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Impact of Thermal Treatment and Ozone on Quality Parameters and Shelf-Life of Mango Nectar

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Abstract

The aim of this research is to improve the quality and shelf-life of mango nectar using ozone and/or in combination with thermal hurdle treatments. The effects of four treatments i.e. pasteurization at 92±1˚C for 16 sec; (T1), sterilization at100±1˚C for 15 sec; (T2), ozone with40 ppm+70 ˚C for 30 min; (T3), and ozone with 20 ppm +76 °C 30 min; (T4) on the physical, chemical, sensory, and microbiological quality of mango nectar were evaluated. The chemical analysis i.e. moisture, available carbohydrates, and mineral contents have non-significant differences ($P > 0.05$) between all treatments. The T1 had significantly lower ($P < 0.05$) in ash and crude fiber contents than the other treatments ($P < 0.05$). The color values demonstrated that L* value was the highest in T2, while a* and b* was the highest in T3 and T4 up to 6 months of storage. Ozone treatment, particularly T4, maintained the lowest titratable acidity and highest pH value in nectar throughout the storage period, followed by T3. The T3 recorded highest T.S.S., vit. C, and total carotenoids in nectar, whereas T4, retained the highest total phenolic values. The sensory acceptability of nectar revealed that T4, had the best characteristics i.e. odor, taste, and appearance scores, as well as the best microbial quality when compared to the others treatments. Finally, tested ozone hurdles, particularly T4, produced the best nectar quality. Results demonstrated that novel technology (Hurdle technology) is the best way for keeping quality and safety of nectars.

Keywords: Mango nectar; thermal treatment; ozone; quality parameters; shelf-life

Introduction

Fruit nectar (FN) is the most important product in Egypt and worldwide. The FN is a good source of carbohydrates, vitamins, minerals, and fibers as well bioactive compounds i.e. tocopherols, carotenoids, polyphenols, and phenolic **(Liu, 2013, Kongkachuichai *et al.* 2015)**. FN has health benefits such as inflammation, cardiovascular diseases, cancer, and aging-related disorders **(Escudero-López *et al.*, 2016)**. However, the shelf life of FN is short and heat treatments affect of nutritive value as well acceptability. Mango fruit is very important raw material for making juices, especially nectars. Also, it is widely spread all over the world with a production of over 25.1 million tones, while in Egypt 1.473 tones (FAOSTAT, 2018). The quality of nectar is one of the important criteria for judging the consumer for election. Where the quality elements such as nutritional value, sensory attribute, and microbial quality. Therefore, different preservation methods are used to keep the juice quality, such as heat treatments and modern methods.**Williams *et al.* (2005)** reported lower efficacy of single ozone treatment for the inactivation of *E. coli* O157:H7 and Salmonella in unpasteurized apple cider and orange juice compared to a combination treatment of ozone and antimicrobial agents such as dimethyl dicarbonate and hydrogen peroxide, which achieved a 5-log reduction. When apple juice (18°Brix) was treated with 0.90 g/h ozone gas at room temperature, about 0.5 and 4.5 log CFU/ml reductions of *E. coli* O157:H7 were observed after 30 s and 60 s, respectively **(Choi *et al.*, 2012).** Unpasteurized apple cider and orange juice containing *E. coli* O157:H7 and *S. Typhimurium* were treated with gaseous ozone at 4, 20, and 50°C **(Williams *et al.*, 2004).** Heat treatments processing is the most common method for extending the shelf life of nectar by inactivating microorganisms and enzymes, which relies on a mathematical calculation to ensure the safety of the products Thermal process design is normally adopted to maximize microbial inactivation with minimal collateral degradation to product quality (Bopel, 1995). Pasteurization and sterilization of mango nectar, puree generally led to a decrease in the levels of vitamin A, phenolics total carotenoids, and ascorbic acid were reported to be stable depending on the severity of the process **(Vasquez-Caicedo *et al.*, 2007 and Djioua *et al.*, 2009)**.

Modern methods such as ozone and hardly technology has successfully proven to be one possible candidate for fruits and vegetable preservation, providing antimicrobial, and antioxidant (i.e., increased vitamin C and phenolic content) activities. However, discrepancies in results are often found in the literature due to the great number of variables that

may influence ozone efficacy for preservation of fruits and vegetables. These include the O3 generation and application method, O3 concentration, duration time, method of O3 exposure, storage conditions, commodity, and microbes. The bactericidal effect of gaseous ozone on apple juice has been reported by several studies. **Choi *et al.* (2012)** investigated the effect of the solid content of apple juice on gaseous ozone against *E. coli* O157:H7, *S. Typhimurium* and *L. monocytogenes*. **Patil *et al.* (2010)** studied the antimicrobial efficacy of gaseous ozone against E. coli in apple juice of various pH levels. However, there have been very few research studies investigating the bactericidal effect when apple juice is treated with both heat and ozone gas simultaneously and their effect on quality changes of apple juice. Therefore, in this study, we investigated the combination or synergistic effect of ozone and heat treatments on apple juice to inactivate *E. coli* O157:H7, *S. Typhimurium* and *L. monocytogenes*. Also, changes in color and residual ozone of apple juice after treatment were investigated

The aim of this work is investigate the effect of thermal treatment and ozone on quality parameter microbe of load and sensor acceptability on mango nectar.

2. Materials and methods

2.1. Materials

Mango pulp (*Mangifera indica* L.) variety Zebdyia, 12.1°Bx season 2018 were purchased from Kaha Company for preserved Foods, Kaha, Qalyabia governorate, Egypt. Citric acid, ascorbic acid, and pectin were purchased from El-Naser Company (Cairo, Egypt). Sugar was supplied from a local market, Cairo, Egypt. Glass bottles volume 200 mL and 1000 mL were purchased from El-Motahda Company, Cairo, Egypt.

2.2. Preparation of mango nectar:

Mango nectar (25% of mango pulp) was prepared as recommended methods described by **Egyptian Standard: ES- 7650/2013**. The mango pulp was mixed with sugar solution, citric acid, pectin to get total soluble solids 15±1% and pH 3.5±0.1. The mango nectar was divided to four Treatments T1 Pasteurization at 92 ±1°C, T2 Sterilization at100 ±1°C, T3 40 ppm of Ozone at 70°C, and T4 Hardly technology 20 ppm of Ozone at 76°C. Afterward, the nectar was filled in glass bottles 200 and 1000 mL, then closed tightly and stored under ambient temperature (25±1 °C).

2.3. Heat treatments:

2.3.1. Pasteurization:

Pasteurization of nectar was conducted at 92±1°C for 16 sec in pasteurizer unit (Alfa Laval, Model 2015, Turkey), then stored at room temperature (25±1°C) for 6 months **(Mostafa *et al.*, 1997).**

2.3.2. Sterilization:

Sterilization by combined heat and Peak Expiratory Flow (PEF) treatment can be used in low acid products like mango to avoid color change and to inactivate bacteria spores and enzymes. A standard thermal treatment of these purees is at 100 ±1°C °C; for 15 sec due to the puree color was changes of mango Product and process can be improved by using a lower temperature followed by PEF treatment in less than a second.

2.3.3. Ozone treatment:

Ozone gas was generated in a closed system using water ozone user (Model SY- 004, Taiwan) by corona discharge method in a 200 mL beaker. The fixed ozone output concentration at 600 mg/h was measured using an ozone sensor (Model 200 Series, Aeroqual, New Zealand). Ozone gas was directly pumped into the juice for up to 30 min through the food-grade silicone tube into the beaker and stirred using magnetic stirrer (100 rpm) to ensure the ozone molecules were completely mixed with the nectar. The gas flow rate was fixed at 0.2 L/min and temperature treatment was fixed at 20°C. Untreated mango nectar and treated fruit juice were stored at 4±1°C in sterile dark glass bottles to protect from light. All experiments were carried out in triplicate and analyses were immediately performed after processing (within an hour).

Experiments were carried out in a 250 ml bubble column with a built-in diffuser. Ozone was generated using an ozone generator (Model OL80, Ozone services, Canada). Oxygen flow rate was controlled using a gas flow regulator. The experimental design for this work was based upon a parallel inactivation study for *E. coli* O157:H7, using the same control conditions. A 5-log reduction was achieved in under 5 min at an optimum flow rate of 0.125 l min1 and a maximum ozone concentration obtainable (4.8% w/w) at this flow rate **(Patil *et al.*, 2009)**. Ozone concentration in the gas supply was varied (1–4.8% w/w of oxygen) and recorded using an ozone gas analyses (Model OLA-DLS, Ozone services). Ozone treatments were performed at 20±0.5°C.

2.4.1. Porximate chemical composition of mango pulp and nectar:

The moisture, ash, crude fiber, titratable acidity, total sugars, reducing sugars, non-reducing sugars, ascorbic acid and minerals, content were determined according to the method described by the **AOAC (2016)**.

2.4.2. Physical properties:

The pH value was measured by using a pH meter model consort pH meter p107, according to **AOAC (2016)**.T.S.S. was mesarued using Abbe referctometer model 1T at 20°C according to **AOAC (2016)**.

2.4.3. Determination of carotenoids:

Carotenoids were determined according to **(Nagata and Yomashita., 1992).**

Carotenoids content was calculated by equation follows as equations: Carotenoids (mg/100 mL of

extract) =
(0.216 x OD 663 - 122 x OD 645 - 0.304 x OD 505 + 0.452 x OD 453).

2.4.4. Color measurements:

Color of nectars was measured using Hunter Lab instrument at the Horticultural research institute, Agricultural research center, Egypt. Model D 65 color and color difference meter (C1E LAB 10/D 65). Results were expressed as load per gram, where L* value (indicates of lightness), a* value indicates of (redness to gereenness) and the b* value indicates (Yellowness to blueness) as described by **Hunter, (1959).**

2.5. Determination of total phenolic content:

Total phenolic content of all treatments were analyzed according to the folin-Ciocalteu method **(Veligolu *et al.*, 1998)**.

2.6. Microbiological examination:

Total viable bacterial count and total coliforms, yeasts and molds, thermo flic were enumerated according to the methods established by American Public Health Association **(APHA, 1992)**.

Moulds and yeasts: were counted according to the methods describes by **(APHA, 1992)**.

2.7. Sensory evaluation:

Sensory evaluation were carried out by properly well trained panel of the 15 member internal panel evaluated the different nectars blends for color, odor appearance, taste, and overall acceptability. Mineral water was used by the panelists to rinse the mouth between samples. **Pastor *et al.* (1996)**. The Sensory evaluation for fruit nectar was done before and during storage periods.

2.8. Statistical analysis:

The statistical analysis was carried out using two-way ANOVA using SPSS, ver. 25 **(IBM Corp. Released 2013)**. Data were treated as a complete randomization design according to **Steel *et al.* (1997)**. The significance level was set at < 0.05.

3. Results and discussion

3.1. Proximate chemical composition and mineral contents:

Mango pulp is an important raw material for producing the nectar. Data in **Table (1),** showed that the moisture, protein, fat, ash, fiber, and available carbohydrates contents of mango pulp were 86.30, 0.72, 0.23, 0.60, 1.81 and 10.34%, respectively. Also, the chemical composition of mango nectar treatments were ranged from: 84.28-84.90% moisture, 0.20-0.22% crude protein, 0.05-0.06% fat, 0.18-0.20% ash, 0.34-0.39 crude fiber and 14.27-14.90% available carbohydrate.

Table 1. Chemical composition and mineral contents of mango pulp and nectar (mean±SE) (on wet basis**).**

Treatments		Components (%)						Mineral contents(mg/100 g)		
		Moisture	Crude protein	Fat	Ash	Crude fiber	Available carbohydrate*	Ca	K	Fe
Mango pulp		84.30± 0.33^{a}	0.72±0 .01^{a}	0.23±0 .01^{a}	0.60±0. 01^{a}	1.81±0 .01^{a}	12.34±0.3 6^{b}	14.38± 0.49^{a}	157.00± 1.73^{a}	0.15±0 .00^{a}
Control sample		84.72± 0.23^{b}	0.21±0 .01^{b}	0.06±0 .00^{b}	0.19±0. 01^{c}	0.35±0 .01^{c}	14.47±0.2 2^{a}	3.86±0. 04^{b}	35.11±1 .07^{b}	0.04±0 .00^{b}
T 1	Pasteuriz ation	84.73± 0.23^{b}	0.22±0 .01^{b}	0.06±0 .00^{b}	0.18±0. 01^{c}	0.34±0 .01^{c}	14.47±0.2 2^{a}	3.96±0. 04^{b}	35.14±1 .07^{b}	0.04±0 .00^{b}
T 2	Sterilizat ion	84.84± 0.40^{b}	0.20±0 .01^{b}	0.05±0 .00^{b}	0.20±0. 00^{b}	0.39±0 .00^{b}	14.32±0.4 1^{a}	3.96±0. 03^{b}	36.67±0 .77^{b}	0.04±0 .00^{b}
T 3	40 ozone at 70°C	84.90± 0.18^{b}	0.21±0 .00^{b}	0.05±0 .00^{b}	0.19±0. 00^{bc}	0.38±0 .00^{b}	14.27±0.1 8^{a}	3.85±0. 08^{b}	36.50±0 .87^{b}	0.04±0 .00^{b}
T 4	20 ozone at 76°C	84.28± 0.15^{b}	0.20±0 .00^{b}	0.05±0 .00^{b}	0.19±0. 00^{bc}	0.38±0 .00^{b}	14.90±0.1 6^{a}	3.95±0. 09^{b}	35.67±0 .77^{b}	0.04±0 .00^{b}

*** Available carbohydrate calculated by difference.**

a, b & c: There is no significant difference (*P>0.05*) between any two means, within the same column have the same superscript letter.

The results revealed that there is non significant difference (P>0.05) in moisture, protein, fat and available carbohydrate contents for all nectar treatments, while there is a significant difference in ash and crude fiber contents. These results are in agreement with those reported by Tharanathan et al. (2006) who found that the chemical composition of mature mango fruit were: moisture content 78.90-82.80%, ash content 0.34-52%, total lipid content 0.30-0.53%, total protein 0.36-0.40, total dietary fiber 0.85-1.06% and total carbohydrate 16.20-17.18% (on wet basis). Kilima (2014) found that the total soluble solids (TSS) for mango, was 14.03°Brix. Whiles Abdelrahman (2021) found that the chemical composition of mango juice for moisture, T.S.S., ash, crude protein and fat contents was 81.87, 15.83, 0.69, 0.83 and 0.58%, respectively. While, mango nectar was 80.55, 17.23, 0.28, 0.18 and 0.11%, respectively. USDA (2018) reported that the total carbohydrate and sugar contents of Tommy Atkins, Haden, Kent and Keitt cultivars were 14.98 and 13.66%, respectively (sucrose, 6.97 g; glucose, 2.01 g; and fructose, 4.68 g) and 1.6 g of dietary fiber/100 g of fruit.

Results in the some table shown that the content mango pulp of minerals such as Ca, K and Fe was 14.38, 0.157 and 0.04 mg/100 mL, respectively. The obtained data in shown that a significant difference in Ca, K and Fe content between mango pulp and different treatments. Results indicated that there is non significant difference in Ca, K and Fe contents for different nectar treatments. These obtained results are in agreement with **USDA (2018)** reported that the essential mineral contents of edible portion of mango fruit were: Ca 7-16, Fe 0.09-41, P 10-18, and K 120-211, mg/100 g.

3. 2. Effect of heat treatments and ozone on mango nectar properties during storage:

3.2.1. Color parameters (*L**, *a** and *b**):

Data in **Table(2).** Showed that, The control samplewas rejected after 2 months**.**

Data in **Table (2)** shown that the treatments that take place on mango nectar affect on *L** value. The highest of *L** value was in zero time for (T1) (46.50±0.29) and lowest value was in T3 (42.50±0.17). Results demonstrated that there is non significant difference in *L** value between T1, T2 and T4. Also there is non significant difference in *L** value between T2, T3 and T4. Furthermore there is non significant difference in *L** value between T1 and T2 and betweenT3andT4 during storage period .These results are in agreement with those reported by **Cadena *et al*. (2013)** who found *L** value was 50.17 in mango nectar at zero time. Data in **Table (2)** shown that the treatments that take place on mango nectar affect on *a** value. The highest of *a** value was in zero time for T3 (2.73±0.01) and lowest value was in T2 (2.19±0.02). Results demonstrated that there is a significant difference in *a** value between all treatments. The obtained data in **Table (2**) shown that there is a significant difference between all treatments in *a** value during storage period. The obtained results showed that T3 had the highest value of *a** at zero time and in all period storage, while T2 had the lowest value at zero time and during all storage periods.These results are in agreement with those reported by **Cadena *et al*. (2013)** who found *a** value was 3.95 in mango nectar at zero time. They found there is a significant increase with increasing period.Data in **Table (2)** shown that the treatments that take place on mango nectar affect on *b** value as the highest of *b** was in zero time for T3 (18.68±0.20) and lowest content was in T1 (15.14±0.05). Results demonstrated that there is a significant difference in *b** content between all treatments. There is a significant difference between all treatments in *b** content during storage period. The obtained results showed that T3 had the highest value of *b** content at zero time and during period storage, while T1 had the lowest value at zero time and during storage periods. There is a significant decrease in T1 (12.90±0.52) compared other treatments. These results are in agreement with **Cadena *et al*. (2013)** who found that *b** value was 16.03 in mango nectar at zero time. They found there is a significant increase with increasing period. Also, they found the color parameters (L*, a*, b*) underwent significant ($p<0.05$) alterations throughout the shelf life. **Kumar *et al*. (2013)** found that the control juice sample had redness (a*), yellowness (b*) and luminosity (L*) values of 0.14±0.005, 20.61±0.005 and 19.62±0.010, respectively. The redness (a*), yellowness (b*) and luminosity (L*) value of mango nectar increased significantly ($p<0.05$) after thermal processing and also throughout the storage. The increase in the Luminosity (L*) values evidently indicated the degradation of carotene pigment in mango nectar.

Table 2. Effect of different heat processing and ozone on *L**, *a** and *b** values of mango nectar (mean±SE).

Treatments	Storage period (month)				Mean of storage periods
	0	2	4	6	
			L*		
Control	**46.51±0.29**	**R***	**-**	**-**	
T1	**46.50±0.29^{aC}**	**48.76±0.15^{aBC}**	**50.61±0.24^{aB}**	**53.36±0.08^{aA}**	**49.81±0.76^{a}**
T2	**45.10±0.05^{abC}**	**50.63±0.22^{aB}**	**52.54±0.12^{aB}**	**55.10±0.05^{aA}**	**50.84±1.11^{a}**
T3	**42.50±0.17^{bB}**	**43.50±0.20^{bB}**	**44.63±0.25^{bB}**	**47.16±0.10^{bA}**	**44.45±0.53^{b}**
T4	**44.02±0.02^{abC}**	**44.45±0.15^{bBC}**	**46.99±0.06^{bB}**	**49.29±10.26^{bA}**	**46.19±3.54^{b}**
Mean of treatments	**44.53±0.95^{C}**	**46.84±1.40^{BC}**	**48.69±1.64^{AB}**	**51.23±3.24^{A}**	
			a*		
Control	**2.55±0.03**	**R***	**-**	**-**	
T1	**2.56±0.03^{cC}**	**2.72±0.01^{bB}**	**2.77±0.01^{cA}**	**2.80±0.00^{bA}**	**2.71±0.05^{c}**
T2	**2.19±0.02^{dD}**	**2.44±0.12^{cC}**	**2.53±0.02^{dB}**	**2.60±0.01^{cA}**	**2.44±0.05^{d}**
T3	**2.73±0.01^{aD}**	**2.82±0.00^{aC}**	**2.89±0.00^{aB}**	**3.00±0.01^{aA}**	**2.86±0.03^{a}**
T4	**2.66±0.01^{bC}**	**2.78±0.01^{aB}**	**2.80±0.01^{bAB}**	**2.83±0.02^{bA}**	**2.77±0.02^{b}**
Mean of treatments	**2.54±0.27^{D}**	**2.69±0.25^{C}**	**2.75±0.24^{B}**	**2.81±0.25^{A}**	
			b*		
Control	**15.13±0.05**	**R***	**-**	**-**	
T1	**15.14±0.05^{dA}**	**13.80±0.03^{dB}**	**12.03±0.01^{dD}**	**10.62±0.02^{dC}**	**12.90±0.52^{d}**
T2	**16.51±0.02^{cA}**	**15.93±0.04^{cB}**	**15.25±0.13^{cC}**	**13.10±0.03^{cD}**	**15.20±0.39^{c}**
T3	**18.68±0.20^{aA}**	**18.24±0.00^{aB}**	**17.83±0.10^{aC}**	**17.59±0.03^{aD}**	**18.09±0.13^{a}**
T4	**17.94±0.05^{bA}**	**17.82±0.10^{bB}**	**17.10±0.08^{bC}**	**16.22±0.15^{bD}**	**17.27±0.21^{b}**
Mean of treatments	**17.07±1.56^{A}**	**16.45±1.63^{B}**	**15.55±1.75^{C}**	**14.23±1.89^{D}**	

L* value = indicates degree of lightness *L=luminosity; **a* value = indicates degree of redness to greenness and b* value = indicates yellowness to blueness**

a, b & c: There is no significant difference (*P>0.05*) between any two means, within the same column have the same superscript letter.

A, B & C: There is no significant difference (*P>0.05*) between any two means for the same attribute, within the same row have the same superscript letter.

R* =Rejected

3.2.2. Titratable acidity content and pH value:

Data in **Fig. (1).** The control was rejected after 2 months**.**

Data in **Fig. (1)** shown that the impact of heat and ozone treatments on acidity mango nectar. The titratable acidity content as the highest content in zero time for T2 (0.42±0.00%) and lowest content was in T4 (0.35±0.00%). Results revealed that there is a significant difference in titratable acidity content between all treatments. The obtained data in **Fig. (1)** shown that there is a significant difference (*P<0.05*) between different treatments in titratable acidity content during storage period. The obtained results showed that T2 had the highest value of titratable acidity content at zero time and in all storage periods, while T4 had the lowest value at zero time and during all storage periods. Furthermore there is significant increase in titratable acidity content for mean of treatments with increasing storage period. **Abdelrahman (2021)** reported that acidity 0.37% mango nectar, was brix 17.23° and served as an ideal recipe for nectar.

Data in **Fig. (1).** The control was rejected after 2 months**.**

Data in **Fig. (2)** showed that there is a significant difference (*P<0.05*) in pH value between different treatments. Also, there is a significant difference (*P<0.05*) between all treatments in pH value during storage period. The obtained results showed that T2 had the lowest value of pH value in zero time and during period storage, while T4 had the highest value at zero time and during all storage periods.These results are in agreement with **Cadena *et al*. (2013)** who found the titratable acidity 0.15% and pH values 4.13 of the mango nectars at zero time, there were no significant differences (*p > 0.05*) between the different samples, the values did not change during the shelf life. **Abdelrahman (2021)** reported that 25% mango pulp, 17.23°brix and pH value was 3.80.

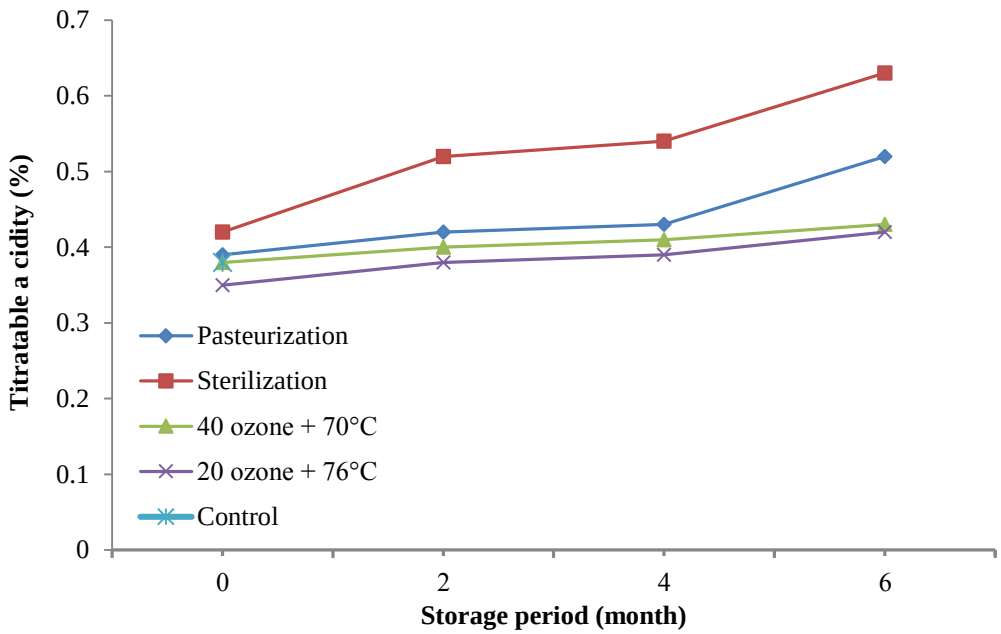

Fig. (1). Effect of heat and ozone treatments on titratable acidity in mango nectar during storage period at 25 ˚C.

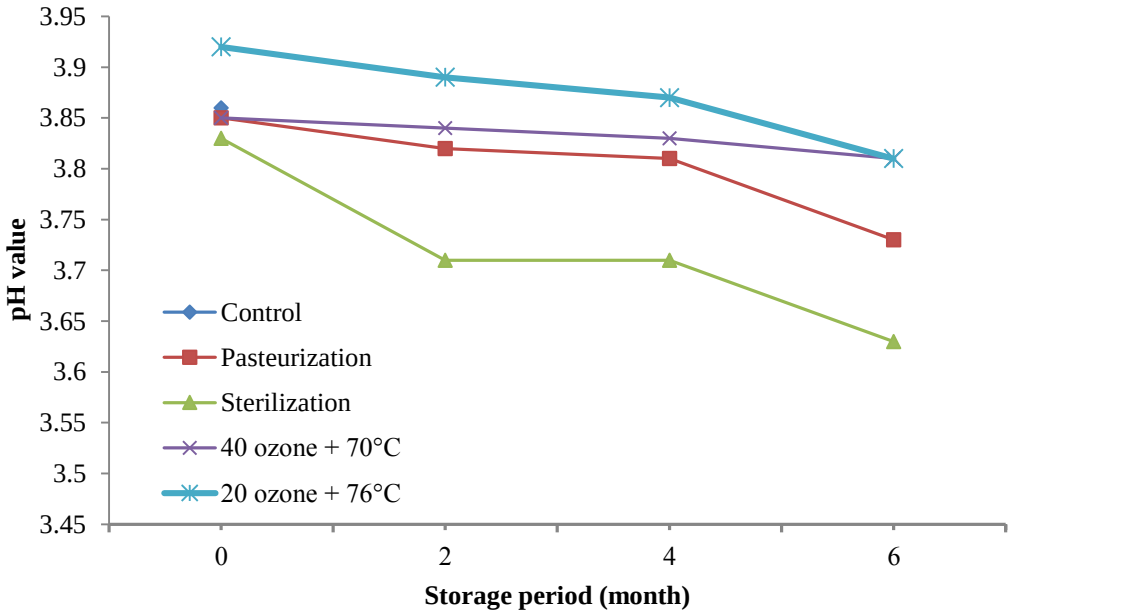

Fig. (2). Effect of heat and ozone treatments on pH value in mango nectar during storage period at 25 ˚C.

Data in **Fig. (3)** shown that the impact of heat and ozone treatments on mango nectar. The T.S.S. content as the highest content in zero time for T4 (15.30±0.06%) and lowest content was in T1 (14.85±0.03%). Results revealed that there is a significant difference in T.S.S. content between T4 compared with other treatments. Also, there is non significant difference between T3 and T4 in T.S.S. content during storage period, while, there is a significant difference between T3 compared with other treatments.Regardless of the different treatments, the obtained data shown that there is a

significant decrease in T.S.S. content for mean of treatments with increasing storage period. Rregardless of the storage period, there is non significant difference in T.S.S. content between T3 and T4; while there is a significant decrease in T1 (14.66±0.04%) compared other treatments. These results are in agreement with those reported by **Cadena *et al*. (2013) w**ho found the T.S.S. was 14.00% of the mango nectars at zero time. Comparing the given results with Egyptian standardizations (not less than 15.1 %) and international limits (not less than 13.5%), while **Babarinde *et al*. (2019)** reported that the T.S.S. of mango nectar values obtained from samples prior to storage ranged from 11.50 to 14.30 °brix.

Data in **Fig. (4)** shown that the Vit. C content was the highest content in zero time for T3 (17.40±0.10 mg/100 mL) and lowest content was in T2 (13.23±0.01 mg/100 mL). Results revealed that there is a significant difference in vit. C content between all treatments. **Fig. (4).** Also, that there is a significant difference between T3 and other treatment in TSS content during storage period. The obtained results showed that T3 had the highest value of Vit. C content at zero time and during period storage, while T2 had the lowest value at zero time and during all storage periods. Regardless of the different treatments, the obtained data in **Fig. (4)** shown that there is a significant decrease in Vit. C with increasing storage period. Rregardless of the storage period, there is a significant difference in Vit. C content between T3 and other treatments while there is a significant decrease in T2 (11.31±0.38 mg/100 mL) compared other treatments. These results are in agreement with reported by **Abdelrahman (2021)** who found that the ascorbic acid content of mango nectar was 13.54 mg/100 g sample. **Kumar *et al*. (2013)** found that ascorbic acid content of fresh mango nectar was found to be 9.2±0.005 mg/100 mL. While thermally treated (780 sec at 96°C) samples had 5.17±0.005 mg/100 mL. The color, and ascorbic acid content of the mango nectar were significantly ($p<0.05$) reduced during storage period at temperature (27-30°C) but still the quality of the nectar was good up to 180 days.

Data in **Fig. (5)** shown that the impact of heat and ozone treatments on mango nectar. The total carotenoids content as the highest content in zero time for T3(1.89±0.00 mg/100 mL) and low content was in T2 (1.74±0.02 mg/100 mL). Results revealed that there is a significant difference in total carotenoids content between all treatments. The obtained results showed that T3 had the highest value of total carotenoids content at zero time and in all period storage, while T2 had the lowest value at zero time and during storage periods. **Kumar *et al*. (2013)** showed that the carotene degradation is one of the important factors to cause color change in thermally processed mango nectar. The color and carotene content of the mango nectar were significantly ($p<0.05$) reduced during 180 days of ambient (27-30°C) temperature storage, but still the quality of the nectar was good up to 180 days.

Data in **Fig. (6)** shown that the impact of heat and ozone treatments on mango nectar. The total phenolic content as the lowest content in zero time for T2 (44.75±0.14 mg/100 mL). There is non-significant difference in total phenolic content between all treatments. Also ,there is non-significant difference between T3 and T4 and between T1and T2 in total phenolic content during storage period. The obtained results showed that T3 had the lowest value of total phenolic content at zero time and in all storage period, while T4 had the highest from storage period. The obtained results indicated that the total phenolic content less than results record **by Ramirez *et al*. (2013)**. They reported that the peel of Pica cultivar from Chile presented the highest content of total phenolic compounds (66.02 mg/100 g FW) analyzed by HPLC–PDA.

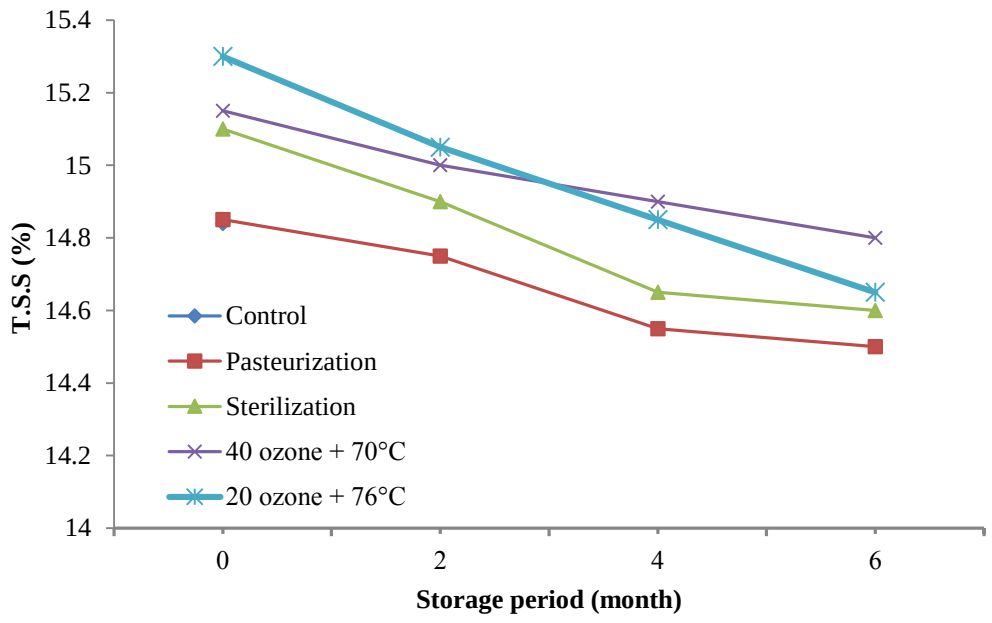

Fig. (3). Effect of heat treatments and ozone on T.S.S (%) in mango nectar during storage period at 25 ˚C.

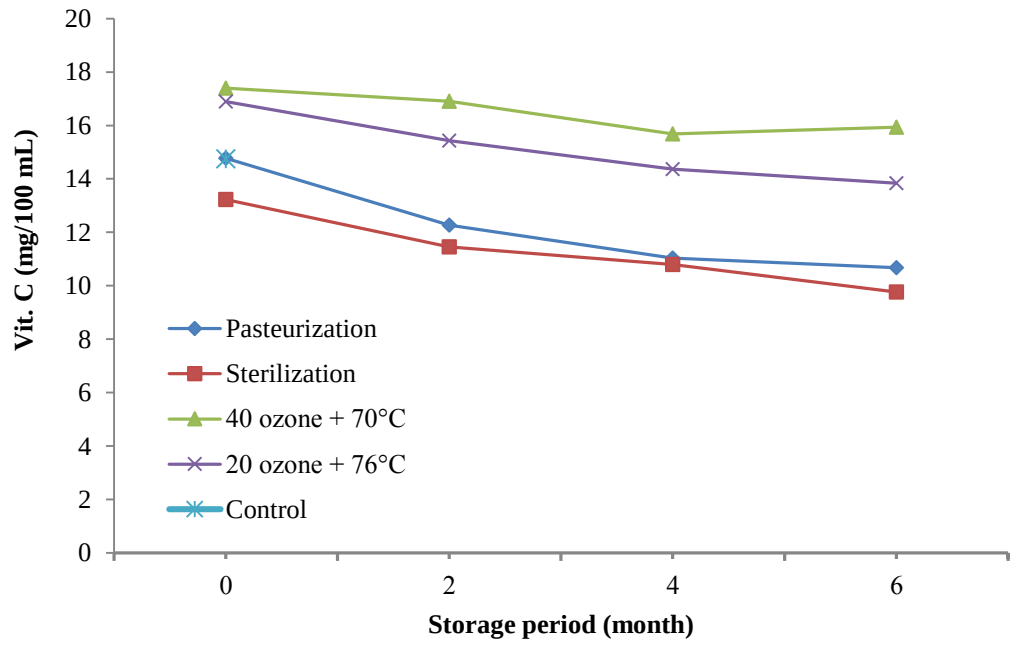

Fig. (4). Effect of heat and ozone treatments on Vit C(mg/100 mL) in mango nectar during storage period at 25 ˚C.

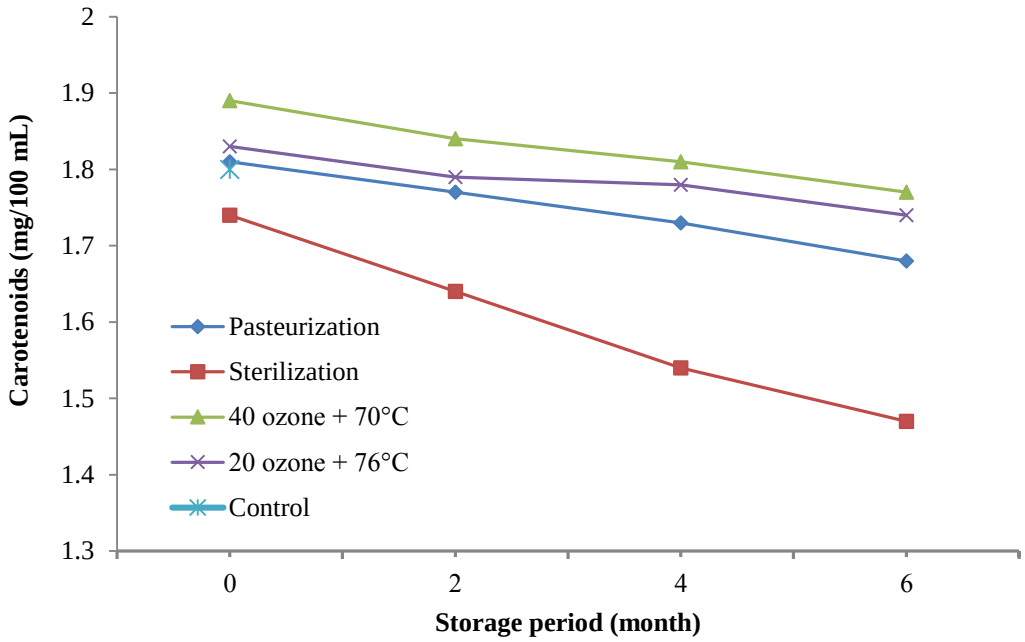

Fig. (5). Effect of heat and ozone treatments on Carotenoids (mg/100 mL) in mango nectar during storage period at 25 °C.

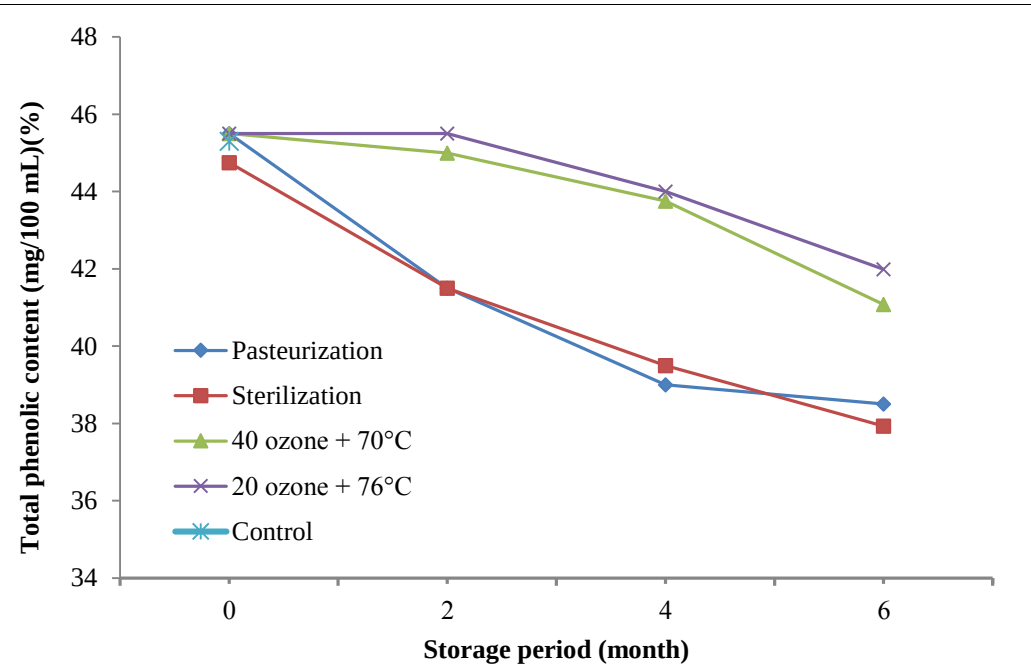

Fig. (6). Effect of heat and ozone treatments on Total phenolic content (mg/100 mL) in mango nectar during storage period at 25 °C.

3.2.4. Total sugars:

Data in **Fig. (7)** shown that the impact of heat and ozone treatments on mango nectar. The highest of total sugars content was in zero time for T4 ozone (11.57%) and lowest content was in T1 (11.43%). Results revealed that there is non significant difference in total sugars content between all treatments at zero time and 6 months of storage period. Also, there is non significant difference between T3 and T4 and between T1 and T4 in total sugars content during storage period while, there is a significant difference between T3 and T4 compared with T1 and T2. For there more there is a significant decrease in total sugars content for mean of treatments with increasing storage period. These results are in agreement with those obtained by **Abu El-Maaty**

(2012) and **Saad (2017).** They found that the total sugars content in mango juice 10.87%.**Abdelrahman (2021)** found that the total sugars content in mango juice and nectar were within the range between 11.22% for mango juice to 14.11% for mango nectar.

Data in **Fig. (8)** shown that the highest of reducing sugars content was in zero time for T2 (3.36%) and lowest content was in T4 (3.19%). Results revealed that there is non significant difference in reducing sugars content between T2 and T3 at zero time, also, there is non significant difference between T1, T3 and T4. Also, there is non significant difference between all treatments in reducing sugars content during storage period. The obtained results showed that T2 had the highest value of reducing sugars content at zero time and during period storage, while T4 had the lowest value at zero time and during all storage periods. Regardless of the different treatments, the obtained data in **Fig. (8)** shown that there is a significant decrease in reducing sugars content for mean of treatments with increasing storage period. Also, regardless of the storage period, there is non significant difference in reducing sugars content between all treatments. These results are in agreement with those reported by **Abdelrahman (2021).** Who found that the reducing sugars content in mango juice and nectar were within the range between 1.98% for mango juice to 2.80%, for mango nectar.

Data in **Fig. (9)** shown that the highest of non-reducing sugars content was (7.96%) in zero time for T4 and lowest content was in T2 (7.75%) . Results revealed that there is non significant difference in non-reducing sugars content between T1, T3 and T4 at zero time, also, there is non-significant difference between T1 and other treatments. Also, there is non-significant difference between all treatments in reducing sugars content at 6 months of storage period. The highest value of non-reducing sugars content at zero time, during of storage period, while T2 had the lowest value at zero time and 2 months of storage periods But, T1 had the lowest value at 4 and 6 months of storage periods. While there is non-significant decrease in non-reducing sugars content for mean of treatments with increasing storage period. Also, regardless of the storage period, there is non significant difference in non-reducing sugars content between T3 and other treatments.

These results are in agreement with those obtained by **Abu El-Maaty (2012) w**ho found that the non-reducing sugars content in mango juice was 7.67% and **Saad (2017)** found that the non-reducing sugars content in mango juice was 9.06%. **Abdelrahman (2021)** reported that the Non-reducing sugars content in mango juice and nectar were within the range between 8.78% for mango juice to 10.75% for mango nectar

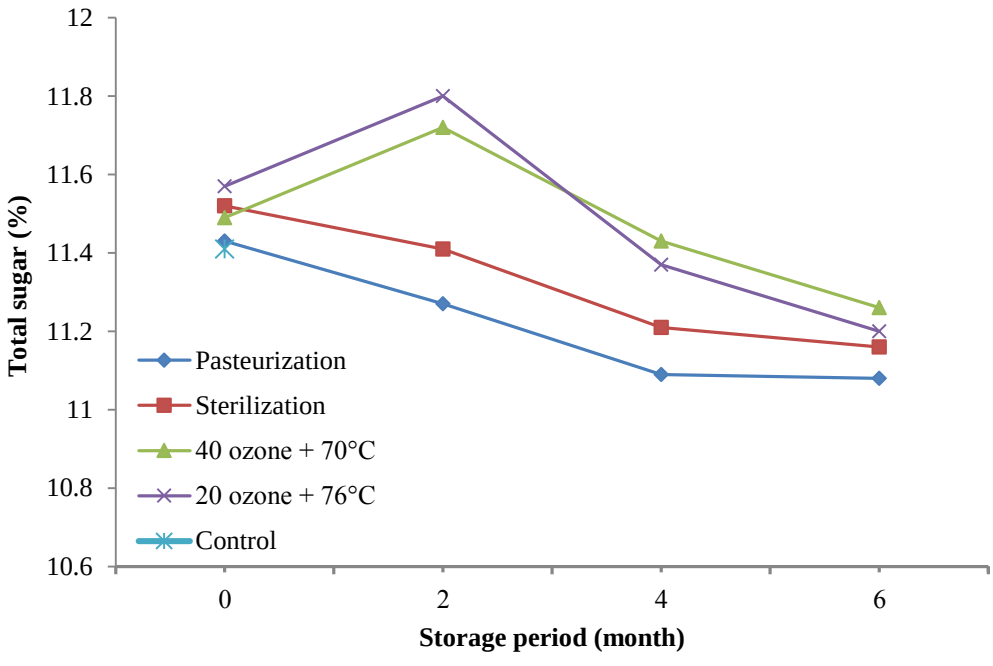

Fig. (7). Effect of heat and ozone treatments on Total sugar (%) in mango nectar during storage period at 25 °C.

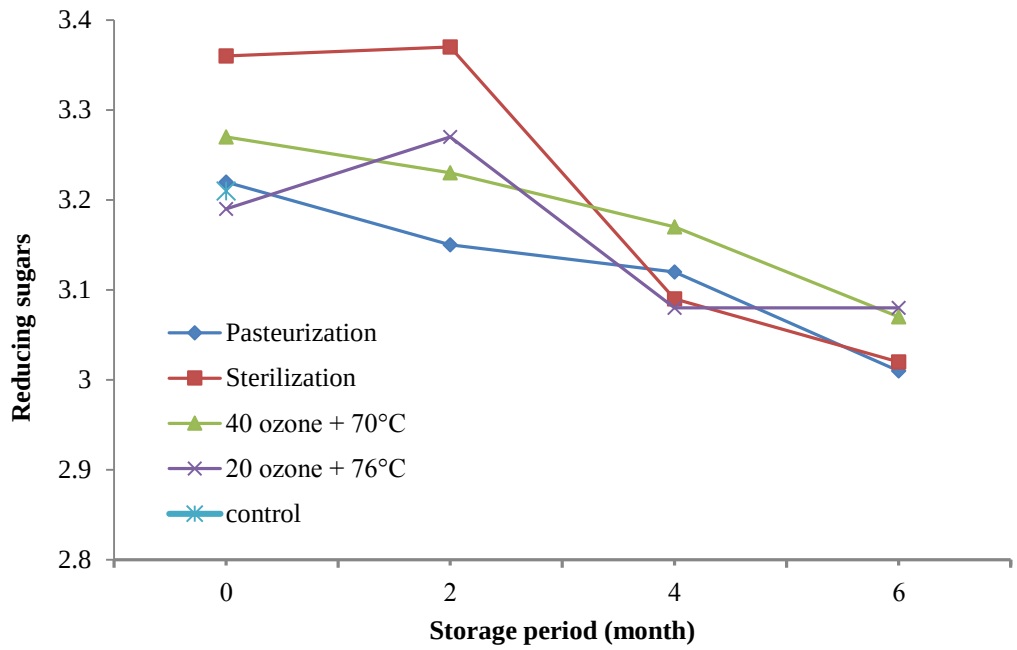

Fig. (8). Effect of heat and ozone treatments on Reducing sugars (%) in mango nectar during storage period at 25 ˚C.

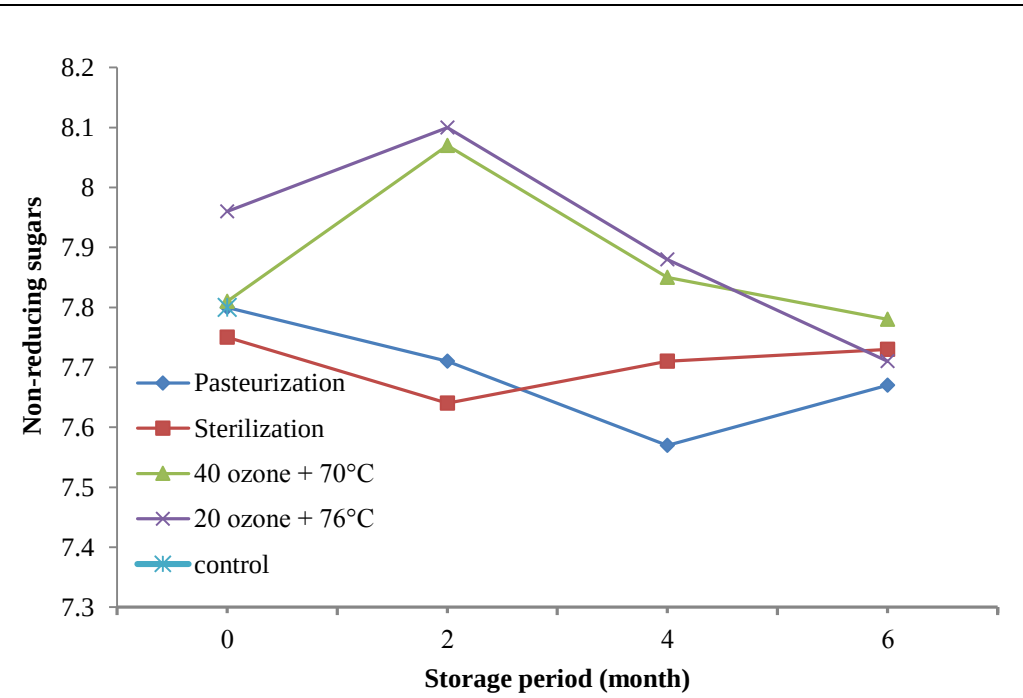

Fig. (9). Effect of heat and ozone treatments on Non-reducing sugars (%) in mango nectar during storage period at 25 ˚C.

3.2.5. Effect of storage period on sensory properties of mango nectar:

Sensory evaluation of food product is an important criterion by which consumer acceptability can be assessed. Data in **Fig. (10)** shows the changes in organoleptic properties i.e. odor, color, appearance, taste and overall acceptability during storage period of mango nectar.

3.2.5.1. Color score:

The color is one of the important parameters for standardizing processing conditions. Color

degradation of mango nectar by thermal processing was investigated using Hunter color lab instrument. The carotene degradation is one of the important factors to cause color change in thermally processed mango nectar (**Kumar *et al*., 2013)**.Data in **Fig.(10)** showed found that there is a significant difference in color score between different treatments. Also, there is non significant difference between T1 and T4 in color score at zero time, while there is non significant difference in color score between T2 and T3 at 2 and 4 months of storage. The obtained results showed that T3 had the highest score in color at zero time (22.88±0.27), while T4 had the lowest score (21.75±0.38). While, there is a significant decrease in color score for mean of all treatments with increasing storage period. Rregardless of the storage period, there is non significant difference in color score between T1, T3 and T4; T2 and T3, while there is a significant decrease in color score for T2 compared other treatments.

3.2.5.2. Odor score:

Data in **Fig. (10)** shows that there is a significant difference in odor score between T3 compared with other treatments. Alsoو there is non significant difference between T1, T2 and T4 in odor score at zero time and after 2 months of storage period. Also there is non significant difference in odor score between T1, T2 and T3 at 4 months of storage. While, T3 had the highest score in odor at zero time (22.85±0.25), while T4 had the lowest score (21.76±0.18).Also, there is a significant decrease in odor score for mean of all treatments with increasing storage period. Rregardless of the storage period, there is a significant difference in odor score between different treatments, while there is non significant decrease in odor score between T2 and T4.

3.2.5.3. Appearance score:

Data in **Fig. (10)** shows that there is a significant difference in appearance score between T4 compared with other treatments. Alsoو that there is non significant difference between T1, T2 and T4 in appearance score at 4 months of storage period. The obtained results showed that T4 had the highest score in appearance at zero time (22.00±0.28), while T2 had the lowest score (18.75±0.26). While, there is a significant difference in appearance score for mean of all treatments with increasing storage period. Also, regardless of the storage period, there is a significant difference in appearance score between different treatments, while there is non significant decrease in appearance score between T3 and T4.

3.2.5.4. Taste score:

Data in **Fig. (10)** shows that there is a significant difference in taste score between T3 compared with other treatments. Also, there is non significant difference between T1, T2 and T4 in taste score at zero time of storage period. The obtained results showed that T3 had the highest score in taste at zero time (22.80±0.20), while T4 had the lowest score (21.71±0.24). While, there is a significant decease in taste score for mean of all treatments with increasing storage period. Also, regardless of the storage period, there is a significant difference in taste score between different treatments, while there is non significant decrease in taste score between T3 and T4; T1 and T2.

3.2.5.5. Overall acceptability score:

Data in **Fig. (10)** Revealed that there is a significant difference in overall acceptability score between T3 compared with other treatments. Also, there is non significant difference between T1 and T4 in overall acceptability score at zero time from storage period. The obtained results showed that T3 had the highest score in overall acceptability at zero time (90.13±0.76), while T2 had the lowest score (85.13±1.32). Regardless of the different treatments, there is a significant difference in overall acceptability score for mean of all treatments with increasing storage period. Also, regardless of the storage period, there is a significant difference in overall acceptability score between different treatments, while there is non significant decrease in taste score between T3 and T4; T1 and T2.**Kumar *et al*. (2013)** reported that the carotene degradation is one of the important factors to cause color change in thermally processed mango nectar. The sensory scores of the mango nectar were significantly ($p<0.05$) reduced during 180 days of ambient (27-30°C) temperature storage, but still the quality of the nectar was good up to 180 days. The thermally processed RTD mango nectar had significant ($p<0.05$) lower overall acceptability score.

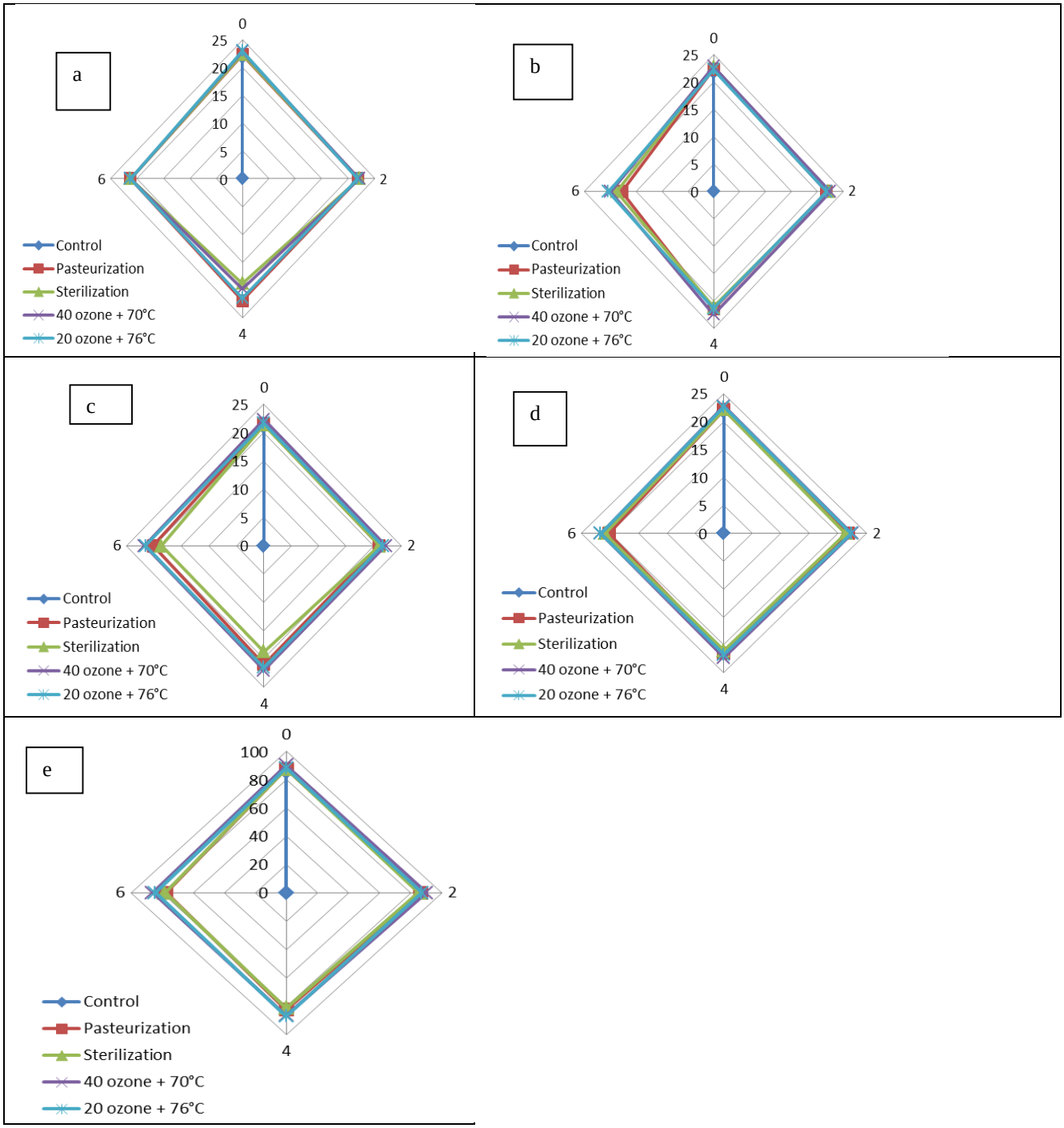

Fig. (10): Effect of different heat processing and storage periods on color (a), oder (b), appearance (c), test (d), and overall acceptability (e) mango nectar (mean±SE).

4.1.5. Microbiology quality of mango nectar:

Data in **Table (3)** showed that the total bacterial count (TBC) in mango pulp was $7.2x10^6$ CFU/mL. But, TBC was decreased in different treatments at zero time. Data shown that the total bacterial count was increased with progress storage period in all different treatments. T1 had given the highest content of TBC $1.8x10^5$ CFU/mL at 6 months, while T4 had given the lowest number $2.1x10^4$ CFU/mL.

By examining all samples at the beginning of storage, the mango pulp or the different treatments, it was found that they were nil of *E. coli* and Coliform bacteria. Also, by re-examination during storage periods, it was also found to be free from *E. coli* or Coliform bacteria.

Kumar *et al.* (2013) concluded that thermal processing at 96°C for a total heating time (*fh*) of 780 s with pvalue of 12.73 would be a good method to produce microbiologically stable mango nectar with the good retention of quality attributes.

Table 3. Effect of different heat processing and storage periods on total bacterial count of mango nectar**.**

Treatments	Storage period (month)			
	0	2	4	6
mango pulp	**$6.9x10^6$**	**$6.9x10^6$**	**$7x10^6$**	**$7.1x10^6$**
Control	**$4.7x10^6$**	**R***	**R**	**R**
T1	**$1.1x10^3$**	**$2.5x10^3$**	**$1.6x10^4$**	**$1.8x10^5$**
T2	**$2.2x10^2$**	**$1.4x10^3$**	**$1.8x10^4$**	**$1.1x10^5$**
T3	**$1.9x10^2$**	**$2.3x10^3$**	**$1.5x10^4$**	**$2.4x10^4$**
T4	**$1.4x10^3$**	**$2.7x10^3$**	**$9.0x10^3$**	**$2.1x10^4$**

Conclusion

In the current study, the impact pasteurization at 92±1˚Cfor16 sec;(T1), sterilization at 100±1˚C for 15 sec; (T2), ozone at40 ppm+70 ˚C for 30 min; (T3), and ozone at 20 ppm +76 °C 30 min(T4) on the physical, chemical, sensory, microbiological quality of mango nectar were evaluated. The moisture, available carbohydrates, and minerals content have non-significant differences ($P > 0.05$) between all treatments. The T1, had significantly lower ($P < 0.05$) in ash and crude fiber contents than the other treatments. The color values demonstrated that L* value was the highest in T2, while a* and b* was the highest in T3 and T4 up to 6 months of storage. Ozone treatments, particularly T4, maintained the lowest titratable acidity and highest pH value in nectar throughout the storage period, followed by T3. The T3, recorded highest T.S.S., vit. C, and total carotenoids in nectar, whereas T4, retained the highest total phenolic values. The sensory acceptability of nectar revealed that T4, had the best characteristics i.e. odor, taste, and appearance scores, as well as the best microbial quality when compared to others treatments. Finally, tested ozone hurdles, particularly T4, produced the best nectar quality. Results demonstrated that novel technology (Hurdle technology) is the best way for keeping quality and safety of nectars.

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تأثيرالمعاملات الحراريه والأوزن علي معايير الجودة والصلاحيةعلي نكتار المانجو

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إستهدفت هذه الدراسة تحسين جودة وسلامة نكتار المانجو بإستخدام بعض طرق الحفظ التقليدية والحديثة (المعاملات الحرارية، الأوزون، تكنولوجيا العقبات). تم إستخدام أربعة معاملات المعاملة الاولي البسترة (92 ± 1م° لمدة 16 ثانية ;)، المعاملة الثانية التعقيم (100 ± 1م° لمدة 15 ثانية؛)، المعاملة الثالثة الأوزون (40 جزء في المليون/70 م° /30 دقيقة؛)، والمعاملة الرابعة الأوزون (20 جزء في المليون /76 م° /30 دقيقة؛) على الجودة الفيزيائية والكيميائية والحسية والمكروبيولوجية لنكتار المانجو. أشارت النتائج بأنه لا توجد فروق معنوية في التحليل الكيميائي (الرطوبة والكربوهيدرات، والعناصر المعدنية) (P> 0.05) بين جميع المعاملات. لوحظ أنخفاض المعاملة الاولي (P <0.05) في محتوى الرماد والألياف الخام مقارنتاً بالمعاملات الأخرى (P <0.05). أظهرت قيم اللون أن قيمة L * كانت الأعلى في المعاملة الثانية بينما كانت a * و b * هي الأعلى في المعاملة الثالثة والرابعة نهاية التخزين. أظهرت النتائج أن معاملة الأوزون، وخاصة الرابعة، كانت أقل فى قيمة الحموضة وأعلى في ال pH في نكتار المانجو طوال فترة التخزين، تليها المعاملة الثالثة. سجلت المعاملة الثالثة مستوى أعلى المواد الصلبة الذائبة، vit. C ، الكاروتينات الكلية في النكتار، بينما احتفظت المعاملة الرابعة بنسبة مرتفعة للفينولات الكلية. كما أظهرت نتائج التقييم الحسي للنكتار أن المعاملة الرابعة ذات خصائص حسية أفضل فى كل من اللون والرائحة والمظهر والطعم. بالاضافة الي ذلك، سجلت المعاملة الرابعة أفضل جودة ميكروبية مقارنتاً بالمعاملات الأخرى. من خلال النتائج المتحصل عليها، يعتبر الاوزون وتكنولوجيا العقبات من الطرق الحديثة والمبتكرة للحفاظ على جودة وسلامة نكتار الخضر والفاكهه.

الكلمات الداله: نكتار المانجو، المعاملات الحرارية، الاوزون، مقاييس الجودة، الصلاحية