Sensory properties of green table olives prepared by different fermentation processes

Taha Rababah*, Muhammad Alu'Datt†, Majdi Al-Mahasneh‡, Sana Gammoh§, Hana’a Mahili¶, Tha’er Ajouly®, Carole C. Tranchant* and Vaida Bartkute-Norkuniene©

*Department of Nutrition and Food Technology, Jordan University of Science and Technology, Irbid, Jordan; †Department of Chemical Engineering, Jordan University of Science and Technology, Irbid, Jordan; ‡School of Food Science, Nutrition and Family Studies, Faculty of Health Sciences and Community Services, Université de Moncton, Moncton, New Brunswick, Canada; ¶Faculty of Business and Technologies, Utana University of Applied Sciences, Utana, Lithuania

ABSTRACT
This study evaluated the effect of debittering fermentation methods on the sensory properties of green table olives. The panelist results of appearance, aroma, taste and texture showed that the most preference sensory attributes are found in treated with NaOH followed significantly by the whole, scratchy and ticked. The panelist results varied and showed the higher values of overall appearance found in NaOH followed by the whole, scratchy, and ticked. Also, the higher values of overall flavor and taste found in treated with NaOH followed by ticked, scratchy, and whole. The higher values of overall texture found in whole followed by treated with NaOH, scratchy and ticked. The higher values of overall bitter taste found in whole followed by scratchy, ticked and treated with NaOH. In conclusion, despite of NaOH processing fermentation debittering method has the most sensory parameters but in general not big differences were found comparison with other methods.

1. Introduction
The olive trees (Olea europaea L.) are a main crop that grows in the Mediterranean regions (Al-Ismael, Ahmad, Al-Dabbas, Ajo, & Rababah, 2011). Olives are the most important fruit that supplies olive oil and table olives (Boskou & Visioli, 2003). Therefore, table olives from an economical point of view are considered one of the significant goods that provide oil with high nutritional value and possible therapy treatments (Ribarova, Zanev, Shishkov, & Rizov, 2003). Worldwide production of table olives according to the International Olive Council (IOC, 2017) is around approximately 3,020,500 tons. Jordan is considered one of the most important countries in olive trees cultivation (12 million trees), it contributes about 72% of the total planted area, which is 36% of Jordanian lands. Jordan also has a considerable production of table olives, with around 20,000 tons in the 2016/2017 (Market Newsletter, 2008). Therefore, table olives are the main component of the Mediterranean diet as they contributed to the prevention of some chronic diseases such as cardiovascular disease (Charoenprasert & Mitchell, 2012). Moreover, olives from an economical point of view are considered one of the significant goods that provide oil with high nutritional value and possible therapy treatments (Ribarova et al., 2003). The fermentation process on table olives is carried out by Lactic acid bacteria (Romeo, Piscopo, Mincione, & Poiana, 2012). Lactic acid bacteria in which; gram-positive, gram-negative and yeast are the predominant microorganism that it’s found on fermentable table olives (Fernández, Adams, & Fernández-Diez, 1997). However, hygienic practices on the fermentation process also organize

CONTACT Taha Rababah trababah@just.edu.jo Department of Nutrition and Food Technology, Jordan University of Science and Technology, P.O. Box 3030, Irbid 22110, Jordan

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The marketing success of food products depends on many factors including consumer sensory satisfaction; were the determination of consumer expectations and attitudes for a given food, and expression of consumer demands into scientifically sound sensory descriptors are essential in the aiming of food marketing, besides other techniques, quantitative descriptive analysis (QDA) is a widely used sensory technique of product description by trained panels. It gives an opportunity to describe and compare food samples, as well as to match consumer demands (Yilmaz & Aydeniz, 2012). In order to assess consumer behavior, affective sensory testing procedures are used, where the primary purpose of affective tests is to assess personal responses posed by current and potential customers of products (Meilgaard, Civille, & Carr, 1991). Also, they demonstrated that acceptance and preference tests were carried out through several techniques. Yilmaz and Aydeniz (2012) investigated the nine-point Hedonic scale which is a common technique used for consumer tests that aim to select the best suitable varieties for green table olive preparation based on sensory descriptors and consumer demands for successful marketing.

2. Materials and methods

2.1. Chemicals

Sodium carbonate Na2CO3, Aluminum Chloride AlCl3, Sodium Hydroxide NaOH, and Sodium Nitrate NaNO2 were purchased from (Scharlau, Barcelona, Spain). Methanol and Folin-Cioloate reagents, 2, 2-diphenylhydrazyl (DPPH), gallic acid were purchased from (Sigma-Aldrich, Switzerland).

2.2. Sample collection

Four different varieties of green table olives; Nabali, Baladi, Crosodi, and K18 (their abbreviations in this study were included N, B, C, and K18, respectively), were collected from Irbid farms in October 2015.

2.3. Debittering methods

Olives were hand-picked when they developed a green-yellow surface color and normal large-size. The collected olives were subjected to sorting concerning their size and washed with tap water to be ready for the fermentation process. Four fermentation treatments were applied; whole, ticked scratches and treated with NaOH (their abbreviation H, D, T, and M, respectively). The de-bittering methods of table olive treated with NaOH were conducted as described by Ünal and Nergiz (2003) like the following, a 2% NaOH solution was added into the four glasses jars containers and the olives (7.5 kg from each variety of table olive) were kept for 8 hours in that solution. During this de-bittering process, penetration of sodium hydroxide solution into the olive flesh was detected by cutting the fruit halfway down its length to see how far the solution has penetrated the flesh from time to time. After penetration of NaOH in a depth corresponding to 2/3 of flesh thickness, the solution was poured with the aid of tap container and the fruits were subjected to water washing several times; 3 times at least to eliminate the excess of alkaline solution remaining on the fruits. To ensure all alkaline are removed from brine solution 2 drops of phenol naphthalene were added to the brine solution. At the end of this period, the water was removed. The olives then placed into glass jars bottles (500 grams capacity) and a 10% NaCl brine solution was added to cover the olives. For whole table olives and de-bittering process olive placed into glass jars container contain tap water and kept for 24 hours, water was changed every 8 hours, and the rest of the fermentation process was similar to treated with NaOH table olives. For the ticked table olives fermentation process, the olives were beaten by hand stone and the process of the de-bittering olive was done as mentioned for the whole table olives. Scratchy table olives processed by knife then completed similarly as mentioned before. Olives filled into glass jars bottles of the four verities stored at room temperature for evaluation during 0, 1, 2 and 3 months for physiochemical (pH, acidity, color, texture, and chemical composition) and phytochemicals (total phenol, antioxidant, flavonoids) properties. For sensory evaluation similar procedures as described before were conducted. The fermentation process was monitored by recording its pH to determine the end of the fermentation process. These samples were heat treatments by water bath (72°C for 15 sec) and kept in a refrigerator until use.

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described before were conducted. The fermentation process was monitored by recording its pH to determine the end of the fermentation process. These samples were heat treatments by water bath (72°C for 15 sec) and kept in a refrigerator until use.

2.4. Determination of pH

pH is approximately the negative of the base 10 logarithm of the molar concentration, measured in units of moles/liter, of hydrogen ions (Bargrizer, Smernik, & Mosley, 2017). More precisely it is the negative of the logarithm to base 10 of the activity of the hydrogen ion (Bates & Vijh, 1973). Solutions with a pH less than 7 are acidic and solutions with a pH greater than 7 are basic pure water is neutral, at pH 7, being neither an acid nor a base (Bargrizer et al., 2017). Contrary to popular belief, the pH value can be less than 0 or greater than 14 for very strong acids and bases respectively (Lim, 2006). The pH of the brine solution for four different types of green table olives at RT (25°C) was determined using a pH meter (pH 510, EUTECH instruments, Malaysia). The pH meter was calibrated with pH buffers at 4 and 7. The glass electrode was placed directly into the brine solution in each olives container, and the resulting pH values were recorded. During the storage period of fermentation, pH measured from the beginning of fermentation until 90 days of storage. For sensory analysis attributes for table olive varieties, a pH measured from the beginning of fermentation until the end of fermentation for each de-bittering method of fermentation record (3.5) in each de-bittering method of fermentation.

2.5. Acidity determination

In chemistry, free acid generally refers to any acid that can lose proton(s) in an acid-base reaction; however, the term is used slightly differently in other fields and used to describe acids such as phosphoric acid, sulfuric acid which are involved in renal physiology; where used to explicitly exclude ammonium (NH4+) as a source of acid, and is part of the calculation for net acid excretion and gets its name from the use of NaOH in acid-base titration to estimate the quantity of free acid (Lim, 2006). The acidity (expressed as a percent of lactic acid) was determined by titration of 10 ml of brine solution with a 1% phenol naphthalene indicator and 0.1 M sodium hydroxide solution. Three replicates were used to calculate the mean value. During the storage period of fermentation, acidity was measured from the beginning of fermentation process until 90 days of storage. For sensory analysis attributes for table olive varieties, acidity measured from the beginning of fermentation until the end of fermentation for each de-bittering method of fermentation (0.3 g LA/100 ml) in each de-bittering method of fermentation.

3. Sensory evaluation

3.1. Descriptive analysis

Eight-member descriptive panel (3 males, 5 females and their ages from 23–40 years), who consumed fermented table olives frequently and at least twice per week, were trained according to the Spectrum de-bittering methodology (Meilgaard et al., 1991). The training process included theoretical and practical sessions held twice a week and that followed the main recommendations of the IOC standard Regulation (International Olive Council IOC, 2011). The experienced panelists took two sensory classes and have been trained for table olive products sensory evaluation for more than 300 hours. The performance of the panel was evaluated by using a mixed model of three-way ANOVA with interaction. The Spectrum de-bittering method involves scoring perceived intensities with references to a determined scale using standard attribute names with their standards that define a scale of intensity. There was no major difference in sensory parameters in comparison with ticked and scratchy table olives fermentation de-bittering methods. Instrumental texture results were agreed with descriptive analysis and consumer results. The panelist results of appearance, aroma, taste, and texture showed that and regarding the de-bittering methods of fermentation the most preference sensory attributes are found in treated with NaOH followed significantly by the whole, scratchy and ticked, respectively. Each treatment from 16 table olives was evaluated for aromatics, basic taste, and feeling factors attributes. Four 3-hour orientation sessions were necessary for the panel to develop the test de-bittering methodology necessary to describe the characteristics of the sensory attributes of fermented table olive samples. All samples were coded with random 3-digit numbers. At each of the test sessions, a warm-up sample was used to ensure that the panel was well trained. Panelists underwent an orientation session using table olives during which the panelists were able to narrow down the list of references for each descriptor Tables 1 and 2. The panelists used the orientation session to improve their reproducibility and accuracy. Panelists underwent an orientation session using table olives during which the panelists were able to narrow down the list of references for each descriptor Tables 1 and 2. The panelists used the orientation session to improve their reproducibility and accuracy. The appearance attributes were assessed by the whole panel on the complete sample before carrying out the tasting. Next, in each sample, first the odor was evaluated, then the flavor and, finally, the texture attributes. The evaluation of the odor was made by direct aspiration of the air over the tasting glass in 2 phases: first with the glass kept still to detect any possible defects, and then after shaking it gently to determine the different odor attributes. Four sessions of 1 hour (4 samples/session) were conducted to complete the analysis. The sixteen fermentation treatments were randomly in 3-digit numbers allotted and evaluated for the following attributes: 1) appearance: oval, glossy, greenness, and yellowness; 2) aroma: briny, ocean-like, musty, soapy, earthy, mushroom, vinegary and flora; 3) taste: sour, saltiness, hay, bitterness, oily, buttery and ripeness; and 4) texture: hardness, juicy moisture, crunchy and fibrous. A 15-point intensity scale anchored by references as defined by the Spectrum de-bittering methodology was used in assigning values to the various descriptors.

3.2. Consumer testing

The consumer sample population was selected from among consumers in Jordan University of Science and Technology, who were 18–60 years of age and various socioeconomic backgrounds. Only those who consumed fermented table olives commonly were selected to participate in the study. With a target of 50 participants, a total of 75 were selected in anticipation of test no shows. Consumer testing was conducted at Jordan University of Science and Technology Laboratories (Ibrib, Jordan). Consumers were directed to taste samples in individual tables and evaluate those using written
Table 1. Descripción, definiciones, referencias e intensidades utilizadas para la evaluación sensorial.

| Descriptor                  | Definición                                                                 | Referencia                                |
|-----------------------------|-----------------------------------------------------------------------------|--------------------------------------------|
| **Appearance**              |                                                                             |                                            |
| Skin color (red)            | Black–reddish brown                                                        | color red skin                             |
| Skin color (green)          | Black–greenish gray                                                        | color green skin                           |
| Skin sheen                  | The vividness vs. dullness of the olive skin                                | Sheen                                      |
| Flesh color (red)           | Black–reddish brown color                                                  | Red flesh                                  |
| Flesh color (yellow)        | Black–yellow color                                                         | Yellow flesh                               |
| Flesh color (green)         | Black–greenish gray color                                                   | Green flesh                                |
| Globeness                   | Resemblance to perfect globe                                                | Marble ball                                |
| Thickness of flesh          | The width of flesh                                                         | Thick                                      |
| **Aroma**                   |                                                                             |                                            |
| Fresh olive                 | Intensity of fresh olive odor                                              | Sensation perceived during mastication of fennel (leaves) |
| Vinegary                    | Aroma of acetic acid fermentation                                          | Vinegar                                    |
| Soapy                       | Aroma reminiscent of soap or lye                                            | Dodecanonic acid                           |
| Musty                       | Odor of typical fungi and wet soil                                         | 2-Etil-1-hekzanol, Geosmin, Wet soil       |
| Briny                       | The aroma of pickling salt                                                 | N/A                                        |
| Sautéed mushroom            | The aroma of sautéed, cooked and savory mushrooms                           | Sautédmshrm                                |
| Earthy/Soil-like            | The aroma of natural wet soil                                               | Earthy/soil                                |
| Oak barrel                  | The aroma of wood                                                          | Oak barl                                   |
| Nutty                       | The aroma of peanut or oil cured olives                                    | Nutty                                      |
| Hay odor                    | Odor of dried grass                                                        | Dried grass wrapped in aluminum paper      |
| Artificial                  | The scent of artificial fruit flavor (e.g. raspberry)                       | Arti/fruit/floral                          |
| Fruity/Floral               |                                                                             |                                            |
| Natural Fruity/Floral       | The mild scent of natural fruit/flower (e.g. chrysanthemum)                 | Extra virgin olive oil from Aloreña variety|
| Vinegary                    | The aroma of fermented vegetables and vinegar                               | Vinegar                                    |
| Alcohol                     | The aroma of ethanol                                                       | Alcohol                                    |
| Fishy/Ocean-like            | The aromas of the ocean and of dried anchovy                                | Fishy/ocean                                |
| Cheesy                      | The aroma of feta cheese                                                   | Cheesy                                     |

After: (Lee, Rudell, Davies, & Watkins, 2012; Rababah et al., 2005, 2013; Soldevilla et al., 2013)
Siguieron a: (Lee et al., 2012; Rababah et al., 2005, 2013; Soldevilla et al., 2013).

Table 2. Descripción, definiciones, referencias e intensidades usadas para la evaluación sensorial.

| Descriptor                  | Definición                                                                 | Referencia                                |
|-----------------------------|-----------------------------------------------------------------------------|--------------------------------------------|
| **Taste**                   |                                                                             |                                            |
| Sourness                    | The taste of citric acid                                                   | Citric acid solution in spring water (0.05% and 0.08% citric acid) |
| Bitterness                  | The taste of caffeine                                                      | 0.3 g of caffeine is dissolved in 1 liter of water 30 ml of dissolution in 50 ml plastic cup (0.05% and 0.08% caffeine) |
| Saltiness                   | The taste of sodium chloride                                               | 2 g of salt is dissolved in 1 liter of water, 30 ml of dissolution in 50 ml plastic cup (0.2% and 0.5% iodized salt) |
| Flavor                      |                                                                             |                                            |
| Ripeness                    | The sensation of green and unripe vs. ripe olives                          | Ripe                                      |
| Buttery                     | The sensations related to high fat/oil content                             | Butter                                    |
| Metallic                    | The sensation related to canned vegetables                                 | Metal                                      |
| Rancid                      | The unpleasant flavor as a result of being stale                           | Pineapple juice (canned)                  |
| Soapy/medicinal             | The sensation related to products containing soap                          | Soap/medicin                              |
| Gassy                       | The sensation related to propane gas                                       | Gassy                                     |
| Firmness                    | Mechanical property of texture related to the strength required to attain a certain penetration of the olive. | Gordal olive with stone                   |
| Moisture release            | The texture of some raw vegetables (e.g. celery)                           | A portion of celery                       |
| Mouth coating               | The amount of moisture released during chewing                             | Moist (Cracker and Applesauce)            |
| Chewiness                   | The amount of time required to chew before swallowing                      | Mouth coat                                |
| Astringency                 | Dry, puckering sensation on the tongue and palate                          | Chewy                                     |
| Residual                    | The amount of particles left after swallowing                               | Alum solution in spring water             |

After: (Lee et al., 2012; Rababah et al., 2005, 2013; Soldevilla et al., 2013)
Siguieron a: (Lee et al., 2012; Rababah et al., 2005, 2013; Soldevilla et al., 2013).

instructions and ballots. Samples were coded with three random digit numbers and presented in a balanced order. Consumer testing was conducted at room temperature (Meilgaard et al., 1991). Each consumer was provided with sixteen plates individually and separately containing five fruits of each treatment of table olives. To eliminate carry-over factors, consumers were also provided with green apple at room temperature and water for mouth cleansing between samples. The consumers were asked to record their acceptability and intensity scores for overall appearance, overall texture, overall taste, overall flavor and overall bitter taste (9-point scale with 9 = like extremely and 1 = dislike extremely); overall bitter taste (9-point intensity scale with 9 = extremely bitter taste, and 1 = extremely not bitter taste).

3.3. Statistical analysis

Data in triplicate of physicochemical and sensory properties were analyzed using the general linear model (GLM)
4. Results and discussion

4.1. Descriptive analysis

Descriptive sensory attributes scores are given in Table 3–4. As seen from the results there are some significant differences (P < 0.05) among all de-bittering methods of table olive varieties for appearance: oval, glossy, greenness and yellowness, aroma: briny, ocean-like, musty, soapy, earthy, mushroom, vinegar and flora, taste: sour, saltiness, hay, bitterness, oily, buttery and ripeness and texture: hardness, juicy moisture, crunchy and fibrous. In general, and regarding the de-bittering methods of fermentation the most preference sensory attributes are found in treated with NaOH followed significantly by the whole, scratchy and ticked, respectively. Also, regarding the type of table olives, the highest panel preference was found in Baladi followed significantly by k18, Crosodi, and Nabali, respectively. The results of appearance in the de-bittering method of fermentation and the four types of table olives (Table 3) showed that there is no significant difference between de-bittering methods of fermentation, but the higher values of the oval were found in treated with NaOH followed by the whole, scratchy and ticked, respectively. The most glossiness was found in whole followed by scratchy, treated with NaOH and ticked, respectively, but there is no significant difference between the de-bittering method of fermentation. There is no significant difference between de-bittering methods of fermentation, but the higher values of greenness were found in ticked followed by the scratchy, whole, treated with NaOH, respectively. The higher values of yellowness were found in treated with NaOH followed by ticked, scratchy and whole, respectively, but there is no significant difference between de-bittering methods of fermentation. Our results are within and agreed with Yilmaz and Aydeniz (2012) who found that the oval appearance ranged from 1.5 to 10.7.

| Trt| Glossy| Greenness| Yellowness |
|----|-------|----------|------------|
| KH| 2.7 ± 0.1 b| 2.1 ± 0.1 de| 2.0 ± 0.1 ab|
| KD| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| KT| 3.0 ± 0.1 c| 2.6 ± 0.1 cd| 2.5 ± 0.1 d|
| KM| 3.2 ± 0.1 b| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| CH| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| CD| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| CT| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| CM| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| BH| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| BD| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| BM| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| NH| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| ND| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|
| NM| 3.0 ± 0.1 bc| 2.7 ± 0.1 cd| 2.5 ± 0.1 d|

All values are means of three replicates and calculated on wet basis

**Means ± SD in the same column with the same letter are not significantly different (P ≤ 0.05).**

| Trt*| Briny| ocean-like| Musty| Soapy| Earthy| Mushroom| Vinegar| Flora |
|----|------|----------|------|------|-------|---------|--------|-------|
| KH*| 5.6 ± 0.3 bc| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| KD| 5.7 ± 0.3 bc| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| KT| 6.0 ± 0.3 b| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| KM| 6.7 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| CH| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| CD| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| CT| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| CM| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| BH| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| BD| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| BM| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| NH| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| ND| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|
| NM| 7.0 ± 0.3 a| 1.2 ± 0.09 c| 2.4 ± 0.1 b| 1.7 ± 0.07 e| 2.5 ± 0.1 b| 2.2 ± 0.1 d| 2.8 ± 0.1 e| 4.3 ± 0.2 ab|

All values are means of three replicates and calculated on wet basis

**Means ± SD in the same column with the same letter are not significantly different (P ≤ 0.05).**

Todos los valores representan la media de tres repeticiones y se calculan en base húmeda.

**Las medias ± DE en la misma columna con la misma letra no son significativamente diferentes (P ≤ 0.05).**
Table 5. Descriptive sensory attribute scores of table olive varieties of descriptive panel after maturity.

| Trt*   | Sour | Saltiness | Hay | Bitterness | Oily | Butter | Ripeness |
|--------|------|-----------|-----|------------|------|--------|----------|
| KH     | 7.7 ± 0.5 | 3.7 ± 0.1 | 4.7 ± 0.3 | 3.3 ± 0.1 | 6.1 ± 0.4 | 3.5 ± 0.1 | 7.01 ± 0.2 |
| KD     | 5.1 ± 0.2 | 5.3 ± 0.2 | 4.0 ± 0.3 | 2.2 ± 0.1 | 3.9 ± 0.2 | 3.9 ± 0.2 | 8.4 ± 0.5 |
| KT     | 5.7 ± 0.2 | 4.9 ± 0.0 | 6.3 ± 0.5 | 2.5 ± 0.0 | 6.0 ± 0.5 | 3.2 ± 0.1 | 7.6 ± 0.6 |
| KM     | 7.1 ± 0.3 | 4.2 ± 0.3 | 3.3 ± 0.1 | 1.8 ± 0.0 | 5.3 ± 0.4 | 4.1 ± 0.1 | 9.4 ± 0.8 |
| CH     | 7.7 ± 0.5 | 3.4 ± 0.1 | 4.0 ± 0.2 | 2.9 ± 0.1 | 5.3 ± 0.2 | 2.2 ± 0.1 | 6.5 ± 0.5 |
| CD     | 3.9 ± 0.1 | 5.3 ± 0.3 | 4.0 ± 0.1 | 2.1 ± 0.1 | 3.2 ± 0.1 | 2.5 ± 0.1 | 8.4 ± 0.7 |
| CT     | 5.1 ± 0.2 | 4.6 ± 0.3 | 4.5 ± 0.1 | 1.8 ± 0.0 | 6.0 ± 0.2 | 3.1 ± 0.2 | 7.8 ± 0.2 |
| CM     | 7.1 ± 0.2 | 3.9 ± 0.2 | 6.0 ± 0.4 | 1.5 ± 0.0 | 5.0 ± 0.2 | 2.9 ± 0.1 | 8.6 ± 0.4 |
| BH     | 7.1 ± 0.5 | 3.7 ± 0.1 | 4.0 ± 0.3 | 3.1 ± 0.0 | 6.1 ± 0.2 | 5.4 ± 0.3 | 7.6 ± 0.3 |
| BD     | 5.1 ± 0.3 | 5.5 ± 0.3 | 4.0 ± 0.3 | 2.2 ± 0.1 | 4.5 ± 0.1 | 5.2 ± 0.3 | 8.5 ± 0.3 |
| BT     | 6.0 ± 0.4 | 5.1 ± 0.1 | 6.2 ± 0.5 | 2.4 ± 0.1 | 6.6 ± 0.3 | 5.1 ± 0.3 | 8.25 ± 0.6 |
| BM     | 6.4 ± 0.3 | 4.4 ± 0.2 | 3.0 ± 0.1 | 1.7 ± 0.0 | 5.3 ± 0.1 | 1.8 ± 0.0 | 9.6 ± 0.8 |
| NH     | 7.1 ± 0.2 | 3.0 ± 0.1 | 4.0 ± 0.2 | 2.8 ± 0.1 | 6.1 ± 0.2 | 4.7 ± 0.2 | 6.7 ± 0.5 |
| ND     | 4.4 ± 0.2 | 5.3 ± 0.3 | 4.0 ± 0.1 | 1.9 ± 0.0 | 3.9 ± 0.2 | 4.9 ± 0.3 | 8.4 ± 0.7 |
| NT     | 7.7 ± 0.3 | 4.6 ± 0.1 | 6.3 ± 0.3 | 1.8 ± 0.0 | 6.0 ± 0.4 | 5.1 ± 0.2 | 7.8 ± 0.2 |

All values are means of three replicates and calculated on wet basis.

*Trt = De-bittering method of different varieties, N = Nabali, C = Crosodi, B = Baladi, K = kish, H = whole table olive, D = ticked table olive, T = scratchy table olive, M = treated with NaOH table olive.

**Means ± SD in the same column with the same letter are not significantly different (P ≤ 0.05)

Todos los valores representan la media de tres repeticiones y se calculan en base húmeda.

**Trt= método de desaramado de diferentes variedades, N= Nabali, C= Crosodi, B= Baladi, K= kish, H= aceituna de mesa entera, D= aceituna de mesa marcada, T= aceituna de mesa áspera, M= aceituna de mesa tratada con NaOH.

**Las medias ± DE en la misma columna con la misma letra no son significativamente diferentes (P ≤ 0.05).
significativamente tratado con NaOH, crujiente y tibio, respectivamente. Nuestros resultados concuerdan con Yilmaz y Aydeniz (2012) quienes investigaron que la dureza valorada entre 3.0 y 7.0, el crujiente valorado entre 5.0 y 7.5 y fibroso de 4.6 a 7.0. Galán-Soldervilla, Ruiz Pérez-Cacho, y Hernández Campuzano (2013) también observaron que hay diferencias significativas en la firmeza y el crujiente en aceitunas de mesa tratadas con NaOH en un rango de 4.5 a 6.2 y 5.1 a 7.4, respectivamente. Soler-Rivas et al. (2000) encontraron que para el tratamiento con NaOH en aceitunas de mesa las valores disminuyeron en el grano de la firmeza; estos resultados podrían ser relevantes para el control del proceso de producción de aceitunas en las olivareras.

4.2. Consumer testing

El juicio sensorial de aceitunas de mesa es un sumario en las Tablas 7 y 8. La escala de juicio en la Tabla 7 mostró que el mayor valor de juicio de las aceitunas tratadas con NaOH fue significativamente inferior al de las aceitunas crujientes y tibias, respectivamente. El juicio de las aceitunas de mesa en NaOH resultó en un mayor valor de juicio de color del aceite de mesa, que fue superior a la aceituna de mesa cruda, en el aceite de mesa crujiente, en el aceite de mesa seco y en el aceite de mesa entero. Además, estos estudios también muestran que el juicio de las aceitunas de mesa en NaOH está asociado con la textura y el sabor de la aceituna de mesa crujiente, en el aceite de mesa seco y en el aceite de mesa entero.

Table 6. Descriptive sensory attribute scores of table olive varieties of descriptive panel after maturity.

| Texture | Trt | Hardness | Juicy moisture | Crunchy | Fibrous |
|---------|-----|----------|----------------|---------|---------|
| KH      | 5.7 ± 0.1 | 5.1 ± 0.3 | 6.5 ± 0.5 | 7.3 ± 0.3 |
| KD      | 3.0 ± 0.1 | 7.0 ± 0.2 | 4.3 ± 0.1 | 5.8 ± 0.4 |
| KT      | 3.4 ± 0.1 | 6.4 ± 0.3 | 4.7 ± 0.1 | 6.1 ± 0.2 |
| KM      | 4.3 ± 0.2 | 6.4 ± 0.3 | 5.8 ± 0.3 | 6.6 ± 0.3 |
| CH      | 6.2 ± 0.2 | 5.1 ± 0.2 | 7.0 ± 0.2 | 7.4 ± 0.3 |
| CD      | 3.0 ± 0.1 | 7.3 ± 0.4 | 3.6 ± 0.2 | 5.5 ± 0.2 |
| CT      | 3.7 ± 0.1 | 6.4 ± 0.3 | 5.0 ± 0.2 | 6.4 ± 0.4 |
| CM      | 4.8 ± 0.2 | 6.7 ± 0.2 | 5.8 ± 0.3 | 6.9 ± 0.3 |
| BH      | 6.3 ± 0.3 | 5.5 ± 0.2 | 7.0 ± 0.2 | 7.5 ± 0.3 |
| BD      | 3.2 ± 0.1 | 7.3 ± 0.3 | 4.3 ± 0.2 | 5.8 ± 0.3 |
| BT      | 4.0 ± 0.2 | 6.7 ± 0.1 | 5.0 ± 0.3 | 6.4 ± 0.4 |
| BM      | 5.0 ± 0.3 | 6.4 ± 0.2 | 5.8 ± 0.3 | 6.9 ± 0.4 |
| NH      | 6.9 ± 0.4 | 5.8 ± 0.3 | 7.0 ± 0.1 | 7.8 ± 0.5 |
| ND      | 3.2 ± 0.1 | 7.6 ± 0.4 | 4.7 ± 0.2 | 5.8 ± 0.4 |
| NT      | 4.0 ± 0.2 | 6.4 ± 0.3 | 5.4 ± 0.3 | 6.6 ± 0.2 |
| NM      | 5.2 ± 0.3 | 6.4 ± 0.4 | 6.5 ± 0.4 | 7.0 ± 0.3 |

All values are means of three replicates and calculated on wet basis.

Table 7. Consumer scores of the effect of fermentation in different de-bittering methods of table olive varieties.

| Hedonic scale | Overall Appearance | Overall Texture | Overall Flavor | Overall Taste | Overall Bitter taste |
|---------------|--------------------|----------------|----------------|---------------|---------------------|
| NH            | 6.6 ± 0.5          | 6.75 ± 0.5      | 4.75 ± 0.3     | 4.85 ± 0.05    | 7.35 ± 0.25         |
| ND            | 4.95 ± 0.3         | 4.65 ± 0.3      | 6.45 ± 0.2     | 6.25 ± 0.5     | 3.95 ± 0.25         |
| NT            | 6.25 ± 0.4         | 5.95 ± 0.4      | 5.75 ± 0.2     | 4.50 ± 0.3     | 6.45 ± 0.05         |
| NM            | 4.65 ± 0.4         | 2.65 ± 0.4      | 7.45 ± 0.6     | 7.55 ± 0.6     | 3.45 ± 0.25         |
| CH            | 6.95 ± 0.3         | 7.15 ± 0.3      | 4.55 ± 0.3     | 4.65 ± 0.3     | 7.25 ± 0.75         |
| CD            | 4.75 ± 0.2         | 4.45 ± 0.3      | 6.35 ± 0.5     | 6.05 ± 0.3     | 4.35 ± 0.25         |
| CT            | 5.95 ± 0.1         | 5.85 ± 0.2      | 4.55 ± 0.4     | 4.75 ± 0.3     | 6.6 ± 0.25          |
| CM            | 6.75 ± 0.3         | 6.55 ± 0.5      | 7.15 ± 0.6     | 7.05 ± 0.6     | 3.55 ± 0.25         |
| BH            | 7.15 ± 0.6         | 7.35 ± 0.4      | 5.15 ± 0.4     | 3.85 ± 0.2     | 7.25 ± 0.75         |
| BD            | 3.85 ± 0.2         | 3.95 ± 0.2      | 6.65 ± 0.5     | 6.25 ± 0.3     | 5.35 ± 0.25         |
| BT            | 5.05 ± 0.4         | 4.75 ± 0.3      | 6.15 ± 0.5     | 5.95 ± 0.4     | 6.95 ± 0.25         |
| BM            | 7.35 ± 0.6         | 6.85 ± 0.5      | 7.15 ± 0.6     | 7.15 ± 0.2     | 3.65 ± 0.25         |
| NH            | 7.15 ± 0.2         | 6.95 ± 0.5      | 4.95 ± 0.3     | 4.95 ± 0.2     | 7.65 ± 0.25         |
| ND            | 3.95 ± 0.2         | 4.05 ± 0.3      | 6.55 ± 0.5     | 6.35 ± 0.2     | 6.05 ± 0.25         |
| NT            | 5.75 ± 0.1         | 4.85 ± 0.3      | 5.95 ± 0.4     | 5.85 ± 0.3     | 6.45 ± 0.25         |
| NM            | 7.45 ± 0.6         | 6.45 ± 0.4      | 7.25 ± 0.7     | 7.45 ± 0.1     | 3.75 ± 0.25         |

All values are means of three replicates and calculated on wet basis.

4.3. Color measurements

La escala de grados de color en la Tabla 8 muestra valores significativamente altos entre los diferentes métodos de fermentación, siendo los valores más altos en el aceite de mesa crujiente, en el aceite de mesa seco y en el aceite de mesa entero. Los valores más bajos se encontraron en la aceituna de mesa cruda, en el aceite de mesa crujiente y en el aceite de mesa entero.
Redness values ranged from 0.7 to 5.4 and the significantly highest value of a* parameter was found in whole followed by scratchy, ticked and treated with NaOH table olives, respectively. Fermentation is significantly affected the yellowness (b*) values, the range of b* values from 54.4 to 61.4. The higher a* value was found in treated with NaOH followed significantly by ticked, scratchy and whole table olives, respectively. Our results are agreed and within color measurements of Yilmaz and Aydeniz (2012) when fermentation completely finished for treated table olive with NaOH as below: lightness values ranged from 49 to 69.6, redness from 1.3 to 18.0 and yellowness from 19.5 to 45.5. They indicated that the explanation of this variation would be caused by the pigmentation differences of different genetic materials (Rababah, Hettiarachchy, Eswaranandam, Meullenet, & Davis, 2005). Also, Savas and Uylaser (2013) found that color scores were lower in olive treated with NaOH than in the other applications because of the lye pre-treatment. They also mentioned that color stability was negatively affected by this pre-treatment. The olives that were processed using scratching method had a straw color.

The results indicated that the olives treated with the lye solution were more sensitive to oxidation and darkened quickly when they were removed from the brine; the best color stability was obtained in the olives that were de-bittered using the scratching method. The color instrumental results regarding the four types of de-bittering methods of fermentation or the variety of table olives were agreed with both descriptive and consumer results (Tables 3 and 8).

4.4. Instrumental texture of table olives

Texture results for hardness (N) of all de-bittering method of fermented table olive varieties are shown in Table 8. As seen in Table 8, the hardness of all de-bittering method of fermented table olive varieties are varied and ranged from 1.7 to 4.2 N. The highest hardness values were found in whole followed significantly by treated with NaOH, scratchy and ticked table olives, respectively. Our results are agreed with Yilmaz and Aydeniz (2012) who reported that the texture by the end of fermentation ranged from 4.2 to 8.7 in treated with NaOH table olives. The explanation of these results could be due to the same reason of hardness in descriptive analysis. Overall, instrumental texture results were agreed with descriptive analysis and consumer results and showed that the fermentation period of storage decreased the hardness and produced soft products.

5. Conclusion

There were some differences in sensory parameters in comparison with the main table olives fermentation de-bittering methods. Instrumental texture results were agreed with descriptive analysis and consumer results. Sensory attributes for Baladi table olives have the most acceptable attributes. Despite of NaOH processing fermentation debittering method has the most sensory parameters but other investigated debittering methods still keeping high amount of sensory properties.

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References

Ali-Ismail, K. M., Ahmad, R., Al-Dabbas, M., Ajo, R. Y., & Rababah, T. (2011). Some physicochemical properties of olive and olive oil of three Jordanian olive varieties. Rivista Italiana Delle Sostanze Grasse, 88(3), 191–198.

Balatsouras, G. D. (1990). Edible olive cultivars, chemical composition of fruit, harvesting, transportation, processing, sorting and packaging, styles of black olives, deterioration, quality standards, chemical analysis, nutritional and biological value of the end product, Olio d'Oliva. Roma. Pescara, Italy, 25–28, 291, 330. doi:10.1099/00221287-136-2-327.

Bargrizen, S., Smerini, R. J., & Mosley, L. M. (2017). Development of a spectrophotometric method for determining ph of soil extracts and comparison with glass electrode measurements. Soil Science Society of America Journal, 81, 1350–1358. doi:10.2136/sssaj2017.04.0119
Bates, R. G., & Vijh, A. K. (1973). Determination of pH: Theory and practice. *Journal of the Electrochemical Society, 120*(8), 263C–263C. doi:10.1149/1.2403829

Boskou, D., & F. Visioli (2003). Biophenols in table olives. In M. P. Vaquero, T. García-Arias, and A. Garbajal (Eds.), *Bioavailability of micronutrients and minor dietary compounds. Metabolic and technical aspects* (pp. 161–169). Trivandrum, India: Research Signpost.

Chaoenprasert, S., & Mitchell, A. (2012). Factors influencing phenolic compounds in table olives (Olea europaea). *Journal of Agricultural and Food Chemistry, 60*(29), 7081–7095. doi:10.1021/jf3017699

Fernández, A. G., Adams, M. R., & Fernández-Diez, M. J. (1997). *Table olives: production and processing*. Chapman Hall, London: Springer Science & Business Media.

Galán-Soldevilla, H., Ruiz Pérez-Cacho, P., & Hernández Campuzano, J. A. (2013). Determination of the characteristic sensory profiles of Aloreña table-olive. *Qrassas Y Aceites, 64*(4), 442–452. doi:10.3989/gya.132312

International Olive Council IOC. (2011). *Method for the sensory analysis of table olives COI/OT/MO/Doc. No 1/Rev*. Madrid, Spain: International Olive Oil Council.

International Olive Council IOC/T.28/Doc No 1/Rev 1 (2017). Guidelines for accomplishment of the requirements of the norm ISO 17025 by the laboratories of sensory analysis of virgin olive oil. Madrid, Spain: International Olive Oil Council.

Lee, J., Rudell, D. R., Davies, P. J., & Watkins, C. B. (2012). Metabolic changes in 1 methylcyclopropene (1-mcp)-treated empire apple fruit during storage. *Metabolomics, 8*, 742–753. doi:10.1007/s11306-011-0373-5

Lim, K. F. (2006). Negative pH does exist. *Journal of Chemical Education, 83*(10), 1465. doi:10.1021/ed083p1465

Market Newsletter. 2008. No. 126 – April 2018, 51st meeting of the advisory committee on olive oil and table olives. 24 April 2018 in Amman, Jordan. Retrieved from file:///C:/Users/Taha/Downloads/Newsletter-Abril-2018-English.pdf

Meilgaard, M., Civille, G. V., & Carr, B. T. (1991). *Sensory evaluation techniques*. 2nd ed., Boca Raton: CRC Press, Inc.

Panagou, E. Z., Tassou, C. C., & Katsabokakis, C. Z. (2003). Induced lactic acid fermentation of untreated green olives of the Conservolea cultivar by Lactobacillus pentosus. *Journal of the Science of Food and Agriculture, 83*, 667–674. doi:10.1002/(ISSN)1097-0010

Rababah, T., Hettiarachchy, N. S., Eswaranandam, S., Meullenet, J. F., & Davis, B. (2005). Sensory evaluation of irradiated and nonirradiated poultry breast meat infused with plant extracts. *Journal of Food Science, 70*(3), 5228–5235. doi:10.1111/j.1152-2355.2005.tb07162.x

Rababah, T. M., Al-u’datt, M., Ereifej, K., Almajwal, A., Al-Mahasneh, M., Brewer, S., & Yang, W. (2013). Chemical, functional and sensory properties of carob juice. *Journal of Food Quality, 36*(4), 238–244. doi:10.1080/0007070x.2013.808891.263C

Rabarova, F., Zanev, R., Shishkov, S., & Rizov, N. (2003). α-Tocopherol, fatty acids and their correlations in Bulgarian foodstuffs. *Journal of Food Composition and Analysis, 16*, 659–667. doi:10.1016/S0952-6731(03)00079-6.

Romeo, F. V., Piscopo, A., Mincone, A., & Poiana, M. (2012). Quality evaluation of different typical table olive preparations (cv Nocellara del Belice). *Grasas Y Aceites, 63*(1), 19–25. doi:10.3989/gya.2012.v63.i1

Savas, E., & Uylaser, V. (2013). Quality improvement of green table olive cv. ‘Domat’ (Olea europea L.) Grown in Turkey using different De-bittering methods. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 41*(1), 269–275. doi:10.15835/nbha4118974

Soler-Rivas, C., Epsin, J. C., & Wichers, H. J. (2000). Oleuropein and related compounds. *J. Sci. Food and Agriculture, 80*, 1013–1023. doi:10.1002/(SICI)1097-0010(20000515)80:7<1013::AID-JSA571>3.0.CO;2-C

Ünal, K., & Nergiz, C. (2003). The effect of table olive preparing debittering methods and storage on the composition and nutritive value of olives. *Grasas Y Aceites, 54*(1), 71–76. doi:10.3989/gya.2003.v54.i1.280

Yilmaz, E., & Aydeniz, B. (2012). Sensory evaluation and consumer perception of some commercial green table olives. *British Food Journal, 114*(8), 1085–1094. doi:10.1108/00070701211252066