bomb, radioactivity, and a negative scared feeling about anything which employed this word. The respondents were almost unanimous. Their agreement that the word was fraught with frightening implications.

"Irradiation"—Although this word was considered suspect, and frightening too by most women, there were those who saw it in a more positive light. Some women associated "irradiation" with sun rays and almost a dozen women defined "irradiation" as the process by which radiation was removed from contaminated food, and thereby made edible.

16. The connotations of the key words in each test label provides understanding of consumer reaction to the labels, upon seeing them displayed on foods in the supermarket replica. The labels evoking the most positive response were:

"Pasteurized with ionizing energy."

"Processed with ionizing energy."

Labels including the words "irradiated" and "radiation" were responded to negatively. (See Table 10.)

17. After a brief explanation of radiation processing, the same respondents (in the experimental study) were asked to select among the seven labels the one that best described the process and those that were least effective in describing the process.

"Pasteurized with ionizing radiation" emerged as the best label in terms of descriptive value. Interestingly, "Irradiated" was selected as a good descriptive word by a significant proportion—but was also faulted by an even greater proportion. (See Table 11.)

18. The survey data confirms the label "Pasteurized with ionizing radiation" as the "most meaningful" among the seven. (This does not necessarily imply the greatest appeal, but rather again attests to the descriptive power of the phrase.) The survey data also confirms the response to "Irradiated" noted in the experimental study. However, the survey respondents also selected "Pasteurized with ionizing energy" as being essentially as descriptive as "Pasteurized with ionizing radiation." (See Table 12.)

Considering all the evidence, the pharse *"Pasteurized with ionizing energy"* might represent an optimum balance between immediate appeal (revealed by the experimental study) and descriptive power (revealed by the survey).

TABLE 1.—*"Have you ever heard of radiation processed food?"*

	Yes, have heard	No, have not heard	Number of cases
	Percent	*Percent*	
Total, United States	24	76	2,939
Region:			
Coastal East	23	77	1,608
Midwest	25	75	820
West	23	77	511
Age of respondent:			
Under 35 years	21	79	908
35 to 54 years	24	76	1,235
55 years and over	27	73	796
Educational level: [1]			
Less than high school degree	15	85	1,268
High school graduate	28	72	1,016
Some college	31	69	404
College degree and more	39	61	224
Annual family income: [1]			
Under $5,000	19	81	1,180
$5,000 to $7,499	23	77	780
$7,500 to $9,999	32	68	523
$10,000 and over	27	73	349

[1] Those whose educational level and/or income was not ascertained are included in the total, but are not shown separately.

TABLE 2.—*Summary of information about radiation processed foods (among those who reported that they had heard of radiation processed foods)*

	Percent
Total reporting	100
Heard the term "radiation processed foods"—do not have any further information	44
Reveal understanding of the term	27
Reveal misconceptions/misunderstanding of the term	26
Not specified	3
Total number of cases	697

TABLE 3.—*"What do you know about radiation processed foods?" (asked of those who reported that they had heard of radiation processed foods)*

	Percent
Total reporting	[1] 100
A method of preserving food	23
Rids food of germs, bacteria	6
Adds to/maintains food value	4
Increases the size of produce	2
Makes food more flavorful	1
The process of the future	3
Misconceptions about the process: use of chemicals, fumigants, refrigeration, etc	13
Misconceptions about results: tenderizes, dehydrates, etc	7
Poisonous, harmful	5
All other explanations	4
No information about what radiation processed foods mean	47
Total number of cases	697

[1] Percentages add to more than 100 percent due to multiple response.

TABLE 4.—*"Would you eat radiation-processed food?" (Asked of those who reported that they had heard of radiation-processed foods)*

	Would eat	Would not eat	Don't know	Number of cases
	Percent	*Percent*	*Percent*	
Total reporting	53	11	36	697
Region:				
Coastal East	51	13	36	375
Midwest	53	8	39	205
West	60	14	26	117
Age of Respondent:				
Under 35 years	52	2	46	187
35 to 54 years	56	18	26	298
55 years and over	50	10	40	212
Educational level:				
Less than high school degree	43	20	37	193
High school graduate	48	6	46	298
Some college	61	12	27	127
College degree and more	78	10	12	88
Annual family income: [1]				
Under $5,000	45	12	43	228
$5,000 to $7,499	65	6	29	177
$7,500 to $9,999	53	15	32	167
$10,000 and over	58	9	33	93

[1] Those whose income was not ascertained are included in the total, but are not shown separately.

TABLE 5.—*Reasons for not eating radiation processed foods (asked of all who did not say that they would eat radiation processed foods)*

	Percent
Total reporting	[1] 100
Fearful; safety must be proven first	46
Convinced the process is not safe	6
Need more information before trying:	
Want information in general	31
Want information about the process	26
Want information about the effect on food	23
Prefer fresh food	8
Concerned over high cost	4
Other concerns, resistances	7
Reason not specified	2
Total number of cases	327

[1] Percentages add to more than 100 percent due to multiple response.

TABLE 6.—*"In view of this information * * * would you eat foods processed by irradiation or not?" (asked after briefing)*

	Would eat	Would not eat	Don't know	Number of cases
	Percent	*Percent*	*Percent*	
Total, United States	57	17	26	2,939
Region:				
Coastal East	53	18	29	1,608
Midwest	60	16	24	820
West	63	16	21	511
Age of respondent:				
Under 35 years	62	60	45	908
35 to 54 years	20	16	15	1,235
55 years and over	18	24	40	796
Educational level: [1]				
Less than high school degree	43	18	39	1,268
High school graduate	69	16	15	1,016
Some college	62	20	18	404
College degree and more	68	12	20	224
Annual family income: [1]				
Under $5,000	46	17	37	1,180
$5,000 to $7,499	57	20	23	780
$7,500 to $9,999	72	13	15	523
$10,000 and over	67	20	13	349

[1] Those whose educational level and/or income was not ascertained are included in the total, but are not shown separately.

TABLE 7.—*"What information * * * is most important to you?" reported after briefing (asked of all who said—after briefing—that they would eat radiation processed foods)*

	Percent
Total reporting	[1] 100
Principal responses:	
FDA approval of products	35
Parallels to fresh foods:	
Flavor same as fresh foods	25
Storage like other fresh foods	16
Preparation like other fresh foods	15
Appearance same as fresh foods	5
Foods are safe to eat:	
Safety, unspecified	18
Not radioactive	18
Gamma rays are not retained	10
Greater availability: Makes larger variety of foods available, seasonal products available	21
Total number of cases	1,633

[1] Percentages add to more than 100 percent due to multiple response.

TABLE 8.—*Reasons for not eating radiation processed foods, reported after briefing (asked of all who did not say—after briefing—that they would eat radiation processed foods)*

	Percent
Total reporting	[1] 100
Fearful; safety must be proven first	46
Convinced the process is not safe	5
Need more information before trying:	
Want more information in general	49
Want more information about the process	7
Want more information about the effect on food	8
Prefer fresh food	14
Concerned over high cost	1
Other concerns, resistances	1
Reason not specified	2
Total number of cases	1,274

[1] Percentages add to more than 100 percent due to multiple response.

TABLE 9.—*Summary of attitudes toward radiation processed foods (asked after briefing, using a multiple-choice exhibit)*

	Would try without hesitation	Would try eventually	Doubtful that would try	Definitely would not try	Not specified	Number of cases
Total United States	Percent 29	Percent 53	Percent 10	Percent 6	Percent 2	2,939
Region:						
Coastal East	25	54	13	6	2	1,608
Midwest	34	51	[1] 8	6	[1] 1	820
West	35	51	7	7	----	511
Age of respondent:						
Under 35 years	33	52	9	5	1	908
35 to 54 years	27	58	8	5	2	1,235
55 years and over	29	45	15	[1] 9	2	796
Educational level: [1]						
Less than high school degree	23	50	16	9	2	1,268
High school graduate	33	55	6	4	2	1,016
Some college	34	56	8	2	----	404
College degree and more	37	59	3	1	----	224
Annual family income:						
Under $5,000	25	[1] 49	15	8	3	1,180
$5,000 to $7,499	35	50	11	4	----	780
$7,500 to $9,999	[1] 28	60	7	5	----	523
$10,000 and over	[1] 35	60	1	2	2	349

[1] Those whose educational level and/or income was not ascertained are included in the total, but are not shown separately.

TABLE 10.—*Consumer reaction to 7 labels—Likelihood of purchase (upon exposure to food displays with the labels in a store replica)*

[In percent]

	Most likely to buy	Least likely to buy
Total	[1] 100	[1] 100
Pasteurized with ionizing energy	44	16
Processed with ionizing energy	38	15
Treated with ionizing energy	29	23
Irradiated	24	58
Pasteurized with ionizing radiation	23	44
Processed with ionizing radiation	9	53
Treated with ionizing radiation	8	65
Number in group	106	106

[1] Percentages add to more than 100 due to multiple response.

TABLE 11.—*Consumer reaction to 7 labels—Descriptive value (after explanation of radiation processing to group exposed to labels in store replica)*

[In percent]

	Describes process best	Describes process least effectively
Total	100	[1] 100
Pasteurized with ionizing radiation	37	13
Irradiated	34	42
Processed with ionizing radiation	13	15
Pasteurized with ionizing energy	8	14
Treated with ionizing radiation	5	24
Treated with ionizing energy	3	40
Processed with ionizing energy		19
Number in group	106	106

[1] Percentages add to more than 100 due to multiple response.

TABLE 12.—*Consumer reaction to 7 labels—Meaningfulness (survey respondent's reactions after briefing)*

[In percent]

	Most meaningful	Least meaningful
Total	100	100
Pasteurized with ionizing radiation	18	4
Pasteurized with ionizing energy	14	6
Irradiated	11	29
Processed with ionizing radiation	6	6
Treated with ionizing energy	6	8
Processed with ionizing energy	6	4
Treated with ionizing radiation	5	9
Not specified	34	34
Number of cases	2,939	2,939

IV. Attitudes of the Trade Toward Radiation Processing of Food

In brief, fewer than 1 out of 10 of the trade personnel studied, indicates a resistance to radiation processing which is likely to prove to be an insurmountable obstacle to their buying and selling of products treated with the process. A majority of the remaining 90 per cent of these businessmen are receptive to irradiated foods, if and when they are approved by the government (FDA).

In order to evaluate the interest of the trade in irradiation of food, and the extent to which the sales of irradiated foods might be helped or hindered by the trade, it was necessary to measure any underlying fears of radiation which might be found to exist among the buyers, store owners, managers, etc. In other words, we sought an answer to the question: is there a significant degree of apprehension about the use of radiation with food products among trade personnel, which might negate the positive aspects of the irradiation process, e.g., longer shelflife, greater variety of products, etc.? Analysis of 310 meetings and discussions with supermarket chain executives, individual fish and fruit store owners and managers, as well as institutional and restaurant personnel, clearly indicates that for a majority of these respondents the answer is no.

In the course of our analysis of the attitudes of the trade, we have found that they may be segmented into four distinct groups, as follows:

Segment I.—Those who are unequivocally opposed to radiation. This group of trade personnel has a basic fear of anything which involves radiation. It is unlikely that there is anything which can be done in the way of education, government assurances, etc., which can convince these people that it would be safe to sell or serve foods processed with radiation. It is interesting to note that a number of these respondents emphasize their general antagonism to any tampering with the "purity" of foods, e.g., use of chemicals. They often speak

of contamination dangers which they do not believe can be accurately measured at this time.

As shown in the table below, 9 per cent of the trade respondents fall into this negative category. Significantly, none of these are chain buyers and only one represents a major institution. The bulk of the trade expressing a basic fear of radiation is found in local fish and food stores, and restaurants.

Segment II.—Those executives who unequivocally favor radiation processing of food.—These respondents express confidence in the safety of radiation for food processing. They have no doubts about the process. For the most part, the confidence of this group is based on the belief that the government would not allow, or encourage, any process which would endanger the public. They apparently assume—and unlike Segment III—do not demand prior FDA approval, etc.

The size of this group (8% of the total) expressing a positive view is comparable to the size (9% of the total) of the group which has a basic fear of radiation.

Segment III.—The "only if FDA approves" group.—These buyers, managers, etc., have made it clear in the course of our discussions with them that they will accept food radiation as a safe process if, and when, it receives FDA approval. Almost half (46%) of the respondents are in this group.

Segment IV.—Those (37%) who have provided no voluntary or stimulated comment on the safety of radiation processing.—These respondents do not mention safety, the dangers of radiation, FDA approval, etc., during their interviews. This lack of response, despite their attention being called to these factors, indicates that the subject is apparently not of interest or meaningful to them.

To summarize, the table below shows that only 9 per cent of the trade fears radiation to an extent which would prove a hindrance to a food irradiation process. In our judgment, 91 per cent would (to varying degrees) go along with the idea of food irradiation once it was approved.

Trade attitudes toward radiation

	Total	Local fish stores	Local fruit stores	Chain fish buyers	Chain fruit buyers	Institutional	Restaurants
Total	*Percent* 100	*Percent* 100	*Percent* 100	*Number* [1]	*Number* [1]	*Percent* 100	*Percent* 100
Attitudes:							
No fear of radiation	8	1	6	1	3	15	10
Acceptance dependent on FDA approval	46	48	35	8	8	48	53
Fear radiation	9	13	11	----	----	2	10
No comment on safety of irradiation (aided and unaided)	37	38	48	8	9	35	27
Number in group	310	71	75	17	20	40	87

[1] Base too small to be meaningfully percentaged (25 or less); therefore, numbers are shown.

About one third (36%) of the trade brings up the attitudes of the consumer when discussing food irradiation. Eighty-five per cent of this trade group believe the consumer will accept irradiated foods as safe, although most of these stress the need for a consumer education program.

TRADE AWARENESS OF THE PROCESS

In discussing trade attitudes toward radiation of food products, it should be noted that three fourths (74%) of the buyers, store owners, department managers, etc., were not aware of irradiation as a method of food preservation prior to our discussions with them. The highest levels of awareness occur in the Midwest and Northeast (38% and 28% respectively), while only 15 per cent in the West and 16 per cent in the Southeast have heard of the process.

The level of awareness is, however,—as might be expected—much higher among chain and institutional buyers than among store-level personnel and restaurant buyers, as shown in the following table:

Awareness of radiation processing as a method of food preservation

[In percent]

	Total	Chain and institutional buyers	Store level personnel and restaurant buyers
Total	100	100	100
Aware	26	56	15
Not aware	74	44	85
Number in group	310	77	233

About half of the chain buyers and three quarters of the major institutional buyers who report little or no interest in the process within their organizations ascribe this low level of interest to lack of knowledge about food irradiation, or even that such a process exists.

V. Finfish

SUMMARY OF FINDINGS AND CONCLUSIONS

The prospects for commercial irradiation of finfish products

The findings of this study support the basic conclusion that finfish products satisfy the criteria established in the Foreword for potential success in commercial irradiation, i.e.,

1. Seasonal stability of production;
2. Significant spoilage losses;
3. Price sufficiently high to make the spoilage losses hurt;
4. The product has sufficient market demand to excite retailer and institutional interest in its development;
5. There are specific companies ready, willing and able to process and sell the irradiated product.

As will be demonstrated later in this report, moreover, a significant degree of consumer interest is found to exist in the purchase of fresh fish in regions of the United States where little or no fresh ocean fish is now available. Specifically, therefore, it is possible to outline the following potential benefits of commercializing marine product irradiation.

Potential benefits

1. The shelf-life extension of two to three weeks for these products will make it possible to extend the marketing radius to encompass interior sections of the United States. Thus, benefits accrue to the consumers in these areas who gain a broader selection of high protein foods.

2. The benefit is also reflected in more sales and presumably higher profits for the fishermen, processors, wholesalers, distributors, and retailers. Our study shows that retailers located in areas in which fresh fish is readily available, and spoilage is at a minimum, find fresh fish a more profitable item than the frozen product.

3. The entire United States fishing fleet can be expected to benefit as the increased profits from a greater consumption of fresh fish will provide the funds necessary for the needed modernization of ships in service and the construction of new vessels.

4. The added profits will stimulate an overall growth in the fishing fleet so that the United States can become more capable of supplying a higher percentage of its annual requirements of fishery products.

5. The nation will benefit from a less wasteful exploitation of natural resources by a sizable reduction in the amount of fish thrown away due to spoilage.

As we understand it, the extensive product research programs have resolved virtually all doubts with respect to product quality, wholesomeness, taste, etc., that might have stood in the way of realizing these benefits. In other words, taste panels and feeding studies indicate that the quality of the irradiated

product is high enough to assure acceptability to the consumer. Secondly, shelf-life extension studies of irradiated products have proved that an average of 15 days can be added to a seven-day-old landed fish with no diminution in quality of the product. Thirdly, biological studies have proven that the small amounts of clostridium botulinum, type E, present in fresh fish are reduced by 95 per cent to 98 per cent with pasteurizing doses of irradiation. And now, this study has provided strong evidence of the existence of consumer interest in fresh fish in the Midwest and Western interior sections of the country. The fact that the fish would be irradiated is also not considered by the trade and institutions to be a hindrance in the marketing of fresh fish. Three quarters (73%) of fish department managers and fish store owners interviewed in this study report that they would handle the irradiated product with FDA approval.

The cost-benefit tables at the end of the summary extrapolate to 1980 the detailed comparison of irradiation processing costs as against potential benefits to be realized by the entire fishing industry, the retail stores, and consumers. These tables demonstrate the measurable benefits that may be derived from irradiation processing, the benefits outweighing the costs by a factor of 20 to 1.

Transportation costs

Fresh ocean products that are consumed outside of a 1,000 mile radius of the ocean ports are most often shipped by air freight which is presently an expensive method of shipment. Although air freight rates are expected to drop over the next four years, surface shipment will remain the least expensive method of transportation. With the extension of shelf-life possible through irradiation, truck shipments will provide an economical means of distributing the fresh ocean products throughout the country.

Spoilage problems

Retail store losses of fresh ocean products as a result of spoilage currently run approximately 5 per cent on a weight basis. It is estimated that between 90 and 95 per cent of this loss can be eliminated by the introduction of irradiation processing. Approximately 40 to 50 per cent of the retail stores handling fresh ocean products "buy short" when placing their weekly orders. Their purpose is to run out of the fresh product before it has a chance to spoil. Because of this, an estimated 15 to 25 per cent additional fresh fish products could be sold if they were available on the retail shelf. Because of the "buying short" practice, consumers who do their shopping late in the day are often forced to turn to the frozen products in lieu of available fresh fish.

Irradiation costs

The cost of irradiation processing which should approximate 1.6 cents per pound based on engineering calculations can be passed along by the wholesaler and should not affect his profit margin. The cost-benefit tables clearly indicate that the value lost because of spoilage is more than enough to cover the cost of irradiation. It can therefore be assumed that the cost can be passed to the retail level without necessarily affecting the consumer cost for the product.

Alternative preservation methods

The only two significant alternatives (to irradiation) for distribution of the fresh fishery products under consideration are: (1) freezing and (2) reduced air freight.

Freezing

Freezing is the most significant alternative to irradiation that would allow the expansion of markets past the current marketing radius for fresh fish. At the present time, the ratio of sales between frozen and fresh fish are estimated at 65/35 respectively. These figures reflect imported fishery products in either fresh or frozen form. Handling the frozen product offers four principal advantages:

1. A storage life of up to one year which permits buying when the supply is heavy and the price is low and holding through to the five months of the year when the supply is lighter and the price is high.
2. Shipment of frozen fish can be more economical (if certain carriers are used) because very little is added to the weight of the product other than the packaging material. The absence of ice reduces freight rates.
3. Holding temperatures are less critical with the frozen products, and a broader range of fluctuations is tolerated. With the frozen product the temperatures can vary from 20° F to −10° whereas with the fresh product, the temperature can only vary from 32° to 35° F.

4. In most cases, the frozen product is truly a convenience food and is much more easily and speedily prepared by the consumers.

However, the following disadvantages are also present when handling the frozen product:

1. Profit margins are lower largely due to the fact that the retail price does not fluctuate during the year. Therefore, a processor who has commitments to supply a quantity of fish may suffer when he is forced to buy in a short market when the price is high. The fresh fish processor, however, merely passes his increased cost along to the retailer who may fluctuate his retail price weekly on the fresh fish.

2. Frozen fish processors can operate profitably only when they are able to acquire their supply of fish at a relatively low price. During periods when supply is heavy, all the fish will be sold at these low prices. However, during periods when the supply is light, only the poorer quality fish may be sold for the low price. This factor, coupled with improper handling on the part of the consumer, often results in a product of lesser quality than a fresh equivalent.

3. Foreign imports, because of their demonstrably lower prices, can compete much more effectively for the frozen fish market than can domestic suppliers.

The main impact of irradiation processing can be to provide a high quality domestic product that can be distributed throughout the United States without any direct foreign competition, unless, of course, other nations install similar irradiation processing facilities. Even then, domestic suppliers could gain the advantage of time. A further possibility not to be overlooked is the possible institution of protective tariffs on the irradiated products that would help domestic suppliers hold the advantage of being first to open new markets.

Reduced airfreight

There are strong indications that airfreight rates will diminish with the future adoption of extended fuselage aircraft. This reduction may be on the order of 10 to 30 per cent. However, although this may stimulate an expanded use of air freight, it does not appear to offer a suitable substitute for surface shipment. The principal reason for this conclusion is that surface freight offers a great deal more flexibility as far as drop shipments are concerned which will allow more versatility in the expansion of the Midwestern markets.

Who should lead the way towards irradiation

The trade believes the major food chains should be expected to lead in distribution of irradiated fish during the early stages of market development. Food chain leadership is stressed by all segments involved in fish marketing, including institutions, restaurants, fish stores, and the chains themselves. However, while most of the chains agree that they will lead in distribution, they add that fish producers and wholesalers would be expected to take the initiative in product development.

VI. Tropical Hawaiian Fruits

PART 1. HAWAIIAN PAPAYA

Summary of findings and conclusions

Summary

Everything considered, we recommend that development work on papaya proceed. This work will center on the Hawaii Development Irradiator scheduled for completion in early 1967. The chances that irradiation of papaya will prove commercially feasible are far from certain at present and appear to hinge mainly on whether sufficient shelf-life extension can be achieved by radiation to make surface shipment of quality fruit practical. Substitution of surface for air shipment can result in cost reductions which far offset estimated costs of radiation processing. Furthermore, the possibility of lower prices for consumers would overcome in part a major hurdle to broadened consumer acceptance of papaya. Papaya appears ideally suited for radiation processing from the viewpoint of crop and engineering logistics. (Concentrated growing location, year-round production.) If only the presently indicated shelf-like extension of about three days can be achieved from irradiation, however, benefits appear to be quite marginal vis-a-vis costs.

Background

The State of Hawaii and the State's papaya growers, through their mainland marketing agents, have active programs and interest in developing the mainland market for papaya to major proportions. Realistically, no one expects this exotic and relatively high-priced fruit to find its place beside major fruits in mainland markets, such as bananas or citrus fruits. Nevertheless, it is conceivable that in time, papaya could reach volume of the order of magnitude achieved by say California avocados and fresh Hawaiian pineapple.

The crucial question from the viewpoint of this study is the contribution that irradiation processing can make in helping Hawaiian papaya realize its mainland potential. As background to coming to grips with that question it is necessary to understand:

1. The current state of papaya's mainland market development;
2. The long-term outlook for the fruit and the substantive considerations that underlie predictions about the outlook;
3. The major marketing problems that must be overcome if the fruit is to enjoy significant volume on the mainland; and
4. In the context of the foregoing, how, if at all, irradiation processing can contribute to alleviating those problems—or in other words what the incentives to commercial investment in radiation processing facilities are.

The following are relevant considerations:

1. At the present time, the market for Hawaiian papayas is small, though growing. Approximately 5 million pounds of fruit were exported to the mainland last year. To provide perspective, this compares with annual production of 8-10 billion pounds of oranges, over 3 billion pounds of bananas imported to the United States each year, about 40 million pounds of fresh Hawaiian pineapple, and up to 100 million pounds of California avocados in recent years.

2. The potential for Hawaiian papaya is estimated at somewhere between 20 and 70 million pounds in 1980. The lower figure is based on continued exportation of one fifth to one fourth of Hawaii's crops, and estimates of total production prepared by the State Department of Agriculture; the higher figure assumes that papaya can achieve a position in mainland markets equivalent to those realized by avocado and fresh pineapple within their first 15-20 years of market exposure.

3. The two most important factors which will inhibit papaya's development in mainland markets are: (1) lack of consumer awareness and trial of the fruit; and (2) its relatively high price. (Typically 49 cents per fruit in West coast stores for sizes serving two persons.)

4. There is a reasonably high probability that the first problem will gradually be overcome in the fifteen year planning horizon taken for this study. This judgment is based on appraisal of the effectiveness of the market development program already underway in behalf of papaya and an expectation that the program will be expanded in the years ahead. The State of Hawaii accords a prominent position to papaya in its long-range plan for development of the State's diversified agricultural resources. Moreover, the State is backing its appraisal of papaya's potential by sharing the costs of the fruit shipper of Hawaii's market development budget. The nature and effectiveness of this development program are reviewed in detail later.

5. Whether or not the second problem, of papaya's high cost on the mainland, can be overcome is quite uncertain. Progress in development of the mainland market over the past five years is attributable almost exclusively to the use of air freight. Air freight makes it possible for papayas to reach mainland retail shelves in three or fewer days after picking. With air freight, retail shelf-life ranges from three to ten days and averages about five days. At the same time that air freight can be assigned a predominant role in development of the mainland market, it also represents a very large share of papaya's retail cost.

6. The commercial incentive to invest in irradiation processing, accordingly, will be predicated on its ability to reduce costs to retailers and prices to consumers. The most significant effect on costs would result from extension of papaya's salable life from what is now about eight to ten days (from harvest to consumption) to approximately seventeen days. Such an extension would make a shift from air to surface shipment practical and thereby make possible a substantial reduction in distribution costs.

7. Experimental irradiation work with papayas to date indicates that shelf-life extension from a practical dose of gamma radiation is approximately three days. This is not adequate to permit effective use of surface vessels.

8. A second, though less significant, opportunity for cost reduction from radiation processing can result from shelf-life extension at retail. Retail revenue lost as a result of reduced-price sales and fruit throwaway is estimated at 11½ per cent of the retail cost of fruit. Shelf-life extension on the order of three days might make it possible to avoid half of this loss. It has to be recognized, however, that from retailers' point of view, papaya spoilage and the need for shelf-life extension are not "top of the mind" problems associated with this fruit. Retailers cite lack of consumer demand, of product movement out of retail, as the fruits' major problem. Thus, between retail shelf-life extension of three days and lower price they elect lower price because they see price as being related to the demand-stimulation need. (This would be forthcoming if the extension in marketing time provided by radiation processing was sufficient to permit surface shipment.) Even the issue of lower price however is of second order importance to the foremost need to awaken consumer interest in the trial of papaya.

9. Analysis of benefits against costs from commercialization of irradiation processing of papaya are marginal—that is benefits just about equal costs—if the benefits are related to the three-day retail shelf-life extension now indicated as possible. Benefits will *substantially* exceed costs if marketing time can be extended sufficiently to permit use of surface vessels for shipment of fruit to the mainland from Hawaii.

10. At the present time the Hawaii Development Irradiator is under construction in Honolulu with completion scheduled for early 1967. Papaya is the first fruit on which the Hawaii State Department of Agriculture intends to expend developmental funds and effort.[4] This activity will establish process costs under simulated commercial operating conditions and will fully evaluate the air-surface shipment alternatives.

11. Papaya appears to be ideally suited to irradiation processing. The fruit is produced year-round (though mainland demand is somewhat seasonal) and growing is concentrated on the Big Island of Hawaii. Thus, two prime criteria for commercial feasibility are met. Moreover, the two papaya importing organizations located on the West Coast which account for most of the mainland sales, while not now attuned to irradiation processing's potential, are aggressive firms. These two organizations operate under considerably different marketing philosophies. Nevertheless, in our judgment, the managerial attitudes and marketing objectives of these firms will be responsive to the cost-reduction potential in irradiation processing—assuming the HDI development work can show commercial feasibility.

PART 2. HAWAIIAN MANGO

Summary of findings and conclusions

Hawaiian mango is a particularly interesting crop from the viewpoint of radiation processing since it is the only product in this study which absolutely requires irradiation as a prerequisite to development of a market. The Hawaiian variety is infested with a seed weevil and therefore quarantined from shipments to the mainland. The fruit is used primarily as a fresh fruit and usually served like a cantaloupe. Like any soft fruit it spoils quickly when cut open. Thus fumigation techniques are ineffective on the seed weevil. Gamma rays however readily penetrate mangos and very low doses (25–75 krad) are lethal to adult mango weevils.[5]

Interest in development of markets for Hawaiian mangos stems from the state of Hawaii's basic policy as expressed in its long-range agriculture plan to develop an export market for diversified crops and from two widely circulated claims for mango: one, that it is the most eaten fruit in the world and two that the Hawaiian mango is superior to mangos available to mainland consumers from other growing areas. Mangos now available to mainland consumers are grown largely in Florida and Mexico. They are not infested with weevils.

From the viewpoint of this study—appraisal of the public benefits from commercialization of radiation processing in the period 1966–1980—the Hawaiian mango cannot be expected to make a major contribution. From the taxpayer

[4] See State of Hawaii, Department of Agriculture, "Program Proposal: Operation, Demonstration and Commercial Prospects for Hawaiian Development Irradiator" (1966).

[5] See Upadhya and Brewbaker, "Irradiation of Mangos for Control of the Mango Seed Weevil," *Hawaii Farm Science*, January, 1966, USDA, Hawaii Fruit Fly Investigations, "Information Sheet: Gamma Irradiation for Fruit Fly Control and for Disinfestation of Hawaii Fruits, Vegetables, Flowers and Baggage," January, 1965; and University of Hawaii Annual Reports to AEC.

viewpoint, the benefits from development of a mainland market for Hawaiian mangos as a result of AEC's support of radiation research, must be counted as an intangible. That is, success would provide consumers with a wider variety of fruits. Prospective benefits from consumer purchases of mangos, however, have to be counted as transfers from other foods since it is illogical to assume per capita consumption of foods will increase. Important tangible benefits can be counted from irradiation of mangos and development of a market, but they will accrue to residents of Hawaii and firms associated with production and distribution of mangos at the expense of others.

Even at that, benefits from development of Hawaiian mango markets will for a number of reasons be long in coming—as we see it mostly after the cut-off year for this study. This conclusion is based on the facts that Hawaii has only a few, small commercial mango farms and that a period of four years is required from seeding or grafting to first production and fifteen years to full production from mango trees.

Moreover, the economic feasibility of disinfesting mango by irradiation faces a number of practical limitations. These suggest that a Hawaiian mango industry could not efficiently justify its own irradiator. Mango has on the one hand a short fruiting season (June through August) indicating annual irradiation costs would be high unless an irradiator were justified by use for other crops with your-round or complementary seasons. At the same time, mango's soil and rainfall requirements indicate commercial orchards if developed would be located on other islands than Oahu or Hawaii where commercial irradiators are most likely to be located. Mango orchards would be most likely planted on Maui and Molokai which have less rain and more suitable soils than Hawaii.

These are not necessarily insurmountable limitations. In short, development of radiation processing for Hawaiian mangos does appear to us to be justifiable, long term, from the State's viewpoint, but not so from the viewpoint of AEC's commercialization objective in light of the existence of more promising products elsewhere.

VII. West Coast Crabs

SUMMARY OF FINDINGS AND CONCLUSIONS

This chapter reviews prospects for commercialization of West Coast Dungeness crab and Alaskan king crab. These prospects appear poor, but for entirely different reasons between the two products.

Industry interest in extended self-life for Dungeness crab is considerable. Marketing of the product is geared to the fresh market. In its fresh cooked form Dungeness crab has a four to five day marketing time. The product does not keep well if frozen, and as a result the industry faces a mercurial price pattern. Accordingly there is serious interest in extending shelf-life of fresh, cooked Dungeness crab.

The negatives, from the viewpoint of commercializing irradiation processing however are compelling. First, landings of Dungeness crab vary substantially from year to year with the basic trend downward. Live landings in 1964 were 24 million pounds compared with a peak of 42 million in 1957. This pattern in supply is said to be due to a biological cycle of unknown origin. Second, Dungeness crab landings are dispersed over many ports along the West Coast (Kodiak, British Columbia ports, Oregon ports, New Portland, Eureka, San Francisco, etc.). Thus what is relatively small and uncertain volume to begin with is not concentrated from a processing viewpoint. Third, the Dungeness crab season lasts only about six months (December to May) though in some areas it is longer. Finally, the major marketers of crab on the West Coast who have financial and managerial capabilities to innovate in processing are primarily engaged in king crab markets. Larger firms in Dungeness crab are located in Alaska, where emphasis is on freezing or expensive air express.

In king crab the circumstances are almost precisely reversed. The market is representative of a true growth industry, large aggressive firms are present, supplies have recently been approximately doubled as a result of opening the Bering Sea to Alaskan fisherman via treaties with Japan and Russia, and processing if heavily concentrated in a single location at Kodiak.

On the other hand, need for the benefits of radiation preservation are totally absent. Virtually all king crabs is frozen in blocks or canned. What fresh marketing there is, is a custom of air freight business nad amounts to less than 1 per cent of the pack. King crab is preserved extremely well by freezing and canning, thereby permitting year-round marketing at stable prices.

APPENDIX A

I. DESCRIPTION OF CALCULATIONS RELEVANT TO DETERMINATION OF PRESENT AND POTENTIAL MARKETS FOR FRESH FINFISH

A. Government data

Table 1a of the Economic and Statistical Analysis Division of the United States Government Economic Research Service (January 12, 1966) is entitled "Commercial Fish: Supply and Utilization, 1947–1966 (Edible Weight)." This table provides total civilian domestic disappearance of all domestic and imported finfish and shellfish (2,041 million pounds in 1965), with subdivisions separating fresh/frozen, canned and cured.

In order first to separate total fresh and frozen shellfish from total fresh and frozen finfish, the 1965 per capita consumption of shellfish was subtracted from the 1965 total per capita consumption of finfish and shellfish. The resulting per capita figure was then multiplied by the total population with the resulting figure equaling total fresh and frozen finfish consumed in the United States (1965: 756 million pounds).

The second step involved separating United States consumption of fresh from United States consumption of frozen finfish. The proportion of total domestic frozen fish was extracted from two Department of Interior publications: "Packaged Fishery Products, 1965" (CFS. 4055), and "Frozen Fishery Products; December, 1965" (CFS. 4000). Of the imported finfish, 90 per cent were assumed to be received and consumed in frozen form. For the year 1965, it was calculated that, of the total 756 million pounds, 267.4 million pounds (35%) were consumed fresh while 488.6 million pounds (65%) were consumed frozen.

The above tabulations were arrived at with the assistance of Mr. E. A. Powers, Staff Specialist, Division of Economics, United States Department of the Interior, Fish and Wildlife Service, Bureau of Commercial Fisheries. Mr. Powers is a coauthor of the "Fishery Statistics of the United States," an annual publication of the United States Department of the Interior. All the final calculations relating to the division of fresh and frozen fish consumed in the United States were submitted to Mr. Powers and were approved by him.

B. Daniel Yankelovich, Inc., data

From the Daniel Yankelovich, Inc. sample the following fish consumption pattern emerged:

Total respondents: 100 percent

	Coastal	*Inland*
	Percent	*Percent*
Serve fish of any kind	94.7	93.9
Serve fresh finfish	48.5	20.0

Total fish consumed: 100 percent

	Total United States	Coastal	Inland
	Percent	*Percent*	*Percent*
Fish of any kind	100	76	24
Fresh finfish	100	90	10

(It should be noted that, while our sample indicates that 20 percent of the inland population consumes 10 per cent of the total fresh fish, an indeterminable amount of this fish is very likely frozen fish that has been thawed and sold to consumers as fresh.)

The fish consumption percentages derived from the sample were then applied respectively (1) to the government total of all finfish and shellfish consumed: fresh, frozen, canned and cured (2,041 million pounds); and (2) to the calculated figure of fresh finfish (267.4 million pounds).

[*In millions of pounds*]

	1965 Total	Coastal	Inland
Total fish	2,041.0	1,551.2	489.8
Fresh finfish	267.4	240.7	26.7

From these total consumption figures per capita consumption of total fish and per capita consumption of fresh finfish was calculated with the following results:

[In pounds]

	1965, United States	1965, coastal	1965, inland
Per capita, total fish	10.60	11.20	9.00
Per capita, fresh finfish	1.38	1.74	.49

C. Possible changes in consumption patterns and levels attributable to irradiation processing

Assumption 1.—Inland per capita fresh finfish consumption (.49) rises to the coastal per capita fresh finfish consumption level (1.74).

The anticipated year of FDA approval of irradiation processing is 1967, with the first irradiator becoming operable in 1969. Supermarket chain headquarters estimate that it will take about four years for irradiation processed fish to reach its optimum market potential. Therefore, the years 1969–1972 constitute the time span over which Assumption 1 would occur.

To be noted in the calculations is the fact that *total fish* per capita consumption levels remain steady as does *coastal fresh finfish* per capita consumption. The only change is *inland fresh finfish* per capita consumption. This increase in inland fresh finfish consumption is assumed to be at the expense of frozen finfish [1] and therefore will not affect *total fish* per capita consumption, but will cause *total fresh finfish* per capita consumption to rise.

Using population predictions from the United States Bureau of Census' *Current Population Reports*, and the above described 1965 starting point figures, total fish consumption and fresh finfish consumption levels were calculated up to the year 1980, with the inland per capita consumptions rising—from the present inland .49 to the coastal 1.74—during the years 1969–1972.

Thus, under Assumption 1, irradiation processing raises the inland consumption of fresh finfish from 9.98 per cent of total United States fresh finfish (1965) consumption to 26.6 per cent (1980).

An indication of (1) *how* the inland per capita consumption of fresh finfish could be raised to the coastal level and (2) what the makeup of the new market would be is contained in the Daniel Yankelovich, Inc. sample. At present, 20 per cent of fish consumers in the Midwest now purchase fresh fish. Thus, 80 per cent purchase frozen fish. Of this 80 per cent, 33 per cent say they prefer fresh, while 67 per cent claim to prefer frozen (probably because they have no fresh fish available as a basis for comparison). Applying these percentages to Midwest population figures, inland per capita consumption of fresh finfish would reach the coastal level of 1.74 if:

1. All of those consumers who buy frozen but prefer fresh; and
2. One half of those consumers who buy frozen and prefer frozen switched to irradiation processed fresh fish.

Assumption 2.—Inland fish consumers who now buy frozen but prefer fresh will switch to irradiation processed fresh finfish.

For this assumption, the point of departure for the calculations was not per capita consumption as in Assumption 1, but actual inland fish consumers.

At present, 10.9 million people in the Midwest (20%) purchase fresh fish and 13.7 million people (33% of those who buy frozen fish) would prefer fresh fish

[1] As almost 50% of the frozen finfish consumed in the United States is imported, it is expected that increased consumption of irradiated fresh finfish would be partly at the expense of imported frozen finfish and partly at the expense of domestic frozen finfish.

if available. Thus, a total of 24.6 million people in the Midwest will conceivably buy irradiation processed fresh finfish.

Over the allotted four year market maturity span, these added fresh fish purchasers would increase. The inland fresh finfish per capita consumption level of .49 to an optimum 1.14 by 1972.

Therefore, projecting Assumption 2 to 1980, irradiation processing raises the inland consumption of fresh finfish from 9.98 per cent of total United States fresh finfish (1965) to 19.2 per cent (1980).

Comparative fresh finfish consumption under assumptions 1 and 2 for total United States and inland areas, 1965–80

[Millions of pounds, fresh finfish]

	1965		1980		Comparative percent increase
	Total	Inland	Total	Inland	
Assumption 1	267.3	26.7	425.5	113.6	16.6
Assumption 2	267.3	26.7	386.3	74.4	9.2

D. Application of assumptions 1 and 2 to New England cod, haddock, sole, and flounder

In order to apply Assumptions 1 and 2 to the supply of New England cod, haddock, sole and flounder, it was assumed that none of these species is canned or cured but sold only in fresh or frozen form. Therefore the total New England catch of the four species (98.2 million pounds in 1965) was percentaged on total United States fresh and frozen supply of finfish (756 million pounds in 1965). New England cod, haddock, sole and flounder were found to make up 13 per cent of total United States fresh and frozen fish. As previously determined, approximately 35 per cent of the total fresh/frozen finfish consumed in the United States is in fresh form.

Applying the 1965 percentages for New England cod, haddock, sole and flounder to total United States fresh and frozen fish consumption of finfish projected to 1980 under Assumptions 1 and 2 with irradiation processing in effect, and also to 1980 assuming no irradiation processing (calculated by multiplying population projections by present United States per capita consumption—.180—of New England cod, haddock, sole and flounder), the poundage increases in consumption attributable to irradiation processing become clear.

U.S. consumption of fresh New England cod, haddock, sole, flounder with and without irradiation processing, 1965–80

[In millions of pounds]

	1965	1980	Pound increase	Percent increase
Without irradiation processing	34.7	44.0	9.3	26.8
With irradiation processing:				
Assumption 1	34.7	55.2	20.5	59.0
Assumption 2	34.7	50.1	15.4	44.3

The poundage increases realized under Assumption 1 (11.2 million pounds) and Assumption 2 (6.1 million pounds) are applicable almost solely to the inland areas. This is so because the assumptions, and therefore their resulting consumption levels, were predicated on an increase in per capita consumption of fresh finfish in the Midwest *only*. Total coastal consumption of New England cod, haddock, sole and flounder is assumed to increase only in direct proportion to population with coastal per capital consumption remaining unaffected by increased irradiation processed supplies.

II. Description of Calculations Relevant to Determination of Potential Market Cost Benefits and Savings Attributable to Irradiation Processing of New England Cod, Haddock, Sole, and Flounder

A. Market cost benefits

As the increased consumption of fresh New England cod, haddock, sole and flounder realized under Assumptions 1 and 2 would be at the expense of frozen New England cod, haddock, sole and flounder, the expected poundage increases were multiplied by the average difference in retail price per pound between fresh (74 cents) and frozen (64 cents) cod, haddock, sole and flounder.[2] The result is the *gross* market benefit attributed to the expected consumption of irradiation processed fish from 1969 to 1980, under Assumptions 1 and 2.

To arrive at *net* market benefit, two expenses involved in handling irradiation processed fish must be subtracted from this gross figure:

1. The cost of the irradiation processing (Jackson and Moreland estimates: 1.25 cents to 1.56 cents per pound for 21 million pounds) which is passed along to the retailer, and
2. The added cost to the retailer of shipping fresh fish as opposed to frozen fish (3.3 cents per pound, calculated from trucking rates for carload quantities shipped from Boston to Chicago).

B. Cost savings

There are two areas of potential cost savings:

1. Spoilage losses, reported by local retailers and chain headquarters to average about 5 per cent of total fresh fish volume, all could be cut in half due to the increased shelf-life of irradiation processed fish.
2. Potential sales losses, resulting from buying short to insure total fish stock disappearance by Friday night, are reported to average about 7 per cent of total fresh fish volume. These losses could be reduced by about 90 per cent since the extended shelf-life of irradiation processed fish would allow it to be held over from Friday night to Saturday or Monday morning.

Spoilage losses and short buying losses were quantified for fresh New England cod, haddock, sole and flounder expanded market consumption levels under Assumptions 1 and 2, 1965 to 1980, and also for the consumption level expected without an expanded market. (The latter calculation is important because irradiation processing could lead to considerable cost savings on present spoilage and short buying losses even if the market grows only in direct proportion to population growth.)

Savings realized as a result of the introduction of irradiation processing were then applied to these present and potential losses.

Appendix B

Engineering Sections

(By Jackson & Moreland division[3] for report of cost-benefit studies of AEC's low-dose radiation preservation of foods program, submitted to Daniel Yankelovich, Inc., September 23, 1966)

SUMMARY

The unit cost of applying a pasteurizing dose of radiation to the foods considered herein—banana, fish, papaya and mango—ranges from 0.2 to 3 cents per pound of food, depending upon the values and interrelationships of several parameters. The range of 1 to 2 cents seems applicable to many practical cases.

The parameters that have the greatest effect on unit cost are the annual throughput rate and the cost per curie of cobal 60.

For the irradiation operations considered herein a radio-isotope source (cobalt 60) is considered to be preferable to a particle accelerator machine.

FOOD TYPES

Banana

The maximum shipping rate per Latin American port is taken to be 20,000,000 boxes per year (42 lb. per box). A bot carries about 100,000 boxes, so the traffic

[2] This price differential of 10 cents is considered to be a conservative figure. Differentials of up to 20 cents per pound between frozen and fresh fish are not uncommon.

[3] Jackson & Moreland, Division of United Engineers & Constructors, Inc., Boston, Mass.

is about 200 boats per year or an average of four per week. The minimum rate is taken to be one-quarter of this at 5,000,000 boxes per year.

At present bananas are packed in boxes at multiple locations near the fields. They are carried to the ports by railroad and the rail cars are spotted on the pier for unloading. There the boxes are manually loaded to conveyors which automatically carry them up over the side of the boat and down into the hold for manual unloading.

The irradiation facility should be located where the various railroad lines converge, near the pier. It is impracticable for several reasons to locate the irradiation facility on the pier, so it is assumed that it will be installed on shore.

It is assumed that each box of bananas will pass twice by an irradiation source, receiving a 35,000 rad dose, and that the conveyor speed will not be greater than one foot per second. These parameters and a 12,000 boxes per hour design rate result in a need for six irradiation sources, if the irradiation is performed "on-line" as the boxes are brought in from the fields and loaded on the ship. Alternatively, the irradiation could be performed "off-line" all through the week, in a smaller facility, with the irradiated product accumulated in a warehouse for loading when a ship arrives.

If a conservative 15% utilization is assumed, this would require a total of 10,000,000 curies in the six sources for the on-line facility. It is assumed that each of the sources will be made up of seven plaques with the intention of replacing one plaque each year to maintain source effectiveness.

The off-line facility would use one source for the 5,000,000 boxes per year rate, and three sources for the 20,000,000 rate.

Several handling systems can be considered. With on-line irradiation it is tempting to decide that once a banana box is manually moved from the rail car to the conveyor for the irradiation process it should not be manhandled again until it is in the hold of the ship. However, a conveyor system the length of the pier is expensive and the rail car system on the pier exists. It seems slightly more economical after irradiation to reload the banana boxes to the rail cars for the trip out the pier.

If irradiation is performed throughout the week on an off-line basis, refrigerated warehouse capacity will be required for the storage of about one boat load (100,000 boxes). Boxes would pass from the irradiation conveyor directly to a conveyor for the warehouse. When a boat arrives the warehouse conveyors would be used to bring the boxes back out of storage. At this point the choice discussed above appears again—do we re-load the boxes to rail cars or do we provide a conveyor to take them out on the pier? Re-loading the rail cars looks slightly preferable.

Atlantic coast fish fillets

The irradiation facility conceived for installation at an Atlantic Coast fishing port would have an initial processing capacity of 21,000,000 pounds per year with the prospect of future growth to 32,000,000 pounds.

Fish processing and marketing is largely a five-day-a-week, one-shift operation. For the irradiation facility, five-day, two-shift operation seems appropriate (one shift underutilizes the expensive radiation source; three shifts requires twice the cold-storage capacity). On this basis the average hourly throughput would be 5,250 or 8,000 pounds of fillets.

The fish are normally obtained by the processor during the morning and are filleted during the next few hours. If the product will be marketed as fresh fish (not frozen), it is usually sold and dispatched by the end of the day.

The irradiation step thus needs to fit into an established, fast-moving processing and marketing cycle for fresh fish. The appropriate time for it is after the fillets are placed in cans by the processor and before they are shipped to the buyer. During the early part of the day shift, pallet loads of cans would be brought to the irradiation facility, treated, and returned to the processors. By the end of the day shift a backlog would have piled up at the facility, which would be processed during the second shift and turned back to the processors next morning. It is evident that coal storage capacity equal to the one-shift irradiation capacity of the facility is needed for this plan.

A typical 20 pound can of fillets as shipped from the Boston Fish Pier is about 15 by 11 by 5 inches deep. The four-pass conveying system used at the Marine Products Demonstration Irradiator in Gloucester for cans of about this size gives a 20 per cent source utilization efficiency. For the purposes of this study a similar arrangement is assumed, although a horizontal labyrinth is probably preferable to the vertical one there.

The source size for 21,000,000 pounds per year is taken as 460,000 curies in the form of seven plaques. The source can be designed to increase its strength somewhat each year for greater throughput by increasing the specific activity (curies per gram) of the annual replacement plaque. It does not seem practicable to extend this technique, and the associated conveyor speed adjustments, to the 32,000,000 pound per year level. Before reaching this point a second irradiating cell and conveyor would be needed.

Papaya

The throughput estimates for a central papaya irradiation facility in the Hawaiian Islands cover a considerable range of speculation, with corresponding effects on plant-operation assumptions, as follows:

Period of time	Annual throughput (million pounds per year)	Processing rate (pounds per hour)	Number of shifts operate
A—Present	5	2,500	1
B—1980	10	2,500	2
C—1980	30	7,500	2
D—1980	50	12,500	2

These figures are based upon operation 50 weeks per year and a five-day week. Second shift labor is assumed to receive a 20% premium in pay.

With 20% utilization efficiency the cobalt 60 sources corresponding to the above throughputs are one 81,000 curie source for A and B, two 121,000 curie sources for C, and three 135,000 curie sources for D.

From a practical standpoint, it would appear sensible to build a first cell with enough shielding for about 121,000 curies, which would fit into a 1980 pattern of either B or C.

Mango

The annual quantity of mangoes to be irradiated in Hawaii is taken to be in the order of 100,000 pounds per year in 1975 and perhaps 1,000,000 pounds per year in 1980. The irradiation process would be similar to that for papayas and should be carried out in the same facility.

Since the mango throughputs given above are only a few per cent of those assumed for papayas, the cost per pound for irradiating occasional batches of mangoes should be considered the same as that for papayas.

COSTS

Banana.—Irradiation cost per pound:

Fixed variables—Utilization efficiency 15 percent, amortization period 15 years

SOURCE COST: 70 CENTS PER CURIE

System	5,000,000 boxes per year	20,800,000 boxes per year
	Cents	*Cents*
A—All conveyor, no warehouse	1.32	0.34
B—No pier conveyor, no warehouse	1.22	.33
C—No pier conveyor, with warehouse	.60	.37

SOURCE COST: 33 CENTS PER CURIE

A—All conveyor, no warehouse	0.74	0.20
B—No pier conveyor, no warehouse	.64	.18
C—No pier conveyor, with warehouse	.50	.30

NOTE.—5,000,000 boxes equals 210,000,000 pounds per year; 20,800,000 boxes equal 874,000,000 pounds per year.

Fish.—Irradiation cost per pound:

Fixed variables—Utilization efficiency 20 percent

Throughput, pound/year	Source cost, per curie	
	70 cents	33 cents
	Cents	*Cents*
Amortization period, 10 years:		
21,000,000	1.56	1.25
32,000,000	1.66	1.32
Amortization period, 15 years:		
21,000,000	1.48	1.19
32,000,000	1.57	1.25

Papaya (also applicable to Mango).—Irradiation cost per pound:

Fixed variables—Utilization efficiency 20 percent, amortization period 15 years

Throughput, pound/year	Source cost, per curie	
	70 cents	33 cents
	Cents	*Cents*
5,000,000	2.98	2.80
10,000,000	2.01	2.00
30,000,000	1.20	1.08
50,000,000	1.00	.94

Procedure for estimating cost

The procedure which has been used throughout for estimating the unit cost of irradiating a food is demonstrated by the particular estimate for one of the fish "cases," as shown on an adjacent page.

The basic method is to estimate the required investment cost, to calculate the annual fixed costs associated with that investment, and to estimate the annual costs for labor, maintenance and source replenishment. From these figures there is determined the gross annual income that will be required for the irradiation enterprise. Dividing this figure by the expected annual throughput in pounds gives a cost per pound for irradiation.

FISH IRRADIATION PLANT

Cost estimate

Utilization efficiency, 20 percent.
Source cost, 33¢ per curie.
Amortization period: 10 years.
Throughput: 21,000,000 pounds per year.

Investment:		
Source cost, 460,000 curies, each 33 cents		($152,000)
Nonrecoverable portion of source cost (6/7)		130,300
Other capital costs:		
Land		15,000
Building	$65,000	
Miscellaneous equipment	74,500	
Conveyors	30,000	
		169,500
Engineering, 15 percent of $169,500		25,400
Special services		30,000
Omissions and contingencies, 15 percent of $15,000 and $169,500		28,000
Depreciable investment		398,200
Recoverable portion of investment (1/7 of source cost)		21,700
Total investment		419,900

Annual income:		
Gross annual income [1]		261,100
Less expenses:		
Source replenishment	$21,700	
Labor and supervision	125,000	
Maintenance, repairs, supplies, 2½ percent of $169,500	4,200	
Insurance, 1 percent of $419,900	4,200	
Amortization: 10-year SF, 10 percent, 0.06275× $398,200	25,000	
		180,100
Income before taxes		81,000
Less income taxes 48 percent		39,000
Operating income for interest and dividends, 10 percent of $419,900		42,000

Unit cost:

$$\frac{\$261{,}100}{21{,}000{,}000 \text{ pounds}} = 1.25 \text{ cents per pound irradiating cost}$$

[1] This figure is the amount required by the needs expressed below it, and is derived by working up the table of figures.

Financial factors

The amortization period has been generally taken as 15 years. However, an alternative figure of 10 years has been used for Atlantic Coast fish fillets in line with a preference for this value that was expressed by a leader in the industry.

The operating income that remains after operating expenses, amortization and taxes is the amount available to pay interest and dividends. It is considered here that this annual amount should be 10 percent of the total investment, except that 11 percent is used for bananas in conformity with the practice of the industry leader.

Source cost

The current United States AEC source cost schedule for cobalt 60 is defined in the September 20, 1963, press release No. F–183. Atomic Energy of Canada Limited released in March 1, 1965, its latest industrial cobalt 60 price schedule (Price List No. 15–15 US–EXP). In both schedules, the price per curie for orders equal to or greater than 100,000 curies is set at $0.50. Encapsulation cost has been quoted in the order of $0.20 per curie. The unit source cost of $0.70/curie, encapsulated, is used as the current installed unit source cost in this study.

Conversations with experts in the field of isotopic irradiation indicate that the unit source cost will eventually be in the order of $0.25/curie with an encapsulation cost of $0.08/curie. Projected source cost in this study is, therefore, set at $0.33/curie, installed.

Cost estimating assumptions

Engineering design and management of construction of a new facility are taken as 15% of direct capital cost excluding land and source. This relatively high value is used on the premise that the facility is in a new area of technology and application on a commercial scale would just be beginning.

Special services include such things as licensing, start-up supervision, etc. Any facility using radioactive materials is required to have an operating license from the AEC Regulatory Licensing Board. Preparation of accident analyses, waste disposal procedures, plant operation procedures, etc., is done as partial fulfillment of licensing requirements. These special services by an engineering firm are estimated to cost $30,000, although they could cost more for a very large irradiator facility.

A 15% allowance for omissions and contingencies is applied to direct capital cost (less source cost).

The recoverable, non-depreciable portion of the cobalt 60 costs is set rather arbitrarily at one-seventh of original cost. After 10 or 15 years of operation and scheduled replenishments, there remains at any given time about two-thirds of the total curies originally contained in the seven plaques of various ages. However, the practical economics of reprocessing and reselling these curies are complex, so a more modest salvage value is assumed.

ENGINEERING FACTORS

Sources of radiation

There are several isotopic sources that have been considered in the literature. Among the most usable are cobalt 60 and cesium 137. Cobalt 60 is by far the most highly developed and is utilized in numerous existing and planned irradiation facilities. High gamma energy (1.17 and 1.33 MeV) and availability appear to be the main factors in this popularity. This does not preclude, however, the possibility of the lower gamma energy (0.66 MeV) cesium 137 becoming popular for specific purposes. A particularly attractive possibility is processing the cesium 137 that happens to be available as a fission product in spent fuel discharged from reactor power plants, which should result in substantially lower unit source cost. At the moment, however, as well as in the near future, it appears that cobalt 60 has the edge among isotopic sources.

The use of particle accelerators is a possibility. Accelerator radiation can be turned off and on at will, with obvious advantages for intermittent use and for maintenance accessibility. However, accelerators presently seem competitive only for pasteurization and other surface-radiation purposes. The reason is that the beam produced directly by an accelerator is composed of charged particles (electrons for this application); charged particles have limited penetrating ability in comparison with radiant energy at the same level. Thus to compete with gamma radiation from a radio-isotope for an application requiring penetration of more than an inch or so, the electron beam from the accelerator must be converted to X-rays. For several reasons the accelerator is at a competitive disadvantage when this added step is required.

If shallow penetration is acceptable, the ability of an electron accelerator to localize radiation on a target material is an advantage in terms of utilization efficiency over an isotopic source with its radiation necessarily emitted in all directions and not focusable.

Potential problem areas such as maintenance downtime, and need for trained operators add to the uncertainties about the competitive position of particle accelerators. Electron energies of up to 10 MeV have the general approval of the Food & Drug Administration for food processing; this upper limit restricts the depth of penertation—or product thickness—which can be processed.

In this analysis cobalt 60 has been used throughout as the source of irradiation energy.

Source strength

A rigorous analytical model has been developed at Brookhaven to optimize source geometry in relation to effective radiation utilization and other parameters. For the analyses of this study, however, an empirical relation for determining source size in the current generation of irradiators (such as the Marine Products Development Irradiator Facility) is used, as follows:

$$S = \frac{86TD}{\gamma}$$

Where S=source strength in curies, T=throughput in pounds per hour, D=required dose in megarads, γ=effective radiation utilization efficiency.

Source geometry is affected by the design of the conveying system. The hourly throughputs in this study require reasonably high conveyor speeds. This being the case, the simple geometry of plaque-type sources is used. Also, the plaque system seems to offer the least operational difficulties in terms of source handling when replenishment is made.

Source replenishment

Cobalt 60 undergoes radioactive decay with a half-life of 5.26 years. Thus the decrease in output level is about 12.2% each year. In order to simplify replenishment accounting, the source plaque is divided into seven sections. One section would be replaced each year to maintain source effectiveness. This results in a 14.3% per year replenishment rate; part of the differential could account for whatever irrecoverable losses there might be.

Replenishment unit cost depends upon batch equal to or over 100,000 curies (Canadian price list) remains at $0.50/curie. There is a $0.05/curie increase in unit cost per 25,000 curie decrease in batch size down to 25,000 curies. Thus it would be possible for a given facility that the replenishment unit source cost could be higher than the initial unit source cost. This has not been considered here because it is not clear how source cost would vary in time as demand increases, nor is it possible to tell what might be the impact of processing the fission

products from spent fuel. Replenishment unit source cost has been taken as equal to initial installed cost.

Dosage

The maximum dosage for a food is limited by taste changes and other deleterious effects. A minimum dosage is required to achieve the desired pasteurization effect. The ratio of these dosages is taken here to be 1.3, although a somewhat larger value may ultimately prove practical for some foods (e.g., banana).

The facility concepts and their estimated costs are basically related to the maximum dosages, which are taken as follows:

	Maximum dosage in rads
Banana	35,000
Fish	200,000
Papaya	75,000
Mango	75,000

Note that minimum dosage is a design limitation affecting two factors, 1) the allowable decay with time of the radiation intensity of a cobalt 60 source, and 2) the handling manipulations necessary to insure that in a particular food package no element is irradiated above the maximum or below the minimum level.

Utilization efficiency

The utilization efficiency is the percentage of the total radiation emitted from the source which is absorbed by the material being irradiated. It is a function of 1) how much of the spherical area around the source is occupied by the material and 2) how much radiation passes on through the material without being captured.

A high utilization efficiency can be achieved by complex conveyor geometry, probably with multiple passes. Such complexity adds cost and may make it difficult to achieve a desired throughput rate.

On the other hand, if one were included to aim toward a very simple single-pass system and accept the resulting low utilization efficiency, another limitation would be encountered. Each element of each food package must receive a dose of radiation that falls between a minimum that will do the desire pasteurization job and a maximum that will avoid taste deterioration or other deleterious effects. This requirement can best be met by multiple passes with the food package differently oriented each time.

The usual result of a design to meet these various needs is a source utilization efficiency of 15 to 20 per cent.

Shielding

Shielding in a cobalt-60 facility is primarily against gamma radiation. The choice of material among different kinds of concrete, lead, etc., is dependent upon the nature of the facility and overall economics. For the type of facility that is examined here, the most practical material seems to be ordinary concrete with a density of about 140–145 pounds per cubic foot, which would also be used for some structural members.

Calculation of shielding thicknesses for a cobalt-60 irradiator was made by Jackson & Moreland for the NASA Space Radiation Facility at Greenbelt, Maryland. The thicknesses used here for economic evaluations are based on the results of the above-mentioned calculations, modified to account for factors unique in these facilities. Shielding thicknesses for the irradiators considered here range from five to seven feet of ordinary concrete.

APPENDIX 13

CORRESPONDENCE AND REPORT ON THE ARMY FOOD IRRADIATION PLAN

HEADQUARTERS, DEPARTMENT OF THE ARMY,
OFFICE OF THE ASSISTANT SECRETARY,
Washington, D.C., December 28, 1966.

Hon. MELVIN PRICE,
Joint Committee on Atomic Energy,
House of Representatives, Washington, D.C.

DEAR MR. PRICE: In accordance with your request during Hearings on Radiation Processing of Foods before the Subcommittee on Research, Development and Radiation of the Joint Committee on Atomic Energy on September 12, 1966, I am pleased to submit the Army Food Irradiation Development Plan.

The presently existing Army research program on irradiation sterilized foods, presented to the Subcommittee on June 9, 1965, is designed to accomplish the research work necessary to submit petitions to the Food and Drug Administration (FDA) and the Department of Agriculture (USDA) for clearance for unlimited human consumption. The development plan is designed to carry irradiation sterilized food items from the point of FDA and USDA approvals through to introduction of the food items into military feeding systems. This plan is necessarily contingent upon two assumptions: (1) that the FDA and USDA will provide timely approval of Army petitions for clearance of irradiation sterilized food items of military importance, such as ham and pork, and (2) that a commercial pilot plant irradiation facility will be available before FY 1970.

On behalf of the Department of the Army, I would again like to express appreciation for your continued interest and support of the Army Food Irradiation Program.

Sincerely,

CHARLES D. POOR,
Deputy Assistant Secretary of the Army (R. & D.).

THE ARMY FOOD IRRADIATION DEVELOPMENT PLAN

BACKGROUND

This plan initiates development work by the Army on irradiation sterilized foods. The 5-year Army research program on irradiation sterilized foods was presented to the Subcommittee on Research, Development and Radiation, Joint Committee on Atomic Energy in testimony of June 9, 1965. Together, these research and development efforts constitute the Army Food Irradiation Program—the Army contribution to the National Radiation Preservation of Foods Program.

The technical feasibility of sterilizing food items by exposure to radiation sources was established when the Food and Drug Administration (FDA) approved the Army petition for bacon sterilized by exposure to cobalt^{60} on February 8, 1963. An Army petition for a second sterilized food item—ham—has been submitted to the FDA and the Department of Agriculture (USDA) and was accepted for filing by the FDA on August 15, 1966. A petition for sterilized pork will be submitted to the FDA and the USDA in early February 1967, subject to a preliminary informal review by the FDA. A planning schedule for future petition submissions and the forecasted maximum Army annual needs for several irradiation sterilized meats, including ham, were presented to the Subcommittee on Research, Development and Radiation in testimony of September 12, 1966.

On September 21, 1965, the Army publicly announced a requirement for 150,000 pounds of irradiation sterilized meats each year for a 3-year period commencing with the availability of a commercial meat irradiation facility. These procurements, subject to approval of the food items for unlimited human consumption by the FDA, will be for test and evaluation to determine the applicability of irradiation sterilized food products to the multiple ration systems in use in the Army. In November 1965, an Interagency Pilot Plant Meat Irradiator Task Force was created by the Department of Commerce with representation from the Atomic Energy Commission (AEC) and the Army to study means of stimulating commercialization of irradiation sterilization of foods. In June 1966, the Task

Force completed its study and recommended to each agency involved that a pilot plant meat irradiator be built and operated by private industry with assistance from the Federal Government. The AEC agreed to solicit the interest of private industry on behalf of the Federal agencies by issuance of a Request for Proposals (RFP) for the private construction and operation of the pilot plant. On July 13, 1966, the Army strengthened its support of the pilot plant concept by offering to provide scientific back-up and technical liaison through the Natick Laboratories for the contractor selected from companies responding to the RFP. On December 7, 1966, the Army provided its comments to the AEC on the content of the RFP and informed the AEC that the combined requirements of the Military Services for irradiation sterilized meat products to be purchased from the pilot plant for test and evaluation were 300,000 pounds annually for 3 years. The AEC issued the RFP on December 19, 1966.

The Army Food Irradiation Development Plan presented herein is based upon two assumptions: (1) that the FDA and the USDA will provide timely approval of Army petitions for clearance of irradiation sterilized food items of military importance such as ham and pork, and (2) that the AEC RFP will result in the timely construction of a pilot plant meat irradiator. Hence, the development plan is tentative until these events occur.

THE DEVELOPMENT PLAN

The presently existing Army research program on irradiation sterilized foods is designed to accomplish the research work necessary to submit petitions to the FDA and the USDA for clearance for unlimited human consumption. The development plan presented herein is designed to carry irradiation sterilized food items from the point of FDA and USDA approvals through to introduction of the food items into regular Army feeding systems. The 5-year development plan on irradiation sterilized foods will be initiated by the Army in FY 68. A summary of proposed funding for the Army Food Irradiation Development Plan is shown in Table 1. These funds are in addition to the fiscal support for the Army research program on irradiation sterilized foods described to the Subcommittee on Research, Development and Radiation in the testimony of June 9, 1965.

TABLE 1.—*Summary of proposed funding for the Army food irradiation development plan, fiscal years 1968 through 1972*

Activity	Proposed funds (in thousands)					
	1968	1969	1970	1971	1972	Total
Development of individual food items	$150	$300	$390	$390	$390	$1,620
Packaging development		50	100	75	50	275
Total	150	350	490	465	440	1,895

A. Development of individual food items

Studies will be undertaken to determine where irradiated food items can replace conventionally processed items in group and individual combat rations and in garrison rations. The desired military and technical characteristics will be determined for each irradiated item, including fabrication of prototypes. Work during the latter 4 years of the plan (FY 69–72) is based on the assumptions that FDA and USDA clearances have been obtained and that the pilot plant meat irradiator will be in operation. The Natick Laboratories will provide scientific back-up upon request during the 5-year period of the plan to assist in solving technical problems which may arise in the operation of the pilot plant. Technical liaison services also will be provided on request by the Natick Laboratories to the operating staff of the pilot plant whereby individuals may collaborate with Army scientists experienced in food irradiation technology. Precise processing techniques will be developed and realistic processing cost data obtained.

Following necessary FDA and USDA approvals, individual irradiated food items will be introduced into the development phase of the program. The planning schedule for development of these individual food items for FY 68 through FY 72 is shown in Table 2.

TABLE 2.—*Planning schedule for development of individual food items*

Phases	Fiscal year 1968	Fiscal year 1969	Fiscal year 1970	Fiscal year 1971	Fiscal year 1972
Individual food item development:					
Metal cans	Ham and pork.	Beef and chicken.	Shrimp, corned beef, hamburger, pork sausage, and codfish cakes.	Barbecued beef, chicken, and pork; frankfurters and luncheon meats.	Lamb, fish, and turkey.
Flexible packaging	----------	Ham and pork.	Beef and chicken.	Hamburger and frankfurters.	Luncheon meats and pork sausage.
Test and evaluation:					
Metal cans	----------	Ham and pork.	Beef, chicken, ham, and pork.	Shrimp, corned beef, hamburger, pork sausage, codfish cakes, chicken, and beef.	Pork sausage; barbecued beef, chicken, and pork; corned beef; hamburger; frankfurters; codfish cakes; luncheon meats; and shrimp.
Flexible packaging	----------	----------	Ham and pork	Ham, pork, beef, and chicken.	Beef, chicken, hamburger, and frankfurters.
Introduction into Army ration systems:					
Metal cans	----------	----------	----------	Ham and pork	Chicken and beef.
Flexible packaging	----------	----------	----------	----------	Ham and pork.

The combined Military Services will procure approximately 300,000 pounds of irradiation sterilized foods annually for a 3-year period for test and evaluation. The Army will utilize approximately 150,000 pounds of these procurements during each of the 3 years in the following manner:

1. *Laboratory studies.*—These studies will utilize approximately 15 percent of the annual procurements of 150,000 pounds over a 3-year period. The individual food items for laboratory studies will be purchased with Army research and development funds. Each item procured will be tested as follows:

a. Chemical analyses, including tests for macronutrient and micronutrient content, color, texture, moisture, and absence of rancidity, radiation-induced odors and induced radioactivity.

b. Analyses to assure microbiological safety of commercially produced irradiation sterilized products.

c. Acceptance tests by expert and consumer panels to assess the quality of production items.

d. Storage tests up to 2 years in duration at ambient and elevated temperatures to determine the shelf-life of commercially produced irradation sterilized foods.

During the interim between commencement of the development plan in FY 68 and the completion of the pilot plant, studies similar to those described above will be undertaken on a limited scale utilizing food items processed by existing laboratory-scale radiation facilities.

2. *Test and evaluation studies.*—When production quantities become available from the pilot plant, and FDA and USDA approvals have been obtained, large-scale troop feeding tests and logistical evaluations will be undertaken. Individual food items will be tested in contrast to non-irradiated control items by using large numbers of troops and repetitive feedings to determine actual consumption by the individual soldier, acceptance and monotony factors, and military performance when the food items are used under garrison and field conditions. These studies involving troop feeding will utilize approximately 85 percent of the annual procurements of 150,000 pounds over a 3-year period. The individual

food items for troop feeding will be purchased with funds budgeted for the procurement of new food items of military interest. These funds are not included in Table 1 since procurement costs are to be negotiated in the future with the private operator of the pilot plant.

B. Packaging development

Work on packaging development will be devoted to adapting rigid metal and flexible food containers and packaging materials approved by the FDA and the USDA for use with irradiation sterilized foods to rigorous military requirements. Irradiation of some food items in the frozen state at temperatures as low as —80° C. ±10° C. has been found to be desirable. Hence, packaging for irradiation sterilized products must withstand extremely low temperatures, in addition to withstanding irradiation and high temperature effects.

Concerning rigid metal containers, the reliability of various sizes and configurations from pilot plant and laboratory production runs will be determined at selected temperatures between 0° C. and —100° C. for each of the food items shown in Table 2. Reliability as a barrier to moisture, gases and microorganisms will be tested as a function of storage time up to 2 years, rough handling, processing temperature, and specific food item. Over a 2-year storage period, can enamels will be tested for softening, blistering, discoloration and loss of adhesiveness. Tin plate will be examined for corrosion and spangling. Information obtained will be utilized in the preparation of procurement documents.

Concerning flexible packaging, FDA and USDA approved packages of flexible laminates will undergo reliability testing after pilot plant and laboratory production runs of the food items shown in Table 2 in the same manner as described for rigid containers. In contrast to flexible packaging for civilian consumption, flexible food packaging for military use must withstand rough handling and a very wide range of storage conditions. Hence, modifications to packaging materials approved for civilian use will be necessary to meet military requirements. These modifications will be based upon studies of burst strength, seal strength, bond strength, leakage and residual molecular structure changes under the various handling and storage conditions encountered in military operations. Information obtained will be utilized in the preparation of procurement documents.

Appendix 14

AEC's Request for Proposals for the Pilot Plant Meat Irradiation

U.S. Atomic Energy Commission,
Washington, D.C., December 19, 1966.

Dear Sirs: The Atomic Energy Commission and the Department of the Army have been conducting research in radiation preservation of foods since 1960 and the early 1950's, respectively. Whereas the AEC's prime interest has been directed toward pasteurization of perishables, such as fish and fruit, by low-dose radiation, and has been aimed principally at the civilian market, the Army's efforts have been directed primarily to the sterilization of meats by high-dose radiation for ultimate inclusion into the military ration.

At the Army's request, the AEC and the U.S. Department of Commerce have agreed to join with it in a cooperative program with industry to encourage private development of a commercial capability for the radiation sterilization of meats. For this purpose, the Government is prepared to consider furnishing specified and other forms of assistance under a cooperative arrangement with a qualified firm which will contract to design, construct, and operate an irradiation facility and to produce under inspection by the United States Department of Agriculture, radiation sterilized meats. It is presently expected that the Government's assistance will be furnished pursuant to the terms of an AEC contract which will be negotiated and administered by the AEC on behalf of the three participating Government agencies. Sterilized foods will be procured under the terms of a companion agreement or purchase orders issued by the Department of Defense. You are invited to submit a proposal for conducting this program to the AEC's Division of Isotopes Development.

As you undoubtedly are aware, the feasibility of radiation sterilization of meats has been demonstrated, to a limited extent, under laboratory conditions. In addition to providing a source of supply for military procurements of radiation sterilized meats, a main objective of Government support for the project in question is a demonstration of the feasibility of commercial production of radia-

tion sterilized meats in economic production runs, and in order to stimulate civilian interest and use, the introduction of such meats into commercial market channels. To be favorably considered, it is not necessary that a firm propose a facility with such capacity as might be appropriate if an active civilian market were in being. However, favorable consideration will not be given to a proposal for a facility with a production capacity of less than one million pounds of sterilized meat annually.

Only products which have been approved by the Food and Drug Administration (FDA) for unlimited public consumption may be sold to the general public. The Army's schedule for submitting meats and meat products to the FDA for clearance is set out in Enclosure "A". As of the date of this letter, bacon is the only meat product which has been cleared, but it is anticipated that other products will have received clearance by the time the facility in question has been put in operation. Although it is not possible to forecast clearance dates, it is expected that clearance will be obtained on all or most of the products within 12 months from the time a request is submitted.

The AEC's financial assistance, up to the limits stated in Enclosure "A", and appropriate technical assistance, will be furnished if requested pursuant to a contract which will call for the design, construction, and operation of a facility, for the production of certain data, and for related undertakings. The Department of Defense will, to the extent appropriate, provide technical liaison and scientific assistance as indicated in Enclosure "A", and will purchase radiation processed meats from this facility in at least the volume indicated in Enclosure "A", subject to the availability of funds and product acceptability. The Department of Commerce, by virtue of its continuing activities in this area, also will be of assistance in developing a civilian market and encourage purchases by non-military agencies.

Proposals submitted will be evaluated by Government personnel, with the technical advice of personnel from AEC National Laboratories. The right is reserved to reject any and all proposals, and to request clarification or modifications of proposals. The AEC expects to negotiate a contract with the firm which proposes to design, construct and operate a facility best suited to the Government's objectives. Proposals will be evaluated primarily on the basis of qualifications and experience of the organization and personnel proposed for undertaking the project, the design and capacity of the facility, the plan for introduction of processed meats into the commercial market, and the amount of Governmental support requested, including price per pound for Department of Defense procurements.

Proposers must demonstrate a satisfactory record of integrity and financial responsibility, and must indicate a willingness to accept standard AEC contract provisions which are applicable to the contract envisioned. (See AEC PR Chap. 9, Part 7—Standard Contract Clauses.)

Current radiation processing procedures for selected products are attached as Enclosure "C." The addresses of this letter are listed in Enclosure "D."

If you are interested in participating in this program as described in this letter and in Enclosure "A," you should prepare a proposal containing the information indicated in Enclosure "B." Ten (10) copies of your proposal should be mailed to reach the undersigned not later than close of business April 17, 1967. In the event you decide not to submit a proposal, a reply to that effect would be appreciated.

It is currently our intent to complete this contractor selection and to initiate a contract so that actual work can begin prior to June 30, 1967.

If there are any questions, please write to the attention of the undersigned, or Mr. George R. Dietz of this Division.

Sincerely yours,

M. EDWARD LOCKYER,
Chairman, Proposal Evaluation Panel, Division of Isotopes Development.

[Enclosure A]

OUTLINE OF MEAT IRRADIATOR PROJECT

I. GENERAL

As part of a cooperative arrangement with the Departments of Army and Commerce, the AEC is soliciting proposals for private design and construction of an irradiation facility to be operated under USDA inspection, capable of

sterilizing a minimum of one million pounds of meat per year. The main objectives of such a program and plant are:

A. Scale-up of laboratory techniques to commercially useful production capacities;

B. Production of sterilized food for military logistical and test purposes;

C. Determination of the economics of radiation processing of the several meats of interest; and,

D. Introduction into the civilian market of radiation sterilized meats in an attempt to induce further commercialization.

II. GOVERNMENT PARTICIPATION

To the extent requested in the proposal, the Government is prepared to offer the following assistance as incentive toward industrial development of the project:

A. Atomic Energy Commission

Pursuant to a contract in which the Contractor will undertake to design, construct and operate an irradiation facility capable of producing at least one million pounds of sterlized meat each year for a minimum of three years, at a doze of approximately five million rad, to accomplish the main objectives stated above, and to furnish reports fully describing the technical and economic aspects thereof, the Atomic Energy Commission will provide a maximum of $140,000 toward the detailed engineering design of the proposed facility and a maximum of $230,000 toward the purchase of the radiation source. In addition, the AEC will consider furnishing technical assistance and related assistance by Brookhaven National Laboratory and other AEC facilities as is reasonably requested and delineated in the proposal.

B. Department of Defense

1. Subject to the availability of funds and to the condition that no meat will be ordered which has not been cleared by the Food and Drug Administration and the United States Department of Agriculture for unlimited public consumption, the Department of Defense will enter into a companion contract with the AEC contractor providing for the production and delivery of sterilized meats complying with DOD acceptability standards during the first three years after the irradiation facility is ready for operation, as follows:

First year: 300,000 pounds.
Second Year: 300,000 pounds.
Third Year: 300,000 pounds.

Although radiation sterilized bacon has been approved by the FDA, there is no significant military requirement for this product during the initial three-year period of pilot plant production. Its clearance is primarily representative of a class of foods, i.e., cured, smoked meats. There are, however, military needs for a variety of other meat items including ham, pork, beef, chicken, frankfurters and luncheon-type meats, primarily to determine the applicability of radiation sterilized food products to the multiple ration systems in use in the Millitary Services. Yearly procurements indicated will be to fulfill this need.

2. The Department of Defense will consider providing the following forms of assistance as are reasonably requested and delineated in the proposal:

a. Scientific backup by the staff of the Army's Radiation Laboratory (Natick, Massachusetts), to assist in resolving problem areas in food research, as related to facility operation.

b. Technical liaison with personnel at the Natick Laboratory during facility operator(s) training.

It is noted for proposers' information that the Department of Commerce is carrying out a program to assist in the development of a civilian commercial market for irradiated foods by consumer education and other appropriate programs, and by encouraging additional Federal, State, and local government and non-government agencies to buy irradiated foods.

III. SCHEDULE FOR PETITION SUBMISSIONS TO FDA

Only those products which have clearance from the Food and Drug Administration will be processed for sale to the Army or used for marketing purposes. For informational purposes, the current schedule for submission of petitions follows. FDA action on any petition could require twelve months or more.

Product:	*Planned time of submission to FDA (fiscal year)*
Bacon	[1]
Ham	[2]
Pork	1967
Chicken	1968
Beef	1968
Product—Continued	
Shrimp	1968
Hamburger	1968
Corned Beef	1968
Pork Sausage	1968

Product:	*Planned time of submission to FDA (fiscal year)*
Codfish Cakes	1968
Turkey	1969
Frankfurters	1969
Barbecued beef, chicken, and pork	1969
Product—Continued	
Luncheon meats	1970
Salmon cakes	1970
Baked fish	1970
Lamb	1970

[1] Cleared.
[2] Submitted July 1966.

IV. FACILITY LOCATION

Location of the proposed facility is to be designated by the proposer. Any location compatible with the fulfillment of program objectives would be acceptable.

V. OTHER USE OF RADIATION FACILITY

If radiation capacity exists for the processing of foods other than the above listed meats, or for products other than foods, such additional use of the facility is encouraged. However, as a general guideline, first considerations for facility use should be to meet project requirements. Concurrence of the Meat Inspection Division, U.S. Department of Agriculture, should be obtained for other proposed facility uses.

The clearance schedules for other products (low-dose) are as follows:

Product:	*Planned submission to FDA (fiscal year)*
Wheat and wheat flour	Cleared.
White potatoes	Do.
Oranges	Submitted December 1963.
Fish fillets (haddock, pollock, ocean perch, cod, flounder, and sole).	Submitted October 1965.
Strawberries	Submitted May 1966.
Onions	1967.
Shrimp	1968.
Clams	1968.

[Enclosure B]

INFORMATION TO BE SUBMITTED

Item 1: Personnel.—List of names and brief experience record of all key personnel (including subcontractors) proposed for assignment to this project. The résumés should clearly set forth education (showing dates), experience (including specific titles of assignments), and duties and responsibilities by years. Experience specifically related to elements of this project should be identified.

Item 2: Organization.—Describe the ownership and corporate structure of your company, and identify officers and directors. Submit a chart for your over-all organization showing how the proposed project is to be integrated into it. Also identify and describe any subcontracts, agreements, commitments or other arrangements which your organization or key staff members have or contemplate, which would relate directly to the conduct of this program.

Item 3: Financial data.—Furnish your firm's certified Balance Sheet and Profit and Loss Statement for the last two fiscal years, if not recently submitted to AEC or if your organization is not currently doing business with the AEC. If a corporation, copies of annual reports to stockholders will suffice.

Item 4: Company background and experience.—Describe the experience which your company or key officials and proposed subcontractors may have had in the

past five years which is related to radiation processing of foods, or to radiation facility design and development.

Item 5: Proposed facility.—Submit a conceptual design of the facility proposed, to include a narrative description of its essential features, staffing, capacities and capabilities. Sufficient information should be included to permit an independent evaluation of capital costs, processing costs, and general adequacy for the proposed functions. Furnish a time schedule for design and construction. List specific products capable of being processed and their proposed hourly volume throughput. The AEC will reserve the right under the contract to review preliminary and detailed designs.

Item 6: Government support.—List specifically the support requested from the Government, using Enclosure "A", para. II, as a guide. One of the factors which will be considered in evaluating proposals is the total amount of Government support required.

Item 7: Cost estimate.—Furnish a detailed estimate of capital costs which you anticipate will be required for facility design and construction. Also provide a proposed project staffing plan and an estimate of yearly operating expenses. A discussion of amortization plans should be included. Assuming the total yearly procurement of 300,000 pounds will be confined to one product, prices to the DOD for assumed military procurements of ham, pork, chicken and beef should be indicated by year, as FOB prices at the plant, including all processing costs but excluding cost of the raw material. For pricing purposes, the radiation processing procedures set forth in Enclosure "C" may be assumed to yield an acceptable product. Costs of the raw material will be based on actual market prices in effect on the dates of government purchases from the contractor. Raw material prices utilized will be market prices officially published by the Department of Agriculture for the particular raw material item involved or, in the case of meats, the daily market prices published in *The National Provisioner Daily Market Service* (the 'yellow sheet').

Item 8: Location.—A description of the area and community proposed for the facility should be furnished. Include transportation facilties, proximity to meat packers, and other data considered pertinent.

Item 9: Commercialization aspects.—Outline plans for the introduction of a portion of the facility throughput into the civilian economy. Indicate anticipated prices, types of marketing and consumer efforts proposed by year, and pounds of product considered adequate for the effort. A statement of anticipated costs of the commercialization effort should be included.

Item 10: Patent and technological data.—In consideration of the relative contributions, financial and otherwise, of the Government and your company to this project, state your views as what would constitute equitable distribution of rights with respect to inventions and technological data, in addition to your company and the Government each acquiring the right to use any inventions, and to use and disseminate the technological data as each may desire.

Item 11: Other.—Furnish any additional data or information concerning your firm and its proposed plans for this project which you believe should be considered in the final evaluation.

Item 12: Contract terms.—Indicate willingness to accept, in principle, applicable AEC contract provisions.

[Enclosure C]

PROCESSING PROCEDURES FOR SELECTED PRODUCTS

The following procedures are applicable to radiation processing of selected meats, based on present best information. Although irradiation of beef at —196° C may further acceptability, the practical lowest temperature to be utilized in the pilot plant will be $-80\pm10°$ C. All products respond favorably at this or higher temperatures during irradiation.

BACON

1. FDA Petitions—Approved: 21 CFR: 121,3002, 121,3004, 121,3005.
2. U.S.D.A.: Consumer and Marketing Service Regulation: (9 CFR Part 318) *Federal Register*, 26 November 1965.

I. *Raw Material:*

A. Sec. 3, Specification LP–DES 9–66, 10 March 1966—"Bacon, Sliced, Canned, Irradiated" (Brisket-Off, 8–12 lbs. Bacon Bellies).

B. Storage: 0°–4° C.

II. *Pre-Irradiation Processing:* None.

BACON—continued

III. *Packaging:* Tin-plate metal can with epoxy-phenolic or polybutadiene.

A. Package (Use of vegetable parchment wrap for complete enclosure of the product is required: FDA approval of vegetable parchment 21 CFR: 121.2543.

Net weight:	*Can size*
1 lb	303 x 509
1¼ lb	307 x 509

B. Procedure:

1. Discard the end slices and slices with fissures.
2. Roll bacon in parchment paper and stuff roll in can.

Example: Place shingled bacon, with the fat side on to parchment paper; fold all 4 edges of paper inward; fold in the middle to obtain an approximate 5'' x 8'' packet; roll packet on long axis; stuff roll in can.

3. Close cans immediately:
   (*a*) 20 inch vacuum.
   (*b*) Use lids with irradiation sensitive indicators.
4. Irradiate or refrigerate 0–4° C; refrigerate not more than 14 days prior to irradiation.
5. If frozen controls are desired, randomly select the desired number of cans and freeze (—29° C).

IV. *Irradiation:*

A. Product and irradiation temperature:

1. Product temperature at start of irradiation shall not exceed 4° C.
2. Product temperature at end of irradiation shall not exceed 27° C.
3. Irradiation Temperature—ambient; the use of refrigeration (control of carrier and/or product) is recommended.

B. Dose:

1. 4.5–5.6 Mrad (presently approved).
2. 3.0–5.6 Mrad (to be petitioned).

V. *Storage:* Same as thermally-sterilized canned foods (no refrigeration).

BEEF

FDA Petition Target Date: FY 67.

I. *Raw Materials:*

A. Specification PP–B–00221e (AGR–ANS) "Beef, Fresh (chilled or frozen)":

1. Grades: (Chilled Only):
   (B) U.S. Choice.
   (C) U.S. Good.
   (E) U.S. Commercial.
   (D) Utility.
2. Style V–b–2 "ribeye" (boneless). Style V–r–2 "loin" (boneless). Style V–p–7 "round" (boneless). Other commercial cuts.

II. *Pre-Irradiation Processing:*

A. Preparation:

1. Remove excess cover fat and trim to stuff.
2. Stuff into No. 7V fibrous prestuck casing (Other procedures may be used).

B. Enzyme Inactivation: Any thermal processing to raise product internal temperature to 70°–75° C.

NOTE.—Use thermocouples and probes to control heating.

III. *Packaging* (Example): Tinplate metal cans with epoxy-phenolic, polybutadiene, or oleoresinous "C"-enamel lining:

A. Package Net Weight—2 lb. 6 oz. (Weight depends on the can size). Can Size—404 x 700. (Other can sizes can be used).

B. Procedure:

1. Pack as soon as possible while product is still hot.
2. Cut into desired lengths to fit can size (6 to 6½ inch lengths for 404 x 700 cans).
3. Pack in cans.
4. Close cans immediately:
   (*a*) 20 inch vacuum.
   (*b*) Use lids with radiation sensitive indicators.
5. Freeze.

BEEF—continued

IV. *Irradiation:*

A. −80° C ± 10° C is sufficient for getting highly acceptable products. When U.S. Commercial grade beef is used an irradiation temperature of −30±10° C is sufficient to obtain acceptable products.

B. Irradiate under controlled condition (product temperature, −30±10° C to −80±10° C).

C. Dose: 4.5–5.6 Mrad (Predicted).

V. *Storage:* Same as thermally-sterilized foods (no refrigeration).

CHICKEN

FDA Petition Tarket Date: FY 67.

I. *Raw Material:*

A. Specification P–C–00248e (ASR–AMS) "Chicken, Chilled and Frozen (Ready to Cook)" Sec. 3, Type I, Class 1, Grade A, Boneless breasts—8 oz. (not more than 3 days post-kill at time of delivery).

B. Storage: 0–3° C not more than 2 days.

II. *Pre-Irradiation Processing:*

A. Enzyme Inactivation:

1. Cut breasts in half.
2. Place parts, one layer thick, in perforated pans.
3. Heat in steam (104° C) to produce internal temperature of 80° C (other thermal processing methods can be used also).

NOTE.—Use thermocouples and probes to control heating.

III. *Packaging* (Tinplate metal cans with epoxy-phenolic, polybutadiene, or oleoresinous "C"-enamel lining):

A. Package (Examples):

Net weight	Can size	Number pieces of half-breasts
2 pounds	404×700	11–13
4½ pounds	607×700	22–25

NOTE.—Other commercially available metal cans can be used also.

B. Procedure

1. Pack as soon as possible after heat enzyme inactivation and while parts are still hot.
2. Discard all broken or damaged pieces.
3. Pack, adjusting weight as close as possible with whole pieces.
4. Close cans immediately:
   (*a*) 20 inch vacuum as a minimum.
   (*b*) Use lids with radiation sensitive indicators.
5. Irradiate or refrigerate 0–3° C; hold refrigerated not more than 24 hours.

IV. *Irradiation:*

A. Product temperature at start of irradiation shall not exceed 4° C. Product temperature at end of irradiation shall not exceed 20° C. (Use of controlled sub-freezing temperature such as −30±10° C product temperature and carrier temperature is recommended.)

B. Dose: 4.5–5.6 Mrad (Predicted).

V. Storage: Same as thermally-sterilized canned foods (no refrigeration).

HAM

FDA Petition Target Dates:

(*a*) At ambient temperature—FY 67.

(*b*) At −30±10° C, FY 67.

I. *Raw Material:*

A. Specification—MIL–H–35094, amendment I, 30 April 1964, "Ham, Cooked, Chilled, or Frozen, Boneless, Cured, Smoked" Sec. 3 Type I, Class I, (boneless, rolled, or equivalent)

NOTE.—Commercial pasteurized cooked canned hams, ovalshaped and Pullman-type hams, may be suitable also. However, more experimental work is required in the field.

B. Storage: 0–3° C not more than 7 days.

HAM—continued

II. *Pre-Irradiation Processing:* None.

III. *Packaging:* (Tinplate metal cans with epoxy-phenolic, polybutadiene or oleoresinous "C"-enamel lining):

A. Package (Examples):
607 x 700 can (4½ lb. net weight).
404 x 700 (2 lb. 14 oz.).

B. Procedure:
1. Remove casing and metal ends.
2. Cut into desired lengths to fit the cans.
3. Pack in cans and adjust weight with cut pieces.
4. Close can immediately:
(*a*) 20 inch vacuum as a minimum.
(*b*) Use lids with irradiation sensitive indicators.
5. Irradiate or refrigerate 0–3° C; hold refrigerated not more than 14 days.
6. If frozen controls are desired, randomly select the required number of cans, freeze at —20° C.

IV. *Irradiation:*

A. Product temperature at start of irradiation shall not exceed 4° C. Product temperature at end of irradiation shall not exceed 27° C. (Use of controlled, sub-freezing, temperatures such as —30±10° C product temperature and carrier temperature is recommended.)

B. Dose:
1. At ambient temperature, 3.5–5.6 Mrad.
2. At —30±10° C, 4.5–5.6 Mrad (Predicted).

V. *Storage:* Same as thermally-sterilized canned foods (no refrigeration).

PORK

FDA Petitions Target Dates:
(*a*) Irradiation at ambient temperature—FY 67.
(*b*) Irradiation at —30±10° C—FY 67.

I. *Raw Material:*

A. Specification PP–00561b:
"Pork: Fresh (chilled or frozen)."
Grade U.S. No. 1; Selection.
(Market cuts)—loins f–4.
Complete boneless, tenderloin removed.

II. *Pre-Irradiation Processing:*

A. Preparation:
1. Remove excess cover fat.
2. If rolls are desired, stuff two whole loins into a No. 7V pre-stuck casing.

B. Enzyme Inactivation:
1. Place loin on pans.
2. Heat by any thermal method to product internal temperature of 70° C.

NOTE.—Use thermocouples and probes to control heating.

III. *Packaging* (Tinplate metal cans with epoxy-phenolic, polybutadiene or oleoresinous "C"-enamel lining):

A. Package (Examples):
Can Size:
404 x 700 (2 lb. 6 oz.).
607 x 700 (4½ lb.).
(Other commercially available metal cans can be used.)

B. Procedure:
1. Cut loin into desired lengths to fit can size.
2. Pack in cans as soon as possible while still hot.
3. Adjust weight using small cut pieces.
4. Close cans immediately:
(*a*) 20 inch vacuum as a minimum
(*b*) Use lids with irradiation sensitive indicators.
5. Irradiate or refrigerate 0–3° C; hold refrigerated not more than 24 hours. If longer preirradiation storage is required, store frozen at —30±10° C.

NOTE.—If frozen controls are desired, randomly select the required number of cans and freeze —29° C.

PORK—continued

IV. *Irradiation:*

A. Product temperature at start of irradiation shall not exceed 4° C. Product temperature at end of radiation shall not exceed 27° C.

NOTE.—Use of controlled sub-freezing temperatures such as −30±10° C product temperature and carrier temperature is recommended.

B. Dose: 4.5–5.6 Mrad (Predicted).

V. *Storage:* Same as thermally-sterilized canned foods (no refrigeration).

SHRIMP

FDA Petition Target Date: FY 67.

I. *Raw Material:*

A. Specification—PP–S–316b:

"Shrimp, Raw and Cooked, Chilled and Frozen."
Type I: Raw.
Condition 1: Chilled.
Form B: Peeled.
Style II: Deveined—with tails removed.

B. Not more than 72 hours post-harvest.

II. *Pre-Irradiation Processing:*

A. Enzyme inactivation:

1. Boil in salt water (2–3%) for 3 to 4 minutes.
2. Cool in cold water to at least 10° C.
3. Drain well before packing.

III. *Packaging* (Tinplate metal can with epoxyphenolic, polybutadiene or oleoresinous "C"-enamel lining):

A. Package (Example): 404 x 700 can; 1 lb. 14 oz., net weight. (Other can sizes can be used depending on purpose.)

B. Procedure:

1. Pack cans immediately after cooling and draining.
2. Add packets of charcoal: 2 to 4% (product wt) to head-space.
3. Close cans immediately:
   (*a*) 28 inch vacuum.
   (*b*) Use lids with irradiation sensitive indicators.

C. Freeze.

NOTE: If frozen controls are desired, randomly select the required number of cans and freeze −29° C.

IV. *Irradiation:*

A. Product temperature at start of irradiation shall not exceed −20° C.

B. Irradiate at −30±10° C controlling both carrier and product temperature.

C. Dose: 4.5–5.6 Mrad (Predicted).

V. *Storage:* Same as thermally-sterilized canned foods (no refrigeration).

OTHER PRODUCTS

Complete irradiation specifications for several products are not available at this time. However, the following irradiation temperature requirements have given acceptable radiation sterilized (about 5 Mrad) products.

Pork sausage	−30±10° C.
Turkey	Ambient to −40° C.
Duck	Ambient to −40° C.
Frankfurters	Ambient to −40° C.
Luncheon meats	Ambient to −40° C.
BBQ pork and chicken	Ambient to −40° C.
BBQ beef	−80° C±10° C.
Corned beef	−80° C±10° C.
Hamburger	−80° C or less.
Lamb	−80° C or less.

[Enclosure D]

COMPANIES RECEIVING INVITATIONS TO PROPOSE

Air Products and Chemicals: Allentown, Pennsylvania 18100; (1) Mr. J. T. Sills, Supervisor-Food Applications, Applied Research and Development; (2) Mr. Dwight Brown.

Allen Products Company, P. O. Box 2187, R. D. 3, Allentown, Pennsylvania 18105; Mr. James G. Schmoyer, Chief, Quality and Research.
American Beef Packers, Inc., Oakland, Iowa 51560, Mr. P. G. Lynch, President.
American Cyanimid Company, 416 Washington Building, NW., Washington, D.C. 20005; Dr. H. G. Klein.
American Home Foods, Milton, Pennsylvania 17847; Mr. Vaughn B. Staller, Manager, Agriculture Division.
American Machine and Foundry (AMF) Whiteford Road, York, Pennsylvania 17402; Mr. Donald H. Weir, Manager, Technical Marketing.
American Meat Institute, National Press Building, Washington, D.C. 20004; Mr. A. Dewey Bond, Washington Representative.
The American Novawood Corporation, 2432 Lakeside Drive, Lynchburg, Virginia 24501; Mr. Lawrence Barrett, President.
American Nuclear Corporation, P.O. Box 426, Oak Ridge, Tennessee 37830; Mr. K. Wayne Graybeal, President.
American Research and Development Corp., The John Hancock Building, Boston, Massachusetts 02116; Gen. George F. Doriot.
Armour and Company, 801 Cermak Road, Oak Brook, Illinois 60521; Mr. W. Lothrop, Head of Corporate Development.
Battelle Memorial Institute, 505 King Avenue, Columbus, Ohio 43201; Dr. Ivan Kinne.
Beta Systems Incorporated, 182 Ninth Street, Passaic, New Jersey; Mr. Chester J. Nadolny.
Bookey Packing Company, P.O. Box 1496, Des Moines, Iowa 50309; Mr. Lester B. Bookey, President.
Boone Chamber of Commerce, 811 Keeler Street, Boone Iowa 50036; Mr. Lawrence R. Erickson, Manager.
C. F. Braun and Company, Alhambra, California 91801; Mr. J. V. Whipp, District Manager, McLean, Virginia 22101.
Bunker Hill Packing Corporation, P.O. Box 525, Bedford, Virginia 24523; Mr. Joseph W. Valiant, II, President; Mr. Ted Muenster, 412 Anderson Building, Lincoln, Nebraska 68508.
Carroll Industrial Development Council, P.O. Box 607, Carroll, Iowa 51401; Mr. W. D. Keith.
Central Soya, Fort Wayne, Indiana 46800; Mr. Norm H. Witte, Manager, Technical Department.
The University of Connecticut, College of Agriculture, Storrs, Connecticut 06268; Mr. Philip G. Stiles, Poultry Science Department, Cooperative Extension Service.
Cook Electric Company, 6401 Dakton Street, Morton Grove, Illinois 60053; Mr. Charles R. Memhardt, Tech-Center Division; Mr. Harold E. Davis, Jr., 2 Torr Street, Andover, Massachusetts 01810.
Fred Dold & Sons Packing Company, 421 East 21st Street, Wichita, Kansas 67214; Mr. John Jaedicke, President.
Douglas United Nuclear, Inc., Richland, Washington 99352; Mr. Bertrand B. Field, Director, Business Research and Area Diversification.
DuPont, 6038 DuPont Building, Wilmington, Delaware 19801; Dr. Edwin A. Gee, Director of Research.
Peter Eckrich and Sons, Inc., P.O. Box 388, Fort Wayne, Indiana 46801; Mr. G. J. Cocoma, Manager, Laboratory Services.
Electra-Process Industries, Inc., Pacific Division, P.O. Box 343, Burlington, Massachusetts 01803; Mr. John McCarthy, President.
Electronized Chemicals Corporation, South Bedford Street, Burlington, Massachusetts 01803; John McCarthy, President.
A. Epstein & Sons, Inc., 2011 West Pershing Road, Chicago, Illinois 60609; Mr. Ralph J. Epstein, Executive Vice President.
Ethicon, Inc., Sommerville, New Jersey 08876; Dr. Charles Artandi, Director of Research Suture Products, Research Division; Mr. Paul Feig, Woodland Road, Salisbury, Maryland 21801.
FMC Corporation, 500 Wyatt Building, 777–14th Street NW., Washington, D.C. 20005; Mr. John A. Rodda, Asst. to the President.
FMC Corporation, P.O. Box 580, 1185 Coleman Avenue, Santa Clara, California 95025; Mr. H. A. Oldenkamp, General Manager.
Food Industries Research and Engineering, 33 South Second Avenue, Yakima, Washington 98902; Mr. Earl W. Carlsen, Director.

Fort Smith Chamber of Commerce, Chamber of Commerce Building, Fort Smith, Arkansas 72901; Mr. Jim Alexander, Chairman, Industrial Committee.
Gamma Process Company, 160 Broadway, New York, New York, 10038; Mr. Jack Armel, President.
General Dynamics Corporation, P.O. Box 608, San Diego, California 92112; Mr. C. A. Rolander, Jr., General Atomics Division.
General Electric Company, Vallecitos Road, Box 846, Pleasanton, California; Mr. G. J. Robertson.
General Mills, Inc., 9200 Wayzata Boulevard, Minneapolis, Minnesota 55440; Dr. J. W. Haun, Vice President & Director of Engineering.
General Radiation Corporation, 1818 South 16th Street, Phoenix, Arizona 85016; Mr. John D. Proynoff, President.
Goed Kist Poultry Growers, P.O. Box 192, Canton, Georgia 30114; Dr. Joseph H. Marshall, Director, Research and Development, Division of Cotton Producers Assn.
B. F. Goodrich Chemical Company, 500 South Main Street, Akron, Ohio 44318; Mr. Edward H. Fitch, Director of Government Relations.
Goren Foods Company, 370 East Eagle Street, Boston, Massachusetts 02128; Mr. Hyman M. Cohen, President.
W. R. Grace & Company, Duncan, South Carolina 29334; Mr. F. W. Greenough, Administrative Assistant, Cryovac Division; Mr. Jack Harbaugh, 327 Ferndale Road, Glen Burnie, Maryland 21061; Mr. Paul F. Harm, City Administrator, City Auditorium, Norfolk, Nebraska 68701.
University of Hawaii, Department of Foods Science and Technology, 1920 Edmondson Road, Honolulu, Hawaii 96822; Dr. James H. Moy, Asst. Prof. of Food Science.
Henry House Packing Company, Inc., 1051 Fourth Avenue, South, Seattle, Washington 98134; Mr. William M. Burke, President.
High Energy Processing Corporation, 9 Maiden Lane, New York, New York; John Flynn, President.
High Voltage Engineering, Burlington, Massachusetts 01803; Mr. David A. Trageser, Industrial Sales Manager.
Hygrade Food Products Company, 11801 Mack Avenue, Detroit, Michigan 48214; Mr. Wells Hunt, Vice President.
Holly Farms Poultry Industries, Inc., North Wilkesboro, North Carolina 28659; Mr. E. S. Kendrick, Executive Vice President.
Holmes & Narver, Inc., 828 South Figueroa Street, Los Angeles, California 90017; Mr. John Garrick; Mr. Ted A. Holtgrewe, Marketing Specialist, Division of Nebraska Resources, Box 446, State Capitol, Lincoln, Nebraska 68501.
George A. Hormel & Company, Austin, Minnesota 55912; Mr. J. A. Zilgitt, Research Director.
Industrial Opportunity Incorporated, 326 First National Bank Building, Rochester, Minnesota 55901; Mr. William H. Harrison, Executive Vice President.
Intercontinental Development Associates, 151 North Main Street, Cohasset, Massachusetts 02025; Mr. John A. Gillis, Vice President.
B.N.S. International Sales Corporation, 52 Broadway, New York, New York 10004; Mr. Frank Mayo, Staff Representative, Foreign Trade Division.
Institute of American Poultry Industries, 425 13th Street NW., Washington, D.C. 20004; Mr. Carl Scott.
Iowa Development Commission, 250 Jewett Building, Des Moines, Iowa 50309; Dr. Richard R. Konicek, Director of Research.
Isochem, Inc., Richland, Washington 99352; Mr. E. T. O'Sullivan, Vice President, Marketing.
Iso Nuclear Corporation, 260 Hamilton Road, Chappaqua, New York 10514; Mr. William A. Loeb, President.
Isotopes Incorporated, 123 Woodland Avenue, Westwood, New Jersey 07675; Mr. Carl Wooten.
State of Kansas, Department of Economic Development, State Office Building, Topeka, Kansas 66612; Mr. Robert Martin, Deputy Director.
Kansas Gas & Electric Company, Wichita, Kansas 67201; Mr. George E. Billings, Director, Industrial Development Sales.
King Meat Packing Company, 3349 Packers Avenue, Los Angeles, California 90058; Mr. Raymond Rosenthal; Mr. J. W. Lesslie, Jr., Apartment 5A, Highland Park Apartments, 3800 West Avenue, Columbia, South Carolina 29203.

Liggett and Myers Tobacco Company, Inc., 630 Fifth Avenue, New York, New York; Mr. Fred Bates, Director of Research.
Lockheed-Georgia Company, 86 South Cobb Drive, Marietta, Georgia 30060; Mr. Roy O. Jones, Sales Representative.
Mankato Cold Storage, Mankato, Minnesota 56001; Mr. Morton J. Kaplan.
Oscar Mayer & Company, Inc., Madison, Wisconsin 53700; Mr. Harold T. Jaeke, Vice President, Engineering and Research.
Martin Company, Middle River, Maryland; Mr. Henry Rosenthal, Mail #717.
Meat Packers Equipment Company, 1226 49th Avenue, Oakland, California 94601; Mr. Julian Anabo, Sales Manager.
John Morrell & Company, 208 South La Salle Street, Chicago, Illinois 60604; Mr. W. W. McCallum, President.
John Morrel & Company, Ottumwa, Iowa 52501; W. L. Brown, Ph. D., Vice President, Research.
McFarling Brothers, 326 West 17th Street, Indianapolis, Indiana 46202; Mr. Robert McFarling.
Nuclear Materials & Equipment Corporation, Apollo, Pennsylvania 15613; Mr. Zalman M. Shapiro, President.
National Broiler Council, 1158 15th Street NW., Washintgon, D.C. 20005; Mr. Franklyn Frazier, Executive Secretary.
National Canners Association, 1133 20th Street NW., Washington, D.C. 20006; Mr. James R. Reed, Washington Research Laboratory.
National Dairy Products Corporation, Research and Development Division, Glenview, Illinois 60025; Mr. Arnold H. Johnson, Consultant.
National Independent Meat Packers, Assn., 1820 Massachusetts Avenue NW., Washington, D.C. 20036; Mr. John Killick, Executive Secretary.
National Meat Canners Association, National Press Building, Washington, D.C. 20004; Mr. A. Dewey Bond, Executive Secretary.
New York State Atomic and Space Development Authority, 230 Park Avenue, New York, New York 10017; James G. Cline, Program Manager.
North Side Packing Company 2200 Spring Garden Avenue, Pittsburgh, Pennsylvania 15212; Mr. Robert G. Hofmann, President.
Nuclear Technology Corporation, 116 Main Street, White Plains, New York; Mr. Joe DeFelice, President.
Oklahoma City Chamber of Commerce, 1629 K Street NW., Suite 510, Washington, D.C. 20006; Mr. Lewis N. Bayne, Washington Director; Mr. Ralph T. Overman, Consulting Service, Box 367, Oak Ridge, Tennessee 37831.
Overseas Service Corporation, 4200 Cathedral Avenue NW., Washington, D.C. 20016; Gen. George A. Horkan (USA Ret.) Representative.
Parsons-Jurden Corporation, 26 Broadway, New York, New York; Mr. J. Harry Frankfort.
Peck Meat Packing Corporation, 231 South Muskego Avenue, Milwaukee, Wisconsin 53203; Mr. Bernard Peck.
Peninsula Meat Company, 41 South Railroad Avenue, San Mateo, California 94401; Mr. Thomas Dinette.
Picker-X-Ray Corporation, 1020 London Road, Cleveland, Ohio 44112; Mr. Robert W. Arndt, Research Center; Mr. Robert E. Plott, 6342 Castejon Drive, La Jolla, California 92037; Mr. Harry N. Pollock, 823 Garrison Avenue, Fort Smith, Arkansas 72901.
Polo Food Products Company, 117 South Water Market, Chicago, Illinois 60608; Dr. Earl Auerbach, Director of Research & Development.
Port of Kennewick, P.O. Box 1113, 222 West Kennewick Avenue, Kennewick, Washington 99336; Mr. John F. Neuman, Manager.
Port of Pasco, Pasco, Washington 99301; Mr. H. W. Parkinson, President.
Port of Walla Walla, Walla Walla, Washington 99362; Mr. Bill Ray, President.
Rad Mat, Inc., 1629 K Street NW., Washington, D.C. 20006; Mr. James Kelly, Director of Operations.
Radiation Dynamics, Inc., 1800 Shames Drive, Westbury, L.I., New York 11590; Mr. Philip Maniscalco, Asst. to the President.
Radiation Facilities, Inc., 63 Dell Glen Avenue, Lodi, New Jersey 07644; Mr. Hector C. Cusumano, President.
Rath Packing Company, Elm & Sycamore Street, Waterloo, Iowa 50703; Mr. Joe Gibson, President.
Raycon, Inc., 300 Governors Highway, South Windsor, Connecticut; James H. Lennon, President.

Reliable Packing Company, 1440 West 47th Street, Chicago, Illinois 60609; Mr. John E. Thompson, President.
Reynolds, Smith, & Hills, 4019 Boulevard Center Drive, Jacksonville, Florida; Mr. James B. McCullough.
Rockwood Industrial Development Board, 306 West Rockwood Street, Rockwood, Tennessee 37854; Mr. Harry M. Seward, Executive Secretary.
Ryan Associates, 908 Massachusetts Avenue NE., Washington, D.C. 20002; Mr. Irwin M. Ryan, President.
Jacob M. Schaffer Associates, 4000 Powder Mill Road, Beltsville, Maryland; Mr. Jacob M. Schaffer, President.
Schluderberg-Kurdle Company, Inc., Baltimore, Maryland 21200; Mr. William G. Hupfeldt, President.
Seattle Field Office, U.S. Department of Commerce, 809 Federal Office Building, Seattle, Washington 98104; Mr. John F. Durr, Manager, Domestic Commerce Division.
Seitz Packing Company, Box 247, St. Joseph, Missouri 64502; Mr. E. Y. Lingle, President.
Shanks Packing Company, Inc., 13th and Hayes, Mattoon, Illinois 61938; Mr. R. E. Shanks, President.
Southern Nuclear Engineering, P.O. Box 10, Dunedin, Florida; Mr. W. A. Maxwell.
St. Joseph Newspress & Gazette, St. Joseph, Missouri 64500; Mr. David Bradley, Publisher.
Starr Parker Associates, 1210 Spring Street, NW., Atlanta, Georgia 30309; Mr. R. Starr Parker.
B. J. Stralser, Conductron-Missouri, Box 426, St. Charles, Missouri 63301.
Swift & Company, 115 West Jackson Boulevard, Chicago, Illinois 60604; Mr. John F. Murphy, Vice President.
Tama Packing Company, 4401 Sixth Street SW., Cedar Rapids, Iowa 52406, Mr. Sam H. Rudnick, General Manager, Meat Division & Assistant to the President.
Textron, Inc., 10 Dorrance Street, Providence, Rhode Island 02903; Mr. Joseph B. Collinson, Executive Vice President.
Tracerlab, Technical Services Department, 1601 Trapelo Road, Waltham, Massachusetts 02145; Mr. Louis S. Sebok, Assistant to the President.
Tri-City Nuclear Industrial Council, Inc., Pasco, Washington 99301; Mr. Robert F. Philip, President.
The Tupman Thurlow Company, Inc., 327 South La Salle Street, Chicago, Illinois 60604; Mr. F. P. Neff.
Vacuum Barrier Corporation, 4 Marten Lane, Woburn, Massachusetts 01801; Mr. Harold E. Davis, Jr.
Varian Associates, 611 Hansen Way, Palo Alto, California 94301; Mr. Richard Lavine, Manager, Applications, Research & Development.
Western Nuclear Corporation, P.O. Box 1156, Idaho Falls, Idaho 83401; Mr. George A. Freund, President.
Western States Meat Packers Association, Inc., 917 15th Street NW., Washington, D.C. 20005; Mr. L. Blaine Liljenquist, President & General Manager.
Wilson & Company, Prudential Plaza, Chicago, Illinois 60601; Mr. John L. Cockrill, Vice President.
The Whipple Company, 58 North Main Street, Natick, Massachusetts 01760; Mr. Alvin W. Crain, General Manager.
York Chamber of Commerce, McCloud Hotel, York, Nebraska 63467; Mr. Daniel Austin.
Zapalac's Food Lockers, P.O. Box 876, Bellville, Texas 77418; Mr. Frank W. Zapalac.
Lemm Industries, Inc., 14851 East Whittier Boulevard, Whittier, California 90605; Mr. R. Husted.
Tri-City Herald, Cascade and Front Streets, Kennewick, Washington 99336; Mr. Carroll Clark, Editorial Department.
Stone and Webster Engineering Corp., Garden City Division, 975 Stewart Avenue, Garden City, L.I., New York; Dr. Phillip Miller.
Research Foundation of Kansas, 708 KPL Tower, Topeka, Kansas 66612; Executive Director, Dr. Christopher E. Barthel, Jr.

APPENDIX 15

CORRESPONDENCE BETWEEN REPRESENTATIVE PRICE AND DEPARTMENT OF THE ARMY ON PILOT PLANT MEAT IRRADIATOR

CONGRESS OF THE UNITED STATES,
JOINT COMMITTEE ON ATOMIC ENERGY,
November 15, 1966.

Hon. STANLEY R. RESOR,
Secretary of the Army,
Washington, D.C.

DEAR MR. SECRETARY: With the Joint Committee's encouragement, the Atomic Energy Commission has for several years been cooperating with the Department of the Army in the field of research and development on food preservation by radiation. As an example, the Commission agreed to cooperate with the Army and to solicit proposals for the private construction and operation of a facility known as a pilot plant meat irradiator on the following basis: the Commission to undertake to provide design assistance and a radiation source to an acceptable entrepreneur; the Army to undertake a commitment, in the early years, to purchase from this facility irradiated meats that had Food and Drug Administration clearance.

You may recall that in June 1965 at my Subcommittee's hearings on the radiation processing of foods, Assistant Secretary Hawkins testified with regard to such a proposed pilot plant irradiator. In this connection, he noted that such a facility is still in the development phase and "we will have to give someone an order big enough" if he is to build such a facility.

In September of this year, my Subcommittee again held hearings to review developments in the food irradiation program. I must say that I was surprised to hear that no real progress had been made in the previous fifteen months to get a proposal out for the pilot plant meat irradiator. I therefore asked the Commission to get on with the task of seeking such a proposal and to do so by the end of October. Although that deadline has now passed, it is my understanding that the AEC several weeks ago furnished a draft request for proposal to the Army but that to date the Department of the Army has not responded.

Mr. Secretary, I would like to solicit your aid in expediting the Army's actions on this project and urge the Army to commit itself, as best it can, to the procurement recommendations of the Interagency Task Force on the pilot plant meat irradiator.

I expect to hold additional hearings on the food irradiation program early next Congress and would hope that this project would be well underway by then.

With all best wishes,
Sincerely yours,

MELVIN PRICE,
Chairman, Subcommittee on Research, Development and Radiation.

DEPARTMENT OF THE ARMY,
Washington, D.C., November 29, 1966.

Hon. MELVIN PRICE,
Joint Committee on Atomic Energy,
House of Representatives,
Washington, D.C.

DEAR MR. PRICE: Thank you for your letter of November 15, 1966, to the Secretary of the Army concerning the proposed pilot plant meat irradiator.

On October 24, 1966, the Atomic Energy Commission forwarded a draft Request for Proposal for the private construction and operation of the pilot plant to the Department of the Army for review and, in addition, requested that the Army coordinate and aggregate the requirements of the other Services for irradiation-sterilized meats. Because of budget implications, procurement regulations, legal considerations, and the need for the other Services to determine their precise requirements over an extended period, I advised the AEC on November 7, 1966, that it would be necessary to undertake formal coordination with the Navy, the Air Force, the Marine Corps, and the Defense Supply Agency in order to prepare a definitive reply.

As soon as the legal aspects of sole source procurement from the proposed pilot plant can be resolved, I will forward the Army comments on the draft Request for Proposal to the AEC and provide the combined requirements of the Military Services for irradiation-sterilized meats to be included in the Request for Proposal. These requirements are 300,000 pounds annually for a three year period. As stated in the Army testimony before your Subcommittee on September 12, 1966, these initial procurements will be for testing and logistical evaluation. Although commitments to utilize larger quantities of irradiation-sterilized products must be deferred until after adequate testing of each product, the testimony cited specific examples of forecasted large-scale Army needs for irradiated meats.

I wish to assure you of continued Army interest and support of the pilot plant project to further the ultimate realization of irradiation-sterilization of foods as a commercially feasible process.

Sincerely,

R. D. O'NEAL,
Assistant Secretary of the Army (R. & D.),

APPENDIX 16

CORRESPONDENCE BETWEEN AEC AND THE JOINT COMMITTEE ON ATOMIC ENERGY ON PROGRESS OF REQUEST FOR PROPOSALS FOR PILOT PLANT MEAT IRRADIATOR

ATOMIC ENERGY COMMISSION,
December 14, 1966.

Mr. JOHN T. CONWAY,
Executive Director,
Joint Committee on Atomic Energy,
Congress of the United States.

DEAR MR. CONWAY: As promised in my letter of December 1, 1966, I am attaching a copy of Assistant Secretary of the Army (R. & D.) Robert O'Neal's letter to me commenting on our draft request for proposals (RFP) for the Pilot Plant Meat Irradiator.

Secretary O'Neal's letter specifies that the Services will guarantee procurements totaling 300,000 pounds per year for each of the first three years of plant operation, to be procured from this plant. Although I am disappointed at the relatively low procurement quantity, as opposed to the Task Force recommendations, we now have a minimum basis for finalizing our RFP and soliciting industry interest. We plan to issue the RFP at an early date.

Needless to say, we are gratified that this major coordination hurdle has been overcome, and we look forward to the further conduct of the program. We will keep you fully apprised of industry interest and progress as this project develops.

Cordially,

JAMES T. RAMEY,
Commissioner.

HEADQUARTERS, DEPARTMENT OF THE ARMY,
OFFICE OF THE ASSISTANT SECRETARY,
December 7, 1966.

Mr. JAMES T. RAMEY,
Commissioner, Atomic Energy Commission,
Washington, D.C.

DEAR MR. RAMEY: In accordance with my letter to you of November 7, 1966, on the Pilot Plant Meat Irradiator Project, I am pleased to provide to you the combined requirements of the Military Services for irradiation-sterilized meat products for a three-year period commencing with the availability of a commercial procurement source. These requirements for insertion into the AEC Request for Proposal (RFP-paragraph II.B.I), are as follows:

	Pounds
1st year	300,000
2d year	300,000
3d year	300,000

These procurements over a three-year period will be for large-scale testing purposes to determine the applicability of irradiation-sterilized food products to the multiple ration systems in use in the Military Services.

Enclosure "A" of the Request for Proposal (RFP) properly informs the prospective offerer that future procurement will be subject to availability of funds and product acceptability. The draft letter accompanying the RFP may lead offerers to a contrary conclusion. It is requested, therefore, that the sentence of the draft letter commencing on line 4, page 3, be revised as follows:

"The Department of Defense will provide technical liaison and scientific assistance as indicated in Enclosure "A", and will purchase meats in at least the volume indicated in Enclosure "A", *subject to the availability of funds and product acceptability.*" (Added phrases italicized.)

The Defense Supply Agency (DSA) will undertake to purchase the 300,000 pounds of irradiation-sterilized foods for each of the first three years of operation of the proposed pilot plant facility, subject to the provisions stated in the RFP when modified in accordance with the requests in this letter. These purchases will be made from the successful AEC contractor at prices arrived at by application of the provisions within Item 8 of Enclosure "B" to the RFP. To comply with specific DSA requirements, it is requested that Item 8 be revised as follows:

"Item 8. *Cost Estimate*

"Furnish a detailed estimate of capital costs which you anticipate will be required for facility design and construction. Also provide a proposed project staffing plant and an estimate of yearly operating expenses. A discussion of amortization plans should be included. Price to the DOD for proposed military procurements should be indicated by year, as FOB prices at the plant, including all processing costs but excluding cost of the raw material. Cost of the raw material will be based on actual market prices in effect on the dates of government purchases from the contractor. Raw material prices utilized will be market prices officially published by the Department of Agriculture for the particular raw material item involved or, in the case of meats, the daily market prices published in *The National Provisioner Daily Market Service* (the 'yellow sheet')."

The approved petition for irradiation-sterilized bacon was submitted to the Food and Drug Administration (FDA) as representative of a class of foods, i.e., cured, smoked meats. It was not submitted because there was a significant military requirement for irradiation-sterilized bacon *per se*. The military requirements for irradiation-sterilized bacon are very limited at present. It is requested, therefore, that the RFP and its accompanying letter state that there is no significant military requirement for irradiation-sterilized bacon for the initial three-year period of pilot plant production, but that there are military needs for a variety of meat items including ham, pork, beef, chicken, frankfurters and luncheon-type meats.

The planning schedule in the RFP (Enclosure "A", paragraph III) for submission of petitions to the FDA does not reflect the revised schedule presented by the Army to the Subcommittee on Research, Development and Radiation, Joint Committee on Atomic Energy, on September 12, 1966. It is requested that the table in the RFP commencing on page 3 of Enclosure "A" be altered to state that the planned time of petition submission to FDA for chicken, beef and shrimp is FY 68. The remaining items in the table are listed correctly.

Subject to the above comments, the Army concurs in the draft RFP and its accompanying letter. In closing, I would like to express my regret for the delay in providing you with comments on the draft RFP and with the procurement requirements of the combined Military Services, necessitated by the formal actions required with the other Military Services and the DSA. I believe we have made substantive progress by these formal actions which have placed the military participation in the proposed pilot plant on a firm foundation. I look forward to learning about the responses you receive from industry resulting from the issuance of the RFP.

Sincerely,

R. D. O'NEAL,
Assistant Secretary of the Army (R. & D.).

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