Date Development, Handling, and Packing in the United States

Agriculture Handbook No. 482

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

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by G. L. Rygg

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Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key—out of the reach of children and animals—and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

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If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State Extension specialist to be sure the intended use is still registered.

PREFACE

Since commercial date growing was established in the United States early in the 20th century, a large amount of experimental work on handling and storing dates has been done by private operators and by government and university personnel. Most of the results of this voluminous work have been published in various outlets. The purpose of this handbook is to bring together in one concise publication the pertinent, available information on the subject together with previously unpublished material and applicable information from other date-growing areas of the world.

Methods of handling dates from harvest to retail marketing are constantly changing. Some of the methods that are described have been discontinued, either because they were superseded by more desirable methods, or because dates are no longer grown where the methods were used. Some changes were adopted because the product is improved; others were forced by economic necessity. The description of the discontinued methods may be useful in guiding others in their practices as they initiate a date-growing industry in new areas.

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Date Development, Handling, and Packaging in the United States

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INTRODUCTION

Dates have been used as a staple food for several thousand years (*69*).[2] Their high energy value and good storability make dates a wise choice of crop in places where they can be grown. About three-fourths of the dry matter in dates is sugar. Few ripe dates have any starch. They contain small amounts of vitamins A, B_1, and B_2, and substantial amounts of nicotinic acid, but none of the other vitamins is present in significant amounts. Dates are a good source of iron and potassium, and a fair source of calcium, chlorine, copper, magnesium, and sulfur, and they contain a small amount of phosphorus (*9, 11, 34, 35, 78, 84, 102*). Sixteen kinds of free amino acids have been identified (*80*).

Most of the sugar in ripe, dry, and semidry cultivars of dates is usually sucrose; the remainder is invert sugar, a mixture of equal parts of glucose and fructose. All or nearly all the sugar in most ripe, soft cultivars is invert sugar. The general relationship between the texture of date flesh and the predominant kind of sugar has been known since Henry B. Slade did his pioneering work in the first decade of the 20th century (*105, 113*). The general association of dry-textured cultivars and high sucrose content does not appear to be causally related, however, as several dry-textured cultivars have very little sucrose. Examples of such cultivars are Ashrazi, Dayri, Fursi, Menakher, Zahidi, and Azmashi (*17*).

Dates pass through several well-defined stages during their growth and ripening. Long (*49*) recognized seven periods in the life of the fruit; the last of these covered ripening and curing.

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[1] Retired.

[2] Italic numbers in parentheses refer to Literature Cited, p. 48.

Vinson (*114*) and Haas and Bliss (*35*) recognized two stages based on fruit development, the first being one of growth and the second one of sugar accumulation. Ripening would constitute a third period. Vinson's first stage may be divided into two parts, making a total of three stages in addition to ripening (*84*). These are determined by compositional changes in the fruit and are related to the color changes as described below.

STAGES OF DATE DEVELOPMENT

American date growers are accustomed to using the Arabic terms in referring to the stages of development of dates. For this reason, these terms are used to designate the various stages in this report.

"Kimri" refers to young, green-colored dates. The kimri stage may be divided into two phases. The first is characterized by rapid increase in size and weight, rapid accumulation of reducing sugars, low but increasing rate of accumulation of total sugars (especially sucrose), high active acidity, and high moisture content. The second phase is characterized by a reduced rate of gain in size and weight, greatly reduced rate of gain in reducing sugars, considerable reduction in the already low rate of gain in total sugars, slightly reduced active acidity, and a moisture content slightly higher than that in the first phase (*84*).

The kimri stage continues until the dates begin to change from green to the characteristic color of the "khalal" stage. The khalal stage corresponds to the second stage of Vinson and of Haas and Bliss, the third of Rygg, and the sixth of Long. Dates in the khalal stage may be yellow, pink, red, or scarlet, or yellow spotted with red, depending upon cultivar. The rate of gain in size and weight continues to decrease, the weight may even decrease slightly, invert sugar accumulates slowly but sucrose accumulates at a rapidly increasing rate, active acidity decreases, and moisture content decreases in both percentage and in quantity per fruit.

The "rutab" stage follows the khalal and encompasses the ripening period as understood in the United States. According to Dowson and Aten (*22*), this term means "wet." This stage begins when the fruit begins to soften and merges into the final "tamar" stage. Little or no sugar accumulates during the rutab stage. Dates continue to lose water but not enough to make them self-preserving.

Dates in the tamar stage have dried to a fairly firm consist-

ency, and the sugar-to-water relationship is such that the dates are not subject to fermentation.

"Hababauk," a term not commonly used in the United States, refers to the earliest stage of development of the date fruit. The color at this stage is cream to faint green (*22*). This stage is usually included in the kimri stage in American usage.

PHYSICAL AND CHEMICAL CHANGES IN GROWING DATES

Young date fruits contain as much as 85 percent or more water up to the time they have attained nearly full size. Invert sugar constitutes from 40 to 97 percent of the total sugar in the very early stages of growth and remains high during the main period of growth (*3*, *84*). Invert sugar decreases rapidly in percentage as sucrose accumulates after the fruit has attained approximately full size. No other sugar, even in minute quantity, has been detected in dates. As dates approach full development, sucrose usually constitutes above 80 percent of the sugar present. This is true for soft as well as for semidry and dry kinds. Table 1 gives the proportion of sucrose in the Deglet Noor (semidry) and Barhee (soft) dates at representative periods as they grow and ripen. Some cultivars of soft dates have a smaller proportion of sucrose prior to ripening; for example, in Khad-

TABLE 1.—*Percentage of sucrose in total sugar in Deglet Noor and Barhee dates at various stages of development*[1]

Date	Stage of maturity	Deglet Noor	Barhee
		Percent	*Percent*
May 17	Kimri	59	--
May 23	--do--	--	23
June 14	--do--	17	--
June 21	--do--	--	12
July 19	--do--	16	--
July 21	--do--	--	8
Aug. 23	Khalal	76	--
Sept. 2	--do--	--	78
Sept. 11	--do--	--	80
Sept. 11	Rutab	--	.3
Sept. 13	Khalal	83	--
Sept. 13	Rutab	71	--

[1] Adapted from Rygg (*84*).

rawy only 30 to 40 percent of the sugar is sucrose (*43*), in the Zagloul 57 percent (*3*), and in the Hayany about 73 percent (*22*).

A small amount of starch appears in young dates for a short time after pollination (*48*), but this soon disappears in most cultivars. The Samaani cultivar in the United Arab Republic, however, is reported to have 12.8 percent starch (dry weight basis) in the green kimri stage and 3.1 percent in the ripe rutab stage (*4*).

Fiber increases in quantity per fruit but decreases on percentage basis as the fruit grows (*14, 84*).

Pectic materials increase in quantity per fruit until ripening begins. The amount of protopectin reaches its maximum when the fruit attains full size, but soluble pectin increases slowly until ripening begins (*84*).

Tannin and tanninlike compounds reach a maximum concentration in late May or early June, while the dates are still small and green, and gradually decrease on a percentage basis (110). Maier and others (*51, 57, 59*) found that much of the substrate that is involved in enzymic browning in ripe Deglet Noor dates is a hitherto undescribed compound, which they called dacylifric acid, along with the isomers neodactylifric and isodactylifric acids.

Acidity in dates is highest during the period of most rapid growth. It decreases in the latter part of the growing season and continues to decrease as the fruit ripens (*84*).

Date development is influenced by cultural factors, and by environmental factors, some of which may occur early in the growing season but the effects of which may not be detected until considerably later. Heat units accumulated by the end of April may largely determine the earliness of harvest (*19*). Halawy palms deprived of water in June and July bear an abnormally high proportion of dates with hard ends and khalal shrivel, and they have a heavy immature shatter. Palms deprived of water later in the summer are less affected (*29*). Date palms tolerate a fairly high salt concentration in the soil, apparently largely because of their ability to exclude the salt (*30*). Heavy nitrogen fertilization increases yield but lowers quality (*28*). Heavy loads of fruit on the bunches reduce the size of the fruit but may not lower the quality (*31*). High atmospheric moisture shortly before the dates ripen may cause shrivel in the Maktoom variety (*41*). Prolonged high temperatures in the spring may adversely affect Deglet Noor date development in a way that does not become noticeable until the dates ripen (*91, 92*). This effect is discussed in greater detail on page 6.

PHYSICAL AND CHEMICAL CHANGES ASSOCIATED WITH RIPENING, AND THE COMPOSITION OF RIPE DATES

Pronounced changes, both physical and chemical, occur in dates as they ripen. The surface changes from the characteristic khalal color to another color, also characteristic of the cultivar, usually amber or brown, but sometimes black. Along with the change in color is a change in texture from crisp to soft and yielding. A few cultivars, including dry-textured ones such as Thoory and Kenta, do not become soft at this stage. They remain hard, but instead of being crisp they become chewy or brittle, depending on moisture content. As ripening progresses in the more common cultivars moisture is lost and the skin becomes more or less wrinkled.

Just before the onset of ripening, from 80 to 85 percent of the total sugar in Deglet Noor dates is sucrose or cane sugar; the remainder is invert sugar. During ripening, some of the sucrose is hydrolyzed into invert sugar, and, in ripe fruit, sucrose usually constitutes from 60 to 80 percent of the total sugar. A number of factors influence the amount hydrolyzed during ripening. Cultural treatments during the growing season, and the temperature, humidity, and rainfall during ripening undoubtedly influence the amount of hydrolysis (*28*, *29*, *84*, *103*).

In many invert sugar cultivars, the proportion of each kind of sugar just before ripening is similar to that of Deglet Noor at the same stage (*84*, *113*, *114*). All or nearly all the sucrose of the soft or invert sugar cultivars is converted into invert sugar during ripening, whereas in the Deglet Noor only a small part of the surose is converted. The basis of the difference in sucrose hydrolysis in the two types is found in the state of the sugar-splitting enzyme invertase (*113*). Table 1 shows the marked difference in sucrose hydrolysis in these two types of dates as they ripen.

Although starch is not usually found in ripening or ripe dates, other acid-hydrolysable polysaccharides occur in small quantitites. These materials do not diminish during ripening (*84*).

Some of the insoluble pectic substances are converted into soluble pectin in the course of ripening, and the amount of total pectic substances decreases (*84*).

Fats and waxes in the dates have received little attention. Hilgeman and Smith (*42*) found that the ether extract of the skin of ripe dates constituted from 2.52 to 7.42 percent of the skin.

The amount of ether extract in the skin of cultivars of soft dates was inversely related to susceptibility to loss from moisture damage, but Deglet Noor dates were high in crude fat content and were also highly susceptible to moisture damage.

The edible portion of Halawy dates grown in Iraq contains 1.90 percent fat or ether extract (*13*). Chatfield and Adams (*11*) give an average value of 0.6 percent fat in the edible portion.

The wax in ripe Deglet Noor has at least two fractions. The major fraction melts at about 183° F (84° C) and the minor fraction, at about 160° F (71° C) (*82*).

The acidity of dates usually decreases (that is, the pH rises) when they ripen. The pH of the Deglet Noor may rise from about 5.3 to 5.6 to about 6.0 to 6.4. The pH of the flesh of ripe fruit varies greatly, however, depending upon the quality. A high pH value is characteristic of dates of high quality. An overall range in ripe Deglet Noor from 3.9 to 6.8 has been observed, but most fruits of this cultivar fall within the range from pH 5.3 to 6.3 (*87*).

The pH of invert sugar cultivars is in the same general range as the Deglet Noor. Occasional values as high as 7.2 have been found (*3*, *99*).

High temperatures in the early part of the growing season, April and May, have been associated with the development of dry-textured ripe fruit in the Deglet Noor. The fruit of this cultivar appears to be particularly sensitive to high temperatures at that time but rapidly acquires tolerance to heat about the first of June. Rapid cell division characterizes the fruit development at that time. The young seeds seem to be the most tender part of the fruit (*91*, *92*). Dates that are injured by high spring temperatures are more acid than normal when they ripen and are more difficult to hydrate. These differences become noticeable only after the dates ripen (*87*).

The suddenness of the onset of hot weather during the heat-sensitive period may influence the degree of injury. Yarwood (*118*) has demonstrated that some plants exposed to moderately high temperatures for several short periods can develop a certain degree of heat tolerance.

Soft cultivars are not subject to the kind of heat injury described for Deglet Noor, but Nixon (*71*) has shown that skin separation in ripe dates may be increased by high temperatures or high humidity or both during the early part of the growing season.

One of the conspicuous changes in composition associated with date ripening is the conversion of the bitter soluble tannin into insoluble, tasteless forms. The nature of the precipitating reac-

tion is not known but is thought to be similar to that occurring in the tanning of leather. If this comparison is correct, the tannin combines with protein to form an insoluble product (*24, 68, 84, 113, 114*). The immature khalal stage of some cultivars, including Barhee and Braim, contains so little tannin that they are only slightly, if any, astringent.

Polyphenols (tannin and tanninlike substances) constitute about 3 percent of the dry weight of date flesh (*58*). Three polyphenols make up about 98 percent of the total amount of this group; the remaining 2 percent consists of at least 10 constituents.

The moisture content of dates decreases as the fruit ripens. Deglet Noor fruit drop from 66 to 50 percent moisture during the khalal stage (that is, fruit in the red stage between the green kimri and amber rutab stages). Ripe fruit of this cultivar usually contain less than 30 percent moisture (*84*) and are generally harvested in the United States when the moisture gets below 20 percent. The climatic conditions during ripening will modify these values somewhat.

Similar decreases in moisture content occur in the other cultivars as they mature, but ripe fruit of the soft kinds usually contain more mositure, some having 40 percent or more. The high moisture content of ripe fruit constitutes the basis of one of the major operations in preparing the soft cultivars for the market, that of reducing the moisture to a percentage that permits the dates to be marketed with a minimum of spoilage.

Inorganic Constituents of Ripe Dates

The mineral content of dates does not change materially as the fruit ripens, but the amount present is nutritionally significant. Haas (*34*) analyzed six cultivars—Khadrawy, Halawy, Deglet Noor, Zahidi, Kustawy, and Barhee. Khadrawy and Halawy had a slightly higher mineral content than the other cultivars analyzed, but the overall range was 2.14 to 3.38 percent ash.

Potassium constituted from 41 to 44 percent of the total ash. Other minerals were calcium, 2 to 4 percent; magnesium, 2 to 3 percent; sodium, 8 to 12 percent; and inorganic phosphorus, 4 to 13 percent. Minor inorganic elements were iron, 5 to 26 parts per million (p/m); manganese, 2 to 4 p/m; and copper, 3 to 6 p/m. Copper was measured only in the Deglet Noor. The high potassium to sodium ratio is of dietetic significance for people who must restrict their intake of sodium.

Enzymes in Dates

Invertase has been studied more than any other enzyme in dates. Investigators chose this enzyme because of the ease with which its activities are followed. They assumed that conditions that favored invertase activity would also be likely to favor the activity of other enzymes. Vinson (*114*) divided the invertase into endoinvertase and ektoinvertase according to whether it was attached to the cell constituents or was free to escape into the surrounding liquid when the cells were broken. Its most noticeable activity is to convert sucrose into glucose and fructose. In soft cultivars, this conversion is carried to completion or near completion, but in most semidry and dry types only a portion of the sucrose is hydrolyzed. Its activity is promoted by high moisture content and a warm temperature.

Hasegawa and Smolensky (*39*) have recently added significantly to the information on invertase and its activity in dates. Green dates contain fairly large amounts of insoluble invertase (called endoinvertase by Vinson (*113*)), and practically no soluble invertase (called ektoinvertase by Vinson). As the dates turn red, the insoluble invertase is reduced to about one-half its former amount, as expressed in units per date fruit, and remains fairly constant as the fruit continues to mature.

Soluble invertase, as found by Hasegawa and Smolensky (*39*), increased from about 3 percent of the total invertase in green dates to a maximum of about 75 percent of the total in the late red stage and then decreased slightly as the fruit matured. In the meantime, the total invertase activity in the Deglet Noor fruit they used increased from 5 units per date to about 12.4 units. They suggested that the sharp increase in invertase activity is the prime reason for the increase in reducing sugar that accompanies maturation and ripening rather than a loss of membrane system integrity.

The relative invertase activity in dates of various qualities appears in table 2 by Hasegawa and Smolensky (*39*).

The invertase activity is stable at temperatures below 104° F (40° C), about 50 percent activity is lost by heating at 122° F (50° C) for 10 minutes, and 90 percent is lost by heating at 149° F (65° C) for 10 minutes (*39*).

Peroxidase occurs in dates, but its function is not known. It is not involved in the reactions associated with darkening. The optimum acidity is pH 4.7 (*79*). It is more tolerant to heat than both invertase and polyphenolase (*59*, *79*). High concentrations of

TABLE 2.—*Comparison of invertase activity in four different qualities of dates* (39)

Grades	Activity (units/date)[1]		
	Insoluble	Soluble	Total
Natural	2.27_b (2.87_b)	8.61_c (10.9_c)	10.88 (13.77)
Waxy	2.19_b (2.88_b)	8.96_c (11.9_d)	11.15 (14.78)
No. 1 dry	2.00_b (3.03_b)	6.43_b (9.7_b)	8.43 (12.73)
No. 2 dry	1.50_a (2.54_a)	4.90_a (8.3_a)	6.40 (10.84)

[1] Values with common subscript letters within a column are not statistically different at the 0.05 probability level. Activity expressed as units per 10 g dry weight is shown in parentheses.

sucrose greatly inhibit the activity, but dextrose has little or no effect (*79*).

Polyphenolase is responsible for the enzymatic oxidative portion of date darkening. It is more sensitive than peroxidase to acid but is more tolerant to alkalinity. Its optimum acidity is pH 5.0. Its tolerance to heat is intermediate between that of invertase and that of peroxidase (*59, 60, 79*).

Polygalacturonase (PG), one of the pectic enzymes, was studied by Hasegawa and others (*38*). Its activity was nearly absent in Deglet Noor dates in the green stage, but increased as maturity progressed. Most of the enzyme was formed or activated in the late red stage with the peak acitvity occurring when the fruit began to soften. That the activity is related to the softening process is evident by the fact that they found 20 times higher activity in the softened apical end than in the still hard basal end of half-soft fruit.

In relating PG activity to maturity, Hasegawa and others (*38*) found the following amounts at the various maturities: Green, trace; early red, 0.18; late red, 2.3; 50 percent soft, 2.5; 100 percent soft, 2.5; and soft-ripe, 0.81. The values are units per gram dry weight.

PG activity in the several grades of dates was: Natural, 1.68 units per gram dry weight with relative activity of 100; waxy, 1.39 units and 83 relative activity; No. 1 dry, 1.17 units and 70 relative activity; and No. 2 dry, 1.06 units and 63 relative activity. The lower PG activities were associated with the drier and harder grades of dates, but the significance of this association is not yet clear.

Dates undoubtedly contain additional enzymes, but data on their characteristics are not available.

Composition of Seeds of Ripe Dates

Interest in the composition of date seeds stems from their possible use in livestock feed. The compositional data on these seeds, reported by various workers, vary tremendously. In their summary of composition of various foods, Chatfield and Adams (*11*), list the following values for date seeds: Water, 17.0 percent; crude protein, 1.0 percent; crude fat, 0.5 percent; crude fiber, 2.1 percent; ash, 1.6 percent; and total carbohydrates, 65.6 percent. The total of these values is 88.7 percent; the nature of the remaining material is not stated. Other reports give crude protein values as high as 6.9 percent (*107*); crude fat, 9.0 percent (*107*); crude fiber, 23 percent (*1*); and ash, 3.1 percent (*2*). Total carbohydrates or nitrogen-free extract values range from 23.0 percent (*10*) to 72.7 percent (by difference) (*107*). The carbohydrates in date seeds are largely in the form of hemicellulose, which is readily converted to dextrose by acid or enzyme hydrolysis (*22*). Date seeds contain 1.9 p/m estrone (*40*).

Dowson and Aten (*22*) gave the following additional information on date pit composition:

	Percent
Moisture	6.46, 7.7
Oils	8.49, 8.8
Proteins	5.22
Carbohydrates	62.51
Fibers	16.20
Ash	1.12

The fatty acids consisted of the following fractions:

	Percent
Capric acid	0.7
Caprinic acid	.5
Lauric acid	24.2
Myristic acid	9.3
Palmitic acid	9.9
Oleic and linoleic acids	52.2
Stearic acid	3.2

The fatty acids constituted 1.3 percent of the oil; the iodine number was 56.3. They also listed a number of characteristics of the date pit oil.

MATURITY AT HARVEST

Several factors must be taken into account to determine how well matured the dates should be when harvested. The capacity

of the fruit to develop good quality during aritificial ripening and maturation determines the minimum maturity. Considerations that govern the desirability and advisability of early harvesting include: (1) Effect upon total yield; (2) need for earliest possible harvest to minimize loss from unfavorable weather, especially rain, and from insect infestation; (3) desirability of early marketing of as much of the crop as possible; (4) relative cost of all aspects of handling and placing on the market dates picked at different stages of maturity; (5) market preference as to type of date (for example, hydrated versus nonhydrated); (6) availability of pickers; and (7) amount and kind of hydrating and drying equipment available at the packinghouse (*18, 20, 67, 97*).

The unequal ripening of fruits on a bunch historically required that each fruit be picked individually in all but the dry cultivars if the best possible quality was to be retained. Current economic and labor conditions dictate that the number of harvests be held to a minimum.

In the cultivars such as the Deglet Noor, there is more uniformity within a given bunch than between bunches. Therefore, it has become the accepted practice to harvest this cultivar by the bunch whether harvest is by machine or by hand. For economic reasons, all bunches in an orchard are often harvested in one operation. However, better quality fruit is obtained if bunches are harvested selectively as they ripen. At least two separate harvests are desirable—one near the middle of the season, and the other near the end.

The stage of development at which dates have accumulated the maximum sugar per fruit differs somewhat among cultivars. In the Deglet Noor, this stage appears to be at the time softening has progressed about one-half the distance from the tip to the base of the fruit; whereas, in the Barhee, the sugar influx is complete when the first translucent spot associated with normal ripening appears (*84*). In the Maktoom, sugar accumulation is practically complete when 15 percent of the surface has become translucent; however, in the Khadrawy sugar may continue to accumulate until the fruit is soft ripe, full rutab (*1, 42*). The total yield obviously increases as long as the amount of sugar and other dry matter per fruit continues to increase, barring loss from rain, insect damage, disease, or other causes.

The Deglet Noor should not be harvested before the turning stage in which the texture is yielding to pliable and the color is amber to cinnamon. Fruit of this variety has a better storage

potential if harvested when it has a reddish or lavender ring at the perianth end than if it is allowed to remain on the palm until this ring has faded with more advanced maturity (*8, 103*).

Halawy should reach the soft ripe stage, but Maktoom can be ripened into an acceptable product if harvested when 10 to 25 percent of the surface is translucent (*42*). A given variety may be harvested at a less advanced maturity in the latter part of the harvest season than at the beginning. Sugar content alone can not be used as an index of harvest maturity because other factors not directly associated with sugar content—such as texture, aroma, flavor, and appearance—contribute to the overall quality.

Deglet Noor dates that must be harvested before the optimum stage of maturity has been reached attain better texture and flavor if the bunches are cut and hung under a shelter until the fruit ripens than if the dates are stripped from the bunches while much of the fruit is in the khalal stage and ripening is completed on trays. Moderate warming during final ripening helps improve date quality. The longer one can defer bunch cutting or stripping, up to the time nearly all the dates are ripe, the higher average quality and yield are likely to be (*89*).

Factors That Influence Time of Harvest

The need for harvesting as early as possible is determined largely by the likelihood of rain during the normal harvest season. The loss from tearing and cracking of the fruit and from the activity of micro-organisms under those conditions may become exceedingly heavy. The threat of rain varies considerably in the different date-growing areas, and local experience will determine how much consideration it must be given.

Insect infestion in the unharvested fruit varies from year to year and may be an incentive to early harvesting because the infestation may increase with increasing maturity and with damage from rain. This infestation may be reduced by dusting the bunches with insecticides at appropriate times before and during the early stages of ripening (*23, 47*). Growers must be careful to comply with legal regulations governing the use of pesticides. Visible pesticides residues are removed at the packinghouse before the dates are marketed.

The cost of grading dates that have suffered rain damage or insect infestation is higher than it would otherwise be, and the accuracy is lowered because of hidden damage that can be detected only upon cutting the fruit. The need for occasional

regrading adds to the cost per pound of handling the salable fruit.

The increased cost of handling dates harvested before full maturity tends to offset the advantages of early harvest. Dates harvested before they are ripe must be processed to complete the ripening that otherwise proceeds on the palm. They also must be dehydrated enough to reduce the moisture content to a reasonable, safe level unless the dates are to be marketed through low temperature channels such as frozen food outlets.

The amount of shrinkage from dehydration can be determined from figure 1 (*85*). Early in the khalal stage, Deglet Noor dates may have a moisture content of about 66 percent, but this value decreases to about 50 percent later in the season (*84*). This cultivar is generally harvested when the moisture content has dropped to 20 percent or less.

In addition to normal shrinkage from moisture loss, the processing of immature fruit entails varying amounts of loss from spoilage resulting from the activity of yeasts, molds, and bacteria. The cost of processing Deglet Noor dates picked prematurely is so great that immature, moist fruit is often graded as culls to avoid the expense of completing ripening and dehydration.

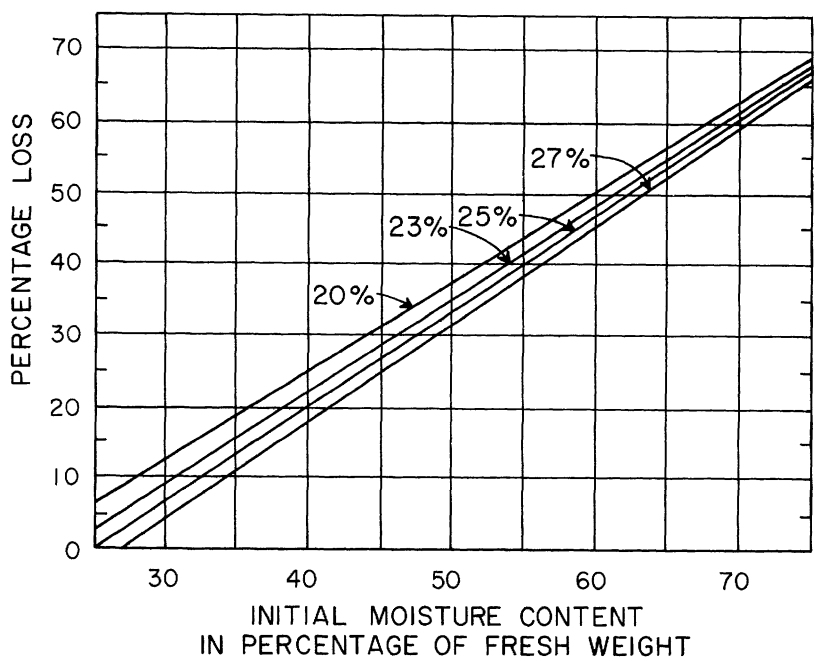

FIGURE 1.—Percentage loss in weight when the moisture content is reduced from the initial value to a final value of 20, 23, 25, and 27 percent.

Market preference may influence harvest maturity within certain limits. This influence is more likely to be felt in the Deglet Noor and other semidry cultivars than in the soft ones. If the preference is for hydrated dates, it may be desirable to delay harvest until the dates are fairly dry. Because the tendency for the Deglet Noor to dry on the palms differs greatly from year to year, the need for hydration is influenced materially by the climate of the season as well as the wishes of the handlers and consumers.

The availability of pickers and the pay they receive indirectly affects the maturity of dates at harvest. When pickers are plentiful and relatively inexpensive, picking can be made at short intervals and the fruit can be picked at near optimum maturity. Conversely, when pickers are scarce and costly, the intervals between picking are lengthened, and increasing portions of the crops dry beyond the best texture and consistency.

Packinghouse operators establish requirements of maturity of fruit brought in according to the equipment available for handling slightly immature fruit, and according to the capacity of the house in relation to the rate at which fruit is received. Houses designed primarily to handle the Deglet Noor are usually well equipped to handle large quantities of dry dates that require hydration; whereas, the capacity for maturation and dehydration is not so great. Dates in need of maturation and dehydration must be attended to without delay, but dry dates may be hydrated when convenient.

Frequency of Picking

Dry or "Bread" Kinds

Dry types of dates are grown on a very limited scale in the United States. Thoory and Kenta are two of the most important dry cultivars. These cultivars are usually allowed to ripen fully on the palm, are very dry and hard when picked, and are usually harvested in one picking.

Semidry Kinds

The Deglet Noor cultivar is the most popular in the United States. These palms were formerly picked as many as seven times a season. With changes in handling methods, market demands, increasing costs, and decreasing availability of pickers, the number of pickings has been reduced to one or two. The reduced number of pickings decreases the proportion of dates harvested as naturals but improves handling and processing.

The principal consequence of reducing the number of pickings is to increase the proportion of dates in the dry categories (*73*, *74*, *89*). This may constitute an economic advantage, as dry dates are more stable, less perishable, and more easily handled than the softer, more moist dates. On the other hand, the dry dates have lost some of the delicate flavor and aroma that they contained at the optimum stage of ripeness.

The lowest number of pickings that can be made without undue sacrifice of yield and quality is determined to some extent by the climatic characteristics of the season. The drier the harvest season the lower the number of pickings that can be tolerated. In years with a less dry harvest season, whether because of rain or because of high humidity with little or no rain, more pickings with shorter intervals between pickings must be made to reduce losses from rotting, fermentation, and insect infestation to a practical minimum.

Soft Kinds

The frequency of picking soft kinds of dates is governed by cultivar as well as by climatic and economic factors. The firmer kinds are often harvested in two pickings by allowing dates that ripen first to remain on the palm until half or more are ripe and then picking the ripe ones. The remaining dates are picked when all or nearly all are ripe.

The softer, more moist kinds must be picked soon after they start to ripen to avoid heavy losses from fermentation and insect infestation. Cultivars of this kind include the Hayany, Tárbarzal, and Sphinx.

The customary procedure for harvesting dates has been for pickers to ascend the palms with buckets or other containers and handpick the dates into the container as illustrated in figure 2.

Mechanical Harvesting[3]

In recent years, mechanical aids to havesting have been developed. Illustrations depicting equipment used to a considerable extent in the Coachella Valley appear in figures 3 to 6.

The adoption of mechanical harvesting aids (*76*) necessitates changes in handling procedures at the packinghouses. Entire bunches are necessarily harvested at one time, but all the bunches on each palm tree need not be harvested at one time. Variations in time of maturity among the bunches require more

[3] Portions of this section were revised or updated by P. F. Burkner, agricultural engineer, USDA, ARS, Riverside, Calif., to reflect changes in the industry since original preparation of the manuscript.

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FIGURE 2.—Dates being harvested in the traditional manner by picking individual dates into a bucket. Soft kinds are picked in this manner, but shallow containers are used to avoid crushing the tender fruit.

than one passage through the garden by the harvesting crew.

Only the drier kinds are suited to mechanical harvesting. The softer kinds are too tender and would be damaged.

Mechanical harvesting of the Deglet Noor cultivar has been used commercially since 1963. Currently, over 80 percent of this cultivar, which constitutes 90 percent of U.S. production, is

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FIGURE 3.—Date bunches are severed from the palms by a man positioned in the fruiting area. The bunches drop into a large container.

harvested mechanically. With machines, 25 men can harvest as much fruit as 100 hand pickers.

The basic mechanical harvesting system consists of selectively harvesting by bunches and then removing the fruit with a mechanical shaker. The dates are then handled and stored in 20-inch-deep bulk bins containing about 750 pounds of fruit.

Several experimental mechanical harvesting systems were tried before a commercially acceptable system was developed.

PN-4384

FIGURE 4.—The container with the date bunches has been lowered to a hopper containing a shaking device for removing the dates from the bunches; the dates drop into a bin underneath.

PN-4385

FIGURE 5.—Filled containers being removed and readied for hauling to the packinghouse.

These systems varied in the method pickers were positioned in the tree and how the fruit was shaken off the bunch.

The harvesting system adopted by the industry uses a truck-mounted telescopic boom to position a worker in a basket near the bunches. This worker cuts mature bunches and places them in the basket. The basket and man are then lowered to a shaker trailer drawn by the boom truck. Here, the fruit is mechanically shaken from the bunches and flows into bulk bins. Three men operate the system: One truck driver-boom operator, one bunch cutter, and one shaker operator.

Mechanical harvesting compared with the same number of pickings made by hand shows no effect on the quality of the product (*72*). In this comparison, all the fruit was removed from the harvested bunches, but two pickings were made by each method.

The depth of dates in a bin is limited by the moisture content of the wettest ripe dates, and probably should not exceed 15 to 18 inches (*96*). Unripe dates should not be allowed to drop into these

containers. These dates ripen on standing and, having a high moisture content, will be crushed, and the released sirup will make the neighboring dates sticky.

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FIGURE 6.—Filled bins at the packinghouse awaiting handling procedures.

Unpollinated Deglet Noor Dates

Deglet Noor dates sometimes grow to nearly full size even though they are not pollinated. Such dates are seedless or have only rudimentary pieces of hard material. In years when this kind of date is abundant, growers and packers are tempted to try to realize some income from them by ripening and drying them and using them in products. When used for this purpose, all fragments of seedlike tissue must be removed.

These dates, if left on the palm until they have ripened or at least started to ripen, can be utilized in products by completing the ripening and maturation in a packinghouse and drying to the required moisture content as determined by the use intended.

The economic feasibility of this practice may be questioned, however, because of the cost of preparing this material, which will bring a relatively low return per pound, and because of the high shrinkage, especially if the dates are picked in the khalal stage of maturity as is often done. The percentage loss in weight can be determined from figure 1. The initial moisture content is likely to be more than 40 percent and may be nearly 70 percent (*85*).

HANDLING AT THE PACKINGHOUSE

The first step in handling dates on arrival at the packinghouse is determined by the organization of the house. Samples are commonly taken and classified immediately after the load is weighed. The returns paid to the grower are based upon the gradeout of the samples. The bulk of the fruit loses its identity as it passes through the packinghouse. Sampling is not necessary in houses that provide custom grading and packing because each grower's fruit retains its identity until it leaves the house.

Fumigation

Dates are fumigated as soon as possible after they are picked to arrest all forms of insect life. Specially constructed rooms are required for this process for they must be as nearly gastight as possible. The impervious layer of the walls, ceiling, and floor should be as near the inner surface as possible to avoid the exposure of porous materials to the fumigating gas. Linings of sheet metal with soldered joints are excellent. A suitable gas barrier consists of two or more layers of strong building paper composed of two sheets laminated by a heavy layer of asphalt. The seams must be lapped and cemented. The paper may be protected with a covering of wallboard or lumber. Masonry walls are usually porous and need to be sealed with dense plaster or with hot asphalt or asphalt emulsion. The floors must be gastight, and care must be taken to form a seal at the junction of the walls with the floor. The doors must be fitted with gastight gaskets. Two doors are commonly provided in opposite walls so that fruit may be introduced through one from the outside and the fumigated fruit withdrawn from the other into the packinghouse, thus minimizing the opportunity for reinfestation.

Provisions must be made for circulating and distributing the fumigating gas and for exhausting the gas to the outdoors.

Facilities for heating the rooms should be provided for use in

the cooler part of the year because the fruit should be fumigated at a temperature of 60° F (16° C) or higher.

A recent development consists of fumigating dates in bins or field boxes stacked outdoors and covered with heavy plastic sheeting. This procedure permits refumigation as often as needed while awaiting processing and packing for shipment.

Methyl bromide is the most commonly used fumigating gas. Instructions for its use, suitable concentrations, and applicators to aid in the application of suitable dosages are available from the manufacturers. Methyl bromide is a very poisonous gas, and its odorless nature requires that it be handled with utmost caution. Carbon disulfide, hydrocyanic acid, and ethylene oxide have also been used for fumigation (*21, 108, 115*). Current regulations should be consulted before the fumigant is chosen.

Temperatures of 40° F (4° C) or lower prevent insect activity but do not kill all forms of insect life. Temperatures considerably below 32° F (0° C) are required to effect a complete kill.

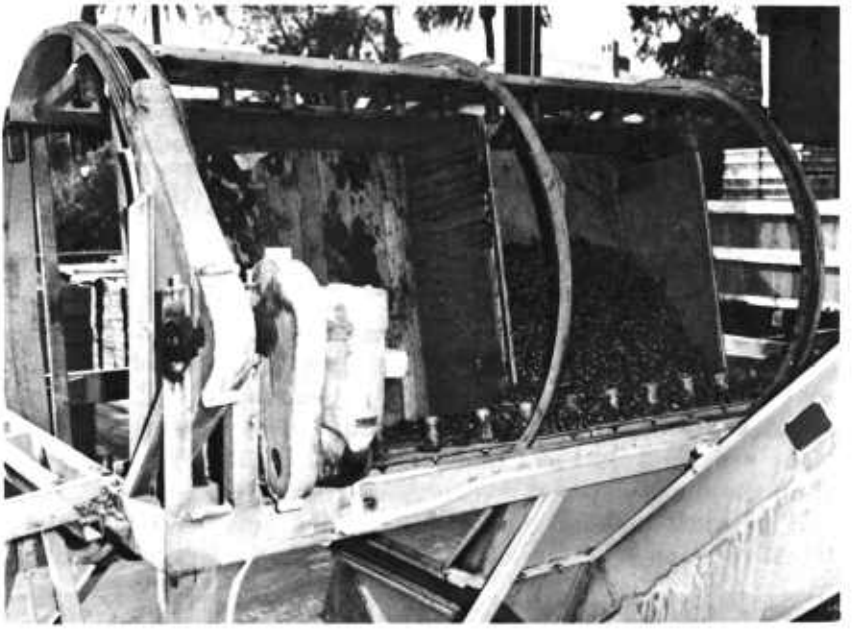
The mushroom mite (*Tyrophagus lintaeri* Osborn) sometimes attacks stored dates. Its small size and ability to survive long periods of drying and absence of food make complete control difficult (*108*).

Cleaning

For many years, dates were cleaned by passing them over damp toweling attached to sloping mechanical shakers or placed inside sloping revolving cylinders. Dust and coarse foreign matter were removed by passing the dates over a coarse screen and suction before they reached the toweling. Frequent towel changes and the use of germicides on them were helpful in maintaining a low microbial population.

In more recent years, washers have been used for cleaning dates. Loose foreign matter is removed by passing the dates over slats before they reach the washer. The washer may have revolving brushes moistened with water and detergent, or the cleaning may be accomplished with jets of water and detergent. In either method, the detergent is removed with a water rinse. Experience has shown that recirculating the washing solution is undesirable because of the buildup of micro-organisms. Washers depending upon brushes for their cleaning action cannot be used on soft cultivars, but spray jets give good results (*111, 112*).

Figure 7 shows one of the large bins used with the mechanical aid being dumped at the beginning of the passage of dates through the packinghouse.



PN-4387

FIGURE 7.—Dates being dumped from the large bin to start the packinghouse operations.

Various devices have been used to remove the excess water after washing. Dates that are too moist are trayed and held in dehydrating rooms; dry dates are usually taken directly to the hydrator. The excess surface water on dates that are packaged immediately after washing and grading is removed by passing them on a conveyor under a blast of air.

Sorting

Immediately after they are cleaned, the dates are sorted to remove culls and to separate the remaining fruit into uniform lots. The first sorting operation produces fairly broad classes based largely on maturity and texture. Subsequent sorting separates these classes into several lots, each of which is uniform in color, texture, size, and moisture content. This procedure is necessary with Deglet Noor but is often dispensed with for soft cultivars. Dates that are too moist are placed in single layers in shallow trays with wire mesh bottoms and transferred to drying rooms where any necessary maturation is accomplished and the excess moisture removed. Those that are too dry and firm are taken to hydrating rooms where the tissue is

softened, and moisture is added by methods described under the sections on hydrating and canning.

Dates are mechanically separated into several sizes. Hand sorting is required to separate dates into categories based on texture, blemishes, and various properties that make them unfit for human use (culls) (fig. 8).

Grading

The U.S. Department of Agriculture (USDA) grades of dates are based on color, uniformity of size, absence of defects, and character. Sugar content is not closely related to grade. Dates of all commercial grades may have approximately the same total sugar content, but the dry grades of such cultivars as Deglet Noor are likely to have more sucrose and less reducing sugar than the moist dates of desirable texture (*14*, *87*, *104*).

A detailed description of date grades may be found in the latest revision of "United States Standards for Grades of Dates,"

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FIGURE 8.—Dates are separated by hand into several groups according to moisture, color, texture, and appearance.

copies of which are available from Processed Products Standardization and Inspection Branch, Fruit and Vegetable Division, Agricultural Marketing Service, U.S. Dept. of Agriculture, Washington, D.C. 20250.

Most American date packinghouses have USDA inspectors on continuous duty during operating hours. Inspection covers adherence to grade standards, which include cultivar characteristics; uniformity of color; freedom from insects, diseases, and various other defects; and uniformity of size for the grade. Inspection for adherence to size requirements is illustrated in figure 9.

Artificial Maturation

Deglet Noor

Artificial maturation of Deglet Noor dates is not practiced extensively in areas well adapted to the culture of this cultivar, but is employed in marginal areas where the dates do not ripen properly on the palm or where damage from rain is likely to occur if the dates are left on the palms until they ripen natu-

PN-4389

FIGURE 9.—The larger packinghouses have continuous USDA inspection. In this operation, the date size is checked to assure that the fruit complies with grade specifications.

rally. In seasons when the dates are late in ripening, it may become necessary to complete the process in rooms designed for the purpose.

Maturation rooms must be provided with means for circulating the air uniformly in all parts of the room and for introducing fresh air as needed. The temperature and humidity must be controlled.

Less mature fruit needs higher temperature and higher humidity than more mature fruit, but for the Deglet Noor the temperature should not exceed 95° F (35° C) for best results. Higher temperatures result in too much darkening and loss of flavor. Freeman (*27*), in 1911, suggested maturing this variety at 113° to 118° F (45° to 48° C), but later experience has shown this temperature to be too high (*56*).

Other Cultivars

Artificial maturation of soft cultivars is usually accomplished at temperatures somewhat higher than those used for Deglet Noor. Temperatures of 95° to 115° F (35° to 46° C) are commonly used to save time and to complete maturation before the dates spoil from mold growth or fermentation.

Different cultivars and different lots of each cultivar may require modifications in the details of the procedure used. Therefore, considerable skill and experience are essential for an operator to develop a high quality product consistently.

In Arizona, where dates are usually harvested at an earlier stage of maturity than is commonly practiced in California, the cultivars have been classified into three groups according to their maturation requirements (*46*).

Group A includes the Khadrawy, Kustawy, Hayany, Sayer, Khalasa, and Sphinx. Dates in this group are matured at 104° to 110° F (40° to 43° C) for best results. Temperatures up to 130° F (54° C) may be used, but some of the cultivars become too dark, and some of the enzymatic processes associated with maturation are interfered with and the final quality is lowered. Maturation is complete when the fruit has lost its translucency and little or no hard tissue remains. This should not require more than 18 to 24 hours.

Group B consists of Halawy, Dayri, Deglet Noor, and Zahidi. These cultivars are more fibrous than those in group A and require more time for maturation, 2 to 4 days or more. A safe temperature is 95° to 100° F (35° to 38° C), but instead of removing water as in group A, it is often necessary to add water to dates in group B. Usually, this may be accomplished by maintaining a relative humidity (RH) of 80 to 90 percent, but some-

times the "sweat box technique" is required. This process consists of placing the fruit in lug boxes lined with wrapping paper and covering the contents with the same paper. The lugs are stacked in a room held at 95° to 100° F (35° to 38° C), and 70 to 80 percent RH. Dry and hard dates, especially Zahidi, need to be sprinkled at intervals.

Group C consists of Iteema, Maktoom, and Saidy. Because of the heavy, thick tissue and the late ripening, these cultivars are matured at 113° to 115° F (45° to 46° C) and 70 percent RH. Even at this high temperature, 2 to 4 days or longer is required to complete the process.

The procedures described above are at best only outlines upon which to base the practice of artificial maturation. The operator must change and modify the conditions and determine the length of treatment for each lot of fruit. The importance of his judgment has been expressed aptly by Hyde in "Processing Arizona Dates" (*46, p. 10*):

> Since the character of the fruit entering the maturation rooms changes from week to week during the harvest and from season to season, no hard and fast rules can be established. Successful maturation can never be reduced to a science; it is an art to be mastered only after years of close observation and never-ceasing attention to detail. When the processor can manipulate the temperatures, the air movements, the humidity, and the time so that his dates have a light golden amber for Iteema, Khadrawi and Maktoom, and a deep shining black for Hayany and Sphinx; when the skin is thin, soft, pliable with no trace of crust or shell; when the fruit tissue is uniform, devoid of fibre, and melts in the mouth like a soft fresh chocolate cream; when the rag around the pit has been reduced to a mellow pulp; when the rather timid flavoring esters remain unchanged or unmasked; when a processor can accomplish these things, then he will have "arrived."

Chemical Aids to Ripening

Numerous chemicals have been tried to hasten date ripening and to improve the quality of the final product. A few have given sufficiently favorable results to encourage their use for a time, but all were eventually abandoned in the United States because naturally ripened dates were better and less labor and shrinkage were involved.

Vinson (*113*) observed the effect of more than 100 chemicals on

date maturation, and found that several hastened the process. The most promising of these was acetic acid. Freeman (*27*) used ammonia experimentally to some extent but devoted more time to incubation at various controlled temperatures and humidities.

Other compounds that have found limited favor for a short time include carbon dioxide, ethylene, hot lye, and salt (*21*, *24*, *44*, *66*).

Gibberellin applied to young dates has given unfavorable results. When applied to Deglet Noor dates within a few weeks after the spathe opened, it increased shrivel prior to ripening and increased the susceptibility of the fruit to checking and blacknose. When applied to half-grown dates, gibberellin prevented the dates from developing a full khalal color and slightly delayed ripening (*70*).

Freezing to Promote Ripening

Completely turgid, immature dates (khalal) may be ripened into an edible, although not an especially high quality product, if they are first frozen (*61*, *62*, *89*, *109*). This treatment removes the astringency by converting the soluble tannin into an insoluble form; it also develops the translucent appearance of a normally ripened date, but the flavor is not equal to that of fruit that has been permitted to ripen naturally, and the high initial moisture content introduces a high but unavoidable shrinkage.

Dehydration

A sizable portion of the crop of both semidry- and soft-date types must be freed from excess moisture before it can be marketed unless it is to be consumed immediately or stored at very low temperatures. This drying is accomplished in specially constructed rooms similar to those used for maturation, and the two processes are often accomplished simultaneously. Provision must be made for thorough circulation of the air, for frequent changes to remove the moisture, and for heating.

Dates are spread in a single layer in shallow wire mesh trays. Stacks of trays are stowed in a manner that will allow good air circulation. To avoid too rapid drying and the development of hard brittle skin, the relative humidity should not be permitted to fall much below 50 percent unless fairly short cycles of alternate dry and more humid air are used in blowing air across the fruit. This is accomplished by recirculating air until a fairly high humidity is built up and then introducing fresh preheated air at a very low humidity. With Deglet Noor, a temperature of 85° to 90° F (29° to 32° C) is desirable. The dehydration process

may take from 3 to 8 days depending on the condition of the fruit and the time of year (*18*).

The amount of drying required depends on the objective of the operator. A desirable moisture content for Deglet Noor in California is from 23 to 25 percent. Fruit with this moisture content has a desirable soft texture and is dry enough to store well without being unduly subject to molding, fermenting, darkening, and loss of flavor (*8*). In soft cultivars, the usual practice in California is to reduce the moisture content to 25 to 28 percent. In Arizona, a moisture content from 25 to 30 percent is used for dates entering the usual commercial channels through refrigerated warehouses. Dates intended for shipment directly from cold storage, for immediate consumption soon after packing, are allowed to have a moisture content of about 35 percent.

A practice used on a small scale in California consists of placing soft cultivars of dates, with moisture contents of 30 to 40 percent, in storage at 0° F (−18° C) immediately after cleaning and within 1 day of harvesting. Such dates are kept at a low temperature until they are sold. Consumer acceptance has been satisfactory, but this method has not been exploited extensively.

Dates harvested during and soon after wet weather present a special problem in drying. These should be placed on wire mesh trays and held in cold storage with good air circulation while awaiting regular packinghouse handling procedures (*119*). Spoilage in such dates has been reduced materially by dusting them with sulfur before they are picked (*117*). The sulfur presents a cleaning problem, but modern cleaning equipment should aid in its removal.

Since moisture control is one of the most important phases of date handling, a quick and easy method for measuring moisture is desirable. Such a method, with sufficient accuracy for the needs, is found in the small hand refractometer. These refractometers are made for two ranges of soluble solids contents, the low range extending from 0 to 60 percent solids (40 to 100 percent moisture) and the high range, from 45 to 85 percent solids (15 to 55 percent moisture). The high range instrument is needed for use with dates.

A paste is prepared from the flesh and applied to the ground glass surface in the instrument. The percentage of soluble solids is read from a scale that is calibrated in percentage of sugar. The reading must be given a suitable correction for temperature and an additional correction for insoluble solids. The latter correction differs with cultivar. Corrections for some of the commonly grown cultivars are: Deglet Noor and Dayri, −1.4; Zahidi, −1.3; Khadrawy and Halawy, −1.2; Saidy, −1.1; Medjool,

−1.0; Maktoom, −0.7; and Barhee, −0.3 (*83*). These values are subtracted from the moisture content found after the temperature correction has been applied to the percentage of soluble solids as read on the instrument.

More accurate results are to be had by drying to constant weight the ground date tissue in thin layers under vacuum at 149° to 158° F (65° to 70° C), but this method is much more time consuming and requires rather expensive equipment; furthermore, the equipment is not portable as is the refractometer.

An important advantage of the refractometer method is the small size of sample needed. The moisture content of single fruits can readily be measured. A good practice is to measure the moisture content of individual dates that are representative of the wettest and the driest in a lot to determine the uniformity of grading. A uniform moisture content is important. An occasional very moist date in a package may ferment and cause the entire package to be unacceptable. Moisture contents of dates in a package do not equalize rapidly, and moist dates may spoil before the moisture content of these dates is reduced to the average of the remaining dates in the package even though a fungicide may have been used in the package.

Hydration

The purpose of hydration is basically to soften the texture of the fruit. This may be accomplished by simply incorporating additional water in the flesh or it may be necessary to break down the fibrous tissues; a combination of these two processes is often necessary.

Dates, especially of the soft cultivars, which have become too dry and hard as a result of remaining on the palms too long after they were ripe or from being kept in a dry atmosphere too long, can be softened readily by increasing the moisture content.

The need for hydration in the Deglet Noor may be great or small according to the climate of the season, cultural practices of the grower, the soil on which the dates were grown, and the frequency of picking the ripe fruit. Dates that have dried too much from too long exposure to dry air are readily softened if they are otherwise of good quality. Dates that are hard and dry, because of the nature of the climate during the growing season or because of the soil on which they were grown, are more difficult to soften because of the necessity of breaking down the fibrous flesh. These dates are more acid than those which soften on the palm as they ripen, and the more acid the tissue the more

difficult it is to soften by hydration. Deglet Noor fruit with a pH value of 5.5 or lower soften with considerable difficulty, and the product is of low quality. Rubbery dates have low pH values and can not be hydrated satisfactorily (*90*, *91*).

Almost all Zahidi dates require hydration. Fortunately, however, this cultivar responds quite readily to the treatment.

In California, the most commonly used hydration procedure consists of traying the dates and exposing them to live steam. The time and temperture required are governed by the condition of the fruit to be hydrated. The length of the treatment can be reduced by raising the temperature, but the quality of the product is likely to suffer. A common treatment for Deglet Noor dates is to introduce live steam at 5 psi until the temperature reaches 140° F (60° C) and to maintain it for 4 to 8 hours. For this purpose, small, well-insulated rooms with forced air circulation are used so that the temperature and humidity may be uniform and accurately controlled to bring the warm moist air equally to all the dates. The doors may remain closed after the steam supply is turned off, or the dates may be moved to another tight room where they are allowed to cool slowly in the moist air to increase the moisture absorption and tissue softening. The operator needs considerable skill to obtain the best results.

Dates to be hydrated are spread on mesh-bottom trays one to two dates deep, as shown in figure 10. A stack of such trays ready to be trucked into a hydrating chamber appears in figure 11.

The conditions used for hydrating and softening Deglet Noor dates in Algeria, the original home of this cultivar, are somewhat different from those used in California. In that country, the temperature used is somewhat higher, 149° to 158° F (65° to 70° C), the humidity is lower (55 percent RH), and the duration shorter (2 to 4 hours) (*97*). Deglet Noor dates grown in Algeria, especially in the vicinity of Biskra and Tolga, may be less difficult to soften than those grown near Indio, Calif., because of the lower prevailing temperatures in April and May, and possibly in September (*98*).

Moderately dry dates and those not too high in acid may be hydrated or softened without heating above room temperature by exposing them to a partial vacuum while immersed in water. A return to atmospheric pressure forces water into the flesh. Such dates, on standing several days at room temperature or under refrigeration, attain a desirable texture. If the treatment is properly executed, the dates will not become too soft and sirupy. Dates that require more severe treatment may be soft-

ened by utilizing a combination of the vacuum and the steam treatments. The reduced exposure to heat compared with steam hydration alone improves flavor retention.

The "sweat box technique," described in the section "Artificial Maturation," is a form of hydration.

In addition to softening the dates, steam hydration tends to improve the keeping quality over that of nonhydrated dates with similar moisture content as a result of killing a high proportion of the micro-organisms on and in the fruit (*99*).

Not all the chemical changes brought about by hydration have been ascertained. In dates that contain appreciable quantities of sucrose, hydrolysis of some of this sucrose has been noted (*7*, *27*), but this change probably is not entirely responsible for the great change in texture. Other hydrolytic changes affecting the structural components of the fruit no doubt occur, but data on the

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FIGURE 10.—Dry dates are trayed before introduction into the hydration chambers. The paddle wheel at the rear smooths the dates on the mesh-bottom trays and removes the excess.

PN-4391

FIGURE 11.—Stack of trays on a handtruck about to be placed in a hydrating room.

nature or extent of these changes are not available. Maier and Metzler (*52*) suggested that soft-textured, low moisture Deglet Noor dates may be produced by adding moisture and perhaps invertase and holding at about 140° F (60° C), long enough to produce the desired hydrolytic reactions, and then cooling and removing the excess moisture. Former practices were designed to hold sucrose inversion to a minimum to retain as much as possible of the peculiar quality of Deglet Noor dates. Coggins and others (*15*) have studied the chemical and histological changes that accompany softening.

Acidity in dates changes very little during hydration unless neutralizing agents are deliberately introduced. Alkaline ammonium sulfite added to the water to be infiltrated into the dates by partial evacuation improves the quality of the product when the dates to be treated are moderately acid. The ammonium

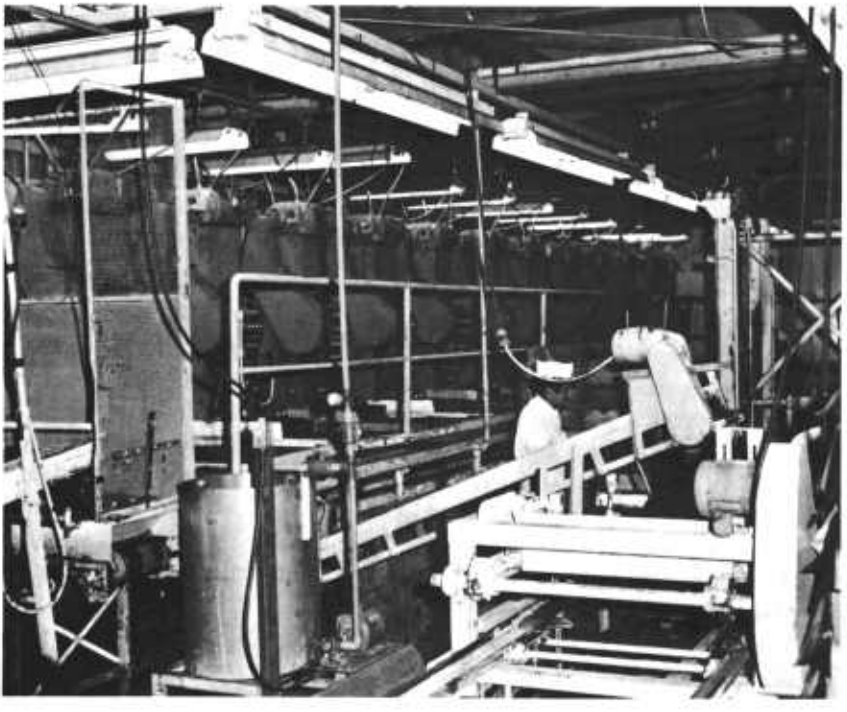
hydroxide used in this treatment decreases the acidity, and the sulfite prevents excessive darkening (*95*). No commercial use has been made of this method of neutralizing the acid.

Pitting

Increasing proportions of dates are pitted before they are offered for sale. Eighty percent or more of the Deglet Noor dates packed by the California Date Growers' Association in 1970 was pitted for greater consumer convenience and to avoid paying the transportation of the pit, which constitutes about 10 percent of the weight of a whole date. Figure 12 shows a bank of 12 mechanical pitters.

Pasteurization

Pasteurization is intended to kill all forms of micro-organisms and insects in dates. In actual practice, the insect mortality is complete, but not all micro-organisms (spores) are killed. In 1916, Forbes (*26*) used this treatment successfully to kill all forms of



PN-4392

FIGURE 12.—A bank of 12 mechanical pitters.

insect life by holding the dates at 149° F (65° C) 2 to 4 hours. Clague and Fellers (*12*) recommended a temperature of at least 151° F (66° C) for 1 hour at 100 percent RH. At higher temperatures, one may use shorter periods and lower humidities.

A room used for pasteurization must be well insulated and equipped with heating facilities of sufficient capacity to heat a charge of dates rapidly, and the air must be circulated rapidly to obtain uniform heating. Provision should be made for introducing fresh filtered air.

Maturation and drying should be completed before the dates are pasteurized because the temperatures used tend to destroy some of the enzymes whose activities promote maturation, and sirup exudes from dates that have more than about 35 percent moisture. Pasteurizing dates that have a high moisture content does not consistently give good results as they sometimes mold or ferment in spite of the treatment (*43*). Hilgeman and Smith (*43*) failed to kill all fungi and bacteria in dates held 1 hour at 176° F (80° C) or 2 to 4 hours at 158° F (70° C).

In Arizona, dates are pasturized by raising the fruit temperature to 150° F (66° C) and holding for 30 minutes. To do this, the air temperature needs to be raised to about 162° F (72° C). With good equipment, about 1 hour is needed to bring the dates to the required temperature. More severe conditions than these accomplish a higher percentage of kill, but they are objectionable because they produce excessive darkening and loss of flavor and make the dates less attractive (*43*, *46*, *63*). Pasteurization is not commonly practiced in California except incidentally during steam hydration.

Sharples (*101*) found that pasteurization at a fruit surface temperature of 165° F (75° C) for 30 minutes sometimes reduced the bacterial population by perhaps 75 percent and sometimes slightly or not at all. Fumigation with ethylene oxide likewise reduced the bacterial population only slightly. Both pasteurization and fumigation reduced the yeast population, but neither reduced the mold population enough to effect a reliable prevention of spoilage from this cause. Dates thus treated are therefore likely to contain enough viable molds and bacteria to spoil the fruit when a suitable environment is provided. Dark dates appeared to be more prone to spoil from microbial action than light-colored ones of the same cultivar and moisture content.

Surface Coating

Many materials have been used to coat dates to reduce stickiness and enhance the appearance. A spray composed of 2

percent butylated hydroxyanisole, 2 percent butylated hydroxytoluene, 6 percent vegetable oil, and 90 percent water, with a small amount of wetting agent added, gave good experimental results. A 5-percent solution of soluble starch as a dip gave good results at the time of treatment, but date surfaces with bloom retained too much material. The coating from these surfaces later peeled and left a dull surface. Schiller and Maier (*100*) recommended 6 percent soluble starch or 3 percent methyl cellulose for coating dates.

BLEMISHES

The appearance and texture of dates are sometimes seriously impaired by blemishes caused by unfavorable environmental conditions during the growing season or by mites. No pathological organism has been found associated with these defects. The incidence varies among types and cultivars and from season to season within a given cultivar. The more important blemishes found on American dates are blacknose, black scald, and puffiness or skin separation.

Blacknose

Severe checking of the skin of some date cultivars, induced by high humidity just before the beginning of the khalal stage, results in darkening, shriveling, and hardening of the flesh at the tip of the fruit. This condition, known as blacknose, and in some cases as sugartip, lowers the grade of the fruit, and if severe, may cause it to be culled (*68*). The Deglet Noor is especially prone to develop this blemish.

Black Scald

Black scald consists of a blackened and sunken area with a definite line of demarcation. It appears at the tip or on the sides of the fruit. The appearance suggests exposure to high temperatures, but the cause is not definitely known (*68*).

Puffiness or Skin Separation

Puffiness usually affects only soft cultivars of dates, and these differ in susceptibility. The condition develops during ripening and may or may not increase during curing and drying. Puffi-

ness causes dates to lose grade, and is especially objectionable if the separated skin becomes hard and brittle.

The cause of puffiness is not known, but high temperature or high humidity, or both, at a stage before the beginning of ripening, may predispose the dates to skin separation. Reducing the number of strands in a bunch tends to reduce the affliction; whereas, severe cutting back of the strands tends to aggravate it (*32, 68*).

Gefen and Fahn (*32*) found that the skin of Barhi dates, which blistered badly, had fewer stomatal cells than the Dairi, which formed no blisters; the skin of the Barhi also was less elastic. Dates dried at 113° F (45° C) formed fewer blisters than those dried at 149° F (65° C). Dates dipped in a wax substance, especially Myvocet, formed fewer blisters than undipped dates, and the treatment did not affect drying.

RESPIRATION

Since the rate of respiration by ripe dates is so low, it does not need to be considered in selecting the materials to be used for packaging the fruit. The rate increases as the moisture content increases. Cured Deglet Noor dates, with 20 to 22 percent moisture, produce about 0.4 milligram (mg) carbon dioxide per kilogram per hour at 75° F (24° C). The rate is about 2 mg in dates with 27 percent moisture.[4] These rates compare with about 27 mg in oranges and 61 mg in peaches, both at 70° F (21° C) (*37*). The presence of growing mold, yeast, and bacteria on the dates materially increases the apparent rate of respiration and the need for aeration.

According to Hussein and Aref (*45*), respiration in dates reaches a climacteric peak when the color begins to change from green to yellow or red. Luthra and Chima (*50*) observed a similar rise to a maximum in Malta oranges at the onset of the change from green to yellow.

Both enzymatic and nonenzymatic reactions cause oxygen to be absorbed and carbon dioxide to be produced. Nonenzymatic reactions cause about two-thirds of the gas exchange in date flesh. Enzymatic reactions are involved in enzymatic browning as well as in normal respiration. Only a small fraction of the total oxygen absorbed and carbon dioxide produced is associated with true respiration. Seed respiration accounts for about one-fifth of the gas exchange in whole dates (*59*).

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[4] BARGER, W. R. COLD STORAGE OF DATES. Office report, 52 pp. 1937.

PLANT SANITATION

Certain practices are necessary to promote a high degree of sanitation in any plant in which food is handled. The need for such practices in a date packing plant is apparent because of the high sugar content of the product and the resulting tendency of objects coming in contact with the dates to become sticky. These sugary films provide places for the growth of innumerable populations of micro-organisms.

Practical measures for controlling microbial growth have been suggested by Vaughn, Winter, and Smith (*112*) and by Sharples (*101*). Equipment and workers' hands coming in contact with the fruit should be cleaned and sanitized continuously or at frequent intervals. They suggest hand cloths should be rinsed in a sanitizing solution at frequent intervals, and the rinse water should be changed at least every 2 hours. They recommend conveyor belts should be cleaned and sanitized continuously by using a revolving brush or, preferably, by using an immersion type of belt sanitizer. A squeegee is used to dry the belt.

Disadvantages of these methods are that workers have to remember to use the hand cloths, and the treated water used to sanitize the hand cloths and the belts must be changed at intervals not exceeding 2 hours to avoid bacterial buildup. A continuously chlorinated spray, rather than an immersion belt cleaner, would avoid part of this problem.

A continuous cleaning arrangement has the advantage of obviating the need to stop the belt periodically for cleaning, or running it without a load long enough to allow hand cleaning. Furthermore, as it is always clean, no extensive cleanup is required at the end of the day. Reagents found to be effective in reducing microbial population (*112*) were hypochlorite and chloramine-T. Sharples (*101*) obtained slightly better bacterial control with a quaternary ammonium compound than with hypochlorite.

FORMS OF DETERIORATION

Two general forms of deterioration affect dates, pathological and nonpathological.

Pathological

The micro-organisms concerned in pathological date spoilage fall into the three general groups: Yeasts, molds, and bacteria. Of these, yeasts are of greatest economic importance. The most harmful yeasts are those capable of growing in relatively con-

centrated solutions of sugar. Species of *Zygosaccharomyces* are more tolerant of high sugar concentrations than others found in dates, and these are followed by a species of *Hansenula* (*63*, *64*, *65*). Dates that have been attacked by yeast can be detected by an alcoholic odor. White aggregates, which include yeast cells, may often be seen in skin cracks of badly fermented dates. Gas pockets may form under the skin, the flesh may be discolored, and the flavor is noticeably impaired. When the moisture content is just high enough to allow slow yeast growth, the dates gradually develop undesirable odor and flavor.

Molds are of little consequence in the spoilage of commercially packed dates except in very moist lots. They may cause large losses before and just after the fruit is harvested if rains or periods of high humidity occur at that time. Species of *Aspergillus*, *Alternaria*, and *Penicillium* are the most common molds found in dates. Mold growth may be detected by mycelia and spores and by color, odor, and flavor. These organisms usually develop before the dates are cured or dried because they cannot develop on the cured product. *Catenularia fuliginea* Saito is capable of growing on dates that are somewhat drier than the fungi previously mentioned and appears occasionally on packaged dates in the market. Even this mold organism requires a fairly moist date to develop (*25*, *65*, *110*).

The role of bacteria in date spoilage has not been determined with any degree of certainty. *Acetobacter* is known to convert the alcohol produced by yeast into acetic acid; the odor of vinegar is sometimes pronounced in spoiled dates. In this event, the dates are already ruined commercially before the bacteria become active. Lactic acid bacteria have been suggested as possible contributors to the gradual deterioration of dates (*36*, *63*, *101*).

Whatever deterioration may be caused by bacteria, its economic importance compared with the deterioration caused by yeasts and molds is in all probability exceedingly small. The bacterial population on dates at harvest is of the same order of magnitude as that of molds (*101*).

Nonpathological

Aside from the obvious and very objectional molding and fermentation caused by pathological factors, dates may darken, become sirupy, develop sugar spots, lose flavor, become too dry or too moist, or develop an objectionable granular texture. Hydrolytic changes, including the inversion of sucrose into reducing sugars (fructose and glucose, or invert sugar), occur more rapidly at high than at low temperatures and at high than at

low moisture contents. The same is true of acid production. Most of this acid is produced by nonoxidative, nonenzymatic reactions (*58, 59, 60*). The acidity increases even if the dates have been heated as in hydration or fumigated with a volatile fungicide such as ethylene oxide (*99*). Fermented dates have considerably more acid than sound ones as a result of the bacterial conversion of some of the alcohol to acetic acid.

The rate of darkening varies with temperature and moisture content, and possibly with cultivar and previous treatment. Darkening is the result of both oxidative and nonoxidative reactions (*53, 54, 55, 57*). Oxidative darkening can be reduced by storage in inert gas or vacuum (*59, 60, 79*). General darkening can be delayed by lowering the storage temperature and reducing the moisture content (*93, 94*).

A form of deterioration, perhaps less serious than those already described, is that of sugar spotting. Sugar spotting reduces the market value by disfiguring the affected dates rather than by making them inedible. The light-colored spots under the skin are composed mainly of sugar crystals and may be removed by gentle heating. They will reappear on standing, however, if conditions are suitable for their formation. Fine sugar crystals sometimes form on the surface of dates and have been referred to as "sugar bloom." These, too, are readily removed by gentle heating.

Sugar spotting is restricted almost entirely to the invert sugar type of dates and appears only rarely in cane sugar types such as Deglet Noor. Sugar crystals may form, however, within the flesh of Deglet Noor dates as they become old. Deglet Noor dates that have sugar spots do not have abnormally high reducing sugar content. Analysis of such dates showed that only 25 percent of the sugar was in the reducing form.

Practically all soft cultivars grown in the United States are of the invert sugar type, but the cultivars within this group vary considerably in their tendency to form sugar spots. Several of the semidry cultivars and nearly all of the dry cultivars contain large amounts of sucrose (*16, 17*) and are much less subject to sugar spotting.

Temperature and moisture content influence the development of sugar spots in a given cultivar. Lowering the temperature below ordinary room temperature reduces the rate of formation. Soft cultivars of dates are most prone to spot when the moisture percentage is in the high 20's. Little or no spotting is likely to occur in dates with a moisture content higher than about 33 percent, and spotting decreases as the moisture falls below 22 percent (*6, 43, 81, 101*).

PACKAGING

The percentage of the American date crop that is placed in consumer packages before it is shipped from the area of production has increased over a period of years. In 1970, about 85 percent was handled in this manner.

Most of the nonprepackaged Deglet Noor dates are marketed in 15-pound flats of fiberboard or wood. Others are packed in 5- and 10-pound cartons. Soft cultivars must be packed in shallow containers to avoid crushing unless they are thoroughly cured.

Large reinforced fiberboard cartons are used for packing dry grades for export. Such dates are not readily damaged by crushing. Figure 13 shows such cartons being check weighed and readied for lidding and loading.

A variety of sizes of packages increases date sales over the display of only one size (*33*, *75*, *106*). Consequently, consumer

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FIGURE 13.—A dry-type Deglet Noor date is packed in large fiberboard cartons for export and subsequent processing. Each package is checked for full weight.

packages are made in a number of sizes and shapes. They range in size from 8 ounces or less to 3 pounds. In addition, small quantities are packed in 2-ounce bags for eating out of hand. The containers may be bags of transparent film or trays overwrapped with film. Round fiberboard cans with metal tops and bottoms are used for some of the better grades; these contain 1 to 3 pounds. All-metal cans with friction tops are used, and rigid, transparent, 8- and 12-ounce plastic containers have received excellent consumer acceptance. These plastic containers are shown check weighed in figure 14.

To prevent mold and fermentation in the packages, small, carefully measured portions of a volatile fungicide were introduced into the containers just before they were closed. Formerly, the active ingredient most commonly used for this purpose was

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FIGURE 14.—Pitted dates are packed in 8-ounce plastic containers. Each container is weighed to assure full weight.

ethylene oxide, but propylene oxide also was used. The amount added varied with the nature of the container and the composition of the mixture (*65, 116*). These materials are not currently allowed in the United States.

A small quantity of dates has been canned with varying degrees of success. Good results have been achieved by the use of a method in which the dates are held under vacuum (*67*). The sealed cans are immersed in water at about 190° F (88° C) for 30 to 45 minutes to destroy micro-organisms. The specific conditions are governed by the nature of the dates. Since canned dates may be kept on store shelves or in warehouses longer than the dates are likely to remain in good, tasty, and attractive condition, special precautions should be taken by the packers and distributors to make certain that no cans remain in the market channels from one season to the next. Consumer acceptance of this package has not been good, probably because of the lack of visibility, the increased cost, and the presence of old packs on the shelves.

STORAGE

American dates were kept in cold storage at least as early as 1916. F. W. Butler and Sons of San Francisco stored fresh dates successfully at 34° to 36° F (1° to 2° C) for 5 months from September 1916 to February 17, 1917. In 1917, they stored Hayany dates up to 6 months. The dates that were partly dried before storage retained the best flavor (*26*). Later experience has shown that some of the water should be removed from very moist dates before they are stored. Present information on the Hayany suggests that the dates stored by Butler without drying probably contained about 50 percent water.

Dates are usually placed in cold storage after they have been cleaned, graded, and, if necessary, matured and dehydrated. Dates to be sold in bulk are often packed in 15-pound containers before they are stored. At the peak of harvest, when packing-houses receive dates more rapidly than they can handle them, a considerable tonnage may be placed in cold storage until packing facilities become available. This practice results in a better product than if the surplus dates are allowed to remain at prevailing room temperatures over an extended period. To get the full benefit of cold storage, the dates should be cooled as rapidly as possible after they are placed in storage. Quick cooling is promoted by proper stowing of the containers, good air circulation, and air temperature low enough to produce the desired conditions (*5*).

The most desirable temperature for date storage is determined by considering the cost in relation to the minimum requirements of the dates. The keeping quality of all dates apparently improves as the temperature is lowered within reasonable limits. The lower limit of storage temperature is governed by the cost and not by the effect of low temperatures on the dates. In any discussion of storage temperatures for dates, the recommended temperatures are the highest at which dates of a given description are likely to retain acceptable quality for the required length of time. Lower temperatures conserve the quality better than the temperatures recommended but they cost more.

Deglet Noor and similar varieties retain good quality up to 1 year at 32° F (0° C). Soft types should be stored at 0° F (−18° C) to retain good color and flavor and to minimize sugar spotting.

Both temperature and moisture content are important in limiting the storage life of dates (*93*, *94*). Figure 15 shows the general effect these factors have on the storage life of Deglet Noor dates.

Storage at temperatures of 32° F (0° C) or lower for a month very substantially reduces the population of yeasts, molds, and bacteria. A complete kill is not accomplished, however, and upon return to favorable temperatures the surviving organisms resume activity and under suitable conditions can cause spoilage (*101*). Modern facilities permit stacking palletized cartons of packed dates to the ceiling of high cold storage rooms.

The humidity of the storage room is important unless the dates are enclosed in moisture-proof containers or the tempera-

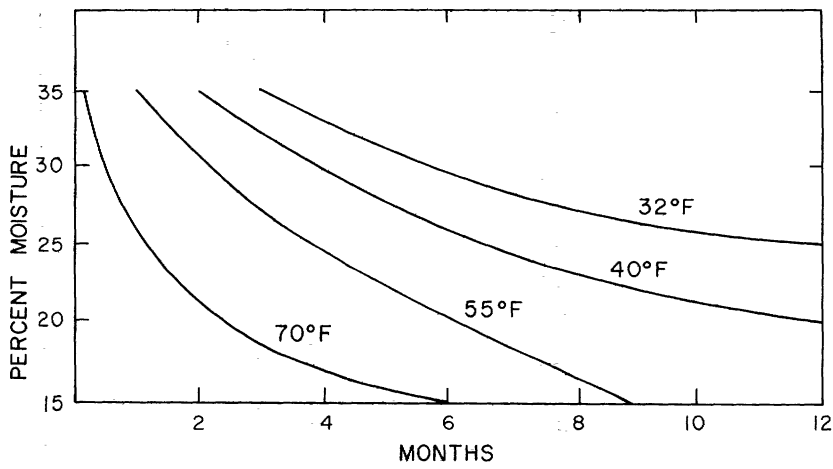

FIGURE 15.—Effects of temperature and moisture content on storage life of Deglet Noor dates.

ture is somewhat lower than 32° F (0° C). The relative humidity required to maintain constant moisture in the dates depends on the initial moisture content and on the temperature of the storage space (*22, 86, 88*). Constant temperature is important to avoid undue fluctuations in the relative humidity and the consequent drying or moistening of portions of the stored dates. Soft types require slightly lower storage humidity to maintain a constant moisture content than Deglet Noor with the same moisture content.

At the point of production, cleaned and graded dates are stored only in bulk containers such as 15-pound flats and 30-pound lugs and more recently in bulk bins holding 750 to 1,000 pounds. Consumer-sized packages are filled just prior to shipment to distributors. By this practice, fresh appearing packages are sent to the distributors, and dates that may have become unfit for packaging while in storage may be eliminated.

Dates stored with other aromatic products are likely to absorb the flavors of their neighbors. It is therefore essential that the air in the storage rooms be free from foreign aromas. The flavors of apples, onions, and potatoes were noted in dates stored with these products at ordinary cold storage temperatures, and the flavor of meat was very marked in dates stored in frozen food locker plants in the same room with meat (*109*).

TRANSPORTATION

A low transit temperature is desirable for dates, but the dates should be cooled before they are loaded into the railroad car or truck. Removing the heat from the loaded packages is a slow, difficult, and expensive process. This is so because most dates are packed in tight consumer packages which are in turn packed in tight master containers. The master containers are stowed tightly in the vehicle with no provision for refrigerated air to pass through or between the containers.

Date temperatures during transit in iced refrigerator cars were measured with recording thermometers in 12 test shipments made to New York. The services varied from no ice to full-bunker standard refrigeration (daily re-icing). Loading temperatures were 52° to 100° F (11° to 37° C). Some cars were equipped with circulating fans and wall flues; others had neither. The dates were packed in wooden flats or in fiberboard cartons. The flats contained 15 pounds of bulk dates, and the cartons contained twenty-four 8-ounce film-over-wrapped packages.

Representative temperatures at the middle layer, quarter-

length, center-line position are shown in figure 16 from Rygg (*95*). In fan-equipped cars, the temperature at this position is generally lowered somewhat less rapidly than in top or bottom layers where surface exposure to air is greater. In nonfan cars, middle-layer temperature reduction is usually intermediate between the slow cooling in top layers and rapid cooling in bottom layers, but because of the tight load in date cars, even the top layers cool more rapidly than the middle layers.

The amount of cooling en route was from none (not shown in fig. 16) to a loss of 29° F (16° C) (car A, fig. 16). The cooling in eight of the loads was 10° F (6° C) or less.

The poor cooling can be attributed to lack of circulation of air through the load. The amount of ice and the presence or absence of fans had little or no effect. The greatest amount of cooling was obtained in car A under standard refrigeration with full bunkers. This car was not equipped with fans. The load, which

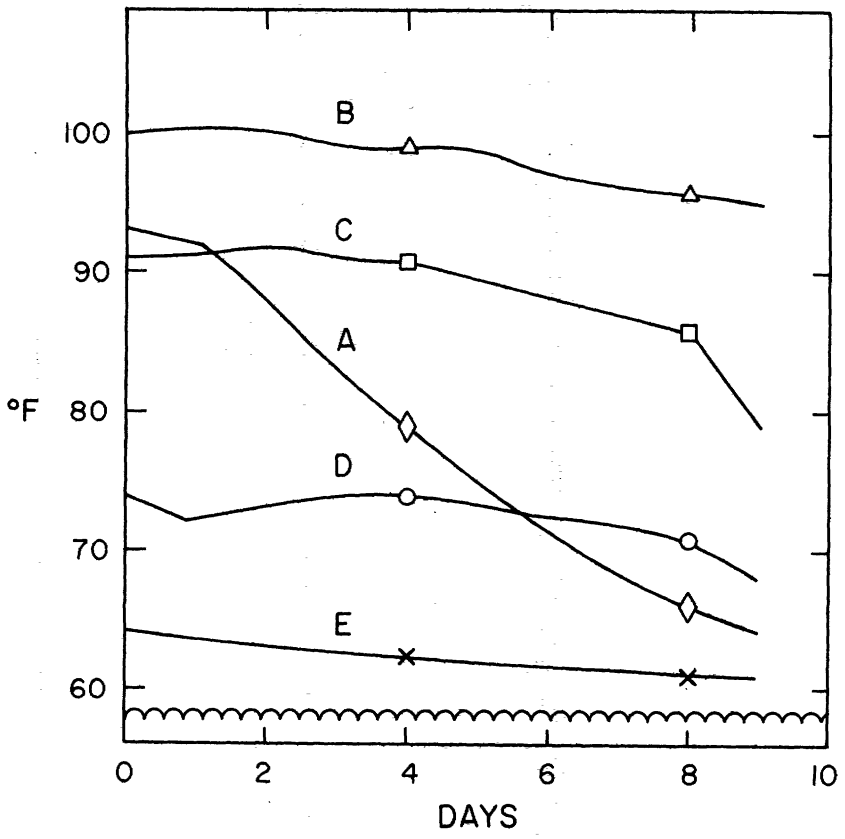

FIGURE 16.—Transit temperatures of dates under various icing services.

consisted of dates packed in 15-pound wooden flats, permitted a fair amount of vertical air movement. The load in another car (not shown in fig. 16) refrigerated in the same manner but loaded with dates in cartons cooled by only 4° F (2° C). Although this car was equipped with air-circulating fans, almost no heat was removed from the load. Practically no air circulation could take place within the loads of cars containing dates in cartons. The dates were enclosed in sealed film packages, and these were enclosed in nonventilated fiberboard cartons. The cartons were lock loaded with the layers alternating, thus effectively preventing vertical air movement. Tight stowing also prevented lateral air movement.

In view of the small amount of cooling in transit, especially in loads of dates in cartons, the refrigeration service is probably not worth the cost. A more effective and less costly method of maintaining date quality is to cool the dates before they are loaded into the car. Since dates produce very little heat from respiration, only enough refrigeration is then required to remove heat entering from the outside.

Dates,[5] like other dried processed fruits, should be stored and shipped at cool temperatures, with a generally recommended upper maximum of 45° F (7° C). During hot weather, properly precooled dates should be shipped in refrigerated railcars, truck vans, or ship containers set at 35° to 40° F (2° to 4° C) to avoid the warming and later deterioration that may occur in outer packages of dates in nonrefrigerated shipments. If dates are not precooled, refrigeration costs are largely wasted unless the dates are packaged in vented cartons and stacked in a pattern allowing cooling of the product. During cooler parts of the year, refrigeration is not necessary. Low-temperature protection is not needed as freezing does not harm dates.

Dates should be marketed soon after removal from cold storage; otherwise the benefits of cold storage are gradually lost. Dates stored 1 year at 32° or 0° F (0° or −18° C) were acceptable after 1 month at 70° F (21° C), but after 2 months they had darkened and lost flavor noticeably, and after 3 months benefits of the previous cold storage were lost (*95*). Dates stored at warmer temperatures deteriorated faster when held at 70° or 80° F (21° or 27° C) during shipping or marketing (*93*).

Moisture content of dates, temperature during storage, and time

[5] The rest of this section on "Transportation" was prepared by L. G. Houck, plant pathologist, USDA, ARS, Riverside, Calif., to reflect changes in the industry since original preparation of the manuscript.

of holding all affect date quality. Drier dates (18 to 26 percent moisture) are expected to have somewhat longer storage life, especially at the higher temperatures; more moist dates (26 percent moisture or more) have shorter storage life (*94*). Transit and marketing life is dependent upon condition of the dates at the time they are shipped as well as their shipping and distribution temperatures. Much of the date crop is distributed from the packinghouses in trucks, as shown in figure 17.

FIGURE 17.—Palletized date packages being loaded into trucks. PN-4395

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