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Processing California Olives

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Olives grown in California are processed into black-ripe (99 percent) or California-style green and Spanish-style green olives (less than 1 percent). The method used is pickling—the process of adding an edible acid, generally lactic or acetic acid in the form of vinegar—to a food. The acidification preserves the olive without fermentation. The history of pickling olives extends into antiquity, and the methods of preparing and pickling fruits and vegetables presumably originated in Asia as early as 300 B.C.

OLIVE COMPOSITION

Chemical Composition

As a representative example, Mission olives are typical of a wide range of olive cultivars. Their composition is given in table 22.1.

Ripe Mission olives contain 20 to 25 percent oil, Manzanillo olives 16 to 18 percent, and Sevillano and Ascolano cultivars less than 15 percent. The fatty acid content of olive oils varies somewhat by cultivar, maturity, and growing area. Generally, they are as follows: stearic acid (18:0), 2.0 to 2.7 percent; oleic (18:1), 70.5 to 78.4 percent; linoleic (18:2), 7 to 12 percent; linolenic (18:3), 0.4 to 0.8 percent; palmitic (16:0), 9 to 12 percent; palmitoleic (16:1), 0.71 to 0.76 percent; arachidic (20:0), 0.42 to 0.55 percent; and ecosanoic (20:1), 0.24 to 0.46 percent.

Table 22.1. Composition of Mission olives

Ripe Mission olives	Moisture	Oil	Total sugars	Protein	Mannitol	Water soluble solids	Alcohol-precipitable solids
Before pickling	55.0	21.4	4.6	1.65	4.40	13.1	0.47
After pickling	63.4	26.4	0.10	1.56	0.94	7.2	0.43

Oleuropein

Unpickled olives are very bitter due to the presence of the glucoside compound oleuropein. The bitterness is destroyed by treatment with a dilute base (alkali) at room temperature. Removing the excess base does not cause a return of the bitterness. Commercial processing destroys oleuropein by treatment with a 1 to 2 percent lye solution at room temperature prior to canning.

Pigments

Anthocyanins are the major pigments in olives. The most prevalent anthocyanins in ripe olive fruits are cyanidin-3-glucoside and cyanidin-3-rutinoside. During olive development, anthocyanins increase rapidly until reaching a maximum, then decrease as the fruit becomes overripe. Light greatly influences pigment formation, and fruit ripened in light normally develops 10 times more anthocyanins than fruit ripened in darkness.

STORAGE OF FRESH OLIVES

Fresh olives picked at the mature-green or fully-ripe (black) stages can be stored between harvest and processing for a few days to a few weeks, depending on storage conditions. Storage can be used to maintain quality and safety of fresh olives and to extend the processing season while maintaining an orderly flow to the processing plant. Storage conditions and duration can greatly influence the quality of the fresh olives at the time of processing and of their processed products, including oil. Quality attributes of fresh olives include size, color, and freedom from defect (such as mechanical damage, shrivelling, surface blemishes, scale and other insect injuries, and chilling injury) and decay. Initial sorting of fresh olives to remove those with serious defects or decay, as well as leaves and twigs, is the first step in successful storage.

Chilling Injury

The optimal storage temperature range is 41° to 45°F (5° to 7°C) because lower temperatures can cause chilling injury of green olives and higher temperatures accelerate ripening as indicated by changes in skin color and flesh softening (fig. 22.1). A relative humidity of 90 to 95 percent is recommended to minimize water loss from fresh olives. Black olives can be stored at 36° to 41°F (2° to 5°C) because they are less susceptible to chilling injury than green olives. Cooling fresh-green olives to 41°F (5°C) and black olives to 36°F (2°C) using forced-air cooling before storage and maintaining good air circulation within the storage room are strongly recommended to maximize the benefits of refrigerated conditions between harvest and processing.

The incidence and severity of chilling injury in fresh olives depend on temperature and duration of storage as well as the cultivar and ripeness stage. A comparison of sensitivity to chilling injury among mature-green olives of four cultivars (color plate 22.1) revealed that Sevillano was the most susceptible, followed by Ascolano, Manzanillo, and Mission (least susceptible). Symptoms of chilling injury include internal browning, which begins in the flesh around the pit and radiates outward toward the skin as time progresses. Skin browning indicates an advanced stage or greater severity of chilling injury. Chilling injury can be a major cause of deterioration when fresh olives are stored before processing for longer than 2 weeks at 32°F (0°C), 5 weeks at 36°F (2°C), or 6 weeks at 38°F (3°C).

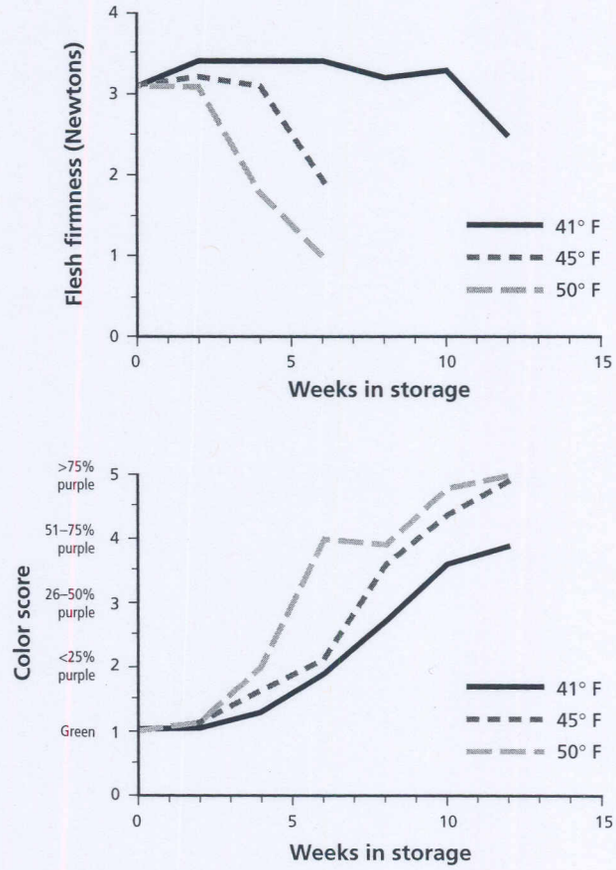

Figure 22.1. Changes in flesh firmness and skin color of Manzanillo olives during storage at three temperatures for 12 weeks

Respiratory Heat and Ethylene Accumulation

Respiration rates of fresh olives range between 5 to 10 milliliters of carbon dioxide per kilogram per hour for mature-green olives and 10 to 20 milliliters carbon dioxide per kilogram per hour for black-ripe olives at 41°F (5°C). Respiration rates increase two- to threefold for every 18°F (10°C) increase in fruit temperature. The accompanying heat production (2200 to 4400 Btu/ton [.9 metric t]/day at 41°F [5°C]) must be included in calculating the refrigeration load required to maintain the olive temperature during storage. Effective air circulation throughout the olives within the storage room is critical to preventing respiratory heat accumulation in any area within the stored olives since this heat can accelerate deterioration of the fruit.

Fresh olives produce very small quantities of ethylene (less than .1 microliters per kilogram per hour by mature-green olives and .3 to .5 microliters per kilogram per hour by ripe black olives kept at 68°F [20°C]). These rates decrease with lowering of temperature. Exposure to ethylene above 1 part per million can hasten loss of green color and softening of mature-green olives. Thus, to keep the ethylene concentration below this level, ethylene-free air should be introduced into the storage room, and sources of ethylene, such as ripening fruits and propane-operated forklifts, must be avoided.

Storage Potential

Black-ripe Manzanillo and Ascolano olives can be stored at 41°F (5°C) for up to 4 weeks whereas Mission and Sevillano olives can be stored for up to 8 weeks at 41°F (5°C) while maintaining good fruit and oil quality. Differences in storage potential of these four cultivars are related to rates of softening and decay incidence (fig. 22.2).

Exposure to carbon dioxide levels above 5 percent aggravates chilling damage if olives are kept below 45°F (7°C) while 2 percent oxygen atmospheres can be beneficial in maintaining green color and flesh firmness in olives kept at 41°F (5°C) or higher temperatures. Exposure to oxygen concentrations below 2 percent can cause off-flavors in both green and black olives. Under

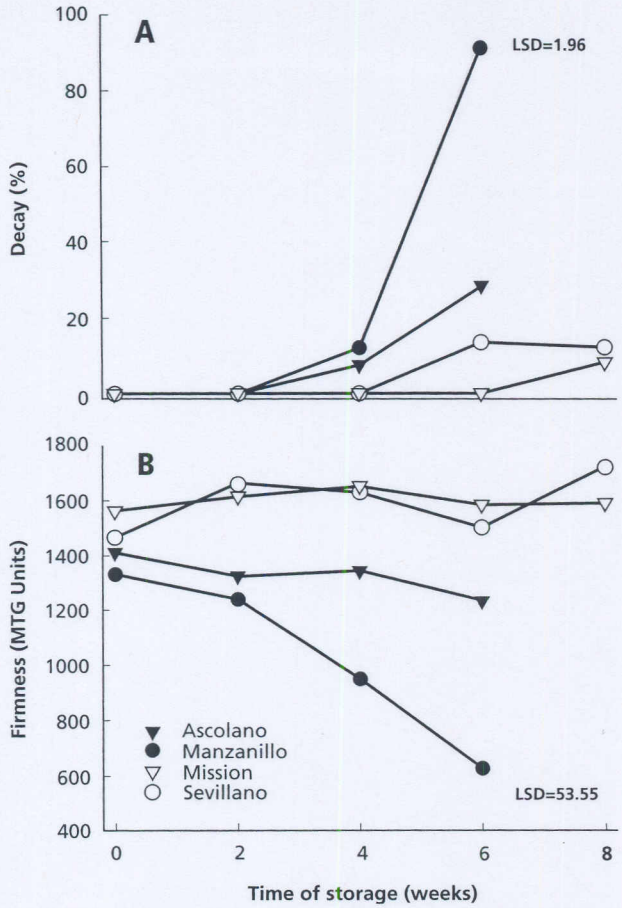

Figure 22.2. Intercultivar differences in the incidence of decay (A) and softening rate (B) of olives picked at the black-ripe stage and stored at 41°F (5°C) (Agar et al. 1998).

an optimally controlled atmosphere of 2 to 3 percent oxygen and 0 to 1 percent carbon dioxide, fresh-green olives can be stored for up to 12 weeks at 41°F (5°C) or 9 weeks at 45°F (7°C), while fresh black olives can be kept in good quality (of fruit and oil) for 4 weeks at 36°F (2°C) to 41°F (5°C); decay incidence was the main factor in determining storage potential.

HOLDING AT THE PROCESSING FACILITY

During harvest, most processing plants do not have enough vats to process all the olives available. Therefore, much of the crop is stored until pickling vats become available. Almost all olive storage today is done in a relatively-dilute, acidulant solution that includes an antimicrobial agent rather than in the traditional salt brine. Olives for premium product are always processed by July of the following year. However, olives can be stored in acid for up to 3 years; in general, these olives would be used as generic, sliced product.

Holding in Salt-Free Solution

Because it is difficult to dispose of waste brines without contaminating the soil or water, an alternative method for storage has been perfected that uses an acidulant solution containing 0.67 percent lactic acid, 1.0 percent acetic acid, 0.3 percent sodium benzoate, and 0.3 percent potassium sorbate. Sorted, size-graded olives are placed in open-top redwood tanks 5 feet (1.5 m) high and 6 feet (1.8 m) across, of 2.5-ton (2.3-metric t) capacity, with a slatted false head fixed in place. The olives and the false head are covered with the solution, and then polyethylene sheets (6 millimeters thick) are spread over the solution and secured with pliable slats nailed to the inside of the tank. A wax compound (for example, Sealtite) forms an airtight seal between the plastic and the inside of the tank.

No fermentation occurs in this system, unlike in brine storage. The flavor of olives kept in salt-free storage is as good as or better than that of the same cultivars processed from salt storage. The flavor and texture of Sevillano olives are improved, lacking the characteristic strong flavor and woody texture of brine-stored Sevillano olives. Shrivel, always a problem with Ascolano and Sevillano olives stored in salt brine, is virtually eliminated, and so, therefore, is the step of passing the olives over a needle board. More than 90 percent of California olives are now stored by the salt-free method.

Holding in Brine

The traditional method of storage in sodium chloride brine uses paraffin- or plastic-coated concrete tanks or wooden tanks of a 20-ton (18-metric t) capacity. The initial brine contains 5.0 to 7.5 percent salt, or about 20° to 30° salometer. (A saturated solution of sodium chloride, 26.5 percent salt, reads 100° salometer.) At intervals of one to several days, salt or saturated brine is added so that the brine is gradually strengthened to 30° to 36° salometer (7.5 to 9 percent salt); the brine is kept at this concentration for the first 3 months of storage. Added salt or brine must be mixed thoroughly into the tank by means of a circulating pump. As the weather becomes warmer, the brine should be strengthened to 40° salometer. Ascolano and Sevillano olives require an initial brine of 15° salometer to avoid shriveling, and the final salometer reading should be maintained at 30° to 32°.

Holding tanks are located outdoors, where sunlight prevents the growth of putrefactive microorganisms. A mild lactic acid fermentation takes place that helps pre-

serve the fruit until processing. The lactic acid content in the brine may reach .4 to .45 percent in 4 to 6 weeks. It is important that olives be kept under the brine. The head must have openings that allow circulation by pump when salt or saturated brine is added.

If the salt concentration is too low or the acidity insufficient, bacterial softening in the olives is apt to occur due to the growth of bacteria of the *Escherichia coli* and *Enterobacter aerogenes* group. These bacteria cause gas blisters in the olives and are responsible for what is termed *Fisheye spoilage*. At the first sign of spoilage, the brine should be fortified to an 8 percent concentration and acidified with .5 percent lactic or .25 percent acetic acid.

Delay in placing the olives in brine after harvest may cause nailhead, a condition in which small depressions form beneath the skin. These depressions persist in the pickled product and are thought to be caused by bacterial action, as colonies of bacteria are found in them. Nailhead is avoided by pickling olives promptly after harvest or storing them promptly in brine.

The pink yeasts associated with softening of olives—*Rhodotorula glutinis* var. *glutinis*, *R. minuta* var. *minuta*, and *R. rubra*—produce polygalacturonases that cause a slow softening of olive tissue. Commercial control of these yeasts is not difficult when anaerobic conditions are provided. Otherwise, processors must remove the yeast film from the brine surface manually, by skimming or by flagellation.

Other Holding Methods

Chemical salts other than sodium chloride are partially successful in holding olives for several months without spoilage. Ammonium nitrate brines can be used for periods of up to 15 weeks; however, it is difficult to remove the salt completely during preparation for canning.

CALIFORNIA-STYLE BLACK-RIPE OLIVES

The industrial-scale processing of California-style black-ripe olives is laid out in figure 22.3. California-style black-ripe olives can be made from either fresh or stored olives. Generally, the olives are size graded before being loaded into tanks for lye treatment.

Loading

Size-graded olives are placed in paraffin- or plastic-coated cement tanks of a 10- to 20-ton (9- to 18-metric t) capacity. The tanks usually have dimensions of 10 × 5 × 2½ feet (3 × 1.5 × 0.8 m) deep. Redwood tanks can also be used. The tanks are supplied with four overhead pipelines containing water, dilute lye, dilute brine, and compressed air. Air for aeration and stirring is distributed by perforated pipes at the bottom part of the tank. The tanks are equipped with outlets for discharging spent lye, brine, and wash water.

Lye Treatment

In the pickling process, olives are subjected to two to six applications of .5 to 1.5 percent lye (sodium hydroxide) solution at temperatures of 50° to 70°F (10° to 21°C), depending on the cultivar. Also, when fruit has been stored longer and ambient storage temperatures have been high, lower temperatures and weaker lye concentrations are required in processing.

A more dilute lye is applied when previous storage time in brine was long. The greater the number of lye applications and the shorter the duration of each one, the better the color will be. Lye treatments help natural phenolic compounds in olives to oxidize and polymerize, forming a black pigment. Proper lye treatment and exposure of olives to air, or aerating olives in water between lye treatments, develops the black color.

In most processing plants, the first lye treatment is allowed to penetrate about one-fourth of the distance into the flesh, determined by using a drop of phenolphthalein in 95 percent alcohol as an indicator on the cut surfaces of olives or by noting discoloration of skin and flesh. Each subsequent lye application penetrates another one-fourth of the distance to the pit. In some plants, the first three or four lye treatments last only long enough for the lye to barely penetrate the skins of all olives.

Color formation is most rapid at a pH of 8.0 to 9.5. Color retention is better in olives pickled in solutions made with hard water probably because calcium salts aid color fixation. Calcium chloride greatly improves color retention when added in low concentration (.1 to .5 percent) to storage solutions before pickling, to lye solutions, or to the water bath between lye treatments.

The effects of harvest maturity on the pectin and texture of canned black olives have been studied. As the maturity of Sevillano olives advances from a green-straw color to bluish, purple-red, and then to dark black, firmness gradually decreases. Olives harvested at a green-straw color have a firm texture after canning.

Lye Removal

Lye is removed by changing the water in the pickling tanks at least twice daily and stirring it frequently by means of compressed air or paddles. If the wash water is stirred continuously, it is possible to remove the lye

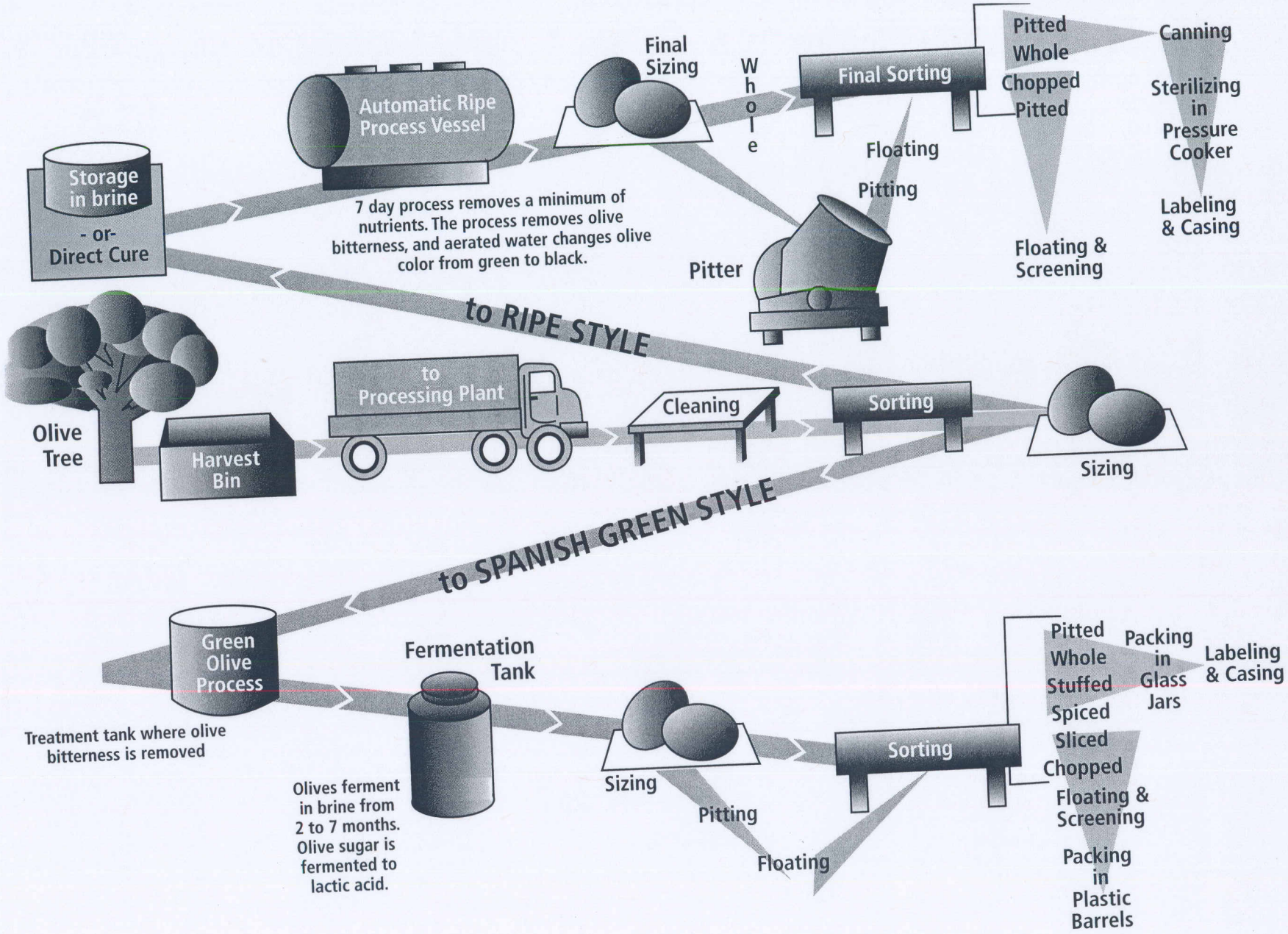

Figure 22.3. Processing sequence of California style black-ripe and Spanish green style olives.

in 3 to 4 days. In several plants, the wash water is replaced with 10° to 12° salometer brine after leaching in water for 2 to 3 days.

CURING IN DILUTE BRINE

When all the lye is removed by washing, olives are stored in dilute brine for about 2 days, first in 3°, then in 6°, and finally in 10° salometer brine (2.5 percent salt). Longer storage is undesirable because bacterial growth, texture breakdown, and other microbial troubles may arise. It is at this time that ferrous gluconate at a concentration of .1 percent (P/V) is added to fix the color. Aeration must be avoided during this time. Usually, only 24 hours is required to fix the color.

Cured olives are sorted on a conveyor belt to remove those that show a mottled color at the blossom end. Broken and soft olives are sent to the oil mill. Olives to be pitted are put through an automatic pitter at this time. Pitted olives are canned in the same manner as unpitted ones.

Canning

The pH value of olives at the time of canning greatly affects color retention during canning and subsequent storage; a pH of 7.0 to 7.5 appears to be most favorable.

Well-pickled olives are packed by weight into cans with a protective C-enamel, which prevents bleaching of the olive color after canning. The most commonly used can sizes are No. 300 (300 × 407 mm), Buffer (211 × 304 mm), Picnic (211 × 400 mm), No. 1 Tall, and No. 10. For chopped or sliced olives, 4-ounce (113-g) cans are used.

After filling, a brine of 8° to 10° salometer (2 to 2.5 percent salt) is added. The cans are exhausted at 199° to 205°F (93° to 96°C) for 5 minutes to reach 170°F (77°C) or higher; then they may be rebrined and sealed at 170°F (77°C) in a double seamer. An alternative practice is to add hot brine at 205°F (96°C) to the cans, followed by sealing at 170°F (77°C) in the double seamer. If the olives are cold, it is advantageous to seal with steam injection at 5 pounds per square inch (.35 kg/cm^2). Another variation of this procedure is to add a salt tablet and hot water at 205°F (96°C) to each can, followed by double seaming with steam injection.

Olives in No. 300 cans are heat processed at 240°F (116°C) for 60 minutes in a nonagitating retort or at 250°F (121°C) for 50 minutes. For glass containers, the process is 70 minutes at 240°F (116°C). The California State Board of Health requires that a temperature-chart record of every retort load of canned olives be made available to the inspection service. Records of the double-seam inspection, fill weight, and temperature-time recording chart must be kept on each lot (coded with numbers) and be available to the inspection service.

Olives packed in water in glass jars must be sterilized in a retort with superimposed compressed air. Otherwise, the pressure that develops in the jar during processing forces off the lids.

Spoilage

Spoilage in California ripe olives during processing is characterized by the softening and ultimate sloughing of skin and tissue from the olive. Spoilage can be controlled by reducing the washing period from the customary 4 to a maximum of 3 days. Microorganisms associated with spoilage include some gram-negative pectinolytic bacteria (*Enterobacter aerogenes, Escherichia intermedia, Paracolobactrum aerogenoides, Aeromonas liquefaciens,* and *Achromobacter*).

CALIFORNIA-STYLE GREEN-RIPE OLIVES

For the processing of canned, green-ripe olives, ripe Manzanillo, Mission, and Sevillano olives of pink or straw-yellow color are subjected to successive treatments of a 1.25 to 2.0 percent lye solution at 61° to 70°F (16° to 21°C) until the lye reaches the pits. To avoid darkening between treatments, the olives are never exposed to air. The process may take 24 to 30 hours; the end point is indicated when a drop of phenolphthalein indicator (1 percent in 95 percent ethyl alcohol) turns red on the cut surface of an olive.

When lye penetration is complete, the lye solution is removed quickly and replaced with cold water to leach out excess lye. The leaching water is changed every 4 to 6 hours during a 24- to 30-hour period. Some packers add .25 percent hydrochloric acid to the washing water to neutralize the last trace of lye. Prolonged washing and undue exposure of fruit to air may result in an undesirable darkening. Olives are then stored in dilute brine for 2 to 3 days, first in 3°, then in 6°, and finally in 10° salometer brine (2.5 percent salt) and then canned in 2.5 percent brine as described previously for black-ripe olives.

SPANISH-STYLE PICKLED GREEN OLIVES

Pickling of green olives is a minor industry in California as the foreign product is more cost competitive. Sevillano, Manzanillo, and Barouni are popular cultivars

for green pickling although the Mission cultivar is also used to some extent. Olives for pickling are allowed to reach full size but are picked before they have begun to darken. Fruit are graded for size and placed promptly in shallow paraffin- or plastic-coated concrete pickling vats.

Lye Treatment

Dilute lye solution (1.25 to 1.75 percent) is applied at 54° to 70°F (12° to 21°C). The alkali is allowed to penetrate three-fourths of the way to the pit in 8 to 12 hours. Round redwood vats, each holding 7 to 8 tons (6.3 to 7.3 metric t) of size-graded olives, may also be used for lye treatment.

Removing the lye solution before it penetrates to the pits leaves a small amount of untreated bitter flesh, which contributes to the flavor of the pickled olives. One drop of phenolphthalein indicator solution is applied to the cut surface of an olive to show the depth of lye penetration into the flesh.

After the lye treatment, olives are washed with cold water for 24 to 36 hours; the water is changed every 4 to 6 hours. After washing, the treated flesh of the olive should respond only faintly to the phenolphthalein color test.

Fermentation

Washed, lye-treated olives are transferred to 50-gallon (189-L) oak barrels or 180-gallon (681-L) chestnut barrels. To fill the containers, the heads are removed. After filling, the heads are replaced and the hoops driven into place with a mechanical hoop driver or a hand hoop iron. Brine of 11 percent salt (approximately 44° salometer) is added through a side bung to fill the barrel. Due to the problem of shrivelling with Sevillano olives, it is customary to start with a 20° to 30° salometer brine, and then to add salt daily or every other day until the brine reads 30° salometer.

The favorable temperature range for fermentation is 75° to 80°F (24° to 27°C). Some olive-processing plants in California now ferment green olives in closed redwood tanks, each holding several tons. Steam pipes beneath the tanks can maintain a favorable temperature, or tanks can be stored in a heated room. The total acid, expressed as the lactic acid content of the brine, should be 0.8 to 1.2 percent. In California, a small amount of glucose or sucrose is added to the barreled olives after fermentation has proceeded for several weeks. Total acidity, pH, and salometer readings of the brine are monitored frequently.

The pH should be 3.8 or less when fermentation starts. Fermentation may be completed in 3 to 4 weeks or may take as long as 1 year, depending on the temperature, salt concentration, and number of lactic acid bacteria present. Control measures should be carefully integrated to maintain optimal brine temperature and concentration, to ensure the presence of lactic acid bacteria in the brine, and to add enough glucose or sucrose to the brine so that the right acidity is produced. Most processors do not use pure cultures of lactic acid bacteria as starters, but instead take 1 or 2 quarts (0.9 or 1.9 L) of brine per 50-gallon (189-L) barrel from a barrel of the current season in active fermentation.

Many processors perform all steps—lye treatment, washing, brining, and fermentation—in tanks of 10- to 20-ton (9- to 18-metric t) capacity made from paraffin- or plastic-coated concrete, glass fiber, plastic, or stainless steel. The bulk fermentation process is more economical than barrel fermentation in terms of labor cost, but it requires supervision by trained personnel to avoid losses from acute microbial spoilage.

Under favorable conditions, lactic acid bacteria, some yeasts, and some gas-forming bacteria of the *Enterobacter aerogenes* group grow fairly well. Eventually, the lactic acid bacteria predominate.

Packing

Pickled olives are destemmed and size graded, if this was not done earlier, then sorted on a conveyor belt to remove defective, blemished, and off-color olives. Defective olives may be made into minced olives or relish. Pickled olives should be free of fermentable sugar and have a total acidity above .75 percent (.75 g lactic acid per 100 g). Other desirable qualities include a uniform, yellow-green color, a crisp texture, and a pleasant flavor and aroma.

Sorted olives are packed carefully, often in glass jars in a definite pattern. Packed jars are then filled automatically with water or brine, then emptied to rinse off any adhering sediment. The jars are then filled with brine of 28° salometer. Some packers may acidify the brine with .2 to .5 percent lactic acid if the olives are below the optimal acidity. Jars are then sealed in a capping machine. Table 22.2 gives the industry-suggested drained weight of different canning styles.

Although it is not customary, it is advantageous to pasteurize bottled olives at 140°F (60°C) or to use hot brine at 175° to 180°F (79° to 82°C). This will prevent sedimentation from bacterial growth.

Spoilage

Occasionally, barrels of olives develop an off-odor and off-flavor, termed Zapatera spoilage. This spoilage is characterized by a penetrating, unpleasant odor in fermenting olives. In the early stages, the odor is usually

Table 22.2. Suggested drained weight of olives (% of fill weight)

Trade type, style, and size	Content of containers ≤250	251–500	501–2,000	2,001–10,000
Green olives*				
Whole and stuffed				
>300 fruit/kg	65	65	68	70
150–300 fruit/kg	60	62	66	68
<150 fruit/kg	55	60	64	65
Pitted				
>150 fruit/kg	50	55	60	60
<150 fruit/kg	45	50	55	55
Halved	45	50	50	50
Sliced	50	55	55	55
Broken	80	85	90	90
Chopped (minced)	90	95	95	95
Black olives in brine				
>300 fruit/kg	65	68	70	70
150–300 fruit/kg	55	60	65	65
<150 fruit/kg	50	58	60	60
Black olives in dry salt†	50	58	60	60
Whole and stuffed				
>300 fruit/kg	52	54	57	60
150–300 fruit/kg	50	52	57	60
<150 fruit/kg	48	50	55	58
Pitted				
>150 fruit/kg	40	44	45	45
<150 fruit/kg	38	42	44	44
Halved	45	50	55	55
Sliced	45	50	55	55
Broken	80	85	85	85
Chopped	90	90	90	90

Source: FAO/WHO Codex Alimentarius Committee 1971.
*Olives that do not require heat sterilization for preservation.
†Olives that require heat sterilization for preservation.

described as cheesy or sagey, but as deterioration progresses it becomes a foul, fecal stench.

Under California conditions, Zapatera spoilage, unlike butyric fermentation, occurs when lactic acid fermentation is allowed to cease before the brine pH has dropped below 4.5. A continuous loss of acidity (or rise in pH) as the spoilage progresses begins only at pH values above 4.2. Hence, maintaining pH values below 4.2 is advisable.

Whereas normal brines contain acetic and lactic acids, suspect and spoiled samples contain additional acids. Propionic acid occurs most frequently, followed by butyric acid; succinic, formic, valeric, caproic, and caprylic acids have also been found. These latter volatile acids, together with butyric acid, are partly responsible for the odor of Zapatera spoilage. The lactic and acetic acids furnish energy for the bacteria—two species of the genus *Propionibacterium* and several species of *Clostridium*—that appear to cause Zapatera spoilage.

If the start of lactic fermentation in olives is delayed unduly, the continued high pH permits various butyric acid bacteria to grow, producing butyric odor and flavor and making the olives inedible. Either inoculation with lactic cultures or initial acidification prevents butyric spoilage.

Yeasts and bacteria of the *Enterobacter* group may cause Fisheye spoilage. Acidification of the brine with lactic acid and using a higher initial salt content (44° salometer or higher) in the brine discourage this type of spoilage.

STUFFED OLIVES

To prepare stuffed olives, pickled and fermented green olives are pitted, either by hand or with high-speed automatic pitters. The pitted olives are stuffed with strips of red pimento previously preserved in heavy brine. Small onions and almond meats are also used. The stuffed olives are barrel fermented for several weeks in 30° salometer brine before packing. Occasionally, stuffed, Spanish-style green olives in bottles show gas formation and spoilage. To prevent this, the pimento must be properly treated in brine to remove the sugars before stuffing.

Stuffed olives are packed in the same manner as Spanish-style pickled green olives, described in the previous section.

GREEK-STYLE NATURALLY RIPE OLIVES

Greek-style olives are made from olives picked when they are purple or black. The fruit is put into wooden or concrete tanks of a 1- to 20-ton (.9- to 18-metric t) capacity that are coated with paraffin or plastic paint. These are covered with brine of about 40° salometer (10 percent salt). Salt is added from time to time to maintain this brine concentration. Fermentation occurs through the action of lactic acid bacteria and yeasts. When fermentation is completed, the olives are graded for size and color and packed in fresh brine in tin containers or paraffin-coated barrels of about a 300-pound (136-kg) capacity. They may also be packed in vinegar brine to be used as an appetizer.

In an alternative method, olives are picked when overripe, placed in baskets, and washed with water. After 2 to 3 days, the olives are removed and placed in fresh baskets in alternate layers with solid salt. By this means, the natural wrinkles become more pronounced, and the partially dried product keeps well due to the high salt concentration.

The fermentation of Greek naturally ripe olives in brine is thought to be due to the activity of a mixed flora composed of coliform, yeast, and possibly *Lactobacillus* species. The total acidity of the brine is usually less than .5 percent. Sometimes a layer of molds, yeasts, and bacteria forms over the surface of the brine, causing removal of sugar and acids and thereby increasing the pH of the brine. This spoilage may also result from the growth of clostridia, propionic acid bacteria, and possibly sulfate-reducing organisms. Softening is another type of undesirable change.

As no lye treatment is used in the preparation of this product, bitterness and other fruit components are only partially and slowly leached into the brine. The degree of blackening depends on, and is favored by, high pH values. Under certain conditions, naturally ripe black olives undergo complete lactic fermentation, developing a total acidity as high as 0.8 to 1.0 percent. The product can be kept in brines of moderate salt content.

GRADES AND STANDARDS FOR PROCESSED OLIVES

Food standards are the body of rules directly governing foodstuffs, whether they are issued by official, semiofficial, or factory authority. The U.S. Department of Agriculture (USDA) grade standards for processed olives are voluntary, and therefore not required by federal law for olive processors and distributors. The standards are widely used, however, as an aid in wholesale trading because the quality of a product affects its price. The USDA grade is sometimes, but not always, shown on processed vegetables in retail stores. The justification for establishing food standards is threefold: (1) to prevent the transmission of disease, (2) to limit the sale of unsatisfactory products, and (3) to simplify the marketing of foods.

Canned Table Olives

Table olives are prepared from sound, clean, and sufficiently matured fruit classified according to trade type (in which both the stage of ripeness and the processes undergone are taken into account).

Trade Types. Processed olives fall into five main trade types:

1. Green olives in brine: treated green olives (bitterness eliminated by treatment with lye) and untreated green olives
2. Olives turning color in brine: treated olives turning color and untreated olives turning color
3. Black olives in brine: treated black olives, untreated black olives, and naturally shriveled black olives
4. Black olives in dry salt: treated black olives in dry salt, untreated black olives in dry salt, and pierced black olives in dry salt
5. Other trade types: bruised olives, treated split olives, untreated split olives, treated olives darkened by oxidation, and specialties

Styles. Whole olives may be offered in one of the following styles:

1. Whole: olives of natural shape from which the pit has not been removed, with or without the stem attached
2. Whole stoned (pitted): olives of natural shape
3. Whole stuffed: whole stoned olives stuffed with suitable products, such as pimento, onion, almond, celery, or anchovy
4. Halved: whole stoned or stuffed olives that have been split into two approximately equal parts along or perpendicularly to the fruit's major axis
5. Quartered: stoned olives split into four approximately equal parts
6. Sliced: stoned or stuffed olives sliced into parallel segments of fairly uniform thickness
7. Chopped or minced: small pieces of random shapes and sizes
8. Broken: olives that have broken while being stoned or stuffed

Sizes. Table olives may or may not be size graded. Whole olives should be size graded according to the number of fruit in one kilogram or hectogram. When the unit is a kilogram, the size range is expressed in steps of 10 olives up to size 150/160, 20 from this up to size 200/220, and 30 up to size 370/400; above 400 per kilogram, the steps are 50 olives. When the weight unit is the hectogram (not shown here), the range is expressed in steps of 1 olive up to size 15/16; 2 olives from this up to size 20/22, and 3 olives up to size 37/40; above 40 olives per hectogram, the steps are 5 olives (table 22.3).

Table 22.3. Olive size counts

Count designations			
Per kilogram	**Per pound**	**Per kilogram**	**Per pound**
400/450	181/223	140/150	64/68
370/400	167/181	130/140	59/64
340/370	154/167	120/130	54/59
310/340	141/154	110/120	50/54
280/310	127/141	100/110	45/50
250/280	114/127	90/100	41/45
220/250	100/114	80/90	36/41
200/220	91/100	70/80	32/36
180/200	82/91	60/70	27/32
160/180	73/82		
150/160	68/73		

Source: FAO/WHO Codex Alimentarius Committee 1971.

Description of Trade Types of Table Olives

Green Olives in Brine. These are prepared from green olives harvested while still ripening (before full ripeness is attained but after fruit has reached its normal size). Green olives are firm, sound, resistant to slight finger pressure, and without marks other than the natural pigmentation. The color of the fruit may vary from clear green to straw yellow.

Green olives treated in brine are then treated with lye, stored in brine, and preserved by natural lactic fermentation or partial natural fermentation. This may be followed by pasteurization, sterilization and pasteurization, the addition of preserving agents, refrigeration, or a combination of these processes.

Green olives untreated in brine are placed directly in brine and preserved by natural fermentation.

Olives Turning Color. Olives turning color are rose, wine rose, or brown in color. They are harvested before complete ripeness is attained and may or may not have been subjected to lye treatment. Treated olives turning color are obtained from fruit treated with lye solution, preserved in brine, and heat sterilized. Natural olives turning color are preserved in brine and are ready for consumption.

Black Olives in Brine. Black olives in brine are firm, smooth, and glossy skinned. Owing to their methods of preparation, they may have slight depressions. The color varies according to production region and time of harvesting, from reddish black through violet-black, deep violet, yellowish black, to deep chestnut. Natural black olives retain a more pronounced fruity taste than treated black olives and may be slightly bitter.

Treated black olives are come from firm and practically ripe fruit treated with lye. After natural oxidation, they are preserved by one or a combination of the following: brine, sterilization or pasteurization, or a preserving agent.

Natural black olives are prepared from firm fruit harvested when fully ripe or slightly before full ripeness is attained. They are placed directly in brine and preserved by means of one or a combination of the following processes: brine, sterilization or pasteurization, or a preserving agent.

Naturally shriveled black olives are obtained from olives harvested when fully ripe, after they have become shriveled on the tree. They are placed directly in brine.

Black Olives in Dry Salt. These have a shriveled or furrowed appearance, although the skin is intact. Natural black olives in dry salt retain a slightly bitter taste and a more pronounced fruity flavor than treated black olives in dry salt.

Treated black olives in dry salt are obtained from firm, practically ripe fruit. After a slight lye treatment, they are preserved in alternating layers of olives and dry salt or by sprinkling dry salt over the olives.

Natural black olives in dry salt are made by placing fully ripe olives immediately in alternating layers with dry salt or by sprinkling dry salt over the olives.

Naturally shriveled black olives in dry salt are obtained from fruit harvested when fully ripe, after they have become shriveled on the tree. They are preserved in alternating layers of olives and dry salt or by sprinkling dry salt over the olives.

Pierced black olives in dry salt are obtained from fruit harvested when fully ripe. After the skin has been pierced, they are preserved in alternating layers of olives and dry salt or by sprinkling dry salt over the olives.

Other Trade Types. These include bruised olives, split olives, and treated olives darkened by oxidation.

Bruised olives are obtained from whole fruit, fresh or previously treated in brine. They are subjected to a process whereby the flesh is bruised or crushed and the stone left whole and untouched within the fruit. They may be treated in weak lye to remove bitterness and are preserved in brine, sometimes spiced. There are three types of bruised olives: bruised fresh olives, bruised treated olives, and fermented green olives turning color.

Treated split olives are obtained from green olives, olives turning color, or black olives split lengthwise after treatment in a lye solution. They may be preserved in a vinegary brine, with or without the addition of olive oil and possibly aromatic substances.

Untreated split olives are obtained from green olives, olives turning color, or black olives split lengthwise. They may be preserved in a vinegary brine, with or without the addition of olive oil and possibly aromatic substances.

Treated olives darkened by oxidation are obtained from olives not yet fully mature. The bitterness has not

been removed by lye treatment, but they have been darkened by oxidation. They are packed in brine and preserved by heat sterilization.

Qualitative Classification of Trade Types

The following descriptions are adapted from the Standard of the International Olive Oil Council, applicable to table olives for delivery to international trade. More detailed tolerances are given in the Standard. Table olives ready for consumption are classified as first class, standard class, or market class. Stuffed olives may be prepared only from first- or standard-class (green) olives.

First-Class Olives. Olives in this class must be prepared using fruit of suitable ripeness, of one sole variety, and having the organoleptic characteristics of this variety in the highest degree. First-class olives must be very uniform in color, taste, appearance, texture, and size. Provided that the general good appearance is not impaired, first-class olives may have very slight variations in color, shape, and firmness of flesh—if these slight variations do not upset the general uniformity—and very slight superficial damage, hardly visible to the naked eye, in the form of scratches or scalds, or that caused by insects or physical knocks. In the case of whole olives stuffed with pimento, very slight defects of color or very slight imperfections in the consistency or placing of the stuffing are permissible.

A tolerance of 10 percent not possessing the required first-class characteristics but having those required for classification as standard class is permissible, excluding such olives admitted into the standard class though in fact belonging to the market class.

Batches of table olives (including stuffed olives) meeting the requirements for the first class, but containing no fruit benefiting from tolerances of size or quality and packed in containers of less than 2.5 kilograms and of perfect appearance, may be offered on the international market under the description "extra."

Standard-Class Olives. Olives in this class must be prepared using fruit of suitable ripeness, of one sole variety, and having the organoleptic characteristics of that variety. Standard-class olives ready for consumption must be very uniform in color, taste, appearance, texture, and size. Provided that their general appearance is not affected, standard-class olives may have slight variations in color, shape, and firmness of the flesh—if those slight variations do not upset the general uniformity—and slight superficial damage in the form of scratches or scalds or that caused by insects or physical knocks. In the case of whole olives stuffed with pimento, slight imperfections of color or slight imperfections in the consistency or placing of the stuffing are permissible.

A tolerance of 10 percent of olives lacking the required standard-class characteristics but having those required for classification as market class is permissible.

Market-Class Olives. Olives in this class must be prepared using fruit of suitable ripeness, of one sole variety, and having the organoleptic characteristics of that variety. They are prepared from fruit that cannot be included in the higher classes but that nonetheless meet the minimum quality requirements of goods recognized as sound, fair, and marketable according to international trade practices.

Provided that they do not in any way affect the nature of the product, olives with the following defects or blemishes are allowed: variations of color, shape, firmness of the flesh; defects in the specific flavor of the fruit; damage in the form of scratches or scalds or that caused by insects or physical knocks; and olives not meeting the general specifications for ripeness.

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