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Innovative Egyptian style sweet and sour table olives

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ABSTRACT

Egypt and the EU are the main producers and consumer countries of table olives in the world. The effect of using sugar (3%) in two different treatments (olives treated with NaOH and natural olives) in brine and packaging solutions on the fermentation process was studied. Physical–chemical parameters, including pH, acidity, NaCl content, reducing sugar, and phenol content, were determined for 12 months of storage time, as well as sensory analysis. Results revealed that pH limits were ≤4.0 for treated olives and ≤4.3 for natural olives after 8 months of storage. Moreover, acidity increased with increasing storage time, irrespective of the treatment used. Regarding salt content, values in all treatments were higher than the established limit of the IOC. In addition, data illustrated that treated olives had a lower content of reducing sugars than those of natural table olives. Results also revealed that the phenol content of treated and natural table olives decreased continuously during the fermentation process. The sensory profile regarding hardness, fibrousness, crunchiness, saltiness, acidity, and bitterness was evaluated after 12 months. All treatments were free from abnormal fermentation and defects. The organoleptic analysis of table olives with added sugars showed a unique profile with an increase in acidity and sweetness.

Contribution/Originality: This study focused on the processing and preservation of innovative sweet and sour table olives.

1. INTRODUCTION

Pickling is one of the widely and preferred methods for preservation food by fermentation. It is a lactic fermentation process (Hien, Truc, & Muoi, 2022). Pickles are preserved by acid, salt and sugar; therefore, it was categorized into three categories; dill pickles, sour pickles, and sweet pickles. The efficient mixing of salt, sugar, spices and vinegar with food donates firm texture, crisp and pungent sweet, sour flavor (Akpinar-Bayizit, Ozcan-Yilsay, & Yilmaz, 2007). It found in numerous types of sizes and shapes (squared, slices, quartered and whole) plus in sweet and sour flavours (Khandekar, Kamble, & Badarkhe, 2020).

Lactic acid bacteria (gram positive bacteria) are responsible for fermentation process of fruits, and vegetables by producing lactic acid. It is classified as a probiotic for its positive effect on health i.e. lowering blood cholesterol, inducing the immune system, increasing intestinal motility and detoxification, producing various metabolites, and metabolism of vitamins, minerals, and hormones. For that, consuming foods with sufficient content of Lactic acid bacteria can have positive impact on health (Fevria, Vauzia, Advinda, Farma, & Edwin, 2023).

Olive (*Olea europaea* L.) is one of the most crops in Mediterranean region which used for olive oil and table olive production. Table olive is one of important Egyptian appetizers (Eid, Ali, Mostafa, & Elsorady, 2021). It can use as snacks, appetizer, and flavoring or in Mediterranean dishes like salads, pizza, sauces, relishes or antipasto platters. The main table olive varieties used in Egypt are Aggezi Shami, Hamed and Toffahi cultivars (Elsorady, 2010).

Egyptian empire realized the medical useful nesses and food preservation characteristics of olives, olive oil, and olive leaf. In spite of that, scientists started at the middle of the 20th century to check antimicrobial components in these products, particularly in table olives (Medina, Brenes, Romero, García, & Castro, 2007). Egypt is one of the main countries in producing and consuming of table olives, with global production of table olives amounting to 2653.5 thousand tons (2023/2024). According to the recent report by international olive council (IOC) (IOC, 2024) Egypt and the European Union account for more than 45% of the world's table olive production. Egypt and the European Union are the world's leading producers of table olives with approximately 600.5, 600 thousand tons, respectively. The European Union and Egypt are also the two main consumers of table olive in the world. The consumption of Egypt is approximately 17.80% of global table olives consumption after the European Union 20.34% (IOC, 2024).

Preservation and remove of bitterness of olives is used by a lye and/or salt fermentation process as Spanish-style green, Californian-style black or Greek-style black. Salt, acetic acid, lactic acid, pH adjustment, preservatives, sterilization or pasteurization are used to ensure that produced table olives are free from harmful organisms on health or that can deteriorate sensorial attributes of table olives (Elsorady, 2010). Sugar is one of the effective factors on the growth of lactic acid bacteria which uses sugar as a nutrient and carbon source for metabolism and cell growth. With optimal nutrition, the number of bacteria also increases (Fevria et al., 2023). Sugar is used to give sweet flavour to pickles (Khandekar et al., 2020). Table olives, one of the most important fermented foods in Mediterranean region, have various kinds in market and varieties to satisfy all tastes, even the most sophisticated of palates. The appeal of olives is related to their aroma, flavor, texture, and mixture of flavors varying from sweet to sour, to bitter, and to pungent (Franzetti, Scarpellini, Vecchio, & Planeta, 2011). Taste is the most important attribute of our food perception. Taste perception consists of five basic taste (sweet, sour, salt, bitter, and umami) which interact in food. Taste interactions occur when presenting at least two attributes. It can either be enhancing or suppressing taste quality (Junge et al., 2020). Therefore, the objective of the present study was to produce sweet and sour table olives using Egyptian style procedure.

2. MATERIALS AND METHODS

2.1. Materials

Green olive fruits (Olea europaea) of the Agazi cultivar, salt (sodium chloride, food grade), and sugar were purchased from the local market in Egypt. All chemicals used (analytical grades) were purchased from El-Nasr Pharmaceutical Chemical Company in Egypt.

2.2. Methods

Olives with a green-yellow surface color were graded to eliminate leaves and small fruits. The treatments of olives were indicated at Table 1.

Table 1. Table olive treatments.

Treatments	Treatment no.	Brine solution	Packaging solution
Treated with NaoH	T1	10% salt+0.5% lactic acid	10% salt+0.5% lactic acid
	T2	10% salt+0.5% lactic acid	7% salt+3% sugar+0.5% lactic acid
	T3	7% salt+3% sugar+0.5% lactic acid	7% salt+3% sugar+0.5% lactic acid
Non-treated natural	T4	10% salt+0.25% lactic acid	10% salt+0.25% lactic acid
	T5	10% salt+0.25% lactic acid	7% salt+3% sugar+0.25% lactic acid
	T6	7% salt+3% sugar+0.25% lactic acid	7% salt+3% sugar+0.25% lactic acid

2.2.1. Treated Olives

Olive fruits were treated with NaOH solution (2.0%, w/v). It was lasted for 4h at room temperature till NaOH solution penetrated two-thirds to pit into flesh, checked by ph.th indicator every one-half hour according to Garrido-Fernandez, Fernandez Diez, and Adams (1997). Then, NaOH solution was poured, and olives were washed by running water for 24h (3times/8h). Lastly, olives were covered with brine solution for fermentation as indicated at Table 1.

2.2.2. Non-Treated (Natural) Olives

Olive fruits were put directly in brine solution as illustrated at Table 1. The time of fermentation process was 8 months.

2.3. Chemical Analysis of Treatments

Critical Control Points (CCP) of fermentation such as titratable acidity, pH, and sodium chloride content plus sensory analysis were determined (IOC, 2005). The mean was recorded form triplicate for each parameter.

2.3.1. Titratable Acidity

Titratable acidity was determined according to Fernandez et al. (1985).

2.3.2. pH

pH was determined by using pH meter (JENWAY 6405 UV/Vis. Spectrophotometer, England) according to AOAC method (AOAC, 2000).

2.3.3. Sodium Chloride Content

Sodium chloride was determined by Volhard titration method (Garrido-Fernandez et al., 1997) using silver nitrate and potassium chromate as indicator. Before titration, olive flesh juice was diluted with distilled water.

2.3.4. Reducing Sugars

Reducing sugars in olive flesh were determined according to Garrido-Fernandez et al. (1997) and expressed as g of glucose/100 ml.

2.3.5. Total Phenols

Total phenols content, expressed as (mg/kg), was determined at 725 nm using Folin-Ciocalteau reagent as described by Gamez-Meza et al. (1999).

2.4. Sensory Analysis of Table Olives

Sensory analyses of table olives were performed by a panel of eight trained tasters according to IOC method (IOC, 2021).

3. RESULTS AND DISCUSSIONS

Regular monitoring of physical–chemical parameters (pH, titratable acidity, NaCl content, reducing sugars and phenols content) for 12 months of storage time was determined.

3.1. pH

The initial pH value of fresh olives was 5.50. After lye treatment, it increased to 8.0. Data at Figure 1 showed that pH values were decreased during storage. The final pH values were 3.8, 3.6 and 3.5 for T1, T2 and T3, respectively.

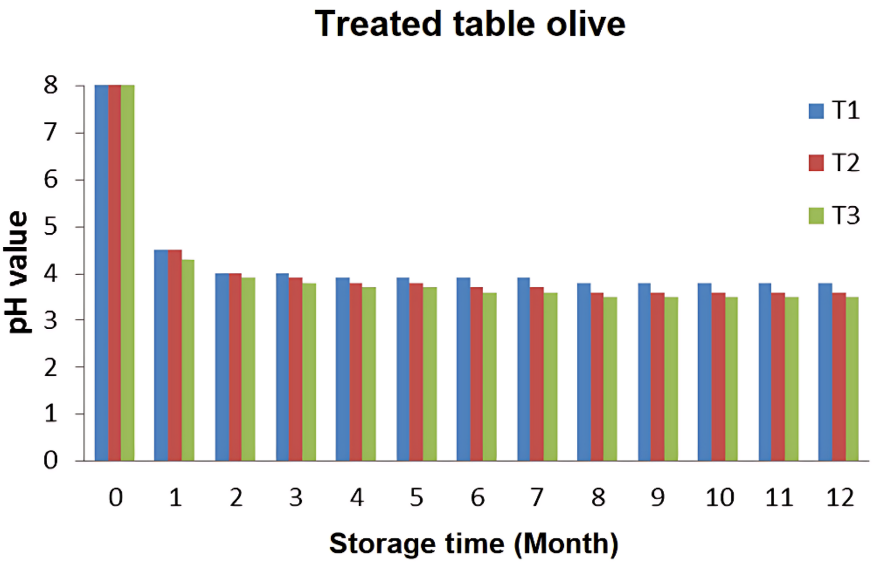

Figure 1. Effect of storage time on pH values of treated table olive.

The initial pH value of fresh olives was 5.5. Then, it was decreased to 4.8 inT4 and T5 and to 4.5 in T6 Figure 2. After 8 months of storage, these values were decreased to 4.0, 4.0 and 3.8 for T4, T5 and T6, respectively. Then, pH values were remained constant during the storage at T4 and T6. It was slightly decreased to 3.9 at T5, it may be related to sugar in packaging solution. Likewise, García-Parra et al. (2011) showed decrement in pH during storage due to the lactic fermentation of sugars leading to acidity. The obtained results were in accordance with the maximum pH limits reported by IOOC (2004) which were ≤ 4.0 for treated olives and were ≤ 4.3 for natural olives.

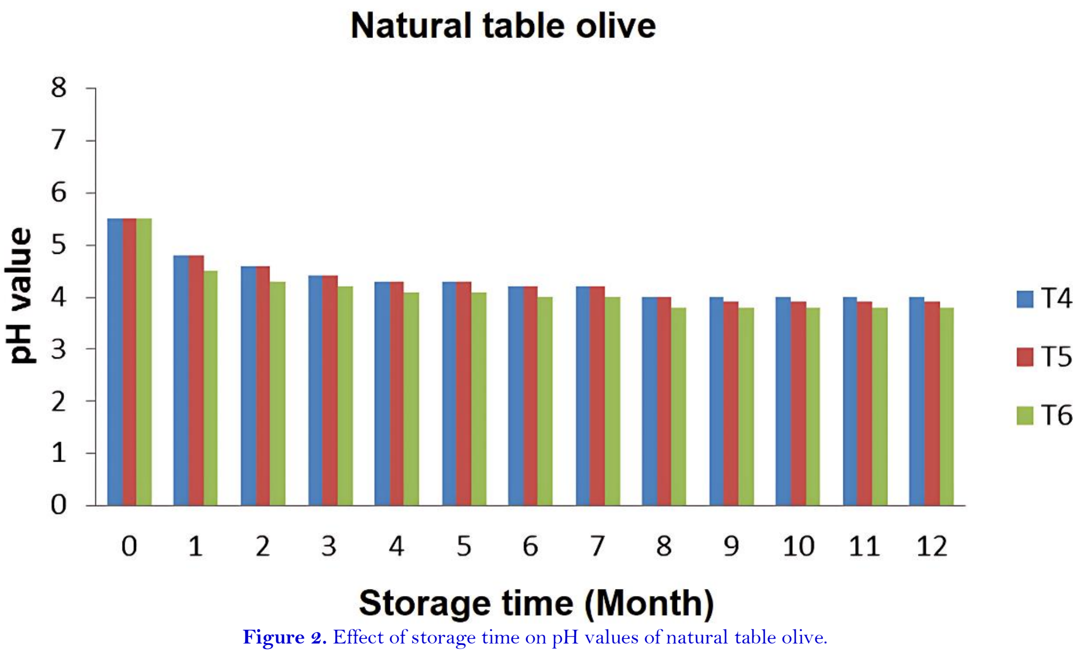

Figure 2. Effect of storage time on pH values of natural table olive.

Sánchez, García, and Rejano (2006) and Lanza (2012) mentioned that acidity is lower in natural table olives at the end of fermentation. It related to the decrease in olive skin permeability when no alkali treatment is used and the decrease in sugar content with olive ripening. Erten, Boyaci Gunduz, Ağırman, and Cabaroglu (2015) reported that the pH is 3.4-4.4, and total acidity is 0.8-1.2 % as lactic acid, in treated table olive at the end of fermentation whereas, the pH value is 4.3-4.5 and total acidity is 0.5-1.0 % as lactic acid, in natural table olive at the end of fermentation.

Phenolic acids can be metabolize and degraded by Lactic acid bacteria through decarboxylase and reductase (Wang et al., 2021). Nevertheless, all treatments indicated acceptable values of pH and titratable acidity, avoiding undesirable and pathogens during storage and allowing good preservation of table olives. PH is a critical parameter in food preservation, as it controls the growth of bacteria that cause food poisoning and food spoilage. Foods with a pH value of less than 4.2 are generally considered safe for the growth of pathogenic bacteria (Montville, 1997). The pH limits for treated and untreated olives are established to be 4.0 and 4.3, respectively (IOOC, 2004).

3.2. Titratable Acidity

The titratable acidity of table olives prepared using different treatments and fermentation time are presented in Figures 3 & 4. Titratable acidity was increased with increasing storage time, irrespective of treatment used. The titratable acidity was higher in treated table olive than that in natural table olive. The lowest value (0.45%) was observed in T4 after 12 months, while the highest value (0.90%) was observed in T3 after 12 months. These results were agreed with the obtained pH values. All acidity values were within the limits set by IOOC (2004) that established the minimum values for titratable acidity, expressed as lactic acid, to be 0.5 and 0.3% for treated and natural olives, respectively.

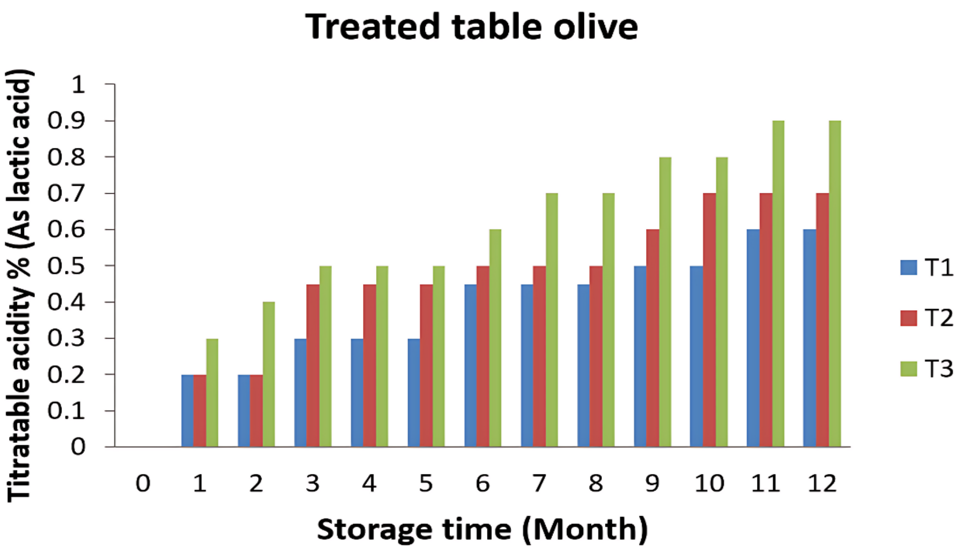

Figure 3. Effect of storage time on titratable acidity of treated table olive.

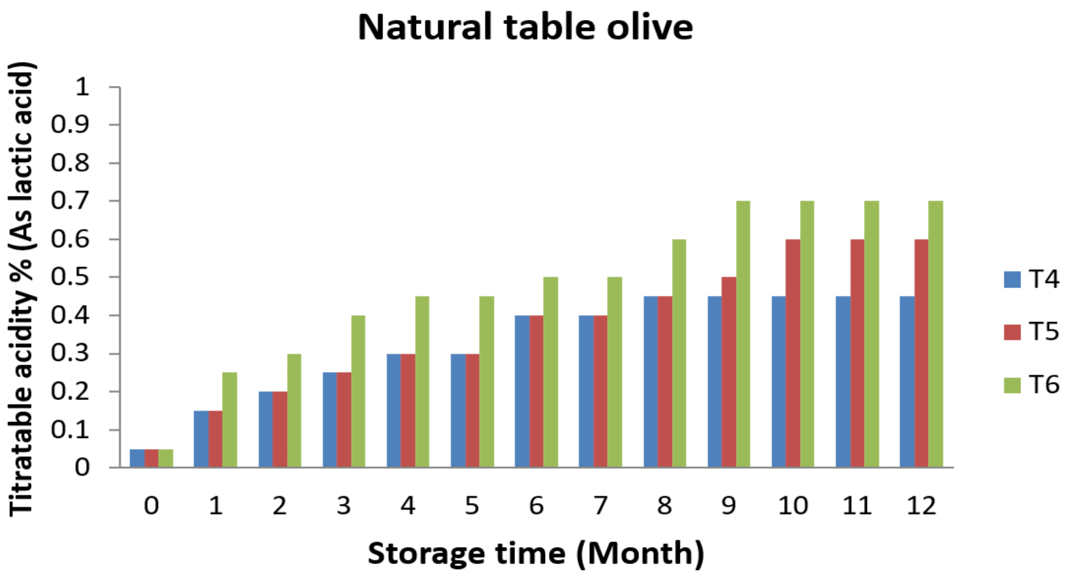

Figure 4. Effect of storage time on titratable acidity of natural table olive.

The increment of acidity in pickles is related to lactic acid fermentation. During this fermentation, pH is decreased and acidity is increased in several foods (Gupta, 1998). Saroj (2018) observed higher acidity in sweet mango pickle as compared to other recipes. It might be related to sugar addition. Also, Fleming (1982) indicated that increasing reactive sugar can increase acidity by lactic acid fermentation.

3.3. Nacl Content

Salt is used to inhibit the undesired microorganisms' growth and enhance texture and sensory properties of the product (Campus et al., 2015; Marsilio, Campestre, Lanza, & De, 2002; Medina et al., 2010; Pino et al., 2018). Recently, salt usage in olive industry tends to be reduced because of masking the fruit aroma by excess salt, healthy diet with low sodium intake (Degirmencioglu, 2016; Medina et al., 2010). Fresh harvested olive fruit does not contain sodium chloride. Sodium chloride concentration is one of the important parameters affecting the fermentation of table olive (Aponte et al., 2010). It controls the rates of diffusion of soluble components between brine and olive flesh due to the difference in osmotic pressure where phenols, reducing sugars, organic acids, vitamins and other soluble components move to brine and Nacl moves in olive flesh (Bautista-Gallego et al., 2013; Borcakli, Özay, Alperden, Özsan, & Erdek, 1993). This transformation continues until the amounts of components on both sides are balanced (Kanavouras, Gazouli, Leonidas, & Petrakis, 2005).

Regarding the salt content, the NaCl values in all treatments (Figures 5 & 6) were slightly higher than the established limit values of 6% and 5% for natural fermented olives and treated olives (IOOC, 2004). NaCl content was increased in all samples until constant content. The salt content was higher in natural table olive than in treated table olive. As expected, the salt content in the olives was higher in the olives brined at a NaCl 10%. Also, Salt contents were lower at T3 and T6 as compared with those treatments. Results revealed that the higher acidity was obtained for olive brined with 7% (w/v) of sodium chloride than those brined with 10%. It was agreed with Özay and Borcakh (1995); Anagnostopoulos et al. (2019) and Pervin, Aziz, Islam, and Miaruddin (2021). Susilowati, Laia, and Purnomo (2018) cited that, total acidity was decreasing if salt concentration was increased and longer fermentation time.

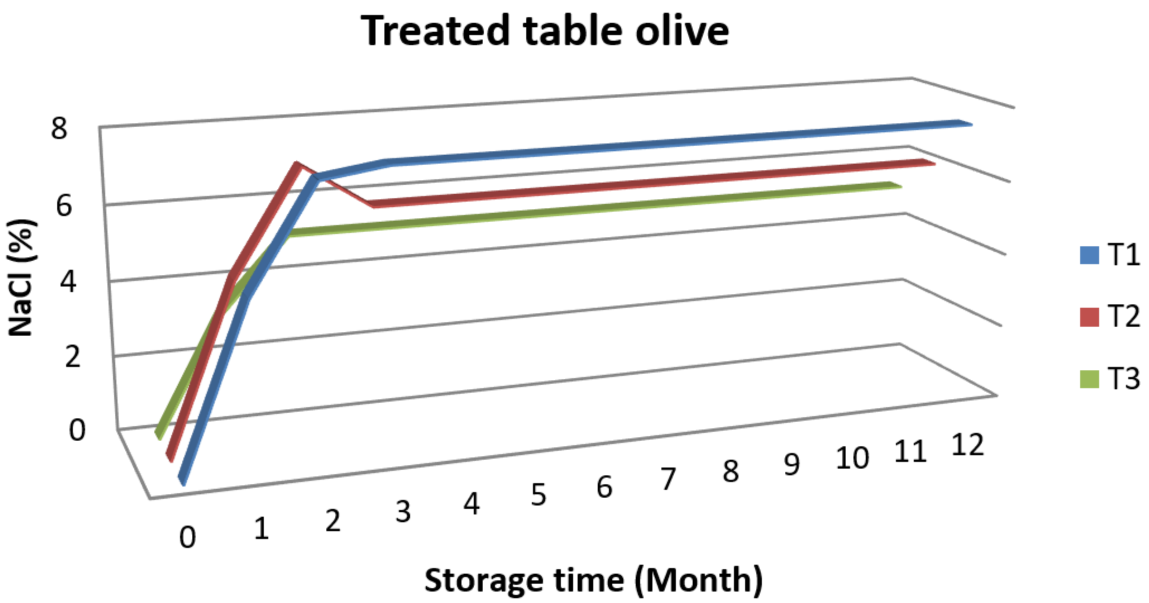

Figure 5. Effect of storage time on NaCl content of treated table olive.

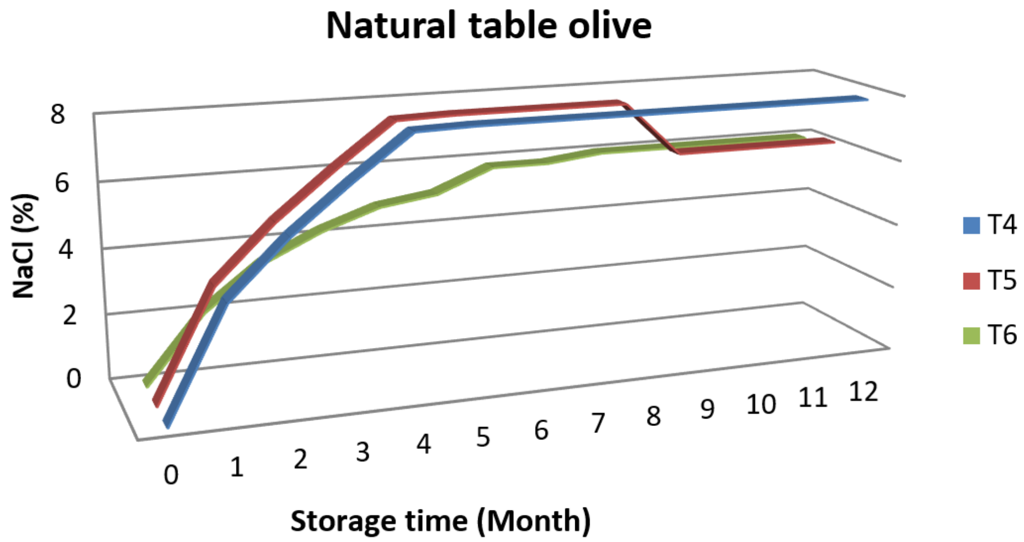

Figure 6. Effect of storage time on NaCl content of natural table olive.

3.4. Reducing Sugars

Concerning with reducing sugars during table olive fermentation, it transits from olive flesh to brine (Kiai, Raiti, El Abbassi, & Hafidi, 2020). Due to this transition, reducing sugar is decreased (Kara, 2023). It depends on the permeability of olive exocarp, the salt concentration, temperature and ratio of olive to brine (Borcakli et al., 1993; Kiai & Hafidi, 2014). Microorganisms convert sugars, the main nutrients, into lactic acids and thus increase acidity (Alak, 2016; Kiai & Hafidi, 2014; Ünal & Nergiz, 2003).

Data in Figures 7 & 8 illustrated that, treated olives had lower content of reducing sugars than those natural table olives. It is related to lye treatment and washing step of treated olive. Also as expected, the content of reducing sugar in olive flesh in brine containing sugar was higher. Arroyo-López, Durán-Quintana, Romero, Rodríguez-Gómez, and Garrido-Fernández (2007) indicated that the sugar elimination during storage was faster in washed than in unwashed olives and also resulted with a lower residual content. Saroj (2018) mentioned that sweet pickle had high sugar content due to sugar addition. Fevria et al. (2023) showed that the higher sugar content, the faster fermentation due to more lactic acid bacteria growth.

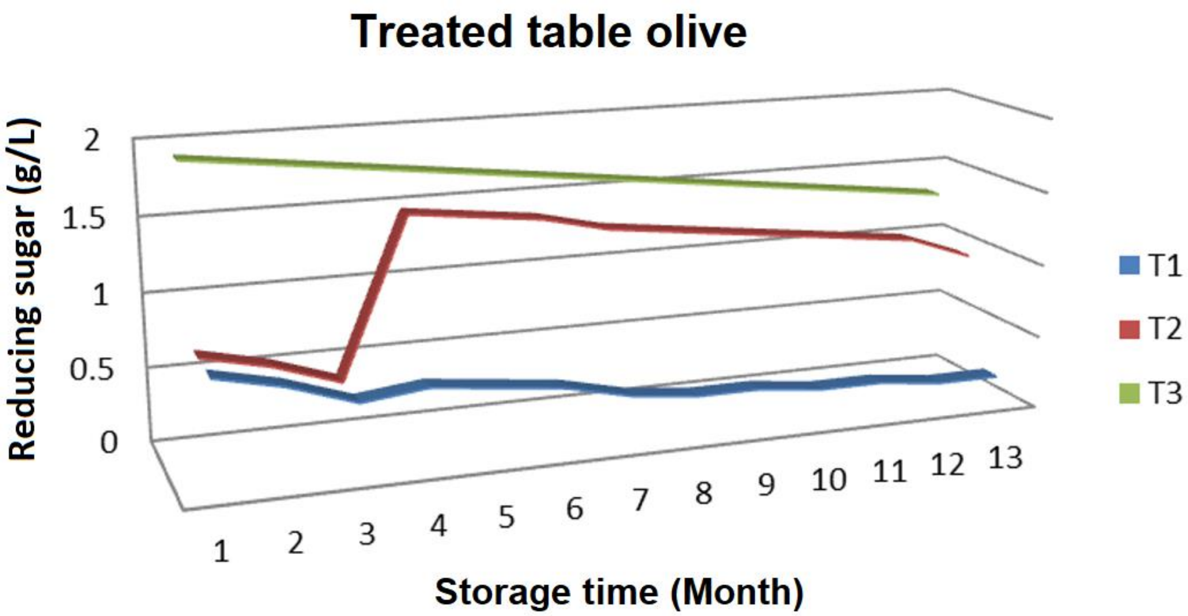

Figure 7. Effect of storage time on reducing sugar of treated table olive.

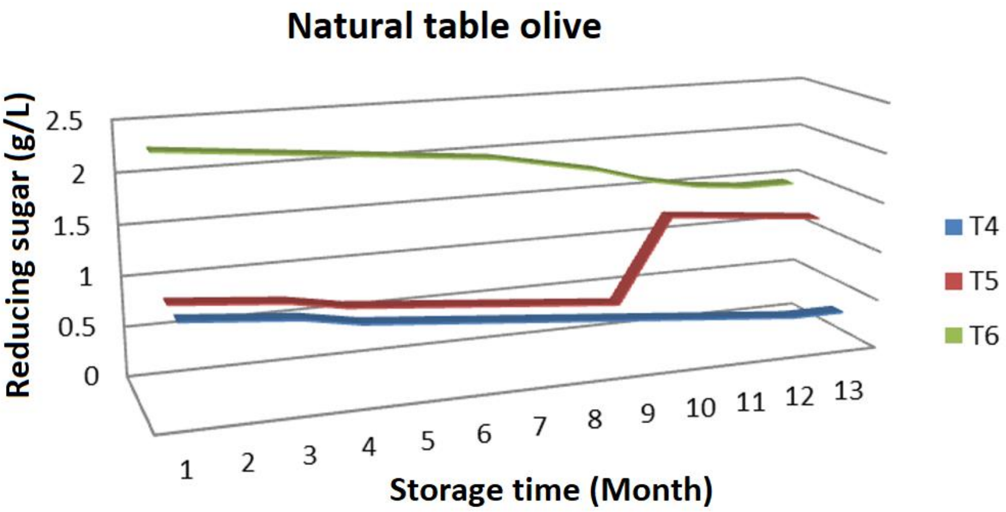

Figure 8. Effect of storage time on reducing sugar of natural table olive.

Olives brined with lower sodium chloride concentration had lower phenol content, antioxidant activity. The diffusion of polyphenols and reducing sugars from the flesh into brines was noticeable and significantly higher in olives processed with a 4% sodium chloride concentration (Fadda, Del Caro, Sanguinetti, & Piga, 2014).

The interaction between various treatments of sodium chloride-sucrose concentrations used pickle preparation, the highest acidity was in treatment that had 5%NaCl+12%sucrose and the lowest was 3% NaCl+10%sucrose treatment. This increment of acidity during fermentation related to lactobacilli bacteria, which were produced and converted sugar to lactic acid (Pervin et al., 2021).

3.5. Phenols Content

Oleuropein is the main olive phenols components. During the process of table olive production, oleuropein is degraded by microorganisms or by lye treatment to eliminate its bitterness taste. During fermentation, elenolic acid glucoside is degraded to glucose and elenolic acid. Phenols are diffused from olives into brine, and thus, the amounts of phenols in olives are decreased (Ozdemir, Guven, & Ozturk, 2014). Results at Figures 9 &10 revealed that phenols content of treated and natural table olives were decreased continuously during fermentation process. This decrease was related to phenols hydrolysis by the acidification and microorganism's effect. The solubilization of phenols was slower than sugars. It related to their more difficult diffusion because of the size of their molecules (Arroyo-López et al., 2007).

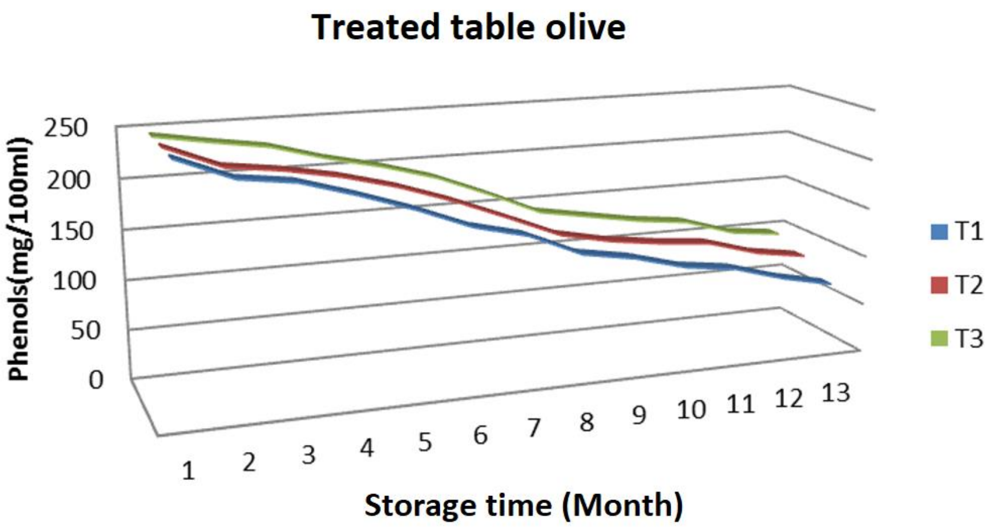

Figure 9. Effect of storage time on phenols content of treated table olive.

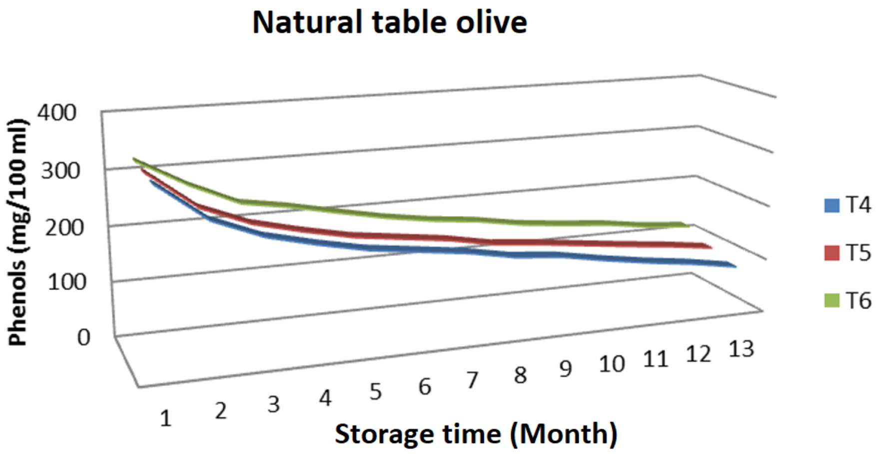

Figure 10. Effect of storage time on phenols content of natural table olive.

Garrido-Fernandez et al. (1997) and Soner and Akpinar-Bayizit (2009) indicated that lye and washing treatments before fermentation process of Spanish-style table olives, phenols removed from olive fruits, and their final content in table olives significantly depends on the processing method. There is a linear correlation between phenols content and antioxidant activity of table olives (Romero et al., 2004; Sousa, Malheiro, Casal, Bento, & Pereira, 2014). Romero et al. (2004) and Sanchez-Rodriguez et al. (2018) showed that phenols content is depended on variety, processing method, and the ripening degree of olive. Although of longer processing time of direct brine fermentation, but it results in olives that contain health-promoting phenols (Conte, Fadda, Del Caro, Urgeghe, & Piga, 2020). Marsilio et al. (2005) indicated that phenols content in untreated olives was higher than those treated with lye. Phenols diffusion from olive flesh to brine were higher in table olives brined with 4% Nacl than those brined with 7% Nacl (Fadda et al., 2014).

3.6. Sensory Analysis

Sensory analyses of the treated and natural olives after storage for 12 months are shown in Figures 11 & 12. The sensory analyses of treated and natural table olives show a different sensory profile with regard to hardness, fibrousness and crunchiness, salty, acid and bitter sensation. All treatments were free form abnormal fermentation and defects. The organoleptic analysis of table olives with adding sugars showed a unique profile with an increase in acid and sweet sensation. The median value of the defect predominantly perceived (DPP) for all treatments is ≤ 3 "Extra or Fancy" category (IOC, 2021).

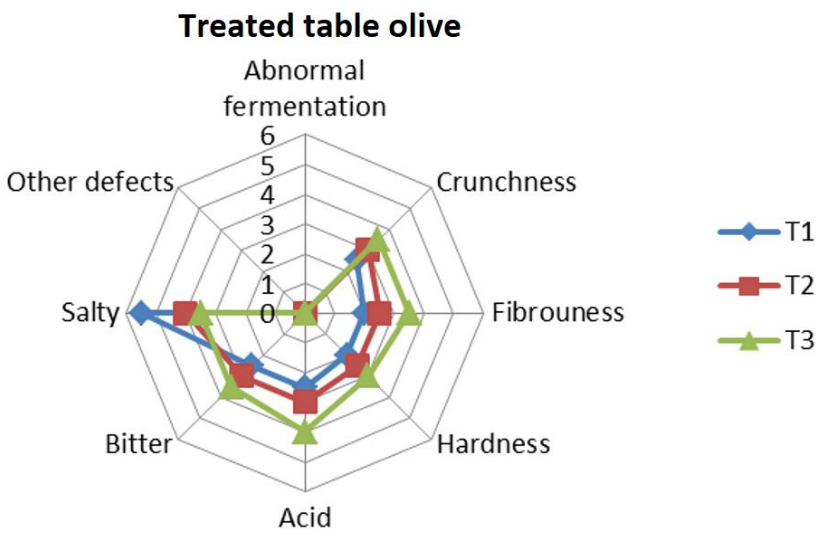

Figure 11. Sensory profile of treated table olives storage for 12 months.

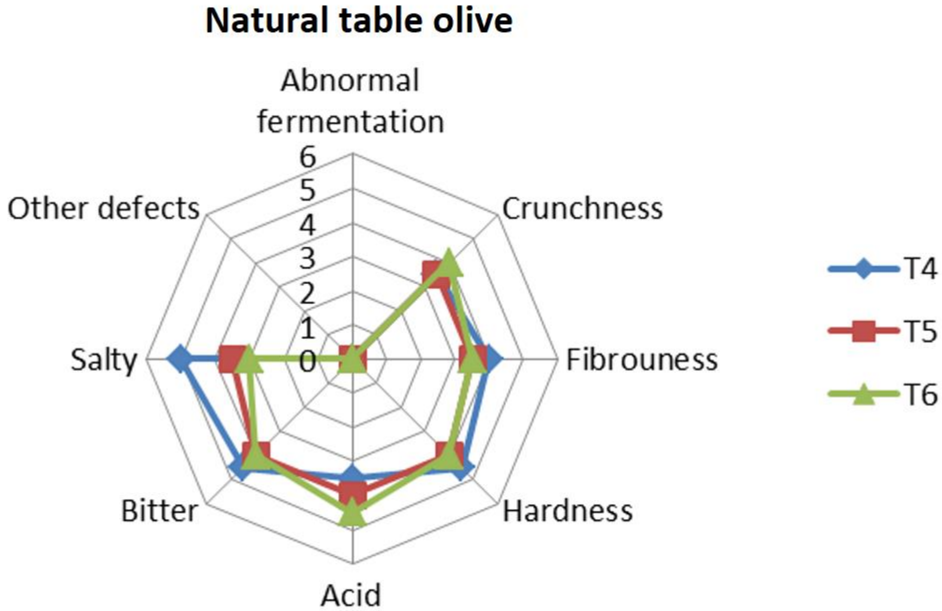

Figure 12. Sensory profile of natural table olives storage for 12 months.

4. CONCLUSION

Table olives are consumed worldwide. They are products with high added value, possessing both nutritional benefits and sensory properties. This study focused on the processing and preservation of innovative sweet and sour table olives. Results revealed that the innovative style has an acceptable taste, as well as effective process control and the development of a new Egyptian table olive style.

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Transparency: The authors declare that the manuscript is honest, truthful and transparent, that no important aspects of the study have been omitted and that all deviations from the planned study have been made clear. This study followed all rules of writing ethics.
Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.

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