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A Study on Table Olive Fermentations of Gemlik Olive cv. Through Physico-Chemical, Sensory Analyses and Mathematical Model Fitting

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Abstract: Gemlik olive was studied by a combined strategy consisting of physic-chemical, sensorial analyses and mathematical relationship among these parameters. Moisture contents of olive fruits decreased from 36.64% to 23.86%, both salt concentration and firmness increased to 9.35 g NaCI/100 g and 51.6% respectively. Total phenols of olive fruits changed from 1714.5 mg GAE/kg to 451.4 mg GAE/kg and radical scavenging activity (DPPH %) decreased from 91.48% to 32.14% respectively. L*, a* and b* values of Gemlik olives were decreased during fermentation. There was a close relationship among physicochemical parameters of Gemlik olives in mathematically. In order to model this mathematical relation, Vandermonde matrix based 3th degree polynomial equations was used because it gave best model fits for the data of physical and chemical parameters of olive fruits. On the other hand, according to the results of sensory evaluation, the attributes of saltness and crispiness were highly scored (7.21-7.34) but the sensory scores of astringency and bitterness were evaluated from 4.56 to 5.61 by participants. The physico-chemical characteristic changes during the fermentation of Gemlik olives subjected to dry salting method for producing table olives were modeled and suggested with the determined physico-chemical evaluation scores to future studies.

Key words: Gemlik, table olive, fermentation, physico-chemical, color, mathematical relationship, sensory attributes, Vandermonde.

1. Introduction

Olive and olive products not only have an important place in daily diet of Mediterranean people, but also, they are of great importance from both economic and social perspectives. According to the statistical data of FAO (2009), 19.3 million tonnes of olive were produced in the world, mainly in Spain (41%), Italy (17%), Greece (10%), and Turkey (7%) [1]. And 1.4 million tonnes of olive fruit and olive products whose 1.04 million tonnes for oil and the rest of total production for table olives were produced in Turkey [2]. The olive fruit belongs to the *Oleaceae* family, the most important feature distinguishing it from the other cultivar is that it has high fat level with a low sugar amount and higher amount of phenolic compounds in terms of chemical composition [3]. Additionally, the antioxidant activity of phenolic compounds is mainly due to their redox properties which allow them to act as a reducing agent and hydrogen donator [3]. Phenolic compounds, such as phenolic acids, phenolic alcohols, flavonoids and secoiridoids are among the most important secondary metabolites in olives [4, 5]. It is stated that phenolic compounds found in olives are primarily related to antioxidant activities which have significant biological activity in preventing diseases by stemming from oxygen radical formation in living organisms. Phenolic compounds in olive fruits are important in terms of nutrition and they are source of bitter and astringent taste. It is possible to consume olive fruits after removing bitterness and astringency via lye treatment or salt. Phenolic compounds found in olive flesh decompose

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significantly (especially oleuropein) due to the hydrolysis in the table olive treatment. Nevertheless, table olives are still an important source (56 mg/100 g) of phenolic compounds [6]. The table olive production methods (known as debittering process which is applied to olive fruits) are carried out by hydrolysis of phenolic compounds in particular oleuropein [6]. These methods are: Spanish-type pickled green olive production, California-type black olive production, and Greek-type black pickled olive production. Not much widespread, one of the debittering processes in olive production is Greek type dry-salting method [7]. The processing of the olives at four types of table olive production causes significant modifications of phenolic profiles, affects both organoleptic properties and antioxidant activities of the processed products. It is stated that olive fruits which are subjected to the same table processing method react differently, depending on their varietal, chemical and physical properties [8, 9].

It is stated that in Spanish type of fermented green table olives where lactic acid bacteria especially *L plantarum* are the predominate microorganisms involved, an alkaline solution is being used to debitter the olives. However, such microorganisms are almost inhibited in debittering table olive production. Inhibition of these microorganisms is attributed to the presence of phenolic substances, especially oleuropein in salt solutions [10, 11]. The fermentation of Spanish-type olive production is carried out by using homo-and hetero-fermentative LAB bacteria for Greek and Californian type of table olive production where fermentation organisms that represent microflora are being used as small amounts of lactic acid bacteria and yeast [8, 11].

Dry-salted olives are special type of naturally black olives which are called “naturally black dry-salted olives Thassos style” that are traditionally cultivated on the island of Thassos in Greece [11]. In this traditional method of Greek type, freshly harvested olives are placed in concrete tanks and 40 g NaCl was placed on the top for every 100 g olive and as a result of the high osmotic pressure applied by the salt, olives are debittered and became completely consumable in 40 to 60 days [12, 13]. It is stated that the olives obtained by this method are different from the olives produced by other methods. These olives have strong aroma, flavor, they taste slightly acidic and have high salt level so these table olives cannot be found too much in the markets [8]. Some physico-chemical properties of the olives produced by Greek type dry salting process are: 0.75-0.85 for a_w values, 4.5-5.5 for pH values, 35-39 g/100 g for fat level, 2-2.5 g/100 g for reduced sugar level and 30-35 g/100 g for moisture content [12]. It is stated that olives with a low a_w/high salt concentration can be safely stored even though they have microorganisms and yeasts whose growth may negatively affect the nutritional value and visual impact of olive fruits. So, this type of olive should be packaged in a modified atmosphere (CO_2 or weak acid, K-sorbate) in order to prevent yeast growth [8].

The visual color is an important property affecting consumer preference of a food material. It is an also an indicator of pigment concentration that can be measured by using tristimulus colorimeters for quality controls of related foods. It is reported that many reactions affect the color during the food preparation such as drying, heating, bleaching etc. Among them, the most common ones are pigment degradation, especially chlorophyll, carotenoids, anthocyanin and browning reactions such as Maillard reactions, enzymatic browning, and ascorbic acid oxidation [14]. The color parameters L* (lightness), a* (redness) and b* (yellowness), chroma (saturation index), hue angle and total color differences have been used to describe the color changes in processing of fruits and vegetable products [14]. There is a close relationship between color parameters of Gemlik olive cv. grown in Osmaniye and Saurani, Kargaburun, Halhali and Erkence grown in Hatay with ripening period of olive fruits and these parameters can be expressed in terms of mathematics [15, 16].

In the light of the above, the aim of the present study is to evaluate the color, physical, chemical changes and sensory attributes of Gemlik olives with fermentation carried out by dry-salting process (50 day) at room temperature (20 °C) and different mathematical equations will be achieved for the relationships between physico-chemical parameters of Gemlik olive cv. in Osmaniye.

2. Materials and Methods

2.1 Fermentation Process (Dry Salting Method)

Gemlik olives that grew at Fakıuşağı region in Osmaniye province were supplied and transported to the laboratory. The olives were hand picked, washed througly under tap water and left to dry. Approximately 6 kg of fresh Gemlik olive samples were packed in a 10 L total volume (PVC drum) together with finely dispersed coarse salt (10%, 1-3 mm particle size). The surface of olive fruits was covered with a layer of coarse salt to avoid fungal growth. During the salting process of Gemlik olives, PVC container was kept at 20 °C room temperature and the drum was over turned on daily basis. Values of parameters that are the total phenol, DPPH, NaCl, L, a, b, firmness and moisture (Attribute samples) were measured by every 10 days along 50 days.

2.2 Physico-Chemical Analyses

The lactic acid, moisture level, salt concentration and oil level of Gemlik olive samples were determined by titrimetric methods that were described at IOOC (1990) [17] and all analyses were done in triplicate. The color values of L*, a*, b* values of olives were measured by color meter (Minolta, CR 400) whose apparatus was calibrated with a standard white tile (L*: 96.24, a*: 0.97, b*: 7.39) and the color values were expressed as the mean of replicate readings of olive fruits.

2.3 Total Phenols (mg GAE/kg)

A total of 1 g of grounded olive sample was taken, 5 mL methanol/water was added, (60:40 v/v) and then they were shaken for 2 min. Later, they were passed through the filter of 0.45 μm (AIM Syringe Filter PTFE) after being centrifuged for about 10 min at 3,500 rpm. The operation was repeated with the rest by adding 5 mL methanol/water and the volume of the extract was completed to 10 mL by adding pure water. Then 0.1 mL was taken from the obtained extract and put in 50 mL volumetric flask, 5 mL pure water and 0.5 mL Folin-Ciocalteu solution was added to this and after waiting for 3 minutes, the volume was completed to 50 mL by adding distilled water and 1 mL sodium carbonate (35% w/v). The volume was kept in dark for 2 hours and then absorbance value was measured at 725 nm (Shimadzu UV 1800, Japan) by comparing it to the replicate sample and the obtained results were specified in terms of gallic acid equivalent (mg GAE/kg) [18].

2.4 DDPH% (2,2-Diphenyl-1-Picrylhydrazyl)

The antioxidant activities of phenolic extracts obtained from the olive were determined by the DPPH method. Then 0.1 mL of the extracted solution was added to 2.9 mL DPPH solution, kept in dark for about 30 min. Then the absorbance value was measured at 515 nm by spectrophotometer (Shimadzu UV 1800). The antioxidant activities of olives (DPPH, radical scavenging activity, %) were determined in terms of antioxidant activity, expressed in percentage inhibition of the DPPH radical [19]:

DPPH% (Antioxidant Activity) = [(Acontrol – Asample)/Acontrol] × 100

2.5 Firmness (%)

Firmness was determined by using a Texture Analyzer (Model CT3, Brookfield), and by applying force to randomly selected 10 olive's axes (F; N) via the assistance of penetrometer with 2 mm tip. The percentage of firmness with time for olive samples was calculated as:

% Firmness = $(F_{max}/F_1) \times 100$

where F_{max}: maximum penetration force (N) for olives at time and F_1: maximum penetration force (N) for initial sampling [20].

2.6 Sensory Analysis

A descriptive method UNI (2003) [21] was used to evaluate the sensory profile of dry-salted olives and 18 proficient subjects (13 males, 5 females; ages of 19-44) participated in sensory analyses. The participants were trained by using different olive samples in preliminary sessions. Sensory profiles of olives were evaluated for bitterness, saltiness, astringency, juiciness, crispiness, sweetness and sourness whose scale ranged from 0 to 10. Each attribute (except overall attributes) was extensively described and explained in order to avoid any doubt on the relevant meaning.

2.7 Modelling (Vandermonde Matrix Based Polynomials)

In the Vandermonde matrix based polynomial model equations, the output y_n and input x_n are represent the any of attributes contain the physicochemical or time values were measured in experiment. So, in this study like the studies in the literature, the polynomial models were created as in Eq. (1) while the values c_n in Eq. (1) are polynomial coefficients calculated by Vandermonde Matric as in Eq. (2) [22].

$$c_n {x_n}^n + \cdots + c_2 {x_n}^2 + c_1 {x_n}^1 + c_0 {x_n}^0 = y_n \quad (1)$$

$$\begin{bmatrix} {x_0}^0 & {x_0}^1 & {x_0}^2 & \cdots & {x_0}^n \\ {x_1}^0 & {x_1}^1 & {x_1}^2 & \cdots & {x_1}^n \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ {x_n}^0 & {x_n}^1 & {x_n}^2 & \cdots & {x_n}^n \end{bmatrix} \begin{bmatrix} c_0 \\ c_1 \\ \vdots \\ c_n \end{bmatrix} = \begin{bmatrix} y_0 \\ y_1 \\ \vdots \\ y_n \end{bmatrix} \quad (2)$$

In this study, eight different polynomial models were created to determine the physicochemical or time relations between the added NaCl and other attributes (Phenol, DPPH, L*, a*, b*, firmness, moisture and time). Coefficients were calculated with using MATLAB R2014a software.

3. Results and Discussion

In the study, values of parameters that are the total phenol, DPPH, NaCl, L*, a*, b*, firmness and moisture (Attribute samples) were measured by every 10 days along 50 days. The measurement results can be seen in Table 1.

As can be seen in Figs. 1 and 2, the moisture and oil level of Gemlik olives were 36.64% db and 33.48% db respectively before dry-salting process. The moisture level decreased during the dry-salting process. The moisture loss was steady during the first 30 days and then it reduced gradually until the end of dry-salting process.

Moisture loss was accompanied by a salt intake in olive flesh whose salt concentration increased to 9.35 g NaCl/100 g at the end of fermentation period. These results, in terms of salt intake, are comparable to the findings of Panagou [8] for Greek dry salted olives and the standards of Olive Council for table olives (6%; the minimum sodium chloride level) [17, 20]. Salt intake of olive flesh is linked to moisture loss during salting period and the moisture content of table olive decreased from 36.64% db to 23.86% db during salting period. The salt content of Gemlik olive cv. sharply increased up to the 30th day of fermentation, then it gradually increased to the final salt content. The

Table 1 Parameter values that were measured every 10 days during fermentation.

Time (day)	NaCl (%)	Total phenol (mg GAE/kg)	DPPH (%)	L*	a*	b*	Firmness (%)	Moisture (%)
0	0	1714.5	91.48	31.137	4.822	3.572	0	36.64
10	1.2	1301	89.97	29.227	4.53	3.1095	6	33.48
20	5.84	941	87.34	25.22	3.427	2.812	32	28.49
30	7.85	657	55.56	25.591	3.17	2.406	53	24.90
40	8.16	494	36.06	26.876	3.481	2.127	49.2	24.39
50	9.35	451	32.14	23.024	2.284	1.634	51.6	23.86

lactic acid concentration of Gemlik olives reached to 0.489% and the differences in salt (%) and lactic acid (%) level were statistically significant ($p < 0.05$). After 30 days of salting process, the salt concentration of olive flesh slightly increased but lactic acid content (%) increased more especially after the 40th day of salting process. It is reported that the table olives should have a pH level from 3.8 to 4, a total titratable acidity from 0.4 to 0.7% and a salt concentration from 4 to 8% depending on various factors such as the final pH value, organic acid addition and storage temperature [12].

The firmness of olive flesh changed between 0 and 51.6% during the salting process. Until the 30th day of the process, firmness of Gemlik olives increased sharply and then it almost remained constant. Change in firmness of olives was statistically significant ($p < 0.05$) during the salting period and the reason for increase in firmness is believed to be a decrease in moisture level during the first 30 days of fermentation process. Similar studies have been found for dry-salting of Thassos olive varieties [8] whose total weight loss increased until the first 50 days of salting process and then it remained constant. Additionally, high pressure treatment to the olives and conventional heat treatment to the green beans increases the softness of olives and beans respectively [23, 24]. It is reported that one of the reasons for the softness of olives during high pressure treatment was thought to be ß-elimination of pectin and activation/or retention of pectin methylesterase (PME) during the storage of table olives [24]. Additionally, high concentration of NaCl and low pH level stimulate the performance of hydrolytic enzymes which accelerate the changes in olive's cellular walls, thus, softening takes place in brine [24]. But in production of dry-salted olive without brine, olive fruits loose their moisture, gain salt and become saltier. As a result, firmness of olive flesh increased throughout fermentation period.

The phenolic content of olives varied from 1,714.5 mg GAE/kg to 451.4 mg GAE/kg. The phenolic content of olive flesh steadily decreased during salting period and the decrease in total phenol was statistically significant ($p < 0.05$). It is reported that the total phenol found in table olive fruits varied from 1,029 mg GAE/kg to 2,716 mg GAE/kg [23]. So, our results of salted Gemlik olives were similar to those obtained by Borzillo et al. [25] for some Italian cultivars and by Soufi et al. [24] for Algerian black olive cultivars. The dry salting process caused a variable decrease in phenolic contents and the loss of phenols reached to 73.6% at the end of fermentation period. The higher salt content affected negatively the o-diphenol profile of Algerian black olive cultivars, decreased the total phenols at a level of 6-46% [23]. Also, our results confirmed the decrease in total phenols of Gemlik olive cv. during fermentation period.

The antiradical activity (DPPH, %) is used to maintain an information on the radical scavenging activity of Gemlik olive cv. whose radical scavenging activity (DPPH, %) varied from 91.48% to 32.14% and significant antiradical activity loss occurred during fermentation period ($p < 0.05$) where the loss rate in radical scavenging activity was 59.3%. Our results revealed that salting process negatively affected the radical scavenging activity and these results are similar to those obtained by Soufi et al. [24], the loss of radical scavenging activity varied from 29% to 58% for Algerian olives, Abeloit cv. and Sigoise cv. respectively. Differences in the results of radical scavenging activity could be explained by the amount and the type of phenolic constituents in olive cultivars.

Olive cultivars that have radical scavenging activity can be explained by the presence of the hydroxyl groups that contain phenolic compounds such as oleuropein, luteolin-7-O-glucoside and hydroxytyrosol which is an important phenolic alcohol of olive cultivars [6, 24]. Additionally, the phenolic compounds of olives with ortho function have important antiradical activity and that

o-diphenols are relatively the most abundant phenolic constituents in dry-salted olives. It is reported that the individual o-diphenols have hydroxyl groups bonded to the aromatic ring in an ortho position where the substitution seems to be the most important factor associated with a strong radical scavenging activity of olive cultivars.

The color values of Gemlik olives (L*, a* and b*) were gradually decreased during fermentation period (50 days). L*, a* and b* values were varied from 31.130 to 23.02, from 4.820 to 2.282, from 3.570 to 1.630 respectively. By statistics there were significant differences among color values of L*, a* and b* values of Gemlik olive during fermentation period at $p < 0.05$ level. Color parameters showed that the surface color of olive fruits became darker with fermentation period. This effect can be attributed to the degradation by light of pigment derivatives found in Gemlik olive cultivars.

The accuracies of modeling methods were compared and the Vandermonde matrix based polynomial modelling method was selected as the modelling method since it gave the best accuracy (fit accuracy) as compared to other methods. Thus, the mathematical relations between time and attributes were expressed by Vandermonde matrix based polynomial models. The fit accuracy comparison of modeling methods can be seen in Table 2. Furthermore, all of the polynomials in Table 1 are the third degree since all available degrees were tried and best fit was determined according to the approximation theory as three. Other degrees gave the over-fit or low determination coefficient. Also, all polynomials are in 95% confidence interval. All of the fitting accuracy terms of the polynomial models and polynomial coefficients can also be seen in Table 3.

After selection of the Vandermonde matrix based polynomial modeling method, the polynomial models were plotted for visual evaluation of interactions between time and other attributes as can be seen in Fig. 1. Also, same polynomials were plotted again for better evaluation using Fig. 2. However, the vertical

Table 2 Fitting accuracy of models that determine the interaction between time and attributes.

Interactions	Determination coefficient (R^2)				
	Linear	Exponential	Power	Gaussian	Vandermonde based polynomial (3th degree)
Time-NaCl (%)	0.909	0.950	0.931	0.826	0.963
Time-total Phenol (mg GAE/kg)	0.9324	0.990	0.983	0.990	1
Time-DPPH (%)	0.897	0.888	0.925	0.969	0.979
Time-L*	0.743	0.796	0.799	0.616	0.864
Time-a*	0.857	0.862	0.862	0.861	0.885
Time-b*	0.995	0.994	0.995	0.989	0.998
Time-firmness (%)	0.960	0.838	0.875	0.835	0.960
Time-moisture (%)	0.901	0.971	0.967	0.951	0.990

Table 3 Fitting accuracy terms of polynomial models and polynomial* coefficients.

Interactions	RMSE	R^2	SSE	Coefficients
Time-NaCl (%)	0.8350	0.963	2.790	c_4=-0.000093, c_3=0.0039, c_2=0.2271, c_1=-0.3301
Time-total Phenol (mg GAE/kg)	3.0960	1	38.34	c_4=0.0043287, c_3=0.1468, c_2=-43.42, c_1=1715.1
Time-DPPH (%)	4.4990	0.979	80.99	c_4=0.0019240, c_3=-0.159, c_2=1.9453, c_1=89.934
Time-L*	1.2060	0.864	5.818	c_4=-0.000237, c_3=0.0198, c_2=-05619, c_1=31.6130
Time-a*	0.3530	0.885	0.498	c_4=0.0000310, c_3=0.0032, c_2=-0.111, c_1=4.9559
Time-b*	0.0348	0.998	0.005	c_4=-0.000011, c_3=0.0008, c_2=-0.052, c_1=3.57010
Time-firmness (%)	5.4830	0.960	120.3	c_4=-0.001190, c_3=0.0647, c_2=0.7637, c_1=-1.8190
Time-moisture (%)	0.6067	0.990	1.472	c_4=0.000130, c_3=-0.00423, c_2=-0.369, c_1=36.853

*Polynomial equation; $P = c_1x^3 + c_2x^2 + c_3x + c_4$.

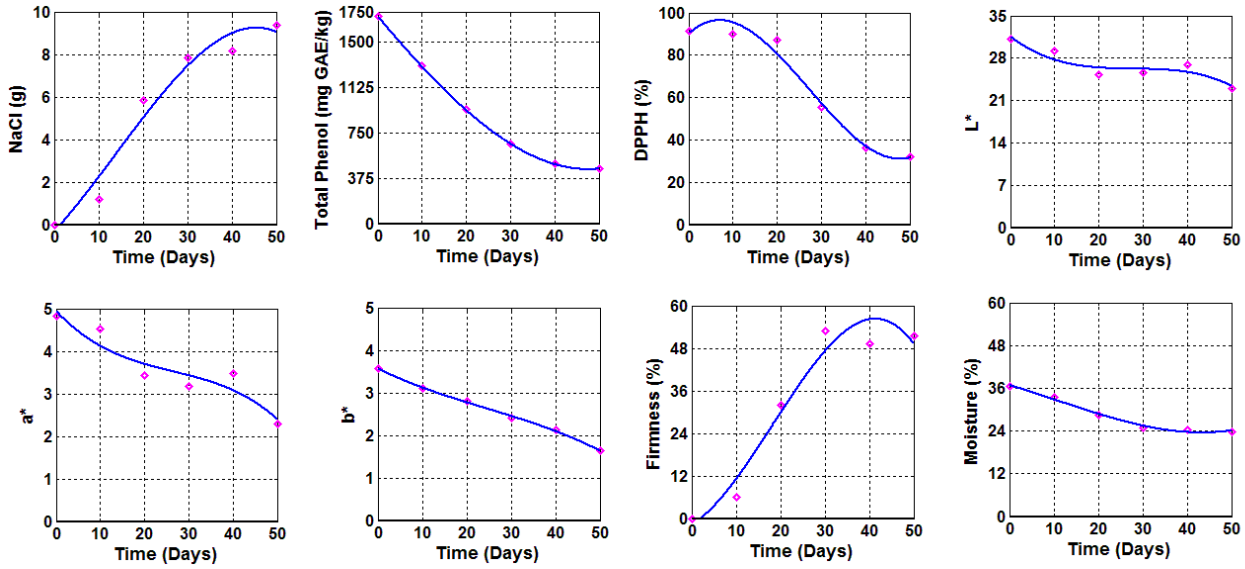

Fig. 1 Polynomial models represent the interactions between time and attributes during fermentation.

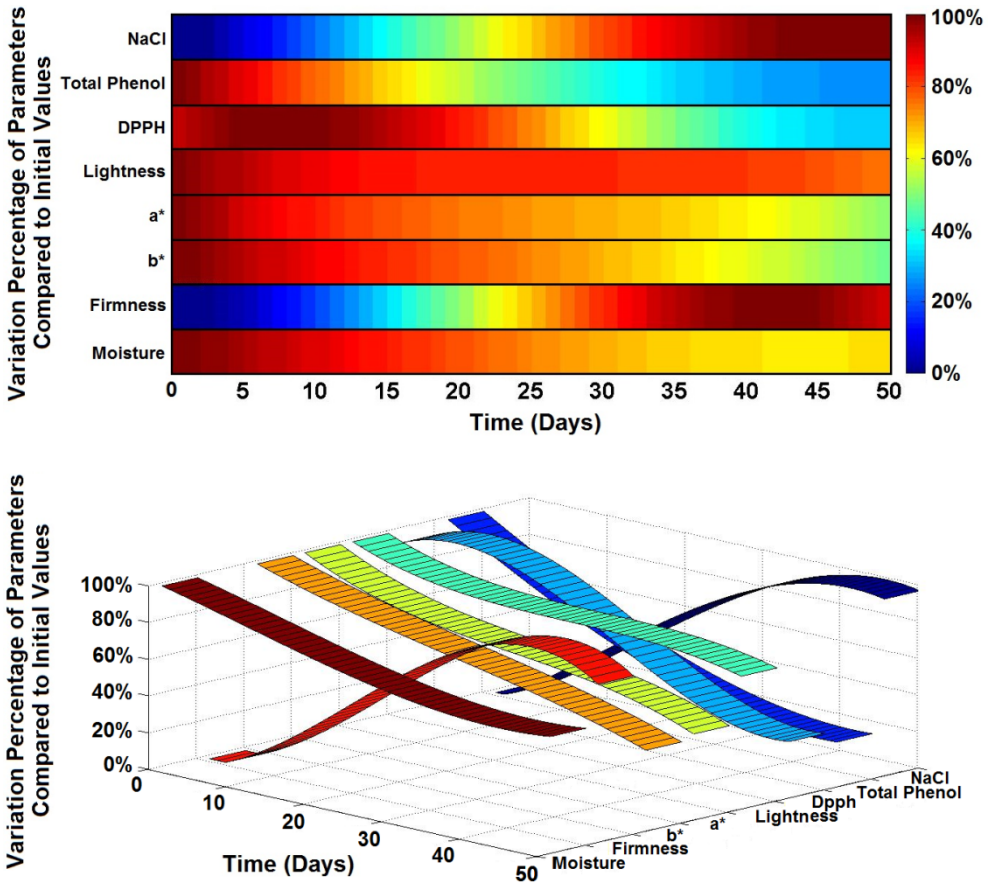

Fig. 2 Polynomial models represent the interactions between time and variation percentage of attributes during fermentation.

axes of polynomials in the Fig. 2 were normalized between 0% and 100% since the parameter units (attribute units) are different. That is, the curves shown in the Fig. 2 are the parameter.

In the study, after analyzing the parameter variation percentage by means of polynomial models, the

relationships between these parameter variations were also investigated to compare the similar analyses in the literature. Correlative relationships between these polynomial models can be seen in Table 4.

As can be seen in Table 4, the results of dry-salted Gemlik olives confirmed the high polynomial relationship 0.932 (r) between total phenols (mg GAE/kg) and radical scavenging activity (DPPH %). Like this result, the results of olive cv. that obtained by Soufiet. al. [24] and Otman et al. [3] showed that the linear relationship was found between total phenols and DPPH with the correlation coefficient as 0.91 (r) for Algerian black olive cultivars [24] and Tunisian Meski cultivars of olive with correlation coefficient (r) as 0.9076 [3].

The polynomial models of TPC-Time, DPPH (%)-Time, and TPC-DPPH (%) of Gemlik olive cv. gave very good fitting with higher determination coefficients (R^2=1, 0.979 and 0.932 respectively can be seen in Table 3, low RMSE and SSE values in terms of polynomial relationship. These results confirmed the similarity of Kargaburun, Erkence, Halhali and Saurani olive cv. of Hatay province and Gemlik olive cv. of Osmaniye province in Turkey [15, 16]. There were inverse relationships among TPC, DPPH and salt concentration during fermentation period of Gemlik olives. The total phenols and radical scavenging activities (DPPH %) of Gemlik olive cv. decreased meanwhile salt concentration increased and the relationship among these parameters can be expressed in terms of mathematics where the polynomial equation gave best fitting due to statistical results.

There were close relationships between time and all parameters except L* and a* values of olive fruits and these relationships were expressed as polynomial (third order) due to the statistical results of fitting process. The determination coefficients (R^2) varied from 0.96 to 1 with low RMSE and SSE values which meant good fitting results of mathematical relationship. The firmness and salt concentration were increased during fermentation period where Gemlik olives became more salty and harder. There were close relationships among firmness, NaCl of Gemlik olive cv. versus time due to statistical results of fittings mathematically where the polynomial equation gave good fitting results. These fitting scores approved that higher salt content stimulates the performance of hydrolytic enzymes that accelerate cell wall destruction of Gemlik olive cv. resulting more occurrence of liquid leakage [24].

In sensory evaluation of the table olives, saltness, juiciness, bitterness, astringency, sweetness, sourness, crispiness and overall sensory attributes were evaluated by the participants. After 50 days of fermentation period, Gemlik olives became more crispy and salty owing to salt intake into the flesh, with an increasing firmness. According to the specifications of International Olive Oil Council [31], salt intake of Gemlik olives did not exceed the limit of 10 g NaCl/100 g (9.35 g/100 g)—otherwise olives could become organoleptically undesirable. After 50

Table 4 Correlative relationships of polynomial models that represent the interactions between time and physico-chemical parameter variations.

Interactions	T-NaCl	T-phenol	T-DPPH	T-L*	T-a*	T-b*	T-firmness	T-moisture
T*-NaCl (%)	1	-0.998	-0.950	-0.913	-0.966	-0.974	0.996	-0.998
T-T. phenol**	-0.998	1	0.932	0.9312	0.970	0.970	-0.993	0.999
T-DPPH (%)	-0.950	0.932	1	0.802	0.926	0.966	-0.942	0.932
T-L*	-0.913	0.9312	0.802	1	0.967	0.927	-0.883	0.914
T-a*	-0.966	0.970	0.926	0.967	1	0.992	-0.941	0.958
T-b*	-0.974	0.970	0.966	0.927	0.992	1	-0.953	0.962
T-firmness (%)	0.996	-0.993	-0.942	-0.883	-0.941	-0.953	1	-0.998
T-moisture (%)	-0.998	0.999	0.932	0.914	0.958	0.962	-0.998	1

*T: time; **(mg GAE/kg).

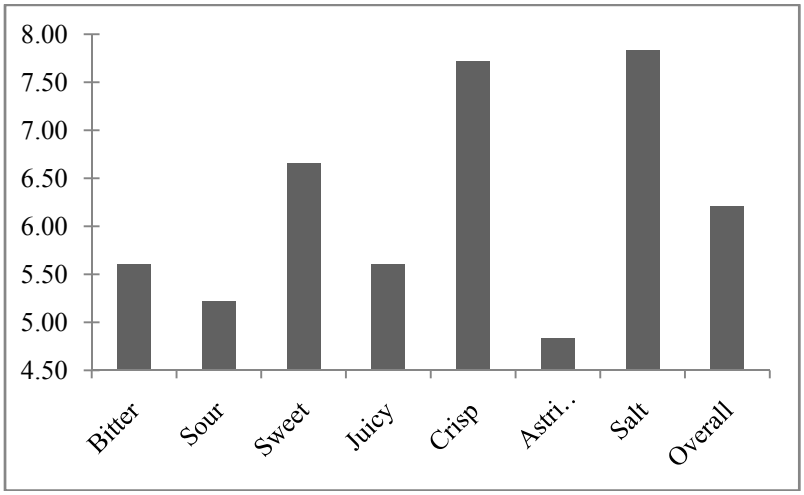

Fig. 3 Sensory scores of Gemlik olive cv. after fermentation period.

days of dry-salting process of olive sample, the sensory scores of saltness and crispiness of dry-salted olives were higher as 7.21 and 7.34 respectively. Additionally, the sensory scores of astringency, sourness and bitterness were evaluated by participants whose scores varied from 4.56 to 5.61 (Fig. 3).

Overall sensory attributes of dry-salted olives were evaluated as 6.21. It is stated that black table olives are favorable and 85% of consumable olives are black type (more consumed especially at breakfast throughout all Mediterranean) [26]. So, our results confirmed Gemlik olive cv. for consuming as table olive. The microbial population is important for table olive cv. and yeast growth negatively affects the fermented olive cv. So different packaging conditions (modified atmosphere, K-sorbate etc.) should be used to prevent microbiological deterioration of olive fruits.

4. Conclusion

The results of this experiment constitute an attempt to observe the effects of salting process of Gemlik olives during 50 days of fermentation. The table olives were maintained the physico-chemical and sensorial properties during the salting process. The olive fruits became more acidic and saltier while maintaining lower moisture level. TPC and DPPH of Gemlik olive cv. were decreased during fermentation. The color parameters of Gemlik olives were decreased during fermentation period. The polynomial equation gave best fitting due to statistical results with regression coefficients, RMSE and SSE values. Vandermonde matrix can be used for fitting of data to obtain best mathematical models. The results of sensory evaluation showed that sensory attributes of salted Gemlik olives, such as astringency, bitterness, acidity, saltness, crispiness, and juiciness were acceptable. Gemlik olive cv. had higher scores of sensory attributes at the end of fermentation period by using 10% of NaCl whose concentration was sufficient for physico-chemical and sensory attributes of olive fruits.

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