

TABLE OLIVE FERMENTATION

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Sofralık Zeytin Fermentasyonu

Özet

Türkiye dünyanın en büyük zeytin üreticilerindedir. Sofralık zeytin fermentasyonu, salamuranın tuz yoğunluğuna, pH' sına, uygulanan ön işlemlere, mikrofloranın kompozisyonuna ve havalandırılma yapılıp yapılmadığına bağlı olarak zeytinde gaz ceplerinin oluşmasına ve zeytinin yumuşamasına, büzüşmesine, ve kısa raf ömrüne neden olabilir. Düşük tuz yoğunluğu, pH kontrolü ve havalandırma kalitenin iyileşmesine ve raf ömrünün uzamasını sağlamaktadır. Starter kültür uygulamaları kaliteyi daha da iyileştirebilir.

Abstract

Turkiye is the one the biggest olive producer in the world. Table olive fermentation may cause gas pockets in the flesh of the olive and subsequent softening, shrivelling of the olives and short shelf life depending on the fermentation conditions such as salt concentration and pH of the brine, pre-treatment of olives prior to fermentation, composition of microflora, aeration besides variety. Low salt concentration together with pH control and aeration obtains promising results and improves quality. Application of starter cultures may further increase quality.

Introduction

Olive is one of the major agricultural products of Turkiye with an annual production rate of 120 000 tonnes. Turkiye is also the second biggest olive producer in the world behind Spain. Preserving and processing olives in brine is very old and widespread tradition in Mediterranean countries (Borcaklı et al., 1993a). In the fermentation of olives, polyphenol and reducing sugar content, microbial load and flora of the fruit, salt concentration and pH of the brine are important factors. Microbial flora and chemical composition of raw olives of Gemlik and Edincik variety is given in Table 1 and Table 2 respectively. Microbial flora of Turkish raw olives are mainly composed of Gram-negative bacteria and yeasts (Table 1). Lactic acid, anaerobic sulphide producing and coliform bacteria and staphylococci are not present in the raw olives. Composition of microflora and its development are important factors influencing fermentation of the olive and final product quality. Among other Turkish olive varieties, Edincik is known for its texture, high moisture content (Table 2). It is also known as easily fermentable olive due to its high reducing sugar content which are converted to other products (mainly acids) depending on the types of micro organisms present in the media (Özay and Borcaklı, 1996). Concentration of the fermentable sugars in the brine controls the fermentation rate, because it is dependent on rate of diffusion of the sugars from olive flesh into the brine which depends on permeability of the skin, temperature, salt concentration and ratio of the olive to brine (Borcaklı et al., 1993b). Gemlik, one of the other heavily cultivated Turkish olive variety, is widely used for oil production due to its high oil content (51%). Edincik variety have higher oil content and reducing sugar content than major Spanish varieties (Lechin, Hojiblanca, Verdial) except for Gordal variety which have about same amount of reducing sugar content (5.96 %) but also lower oil content (Borcaklı et al., 1993a). Phenolic

substances, naturally present in the olive, are responsible for bitterness, inedibility and partly for the colour of the olives (Alperden and Özay, 1993). Polyphenoles have also inhibitory effect on the micro organisms, particularly on the lactic acid bacteria but not yeast (Borcaklı et al., 1993b; Özay and Borcaklı, 1996). Brining of the olive removes the bitterness by leaching out polyphenols such as oleuropein from flesh (Borcaklı et al., 1993b). Lye treatment hydrolyse the phenolic substances in the processing of green olives and Californian-style ripe olives (Özay and Borcaklı, 1996). Borcaklı et al., (1993b) stated that Edincik variety is more suitable for the fermentation of table olives since its soluble compounds (reducing sugars, polyphenols) diffuses rapidly into the brine compared to Gemlik variety. Edincik variety also yields better sensory scores in terms of colour, texture and taste.

Method of Table Olive Fermentation

Salt concentration of the brine is of crucial important because it governs controlling the type of micro-organisms carrying out fermentation, the diffusion of soluble constituents into the brine, and therefore the rate of fermentation (Alperden and Özay, 1993). Micro-organisms in olive may bring about glassy deterioration, malodorous fermentation and tissue softening which also depend on fermentation conditions (Alperden and Özay, 1993). Fermentation methods can be classified as high salt fermentation and aerated fermentation according to fermentation conditions.

High Salt Fermentation (HSF)

It is usually employed in Türkiye and Greece, and its salt concentration of the brine is between 10 to 14 g NaCl/100 ml (Özay and Borcaklı, 1996). The fermentation is carried out in concrete basins of 10 metric tonnes (2x2x2.5) with fully ripe olives. The ratio of olive to brine is 4 to 1. Growth of spoilage bacteria is controlled mainly with high salt concentration which also favour growth of yeast rather than lactic acid bacteria (Alperden and Özay, 1993). After separation of mouldy and damaged olives, olives are sized prior to fermentation, and then placed into basins I brine. The brine is circulated once a month and no salt is added during fermentation (Borcaklı et al., 1993a). During fermentation reducing sugar and polyphenol contents are decreased gradually in the fruit while other components are slightly changes or remained unchanged. HSF fermentation takes 9-10 months due to slow leaching out of soluble component such as reducing sugars and oleuropein

into the brine (Borcaklı et al, 1993a). Dominant culture is yeast in the fermentation and rarely accompanied by lactic acid bacteria. *Debaryomyces hanseii* is the predominating yeast species between 40th and 75th day of the fermentation which is replaced by *Candida membranifaciens*, *C.manolise*, *Rhodotorula mucilaginosa*, *R. glutinis*, *Saccharomyces cerevisiae*, *Torulopsis delbruehii*, *Cryptococcus hungaricus*, *D. hansenii* afterwards (Borcaklı et al., 1993a). Lactic acid bacteria are not able to reduce the pH values to desired levels at the beginning of the fermentation because it is not able to grow due to high salt content of the brine, low sugar content of the brine and the inhibitory substances of the olive (Alperden and Özay, 1993; Borcaklı et al., 1993b). *Lactobacillus plantarum* is detected after 76th day of the fermentation during which the reducing sugar concentration is maximum (Borcaklı et al., 1993a). *Pediococcus sp.* with a concentration of 5×10^4 cfu/g are found. There is no pH control in the HSF. The initial pH values of the brine are approximately 6 in Edincik and Gemlik varieties. It stabilises between pH values of 4.2 and 4.5 after 100 days for Edincik and between pH values of 4.9 and 5.2 after 150 days of fermentation for Gemlik variety (Borcaklı et al., 1993b).

HSF results in swollen fruits with gas pockets in the flesh due to metabolic changes in the olive or dominating microflora of yeast, and shrivelling of olives (Borcaklı et al., 1993b). *S. oleaginosus* and *Hansenula anomala* are found to be mainly responsible for the formation of gas pockets (Fernandez et al., 1985; cited by Borcaklı et al., 1993b). Moreover, principle bitterness does not disappear completely from the final product and residual reducing sugars may also still remain at a high level after a long fermentation period which may cause secondary fermentation in the later stages of the preservation of the olives (Borcaklı et al., 1993a; Özay and Borcaklı, 1996). Residual sugar content in the brine above 0.4-0.6 g/100 ml exposes to undesirable microbial growth. Gemlik variety had higher sugar content in the flesh (1.8 g/100 g) after 237 days of fermentation compared to Edincik variety (0.65 g/100 g) after 225 days of fermentation (Borcaklı et al., 1993b). Gas-pockets, making the product worthless, formed in the flesh of the olive are 40% (IOOC, 1990 cited by Borcaklı et al., 1993a). In addition, lactic acid content in brine increased to the values of 0.3-0.4%, and salt contents in fruit reaches the final values of 6.9-7.4%.

Medium Salt - Aerated Fermentation (MSAF)

Borcaklı et al., (1993a) employed aerated fermentation with medium salt concentration brines (12 g NaCl/100 ml) (MSAF). Air was injected into the brine at a rate of 0.3-0.5 l/hr per one litre capacity of the basin for 8 hr in a day from the bottom through aeration tube by means of blower. The basins were rounded at the bottom in order to prevent any localised regions with high concentration of CO₂, and covered at the top to prevent any contamination from the air. pH was maintained between 4 and 4.5 with acetic acid after the 20th day of the fermentation to prevent growth of spoilage bacteria. Moreover, brine was changed on the 187th day of the fermentation to eliminate the bitterness completely. Aeration, however, enhanced growth of yeast which softens olives and dominated in the medium, beginning from the first day of the fermentation. Initial cryptococcus species were replaced by a mixture of yeast population consisting of *Debaryomyces hansenii*, *Saccharomyces cerevisiae*, *Cryptococcus laurentii* and *Candida membranifaciens*. Gram-negative bacteria disappeared before 2 week of the fermentation due to low pH. *Lactobacillus plantarum* was detected after 50th day of the fermentation during which the reducing sugar concentration was maximum.

The final salt content of the olive was 6% compared to 7.6% in the HSF. Shelf life of the olive fermented with MSAF was prolonged due to small amount of the residual reducing sugar in the olive after fermentation. In fact, reducing sugars were readily consumed in the MSAF due to rapid growth of yeast. Fermentation time is decreased to 5-6 months in MSAF since soluble substances leached out more rapidly in the MSAF system compared to HSF due to pre-treatment of the olives in water, replacement of the brine at predetermined periods, lower salt concentration, and aeration (Borcaklı et al., 1993a). Moreover, gas pockets were lowered to 2% with the MSAF with the help of aeration eliminating CO₂ formed in the olive due to microbial activity and plant metabolism (Alperden and Özay, 1993; Borcaklı et al., 1993a). So that, the final product had improved texture, appearance, taste, uniform dark colour independent of maturity.

Starter cultures

Application of starter cultures after eliminating the bitter substances are recommended to initiate and further progress the fermentation (Fleming et al., 1985 cited by Borcaklı et al., 1993b). It enables a better control of fermentation and undesirable microbial activity, complete removal of

fermentable sugars for prevention of secondary fermentation and longer shelf-life (Alperden and Özay, 1993). They also improves the aroma and flavour characteristics of the product (Borcaklı et al., 1995). Active role of lactic acid bacteria is desirable since some yeast species have been found to be responsible for the gas-pocket formation and softening of the fruit (IOOC, 1990 cited by Borcaklı et al., 1993a). Brined fruits and vegetables undergo a natural lactic acid fermentation provided that the salt concentration does not exceed 8 g NaCl/100 ml and bacterial inhibitors are not present. Maintaining pH at about 4.5 (above 4.4 not to impair the colour of the olive) to prevent development of the spoiling bacteria enables decreasing salt concentration of brine from about 14 g NaCl/100 ml to 6 NaCl/100 ml. pH can be rapidly decreased with ripe olives at low salt concentration. Lactic acid bacteria produce lactic acid by converting the sugars originally present in fruits and vegetables, and inhibit growth of acid sensitive bacteria such as gram-negative and coliform bacteria that inhibit lactic acid bacteria in the raw plant (Borcaklı et al., 1993a; Özay and Borcaklı, 1996). Moreover, low salt containing brine enable to decrease salt content of the fruit flesh of the final product, being important organoleptic quality factor, from 5.2 g/100 g in HSF to 3.27 g/100 g (Özay and Borcaklı, 1996). Therefore, aroma of the olives are not masked by salty taste (Borcaklı et al., 1993b). Fermentation time is reduced to about 5 months.

Lactobacillus plantarum strains are used in olive fermentation in Spain. Starter cultures are not employed during fermentation of olives in Türkiye (Borcaklı et al., 1993a). However, pilot scale application of the starter cultures yielded high quality final products in pH controlled fermentation (pH=4.5) with 6 g NaCl/100 ml salt content brine. Starter cultures, inoculated at 5×10^{10} - 2×10^{12} , also prevent contamination of fermentation medium with *Leuconostoc* and heterofermentative *Lactobacillus* bacteria which are responsible for the gas-pockets in the olive. Moreover, lye treatment for splitting the bitter phenolic, oleuropin, also increases quality of the olives further, especially if used in conjunction with starter cultures. All these treatments strongly favours a lactobacillus flora, consisting of mainly *Lactobacillus plantarum* (Borcaklı et al., 1993a). Replacement of the brine that is adjusted to pH of 4.5, with 10 to 15 days intervals increases quality further. *L. plantarum* singly or even in conjunction with *Debaryomyces hansenii* or *S. cerevisiae* effectively proceeds the fermentation (Alperden and Özay, 1993). *L. plantarum* yielded the better organoleptic scores when olives are pre-treated with water (pH = 4.5) for 3 days, then covered with



brine of 6 g/100 ml salt content (pH=4.5), aeration is provided, and temperature is maintained at 15 °C. Moreover, fermentation time is only 5.5 months (Borcaklı et al., 1995).

Conclusion

Most of the factory employs HSF in order to prevent unwanted microbial activity. Low salt concentration together with pH control of the brine and aeration obtains promising results and improves quality. Application of starter cultures may further increase quality. However, further research is needed for starter culture selection, and its industrial application. Shelf life studies is also necessary in order to compare different fermentation methods.

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TABLE OLIVE FERMENTATION

Table 1		
Microbial composition (cfu/g) of raw olives of Edincik and Gemlik variety ¹		
Micro-organisms	Edincik	Gemlik
Lactobacilli	<10	<10
Streptococci	<10	<10
Yeasts	5x10 ⁴	1x10 ⁵
Gram-Negative	2x10 ⁴	3x10 ⁵
Anaerobic sulphide producing bacteria	<10	<10
Coliform (MPN g ⁻¹)	<1x10 ³	<1x10 ⁴
Staphylococci	<10	<10

¹ Data are gathered from Borcaklı et al., 1993a.

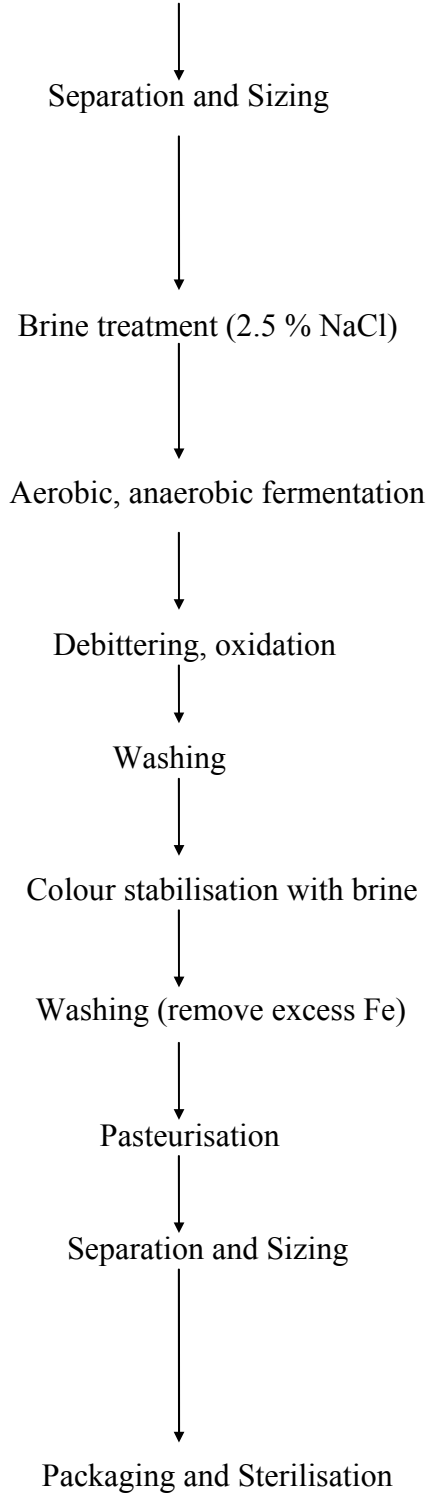
Table 2		
Chemical composition (%) of raw olives of Edincik and Gemlik variety ¹		
Chemical constituents	Edincik	Gemlik
Reducing sugar (glucose+fructose)	5.94	4.45
Oil	33.80	51.0
Moisture	59.53	43.18
Protein (Nx6.25)	1.16	1.67
Ash	1.42	1.65
Ployphenol (Tannin acid in the juice)	2.50	2.40
Salt	0.043	0.05
Titratable acidity (lactic acid)	0.080	0.074

¹ Data are gathered from Borcaklı, et al., 1993a.

TABLE OLIVE FERMENTATION

CALIFORNIA METHOD

Harvest (claret red) and Transportation



METHOD USED IN TURKIYE, SPAIN, GREECE

Harvest (full maturity) and Transportation

