Evaluation of physicochemical and sensory properties of green olive pastes

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In this study, the physicochemical and sensorial characteristics of green olive pastes from retail markets were analyzed. Physicochemical analysis showed that the titratable acidity, salt and pH values of the pastes varied between 0.58–1.78 gm 100 gm⁻¹, 3.45–7.16 gm 100 gm⁻¹ and 2.82–4.08, respectively. The major fermentation compounds were lactic acid, ethanol and methanol, which were significantly different in all samples (p<0.01). Sucrose was detected in only one sample, at a concentration of 5.17 mg 100 gm⁻¹; the glucose, fructose and citric acid concentrations ranged from 1.44–243.85 mg 100 gm⁻¹, 5.58–474.25 mg 100 gm⁻¹ and 102.5–774 mg 100 gm⁻¹, respectively. Acetaldehyde and n-propanol were detected at very low concentrations. All green olive pastes were recognized as “generally acceptable” by the panelists, however, sample D was the most preferred paste in terms of the overall sensorial attributes.

Keywords: Green olive paste, Physicochemical characteristics, Sensory characteristics, Fermentation

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The olive fruit (Olea europaea L.) is a small, thinner-fleshed drupe that is 1–2.5 cm long and grows on a small tree, which belongs to the family Oleaceae, and is native to tropical and warm temperate regions of the world¹. Olive is a rich source of valuable nutrients and bioactive compounds with health benefits, such as hydrophilic (phenolic acids, phenolic alcohols, flavonoids and secoiridoids) and lipophilic (cresols) phenolic compounds, phytosterols, tocopherols, pigments (carotenoids, chlorophyll and squalene), pectin and organic acids. The olive has high oil content, and extracted olive oil is very popular for its nutritive and health-promoting potential, especially against cardiovascular disorders due to the presence of high levels of mono-unsaturated fatty acids and flavonoid polyphenols such as hydroxytyrosol and tyrosol. These components are known to possess various biological activities such as antioxidant, anticarcinogenic, anti-inflammatory, antimicrobial, antihypertensive, antidiyslipidemic, cardiotonic, laxative, and antiplatelet².³ Naturally, olive fruits have a bitter flavor; hence they are subjected to fermentation or cured with lye or brine to make them more palatable⁴.

Aside from the chemical composition of olive oil, olive paste is recognized not only by its excellent taste and quality, but also by its health-promoting effects. In addition, olive paste recipes can include a lot of heterogenic components of animal and of vegetable origins.

For green olive paste production green table olives, which are harvested at the green mature stage of ripening, are treated to remove bitterness, destoned, ground and mixed with olive oil and salt⁵. It can easily be converted into a traditional tapenade with the addition of aromatic herbs and spices like garlic, rosemary, thyme, chili, peppers and capers.

Table olives and olive products are traditional food in many Mediterranean countries. Eighty eight varieties of olives (Olea europaea L.) are cultivated within 35 cities in the Anatolian region⁶. The “Domat” variety is generally preferred for green olive paste production because of its high flesh/seed ratio than all major varieties and the easiness of separation of its flesh from the seed⁷.

The food industry is a dynamic system that needs to innovate itself almost constantly in order to meet consumers’ demands. During the development and marketing of a new foodstuff it is important to consider many aspects related to its quality of psychological, technological, legal, etc. Concerning

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legal matters, it is crucial to consider food safety as well as its nutritional, sensory and commercial quality, among other aspects. Currently, it is relatively easy to produce a food item that qualifies as “green olive paste”, as so many manufacturers offer this product in their portfolio, but little is known about the consumer profile or ideal production methods. Although the Institute of Turkish Standards has published a standard for black olive paste\(^9\), there is no published standard for green olive paste, and also research on olive paste production and quality is very limited\(^{1,9,10,11,12}\). In this context, this work reports the physicochemical and sensorial properties of olive pastes prepared with green olives.

**Methodology**

All samples were collected from retail markets in Bursa, Turkey, between September 2009 and September 2010. A total of 36 green olive pastes were collected within their original packages from 6 different brands and stored at 4±1°C until their physicochemical and sensory quality properties were analyzed.

**Physicochemical analysis**

Titratable acidity (gm 100 gm\(^{-1}\)), salinity (gm 100 gm\(^{-1}\)), pH, reducing sugar (mg 100 gm\(^{-1}\)), sugar composition, organic acid content and total volatile compounds analysis were performed with the homogenized olive paste samples. The acidity, salinity and pH of samples were measured as described in TS 7630\(^{13}\), while reducing sugar was determined using the method of Cemeroglu\(^14\). Organic acid content and sugar composition were analyzed using HPLC methods, as described by Sanchez et al.\(^{15}\), using a Hewlett Packard series 1050 liquid chromatograph equipped with LC-25 refractive index detector. An Aminex HPX-87C column (300 x 7.8 mm i.d., Bio Rad Labs) held at 70°C and deionized water as eluent at 0.7 mL/min were used for sugar composition analysis. For organic acid (lactic, citric and malic) analyses a Spherisorb ODS-2 (5 µm, 25 cm x 4 mm i.d, Teknorama) column with deionized water (pH adjusted to 2.2 using concentrated H\(_3\)PO\(_4\)) as mobile phase was employed. Flow rate was 1.0 mL min\(^{-1}\). Concentrations were calculated by comparison of peak heights with those of external standards for each compound. Headspace solid-phase microextraction (HS-SPME)-gas chromatography-mass spectrometer using flame ionization detection was applied to specificity the volatile compounds\(^{16}\). A HP Innowax column (0.25 µm, 60 x 0.25 mm i.d.) held at 80°C was used. Helium was the carrier gas at 1 mL min\(^{-1}\). The ion source and transfer line temperatures of mass spectrometer were 200°C.

**Sensory analysis**

For sensory analysis, hedonic tests were performed to obtain the degree of appreciation by a panel of 12 judges in test rooms using criteria described by Marsilio, Russi, Iannucci & Sabatini\(^{17}\). The proof sheet contained a list of sensory descriptors (appearance, texture, aroma, salty taste, sourness and overall acceptability). A tasting chart with 5 points was used, being number 1 and 5, with 1 representing highly unpleasant and 5 representing highly enjoyable.

**Statistical analysis**

Statistical analysis was carried out with SPSS for Windows version 14, with means and standard deviations compared by ANOVA (p <0.01).

**Results and discussion**

The results of the physicochemical analyses of green olive paste samples are given in Table 1. According to the results of analysis of variance of the green olive paste varieties there were significant differences in pH, titratable acidity, salt, organic acid, total sugar contents and volatile components (p <0.01). We propose that this difference arises from the olive type used in product recipes, the production method, the characteristics of the olives and the additives used in the products, especially acidity regulator, its type and the amount used.

The results were compared with the TS 774 Edible Olives Standard because of the lack of a standard for olive paste, either green or black\(^{18}\). The acidity values of all samples were higher than the reported minimum value of 0.4 gm 100 gm\(^{-1}\) (m/m). According to the Turkish Food Codex Edible Olives Communiqué\(^8\), the pH value of pasteurized edible green olives should be less than 4.5, and salinity should be higher than 1 gm 100 gm\(^{-1}\). Only Sample B was close to the pH cut-off (pH 4.08), however, because the salinity was over 1 gm 100 gm\(^{-1}\) in all samples they were evaluated as being within limits of Turkish Food Codex Edible Olives Communiqué\(^8\). The reducing sugar content ranged from 0.019 to 0.145 mg 100 gm\(^{-1}\). Sahin et al.\(^{19}\) stated that the reducing sugar of fresh Domat olives is 0.69 mg 100 gm\(^{-1}\), whereas Savas\(^7\) reported
The reducing sugar contents of samples were likely lower probably due to the lye treatment and washing process or utilization of reducing sugars by microorganisms during the fermentation process \(^{15,20,21,22}\). In general, any table olive processing method aims to remove the natural bitterness of this fruit, caused by the glycoside oleuropein, and the Spanish method is used for the processing of green olives \(^{23}\), especially for 

\[ \text{Domat} \] type olives \(^{24}\). Montano, Sánchez, Casado, Castro & Rejano \(^{25}\) detected basic components such as ethanol, methanol, lactic, acetic, formic and succinic acid, with other metabolites such as mannitol, glucose, sucrose, citric acid, \(n\)-propanol, 2-butanol and acetaldehyde, in green olives after fermentation; and concluded that these compounds are produced during processing. The high lactic acid content of the green olive pastes examined is the natural result of lactic acid fermentation, which is employed in table olive production \(^{24,26}\). The citric acid ratio is also very high because it is added as an acidity regulator, and it is also formed naturally during fermentation. Sucrose, which is a residue of fermentation, was detected in only one sample (Sample D), but glucose, fructose and mannitol, which are present due to the incomplete fermentation of the olives, were found in all samples.

### Table 1—Physicochemical analysis of green olive pastes

<table>
<thead>
<tr>
<th>Green olive paste variety</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{pH} )</td>
<td>3.48(^d)</td>
<td>4.08(^b)</td>
<td>3.57(^c)</td>
<td>3.80(^b)</td>
<td>2.82(^f)</td>
<td>3.27(^e)</td>
</tr>
<tr>
<td>( \text{Titratable acidity (gm 100 gm}^{-1} )</td>
<td>0.96(^b)</td>
<td>0.70(^c)</td>
<td>1.12(^b)</td>
<td>0.58(^c)</td>
<td>1.78(^a)</td>
<td>1.78(^e)</td>
</tr>
<tr>
<td>( \text{Salt (gm 100 gm}^{-1} )</td>
<td>4.13(^d)</td>
<td>5.58(^b)</td>
<td>3.45(^e)</td>
<td>3.71(^c)</td>
<td>7.16(^a)</td>
<td>5.22(^c)</td>
</tr>
<tr>
<td>( \text{Reducing sugar (mg 100 gm}^{-1} )</td>
<td>0.019(^d)</td>
<td>0.050(^d)</td>
<td>0.111(^ab)</td>
<td>0.077(^bc)</td>
<td>0.110(^ab)</td>
<td>0.145(^a)</td>
</tr>
<tr>
<td>Sugar composition (mg 100 gm}^{-1} )</td>
<td>10.36(^d)</td>
<td>2.83(^c)</td>
<td>11.89(^c)</td>
<td>12.71(^b)</td>
<td>1.44(^f)</td>
<td>243.85(^a)</td>
</tr>
<tr>
<td>( \text{Glucose} )</td>
<td>6.81(^c)</td>
<td>1.97(^f)</td>
<td>3.22(^e)</td>
<td>21.32(^a)</td>
<td>6.38(^d)</td>
<td>11.34(^b)</td>
</tr>
<tr>
<td>( \text{Mannitol} )</td>
<td>0.00(^b)</td>
<td>0.00(^b)</td>
<td>0.00(^b)</td>
<td>5.17(^a)</td>
<td>0.00(^b)</td>
<td>0.00(^b)</td>
</tr>
<tr>
<td>( \text{Sucrose} )</td>
<td>15.10(^f)</td>
<td>5.38(^c)</td>
<td>20.01(^b)</td>
<td>12.77(^d)</td>
<td>0.00(^f)</td>
<td>474.25(^a)</td>
</tr>
<tr>
<td>Organic acid content (mg 100 gm}^{-1} )</td>
<td>26.00(^f)</td>
<td>362.50(^b)</td>
<td>114.50(^d)</td>
<td>413.00(^a)</td>
<td>76.00(^f)</td>
<td>140.50(^f)</td>
</tr>
<tr>
<td>( \text{Lactic acid} )</td>
<td>156.50(^d)</td>
<td>102.50(^f)</td>
<td>374.00(^e)</td>
<td>143.00(^c)</td>
<td>656.50(^b)</td>
<td>774.00(^b)</td>
</tr>
<tr>
<td>( \text{Citric acid} )</td>
<td>10.00(^f)</td>
<td>4.50(^f)</td>
<td>24.00(^f)</td>
<td>59.50(^b)</td>
<td>27.00(^b)</td>
<td>25.00(^c)</td>
</tr>
<tr>
<td>Volatile compounds (mg 100 kg}^{-1} )</td>
<td>3.317(^d)</td>
<td>21.216(^a)</td>
<td>2.538(^b)</td>
<td>1.470(^c)</td>
<td>17.001(^b)</td>
<td>4.587(^a)</td>
</tr>
<tr>
<td>( \text{Acetaldehyde} )</td>
<td>0.335(^e)</td>
<td>0.599(^e)</td>
<td>0.2595(^cd)</td>
<td>0.188(^d)</td>
<td>0.482(^b)</td>
<td>0.214(^d)</td>
</tr>
<tr>
<td>( \text{n-Propanol} )</td>
<td>0.000(^e)</td>
<td>0.764(^e)</td>
<td>0.387(^bc)</td>
<td>0.110(^d)</td>
<td>0.431(^b)</td>
<td>0.312(^c)</td>
</tr>
<tr>
<td>( \text{Ethanol} )</td>
<td>5.986(^d)</td>
<td>20.839(^a)</td>
<td>6.302(^d)</td>
<td>3.281(^c)</td>
<td>9.022(^e)</td>
<td>11.795(^b)</td>
</tr>
<tr>
<td>2-Butanol</td>
<td>8.550(^b)</td>
<td>16.393(^a)</td>
<td>1.120(^d)</td>
<td>0.097(^d)</td>
<td>3.702(^e)</td>
<td>0.181(^d)</td>
</tr>
</tbody>
</table>

\(^*\) Superscript with different alphabets in the same column differ significantly (\(p<0.01\)).

this value as ranging from 1.24 to 1.36 mg 100 gm\(^{-1}\). The reducing sugar contents of samples were likely lower probably due to the lye treatment and washing process or utilization of reducing sugars by microorganisms during the fermentation process \(^{15,20,21,22}\).

In general, any table olive processing method aims to remove the natural bitterness of this fruit, caused by the glycoside oleuropein, and the Spanish method is used for the processing of green olives \(^{23}\), especially for 

\[ \text{Domat} \] type olives \(^{24}\). Montano, Sánchez, Casado, Castro & Rejano \(^{25}\) detected basic components such as ethanol, methanol, lactic, acetic, formic and succinic acid, with other metabolites such as mannitol, glucose, sucrose, citric acid, \(n\)-propanol, 2-butanol and acetaldehyde, in green olives after fermentation; and concluded that these compounds are produced during processing. The high lactic acid content of the green olive pastes examined is the natural result of lactic acid fermentation, which is employed in table olive production \(^{24,26}\). The citric acid ratio is also very high because it is added as an acidity regulator, and it is also formed naturally during fermentation. Sucrose, which is a residue of fermentation, was detected in only one sample (Sample D), but glucose, fructose and mannitol, which are present due to the incomplete fermentation of the olives, were found in all samples.

Fig. 1—Effect of sample formula on sensorial attributes of green olive pastes compared to overall appreciation

Propanol, 2-butanol and acetaldehyde were also detected in the samples, although these compounds are not characteristic products of lactic acid fermentation. The high volatile compound content mainly contributes to and shapes the characteristic aroma profile of the product.

The sensory evaluation of green olive pastes were given in Fig. 1. The correlations of the different sensory attributes indicated that the panel was positively influenced by all evaluated attributes when
Table 2—Sensory analysis of green olive pastes

<table>
<thead>
<tr>
<th>Sample</th>
<th>Color</th>
<th>Texture</th>
<th>Taste</th>
<th>Odor</th>
<th>Salinity</th>
<th>Soursness</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2.833³</td>
<td>3.500ab</td>
<td>3.7500</td>
<td>4.083³</td>
<td>4.083ab</td>
<td>3.583ab</td>
<td>3.833³</td>
</tr>
<tr>
<td>B</td>
<td>1.250d</td>
<td>2.416bc</td>
<td>2.5000</td>
<td>2.6667ab</td>
<td>2.4167c</td>
<td>2.4167bc</td>
<td>1.9167c</td>
</tr>
<tr>
<td>C</td>
<td>4.750³</td>
<td>3.250ab</td>
<td>3.1667</td>
<td>3.1667ab</td>
<td>3.5000bc</td>
<td>4.333³a</td>
<td>2.833³bc</td>
</tr>
<tr>
<td>D</td>
<td>3.6667bc</td>
<td>4.1667a</td>
<td>3.8333</td>
<td>4.0000a</td>
<td>4.333³a</td>
<td>4.2500¹</td>
<td>4.333³a</td>
</tr>
<tr>
<td>E</td>
<td>3.833³b</td>
<td>1.833³c</td>
<td>3.0000</td>
<td>3.583³ab</td>
<td>2.1667c</td>
<td>1.4167d</td>
<td>2.2500²</td>
</tr>
<tr>
<td>F</td>
<td>3.1667bc</td>
<td>3.6667ab</td>
<td>2.5833</td>
<td>2.333³b</td>
<td>2.833³bc</td>
<td>2.2500⁰d</td>
<td>2.2500⁰c</td>
</tr>
</tbody>
</table>

* Superscript with different alphabets in the same column differ significantly (p<0.01)

compared to overall acceptability. The variance analysis showed that while there were significant differences in values of texture, fragrance, saltiness, sourness and total acceptability between samples ((Table 2, p<0.01), there was no difference in the taste values (p>0.05). Texture, an important attribute of food, largely determining its organoleptic quality, has a great influence on the processing, storage, maintenance and acceptance by consumers. Stickiness, a very soft or putty-like texture, was regarded unfavorably by the panelists. Under unsuitable fermentation conditions, the olive fruit tissue becomes soft, so that when the olives are separated into parts in the pulper, they are crushed completely; and the final product exhibits a sticky characteristic in the mouth. Concerning texture, the panelists liked green olive pastes with rougher texture, meaning hardness, which can be interpreted as a textural characteristic during the first chew, as in relevance to expectancy of green table olive tissue. The color values showed the highest for Sample C, which was yellow-green similar to green table olives. The highest values for fragrance were found in Samples A & D. With regard to scores for texture, saltiness, sourness and overall acceptability Sample D revealed highest values.

Conclusion

Nowadays food is not just foods; consumers have developed more dynamic, complex and differentiated demands. Today’s consumer food quality perception in sense of quality attributes can be distinguished into four groups which are sensory, health, process and convenience. Diet-related chronic health conditions such as obesity, diabetes, and heart disease have attracted a lot of attention. The increased consumption of energy-dense foods rather than foods such as fresh vegetables and fruits may be the reason for an increased prevalence of poor nutrition and chronic diseases. Therefore, there is great demand for health-promoting foods with high polyphenol content, lower fat concentration and relative high proportion of monounsaturated or polyunsaturated fatty acids. In addition, the quest for fatty acids with potentially positive health benefits, such as linoleic acid and omega-3, is also increasing. The olive fruit together with olive oil are one of the main ingredients of Mediterranean diet, and has a high content of oil rich in polyphenols aside with triacylglycerols composed mainly of a mixture of oleic, palmitic and linoleic acids. Green olive pastes are traditional foods produced from olives of table olive quality and have been consumed locally or regionally for many generations, however, can be processed from small-size graded or turning color olives, as they play an important role in the economy. Following the consumer tendency for functional traditional foods olive paste can be recognized not only by its excellent taste and quality, but also by its potential beneficial effects on human health.

The main objective of this study is to report the physicochemical and sensorial characteristics of green olive pastes produced with traditional methods and sold in retail markets. The selection and consumption of any food product has always been a matter of subject to a complex network of cultural and individual factors. Thus, understanding the relationship between food texture perception and food structure is of increasing importance for companies wishing to develop innovative food products favored by consumers having health-promoting properties. In this context it is crucial to define the food’s composition. Since, traditional foods are significant elements of cultural inheritance and have critical economic inputs in any region, improving the opportunities of their competitiveness and marketing is a key parameter for rural sustainable development. This may be maintained by modernization of traditional processing methods whilst ensuring that the products remain safe and of the highest quality.
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