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This section of the FEDERAL REGISTER contains documents other than rules or proposed rules that are applicable to the public. Notices of hearings and investigations, committee meetings, agency decisions and rulings, delegations of authority, filing of petitions and applications and agency statements of organization and functions are examples of documents appearing in this section.

DEPARTMENT OF AGRICULTURE

Food Safety and Inspection Service

[Docket No. 95–025N]

Comparison of Methods for Achieving the Zero Tolerance Standard for Fecal, Ingesta, and Milk Contamination of Beef Carcasses: Notice of Conference

AGENCY: Food Safety Inspection Service, USDA.

ACTION: Notice.

SUMMARY: The Food Safety and Inspection Service (FSIS) will host a conference to consider ''Achieving the Zero Tolerance Standard for Fecal, Ingesta and Milk Contamination on Beef Carcasses'' on October 23 and 24, 1995, from 8:30 a.m. to 5 p.m., at the United States Department of Agriculture in Washington, DC. The conference will consist of two sessions on consecutive days. At the first day's session, participants will discuss available scientific and technical data comparing the efficacy of the methods for achieving the zero tolerance standard for fecal, ingesta, and milk contamination of beef carcasses. Participants are invited to make presentations regarding this scientific and technical data during this first session. At the second day's session, participants will discuss relevant public policy issues, including public heath, regulatory, and economic issues.

The input provided at this conference will be taken into account by FSIS in deciding whether to approve any methods in addition to trimming for achieving the zero tolerance standard.

ADDRESSES: The conference will be held at the U.S. Department of Agriculture, in the back of the South Building Cafeteria, (between the 2nd and 3rd wings), 14th Street and Independence Avenue, SW., in Washington DC. Persons wishing to make presentations at the first session of the conference are requested to submit in advance brief statements describing the general topics of their presentations. Send descriptions to Dr. William James, Director, Slaughter Inspection Standards and Procedures Division, FSIS, USDA, Room 202 Cotton Annex, 300 12th Street, SW., Washington, DC 20250.

FOR FURTHER INFORMATION CONTACT: For further information, contact Dr. William James at (202) 720–3219.

SUPPLEMENTARY INFORMATION:

Background

Effective prevention and removal of fecal, ingesta, and milk contamination are among the most important steps companies must take to ensure the safety of beef carcasses. Such contamination may harbor *E. coli* 0157:H7, *Salmonella*, and other enteric pathogenic microorganisms. FSIS has a zero tolerance standard for fecal, ingesta, and milk contamination of beef carcasses, and is continually seeking the most effective, scientifically supportable means of implementing this standard.

The policy of FSIS has been to require the physical removal of all feces, ingesta, and milk from beef carcasses by trimming. Before February 1993, however, ambient temperature washes were sometimes used to remove small flecks of contaminants. Use of ambient temperature water washes for this purpose varied across the country and among inspection personnel. A distinction between flecks of contamination as to their source was not always made, i.e., determinations were not made about whether flecks were fecal contamination or rail dust, and, in some localities, whether they could be removed by washing.

In February 1993, after an outbreak of *E. coli* 0157:H7 in several Western States, FSIS reinforced that trimming was to be the only means of removing feces, ingesta, and milk contamination from beef carcasses. The trim-only policy was based on the judgment that trimming was more effective for removing fecal contamination than alternative approaches. At the time, there were no scientific data available to the Agency comparing the efficacy of trimming and alternative procedures.

Trimming, if performed properly, is an effective means of physically removing from beef carcasses the visible contamination and any accompanying microbial contamination. A primary conceptual advantage of trimming over ambient temperature washing is that it physically removes visibly contaminated tissue (which is more likely to be microbiologically contaminated) rather than relying on a wash to remove bacteria that, depending on the circumstances, may be firmly attached. Also, trimming, when properly performed, is presumed to have less potential than ambient temperature washing for spreading contamination to other parts of the carcass. On the other hand, if trimming is performed incorrectly, it has the potential to cause cross-contamination as the knife moves from areas contaminated with bacteria to newly exposed uncontaminated areas. The effectiveness of trimming also depends on the skill of the operator in visually detecting and effectively removing contamination, while avoiding further contamination by handling the carcass during this process.

Strict enforcement of the policy requiring that trimming be the only means to achieve zero tolerance, following the 1993 *E. coli* 0157:H7 outbreak in the Western States, was also based on the Agency's need to directly and aggressively remove any potential source of pathogenic contamination. FSIS believes that strict enforcement of the trim-only approach was appropriate, based on the information available at the time.

Since 1993, numerous other approaches to removing contamination have been devised and studied to assess their potential as effective alternatives or supplements to carcass trimming to achieve the zero tolerance standard. FSIS is now considering whether to permit the use of some or all of these alternative approaches. The following material reviews current scientific data concerning different approaches to achieving the zero tolerance standard for fecal, ingesta, and milk contamination on beef carcasses, as they would apply under commercial conditions.

Data Review

I. Condition of the Animal on Arrival at the Abattoir

Any discussion of the sources of pathogen contamination on beef carcasses must consider animal husbandry practices and the farm environment (Hancock *et al.*, 1994), the possibility of cross-infection during transport (Gronstol *et al.*, 1974 a, b), and

lairage of the animals before slaughter (Anderson *et al.,* 1961; Grau *et al.,* 1968). The practice of regularly cleaning and disinfecting transport vehicles and holding facilities reduces the level of bacterial contamination in the environment and decreases the risk of pathogens being spread between live animals (ICMSF, 1988).

Soil, feces, and moisture present on the hides and feet/hooves of animals entering the slaughterhouse pose a considerable challenge to hygienic slaughtering practices (Troeger, 1995). Seasonal and geographical factors, together with animal management systems, have a tremendous effect on the cleanliness of live animals presented for slaughter.

Although it would be desirable to exclude grossly contaminated animals from the slaughterhouse, Mackey and Roberts (1991) concluded that such an action could be difficult to rationalize and enforce. Data from Finland, however, indicate that exclusion of cattle carrying excessive loads of soil and manure can be accomplished, with resulting improvements in meat hygiene (Ridell and Korkeala, 1993). As a result of imposing regulations requiring that excessively dirty cattle either be slaughtered at a ''casualty'' abattoir or processed separately at the end of the day using extra care (with any extra costs being incurred by the farmer), the number of ''excessively dungy'' animals presented at slaughter in Finland has decreased dramatically. Exclusion of grossly contaminated cattle is deemed justifiable since such animals yield more highly contaminated carcasses, even when slaughtered with extreme care and using reduced line speeds. Carcasses from ''excessively dungy'' cattle had, on average, 5-fold more microorganisms per cm^2 than carcasses from ''control'' cattle despite the added precautions.

Attempts have been made to clean live animals following arrival at the slaughterhouse. In general, however, these efforts have not been regarded as effective (Empey and Scott, 1939; Roberts, 1980). Though Empey and Scott estimated that a cold water wash reduced the bacterial levels present on cattle by approximately one-half, such treatments have to be applied in such a manner as to restrict later potential microbial growth on a wet hide and reduce practical difficulties associated with handling wet, slippery hides. These investigators also conducted small-scale experiments on the effects of hot water and chlorine on microbial loads of hide-on cattle feet (not live animals). While chlorine showed some potential, application of hot water was thought by the authors to have practical limitations for live animals as water temperatures of 75 to 80°C were necessary to achieve significant microbial inactivation. Animal welfare concerns and the effect on meat and hide quality may complicate or preclude application of such antimicrobial treatments to the live animal.

II. Bacterial Contamination During Slaughter

It is generally agreed that deep muscle tissue of healthy live animals is essentially sterile (Gill, 1979, 1982; Zender, *et al.,* 1958). During slaughter and dressing procedures, the surfaces of livestock carcasses become contaminated with microorganisms. The extent of this contamination varies depending on the condition of the animal upon arrival at the establishment and methods used during slaughter and dressing (Roberts, 1980). Contamination of carcasses is undesirable, but cannot be completely avoided, even under the most hygienic conditions (NRC, 1985; Roberts, 1980; Roberts *et al.,* 1984; Grau, 1987; Dixon *et al.,* 1991).

When meat is produced under hygienic conditions, numbers of pathogens contaminating the surface of the carcass are usually small, and the micro-flora consists primarily of saprophytic bacteria, such as *Pseudomonas.* Results from beef carcasses sampled for pathogens and other bacteria of interest, reported in *Nationwide Beef Microbiological Baseline Data Collection Program: Steers and Heifers,* reflect low numbers of pathogens contaminating the surface of beef carcasses. *Staphylococcus aureus* and *Listeria monocytogenes* were recovered from approximately 4% of 2,000 beef carcasses. *Salmonella* and *Escherichia coli* 0157:H7 were recovered from 1% and 0.2%, respectively, of more than 2,000 beef carcasses. Only 3.6% of the carcasses had coliform counts greater than 100 colony-forming units (CFU)/cm^2 (2.0 logs) and 6.9% of the carcasses had aerobic plate counts of over 10,000 CFU/cm^2 (4.0 logs). Although raw meat containing over 10,000 CFU/cm^2 of non-pathogenic spoilage bacteria does not present a health risk, it is generally considered aesthetically undesirable, has reduced shelf-life, and is often viewed as having been produced unhygienically.

Good hygienic practices during the slaughter and dressing of livestock are critical to safeguard the microbiological safety and quality of meat (Empey and Scott, 1939; Ayres, 1955; ICMSF, 1988). Adherence to good hygienic practices, however, does not preclude the presence of pathogenic bacteria on the final dressed carcass. *Salmonella, E. coli* 0157:H7, *Listeria monocytogenes,* and *Campylobacter jejuni* have all been recovered from hygienically-slaughtered beef carcasses (Stolle, 1981; Weissman and Carpenter, 1969; Chapman *et al.,* 1993; Loncarevic *et al.,* 1994; Stern, 1981; Gill and Harris, 1982).

Feces, ingesta, and milk from infected cows may contain *Salmonella, E. coli* 0157:H7, and other pathogens (Grau *et al.,* 1968; Munroe *et al.,* 1983; Martin *et al.,* 1986). Accidental carcass contamination with feces, ingesta, and milk is thought to be the primary route by which pathogens enter the food chain (Chapman *et al.,* 1993). Removing such visible contamination from carcasses should reduce the risk to consumers but is unlikely to produce pathogen-free carcasses.

Slaughter Floor Contamination

The main direct sources of carcass microbial contamination on the slaughter floor include the animal (especially the hide and feet/hooves), dressing equipment and tools, personnel and their clothing, and the plant environment. Water is sometimes mentioned as a possible source of microorganisms, but this association is largely historical since contemporary abattoirs use exclusively potable water (or reconditioned water of equivalent microbiological quality). Similarly, the contribution of airborne microbes to carcass contamination on the slaughter floor has been mentioned, but Roberts (1980) concluded that, ''air deposits only tens or hundreds of microorganisms per cm^2 per hour, where operatives and equipment carry tens or hundreds of thousands—or even millions.''

Although some microbial contamination of deep-muscle tissues may occur during stunning and bleeding processes when intact skin is broken, thus allowing bacteria to enter the bloodstream, these actions do not generally introduce significant numbers of bacteria (Roberts and Hudson, 1986). The primary source of bacterial contamination of the carcass is generally the hide (Empey and Scott, 1939; Ayres, 1955; Newton *et al.,* 1978; Smeltzer *et al.,* 1980a). During the initial stages of hide and leg removal, microorganisms present on the hide are transferred to subcutaneous tissue by the skinning knife. Additional microbes may be directly transferred to the subcutaneous tissues from the hide when a loose outer flap of the hide contacts the carcass surface during hide pulling (Mackey and Roberts, 1991). Contamination may also be transferred indirectly from the

tools, hands/arms, and clothing of workers (Mackey and Roberts, 1991). A classic example is a worker holding the carcass with an unwashed hand that previously had been in contact with the outer surface of the hide.

Studies have shown that workers handling hide-on beef carcasses are more likely to have a higher incidence and prevalence of salmonellae on their hands than are personnel performing other on-line tasks (Smeltzer *et al.,* 1980b). Similarly, knives and other equipment used for hide removal are more likely to be contaminated with *Salmonella* than are implements used for other operations (Peel and Simmons, 1978; Smeltzer *et al.,* 1980a). Grau (1979) found that *Salmonella* contamination was especially likely to occur when a knife was used to free the rectum and anal sphincter during hide removal. Studies have shown that knife decontamination in hot water is often an inadequate means of inactivating *Salmonella* and other bacteria on the knife surface, usually because of insufficient exposure time (Peel and Simmons, 1978). Greater than 10 seconds exposure was necessary for microbial inactivation when a contaminated knife was dipped in 82°C water. Cross-contamination is reduced when knives and other implements are frequently decontaminated, and hands, arms, and aprons are washed and sanitized regularly (Norval, 1961; Childers *et al.,* 1973; Peel and Simmons, 1978; Roberts, 1980; Smeltzer *et al.,* 1980a and b; de Wit and Kampelmacher, 1982; Grau, 1987).

After the removal of hide, hooves, and head, most subsequent microbial contamination is attributable to the hygienic practices of the workers or technical errors, such as puncturing the animal's gastrointestinal tract (Roberts, 1980). Knives and other equipment used for evisceration are generally less contaminated than tools used for hide and leg removal (Smeltzer *et al.,* 1980a). The incidence of *Salmonella* on beef carcasses, knives, and aprons increases at the stage of evisceration, but to a lesser degree than during hide and leg removal (Stolle, 1981; Smeltzer *et al.,* 1980a). Thorough training and careful evisceration practices (especially closing off the ends of the gastrointestinal tract and removing the intestines from the body cavity) are necessary to prevent carcass contamination with ingesta or feces (Grau, 1987; ICMSF, 1988; Mackey and Roberts, 1991).

Microbiological contamination acquired during the slaughter and dressing process of livestock is not spread evenly over the carcass, and may be expected to vary between sides of the same carcass, between different carcasses processed on the same day at an abattoir, between carcasses produced on different days at an abattoir, and between carcasses produced at different establishments (Empey and Scott, 1939; Kotula *et al.,* 1975; Ingram and Roberts, 1976; Roberts 1980; Johanson *et al.,* 1983). This variability can be due to a number of factors, such as differences in dressing methods, worker skill, application of washing or other carcass treatments, season of the year, and weather.

III. Attachment of Bacteria

The rate of attachment, growth, and multiplication of bacteria on carcasses is dependent on the structure, composition, and water activity of the exposed tissues, the acidity of the surface, the temperature of air and the carcass, the bacterial strain, and various bacterial attachment mechanisms (Lillard, 1985). The skinned ''hot'' beef carcass provides an ideal environment for bacterial survival and multiplication. Surfaces of chilled carcasses, especially those that have experienced significant dehydration, may be less attractive sites for bacterial attachment.

The process by which bacteria attach to meat surfaces is believed to consist of two stages. The first stage is where bacteria are either attached by weak physical forces or freely floating in the water film that covers the meat surface. The second stage is characterized by a stronger attachment mechanism involving, in part, the formation of polysaccharides over time (Firstenberg-Eden, 1981). This consolidation stage is followed by colonization or growth of the microbes on the meat tissue. Once attachment and colonization have occurred, it is very difficult to completely remove pathogenic microorganisms from meat or poultry surfaces by normal processing methods (Benedict *et al.,* 1991).

There is considerable variability among bacteria in their ability to attach to different surfaces. This is likely to be a reflection of the different mechanisms (including pili, flagella, extracellular polymers) used by different bacteria. It has been suggested that bacteria from feces attach more strongly and in higher numbers than the same bacteria grown in laboratory media or meat surfaces (Notermans *et al.,* 1980). Enhanced binding by bacteria present in feces may have to be considered when evaluating the efficacy of carcass decontamination treatments.

It appears that specific bacterial binding sites (receptors) exist on animal cells. Collagen, in particular, seems to be a target for bacterial attachment (Mattila and Frost, 1988; Benedict *et al.,* 1991). Notermans and Kampelmacher (1983) concluded that attachment cannot be completely prevented by manipulating water sprays or baths through the addition of chemicals or manipulating pH. Therefore, the only way to absolutely prevent attachment is to prevent contact between bacteria and meat. While bacteria are still freely floating in the water film, they can be displaced using clean water (Notermans and Kampelmacher, 1983). Measures designed to block attachment should be applied as soon as possible following contamination. Two points on the slaughter line that appear to be likely sites for the application of carcass sprays are following hide removal and following evisceration.

IV. Methods To Decrease Carcass Contamination

In addition to trimming as a means of removing bacteria associated with visible contamination, bacteria are removed from carcasses by several recommended methods, such as rinsing or washing with water (both hot and ambient temperatures), either with or without one of several approved food-grade organic acids (lactic, acetic, or citric) or chemical sanitizers, such as chlorine. Each of these factors is reviewed in the following sections for its relevance to beef carcass decontamination.

A. Water Rinsing

Rinsing a carcass can remove physical contamination (dirt, hair, fecal matter, etc.) to a varying degree, carrying with it some of the resident microorganisms. As indicated above, interventions of this type or others that physically remove bacteria should be used as early as possible after likely introduction of contamination (e.g., after hide removal) to prevent or retard bacterial attachment and growth. Various factors associated with rinsing carcasses can be manipulated, increasing the effectiveness of this approach. Major factors include water temperature, water pressure, line speed, and method of application (Anderson *et al.,* 1979; Crouse *et al.,* 1988). While numerous studies have examined the efficacy of washing techniques, most investigations have been conducted under research conditions, and only a few have directly evaluated effectiveness in production settings.

The use and timing of hot water (95° C) application during processing were investigated by Barkate *et al.* (1993) to determine effectiveness in reducing the numbers of naturally

occurring bacteria on beef carcass surfaces. They found a 1.3 $\log_{10}$ CFU/cm^2 reduction in aerobic plate counts (APCs) for samples sprayed with hot water before the final carcass rinse as compared to a 0.8 $\log_{10}$ CFU/cm^2 reduction in samples sprayed with hot water after the final rinse. The fact that fewer bacteria were removed from the samples sprayed with hot water after the final rinse may have been due to the length of time (approximately 15 to 20 minutes) that elapsed before hot water was applied. In this connection, the authors interpreted Butler *et al.* (1979) as indicating that the time lapse may have allowed more bacteria to become attached and more resistant to the lethal effects of hot water.

Anderson *et al.* (1979) reported that under laboratory conditions, bacterial counts were reduced 1.0 and 2.0 $\log_{10}$ CFU/cm^2 when beef plates were treated with cold (15.6° C) and hot (76–80° C) water, respectively. During subsequent storage at 3.3° C, the time to reach microbial spoilage (108 CFU/cm^2) was 6 days with cold water and 12 days with hot water. The untreated controls took 7 days to reach spoilage levels.

Smith and collaborators (Smith and Graham, 1978; Smith, 1992; and Smith and Davey, 1990, and Smith *et al.*, 1995) have investigated the effectiveness of hot water (140° F) washes versus a more commonly used wash temperature (100° F). Hot water was effective against pathogens such as *E. coli* 0157:H7, *Salmonella, Yersinia enterocolitica,* and *L. monocytogenes.* Quantitative studies assessing the effect of hot water treatment on the survival of *E. coli* 0157:H7 indicated that levels on artificially inoculated carcasses are reduced by 84–99.9% (Smith, 1992; Smith and Davey, 1990; Smith *et al.*, 1995) Other studies have reported reductions in *E. coli* biotype 1 as great as 99–99.9% (Davey and Smith, 1989).

Hot water sprays are most effective when the water film on the carcass surface is raised to 82° C (180° F) for at least 10 seconds. If beef tissue is exposed to this temperature for more than 10 seconds, the surface of the fat and lean tissues can become gray to a depth of about 0.5mm. These carcasses, however, regain their normal color after chilling (Smith and Graham, 1978; Barkate *et al.*, 1993; Patterson, 1969). Carcass bloom, however, is permanently and adversely affected if exposed for 20 seconds to temperatures above 81.4° C–82° C (Davey, 1989, 1990; Barkate *et al.*, 1993). Lower temperatures applied for longer periods of time also have been found (Davey and Smith, 1989) to permanently affect bloom.

Similar results have been reported by investigators worldwide. Patterson (1970) sprayed beef carcasses with steam and hot water at 176–204.8° F (80–96° C) for two minutes, applying in the case of water 18.9 liters to each carcass at a distance of one foot (25cm), to determine the effectiveness of hot water in reducing carcass contamination. Although some discoloration of the carcass occurred initially, cooling for 24 hours restored normal color. Approximately a log reduction in total plate count was observed; however, there was no significant reduction in fecal streptococci. A differential in bacterial counts between treated and untreated carcasses was still evident after 48 hours of refrigerated storage. Smith and Graham (1974) used beef and mutton samples inoculated with *E. coli* to compare the effectiveness of hot water treatment, steam chamber, steam injection, or washing with water at 37° C (91° F) on microbial levels and carcass color changes. Water temperatures below 60° C (140° F) produced no significant color change. As temperatures rose above 85° C (176° F), there was permanent and marked color change. Very high temperatures of 95° C (194° F) for three minutes changed the surface coloration to a depth of no more than 0.5mm below the surface. Temperatures equal to or greater than 70° C (158° F) produced a 2 $\log_{10}$ (99%) reduction of *E. coli.*

Water can be applied to a carcass, by either hand or machine, using washing, spraying, or dipping. Hand and machine washing were compared by Anderson *et al.* (1981). Hand-washed carcasses had reductions of 0.99 $\log_{10}$ CFU/cm^2, while an experimental beef carcass washing unit yielded a 1.07 $\log_{10}$ CFU/cm^2 reduction, a non-significant difference.

The angle of water impact has been shown to be an important factor in bacterial removal. When water pressure is normal, a 30° angle is more effective at removing bacteria than a 90° angle (Anderson 1975). When line pressure is increased, the angle degree is less important.

Since bacterial attachment affects the ease of removing bacteria, the point during slaughter and dressing at which water is applied has been deemed significant in retarding or inhibiting attachment. Notermans *et al* (1980) concluded that control of *Enterobacteriaceae* and *salmonellae* was more effective when carcasses were spray-cleaned with water at multiple stages during evisceration than when washing occurred only after evisceration.

Water pressure can influence the effectiveness of carcass washing treatments. De Zuniga *et al* (1991) investigated the effect of increased water pressure on the penetration of bacteria into tissue using Blue Lake dye. As the pressure of the water increased, the dye penetrated to a correspondingly greater depth in the tissue. They recommended an optimal water pressure for washing beef carcasses between 100 psi to 300 psi. They cautioned that higher pressures may drive the organisms deeper into the tissues, while pressures less that 100 psi were less effective at reducing bacterial counts. Kotula (1974) found that water containing 200 ppm chlorine, sprayed at a pressure of 355 psi and at temperatures ranging from 55–125° F, effectively removed bacteria from market beef forequarters. Kotula *et al.* (1974) concluded that water pressure was a more important variable than pH or water temperature for removing bacteria by spray washing. These beef samples, however, were not freshly slaughtered, and may have required more intense pressures. Jerico *et al.* (1995), concluded that washing beef carcasses with water at 200–400 psi at 38°C (100.4°F) did not significantly change the level of bacteria on the carcass. They noted that other investigators (Anderson, 1981; Kotula *et al.*, 1974; Crouse *et al.*, 1988) did not statistically validate the sample size to adjust for variation in counts and sample size, and did not collect samples immediately after washing.

Increasing water pressures has been found to have certain operational disadvantages. For example, greater pumping pressure is required, thus requiring more energy and special equipment, less heat energy can be recovered from the outlet water steam, and the nozzle is more likely to become blocked if water is recirculated (Graham *et al.*, 1978).

B. Beef Carcass Trimming vs. Washing Treatment Studies

Only three studies directly compare hand trimming vs. washing as methods to remove fecal and bacterial contamination from beef carcasses. Hardin *et al.* (1995) conducted an FSIS-supported research project designed to compare traditional hand trimming procedures to washing of beef carcasses for removal of feces and associated bacteria. Paired cuts from four carcass regions (inside round, outside round, brisket, and clod) were removed from hot, split carcasses, then contaminated with a fecal suspension containing either *E. coli* 0157:H7 or *S. typhimurium* (10^6 CFU/ml). Inoculated meat cuts

(400 cm^2 area) were treated by one of four treatments either immediately or 20–30 min post-contamination. One paired contaminated surface region from each carcass side was trimmed of all visible fecal contamination. The remaining paired carcass surface region was then washed either with water (35°C/95°F), water wash with 2% lactic acid (55°C/131°F), or water wash with 2% acetic acid (55°C/131°F). Samples for microbiological analyses were collected pre- and post-treatment from within and outside the defined area contaminated with the fecal suspension.

All treatments significantly reduced levels of pathogens; however, decontamination was affected by carcass surface region. The inside round region was the most difficult carcass surface to decontaminate, regardless of treatment. Washing followed by organic acid treatment performed better than trimming or washing alone on all carcass region surfaces except the inside round, where organic acid treatments and trimming performed equally well. Overall, 2% V/V lactic acid reduced levels of *E. coli* 0157:H7 significantly better than 2% V/V acetic acid; however, differences between the abilities of the acids to reduce *Salmonella* were less pronounced. All treatments caused minimal spread of pathogens outside the initial area of fecal contamination. Recovery after spreading was reduced by the use of organic acid treatments.

This study is limited in relation to evaluating commercial conditions due to the experimental design, which deliberately added inoculated feces to the carcass. A rather large area (400 cm^2) was inoculated and deliberate placement on the meat surface allowed the trimmer to know exactly where fecal contamination occurred. Under commercial situations, fecal contamination must first be visually located and the borders of contamination subjectively evaluated. This subjectiveness may allow the trimmer to inadvertently touch the knife to areas of fecal contamination that are not obviously visible, thereby cross-contaminating the freshly trimmed areas as the knife blade is drawn across. Knife trimming was highly controlled in these experiments, whereas knife trimming under commercial conditions might be expected to yield more variable results. Secondly, although this study was performed in an abattoir, the treatments were performed in an adjacent laboratory setting rather than on a slaughter line where deliberate inoculation of carcasses with pathogens is not allowed by FSIS.

The second direct comparison of trimming vs. washing involved work performed by scientists from four universities. This study was conducted in four phases, and is commonly referred to as the National Livestock and Meat Board study, for the organization that funded the project.

Phase I trials sought to define the proper parameters for the washing experiments (Gorman *et al.*, 1995, submitted for publication; Smith *et al.*, 1995, submitted for publication; Smith, 1995). Results of Phase I suggested that higher pressures of 20.68 bar (300 psi) and 27.58 bar (400 psi) during spray-washing were more effective ($P<0.05$) than lower pressures of 2.76 bar (40 psi) or 13.79 bar (200 psi) bar for removal of fecal material and for reducing bacterial numbers. Phase II compared the efficacy of hand-trimming and six potential carcass decontamination treatments: hot water (74°C), ozone, trisodium phosphate, acetic acid, hydrogen peroxide, and a commercial sanitizer (Smith, 1995; Gorman *et al.*, submitted for publication).

Data from Phase II revealed that application of hot water (74°C at the meat surface) for spray-washing reduced total plate counts and *E. coli* (ATCC 11370) counts exceeding 3.0 $\log_{10}$ CFU/cm^2. The best combination and sequence of interventions for reducing bacteria counts on beef brisket samples were: (a) Use 74°C water in the first wash with water pressure at 20.68 bar, and (b) if colder (<35°C) water is used in the first wash, spray-wash with hydrogen peroxide or ozone in the second wash. Trimming alone or trimming followed by a single spray-washing treatment of plain water (16–74°C; 20.68 bar; 12 or 36 sec) significantly ($P<0.05$) reduced the microbiological counts compared to the untreated, inoculated control. Trimming alone decreased total aerobic plate counts by 2.5 CFU/cm^2 and trimming with plain water (<35°C) wash decreased total aerobic plate counts by 1.44–2.3 CFU/cm^2. These data indicated that trimming reduces microbiological contamination after carcasses are contaminated with fecal material but a significant amount of contamination remained on samples after trimming or trimming with spray washing. It was concluded that washing at 300 psi was as effective as trimming and washing combinations for reducing bacterial counts on the tissues. When water was 74°C, reductions were greater than 3.0 log CFU/cm^2, irrespective of the presence or absence of chemical sanitizer.

Spray-washing with hot water resulted in less variability in bacterial counts obtained after treatment compared to hand-trimming and/or spray-washing with water of lower temperatures. The authors concluded that this greater variability in bacterial counts for hand-trimming treatments indicated the potential for cross-contamination during the process.

Phase IIIA consisted of field studies in six commercial plants and concluded that: (a) Compared to inoculated controls (no trim; no wash), every combination of washing—with or without trimming and with and without chemical agents—lowered ($P<0.05$) total plate counts and *E. coli* counts; (b) compared to the treatment combining trimming plus washing, washing (without trimming) with 74°C water achieved ($P<0.05$) equal reductions in total plate counts and *E. coli* counts; and, (c) washing (without trimming) with 74°C water—based upon comparative standard deviations—achieved more consistent lowering of total plate counts and of *E. coli* counts than did trimming plus washing (Smith, 1995).

Phase IIIB further investigated the effects of hot water washing under commercial slaughter conditions, as the hot water washing trials in Phase III were conducted in only two of the six plants, the number of samples was small, and the parameters of hot water application (temperature, pressure, etc.,) were not consistent (Smith, 1995). The results of Phase IIIB were consistent with Phase IIIA in demonstrating that trimming and washing are effective in reducing the microbial loads on carcasses. Of the several treatments tested, however, the most effective in reducing microbial numbers was combined trimming, washing, and rinsing with hot water for 8 seconds. Other treatments tested included: control (no trimming, no washing), trimming/washing (current ''zero tolerance'' procedure), no trimming/hot water rinse for 2.5 seconds, and no trimming/hot water rinse for 8 seconds.

The use of hot water alone (no trimming) in this study effectively reduced the microbial contamination on carcasses, but the average reduction in counts was slightly less than that achieved by trimming and washing or trimming and washing combined with hot water rinsing. These findings suggest that the application of hot water at 20 pounds per square inch (psi) for 2.5 or 8 seconds is not as effective as the hot water washing system used in Phase IIIA of the studies, i.e., the application of a fine spray at psi's ranging from 150 to 260 and temperatures of 60°C to 75°C (140°F to 175°F).

The third study that evaluated the effectiveness of carcass trimming and/or washing on the microbiological quality of beef carcasses in a commercial slaughter plant was conducted by Prasai *et al.* (1995). The inside rounds of 48 beef carcass sides were evaluated using four treatments: (1) Untreated (no trim, no wash), (2) trim alone, (3) trim plus wash, or (4) wash alone. Samples for aerobic plate counts, *E. coli*, and coliform counts were collected post treatment. Significant differences ($P < 0.05$) were observed in aerobic plate counts (APC) when treatments were compared to controls. *E. coli* and coliform counts were too low to show statistical significance between treatments; however, the mean *E. coli* and coliform counts were higher in control samples ($P < 0.05$) than in other treatments. The greatest reduction in APC counts were observed in trimmed samples (3.0 log CFU reduction vs. control), followed by trim and wash (0.9 log CFU reduction vs. control), and wash alone (0.3 log CFU reduction vs control) samples. Samples receiving trim and wash treatments had APC counts approximately 2 logs higher than trimmed samples, suggesting that washing spreads bacterial contamination. All washed samples, however, had mean reductions of 0.3–0.9 log CFU vs. control samples. The investigators concluded that trimming can be effective in reducing bacterial contamination during slaughter and that additional bacterial reductions can be obtained if trimming instruments are sanitized between trim sites. The authors further concluded, however, that the type of trimming used in the study—i.e., use of sterile instruments and trimming of entire sample surface—is unlikely on a typical slaughter line, and that, under commercial conditions, a combination of trimming and washing could be practical and effective.

C. Organic Acid Sprays

Organic acids, such as lactic, acetic, and citric, reduce pathogenic and spoilage microbial organism populations by altering the environmental pH and by direct bactericidal action (Osthold, 1984). The immediate effect of organic acids on bacteria is to reduce numbers approximately one $\log_{10}$ when the initial aerobic plate count (APC) is less than or equal to 104 CFU/cm^2. A few investigators have reported a two or three log reduction (Snijders, 1979; Smulders and Woolthius, 1983; Netten, 1984). Overall, the available scientific data indicate that treating carcasses with an organic acid rinse, spray, or dip can achieve a 90–99.9% (1–3 log10) reduction in the level of spoilage organisms such as *Pseudomonas fluorescens* (Dickson and Anderson, 1992; Prasai *et al.*, 1991; Frederick *et al.*, 1994). Decontaminating carcasses with lactic or acetic acid can extend the shelf life of treated product (Smulders and Woolthuis, 1985; Woolthius and Smulders, 1985). In addition, organic acid sprays and dips have been shown to decrease the levels of specific pathogens, such as *Salmonella* spp., *Staphylococcus aureus*, *C. jejuni*, Yersinia enterocolitica, and *L. monocytogenes* (Osthold *et al.*, 1984; Bell, *et al.*, 1986; Smulders, *et al.*, 1986; Anderson, *et al.*, 1987; Siragusa and Dickson, 1992; and Cutter and Siragusa, 1994). Reductions in the number of pathogenic bacteria on carcasses reduce the risk of food-borne disease.

Each organic acid differs in its ability to reduce the bacterial population on tissue surfaces. The concentration of the organic acid affects not only bacterial survival, but also the color and odor of the meat, especially if the concentration is 2% or greater. Bleaching and discoloration of tissue have been reported, and may occur at 1% concentrations for lactic and acetic acid (Smulders and Woolthuis, 1985, and Hamby *et al.*, 1987). Balancing antimicrobial activity with organoleptic impact, the practical concentration for use of lactic or acetic acids appears to be 0.5 to 2.5%.

Prasai *et al.* (1991) examined the effect of lactic acid (1.5%, 55°C) applied to beef carcasses at various locations in processing and found that the greatest reduction in APCs occurred on carcasses treated immediately after hide removal and again after evisceration. These reductions, however, were not significantly better than spraying only after evisceration. After 72 hours of storage (1°C), the number of bacteria per cm^2 on treated carcasses was lower than on comparable control carcasses. Decontamination with acids is more effective when employed as soon after slaughter as feasible (Acuff *et al.*, 1987) and at elevated temperatures (53–55°C).

Treating beef carcasses with acids does not completely inactivate all pathogens, particularly *E. coli* 0157:H7, which is relatively acid tolerant. Cutter and Siragusa (1992) reported that there are differences among *E. coli* 0157:H7 isolates in relation to their acid tolerances. *Salmonella* spp., *L. monocytogenes*, and *Pseudomonas fluorescens* are more sensitive to acids than *E. coli* 0157:H7 (Dickson, 1991; Greer and Dilts, 1992; Cutter and Siragusa, 1994; Bell et al., 1986); while *E. coli* biotype 1, particularly *E. coli* 01257:H7, appears to be among the more resistant enteric bacteria to the effects of organic acids (Woolthuis *et al.*, 1984; Woolthuis and Smulders, 1985; Van Der Marel *et al.*, 1988; Bell *et al.*, 1986; Anderson and Marshall, 1990, 1989; Acuff *et al.*, 1994).

The extent of reduction of *E. coli* 0157:H7 achieved has varied among studies. For example, Dickson (1991) found that the reduction of *E. coli* 0157:H7 was similar to that observed for *Salmonella* and *L. monocytogenes*, with up to a 99.9% reduction in the levels of all three bacteria from inoculated tissues. A number of other studies have reported reductions in *E. coli* and in *Enterobacteriaceae* (which belongs to the same family as *E. coli*) of 46 to 99.9% on tissues treated with 1.2% to 2% acid (Bell *et al.*, 1986; Anderson and Marshall, 1990, 1989; Cutter and Siragusa, 1994; Greer and Dilts, 1992; Acuff *et al.*, 1994). Anderson and Marshall (1990) found that although lactic acid exerted a significant antimicrobial effect on some *Enterobacteriaceae*, it did not appreciably affect *E. coli* or *S. typhimurium* on beef issue samples. Conversely, Brackett *et al.* (1993) reported that up to 1.5% acid treatments did not appreciably reduce *E. coli* 0157:H7, whether at 20C or 55C, and was ''of little value in disinfecting beef of EC 0157.'' Dickson (1991) concluded that an acetic acid carcass sanitizer could be used as an effective method to control bacterial pathogens. Cutter and Siragusa (1992) reported that the reduction of *E. coli* 0157:H7 on meat by acid treatment is dependent on acid concentration (5% giving the greatest reduction) and tissue type (greater reduction on fat tissue than lean). They found lactic acid to be more effective than acetic or citric acid against *E. coli*. This has been reported by Hardin *et al.*, 1995, as well. Cutter and Siragusa (1992) suggested that the two primary determinants of effectiveness are the pH achieved at the surface of the carcass and the corresponding period of exposure.

A number of other studies have reported reductions in *E. coli* or *Enterobacteriaceae* ranging from 46 to 99.9% on tissues treated with 1.2% to 2% acid (Bell *et al.* 1986; Anderson and Marshall, 1990, 1989; Cutter and Siragusa, 1994; Greer and Dilts, 1992; Hardin *et al.*, 1995). Anderson and Marshall (1990) found that concentration and temperature of lactic acid solutions had significant but independent effects on reduction in numbers of inoculated microorganisms (aerobes, *Enterobacteriaceae*, and *E. coli*) on the surface of lean beef muscle. *E. coli* cells, however, were

comparatively resistant to the effects of temperature and concentration of lactic acid. Further, Brackett *et al.* (1993) reported that up to 1.5% acid treatments did not appreciably reduce *E. coli* 0157:H7, whether at 20° or 55°C and ''was of little value in disinfecting beef of EC O157.'' Brackett (1994) also concluded that *E. coli* (Biotype I) and *E. coli* 0157:H7 are quite resistant to the effects of organic acids, particularly lactic acid. Hardin *et al.* (1995) observed that *E. coli* 0157:H7 was more resistant than *S. typhimurium* to the effects of both 2% lactic and 2% acetic acid applied to beef carcass surface regions. Reductions in levels of *E. coli* 0157:H7 were 0.6–1.5 $\log_{10}$ CFU/cm^2 greater with lactic acid than acetic acid, depending on the carcass surface tested. Both lactic and acetic acid, however, were equally effective in reducing levels of *S. typhimurium*.

Both acid concentration and temperature have been studied for their effects on reducing bacterial numbers on beef tissue. Anderson and Marshall (1989) observed that both concentration and temperature produced significant, but independent, reductions in numbers of *E. coli* and *S. typhimurium* on beef semitendinosus muscle dipped in an acetic acid solution. Acid concentration (1, 2, 3%) was found to be insignificant at the higher temperature (70°C), but caused significant reduction in numbers of microorganisms at lower temperatures (22, 40, and 55°C). Anderson and Marshall (1989) reported that the most effective treatment was dipping pieces of lean meat in 3% acetic acid at 70°C. They suggested that some direct effects from heat may have contributed to the increased reduction of bacterial numbers in samples treated at this higher temperature. The numbers of surviving organisms were reduced as the temperature of the acid was increased from 25 to 70°C, with acid concentration being less significant at higher temperatures. These researchers later reported similar results for treatments using 3% lactic acid at 70°C (Anderson and Marshall, 1990). Anderson *et al.* (1987) observed a greater reduction in levels of indigenous *E. coli, Enterobacteriaceae* and APC with hot (52°C) acetic acid when compared to cool (14.4°C) acetic acid.

In a more recent study, Anderson *et al.* (1992) reported an increased removal of bacteria as either the concentration or temperature of the acid solution was increased, with the acids performing differently at different temperatures. Lactic acid was reported to be significantly more effective than acetic acid for all bacterial types (aerobes, *Enterobacteriaceae, S. typhimurium, E. coli*) at both 20 and 45°C, and more effective on *S. typhimurium* at 70°C. Cutter and Siragusa (1994) reported that of three concentrations evaluated (1, 3, and 5%), 5% acid (acetic, lactic, or citric) resulted in the greatest reduction in numbers of both *E. coli* 0157:H7 and *P. fluorescens* from beef carcass tissue.

Evaluation of the overall effectiveness of organic acids is confounded by the fact that the various studies have employed different acid types, applied at different concentrations and temperatures to varying types of meat tissue surfaces. Each of these factors has an effect on the removal of bacteria from carcasses. Several studies have evaluated the effect of tissue type (fat and lean) on the effectiveness of organic acids to reduce the number of bacterial cells from beef tissue surfaces. Cutter and Siragusa (1994) reported that the magnitude of bacterial reductions from beef surfaces treated with organic acids was consistently greater when spray treatments were applied to bacteria attached to adipose tissue. Log reductions for *E. coli* 0157:H7 and *P. fluorescens* were 1 and 2 $\log_{10}$ greater on adipose vs. lean beef carcass tissue. These findings agree with Dickson and Anderson (1991), who reported significant reductions in *S. california* from use of distilled water and 2% acetic acid with beef fat tissue, whereas no significant differences were observed between treated and untreated lean tissues. Dickson (1991, 1992) reported similar findings for *S. typhimurium, L. monocytogenes,* and *E. coli* 0157:H7 attached to fat surfaces of beef trim. Acid treatment resulted in an immediate sublethal injury of approximately 65% of *S. typhimurium* (Dickson, 1992) remaining on lean and fat tissue. A residual effect from the acid was observed with the fat tissue, resulting in an additional 1 $\log^{10}$ decrease over four hours. The author suggested that the differences observed in the effects of acid for lean and fat tissue were due to the increased water content of lean tissue and the presence of water-soluble components that may neutralize the acid and its effect on the bacterial cell. In a comparison of methods for the removal of *S. typhimurium* and *E. coli* 0157:H7 from various beef carcass surfaces, Hardin *et al.* (1995) found a significant difference in the type of surface evaluated. The researchers observed that the inside round was the most difficult carcass surface to decontaminate and attributed this to a substantial amount of exposed lean on the meat surface, as well as a pronounced collar of fat at the edge of the lean.

Organic acids have been reported to be more effective in reducing bacterial levels when applied during, or shortly after, slaughter and dressing. Acuff *et al.* (1987) and Dixon *et al.* (1987) reported no significant difference in reduction of aerobic populations from beef steaks and subprimals treated post-fabrication with various organic acids and their controls. They suggested that the application of acid decontamination would be most effective as soon as possible after slaughter, before bacteria have had a chance to attach firmly to meat surfaces. This was supported by Brackett *et al.* (1994), who recently reported that hot acid sprays were ineffective in reducing levels of *E. coli* 0157:H7 inoculated onto the surface of sirloin tips purchased from local butchers. Snijders *et al.* (1985) reported an increase in the bactericidal effect of lactic acid sprayed on hot carcasses (45 minutes postmortem) when compared to spraying on chilled carcasses. They suggested that on hot carcass surfaces, increased reductions may be due to higher levels of bacteria present in the water film and not yet attached to the carcass surface. Van Netten *et al.* (1994) described an *in vitro* model to evaluate the inactivation kinetics of bacteria from meat surfaces treated with lactic acid. A rapid reduction in bacterial numbers due to the replacement of the fluid (water film) on a warm meat surface by a film containing lactic acid was referred to as ''immediate lethality.'' They proposed that organisms on chilled meat are less accessible to lactic acid and are better protected by meat buffering effects than those in the fluid film of hot meat surfaces.

D. Chlorine and Chlorine Compounds

Chlorine, chlorine dioxide, sodium hypochlorite, and hypochlorous acid all have been sprayed onto beef carcasses in an effort to reduce microbial populations.

Chlorine and chlorine dioxide were compared for chickens by Lillard (1979) to determine their relative bactericidal effect. Chlorine dioxide was found to be more potent than chlorine and required only one-seventh as much to produce the same bactericidal effect. Further, chlorine dioxide maintained its effectiveness when both pH and the level of organic matter increased. Chlorine is less effective when the pH or organic load is increased. Kotula *et al.* (1974) treated beef forequarters with chlorinated water (200 ppm) and found initial reductions (45 min post-treatment) in APCs for duplicate testing days of 1.5 and 2.3 $\log_{10}$ CFU/cm^2, respectively. Temperature (12.8 vs 51.7°C) and pH (4 to 7) were found to

significantly affect efficacy, with the greatest reductions observed at a temperature of 51.7° and pH values of 6 and 7.

Anderson *et al.,* (1979) compared the effectiveness of several treatments to reduce APCs on previously frozen beef plate stripes. Meat was washed and sanitized with cold water (15.6°C [60°F]), hot water (76–80°C [168–176°F]) (14kg/cm^2), sodium hypochlorite (200–250µg/ml), or acetic acid (3%)—all at 14kg/cm^2; and at 17 kg/cm^2 steam at 95°C (194°F). They found that the sodium hypochlorite and cold water treatments reduced counts by about one log. Steam reduced the count by only 0.06 log. Hot water reduced counts by 2.0 log and acetic acid reduced counts by 1.5 log. Over time, samples treated with hypochlorite had rates of bacterial re-growth that exceeded those of the untreated controls. Steam and cold water treated samples exceeded APCs on controls after five days, presumably due to greater surface moisture from the treatment. Growth rates associated with the hot water samples were similar to the untreated controls, but, because of the initial 2.0 log reduction in microbial levels, it took nearly five additional days before counts reached 10^8/cm^2. Acetic acid, applied to samples after a cold water wash, provided a 14–16 day delay before counts returned to initial levels, and it took a full 23–24 days before the bacteria reached 10^8/cm^2.

V. Other Technologies

Several other approaches or technologies have been suggested as additional alternative means for decontaminating beef carcasses, such as rinsing with trisodium phosphate (TSP), steam pasteurization of carcasses, steam vacuuming, and chemical dehairing. These approaches have not been as extensively investigated and reported in the scientific literature to date, relative to their use with beef carcasses. A brief discussion of each method follows.

A. Trisodium Phosphate

Trisodium phosphate (TSP) has been shown to reduce *Salmonella* on processed poultry carcasses. In a 1991 patent, Bender and Brotsky presented the claim that trisodium phosphate (Na_3PO_4) could successfully reduce *Salmonella* on processed poultry carcasses. Since then, industry, university, and USDA Agricultural Research Service researchers have conducted studies that demonstrate reductions in *Salmonella* levels on poultry carcasses ranging from 90 to greater than 99.9% (1.2 to 8.3 $\log_{10}$). Dickson *et al.* (1994) studied the effect of TSP on beef tissue dipped in TSP after inoculation with both Gram positive (*L. monocytogenes*) and Gram negative (*S. typhimurium* and *E. coli* 0157:H7) pathogens. They reported reductions of 1 to 1.5 $\log_{10}$ for the Gram-negative pathogens, and a maximum reduction of less than one $\log_{10}$ for *L. monocytogenes* on lean tissue. Reduction of *L. monocytogenes* was greater on fat tissue: 1.2 to 1.5 $\log_{10}$. A reduction of 2 to 2.5 $\log_{10}$ for *S. typhimurium* and *E. coli* 0157:H7 on fat tissue was reported.

In-plant testing of TSP on beef carcasses (Rhone-Poulenc) showed a greater than 1.5 $\log_{10}$ reduction of *E. coli* (biotype I). Further, they found that incidence rates for *E. coli* fell from 51.3% on untreated carcasses to 1.3% on TSP-treated carcasses. The level of *Enterobacteriaceae* was reduced by one $\log_{10}$, and the incidence rates fell from 75% on untreated carcasses to 8.8% on treated carcasses. *Salmonella* was not detected on any carcasses.

B. Steam Pasteurization

A patent-pending process developed by Frigoscandia for steam pasteurization of meat and poultry has been tested at Kansas State University and has received approval by FSIS for in-plant evaluation; the process is applied at the end of beef dressing operations on inspected and passed carcasses. A request by Frigoscandia to evaluate and test the process as an antimicrobial reduction intervention is being considered by FSIS.

Tests of a prototype unit at Kansas State University showed that the process consistently reduces pathogenic bacteria, including *E. coli* 0157:H7, by 99.9% (Frigoscandia, 1995). The process uses pressurized steam applied uniformly to the entire carcass surface, producing surface meat temperatures of 77–93°C (170–200°F) and a uniform bacterial reduction on the entire carcass. Since the steam reaches all exposed surfaces, the reduction is more uniform and operator-independent. The process is reported to not affect the color of the carcass, and to use less energy than is required for a comparable hot water system. Furthermore, the use of a 2% lactic acid cooling spray immediately after steam application appeared to act synergistically to inactivate surface bacteria. It should be noted that the intended use of the steam pasteurization is not the direct physical removal of visible contamination, but the technology has the potential to be integrated into pathogen control systems to enhance their effectiveness.

C. Steam Vacuuming

Alternative methods for removing beef carcass contamination such as air jets and vacuum systems (without steam) have been shown to be effective in removing visible as well as microbiological contamination (Monfort, 1994). Steam vacuuming is a refinement of this approach, combining physical removal with microbial inactivation. Steam vacuuming is a process in which steam and hot water are applied through nozzles to the carcass surface after the hide is removed. This appears to be particularly useful for opening cuts, which are made in the hide to facilitate hide removal. These carcass surfaces tend to be contaminated more frequently than other areas of the carcass. Steam vacuuming treats these surface areas with hot water (above 160°F) and steam while vacuuming the removed contamination and any excess water from the surface. The process of steaming the opening patterns encountered some difficulty in early trials when the steam nozzle was held 6 to 12 inches from the surface. There was a rapid drop in temperature, and as a result no significant differences in bacterial levels were noted from treated areas. These problems were corrected by adjusting the equipment and placing the head of the vacuum directly on the surface. Testing at Kansas State University has shown the effectiveness (>99.9% reduction) of steam vacuuming in decontaminating prerigor meat surfaces that have been inoculated (approximately 10^5 CFU/cm^2) with the pathogens *L. monocytogenes*, *E. coli* 0157:H7, and *S. typhimurium*. Scientists at the U.S. Meat Research Center of USDA's Agricultural Research Service at Clay Center, Nebraska have reported a 3.0 to 3.5 log (>99.9%) reduction in bacteria on steam vacuum-treated meat. Preliminary results from an ongoing industry study (ten plants reported to date) comparing steam vacuuming and knife trimming to remove carcass contamination indicate that carcasses that have been steam vacuumed have approximately 90% (0.94 log) less bacteria than trimmed carcasses in the areas tested. Several inplant trials comparing steam vacuuming versus traditional trimming are currently underway.

D. Chemical Dehairing

The effects of post-exsanguination (post-bleeding) dehairing on the microbial load and visual cleanliness of beef carcasses has been studied by Schnell *et al.,* 1995. Ten grain-fed steers/heifers were slaughtered and

dressed without dehairing. The carcasses of these animals were evaluated for bacterial contamination and visual defects (hair and specks) and for weight of trimmings made to meet ''zero tolerance.'' Overall, no difference was reported in aerobic plate counts, total coliform counts, and *E. coli* counts between samples from dehaired cattle and those from conventionally-slaughtered cattle. The lack of difference in bacterial counts was thought to be due to contamination in the facility from aerosols, and from people and equipment contaminated by conventionally-slaughtered cattle. An interaction was noted, however, between treatment and carcass sampling location. *E. coli* counts were lower in samples taken from rounds of dehaired carcasses than in samples from rounds of conventionally-slaughtered carcasses. The converse was found for samples from briskets, where higher counts were thought to be due to the additional handling of dehaired carcasses, i.e., the necessity of cutting the hide to assist in removal of hides that had become soapy and slippery during the dehairing process.

The investigators stated the opinion that the microbiological status of carcasses from dehaired animals should improve in facilities designed to produce only dehaired carcasses. Dehaired carcasses had fewer visible specks and fewer total carcass defects before trimming (but not after trimming) than did conventionally-skinned carcasses. The average amount of trimmings removed from conventional carcasses to meet the ''zero tolerance'' specification was almost double (2.7 versus 1.4 kg) that from dehaired carcasses.

Additional tests, conducted in support of an industry petition (Monfort, 1995), compared the reduction of bacteria from hide to dehaired hide immediately after the dehairing process. These tests found a 99% reduction in total plate counts.

VI. The Conference

FSIS is committed to ensuring that the most effective means available are used to achieve the zero tolerance standard for fecal, ingesta, and milk contamination of beef carcasses. The Agency's goals are to protect consumers from harmful contamination and thus reduce their risk of contracting foodborne illnesses. Given the importance of these goals, determining the most effective means of implementing the zero tolerance performance standard is one of FSIS's highest priorities. FSIS will act on the basis of sound scientific evidence, discussed in an open public process, to improve the safety of beef products through effective removal of fecal and associated microbial contamination.

Accordingly, FSIS is hosting a conference to review the scientific and technical data and associated public policy issues involved in achieving the zero tolerance standard and improving beef carcass microbial safety. The conference will consist of two sessions on consecutive days. At the first session, participants will discuss available scientific and technical data comparing the efficacy of various methods for decontaminating beef carcass surfaces, focusing on the research summarized above. Participants are invited to make 15-minute presentations during this first session and are requested to submit to FSIS, in advance, brief statements describing the general topics of their presentations (see **ADDRESSES** above). A panel of government scientists and managers will participate in this session and facilitate the discussion; the panel will be moderated by Ms. Patricia F. Stolfa, Acting Deputy Administrator, Science and Technology, FSIS. An opportunity will be provided for open discussion of scientific issues among all participants. Possible scientific and technical questions for discussion are:

1. Do the studies offered to support the various decontamination alternatives conform to appropriate scientific standards?

2. Are key results from individual studies reproducible and have they been replicated in other experiments?

3. How effective is any specific treatment against microbial pathogens, and against *E. coli* 0157:H7 in particular?

4. Is a specific treatment bactericidal or bacteristatic?

5. Has a treatment been studied under plant conditions?

6. What are the most effective locations for treatment on the carcass and on the slaughter line?

7. If water is used, in what amounts? Can water be conserved or reused?

8. Is there any threat to workers or the environment from residual treatment fluids, chemical waste, or biological hazards?

9. Does a proposed treatment create an insanitary condition?

10. Does a proposed treatment spread contamination on a carcass or spread contamination from carcass to carcass?

11. Can - and should - a treatment be combined with other treatments? What would be the optimum combination?

12. Does a proposed treatment interfere with current inspection procedures?

13. When all the relevant studies are considered, does a discernible trend emerge supporting a policy choice?

During the second session, participants will discuss the public policy issues surrounding beef carcass decontamination. This session will be moderated by Thomas J. Billy, Associate Administrator, FSIS, and Dr. Craig Reed, Deputy Administrator, Inspection Operations, FSIS. Possible policy questions for discussion are:

1. What criteria should be used to decide that an alternative approach meets the zero tolerance performance standard for visible fecal contamination and associated microbial contaminants?

2. What amount and quality of scientific data should be required in order to change current policy?

3. Are alternative approaches equally feasible for all establishments that may want to use them?

4. Should FSIS prescribe exactly how fecal contamination may be removed or should there be an organoleptic and microbial performance standard that companies can achieve as they see fit?

5. What techniques should the FSIS inspection force use to verify that an alternative approach is functioning effectively?

6. Should preventive measures be made part of this policy decision?

7. What approaches to achieving the zero tolerance performance standard are consistent with a HACCP approach to process control? Conference Registration

FSIS is requesting that persons planning to attend the conference preregister. If you plan to attend, please contact Ms. Mary Gioglio at (202) 501–7138 to register. Registration will also be available on the days of the conference on a space-available basis.

Also, if you require a sign language interpreter or other special accommodations, please contact Mary Gioglio at the number listed above.

Done at Washington, DC on September 20, 1995.

Michael R. Taylor,

Acting Under Secretary for Food Safety.

References

Acuff, G.R., C. Vanderzant, J.W. Savell, D.K. Jones, D.B. Griffin, and J.G. Ehlers. 1987. Effect of acid decontamination of beef subprimal cuts on the microbiological and sensory characteristics of steaks. Meat Sci. 19:217–226.

Acuff, G.R., J.W. Savell, and M.D. Hardin. 1994. Preliminary Results, Comparison of methods for contamination removal from beef carcass surfaces. In response to Federal Register Notice, Beef carcass trimming versus washing study, Vol 58. No 118, pages 33925–31.

Anderson, E.S., N.S. Galbraith, and C.E.D. Taylor. 1961. An outbreak of human infection due to *Salmonella typhimurium* phage-type 20a associated with infection in calves. Lancet. i:854.

Anderson, M. E., H. E. Huff, H. D. Naumann, R. T. Marshall, J. Damare, R. Johnston, and M. Pratt. 1987. Evaluation of Swab and Tissue Excision Methods for Recovering Microorganisms from Washed and Sanitized Beef Carcasses. J. Food Prot. 50:741–743.

Anderson, M.E., Marshall, R.T., Stringer, W.C., and Naumann, H.D. 1981. Evaluation of prototype beef carcass washer in a commercial plant. J. Food Prot. 44:35–38.

Anderson, M.E., Marshall, R.T., Stringer, W.C., and Nauman, H.D. 1979. Microbial growth on plate beef during extended storage after washing and sanitizing. J. Food Prot. 42:389–392.

Anderson, M.E., Marshall, R.T., Nauman, H.D., and Stringer, W.C. 1975. Physical factors that affect removal of yeast from meat surfaces with water sprays. J. Food Sci. 40:1232–1235.

Anderson, M.E. and R.T. Marshall. 1989. Interaction of concentration and temperature of acetic acid solution on reduction of various species of microorganisms on beef surfaces. J. Food Prot. 52:312–315.

Anderson, M.E. and R.T. Marshall. 1990. Reducing microbial populations on beef tissues: concentration and temperature of an acid mixture. J. Food Sci. 55:903–905.

Anderson, M.E. and R.T. Marshall. 1990. Reducing microbial populations on beef tissues: concentration and temperature of an acid mixture. J. Food Sci. 55:903–905.

Anderson, M.E., R.T. Marshall, and J.S. Dickson. 1992. Efficacies of acetic, lactic and two mixed acids in reducing numbers of bacteria on surface of lean meat. J. Food Safety. 12:139–147.

Ayres, J.C. 1955. Microbiological implications in the handling, slaughtering, and dressing of meat animals. Adv. Food Res. 6:109–161.

Bailey C. 1971. Spray washing of lamb carcasses. In Proceedings of 17th European Meeting of Meat Research Workers. Bristol, England. 175–181.

Barkate, M.L., G.R. Acuff, L.M. Lucia,and D.S. Hale. 1993. Hot water decontamination of beef carcasses for reduction of initial bacterial numbers. Meat Science. 35:397–401.

Beachey, E.H. 1981. Bacterial Adherence: Adhesion-receptor interactions mediating the attachment of bacteria to mucosal surfaces. J. Infectious Diseases. 143:325–345.

Bell, M.F., Marshall, R.T., and Anderson, M.E. 1986. Microbiological and sensory test of beef treated with acetic and formic acids. J. Food Prot. 49:207–210.

Bender, F.G. and E. Brotsky. 1991. Process for treating poultry carcasses to control salmonellae growth. U.S. Patent 5,143,739. Sept. 1, 1992. Int. Cl.[5] A23L 3/34; A22c 21/00.

Benedict, R.C., F.J. Schultz, and S.B. Jones. 1991. Attachment and removal of *Salmonella* spp. on meat and poultry tissues. J. Food Safety 11:135–148.

Brackett, R.E., Y.Y. Hao, and M.P. Doyle. 1994. Ineffectiveness of hot acid sprays to decontaminate *Escherichia coli* 0157:H7 on Beef. J. Food Prot. 57:198–203.

Bryce-Jones, K. 1969. Carcass cleaning. Meat Research Institute, Langfort, Bristol, given at a meeting of the Institute of Meat in London on 19th May, 1969. Inst. Meat Bull. (65), pp.3–15.

Butler, J.L., J.C. Stewart, C. Vanderzant, Z.L. Carpenter, and G.C. Smith. 1979. Attachment of microorganisms to pork skin and surfaces of beef and lamb carcasses. J. Food Prot. 42:401–406.

Chapman, P.A., C.A. Siddons, D.J. Wright, P. Norman, J. Fox, and E. Crick. 1993. Cattle as a possible source of verocytotoxin-producing *Escherichia coli* O157 infections in man. Epidemiol. Infect. 111:439–447.

Childers, A.B., E.E. Keahey, and P.G. Vincent. 1973. Source of *Salmonella* contamination of meat following approved livestock slaughter procedures. J. Milk and Food Tech. 36:635–638.

Crouse, J.D., M.E. Anderson, and H.D. Naumann. 1988. Microbial decontamination and weight of carcass beef as affected by automated washing pressure and length of time of spray. J. Food Prot. 51:471–474.

Cutter, N.C., and G.R. Siragusa. 1994. Efficacy of organic acids against *Escherichia coli* 0157:H7 attached to beef carcass tissue using a pilot scale model carcass washer. J. Food Prot. 57:97–103.

Davey, K.R. and M.G. Smith. 1989. A laboratory evaluation of a novel hot water cabinet for the decontamination of sides of beef. Int. J. Food Sci. 24:305–316.

DeWit, J.C. and E.H. Kampelmacher. 1981. Some aspects of washing hands in slaughter houses. Zbl. Bakt. Hyg. I Abt. Orig. B 172:390–406.

DeWit, J.C. and E.H. Kampelmacher. 1982. Microbiological Aspects of Washing Hands in Slaughterhouse. Zbl. Bakt. Hyg. I Abt. Orig. B 176:553–561.

De Zuniga, A.G., Anderson, M.E., Marshall, R.T., and Iannotti, E.L. 1990. American Society of Agricultural Engineers, St. Joseph, Missouri, March 2–3, 1990. Penetration of Microorganisms into Meat During Spray Cleaning.

Dickson, J.S., C.G. Nettles Cutter and G.R. Siragusa. 1994. Antimicrobial effects of trisodium phosphate against bacteria attached to beef tissue. J. Food Proct. 57:952–955.

Dickson, J.S. and M.A. Anderson. 1991. Control of Salmonella on beef tissue surfaces in a model system by pre- and post-evisceration washing and sanitizing, with and without spray chill. J. Food Prot. 54:7:514–518.

Dickson, J.S. and M.E. Anderson. 1992. Microbiological decontamination of food animal carcasses by washing and sanitizing systems: A review. J. Food Prot. Vol.55:133–140.

Dickson, J.S. 1991. Control of *Salmonella typhimurium, Listeria monocytogenes,* and *Escherichia coli* 0157:H7 on beef in a model spray chilling system. J. Food Prot. 56:191–193.

Dickson, J. S. 1992. Acetic acid action on beef tissue surfaces contaminated with *Salmonella typhimurium*. J. Food Sci. 57:297.

Dixon, Z.R., C. Vanderzant, G.R. Acuff, J.W. Savell, and D.K. Jones. 1987. Effect of acid treatment on beef strip loin steaks on the microbiological and sensory characteristics. Int. J. Food Micro. 5:181–186.

Dixon, Z.R., G.R. Acuff, L.M. Lucia, C. Vanderzant, J.G. Morgan, S.G. May, and J.W. Savell. 1991. Effect of degree of sanitation from slaughter through fabrication on the microbiological and sensory characteristics of beef. J. Food Prot. 54:200–207.

Empey, W.A. and W.J. Scott. 1939. Investigations on chilled beef: Part I. Microbial contamination acquired in the meatworks. Bull. No. 126, Australian Council for Scientific and Industrial Research. Melbourne, Australia.

Firstenberg-Eden, R. 1981. Attachment of bacteria to meat surfaces: a review. J. Food Prot. 44:602–607.

Frederick, T.L., M.F. Miller, L.D. Thompson, and C.B. Ramsey. 1994. Microbiological properties of pork cheek meat as affected by acetic acid and temperature. J. Food Prot. 59:300–302.

Frigoscandia Equipment. 1995. News Release.

Gill, C.O. 1979. A review: intrinsic bacteria in meat. J. Appl. Bacteriol. 47:367–378.

Gill, C.O. 1982. Microbial interaction with meats. pp. 225–264 in Meat Microbiology. Ed. by M.H. Brown. Appl. Sci. Publishers, London.

Gill, C.O. and L.M. Harris. 1982. Contamination of red-meat carcasses by *Campylobacter fetus* subsp. *jejuni.* Appl. Environ. Microbiol. 43:977–980.

Gorman, B.M., J.B. Morgan, J.S. Sofos, and G.C. Smith. 1995. Submitted for publication. Removal of fecal material from beef adipose tissue and reduction of microbiological counts by trimming or spray-washing in a model cabinet with different pressures and chain speeds. Submitted for publication.

Graham, A., Eustace, I.J., and Powell, V.H. 1978. Surface decontamination—A new processing unit for improved hygiene on carcass meat. Proc. 24th Eur. Meet Meat Res. Work., Kulmbach 1:B8:3–B8:6.

Grau, F.H. 1987. Prevention of microbial contamination in the export beef abattoir. pp. 221–234 in Elimination of pathogenic organisms from meat and poultry. Ed. by F.J.M. Smulders. Elsevier Science Publishers B.V., Amsterdam.

Grau, F.H. 1979. Fresh meats: bacterial association. Archiv. Lebensmittelhyg. 30:87–92.

Grau, F.H., L.E. Brownlie, and E.A. Roberts. 1968. Effect of some preslaughter treatments on the *Salmonella* population in the bovine rumen and feces. J. Appl. Bacteriol. 31:157–163.

Greer, G.G. and B.D. Dilts. 1992. Factors affecting the susceptibility of meatborne pathogens and spoilage bacteria to organic acid. Food Res. Inter. 25:355–364.

Grønstol, H., A.D. Osborne, and S. Pethiyagoda. 1974a. Experimental *Salmonella* infection in calves. 1. The effect of stress factors on the carrier state. J. Hyg., Camb. 72:155–162.

Grønstol, H., A.D. Osborne, and S. Pethiyagoda. 1974b. Experimental *Salmonella* infection in calves. 2. Virulence and the spread of infection. J. Hyg., Camb. 72:163–168.

Hamby, P.L., Savell, J.W., Acuff, G.R., Vanderzant, C., and Cross, H.R. 1987. Spray-chilling and carcass decontamination systems using lactic and acetic acid. Meat Science 21:1–14.

Hancock, D.D., T.E. Besser, M.L. Kinsel, P.I. Tarr, D.H. Rice, and M.G. Paros. 1994. The prevalence of *Escherichia coli* 0157:H7 in dairy and beef cattle in Washington State. Epidemiol. Infect. 113:199–207.

Hardin, M.D., G.R. Acuff, L.M. Lucia, J.S. Oman, and J.W. Savell. 1995. Comparison of methods for decontamination from beef carcass surfaces. J. Food Protection. 58:368–374.

Ingram, M. and T.A. Roberts. 1976. The microbiology of the red meat carcass and the slaughterhouse. Royal Soc. Health J. 96:270–276.

International Committee on Microbiological Specifications for Foods (ICMSF). 1988. Microorganisms in foods: application of the hazard analysis critical control point (HACCP) system to ensure microbiological safety and quality. Blackwell Scientific Publications, Oxford, UK.

Jericho, K.W., J.A. Bradley, and G.C. Kozub. 1995. Microbiologic evaluation of carcasses before and after washing in a beef slaughter plant. J.A.V.M.A. 206:452–455.

Johanson, L., B. Underdal, K. Grosland, O.P. Whelehan, and T.A. Roberts. 1983. A survey of the hygienic quality of beef and pork carcasses in Norway. Acta Vet. Scand. 24:1–13. Kansas State University in Nebraska Cattleman's Petition, February 1, 1995.

Kotula, A.W., W.R. Lusby, and J.D. Crouse. 1975. Variability in microbiological counts on beef carcasses. J. Animal Sci. 40:834–837.

Kotula, A.W., W.R. Lusby, and J.D. Crouse, and B. de Vries. 1974. Beef carcass washing to reduce bacterial contamination. J. Anim. Sci. 39:674–679.

Lillard, H.S. 1989. Incidence of and Recovery of Salmonellae and Other Bacteria from Commercially Processed Poultry Carcasses at Selected Pre- and Post-Evisceration Steps. J. Food Protection. 52:88–91.

Lillard, H.S. 1986. Role of fimbriae and flagella in the attachment of *Salmonella typhimurium* to poultry skin. J. Food Sci. 51:54–56, and 65.

Lillard, H.S. 1985. Bacterial cell characteristics and conditions influencing their adhesion to poultry skin. J. Food Prot. 48:803–803.

Lillard, H.S. 1979. Levels of chlorine dioxide of equivalent bactericidal effect in poultry processing water. J. Food Sci. 44:1594–1597.

Loncarevic, S., A. Milanovic, F. Caklovica, W. Tham, and M.-L. Danielsson-Tham. 1994. Occurrence of *Listeria* species in an abattoir for cattle and pigs in Bosnia and Hercegovinia. Acta Vet. Scand. 35:11–15.

Mackey, B.M. and T.A. Roberts. 1991. Hazard analysis and critical control point programs in relation to slaughter hygiene. Proc. 37th Int. Congress Meat Sci. and Technol., Volume 3, pp. 1303–1313.

Marshall, K.C., R. Stout, and R. Mitchell. 1971. Mechanism of the initial events in absorption of marine bacteria to surfaces. J. Gen. Microbiol. 68:337–348.

Martin M.L., L.D. Shipman, M.E. Potter, I.K. Wachsmuth, J.G. Wells, K. Hedberg, R.V. Tauxe, J.P. Davis, J. Arnoldi, and J. Tilleli. 1986. Isolation of *E. coli* 0157:H7 from dairy cattle associated with two cases of hemolytic uraemic syndrome. Lancet. II:1043.

Mattila, T. and A.J. Frost. 1988. Colonization of beef and chicken muscle surfaces by *Escherichia coli*. Food Microbiol. 5:219–230.

McMeekin, T.A., C.J. Thomas, and D. McCall. 1979. Scanning electron microscopy of microorganisms on chicken skin. J. Appl. Bacterio. 46:195–200.

Monfort, Inc. 1994. Non-published microbiological results submitted to USDA–FSIS from testing of vacuum system.

Monfort, Inc. 1995. ''Managing Potential Microbiological and Other Contamination through Chemical Dehairing.'' Petition submitted to USDA–FSIS, July 10, 1995.

NRC. 1985. Committee on the Scientific Basis of the Nation's Meat and Poultry Inspection Program. Meat and Poultry Inspection: The Scientific Basis of the Nation's Program. Food and Nutrition Board, Committee on Life Sciences, National Research Council, National Academy Press, Washington, D.C.

Netten, P., van der Zee, H., and Mossel, D.A. 1984. A note on catalase enhanced recovery of acid injured cells of gram negative bacteria and its consequences for the assessment of the lethality of L-lactic acid decontamination of raw meat surfaces. J. Appl. Bacteriol 57:169–173.

Newton, K.G., J.C.L. Harrison, and A.M. Wauters. 1978. Sources of psychrotrophic bacteria on meat at the abattoir. J. Appl. Bacteriol. 45:75–82.

Norval, J. 1961. Hygiene in slaughterhouses. Veterinary Record. 73:718–784.

Notermans, S. and E.H. Kampelmacher. 1983. Attachment of bacteria in meat processing. Fleischwirtschaft. 63(1):72–78. Notermans, S. and E.H. Kampelmacher. 1974. Attachment of some bacteria strains to the skin of broiler chickens. Br. Poultry Sci. 15:573–585.

Notermans, S., J. Dufrenne, and M. van Schothorst. 1980. The effect of cultural procedures on the attachment of bacteria to chicken breast meat. J. Appl. Bacteriol. 49:273–279.

Osthold. W.H., Shin, K., Dresel, J. and Leistner, L. 1984. Improving the storage life of carcasses by treating their surfaces with an acid spray. Fleischwirtschaft. 64:828–830. (In Woolthuis, C.H., Smulders, F.J.M., 1985. Microbial decontamination of calf carcasses by lactic acid spray. J. Food Prot. 48:832–837.).

Patterson J.T. 1970. Hygiene in meat processing plants. 4. Hot water washing of carcasses. Record of Agr. Res. Ministry of Agr. Northern Ireland. 18:85–87.

Peel, B. and G.C. Simmons. 1978. Factors in the spread of Salmonellas in meatworks with special reference to contamination of knives. Australian Vet. J. 54:106–110.

Prasai, R.K., R.K. Phebus, C.M. Garcia Zepeda, C.L. Kastner, E.A.E. Boyle, and D.Y.C. Fung. 1995. Effectiveness of carcass trimming and/or washing on microbiological quality of fresh beef. J. Food prot. (Submitted).

Prasai, R.K., Acuff, G.R., Lucia L.M., Hale D.S., Savell J.W., and Morgan J.B. 1991. Microbiological effects of acid decontamination of beef carcasses at various locations in processing. J. Food Prot. Vol. 54, November 1991; pp.868–872. Rhône-Poulenc. May 25, 1995 petition to Food Safety and Inspection Service (FSIS) requesting rulemaking: Use of Trisodium Phosphate on Raw Meat Carcasses.

Ridell, J. and H. Korkeala. 1993. Special treatment during slaughtering in Finland of cattle carrying an excessive load of dung; meat hygiene aspects. Meat Sci. 35:223–228.

Roberts, T.A. 1980. Contamination of meat: the effects of slaughter practices on the bacteriology of the red meat carcass. Royal Soc. Health J. 100:3–9.

Roberts, T.A. and W.R. Hudson. 1986. Contamination prevention in the meat plant: the standpoint of an importing country. pp. 235–250. in Elimination of pathogenic organisms from meat and poultry. Ed. by F.J.M. Smulders. Elsevier Science Publishers B.V., Amsterdam.

Roberts, T.A., W.R. Hudson, O.P. Whelehan, B. Simonsen, K. Olgaard, H. Labots, J.M.A. Snijders, and J. van Hof. 1984. Number and distribution of bacteria on some beef carcasses at selected abattoirs in some member states of the European Communities. Meat Sci. 11:191–205.

Schnell, T.D., J.N. Sofos, V.G. Littlefield, J.B. Morgan, B.M. Gorman, R.P. Clayton, and G.C. Smith. 1995. Effects of Post-Exsanguination Dehairing on the Microbial Load and Visual Cleanliness of Beef Carcasses. Accepted for publication. J. Food Prot.

Sheridan, J.J. 1982. Problems associated with commercial lamb washing in Ireland. Meat Sci. 6:211–219.

Siragusa, G.R. and J.S. Dickson. 1992. Inhibition of *Listeria monocytogenes* on beef tissue by application of organic acid immobilized in calcium alginate gel. J. Food Sci. 57:293–296.

Smeltzer, T., R. Thomas, and G. Collins. 1980a. The role of equipment having accidental or indirect contact with the carcass in the spread of *Salmonella* in an abattoir. Australian Vet. J. 56:14–17.

Smeltzer, T., R. Thomas, and G. Collins. 1980b. Salmonellae on posts, hand-rails, and hands in a beef abattoir. Australian Vet. J. 56:184–186.

Smith, G.C., J.N. Sofos, J.B. Morgan, J.O. Reagan, G.R. Acuff, D.R. Buege, J.S. Dickson, C.L. Kastner, and R. Nickelson. 1995. Fecal-material removal and bacterial-count reduction by trimming and/or spray-washing of beef external-fat surfaces. Submitted for publication.

Smith, M.G. and K.R. Davey. 1990. Destruction of *E. coli* on sides of beef by a hot water decontamination process.

Smith, M.G. and A. Graham. 1978. Destruction of *Escherichia coli* and *Salmonella* on mutton carcasses by treatment with hot water. Meat Sci. 2:119–128.

Smith, M.G. and A. Graham. 1974. Advanced meat science techniques I: Meat chilling and handling. Brisbane, CSIRO Div Food Res. Meat Res. Lab. 5pp.

Smulders, F.J.M., P. Barendsen, J.G. van Logtestijn, D.A.A. Mossel and G.M. van der Marel. 1986. Review: Lactic acid: considerations in favor of its acceptance as a meat decontaminant. J. Food Technol. 21:419–436.

Smulders, J.M. and H.J. Woolthius. Immediate and delayed microbiological effects of lactic acid decontamination of calf carcasses. Influence on conventional boned versus hot-boned and vacuum packed cuts. 1985. J. Food Prot. Vol. 48, No. 10:838–847.

Snijders, J.M.A., J.G. van Logtestijn, D.A.A. Mossel, and F.J.M. Smulders. 1985. Lactic acid as a decontaminant in slaughter and processing procedures. The Veterinary Quarterly. Vol. 7 No. 4, pp 277–282.

Snijders, J.M., Schoemakers, M.J.G., Gerats, G.E., and de Pijper, F.W. 1979. Dekontamination schlachtwarmer Rinderkorper mit organischen Sauren. Fleischwirtschaft 59:656–663 (in Casper 1985).

Stern, N.J. 1981. Recovery rate of *Campylobacter fetus* ssp. *jejuni* on eviscerated pork, lamb, and beef carcasses. J. Food Sci. 46:1291, 1293.

Stolle, A. 1981. Spreading of Salmonellas during cattle slaughtering. J. Appl. Bacteriol. 50:239–245.

Tamblyn, K.C., D.E. Conner, S.F. Bilgili, and G.S. Hill. 1993. Utilization of the Skin Attachment Model (SAM) to Determine the Antibacterial Activity of Potential Carcass Treatments. Poultry Sci. 72 supplement (1):298

Troeger, K. 1995. Evaluating hygiene risks during slaughter. Fleischwirtsch. Int. 1:3–6.

Van Der Marel, G.M., J.G. van Logtestijn, D.A.A. Mossel. 1988. Bacteriological quality of broiler carcasses as affected by in-plant lactic acid decontamination. Int. J.Food Microbiology. 6 or 31 **: 31–42.

Weissman, M.A. and J.A. Carpenter. 1969. Incidence of salmonellae in meat and meat products. Appl. Microbiol. 17:899–902.

Woolthuis, C.H.J., D.A.A. Mossel, J.G.V. Logtestijn, J.M. de Kruijf, and F.J.M. Smulders. 1984. Microbial decontamination of porcine livers with lactic acid and hot water. J. Food Prot. 48:832–837.

Woolthius, C.H., and F.J.M. Smulders. 1985. Microbial decontamination of calf carcasses by lactic acid spray. J. Food Prot. 48:832–837.

Zender, R., C. Lataste-Dorolle, R.A. Collet, P. Rowinski, and R.F. Mouton. 1958. Aseptic autolysis of muscle: biochemical and microscopic modifications occurring in rabbit and lamb muscle during aseptic and anaerobic storage. Food Research, 23, pp. 305–26.

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DEPARTMENT OF COMMERCE

Foreign-Trade Zones Board

[Order No. 772]

Grant of Authority For Subzone Status; Fina Oil Company (Oil Refinery), Jefferson County, TX

Pursuant to its authority under the Foreign-Trade Zones Act of June 18, 1934, as amended (19 U.S.C. 81a-81u), the Foreign-Trade Zones Board (the Board) adopts the following Order:

WHEREAS, by an Act of Congress approved June 18, 1934, an Act ''To provide for the establishment * * * of foreign-trade zones in ports of entry of the United States, to expedite and encourage foreign commerce, and for other purposes,'' as amended (19 U.S.C. 81a-81u) (the Act), the Foreign-Trade Zones Board (the Board) is authorized to grant to qualified corporations the privilege of establishing foreign-trade zones in or adjacent to U.S. Customs ports of entry;

WHEREAS, the Board's regulations (15 CFR Part 400) provide for the establishment of special-purpose subzones when existing zone facilities cannot serve the specific use involved;

WHEREAS, an application from the Foreign-Trade Zone of Southeast Texas, Inc., grantee of Foreign-Trade Zone 116, for authority to establish special-purpose subzone status at the oil refinery complex of Fina Oil Company, in Jefferson County (Port Arthur area), Texas, was filed by the Board on December 13, 1994, and notice inviting public comment was given in the Federal Register (FTZ Docket 40–94, 59 FR 65752, 12–21–94); and,

WHEREAS, the Board has found that the requirements of the FTZ Act and Board's regulations would be satisfied, and that approval of the application would be in the public interest if approval is subject to the conditions listed below;

NOW, THEREFORE, the Board hereby authorizes the establishment of a subzone (Subzone 116B) at the Fina Oil Company refinery complex, in Jefferson County, Texas, at the locations described in the application, subject to the FTZ Act and the Board's regulations, including § 400.28, and subject to the following conditions:

1. Foreign status (19 CFR §§ 146.41, 146.42) products consumed as fuel for the refinery shall be subject to the applicable duty rate.

2. Privileged foreign status (19 CFR § 146.41) shall be elected on all foreign merchandise admitted to the subzone, except that non-privileged foreign (NPF) status (19 CFR § 146.42) may be elected on refinery inputs covered under HTSUS Subheadings # 2709.00.1000–# 2710.00.1050 and # 2710.00.2500 which are used in the production of:

—petrochemical feedstocks and refinery by-products (examiners report, Appendix D);

—products for export; and,

—products eligible for entry under HTSUS # 9808.00.30 and 9808.00.40 (U.S. Government purchases).

3. The authority with regard to the NPF option is initially granted until September 30, 2000, subject to extension.

Signed at Washington, DC, this 18th day of September 1995.

Susan G. Esserman,

Assistant Secretary of Commerce for Import Administration; Alternate Chairman, Foreign-Trade Zones Board.

John J. Da Ponte, Jr.,

Executive Secretary.

[FR Doc. 95–23888 Filed 9–25–95; 8:45 am]

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