Food Technology Research Journal, Vol. 2, special issue 2, 145-157, 2023

FTRJ

Production and Evaluation of Natural Sweeteners and Packaging Materials on Peach compote's shelf life

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Original Article

Article information

Received 24/11/2023

Revised 5/12/2023

Accepted 10/12/2023

Published 30/12/2023

Available online 30/12/2023

Keywords:

peach compote, sweeteners, stevia, High fructose corn syrup, packaging, shelf life, quality

ABSTRACT

Peach compote is one of the products that preserve peach fruits from deterioration until consumption. It plays an important role in human nutrition, so this study aims to preserve peach slices by using natural sweeteners such as sucrose, High Fructose Corn Syrup (H.F.C.S), and stevia. The study also examined the effects of packaging in glass and plastic jars on preserving quality and extending the shelf life of peach compote. The samples were stored for 3 months at 4±2°C. The study found that the TSS, titratable acidity, and reducing sugars increased, while the pH, ascorbic acid, non-reducing sugars, and color decreased. The microbiological evaluation showed that all treatments had the lowest microbial load throughout the storage period and were free from mold and yeasts. The sensory evaluation showed that treatments T6 (H.F.C.S + stevia) and T5 (sucrose + stevia) were the best throughout the storage life when packaged in glass jars.

1. Introduction

Peach fruits (*prunus persica* L.) are one of the most popular fruits in Egypt cultivated successfully in (Behera, Kafr El Sheikh, Sharkia, and Ismalia). Where, peaches occupy first place among deciduous fruits in terms of area and importance. Economic as the total area reached about 78,494 thousand acres in 2001, and its production reached about 224,183 tons (HRI, 2003) the rate of peach production in Egypt increased to about 292.4 thousand tons in 2013 (Youssef, 2016) and peach mostly grown in different countries in the world. It was mentioned that the peach contains 7-8 % sugars, 0.6 – 1.2 % protein, 1- 27mg/100g vitamin C (Sharma et al., 2002). Peach fruits are characterized by a high content of sugars, vitamins (A, E), minerals (K, Na, Ca, Mg, P, Fe…. etc.), cellulose, organic acids, and pectin substances. Also contains vitamin C (ascorbic acid), carotenoids (pro-vitamin A), and a phenolic compound which are a rich source of antioxidants (Lamureanu et al., 2015). Where (Mrázová, et al., 2021) declared that all peach sorts are fine sources of phenolic compounds (9.43–577 mg gallic acid equivalent (GAE).100 g^{-1}), flavonoids (1.12–95.1 mg catechin equivalent (CAE).100 g^{-1}), and antioxidant capacity (136–462 mg Trolox equivalent (TE).100 g^{-1}). Peach is considered an excellent fruit of high nutrient contents, as well as peach has medical importance, they are energizing, seizures, diuretic, and slightly laxative, being displayed in treating dyspepsia, hematuria, and urinary lithiasis (Jamba and Carabulea, 2002). Due to the short shelf-life of peaches and further owing to the perishable nature of peaches, as well as to make fruits available throughout the year for consumers, preservation of fruit halves could be an attractive state of consumption. Thus, Peach fruits are usually consumed either fresh or processed such as juice, nectar, syrup concentrated juice, jams, compote canned fruits, beverages, and carbonated beverages (Durst and Weaver, 2013) and (Veringa and Dumitrescu 2016). The nutritional value of canned peaches is nearly comparable to that of fresh peaches (Saif Ullah et al., 2016)., so the Peach is stored in natural sweeteners such as Stevia and high fructose corn syrup,

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where stevia are now widely available, its levels of sweetness are 250 times sweeter than sucrose and it does not cause tooth cavities, In addition, it has no side effect and very safe (Tejo et al., 2013). High fructose corn syrup (HFCS) or high glucose corn syrup (HGCS) is produced from glucose syrup using glucose isomerase enzyme standard (HFCS) it consists of 43-54% glucose, 42-47% fructose, and the remainder is maltose, and oligosaccharides. Besides owing to the greater solubility of fructose than glucose, the high fructose syrup can be shipped at higher solid content (Abou Zeid et al., 1992). regarding the importance of packing peaches after harvest for marketing (Mir, et. al., 2017), the effect of packaging and different ventilation levels on the quality of peach fruits under refrigerated storage conditions was studied. The peach fruits (*Prunus persica L. Batch*) of the "Shan-e-Punjab" variety were harvested at the color separation stage and packed in thermos trays coated with polypropylene (PP). (HRI, 2003) explained that during marketing, lined cardboard or wooden containers are used in which the fruits are placed. In two layers, or use 1-2 kg dishes, where the fruits are placed in one layer and covered with perforated cellophane. However, it was observed that many peach fruits were damaged because of moisture condensation on the fruits immediately after they left the refrigerated refrigerators, which led to the infection of fungal diseases, the most dangerous of which is brown mold. As well as the loss of Humidity, this leads to fruit crunching. In addition to the harmful effects of storing at a temperature below 10°C for a long time, as a change in the natural color of the peach because of these problems, the tendency was to process peaches and turns them into peach juice and peach jam. (Awulachew, 2021) decided the fresh fruits have limited shelf life; therefore, it is necessary to process fresh fruits into different value-added products with the use of good packaging to increase their availability over an extended period and t The processed products have good potential for internal as well as external trade. Jams from fruit impart nutrition, and health with natural goodness, and sweet taste. and keeps the goodness of fruits & value adds and minimizes the post-harvest losses and their important potential to affect the health of the human. Since peaches have a short shelf life after harvesting due to their high moisture content and high metabolic activity, this study was conducted to convert peaches into a product (peach compote) and study the effect of packaging materials on them during storage. To prolong its shelf life and reduce the loss and damage that occurs in large quantities of peaches annually.

Materials and Methods

Materials

Fresh Peach (*prunus persica* L.) variety Florida Prins used in this study was obtained from Orchard or private a culture of reclaimed are at government during season (2019), High fructose corn syrup (78%) was obtained from the national company of maize products, 10th of Ramadan city, sharkia, Egypt. Stevia was purchased from supermarket; Packaging, semi-transparent Plastic Jar (500 ml) made of high-density polyethylene and low permeability to gases and water vapor. and Transparent Glass Jar (500 ml) impermeable to gases and water vapor were obtained from Plastic Formco Company and National Company for Glass and Crystal Company, Industrial City in the 10th of Ramadan – Cairo. Chemical used in this study were of analytical grade and purchased from EL-Gomhoria Company, Cairo.

Methods

Preparation of compote

The peach fruits were sorted and fresh fruits with good appearance and texture were selected, and the unwanted parts were removed, then they were washed thoroughly with clean water, cut into two halves, and dipped in boiling water for three minutes. Then the slides were subjected to different treatments shown in Table 1. Three different types of natural sweeteners were used to make solutions for preserving peach compote at 40% concentration, which are Sucrose, high fructose corn syrup (H.F.C.S), and Stevia, with the addition of citric acid and sodium meta bisulfate at percentages of 1% and 0.5%, respectively, The treatments were then pasteurized in water bath at 80°C for 20 minutes and packed in glass jars and plastic jars, The jars were tightly closed then cold under tap water. (Sahar, and Mousa, 2013)All treatments were stored at 4°c ± 2°c for 3 months. Samples for analysis were taken out from each treatment after processing (zero time) and during storage to evaluate chemical, physical, and organoleptic properties and microbiological growth.

Table 2. Deferent treatments of peach compote with sweeteners (40%)

Treatment	Peach compote with sweeteners in constant concentration 40%	Citric acid	Sodium meta bisulfate
control	Peach fruits in water without any additives	1 %	0.5 %
1	Peach slices sweetened with sucrose	1 %	0.5 %
2	Peach slices sweetened with high fructose	1 %	0.5 %
3	Peach slices sweetened with stevia	1 %	0.5 %
4	Peach slices sweetened with sucrose and high fructose	1 %	0.5 %
5	Peach slices sweetened with sucrose and stevia	1 %	0.5 %
6	Peach slices sweetened with high fructose and stevia	1 %	0.5 %

Analytical methods

Moisture, total soluble solids (T.S.S), total sugars, reducing sugars, non-reducing sugars, total titratable acidity contents ascorbic acid content, crude fibers, and ash contents were determined according to methods described by (A.O.A.C, 2005).

The pH value was measured using a pH meter (Jenway, 3510, UK) at 25°C as described by (A.O.A.C, 2007)

The color of fresh peach compote as well as the color of processed during storage peach compote were measured by the method described by Hunter (1985) using lab model D-25 color. The instrument was standardized on the white standard (L=92.5, a=1.0 and b=0.6).

Hardness was measured according to the method described by (Shannon and Bourne, 1971) using testing machine model No. AIM339.3 (Largo, Floride 33543, USA).

Microbiological analyses

Total plate count was determined using serial dilutions on plate count agar with pour plate method. The duplicated plates were incubated at 30°C for 48 h. The enumeration of total yeast and mold counts with the same dilutions was also carried out on potato dexterous agar at 25°C for 5 days using the pour plate method. Results were expressed as "CFU (colony-forming units)/gm" (AOAC, 2000). Total count, yeasts, and mold contents were enumerated as C.F.U/gm of peach compote after processing directly (at zero time) and after 3 months of storage (end of storage period).

Sensory evaluation

Sensory evaluation was carried out according to (Walter and Hoover, 1986). Twenty trained panelists from the staff of the Food Technology Research Institute, Agricultural Research Centre. The panelists were asked for their decision concerning, color, odor, taste, texture, and appearance, the maximum score is 10 for each sample.

Statistical analysis

The results of the sensory evaluation analysis were submitted to the analysis. Data were treated to be for compote randomization design. The least significant difference (LSD) was calculated at 0.05% level as significant. These analyses were carried out as mentioned by (Snedecor and Cochran, 1980).

Results and Discussions

Chemical analysis of peach of fresh and blanched peach fruits

Table 2. shows the chemical composition of fresh and blanched peaches without any treatments it could be observed that Moisture content was higher in fresh peaches compared to that of blanched peaches (87.50 and 84.62%) respectively. (Wilkinson, 1965) noticed that most fruits contain 80-85 percent of water by weight, some of which may be lost by evaporation although a major portion of its lost by transpiration. Metabolic activity in fresh fruits and vegetables continues for a short period after harvest. From the data given in Table 2., it could be verified that the total soluble solids (T.S.S)

were 10.43% and 10.98% in fresh and blanched peaches respectively, mainly composed of sugars, organic acids, ash, and some vitamins. (Ergun, 2012) declared that SSC (Soluble solid content) or TSS from Royal Glory peaches range from 10 to 11%. As for reducing and non-reducing sugars, they were 18.33% and 18.20%, 43.05% and 43.00% in fresh and blanched peaches respectively. (Moing et al., 1992) reported that in fruit, sucrose is the major sugar (non-reducing sugars) with 40% to 85% of total sugar content; glucose and fructose (reducing sugar) present an equimolar quantity and can reach 17 to 25% of total sugar content, While that total sugars 61.38% in fresh peach, and 61.20% in blanched peach (Génard and Souty 1996). From the same table, it could be concluded that Crude fiber's % ash, titratable acidity, and PH values were 20.33%, 3.06%, 1.92 and 4.53 in fresh peach. On the other hand, Crude fibers %, ash content, titratable acidity, and PH were 23.42%, 3.04%, 1.44% and 4.70 respectively in blanched peach. This trend agrees with the findings of (Pongner et al., 2011). Meanwhile, the blanched peaches had a lower content of ascorbic acid (46.33) mg/100g compared to the fresh peach (84.56) mg/100g fresh weight basis. This reduction is due to the blanched process. (Mahajan et al., 2015) In general, a slight decrease was noticed in the chemical structure of blanched peaches compared to fresh peaches.

Table 2. Physiochemical properties of fresh and blanched peach fruits (on dry weight basis)

Chemical composition	Fresh peach	Blanched peach
Moisture content %	87.50	84.62
Total soluble solids %	10.43	10.98
Total sugars %	61.38	61.20
Reducing sugars %	18.33	18.20
Non- reducing sugars %	43.05	43.00
Crude fibers %	20.33	23.42
Ash %	3.06	3.04
Titratable acidity (as citric acid) %	1.92	1.44
PH value	4.53	4.70
Ascorbic acid (mg/100g) on fresh weight basis	84.56	46.33

Color and Hardness Determination of fresh and blanched peach fruits

The *L, a,* and *b* parameters were verified to be good indicators of the total color change of peach after being exposed to heat. Table 3. shows the results effect of blanching on the color and hardness of peach fruits. The color measurement results (Hunter lab as *L, a,* and *b* values) for peach fruits were 55.66, +3.62, and +20.66, respectively. These values had changed to 49.63, +4.13, and +20.34 for *L, a,* and *b,* respectively after blanching. In this concern, it should be mentioned that the value of *L* means (Lightness) while a value means redness and the *b* value means yellowness of color as indicated by the measurements of the Hunter lab apparatus. A slight decrease has been observed, in *L* and *b* value and an increase in a value after blanching. Also, the authors found similar results as those of (Garza et.al., 1999) with an increase in heating temperature and time peach puree became darker. This corresponded to a decrease in the *L* value of the color scale. The peach puree also lost its yellowness and became redder when heated. This change has been translated by a decrease of the *b* value and an increase of a value and (Maskan, 2006) declared that an increase in treatment temperature and time caused the darkening of the peach puree this was reflected in the decrease of lightness (*L*). The puree color trend in planes a-b indicated a decrease in the *b* values and an increase in values with treatment time. At the same table, it could be detected that slight decrease in hardness after blanching, the values of from 1.24 to 0.93. Perhaps because of exposure to heat, which affected the peach tissues, those results are in agreement with those declared by (Assous et al., 2012).

Table 3. Hunter L, a, b measurements and Hardiness of fresh and blanched peach fruits

Parameters	Fresh peach	Blanched peach
L	55.66	49.63
a	3.62	4.13
b	20.66	20.34
Hardiness (Kg)	1.24	0.93

L= Lightness a = Redness b = yellowness

Physicochemical properties of peach compote

Physicochemical analyses were done at zero time, 45days and at the end of storage period (90 days). The evaluation of treatments and different packages show in the following results:

Total sugars, Reducing sugar and Non - reducing sugar

Table 4. shows the effect of different natural sweeteners and packaging materials on Total sugars. Reducing sugar and non-reducing sugar of peach compote sweetened with different natural sweeteners after processing and during a storage period of 3 months at 4±2°C. From Table 4., a gradual decrease in total sugars in all treatments during storage was detected. T1 had the highest total sugars 68.54 followed by T2 (67.01) and T4 (65.48), while T3 recorded the lowest value of total sugars 31.45% after processing which was sweetened with stevia in both glass jar and plastic jar at Zero time. At the same time, all treatments maintained the level of sugar in peaches compared to the control. Results in Table 4. showed a pronounced decrease in non-reducing and total sugars with a simultaneous increase in reducing ones. The rate of reduction of total sugars and non-reducing sugars were 6.17% and 3.28%; 18.07% and 49.36% in treatments No. T1 and T2 respectively in glass jars. This phenomenon could be explained by the known reaction which usually occurs under acidic conditions within a storage period where the non-reducing sugars are inverted to reducing ones. These results agree with results obtained by (Mohamed et al., 2000; Mendonca et al., 2001 and Saif Ullah et al., 2016). On the other hand, Glass jars and plastic jars showed significant differences during storage whereas; the total sugars and non-reducing sugar content of peach compote decreased continuously during the entire period of storage in all treatments showed in Table 4. While the reduced sugar increased during storage in both containers. Notice that the increase was higher in plastic, followed by glass, perhaps because the plastic is permeable to oxygen over time, unlike glass which is impermeable to oxygen (Mir, et. al., 2015) reported that, other factors like oxygen transmission rate and storage temperature are also responsible for the increase in reducing sugars. on the other hand, it was observed that the percentage of total sugar increased in the glass compared to plastic at the end of the storage period (90 days), as it was 58.81 and 54.13 in T2 in glass and plastic containers, respectively. The delayed increase in the sugar content under film packaging may be attributed to the inherent property of packages in delaying the internal interaction because glass is impermeable to oxygen (Abeles et al., 1992).

Ascorbic Acid (Vitamin C)

The interaction effect of packaging materials, sweeteners, and storage period was highly significant on the ascorbic acid (AA) content of peach compote during the storage period of 3 months at 4±2°C shown in (Table 5.). it could be detected that enunciated decrease in vitamin (C) in all treatments where the decrease ranged from 32.81 to 9.84 mg/100g, 34.52 to 10.38 mg/100g, and 58.71 to 30.31 mg/100g in T1, T2, and T3 respectively. Compared to the control, the sharp decrease from 33.24 to 1.54 meanwhile the maximum loss was achieved at 31.18 in treatment No. T4 after processing (at zero time) compared to all treatments at zero time. This loss would be due to the release of some ascorbic acid during blanching. These results agree with those reported by (Sharma et al., 2002 and Saif Ullah et al., 2016). In the same table, it could be detected that the compote sweetened with stevia (T3) recorded a protective effect of stevia against degradation of ascorbic acid in aqueous solution. In the same table, it could be observed that peach compote had the highest content of ascorbic acid than the control sample (Nigm et al., 2004 and Assous et al., 2012).

All treatments showed a decrease in ascorbic acid trend towards the end of the storage time in both control and all treatments packaged in glass and plastic jars, noting that the compote packaged in glass jar retained ascorbic acid compared to the compote packaged in plastic jar. This may be due to O_2 permeability, as well as levels of oxidation affected by temperature and film permeability during storage. As glass is impermeable to oxygen unlike plastic with high oxygen permeability. (Mosie, T., 2018). Also, significant loss in ascorbic acid was observed during storage especially at the beginning of the storage can be attributed to the immediate reaction of an amount of ascorbic acid with the dissolved oxygen (Polydera et al., 2003).

Table 4. Effect of different natural sweeteners and packaging materials on Total sugars , Reducing sugar, N. R. sugar of peach compote during storage for 3 months at 4 ± 2°C (on dry weight basis)

Treatments	Packaging Materials	Storage Periods								
		After processing (Zero time)			After 45 days			After 90 days		
		Total sugars %	Reducing sugar %	N.R. Sugar %	Total sugars %	Reducing sugars %	N.R. Sugars %	Total sugars %	Reducing sugars %	N.R. Sugars %
Control	G	61.14	18.93	42.21	57.12	30.64	26.48	55.02	31.44	23.58
	P	61.14	18.93	42.21	51.56	26.17	25.39	49.84	32.03	17.81
Sucrose (T1)	G	67.54	32.51	35.03	65.51	33.21	32.30	64.31	35.61	28.70
	P	67.54	32.51	35.03	64.98	34.32	30.66	64.07	36.78	27.29
H.F.C.S (T2)	G	67.01	56.01	11.00	65.31	57.32	7.99	64.81	59.24	5.57
	P	67.01	56.01	11.00	65.06	58.22	6.84	64.13	59.98	4.15
Stevia (T3)	G	31.45	3.30	28.15	30.74	4.08	26.66	29.832	5.46	24.37
	P	31.45	3.30	28.15	30.21	4.76	25.45	9.32	5.49	23.83
Sucrose (T1) +H.F.C.S (T4)	G	65.48	43.25	22.23	64.24	44.81	20.43	63.13	45.68	19.04
	P	65.48	43.25	22.23	63.98	45.42	18.56	63.02	46.77	16.25
Sucrose + Stevia (T5)	G	48.45	18.70	29.75	47.32	19.80	27.52	45.93	20.61	25.32
	P	48.45	18.70	29.75	45.99	20.11	25.88	44.87	21.72	23.15
H.F.C.S + stevia (T6)	G	49.33	29.51	19.82	48.31	30.31	18.00	46.33	31.45	14.88
	P	49.33	29.51	19.82	48.32	30.78	17.54	46.16	31.82	14.34

N. R. sugar: Non - reducing sugar G: Glass Jar H.F.C.S: High fructose corn syrup P: Plastic Jar

Titratable Acidity (TA) (%)

The acid content of fruit is a key quality parameter and is an important factor in determining the taste of the fruit, Titratable acidity (TA) indicates the concentration of organic acids present in the fruit. Data in Table 5. indicate that total titratable acidity ranged between 1.93 to 2.68 % in all treatments at zero time. As for total acidity, it could be observed that a slight increase during storage occurred in all treatments sweetened with sucrose, high fructose corn syrup, stevia and their mixed (T6). The compote sweetened with stevia had the highest value for acidity at zero time and the end storage (2.68 and 2.94 %) respectively in peach compote. These results agree with those informed by (Abd EL-wahab 2007 and Mousa 2011). The acidity of peach compote showed a significant increase during storage, especially peach compote packaged in a glass jar compared to those packed in oxygen-high-permeability plastic. It may be due to the accumulation of the acidic components by dilapidation of pectin substance or oxidation of reducing sugars into acidic compounds. Good barrier properties of packages also affect the maintenance of acidity by keeping an oxygen-free environment, as observed in peach compote packaged in a glass jar (Del Caro 2004) and (Nath et al., 2011). Glass jar packed fruits could maintain a high level of acidity compared with packaged in plastic, this result agrees with (Singh and Pathak 2016) and (Mir 2018).

PH value

As for pH value, from data presented in Table 5. it could be concluded that it is nearly constant at a range from 3.99 to 3.31 after processing in all treatments with very slight decrements which occurred in all treatments during storage periods 4±2 °C, the lowest values for PH was 3.31 and 3.32 in treatment No.T2 packaged in glass and plastic jars respectively after 90 days of storage. It was obvious that there was an inverse relationship between PH value and acidity. On the other hand, the relatively lower pH values of packaged compote in a glass jar than in a plastic jar could be explained by the reduced oxygen rate in the package. Glass is impermeable to oxygen, which helps keep pH values low (Mathooko, 2003). These results were also in agreement with those informed by (Imtiaz, et al., 200), that the pH decreased in banana slices in the mixed solution effect of sucrose-glucose with increased storage period.

Table 5. Effect of different natural sweeteners and packaging materials on Ascorbic acid (mg/100g), Total acidity % and PH value of peach compote during storage for 3 months at 4 ± 2°C (on dry weight basis)

Treatment	Packaging materials	Storage periods (Days)								
		After processing (Zero time)			After 45 days			After 90 days		
		Ascorbic acid mg/100g	Total acidity %	PH value	Ascorbic acid mg/100g	Total acidity %	PH value	Ascorbic acid mg/100g	Total acidity %	PH value
control	G P	33.24 33.24	1.93 1.93	3.70 370	18.89 13.42	2.17 2.16	3.39 3.40	1.54 0.12	2.31 2.28	3.22 3.28
Sucrose (T1)	G P	32.81 32.81	2.24 2.24	3.50 3.50	20.33 19.75	2.32 2.29	3.42 3.45	9.84 9.22	2.58 2.56	3.38 3.41
H.F.C.S (T2)	G P	34.52 34.52	2.03 2.03	3.39 3.39	25.71 25.02	2.112. 11	3.33 3.34	10.38 10.11	2.17 2.15	3.31 3.32
Stevia (T3)	G P	58.71 58.71	2.68 2.68	3.99 3.99	36.58 46.13	2.792. 77	3.44 3.46	30.31 29.79	2.94 2.94	3.39 3.41
Sucrose + (H.F.C.S)(T4)	G P	31.18 31.18	2.01 2.01	3.52 3.52	20.77 20.31	2.18 2.16	3.48 3.49	12.56 12.13	2.24 2.23	3.44 3.46
Sucrose + Stevia (T5)	G P	46.71 46.71	2.15 2.15	3.62 3.62	38.21 37.88	2.28 2.21	3.44 3.45	25.36 24.98	2.56 2.55	3.41 3.43
H.F.C.S + stevia (T6)	G P	44.33 44.33	2.10 2.10	3.46 3.46	37.82 37.65	2.312. 25	3.37 3.38	23.61 23.54	2.54 2.53	3.32 3.35

G: Glass Jar - P: Plastic Jar

Total soluble solids (T.S.S)

Table 6. shows the effect of different natural sweeteners and packaging materials on the physical properties of peach compote after processing and during the storage period (3 months at 4±2°C). From the same table, it could be observed that the total soluble solids (T.S.S) varied between 10.25 % and 26.38% in compote sweetened with stevia and sucrose respectively after processing in all treatments (at zero time), it was also observed that the storage periods causes slight increments in (T.S.S) with all treatments except for the control treatment, it showed a significant decrease in (T.S.S) with an increase in the storage period, unlike the rest of the treatments, as it decreased from (10.98) at zero time to (6.12) at the end of storage, which might be due to the change of constituents between the fruit and solution covered by osmosis leading to such a condition. These results agree with results obtained by (Abd-El-Latif, 1995; Kalia et al., 1998, and Mousa 2011). It was also observed that treatments T5 and T6 retained a higher percentage of (T.S.S) at the end of the storage period compared to the rest of the treatments that retained a lower percentage of (T.S.S), perhaps due to the presence of stevia.

As total soluble solids were found to increase significantly during storage in all treatments.

This might be due to the moisture and oxygen that result in the breakdown of complex sugars of peach compote (Bhardwaj and Pandey 2011). Similar results were reported by (Dar et al., 2011). Also, (Petruccelli, et. al., 2023) reported that the value of TSS is strictly dependent on the concentration of sugars. it is noted that an Oxygen impermeable package prevented this change as is evident from the glass package. Similar results were shown by (Mir, et.al., 2018). The retention of total soluble solids was found more in plastic jars followed by glass jars might be due to moisture loss, and hydrolysis of polysaccharides Because plastic is permeable to water vapor, unlike glass (Singh, and Pathak, 2016).

Color

Results in Table 6., Also show the changes in color differences measured by Hunter during storage of peach compote sweetened with different natural sweeteners, their mixes and packaged in glass and plastic jars, All the tested parameters of Hunter lab difference *L*, *a* and *b* had a slight decrease throughout storage except for the control treatment, it showed a significant decrease in a and b with an increase in the storage period. The results showed that *the L* value (brightness) of the compote had slightly decreased. Moreover, the (*a*) value means the redness degree of the compote. When the compote becomes pal without shining, that means there is a decrease in (*a*) value. In addition, the lowest of (*b*) value reflects the reduction in the color of the prepared and stored compote. These results agree with (Mohamed et al., 2000 and Abd El-Wahab 2007). On the other hand, (Avila, and Silva, 2000) declared that Enzymatic browning is a serious problem when dealing with peaches due to the oxidative enzymes, such as peroxidase and polyphenols, may cause browning accompanied by changes in color, but those enzymes are inactivated, but many other reactions can take place affecting color. Carotenoid degradation and non-enzymatic browning (Maillard) reactions are the most common. Also, the quality of the color decreased with the increase of the storage period, especially in plastic jars, followed by glass jars, perhaps because of the interaction of the plastic with peach compote, as well as the result of the transparency of the containers and the effect of light (Akbudak and Eris, 2003) (Marsh and Bugusu, 2007).

Hardness

From the same Table 6. it could be noticed that the hardness had a slight decrease during storage of all treatments. The control sample showed a sharp decrease in the hardness of the peach from 0.93 at zero time to 0.09 at the end storage period. On the other hand, it could be observed that the compote sweetened with T5 (sucrose mixed with stevia) and T6 (H.F.C.S mixed with stevia) had the highest score (0.77 and 0.74) respectively. On the other hand, compote sweetened with T3 stevia had the lowest value of hardness (0.34) as shown in Table 6. The results agree with those reported by (Abd El-Wahab, 2007 and Mousa, 2011). The progressive decrease in the fruit hardness with the advancement of storage may be due to the effect of thermal processing where the most important changes in texture during thermal processing are related to the structure of both protopectin and pectin which is related to solubilization of pectic components, which is dependent on the degree of methylation (DM) of pectic polymers, and is associated with the heat (Carpita and Gibeaut, 1993).

The degree of methylation of pectin negatively correlates with tissue hardness, particularly after thermal treatment. The higher the methyl ester content, the lower the resistance toward texture degradation during cooking, also the solubilization of pectic compounds in the middle lamella leads to intercellular weakening and cell separation causing texture degradation (Daniel et al., 2005). Heat and pressure also affect the cell wall structure, leading to a reduction in cell wall adhesion and cell separation which starts at approximately 50°C (De Belie et al., 2002). Higher temperatures lead to tissue weakening and hence less hardness.

Table 6. Effect of different natural sweeteners and packaging materials on T.S.S %, Hardness (Kg) and color (Hunter lab) of peach compote during storage for 3 months at 4 ± 2°C

Treatments	Packaging materials	Storage Periods														
		After processing (Zero time)					After 45 days					After 90 days				
		T.S.S %	Hard-ness (Kg)	Hunter L	Hunter a	Hunter b	T.S.S %	Hard-ness (Kg)	Hunter L	Hunter a	Hunter b	T.S.S %	Hard-ness (Kg)	Hunter L	Hunter a	Hunter b
Control	G	10.98	0.93	55.63	4.13	20.34	9.16	0.28	47.52	3.21	16.56	6.12	0.09	39.84	1.41	12.66
	P	10.98	0.93	55.63	4.13	20.34	9.18	0.23	46.95	3.01	16.23	6.89	0.03	39.25	1.27	11.94
Sucrose (T1)	G	26.38	0.41	70.33	3.81	18.33	27.08	0.35	68.84	2.65	17.01	27.91	0.30	66.31	2.35	16.25
	P	26.38	0.41	70.33	3.81	18.33	27.36	0.33	68.23	2.62	16.87	27.95	0.29	60.98	2.31	16.04
H.F.C.S (T2)	G	25.46	0.56	69.74	4.05	20.51	26.34	0.42	68.13	3.24	16.84	26.94	0.33	67.91	2.15	14.26
	P	25.46	0.56	69.74	4.05	20.51	26.38	0.40	67.95	3.12	16.77	26.96	0.32	67.22	2.12	14.05
Stevia (T3)	G	10.25	0.34	70.81	2.54	23.44	11.48	0.28	69.54	2.15	17.32	12.82	0.19	68.24	1.87	15.83
	P	10.25	0.34	70.81	2.54	23.44	11.49	0.27	69.14	2.13	17.31	12.87	0.19	68.21	1.84	15.81
Sucrose + H.F.C.S (T4)	G	25.33	0.48	67.42	3.93	19.46	27.21	0.38	66.48	3.15	17.33	26.13	0.31	65.33	2.75	15.26
	P	25.33	0.48	67.42	3.93	19.46	27.24	0.36	66.16	3.14	17.26	27.45	0.30	65.14	2.72	15.21
Sucrose + Stevia (T5)	G	18.46	0.77	68.07	3.17	20.89	19.28	0.36	67.15	2.40	18.44	21.86	0.24	66.12	2.11	16.04
	P	18.46	0.77	68.07	3.17	20.89	19.29	0.35	67.13	2.42	18.41	21.87	0.23	66.05	2.11	16.01
H.F.C.S + stevia (T6)	G	17.46	0.74	70.35	3.29	21.97	19.91	0.35	68.79	2.90	17.36	24.38	0.26	67.33	2.51	15.06
	P	17.46	0.71	70.35	3.29	21.97	19.92	0.34	68.34	2.87	17.32	24.67	0.26	67.29	2.50	15.04

Total soluble solids (T.S.S), L= Lightness, G: Glass Jar, a = Redness, P: Plastic Jar, b = yellowness

Microbiological quality analysis of peach compote

It was a microbiological evaluation (total bacteria, total yeast, and mold). All evaluation tests were done 3 times (at zero time, after 45 days, and at the end of the storage period of 90 days).

From data in Table 7. all the products of peach compote sweetened with natural sweeteners and their mixes had microbial loads being lower than 30 × 10 -2 cfu/g, also they were free from yeasts and molds and this reflects the efficiency of the heat treatment used in processing and pasteurization (blanching). In addition to the conditions prevailing during preparation and packaging. These results are similar to those obtained by (Castello et. al.,2009). (Shin, et. al., 2023) declared that the intervention effect of hot water treatment as an effective decontamination technology on peach fruit from fungi (e.g., Monilinia sp.) and against decay caused by brown rot fungi (M. fructicola) during the post-harvest. On the other hand, it was found that the control treatment was higher in the growth of bacteria and the appearance of fungi compared to other treatments, perhaps as a result of the control treatment being free of sweeteners, which are considered a preserving factor for peach fruits throughout the storage period, and this result is consistent with (Nanaki, and Koroneos, 2018) reported that the fruits are covered with syrup and the mixture (peach halves and syrup) which leads to removing air, which aims at reducing microbial growth and therefore, extending the shelf life of the final product. It has been observed that compote packed in plastic is higher in bacterial growth compared to glass, because plastic is permeable to oxygen, allowing microbial growth during the storage period, within permissible limits but, they were Completely free from yeasts and molds and this is consistent with the Egyptian standard, which stipulates that peach compote is free of fungi and yeast.

Sensory evaluation

The sensory evaluation for peach compote packaged in different packaging materials with different sweeteners was analyzed at zero time and the end of storage periods (90 days) at 4±2 °C. Organoleptic evaluation data of compote was statistically analyzed. The mean comparison for parameters of colors, taste, odor, texture, and appearance used to evaluate is shown in Table 8. at zero time, which showed the average scores for organoleptic evaluation of compote, There was a decrease in the composite score during storage for all the compote, it could be observed that compote sweetened with T6 (H.F.C.S and stevia) had the highest score in color and texture (9.96, 9.65) compared with all sample and followed by T5 (sucrose + stevia) which (9.36 and 9.34) respectively. It also showed that the peaches had a slight decrease in color during the storage period. The color loss may be due to the Maillard reaction in peach slices. These results are comparable as accessible by (Kumar and Devi 2011 and Petruccelli, et. al., 2023).

Table 7. Effect of different natural sweeteners and Packaging Materials on Total Bacterial Counts (TBC) and Yeast & Mold (Y&M) (10^{-2} cfu / gm) of Peach compote during storage for 3 months at 4 ± 2°C

Treatments	Packaging Materials	Storage period: After processing (Zero time)		After 45 days		After 90 days	
		TBC	Y&M	TBC	Y&M	TBC	Y&M
control	G	2	ND	14	3	27	6
	P	2		16	5	29	8
Sucrose (T1)	G	ND	ND	4	ND	9	ND
	P			6		12	
H.F.C.S (T2)	G	ND	ND	5	ND	11	ND
	P			6		13	
Stevia (T3)	G	ND	ND	8	ND	17	ND
	P			8		19	
Sucrose + H.F.C.S (T4)	G	ND	ND	6	ND	11	ND
	P			7		13	
Sucrose + Stevia (T5)	G	ND	ND	6	ND	14	ND
	P			8		15	
H.F.C.S + stevia (T6)	G	ND	ND	7	ND	13	ND
	P			9		14	

ND: Not Detected

Table 8. Effect of different natural sweeteners and Packaging Materials on Sensory Evaluation of peach compote at Zero time

Treatment	Packaging Material	Color	Taste	Oder	Texture	Appearance
Control	G	9.61 ± 0.51^{a}	8.15 ± 0.40^{b}	8.67 ± 0.80^{ab}	9.11 ± 0.62^{a}	9.18 ± 0.78^{a}
	P	9.61 ± 0.50^{a}	8.06 ± 0.38^{b}	8.62 ± 0.74^{ab}	9.11 ± 0.62^{a}	9.18 ± 0.77^{a}
Sucrose (T1)	G	8.47 ± 0.38^{b}	8.44 ± 0.24^{b}	8.53 ± 0.62^{ab}	8.41 ± 0.23^{b}	8.48 ± 0.64^{b}
	P	8.41 ± 0.35^{b}	8.44 ± 0.24^{b}	8.47 ± 0.43^{b}	8.14 ± 0.05^{b}	8.36 ± 0.41^{b}
H.F.C.S (T2)	G	9.71 ± 0.84^{a}	9.24 ± 0.53^{a}	8.92 ± 0.64^{b}	9.17 ± 0.46^{a}	9.32 ± 0.13^{a}
	P	9.68 ± 0.80^{a}	9.24 ± 0.52^{a}	8.90 ± 0.63^{b}	9.11 ± 0.42^{a}	9.32 ± 0.13^{a}
Stevia (T3)	G	9.11 ± 0.17^{a}	8.46 ± 0.75^{b}	9.21 ± 0.84^{a}	8.57 ± 0.91^{ab}	8.61 ± 0.48^{ab}
	P	8.89 ± 0.62^{ab}	8.39 ± 0.72^{b}	8.82 ± 0.57^{ab}	8.26 ± 0.43^{b}	8.60 ± 0.45^{ab}
Sucrose+ H.F.C.S (T4)	G	8.41 ± 0.74^{b}	9.36 ± 0.84^{a}	9.11 ± 0.36^{a}	9.29 ± 0.44^{a}	9.61 ± 017^{a}
	P	8.40 ± 0.71^{b}	9.31 ± 0.82^{a}	8.68 ± 0.21^{ab}	9.14 ± 0.32^{a}	9.57 ± 0.12^{a}
Sucrose+ Stevia (T5)	G	9.36 ± 0.55^{a}	8.63 ± 0.62^{ab}	9.32 ± 0.76^{a}	9.34 ± 0.73^{a}	9.10 ± 0.81^{a}
	P	8.76 ± 0.53^{ab}	8.61 ± 0.59^{ab}	9.32 ± 0.74^{a}	9.25 ± 0.71^{a}	9.05 ± 0.76^{a}
H.F.C.S+ stevia (T6)	G	9.96 ± 0.13a	9.63 ± 0.07^{a}	9.35 ± 0.16^{a}	9.65 ± 0.12^{a}	9.54 ± 0.19^{a}
	P	9.95 ± 0.13^{a}	9.63 ± 0.07^{a}	9.35 ± 0.15^{a}	9.63 ± 0.10^{a}	9.48 ± 0.16^{a}
L.S.D		0.371	0.641	0.670	0.471	0.538

Values are represented as the mean ± SE. Means with different superscript in a Column differ significantly ($P<0.05$)

Results in Table 8. revealed that the peach compote at Zero time had high acceptability with all treatments and no significant difference between control and other treatments. At the end of the storage period. Table 9. shows a significant difference appeared between the treatments, as the sensory evaluation showed a clear and sharp decrease in the control sample with all measurements compared to the rest of the treatments, significantly ($P<0.05$) reduced from (9.18 to 3.16 and 1.73) packaged with glass and plastic jars respectively, while the highest score (8.64)with T6 about appearance. (Mir, et al., 2017). It was also noted that the samples of compote packaged in glass are more acceptable than those packed in plastic at the end of the storage period. Perhaps the permeability of the plastic makes it not retain the flavor compounds in the peach, which affects the taste and odor, as well as the interaction between the plastic and the sweetener solutions affects the color and appearance (Pongener et al., 2011). However, the statistical analysis revealed that the highest score with compote prepared T6 with mixed of H.F.C.S and stevia had the highest score in all sensory evaluations compared with the control sample and all treatments during storage. These data agree with those reported by (Uddin et al., 2002). These are very good results because stevia has been utilized commercially for sugar substitution in foods, beverages, and medicines, as a natural sweetener. Since the use of artificial sweeteners has recently been questioned, where, Stevia-incorporated products possess better-sweetening potency and also, the health-promoting effects of stevia, where the anti-hyperglycemic, anti-hypertensive, anti-caries, anti-inflammatory, and anti-cancer (Gandh, et al., 2018).

Table 9. Effect of different natural sweeteners and Packaging Materials on Sensory Evaluation of peach compote at the end storage (90 days)

Treatment	Packaging Material	Color	Taste	Oder	Texture	Appearance
control	G	5.83 ± 0.89^{c}	$3.8 4\pm 1.47^{cd}$	3.56 ± 1.32^{cd}	4.67 ± 0.36^{c}	3.16 ± 1.02^{d}
	P	3.14 ± 1.35^{cd}	2.67 ± 1.29^{d}	3.01 ± 1.06^{d}	3.52 ± 1.74^{cd}	1.73 ± 2.34^{d}
Sucrose (T1)	G	7.98 ± 0.74^{bc}	8.30 ± 0.79^{bc}	8.66 ± 0.21^{b}	8.13 ± 0.32^{bc}	8.21 ± 0.46^{bc}
	P	6.86 ± 0.56^{c}	7.54 ± 0.66^{c}	8.12 ± 0.13^{bc}	7.62 ± 0.24^{c}	7.49 ± 1.27^{c}
H.F.C.S (T2)	G	9.33 ± 0.18^{a}	9.15 ± 0.06^{a}	9.27 ± 0.48^{a}	8.54 ± 0.52^{b}	8.63 ± 0.98^{ab}
	P	9.14 ± 0.12^{a}	9.04 ± 0.13^{a}	9.11 ± 0.42^{a}	8.15 ± 0.81^{bc}	7.86 ± 0.22^{bc}
Stevia (T3)	G	8.97 ± 0.15^{ab}	8.14 ± 0.62^{b}	8.22 ± 0.33^{b}	8.13 ± 0.87^{b}	8.15 ± 0.87^{b}
	P	7.95 ± 0.36^{ab}	7.91 ± 0.43^{bc}	8.03 ± 0.21^{b}	7.54 ± 1.54^{bc}	7.02 ± 1.06^{bc}
Sucrose+	G	8.24 ± 0.87^{b}	9.63 ± 0.69^{a}	8.96 ± 0.18^{ab}	9.34 ± 0.88^{a}	8.38 ± 0.73^{b}
H.F.C.S (T4)	P	7.05 ± 0.65^{c}	8.94 ± 1.06^{ab}	8.74 ± 0.25^{ab}	8.91 ± 0.76^{ab}	8.16 ± 0.47^{bc}
Sucrose +	G	8.63 ± 0.47^{b}	8.27 ± 058^{bc}	8.66 ± 0.97^{b}	8.67 ± 0.53^{ab}	8.19 ± 0.38^{b}
Stevia (T5)	P	8.31 ± 0.25^{b}	7.19 ± 0.74^{c}	8.25 ± 0.73^{bc}	8.63 ± 0.48^{ab}	7.52 ± 1.08^{c}
H.F.C.S +	G	9.45 ± 0.18^{a}	9.48 ± 0.51^{a}	8.34 ± 0.22^{b}	9.79 ± 0.72^{a}	8.64 ± 0.57^{ab}
stevia (T6)	P	8.72 ± 0.06^{ab}	9.35 ± 0.32^{a}	7.88 ± 1.34^{bc}	9.75 ± 0.39^{a}	8.33 ± 0.38^{b}
L.S.D		0.373	1.325	0.481	0.520	0.416

Values are represented as the mean ± SE. Means with different superscript in a Column differ significantly ($P<0.05$)
G: Glass P: Plastic

4. Conclusion

Peach fruits have an important nutritional among fruits. it is a source of sugars, phenolic, carotenoids, and anthocyanins, and can also provide valuable antioxidants. but the peach fruit has a short life span after harvesting, so it could be clearly concluded through this study, that it is economic, technical and successful to utilize great quantities of peaches in manufacture of peach compote with different natural sweeteners, the sensory evaluation showed that the peach compote was acceptable and more palatable among the consumers and It was the best treatments T6 (peach slices sweetened with high fructose and stevia) followed by T5 (peach slices sweetened with sucrose and stevia) and packaged in glass. Finally, the result of this study We recommend packing peach compote in glass because it gave good preservation properties more than plastic throughout the storage period for 90 days, but if we had to pack it in plastic because it is characterized by light weight and is not subject to breakage like glass, we must reduce the validity period to 45 days only so that it is possible to consumption peach compote which is of good quality high before deteriorating.

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