

# Processing Technology of the Table Olive\*

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## I. INTRODUCTION

The olive tree, *Olea europaea* L, produces a fruit that must be processed, and while 90% of the olive crop worldwide is pressed for olive oil production, table olives are an important commodity traded internationally. Table olives are a fermented product, and for most of their history this

has been a natural process driven by the microflora on the fruit and in the environment. More recently, this process has been investigated and subjected to more control.

Table olives are defined by the International Olive Oil Council (IOOC) (1990) as “the sound fruit of specific varieties of the cultivated olive tree harvested at the proper stage of ripeness and whose quality is such that, when they are suitably processed as specified in the standard, they produce an edible product and ensure its good preservation as marketable goods. Such processing may include the addition of various spices of good table quality.” The IOOC (1980, 1990) and the Codex Alimentarius (FAO/WHO 1994) impose standards on various aspects of table olive production, including technical description, size grading, essential composition, quality factors, labelling, defects and tolerances, authorized food additives, contaminants, and product hygiene. Despite this, there is confusion in the table olive processing and evaluation literature. The product can be described by a variety of names and classifications, and producers, researchers, processors, and food experts frequently use different and conflicting descriptions of available types and styles.

Olives are perceived to have positive nutritional and therapeutic effects (Romani et al. 1999). Monounsaturated oils, as found in olives, are considered to be healthier than polyunsaturated oils and saturated fats, with a lower incidence of heart disease reported (Nouredine 1992). In addition, the polyphenols of olive fruits show both autoprotective and nutritional-therapeutic effects for a range of medical conditions (Romani et al. 1999).

## II. CLASSIFICATION OF PROCESSED PRODUCTS

The olive fruit can be picked at any stage from the beginning of ripening, when it is green, until it is black and fully mature. To render the fruit edible it is important to remove some or all of the bitter phenolic glucoside oleuropein, which is found in all olives in varying amounts. The fruit is then preserved by one of a number of possible processes. Methods of oleuropein removal and preservation are dependent on many factors, including the olive cultivar, fruit maturity, growth conditions, and cultural preference. There are four main styles of table olives: Spanish style green olives, Siciliano style green olives, Greek style naturally ripe black olives, and Californian style black olives. Processors of Spanish style green olives and Californian style black olives use an alkaline solution (lye) to remove the oleuropein, whereas for the Siciliano and Greek styles frequent washing with water or weak brine solution is used. In

addition, turning color olives may be processed by either method. In most cases, except Californian style black olives, the olives then undergo lactic fermentation in brine solution, which preserves them and increases palatability. Factors such as temperature, pH of the brine solution, concentration of the lye and brine solution, available microorganisms, reducing sugar content of the olives, and exposure to light and temperature all affect the quality of the processing. In this review we consider only the processing of the olive fruit, and do not include the addition of herbs, spices, and other flavorings to the product either during or after processing.

The three most widely used classifications of table olives are based on fruit color, processing method, or processing style, and the three are inevitably linked. In this section, we have included cultural and cultivar categorization under style of processing.

### **A. Fruit Color**

There are three main types of table olives based on color, largely determined by the degree of maturity at harvest time. The IOOC (1990) defines three main categories: green, turning color, and black. Green olives are harvested when the fruit has reached full size, and the color of the fruit may vary from green to straw yellow. Olives turning color are rose, wine-rose, blush or brown-colored fruit harvested before complete ripeness. Black olives are harvested fully ripe or slightly before full ripeness. Depending on cultivar, production region, and time of harvesting, they may be reddish black, violet black, deep violet, greenish black, or deep chestnut. Californian style black olives are blackened by oxidation or dyeing.

The use of color is an effective way of describing table olives. However, difficulties arise when using such a subjective measure, as interpretation may vary between individuals. Objective measures of color, such as reference to Royal Horticultural Society color charts may assist.

### **B. Processing Method**

Table olives can be classified according to the procedure used to remove the oleuropein, and are described as treated or untreated. Treated refers to the use of an alkaline lye solution to remove the bitterness. Untreated olives are not subject to lye but put directly into water or brine solution. This is less efficient than lye treatment, so these olives always retain some residual bitterness, and this is considered to be a positive flavor attribute. Lye is not generally used on olives that have started to develop

color, as the flesh is too soft and it may extract some or all of the anthocyanin pigment. A further classification is on the method used to preserve the olives. This may be in brine, or in dry salt.

### **C. Processing Style**

Olives can be processed in different ways to enhance the most desirable characteristics of a particular cultivar. They are processed according to four main styles: Spanish (or Sevillian) style green olives, Siciliano style green olives, Greek style naturally ripe black olives, and Californian style black olives.

For Spanish style green olives, the fruit are harvested when green. They are treated in an alkaline lye and then put in brine, in which they undergo lactic fermentation (Garrido Fernandez et al. 1997). In contrast, Siciliano style green olives are harvested when green, then processed by putting them directly into water or brine, without using a lye treatment. Fermentation takes place in brine. The olives are considered excellent, but are less important on the international market than Spanish style green olives.

Greek style naturally ripe black olives are harvested completely mature and placed in water or brine, followed by yeast fermentation in brine. There is no initial lye treatment. A variation of this style is naturally ripe olives that have been preserved using dry salt instead of brine solution (Fleming 1982; Garrido Fernandez et al. 1997). In addition, olives may be referred to by cultivar, such as 'Kalamata', which has led to a further variation of Greek style naturally ripe black olives termed Kalamata style olives. Californian style black olives originated in America, and the fruit are harvested at the straw stage. They are treated with lye, brined, and aerated, which oxidizes the pigments and turns the olives black (Fleming 1982; Pederson 1979; IOOC 1993). The olives are not fermented, and the pitted product is widely used in fast-food products such as pizzas.

In addition to these four styles, there are turning color olives. These may be processed by the methods used for either Spanish or Siciliano style olives (IOOC 1990). Californian style black olives are sometimes included in this group.

### **D. Combined Classifications**

The IOOC (1990) and the Spanish Standards use descriptions that include a combination of classifications (Garrido Fernandez et al. 1997). The name used to describe a table olive includes the color (green,

turning color, black), the procedure used to remove the bitterness (treated with lye or untreated), and the method used to preserve the olives (brine or dry salt). Table 5.1 lists some of the commercial preparations described in this way, compared with classification according to style.

In addition to these descriptions, there are many other ways used to describe table olives, in both the scientific and popular literature, some of which are conflicting and confusing. Various words are used, including pickled, water cured, brine cured, lye cured, sweetened, stuffed, pitted, cracked, fermented. Pickling has been variously used in the literature to describe either the treatment of the olives by lye and/or the whole preservation process. Curing has been used to describe either the process of bitterness removal by water, brine, or lye, or the whole preservation process. Sweetening is sometimes used to describe the process of removing the bitterness. Stuffed and pitted refers to culinary treatments not covered in this review. The terms cracked and fermented will be addressed in Section V. In this review we will use the classification according to the four styles of Spanish style green olives, Siciliano style green olives, Greek style naturally ripe black olives, and Californian style black olives, as these are most widely used in the literature.

**Table 5.1.** Comparative table olive classification according to style, color, and method of processing.

Style of processing	Color and method of processing
Spanish style green olives	Treated green olives in brine. Treated, turning color olives in brine.
Siciliano style green olives	Untreated green olives in brine. Untreated, turning color olives in brine.
Greek style naturally ripe black olives	Untreated black olives. Untreated, naturally shrivelled black olives. Untreated, naturally shrivelled black olives in dry salt. Untreated black olives in dry salt.
Californian style black olives	Olives darkened by oxidation. Treated, turning color olives in brine. Treated black olives.
Others	Shrivelled black olives (treated and brined). Treated black olives in dry salt.

### III. WORLD PRODUCTION

Production of table olives worldwide is increasing, with 1,089,000 t in 1997/98, which is an increase on average data for the 1990s of 981,000 t (Rahmani 1995; Anon 1999). Green table olives accounted for 44% of this, compared with 33.5% black and 22.5% turning color olives. The European Union is the largest producer with 39%, compared with 14% from Turkey and 10.5% from the United States. Production of green olives predominates in Spain, Syria, Egypt, Israel, and Argentina, with black olives from Greece, Italy, Turkey, and Peru. The United States produces mainly California style black olives. The largest consumer of olives is the European Union at 35%, followed by the United States at 17%, Turkey 11%, and Syria 7%. Export of table olives is largely from the European Union, Morocco, and Turkey, with 47%, 24.5%, and 8%, respectively. The Table Olive Exporters' Association (ASEMESA) was established in the 1920s, and handles over 80% of the Spanish table olives sold abroad (de Mora 1995). Despite this there is a lack of coordination within the industry, which reduces efficiency in areas such as regulation, promotion, and advertising (Nuvoli and Pulina 1993).

The industry worldwide is dominated by small producers using traditional methods. In Italy, for example, there are around 300 processing plants, 90% of which produce only moderate amounts of 200–400 t annually, with larger cooperative plants accounting for only 15% of production (Marsilio 1993). This results in fragmentation of the industry, and presents problems in quality control (Nuvoli and Pulina 1993). Most fermentation is now conducted in large modular fiber glass containers, which may be above or below ground, although the older cement vats, wooden casks, or PVC drums are sometimes seen. Production of Spanish style green olives and Californian style black olives in particular may be carefully controlled industrial processes.

### IV. HARVESTING

The olives must be harvested at the correct stage of maturity for optimum outcomes (Balatsouras et al. 1988), and fruit ripening stages guide the producer to determine the correct harvest date for the best organoleptic qualities. In broad terms, there are three stages of ripening (IOOC 1990). In the first stage, green color is decreasing, small whitish spots appear on the epicarp, the flesh is whitish, hard, and contains little oil. In the second stage, the epicarp is reddish to dark reddish or reddish black, the

flesh is vinous color and is softening, so that when squeezed gently a few drops of oil will be produced. In the third stage, the epicarp is black to dark shining violet, covered by a mixture of wax and fats, and spotted with stomata. Flesh is evenly dark, vinous red and soft, so it is easily squeezed by light pressure. The black color of the ripe olive is caused by the anthocyanin cyanidin-3- rutinoside (Marsilio 1990).

While color of the fruit is a useful method for determining harvest time of turning color and black olives, it is difficult to know when green olives are sufficiently mature for optimum processing. A wide variety of methods has been used or proposed to address this issue, including fruit removal force, refractive index (Brix), fresh weight, dry weight, total phenolics, oil content, flesh to stone ratio, and peroxide value (Rahmani et al. 1997).

Olives are not generally stored for long periods between harvesting and processing, although 'Manzanillo' olives for Californian style black olives can be stored at 0–5°C, or in 2 kPa oxygen for up to four weeks between harvesting and processing with no commercial loss of fruit quality (Agar et al. 1999). For those olives that are destined to undergo a style of processing that involves a lye treatment, some authors recommend that the olives be placed into a weak lye solution immediately post harvest. This is called transport lye, and it prevents the fruit from bruising (Agabbio et al. 1986; IOOC 1993).

## V. PROCESSING

The olive contains a variety of compounds, including organic acids, tannins and the bitter glycoside, oleuropein. They are all water soluble and their presence decreases as the olives ripen. Some bitterness is desirable, but depending on ripeness some must be removed by processing methods. The current styles of table olive processing have evolved using standard cultivars that have been produced for many hundreds of years, and the details of protocol vary depending upon cultivar, region of production, and cultural preference. For this reason, general rather than specific processing details will be presented for each of the four styles of commercial importance. Some olive cultivars used for the various processing styles are listed in Table 5.2. It should be noted, however, that because of the prevalence of homonyms and synonyms in the olive literature, two trees that bear the same name may have different DNA fingerprints (Mekuria et al. 1999).