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Assessment of the physicochemical and sensorial features of pasteurized cantaloupe juice during storage

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Abstract

The study evaluated the effect of pasteurization temperatures and storage methods on physicochemical properties and sensory attributes of cantaloupe juice. Cantaloupe juice was pasteurized at (85 °C/90 sec and 95 °C/45 sec) and the juice was stored at (4 °C and room temperature) for 28 days. Pasteurization at 95 °C for 45 seconds has a good effect on nutritional values compared with pasteurization at 85 °C for 90 seconds. The refrigerator storage at 4 °C for 28 days allowed maintaining a higher level of quality parameters compared to ambient storage. The results of HPLC analysis confirmed that flavonoids are primarily responsible for the antioxidant activity in the cantaloupe juice, which accounts for 43.71% of total phenolic compounds in the cantaloupe juice. Pasteurization at 85 °C/90 sec harmed sensory attributes while pasteurization at 95 °C/45 sec maintained all sensory attributes. Also, the increase in the storage period leads to a noticeable decrease in the sensory attributes.

Keywords: Cantaloupe, pasteurized, refrigerated, sensory attributes, physicochemical properties, storage

Introduction

The bioactive compounds such as vitamin C, carotenoids, total phenols, and flavonoids existing in fruit and vegetables restrict many risks of diseases, for biological impacts on public health (Garavand *et al.*, 2019; Harwansh *et al.*, 2019) ^[10, 12]. Also, it known by the ability of food protection purposes and many influences, like antimicrobial, antihypertensive, and antioxidant properties (Banožić *et al.*, 2020; Oliveira *et al.*, 2020) ^[3, 15].

Bioactive compounds existing in rich foods and drinks lessen the danger of generating chronic diseases like cardiovascular disease, atherosclerosis, cancer, diabetes, cataracts, cognitive control diseases, and neurological disorders (Biazotto *et al.*, 2019; Murador *et al.* 2019; Santamarina *et al.*, 2019; Mesquita *et al.*, 2020) ^[5, 22, 26, 18].

Cantaloupe (*Cucumis melo* L.) has a distinct flavor that makes it a popular crop to consumers. It is moderate quantities of bioactive substances, including phenolic compounds, vitamin C, pro-vitamin A (β-carotene), and folic acid, but is considered to have significant human health implications (Laur and Tian, 2011) ^[16]. The higher intake of carotenoids is associated with protection from chronic diseases like cardiovascular disease and carcinoma (Wang *et al.*, 2011) ^[32]. Phenolic compounds include a significant benefit in keeping healthy (Paul *et al.*, 2019) ^[23]. Cantaloupe honeydew contained 59.3-109.6 mg/100 of those component groups (INRA, 2009) ^[13]. Benzoic, vanilla and trans-cinnamic acids are the main phenols present in cantaloupes in large amounts, with small concentrations of p-coumaric acid, gallic acid, p-hydroxybenzoic acid, syringic acid, epicatechin, ferulic acid, protocatechuic acid, quercetin, chlorogenic acid, and rutin in cantaloupe juice (Kolayli *et al.*, 2010) ^[14].

Thermal technologies are used for juices to ensure enzyme inactivation, particularly at a pH of less than 4.5. This study investigates the influence of different pasteurization temperatures and storage periods at diverse temperatures on the initial quality attributes of cantaloupe juice.

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Materials and Methods

Materials and chemicals

Cantaloupe (*Cucumis melo* L. var. Bander) was collected from Ismailia, Egypt. The employed chemicals and reagents in this study were analytical grade brought from Sigma firm (St. Louis, USA)

Methods

Processing of cantaloupe

The fruits of cantaloupe were washed with tap water, drained until dried, peeled, and cut into small pieces, the juice got by Moulinex extractor (T574, France). The juice pH adjusted to pH 4 after 6.36 for fresh, the juice is divided into two flasks (500 ml), the primary flask heated to 90°C by boiling water (100°C) within the first water bath, and then put in another water bath adjusted at 90°C to stay the sample for 45 seconds. Similarly, the cantaloupe juice within the second flask pasteurized at 85°C for 90 seconds,

Table 1: The symbols are used for different treatments

Treatments	symbols
Fresh	F
Pasteurized 85°C/90sec + ambient storage	F1
Pasteurized 85°C/90sec + Storage at 4 °C	F2
Pasteurized 90°C/45sec + ambient storage	F3
Pasteurized 90°C/45sec + Storage at 4 °C	F4

90 ml of pasteurized juice placed in 100 ml of sealed sterile glass containers and stored under refrigerated conditions (4 ± 2 °C) and at room temperature (25 ± 5 °C) for 28 days. The analyses were achieved for fresh, after processing, and weekly after that throughout 28 days. The symbols used in various treatments are seen in Table 1.

Physicochemical analysis

Measurement of total soluble solids (TSS), pH, titrable acidity (TA), and vitamin C (VC)

TSS were estimated as Brix degrees using an Abbe refractometer (C10, Vee Gee, USA) at 20°C. The pH was monitored by pH meter Jenway 510 (Bibby Scientific Ltd. Stone, Staff, UK). TA and VC were calculated identical to (AOAC, 2000)^[2].

Measurement of the browning index, total carotenoids (TC), and color parameters

Browning index was assessed by Meydov *et al.* (1977)^[20] method as absorbance at 420 nm. TC determination was achieved by Barros *et al.* (2011)^[4] methods as β -carotene. Color parameters (CIE L*, a*, and b*) were performed by Konika Minolta reader (CR-10, Inc., Osaka, Japan). Hue angle and chroma were calculated from a* and b* values.

Determination of antioxidant activity (AA) and total phenolics (TP)

The DPPH method was employed for AA determination according to Ravichandran *et al.* (2013)^[25]. TP was calculated as stated by Ferrante *et al.* (2004) and Spadafora *et al.* (2016)^[8, 28].

Fractionation of phenolic compounds using HPLC

Phenolic components fractionated by HPLC as described by

Goupy *et al.* (1999) and Mattila *et al.* (2000)^[11, 17]. 5 grams of cantaloupe juice were centrifuged for 10 min with methanol at 1000 rpm. A 0.2-micrometer membrane filter is employed to obtain 1–3 ml extract to injection in HPLC Hewlett Packard (Series 1050) with an automatic sample injector, solvent degassed, ultraviolet detector adjusted at 280 nm, and a quarter pump HP (series1050). Phenols identified by C18 (BDS 5 μ m, Labio, Czech Republic) column (250 x 4 mm, i.d.). Acetonitrile and methanol were used as a gradient separation at flow rate 1 ml/min, and the column was kept at 35°C. Thirteen standard phenolic compounds from Sigma Co., (St. Louis, USA) were injected into HPLC. Retention time and peak area were used to calculate phenolics concentration from the 63 data analysis of Hewlett Packed software.

Sensory evaluation

The method of Min *et al.* (2003)^[19] was used for sensory attributes determination. Ten panelists of Food Technology Institute members, Ismailia, Egypt, conducted a sensory assessment. The panelists assign a suitable score for characteristic color, taste, odor, appearance, mouthfeel, and overall acceptability from 9 points.

Statistical analysis

All values were analyzed in triplicate and represented as means \pm SD (standard deviation). Statistical analyses of data were performed with the COSTAT software (version 6311) at $P \leq 0.05$. 3.

3. Results

The effects of various pasteurization temperatures and storage on TSS, pH, acidity, and absorption at 420 nm, ascorbic acid, total phenols, carotenoids, and AA of cantaloupe juice are revealed in Table 2.

TSS

No significant changes were initiated in TSS among all treatments used and the fresh sample at zero time. TSS increased significantly during storage for 4 weeks in the whole treatments. F4 did not record any changes after 4 weeks compared with the fresh sample and their value at zero time. The importance of chilled storing and pasteurization at 90 °C on maintaining TSS from change has appeared from the results.

pH and acidity

There were no major variations in pH and acidity in treated samples at zero time. By storage ending, the chilled sample (F4 and F2) held the minimal acidity of cantaloupe juice (0.44 ± 0.03 , 0.47 ± 0.04), with no noticeable difference between them and the fresh sample (0.38 ± 0.06).

Browning (absorption at 420)

As regards absorption at 420 cantaloupe juice, increasing pasteurization temperatures to 90°C, as in (F3, F4) increasing absorption at 420 at zero, while pasteurization at (85°C) showed a mild rise in cantaloupe juice browning. The increase in browning continued during storage, with lower browning of the refrigerated samples (F4, F2), especially F4 with a value (0.158 ± 0.15).

Vitamin C

Table 2: Impact of various pasteurized temperatures and storage on TSS, pH, acidity, absorption, vitamin C, total phenols, carotenoids, and DPPH of cantaloupe juice

Sample	Storage weeks	TSS%	pH	Acidity%	Absorption ₄₂₀	vitamin C mg/100g	T. phenols mg/100g	Carotenoids µg/100g	DPPH%
F	Fresh	10.41±0.22 ^f	6.36±0.05 ^a	0.38±0.06 ^{bcd}	0.089±0.012 ^m	56.54±0.05 ^a	127.01±0.38 ^a	817.42±0.32 ^a	34.9±0.35 ^{ghi}
F1	0 time	10.42±0.13 ^f	4.00±0.06 ^b	0.37±0.05 ^{bcd}	0.098±0.005 ^{im}	50.18±0.16 ^c	113.24±0.39 ^f	802.67±0.37 ^c	37.41±0.24 ^e
	1 week	10.55±0.21 ^{cdef}	3.97±0.05 ^b	0.41±0.03 ^{abcd}	0.119±0.003 ^{jk}	47.16±0.13 ^g	103.84±0.08 ^l	769.12±0.18 ^g	35.91±0.48 ^f
	2 week	10.73±0.14 ^{abcde}	3.92±0.04 ^b	0.44±0.05 ^{abcd}	0.154±0.007 ^{efg}	44.01±0.08 ^k	92.65±0.05 ^m	729.95±0.62 ^l	34.87±0.27 ^{ghi}
	3Week	10.84±0.09 ^{abc}	3.89±0.12 ^a	0.48±0.03 ^{ab}	0.193±0.009 ^{bc}	39.82±0.09 ^p	82.79±0.20 ^p	693.46±0.35 ^p	33.44±0.35 ^{jk}
	4week	10.92±0.05 ^a	3.89±0.05 ^a	0.51±0.04 ^a	0.228±0.012 ^a	36.02±0.06 ^s	75.66±0.24 ^q	661.13±3.32 ^r	31.03±0.43 ^l
F2	0 time	10.43±0.16 ^{ef}	4.00±0.07 ^b	0.37±0.04 ^{bcd}	0.096±0.011 ^{lm}	51.23±0.08 ^b	114.85±0.05 ^d	801.37±0.51 ^c	36.84±0.31 ^e
	1 week	10.48±0.15 ^{def}	4.00±0.04 ^b	0.39±0.05 ^{bcd}	0.123±0.012 ^{ijk}	49.60±0.12 ^d	107.75±0.04 ^g	776.42±0.29 ^e	35.06±0.05 ^{gh}
	2 week	10.59±0.18 ^{bcdef}	3.98±0.05 ^b	0.41±0.09 ^{abcd}	0.155±0.008 ^{efg}	44.67±0.07 ^j	102.62±0.18 ^l	748.23±0.47 ⁱ	34.28±0.13 ^{hij}
	3Week	10.76±0.32 ^{abcd}	3.96±0.08 ^b	0.44±0.07 ^{abcd}	0.171±0.005 ^{de}	42.15±0.04 ^m	92.72±0.13 ^m	727.69±1.62 ^m	33.71±0.34 ⁱ
	4week	10.76±0.12 ^{abcd}	3.95±0.09 ^b	0.47±0.04 ^{abc}	0.183±0.007 ^{cd}	39.60±0.03 ^q	84.40±0.28 ^o	697.64±0.77 ^o	32.78±0.67 ^k
F3	0 time	10.45±0.14 ^{def}	4.00±0.06 ^b	0.35±0.06 ^d	0.119±0.006 ^{jk}	47.08±0.11 ^g	122.16±0.32 ^c	806.75±0.84 ^b	39.75±0.40 ^{ab}
	1 week	10.53±0.09 ^{cdef}	3.99±0.05 ^b	0.38±0.07 ^{bcd}	0.138±0.008 ^{ghi}	49.50±0.10 ^d	113.43±0.36 ^f	771.66±2.06 ^f	38.92±0.29 ^{bc}
	2 week	10.69±0.17 ^{abcde}	3.97±0.04 ^b	0.43±0.03 ^{abcd}	0.161±0.013 ^{ef}	46.81±0.14 ^h	105.94±0.44 ^h	735.84±0.35 ^j	37.42±0.23 ^e
	3Week	10.75±0.25 ^{abcde}	3.96±0.10 ^b	0.48±0.09 ^{ab}	0.184±0.014 ^{cd}	40.05±0.16 ^o	90.37±0.56 ^r	702.35±0.20 ⁿ	35.67±0.95 ^{fg}
	4week	10.88±0.15 ^{ab}	3.93±0.06 ^b	0.51±0.10 ^a	0.204±0.004 ^b	37.18±0.22 ^r	87.27±0.31 ⁿ	677.41±0.82 ^q	34.18±0.71 ^{ij}
F4	0 time	10.44±0.18 ^{def}	4.00±0.05 ^b	0.36±0.08 ^{cd}	0.111±0.005 ^{kl}	49.13±0.07 ^e	124.62±0.22 ^b	805.57±0.34 ^b	40.14±0.55 ^a
	1 week	10.46±0.15 ^{def}	3.99±0.12 ^b	0.37±0.03 ^{bcd}	0.124±0.020 ^{hij}	47.75±0.04 ^f	114.24±0.42 ^c	787.74±0.17 ^d	39.15±0.64 ^{bc}
	2 week	10.49±0.12 ^{def}	3.99±0.14 ^b	0.39±0.07 ^{bcd}	0.132±0.007 ^{hij}	45.15±0.14 ⁱ	107.81±0.09 ^g	765.65±0.33 ^b	38.33±0.47 ^{cd}
	3Week	10.53±0.08 ^{cdef}	3.97±0.11 ^b	0.42±0.01 ^{abcd}	0.149±0.011 ^{gh}	43.36±0.15 ^l	100.43±0.08 ^k	749.71±0.15 ⁱ	37.54±0.47 ^{de}
	4week	10.56±0.10 ^{cdef}	3.97±0.12 ^b	0.44±0.03 ^{abcd}	0.158±0.015 ^{ef}	41.54±0.06 ⁿ	94.65±0.14 ^l	732.11±0.17 ^k	36.92±0.73 ^e

The values are the mean ± margin of confidence intervals at 95%.

Data in the same column with different letters differ significantly ($p < 0.05$).

Vitamin C was decreased immediately after thermal treatment relative to the fresh sample. Over the storage cycle the destruction of vitamin C continues, but cold samples (F4, F2) retain significant quantities of vitamin (41.54 ± 0.06; 39.60 ± 0.03 mg/100g) (F1, F3). The use of refrigerated storage with a higher degree of pasteurization (90°C) resulted in a higher content of vitamin C after storage as F4 did.

Carotenoids

The temperature used for pasteurization cantaloupe juice decreased carotenoid content compared to fresh samples. Pasteurized cantaloupe juice at 90°C for 45 seconds has a beneficial effect on carotenoids maintained at storage ending. Previous findings have declared the importance of pasteurization time on the maintenance of carotenoids. Carotenoids were decreased after 4 weeks of storage. The refrigerated samples, specifically F4, gave the lowest decrement by storage ending with a value of 732.11±0.17, followed by F2 at 697.4±0.77.

Antioxidant activity% (AA)

The antioxidant function in fruit has returned to vitamin C,

carotenoids, and polyphenols. The findings revealed that pasteurization in particular at 90°C increased the AA in cantaloupe juice after processing compared to the fresh sample. The destruction of cell membranes and walls by thermal processing-increased AA due to releases carotenoids from the insoluble components of the cantaloupe, which increases the bioaccessibility of carotenoids. Besides the release of certain individual phenolic acids from their complex compounds. During storage, there was a decline in AA in the different samples, and F1 was the lowest. This loss came back to destroy vitamin C, polyphenols, and carotenoids. F4 showed maximal AA% (36.92±0.73) at storage ending.

Identification of phenolic compounds by HPLC

Table 3 summarizes the findings of quantified and separate phenols of cantaloupe juice analyzed by HPLC. The TP in fresh sample was 139.01±0.14 mg/100g as gallic acid. The flavonoids (Flavan3-ols) group, which comprises catechin, epicatechin, epicatechin gallate, has the highest percentage of TP with a quantity of up to 60.77 mg/100 g

Table 3: Impact of various pasteurized temperatures and storage on the concentration of phenolic compounds identified in different treatments of cantaloupe juice

Identification	Rt	F1		F2		F3		F4		
		Fresh	0 time	4 week	0 time	4 week	0 time	4 week	0 time	4 week
mg/100g (fresh weight)										
Hydroxybenzoic acid derivatives										
Pyrogalllic	2.08	7.63±0.05 ^a	6.88±0.08 ^b	4.81±0.02 ^c	6.96±0.62 ^b	5.29±0.06 ^d	7.37±0.08 ^a	5.45±0.21 ^d	7.50±0.12 ^a	5.86±0.12 ^c
Gallic	2.18	9.32±0.07 ^a	8.39±0.05 ^c	5.88±0.06 ^f	8.50±0.28 ^c	6.46±0.23 ^c	8.99±0.04 ^b	6.65±0.18 ^e	9.16±0.13 ^{ab}	7.15±0.15 ^d
P OH Benzoic-3-o-glucoside	3.63	3.37±0.05 ^a	3.04±0.08 ^b	2.13±0.05 ^e	3.08±0.05 ^b	2.34±0.05 ^{cd}	3.25±0.08 ^{ab}	2.41±0.03 ^{cd}	3.31±0.08 ^a	2.59±0.33 ^c
P OH Benzoic acid	8.40	2.32±0.07 ^a	2.09±0.13 ^{abc}	1.46±0.04 ^d	2.12±0.54 ^{ab}	1.61±0.07 ^d	2.24±0.20 ^a	1.66±0.06 ^{cd}	2.28±0.25 ^a	1.78±0.34 ^{bcd}
Flavan 3-ols										
Catechin	2.82	23.95±0.04 ^a	21.57±0.21 ^d	15.10±0.05 ^h	21.85±0.52 ^d	16.61±0.12 ^g	23.11±0.24 ^c	17.10±0.06 ^f	23.54±0.21 ^b	18.37±0.24 ^c
Epi-catechin	2.96	49.61±0.25 ^a	44.70±0.16 ^c	31.28±0.04 ^f	45.27±0.15 ^d	34.40±0.07 ^h	47.88±0.05 ^c	35.43±0.08 ^g	48.76±0.37 ^b	38.06±0.34 ^f

Epi-catechin gallate	3.19	3.53±0.07 ^a	3.18±0.11 ^b	2.23±0.06 ^e	3.22±0.06 ^b	2.45±0.08 ^d	3.41±0.06 ^a	2.52±0.05 ^d	3.47±0.06 ^a	2.71±0.21 ^c
Hydroxycinnamic acids										
Protocatechuic	2.43	3.31±0.12 ^a	2.98±0.04 ^b	2.09±0.18 ^d	3.02±0.19 ^{ab}	2.29±0.31 ^{cd}	3.19±0.17 ^{ab}	2.36±0.05 ^{cd}	3.25±0.05 ^{ab}	2.54±0.08 ^c
Chlorogenic acid	2.61	8.17±0.02 ^a	7.36±0.34 ^b	5.15±0.07 ^c	7.46±0.13 ^b	5.67±0.17 ^d	7.89±0.34 ^a	5.84±0.14 ^d	8.03±0.14 ^a	6.27±0.07 ^c
Caffeic acid	3.91	0.57±0.06 ^a	0.52±0.02 ^{ab}	0.36±0.12 ^c	0.52±0.08 ^{ab}	0.40±0.04 ^{bc}	0.55±0.13 ^a	0.41±0.04 ^{bc}	0.56±0.09 ^a	0.44±0.02 ^{abc}
Syringic acid	4.11	0.16±0.01 ^a	0.14±0.07 ^a	0.10±0.03 ^a	0.15±0.12 ^a	0.11±0.09 ^a	0.15±0.12 ^a	0.11±0.03 ^a	0.16±0.04 ^a	0.12±0.06 ^a
Vanillic acid	4.73	6.20±0.05 ^a	5.59±0.04 ^c	3.91±0.08 ^f	5.66±0.33 ^{bc}	4.30±0.11 ^e	5.99±0.26 ^{ab}	4.43±0.06 ^{de}	6.09±0.18 ^a	4.76±0.42 ^d
P-coumaric acid	5.98	2.99±0.06 ^a	2.69±0.05 ^b	1.89±0.07 ^d	2.73±0.17 ^{ab}	2.07±0.12 ^{cd}	2.89±0.06 ^{ab}	2.13±0.19 ^{cd}	2.94±0.23 ^{ab}	2.29±0.27 ^c
Ferulic acid	6.14	0.76±0.14 ^a	0.69±0.03 ^a	0.48±0.14 ^a	0.70±0.20 ^a	0.53±0.03 ^a	0.74±0.23 ^a	0.55±0.05 ^a	0.75±0.32 ^a	0.59±0.13 ^a
Iso ferulic	6.22	0.41±0.11 ^a	0.37±0.06 ^a	0.26±0.09 ^a	0.38±0.06 ^a	0.29±0.06 ^a	0.40±0.04 ^a	0.30±0.07 ^a	0.41±0.17 ^a	0.32±0.18 ^a
E- vanillic	8.12	0.16±0.04 ^a	0.14±0.09 ^a	0.10±0.07 ^a	0.15±0.07 ^a	0.11±0.04 ^a	0.15±0.07 ^a	0.11±0.05 ^a	0.16±0.03 ^a	0.12±0.06 ^a
O-coumaric	8.24	3.05±0.06 ^a	2.75±0.11 ^{ab}	1.93±0.05 ^c	2.79±0.46 ^{ab}	2.12±0.06 ^c	2.95±0.33 ^a	2.18±0.47 ^c	3.00±0.05 ^a	2.34±0.09 ^{bc}
Cinnamic acid	12.55	3.94±0.15 ^a	3.55±0.08 ^a	2.49±0.06 ^c	3.60±0.15 ^a	2.73±0.18 ^{bc}	3.81±0.63 ^a	2.82±0.04 ^{bc}	3.88±0.16 ^a	3.03±0.12 ^b
Hydrolyzed tannins										
Pyrogallol	2.29	9.45±0.13 ^a	8.51±0.03 ^c	5.96±0.01 ^f	8.62±0.21 ^c	6.55±0.27 ^e	9.12±0.03 ^b	6.75±0.03 ^c	9.28±0.08 ^{ab}	7.25±0.14 ^d
Ellagic acid and derivatives										
Ellagic acid	6.75	0.10±0.02 ^a	0.09±0.05 ^a	0.06±0.11 ^a	0.09±0.04 ^a	0.07±0.02 ^a	0.09±0.03 ^a	0.07±0.04 ^a	0.09±0.01 ^a	0.07±0.05 ^a
Total		139.01±0.14	125.23±0.09	87.66±0.08	126.85±0.22	96.40±0.13	134.16±0.16	99.27±0.11	136.62±0.14	106.65±0.17

The values are the mean ± margin of confidence intervals at 95%.

Data in the same row with different letters differ significantly ($p < 0.05$).

of 139.01±0.14 mg/100 g, with a level of 43.71% of TP in a fresh sample. The hydroxybenzoic acid group plus the hydroxycinnamic group represent the phenolic acids in cantaloupe juice. The hydroxycinnamic acid group is composed of a of 21.37% of TP, containing compounds such as, protocatechuic acid, chlorogenic acid, caffeic acid, syringic acid, vanillic acid, P-coumaric acid, ferulic acid, isoferulic acid, E-vanillic acid, O-coumaric acid, and cinnamic acid. The hydroxybenzoic acid group presented by 10.79% of TP, which contained gallic acid, P-hydroxy benzoic-3-O-glucoside, and P-hydroxy benzoic acid. The hydrolyzed group of tannins, which comprises pyrogallol and pyrogallol consists of 12.28% from TP in fresh sample. The ellagic acid group derivatives include ellagic acid alone, which accounted for 0.072% of TP in a fresh sample. The results showed that the TP content decreased to 125.23±0.09 with a loss rate of 1.71%–9.86% during the pasteurization process. The results also reveal that pasteurization at 90 °C/45 seconds had kept on TP compared to pasteurized at 85 °C for 90 seconds. The drop in TP continued over 28 days of storing. Samples kept at room temperature recorded a loss rate of TP between (31.34 and 37%) compared to (23.27 to 28.58%) for samples stored at 4 °C. Based on these results, the refrigerated

juice had kept a higher amount of TP than stored at room temperature by percent range (8.07 to 8.42%). The rate loss of (T1, T2, T3, and T4) were (36.93, 30.65, 28.58, and 23.27%) at the end of storage.

Color parameter of pasteurized cantaloupe juice during storage

The findings showed in Table 4 is regarding the color values L, a, b, Hue, and chroma for cantaloupe juice. The thermal treatments showed a significant decrease in L* values after heat processing, especially in samples pasteurized at 85 °C such as F1, F2 (76.18±0.73 and 76.08±0.11) while, F4 was the greatest L* (77.30±0.18). There has been a significant decrease in the L* value of samples stored at room temperature than refrigerated samples. F4 recorded the highest L* value (75.13±0.21), followed by F2 with a value of (74.67±0.13) while, F1 was the lowest treatment at the storage ending. Concerning a* value, both treatments have shown that a* is lower than the fresh sample. Pasteurization at 90 °C/45 seconds, preserved a* compared to 85 °C/90 seconds due to a lack of carotenoid degradation that responds to yellow, orange, and red. When the storage effects comparing,

Table 4: Impact of various pasteurized temperatures and storage on L*, a*, b*, Hue and Chroma of cantaloupe juice

Sample	Storage weeks	L*	a*	b*	Hue	Chroma
F	Fresh	79.17±0.07 ^a	2.34±0.08 ^a	5.44±0.15 ^a	66.73±0.14 ^m	5.92±0.17 ^a
F1	0 time	76.18±0.73 ^{de}	1.36±0.08 ^{bc}	3.91±0.4 ^{bc}	70.82±0.86 ^{klj}	4.14±0.06 ^{bc}
	1 week	74.87±0.56 ^{hi}	1.19±0.05 ^{de}	3.65±0.05 ^d	71.94±0.48 ^{hijk}	3.84±0.06 ^{ef}
	2 week	73.71±0.40 ^{jk}	0.94±0.09 ^{ghi}	3.33±0.06 ^{ef}	74.24±1.16 ^{defg}	3.46±0.08 ^g
	3 Week	72.83±0.34 ^l	0.71±0.05 ^{kl}	2.97±0.10 ^{ij}	76.56±0.48 ^{bc}	3.05±0.11 ^{jk}
	4 week	71.45±0.16 ^m	0.48±0.06 ^m	2.65±0.08 ^k	79.73±0.95 ^a	2.69±0.09 ^l
F2	0 time	76.08±0.11 ^{de}	1.38±0.05 ^b	3.93±0.09 ^{bc}	70.65±0.24 ^{klj}	4.17±0.10 ^{bc}
	1 week	75.86±0.08 ^{ef}	1.19±0.08 ^{de}	3.72±0.05 ^{cd}	72.26±0.89 ^{ghij}	3.91±0.07 ^{df}
	2 week	75.29±0.07 ^{fghi}	1.02±0.03 ^{fg}	3.54±0.06 ^{de}	73.93±0.19 ^{efgh}	3.68±0.07 ^f
	3 Week	74.95±0.16 ^{hi}	0.88±0.11 ^{ghij}	3.29±0.04 ^{fg}	75.03±1.61 ^{cdef}	3.41±0.07 ^{gh}
	4 week	74.67±0.13 ⁱ	0.76±0.05 ^{kl}	3.08±0.08 ^{ghij}	76.14±0.53 ^{abcd}	3.17±0.09 ^{ij}
F3	0 time	77.14±0.55 ^{bc}	1.52±0.06 ^b	3.96±0.05 ^b	69.00±0.51 ^l	4.24±0.07 ^{bc}
	1 week	76.67±0.64 ^{cd}	1.21±0.08 ^{cd}	3.61±0.09 ^d	71.47±0.43 ^{ijk}	3.81±0.10 ^{ef}
	2 week	75.54±0.47 ^{efgh}	0.99±0.11 ^{fgh}	3.27±0.06 ^{fgh}	73.16±1.47 ^{fghi}	3.42±0.09 ^{gh}
	3 Week	74.03±0.24 ^j	0.78±0.13 ^{ijkl}	3.06±0.10 ^{hij}	75.70±1.84 ^{bcde}	3.16±0.13 ^{ij}
	4 week	73.15±0.13 ^{kl}	0.63±0.07 ^{lm}	2.89±0.07 ^j	77.70±1.04 ^b	2.96±0.08 ^k
F4	0 time	77.30±0.18 ^b	1.48±0.13 ^b	4.04±0.14 ^b	69.88±0.99 ^{kl}	4.30±0.18 ^b
	1 week	76.08±0.22 ^{de}	1.13±0.07 ^{def}	3.91±0.04 ^{bc}	73.88±0.79 ^{efgh}	4.07±0.06 ^{cd}
	2 week	75.68±0.60 ^{efg}	1.03±0.06 ^{efg}	3.53±0.12 ^{de}	73.73±0.37 ^{efgh}	3.68±0.13 ^f
	3 Week	75.34±0.16 ^{fghi}	0.97±0.05 ^{fgh}	3.33±0.08 ^{ef}	73.76±0.42 ^{efgh}	3.47±0.09 ^g

	4week	75.13±0.21 ^{ghi}	0.83±0.22 ^{hijk}	3.15±0.05 ^{fghi}	75.24±3.52 ^{cdef}	3.26±0.10 ^{hi}
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The values are the mean ± margin of confidence intervals at 95%.

Data in the same column with different letters differ significantly ($p < 0.05$).

a*value (F2, F4) of the samples stored at 4 °C remained higher than (F1, F3). F4 with a range of (0.83±0.22) had the maximal value of a*. The fresh sample was more representing to yellow (66.73) due to the higher content of carotenoids. The increased hue value (77) due to the destruction of the carotenoids by processing and storage made color-approaching green-yellow. F4 held the lowest hue (75.24 ± 3.52) in contrast to other treatments by storage end. The same pattern of decline in L, a, b, and hue realized by chroma (color clarity). After processing, color clarity decreased, and the sequence of treatments is in terms of preference (F4, F3, F2, and F1). A higher temperature for a short time (90°C/45sec) was better than the lower temperature for a long time (85°C/90sec). The order of sample preferences by storage end was (F4, F2, F3, and F1). The previous results declared that the cold storage of cantaloupe juice pasteurized for a short time (90 °C/45sec) was the desired.

Sensory attributes of pasteurized cantaloupe juice during storage

Table 5 displays the scores of various sensory qualities for cantaloupe juice at zero time and after storage. Comparing samples after processing with fresh samples revealed a substantial decline in all sensory attributes such as taste,

color, odor, appearance, mouthfeel, and overall acceptability. No major differences were identified between the three treatments (F4, F3, F2) at zero time. During storage, there was a substantial decline in all sensory attributes of the different treatments under study. F4 was the best treatment with maximum overall acceptability (7.41±0.04) followed by F2, both of which were kept in cold conditions.

Discussion

The results suggest that the temperatures used for pasteurization did not contribute to changes in TSS content at the start of storage. TSS differences after storage were marginally minor and pasteurization at 90 °C/45 sec with refrigerated storage reported the lowest changes in TSS.

As for pH, no variations were found between treatments after adjusted pH and thermal treated at zero time. Also, storage temperature did not influence the pH because there were no undesirable changes compared to the samples at zero time. No effects of various treatments on the acidity of cantaloupe juice were also found at the start or end of storage after 28 days of storage.

Vitamin C is considered an indicator of the nutritional values of fruit juices (Rabie *et al.*, 2015) [24].

Table 5: Impact of various pasteurized temperatures and storage on taste, color, odor, appearance, mouthful, and overall acceptability of cantaloupe juice

Sample	Storage weeks	Taste (9)	Color (9)	Odor (9)	Appearance (9)	Mouthfeel (9)	Overall acceptability (9)
F	Fresh	8.43±0.03 ^a	9.00±0.00 ^a	8.68±0.06 ^a	8.64±0.22 ^a	8.72±0.03 ^a	8.69±0.07 ^a
F1	0 time	7.96±0.09 ^{cd}	8.05±0.07 ^{hi}	7.83±0.07 ^e	7.89±0.05 ^{ef}	8.14±0.06 ^{bc}	7.97±0.07 ^d
	1week	7.73±0.05 ^{fg}	7.93±0.04 ^{ij}	7.63±0.11 ^f	7.70±0.04 ^{gh}	7.73±0.05 ^e	7.74±0.06 ^{ef}
	2 week	7.39±0.04 ⁱ	7.81±0.12 ^{jk}	7.42±0.02 ^{gh}	7.43±0.13 ⁱ	7.28±0.03 ^f	7.47±0.07 ^e
	3Week	7.17±0.13 ^{jk}	7.68±0.16 ^{kl}	7.19±0.06 ^{ij}	7.19±0.15 ^j	6.91±0.06 ^g	7.23±0.11 ^h
	4week	6.82±0.06 ^l	7.52±0.18 ^l	6.92±0.07 ^k	6.90±0.08 ^k	6.53±0.07 ^h	6.94±0.09 ^j
F2	0 time	8.03±0.04 ^{bc}	8.44±0.13 ^{cd}	8.02±0.04 ^{cd}	8.23±0.05 ^{bc}	8.03±0.12 ^{cd}	8.15±0.08 ^c
	1week	7.76±0.05 ^{fg}	8.35±0.08 ^{cde}	7.90±0.14 ^{de}	8.05±0.05 ^{de}	7.74±0.08 ^e	7.96±0.08 ^d
	2 week	7.61±0.07 ^h	8.24±0.07 ^{efgh}	7.66±0.12 ^f	7.68±0.04 ^{gh}	7.38±0.07 ^f	7.71±0.07 ^f
	3Week	7.28±0.04 ^j	8.15±0.06 ^{fgh}	7.40±0.07 ^h	7.36±0.08 ⁱ	6.92±0.6 ^g	7.42±0.06 ^g
	4week	7.11±0.07 ^k	7.93±0.03 ^{ij}	7.22±0.17 ^{ij}	7.14±0.08 ^j	6.56±0.02 ^h	7.19±0.07 ^{hi}
F3	0 time	8.07±0.03 ^b	8.52±0.21 ^{bc}	8.14±0.13 ^c	8.27±0.04 ^b	8.09±0.12 ^c	8.22±0.11 ^c
	1week	7.83±0.02 ^{cf}	8.31±0.16 ^{defg}	7.44±0.08 ^{gh}	7.94±0.14 ^{def}	7.79±0.04 ^{de}	7.86±0.09 ^{de}
	2 week	7.61±0.06 ^h	8.14±0.14 ^{gh}	7.67±0.04 ^f	7.62±0.03 ^h	7.33±0.02 ^f	7.67±0.06 ^f
	3Week	7.26±0.11 ^j	7.92±0.08 ^{ij}	7.31±0.03 ^{hi}	7.36±0.02 ⁱ	6.82±0.10 ^g	7.33±0.07 ^{gh}
	4week	6.92±0.05 ^l	7.71±0.09 ^k	7.14±0.15 ^j	7.07±0.06 ^j	6.48±0.15 ^h	7.06±0.10 ^{ij}
F4	0 time	8.11±0.05 ^b	8.63±0.04 ^b	8.35±0.07 ^b	8.33±0.18 ^b	8.36±0.04 ^b	8.36±0.08 ^b
	1week	7.92±0.01 ^{de}	8.34±0.04 ^{cdef}	8.17±0.05 ^c	8.08±0.12 ^{cd}	8.12±0.12 ^{bc}	8.13±0.07 ^c
	2 week	7.66±0.08 ^{gh}	8.30±0.02 ^{defg}	8.04±0.09 ^{cd}	7.80±0.03 ^{fg}	7.70±0.05 ^e	7.90±0.05 ^d
	3Week	7.47±0.04 ⁱ	8.17±0.03 ^{efgh}	7.89±0.02 ^{de}	7.68±0.05 ^{gh}	7.35±0.06 ^f	7.71±0.04 ^f
	4week	7.19±0.06 ^{jk}	8.05±0.05 ^{hi}	7.56±0.03 ^{fg}	7.43±0.02 ⁱ	6.83±0.02 ^g	7.41±0.04 ^g

The values are the mean ± margin of confidence intervals at 95%.

Data in the same column with different letters differ significantly ($p < 0.05$).

Vitamin C is one of the important bioactive compounds affected by the level of temperature and industrial practices during processing. The temperature used for pasteurization decreased vitamin C after processing compared to the fresh sample. Increasing the degree of pasteurization reduced the vitamin C content compared with lower temperature. However, the higher degree (90 °C) maintained the vitamin eventually of storage. The storage temperature was a significant effect on the residual vitamin, and the cold storage retained a higher amount of vitamin C. VC content decreased

dramatically during storage. This decline was due to the dissolved oxygen in the headspace in the early stages of storage, which oxidized ascorbic acid in the juice or by light exposure (Embaby and Mokhtar, 2019) [7].

A strong correlation was found between the higher vitamin C content and the reduction of browning in the samples by storage end. The preferred order of samples in terms of preference for vitamin C retained, as follows (F4, F2, F3, F1) is associated with the trend to decrease browning. During storage, browning increased in cantaloupe juice, due to the

development of brown pigment over polymerization between ascorbic acid or sugar degradation products or phenolic compounds (Wibowo *et al.*, 2015) [33]. A similar decrease in vitamin was found in a refrigerated stored cantaloupe juice stored at (5±2 °C) for 13 days by Sroy *et al.* (2019) [29]. The same previous order in terms of preference for vitamin C and reduced browning is of the same order obtained by L*, a*, b*, hue, and chroma parameters. A close correlation exists between increasing color quality and vitamin content. Generally, all color parameters L*, a*, b*, hue, chroma were decreased, and browning increased in all samples with storage end. Mokhtar and Ibrahim (2020) [21] have reported related results on guava nectar.

Total phenolic compounds were affected by the degree of pasteurization, the higher degree (90 °C) had less effect, and this compatible with the antioxidant activity at zero time, confirming that the higher degree (90 °C) increased antioxidant activity than (85 °C). This may be due to the release of bound phytochemicals from the insoluble portion after heat treatment, such as carotenoids, by disturbing cell membranes and cell walls, increasing bioaccessible carotenoids, and enhancing absorption (Eberhardt *et al.*, 2000) [6]. The second explanation is related to the impact of pasteurization on conjugate types of phenolic acids, such as chlorogenic acid, which has been converted into caffeic and quinic acid and has improved the antioxidant capacity. By comparing the results of phenols and antioxidant activity at the beginning and end of storage, the correlation between them becomes clear. Generally, total phenolic compounds and antioxidant activity decreased with increased storage period. The pattern of our results was close to that observed by Tahar *et al.* (2019) [30] in pasteurized pear juice and orange juice. The degradation in vitamins, polyphenols, and carotenoids during storage decreased antioxidant activity in juices (Sroy *et al.*, 2019) [29]. Although cantaloupe juice is not high in phenolic content but contains a higher percentage of Hydroxylated cinnamic acids than Hydroxybenzoic acid derivatives, which are more antioxidant activity than Hydroxybenzoic acid derivatives due to their esters have more hydroxyl in the molecule. Related findings were obtained (Tomas-Barberan and Clifford, 2000; Fu *et al.*, 2011) [31, 9].

By comparing the carotenoid findings with the values of a*, b*, and Hue, it has been shown that there is a connection between them. Carotenoids responded to color ranges from yellow to reddish-orange, while the decline in carotenoid content reduced the three parameters. Pasteurization and storage decreased the content of carotenoids, as well as all related parameters, decreased during storage. Similar findings have been conducted by (Sharma *et al.* 2019) [27] through storage on various forms of juice. The preferred arrangement of treatments due to taste, color, appearance, and overall acceptability was (F4, F2, F3, F1), which the same favored order for samples due to vitamin C content, browning reduction, L*, a*, b*, hue, and chroma.

These results showed the correlation between sensory attributes and the results of different previous analyses. Generally, all sensory attributes were decreased at storage ending. Present findings are compatible with those of (Ahmed *et al.*, 2019) [1].

The variations in the values of the physicochemical and sensory analysis show that the use of elevated degrees of pasteurization (90°C) for 45 seconds with refrigerated storage maintains the higher quality of cantaloupe juice after 28 days of storage.

Conclusion

Heat treatment and storage temperature had significant effects on the bioactive compounds and AA of cantaloupe juice. Heat treatment at 85 and 90°C promoted the increase in antioxidant activity of cantaloupe juice. However, the heat treatment at 85°C for 90sec had a marked influence on the sensory, color quality, and bioactive compounds of cantaloupe juice, but heating at 90°C/for 45sec maintained the original quality of cantaloupe juice. The refrigerated storage at 4°C maintained all quality parameters compared with storage at ambient temperature. Therefore, pasteurization at 90°C/45sec with refrigerated storage could use as an appropriate process for heating and storage cantaloupe juice. The content of TP in cantaloupe juice is well preserved under storage at 4 °C.

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