



P-ISSN: 2349-8528

E-ISSN: 2321-4902

[www.chemijournal.com](http://www.chemijournal.com)

IJCS 2021; 9(1): 08-13

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Received: 06-10-2020

Accepted: 13-11 -2020

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## Improving the color and stability of strawberry jam by strengthening with watermelon rind

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DOI: <https://doi.org/10.22271/chemi.2021.v9.i1a.11268>

### Abstract

The color influence the acceptance of consumers for the final product of strawberry jam. The red color of anthocyanin is susceptible to degradation by heat treatments and storage of jam. Mixing strawberries with other byproducts may improve the color and develop a new product with higher quality and nutrition value. Watermelon rind was applied to fortify strawberry jam at different ratios of 0% (control), 20% (T1), 40% (T2), 60% (T3), and 80% (T4) to strawberry puree. Blends were mixed with sucrose (1: 0.8), and the heating was continued until the final TSS reached 68° Brix. Jams analyzed for physicochemical and sensory characteristics after processing and 180 days of storage. The stability of anthocyanin, color parameters, bioactive compounds, sensorial quality were improved by using watermelon rind at 20% and 40% compared with the other treatments by store end. Therefore, we recommend by addition watermelon rind to strawberry jam at the mentioned ratios especially at T1 (20%) to improve the color of strawberry jam produced.

**Keywords:** Strawberry jam, anthocyanins, watermelon rind, overall acceptability, nutrition, fortification

### 1. Introduction

Strawberries (*Fragaria x ananassa* Duch.) are commercially important crops, consumed fresh or processed. Strawberries are a major provenance of high antioxidants like anthocyanins, phenols, and ascorbic acid (Proteggente *et al.*, 2002) [28]. Bioactive compounds found in strawberries protect against several diseases caused by excess oxidative stress, including cardiovascular illness, cancer, and neurodegenerative illness (Roohbakhsh *et al.*, 2015) [31]. Strawberry jams highly respected for their fruity flavor. However, the attractive red color of strawberries is susceptible to color-changing through treating and store. Color is a significant factor for strawberry jams (Pineli *et al.*, 2015) [27], which are responsible for anthocyanins that lost over 70% by heating to get jams (Aaby *et al.*, 2012) [1]. Pelargonidin-3-glucoside is the main anthocyanin in strawberries (Buendia *et al.*, 2010) [11]. Strawberry fruit contained substantial quantities of phenols with high antioxidant potential (Amaro *et al.*, 2013) [5]. The phenols in strawberries are in the form of anthocyanins, ellagitannins, and proanthocyanidins (Zafrilla *et al.*, 2001) [35] and have many health-promoting effects (Alvarez-Suarez *et al.*, 2014) [4]. Strawberries also contain ascorbic acid, which is an antioxidant that enhances the stability of anthocyanins and polyphenols in strawberry commodities (Nikkhah *et al.*, 2010) [26]. Heating to kill microorganisms and stabilize endogenous enzyme activity detracts bioactive compounds through non-enzymatic reactions such as polyphenols and ascorbic acid in strawberries (Holzwarth *et al.*, 2013) [14]. Storage strawberries at high temperatures or for a long time affected vitamin C as well as flavonoids (Mazur *et al.*, 2014) [21]. One of the main issues affecting the food industry is how to make maximum use of waste materials. Watermelon (*Citrullus lanatus*) rinds are the latest and important source of fortification for other products due to their high nutritional value (Mallek-Ayadi *et al.*, 2017) [19]. It accounts for 33% of the overall weight of watermelon fruit. Watermelon rind holds wealth in carotenoids, proteins, flavonoids, pectin, and cellulose (Koocheki *et al.*, 2007) [18]. The rind is also rich in potassium and amino acids such as citrulline that known for its potent antioxidant effects, vital to the heart, vasodilation functions, circular system, and immune system (Quek *et al.*, 2007) [29]. Rejection of watermelon rinds by conventional methods contributes to major environmental contamination problems via a rise in moisture content

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(Athmaselvi *et al.*, 2012) [17]. Therefore, it must be recycled again because it is rich in bioactive substances by using it to support food, thereby eliminating pollution problems (Moon and Shibamoto, 2009) [24]. The acceptance of strawberry jam mainly color assigned directly by anthocyanins. This study aims to estimate the effect of supporting strawberry jams with a different percent of watermelon rinds on their quality.

## 2. Materials and Methods

### 2.1 Raw materials

Strawberries (*Fragaria ananassa* Duch.) and a watermelon (*Citrullus lanatus*) were obtained from the local market of Ismailia, Egypt.

### 2.2 Chemicals

Folin-Ciocalteu and DPPH (Diphenylpicrylhydrazyl) got from Sigma Corporation (St. Louis, USA) while the various chemicals and different solvents from the Fisher chemical (Mumbai, India).

### 2.3 Preparation of pulp, rind, and jam

Strawberry fruits are prepared to extract their puree by removing the inedible fruits by sorting, removing the sepal with a stainless knife, washing with water, then mashing it with an electric mixer and filtering with a muslin cloth. The watermelon fruit was washed, cleaned, and separated into pulp, seeds, and rinds. The rind is cut into thin slices. Jams prepared as listed in Table 1. The blend heating in an open pan with stirring until TSS reached 68 °Brix. Jams were poured into sterilized glass jars (400 ml), then closed, cooled, and stored at room temperature for 180 days. Samples were analyzed after processing and 180 days of storage in triplicate.

### 2.4 Physicochemical analysis

#### 2.4.1 Total soluble solids

Abbe refractometer C10 (USA) was used to define the Brix degree at 20°C.

#### 2.4.2 pH

Jenway 510 (UK) was used to monitor the pH value.

#### 2.4.3 Titrable acidity (TA)

Acidity determined as % citric acid by titration with 0.1N from NaOH as described by (AOAC, 2000) [6].

#### 2.4.4 Vitamin C (VC)

VC calibrated against 2,6-Dichlorophenolindophenol to pink color and identified as mg/100g jam (Ranganna, 2009) [30].

### 2.5 Browning index

Alcohol extract of jam resulted from mixing the same weight of jam and ethyl alcohol 95% was centrifuged for 20 min at 2000 rpm, filtered over Whatman (No. 4) paper, read at 420 (Meydov *et al.* 1977) [22].

### 2.6 Lycopene

A mixture of hexane and ethanol (3:4) using to extract lycopene from the sample. The hexane layer reading by a spectrophotometer at 503 nm, lycopene recorded as µg /100g jam (Barrett and Anthon, 2001) [8].

### 2.7 Total anthocyanin

The total anthocyanin extracted from the sample by acidic ethanol combined from ethanol 95% and HCl 37% (3.92:1),

the mixture was shaken very well, kept overnight at 4°C, filtered through glass wool, the extract read at 535 nm, anthocyanin defined as mg of cyaniding-3-glucoside/100 g jam as described by (Mondello *et al.* 2000) [23].

### 2.8 Color assessment

Color parameters L\* (lightness), a\* (red to green), and b\* (yellow to blue) read using CR-10 (Konika Minolta reader, Japan).

### 2.9 Total phenols (TP)

Folin-Ciocalteu is used to determine TP as described by Vinson *et al.* (1995) [33]. Sample (0.5g) extracted by acidic methanol combined from methanol 75% and HCl 6 M (5:1), then the extract was shaken well and put in a water bath at 90 °C for 120 min, refrigerated to ambient to 1ml of dilution, then 15 ml of NaCO<sub>3</sub> 7% added, then the mix completed to 100 ml by distilled water. The absorption reading at 760 nm and the findings represented per 100 g jam as mg gallic equivalent.

**Table 1:** Formulations of different treatments of strawberry jams

Formulations	Strawberry pulp	Watermelon rind	Sugar	Citric acid	pectin
Control	1000 g	0 g	800 g	1 g	1%
T1	800 g	200 g	800 g	1 g	1%
T2	600g	400 g	800 g	1 g	1%
T3	400 g	600 g	800 g	1 g	1%
T4	200 g	800 g	800 g	1 g	1%

### 2.10 Antioxidant activity (AA)

DPPH (Diphenylpicrylhydrazyl) utilizing to define AA% according to Brand-Williams *et al.* (1995) [10]. Ten ml of methanol added to 2.5 gram, homogenized at 20,500 rpm for 25 sec, centrifuged for 25 min at 4 °C on 20,000 rpm. The supernatant was diluted up to 25 times by methanol. One ml of methanol addition to a 0.5 ml methanolic solution containing DPPH by 0.5 mM. The blend was shaken and left 30 min at room temperature in the dark. The reading employed 517 nm and expressed as AA%.

### 2.11 Sensory evaluation

Sensory tests carried out according to (Hussein and Shedeed, 2011) [15] by ten staff members (semi-trained panelists) for taste (10), flavor (10), color (10), mouth feel (10), appearance (10), consistency (10). The average of total scores for different attributes calculated as overall acceptability.

### 2.12 Statistical analysis

ANOVA analysis for the data conducted at p= 0.05 and the means of treatments compared by SPSS (version 17) software.

## 3. Results and Discussion

Changes in TSS, pH, TA, vitamin C, TP, and AA% after manufacturing and storage give in Table 2.

### 3.1 Effect of treatments and storage on TSS of jams

The TSS of both jams was 68° Brix at zero time. No significant differences were recorded between the samples at zero time and after storing for 180 days.

**3.2 Effect of treatments and storage on pH and acidity of jams:** The pH is a necessary factor in the maintenance of the product and food (Da Silva *et al.*, 2016) [12], it acts as self-

defense against microbial spoilage (HO *et al.*, 2010) [13]. The variation in the building of treatments made considerable variations in pH between them. Increased watermelon rind in this study increased pH and decreased acidity. Storage raised the acidity value after 180 days which ranges from 0.76 to 1.22. These findings are consistent with those stated by (Kanwal *et al.*, 2017) [16] on apricot and guava jam. The generation of hydroxyl methyl furfural and pectic acid from pectin rose acidity during storage (Touati *et al.*, 2014) [32]. T4 recorded the lowest acidity growth in (0.76%), while the control showed the highest acidity value (1.22%).

### 3.3 Effect of treatments and storage on the vitamin C (VC) of jams: The structure of the samples influenced VC content.

**Table 2:** Changes in Brix, pH, acidity, vitamin C, total phenols and DPPH in different treatments of strawberry jams during storage

Sample	Period storage	°Brix	pH	Acidity%	VC(mg/100g)	TP (mg/100g)	AA (%)
Control	0 <sup>th</sup> day	68.0±0.0 <sup>a</sup>	3.73±0.01 <sup>e</sup>	0.69±0.00 <sup>a</sup>	41.6±0.52 <sup>a</sup>	163.5±0.139 <sup>a</sup>	61.3±0.077 <sup>a</sup>
	180 <sup>th</sup> day	68.8±0.3 <sup>A</sup>	3.48±0.02 <sup>E</sup>	1.22±0.04 <sup>A</sup>	9.4±0.58 <sup>C</sup>	61.34±0.063 <sup>C</sup>	31.4±0.814 <sup>D</sup>
T1	0 <sup>th</sup> day	68.0±0.0 <sup>a</sup>	3.78±0.02 <sup>d</sup>	0.65±0.03 <sup>ab</sup>	32.3±0.35 <sup>b</sup>	119.3±0.431 <sup>b</sup>	58.6±0.668 <sup>b</sup>
	180 <sup>th</sup> day	68.6±0.1 <sup>A</sup>	3.51±0.01 <sup>D</sup>	1.03±0.05 <sup>B</sup>	18.3±0.45 <sup>A</sup>	84.05±0.315 <sup>A</sup>	43.2±0.124 <sup>A</sup>
T2	0 <sup>th</sup> day	68.0±0.0 <sup>a</sup>	3.84±0.00 <sup>c</sup>	0.62±0.02 <sup>b</sup>	22.1±0.64 <sup>c</sup>	87.4±0.732 <sup>c</sup>	53.4±0.664 <sup>c</sup>
	180 <sup>th</sup> day	68.6±0.2 <sup>A</sup>	3.63±0.00 <sup>C</sup>	0.94±0.00 <sup>C</sup>	14.4±0.18 <sup>B</sup>	80.4±0.253 <sup>B</sup>	36.6±0.745 <sup>B</sup>
T3	0 <sup>th</sup> day	68.0±0.0 <sup>a</sup>	3.92±0.03 <sup>b</sup>	0.53±0.02 <sup>c</sup>	9.8±0.54 <sup>d</sup>	36.4±0.331 <sup>d</sup>	47.6±0.918 <sup>d</sup>
	180 <sup>th</sup> day	68.4±0.1 <sup>A</sup>	3.76±0.02 <sup>B</sup>	0.83±0.04 <sup>D</sup>	5.16±0.17 <sup>D</sup>	26.39±0.753 <sup>D</sup>	33.6±0.078 <sup>C</sup>
T4	0 <sup>th</sup> day	68.0±0.0 <sup>a</sup>	4.08±0.01 <sup>a</sup>	0.48±0.03 <sup>d</sup>	4.6±0.36 <sup>e</sup>	16.4±0.714 <sup>e</sup>	42.1±0.990 <sup>e</sup>
	180 <sup>th</sup> day	68.6±0.2 <sup>A</sup>	3.86±0.01 <sup>A</sup>	0.76±0.05 <sup>D</sup>	2.36±0.21 <sup>E</sup>	12.47±0.913 <sup>E</sup>	30.6±0.319 <sup>E</sup>

<sup>a-b</sup> Means followed by different superscript alphabets in each column are significantly different among treatments at zero time ( $p < 0.05$ )

<sup>A-B</sup> Means followed by different superscript alphabets in each column are significantly different among treatments after storage ( $p < 0.05$ )

### 3.4 Effect of treatments and storage on the TP of jams

TP showed significant susceptibility to the different composition of treatments. TP increases with increasing strawberry content in the samples. The control sample was marked by the highest value (163.5 mg/100g as gallic acid) of TP, while T4 was the lowest (16.4 mg/100g as gallic acid). The effect of storage was apparent in different treatments. T1 was the highest content of TP (84.05 mg/100 g), followed by T2 (80.4 mg/100 g). T1 contained the highest percentage of TP and VC after storage. VC is a potent antioxidant that prohibited oxidation of TP and polymerization. Martinsen *et al.* (2020) [20] reported the same protective effect of VC on TP, also found the same decrease in TP after heat treatment and storage of strawberry jam. The mixing of watermelon rind with strawberry improved TP during storage.

### 3.5 Effect of treatments and storage on AA % of jams

The AA ranged from 42.1 to 61.3% after processing. The AA increased with an increasing strawberry puree addition during the process. The control sample showed the highest AA against the rest samples. After 180 days at room temperature, the higher AA was associated with a higher content of vitamin C, TP, and anthocyanins. Both treatments differed from others, and T1 showed the highest AA with a value of 43.2%. The antioxidants like ascorbic acid depleted by the Maillard reaction and caramelization (Nayak *et al.*, 2015) [25]. The AA enhanced during jam storage by the developing of ellagic from ellagitannins and proanthocyanidins (Aaby *et al.*, 2007) [2], however, VC, TP, and anthocyanins decreased. The association among increasing or decreasing TP and AA together is referred by (Da Silva *et al.*, 2016) [12].

Vitamin levels ranged from 4.6 to 41.6 mg/100 grams after treatment. Increasing strawberry content in this study increased the level of vitamins. The control was the highest level of vitamin (41.6 mg/100 g) for a higher level of strawberry, while T4 (4.6 mg/100 g) was the lowest at zero time. VC decreased after storage, the highest level got by T1, while T4 was the lowest. Oxygen existing in the headspace oxidized VC in existing light to dehydroascorbic acid followed by furfural generation that reacts with amino derivatives over the Millard reaction. (Mazur *et al.*, 2014) [21] have reported a harmful effect of heating and storage for VC in strawberry juice and jam.

Changes in browning, anthocyanin, lycopene, L\* (lightness), a\* (red to green), and b\* (yellow to blue) parameters as a response of treatments and storage period are given in Table 3.

### 3.6 Effect of treatments and storage on the browning of jams

The browning increased by increasing the percentage of strawberry pulp in the samples. It ranged from 0.240 to 0.486 at zero time. Deteriorating anthocyanin by heating process increased browning. Increasing watermelon rind reduced browning in different treatments, so T4 recorded the lowest browning. Storage raised browning in all samples. T4 was the least browning (0.534), while control was the greatest browning (0.894). The fast depletion of ascorbic acid increased browning during storage. The stability of anthocyanin improved by watermelon rind addition to jam due to the reduction browning for a lower content of VC. Nikkiah *et al.* (2010) [26] also found the same observation of browning reduction by decreasing VC content. Martinsen *et al.* (2020) [20] found that the higher level of VC in a strawberry jam than raspberry jam reduced anthocyanins stability in a strawberry jam. Increasing browning in different treatments was compatible with declines in anthocyanin content for processing and storage (Abdel-hady *et al.*, 2014) [3].

### 3.7 Effect of treatments and storage on anthocyanin jams

Anthocyanin is influenced by sample structure at zero time. Anthocyanin content increased by increasing the amount of strawberry puree in the mixture. The control treatment showed the greatest anthocyanin with 17.4 mg/100 g.

**Table 3:** Changes in browning, anthocyanin, lycopene, L\*, a\* and b\* in different treatments of strawberry jams during storage

Sample	Period storage	Browning	Anthocyanin (mg/100g)	Lycopene ( $\mu\text{g}/100\text{g}$ )	L*	a*	b*
Control	0 <sup>th</sup> day	0.486 $\pm$ 0.020 <sup>a</sup>	17.4 $\pm$ 1.2 <sup>a</sup>	-	22.3 $\pm$ 0.8 <sup>c</sup>	41.7 $\pm$ 0.6 <sup>b</sup>	8.8 $\pm$ 0.3 <sup>A</sup>
	180 <sup>th</sup> day	0.894 $\pm$ 0.026 <sup>A</sup>	3.2 $\pm$ 2.2 <sup>D</sup>	-	9.4 $\pm$ 1.0 <sup>E</sup>	15.2 $\pm$ 0.4 <sup>D</sup>	8 $\pm$ 0.1 <sup>ab</sup>
T1	0 <sup>th</sup> day	0.348 $\pm$ 0.018 <sup>b</sup>	13.7 $\pm$ 2.4 <sup>b</sup>	137.05 $\pm$ 1.43 <sup>d</sup>	24.5 $\pm$ 1.2 <sup>b</sup>	33.7 $\pm$ 0.5 <sup>c</sup>	8.6 $\pm$ 0.4 <sup>B</sup>
	180 <sup>th</sup> day	0.738 $\pm$ 0.019 <sup>B</sup>	5.9 $\pm$ 1.8 <sup>A</sup>	56.85 $\pm$ 0.22 <sup>C</sup>	12.2 $\pm$ 1.1 <sup>D</sup>	22.4 $\pm$ 0.7 <sup>A</sup>	8.3 $\pm$ 0.4 <sup>a</sup>
T2	0 <sup>th</sup> day	0.300 $\pm$ 0.034 <sup>bc</sup>	8.2 $\pm$ 2.2 <sup>c</sup>	153.21 $\pm$ 3.24 <sup>c</sup>	25.4 $\pm$ 1.3 <sup>b</sup>	30.1 $\pm$ 0.3 <sup>d</sup>	8.2 $\pm$ 0.2 <sup>C</sup>
	180 <sup>th</sup> day	0.672 $\pm$ 0.022 <sup>C</sup>	4.1 $\pm$ 0.8 <sup>B</sup>	68.94 $\pm$ 0.25 <sup>B</sup>	13.9 $\pm$ 0.9 <sup>C</sup>	20.9 $\pm$ 0.4 <sup>B</sup>	8.1 $\pm$ 0.6 <sup>ab</sup>
T3	0 <sup>th</sup> day	0.276 $\pm$ 0.023 <sup>cd</sup>	6.3 $\pm$ 1.4 <sup>d</sup>	204.87 $\pm$ 4.47 <sup>b</sup>	27.9 $\pm$ 1.1 <sup>a</sup>	27.5 $\pm$ 0.5 <sup>c</sup>	7.9 $\pm$ 0.3 <sup>D</sup>
	180 <sup>th</sup> day	0.618 $\pm$ 0.014 <sup>D</sup>	3.4 $\pm$ 2.1 <sup>C</sup>	78.15 $\pm$ 13.31 <sup>B</sup>	15.2 $\pm$ 1.0 <sup>B</sup>	16 $\pm$ 0.6 <sup>C</sup>	7.2 $\pm$ 0.5 <sup>c</sup>
T4	0 <sup>th</sup> day	0.240 $\pm$ 0.033 <sup>d</sup>	4.6 $\pm$ 1.4 <sup>e</sup>	221.85 $\pm$ 16.66 <sup>a</sup>	28.9 $\pm$ 0.8 <sup>a</sup>	23.2 $\pm$ 0.8 <sup>a</sup>	6.6 $\pm$ 0.2 <sup>E</sup>
	180 <sup>th</sup> day	0.534 $\pm$ 0.038 <sup>E</sup>	0.71 $\pm$ 0.3 <sup>E</sup>	106.41 $\pm$ 4.49 <sup>A</sup>	26.7 $\pm$ 1.2 <sup>A</sup>	11.8 $\pm$ 0.7 <sup>E</sup>	5.1 $\pm$ 0.3 <sup>d</sup>

<sup>a-b</sup> Means followed by different superscript alphabets in each column are significantly different among treatments at zero time ( $p < 0.05$ )

<sup>A-B</sup> Means followed by different superscript alphabets in each column are significantly different among treatments after storage ( $p < 0.05$ )

The anthocyanin content decreased by increasing the watermelon rind in the jam mixture. Besides, anthocyanin decreased by storage, T1 displayed the highest anthocyanin content after 180 days with 5.9 mg/100 g jam. The decline in anthocyanin through treating and store returned to the complexation or condensation anthocyanins and developed browning. Several factors affect these reactions like pH, TP, sugars, sugar degradation, oxygen, VC, and time. Many reports identify the same deficiency in anthocyanins through treating and store, with the corresponding reasons (Benedek *et al.*, 2020) [9].

### 3.8 Effect of treatments and storage on the lycopene content of jams

The lycopene content increased after treating with increasing the watermelon rind in the jam mixture because the watermelon rind containing some of the watermelon pulp content. The control sample did not contain lycopene because strawberry puree using only without adding watermelon rind. Storage increased the destruction of lycopene, as all treatments decreased significantly in lycopene. Treatment T4 recorded the highest content of lycopene after the store with a value of 106.41  $\mu\text{g}/100\text{g}$  of jam. The decrees in lycopene through treating and store were compatible with those found by (Khashaba *et al.*, 2018) [17] on tomato jams stored for 180 days at room temperature.

### 3.9 Effect of treatments and storage on the color parameters of jams

Color is a significant factor for customers during food choosing. The sample structure influenced the L\* value (lightness) which increased by reducing the strawberry and increasing watermelon rind in the jam mixture. T4 recorded the highest lightning (28.9) and the lowest lightning recorded by control with a value of 22.3. L\* value of all samples

reduced after storage time. The highest percentage of watermelon rind in the jam mixture gave the maximum lightning over the storage period, like T4. L\* values had an irreversible correlation with browning data. Increased watermelon rind reduced anthocyanin, VC, and degradation got in the samples. Redness or a\* value is affected by the variation of the sample structure. The higher content of strawberries in jams led to a higher redness value for a higher red color like the control sample. Storage decreased a\* value, and T4 recorded the lowest while T1 was the highest. After processing, yellowness or b\* value decreased by the reduction in strawberry content in the sample structure. Storage decreased b\* value for all treatments. T1 gave the optimal b\* value after six months of storage, while T4 recorded the lowest yellowness.

Finally, the differences in lightness, redness, yellowness through treating and store jams have demonstrated that the color values are closely related to the concentration of anthocyanins as well as changes that occur in TP, VC, and non-enzymatic browning processes. Lightness, redness, yellowness decreased by anthocyanin pigment destruction reactions, and the browning increased. The former changes were dependent on the content of TP and VC besides their depletion. Processing and storage significantly reduced all colorimetric parameters, which are compatible with Benedek *et al.* (2020) [9] on blackberry jams.

### 3.10 Effect of treatments and storage on the sensory attributes of jams

Table 4 shows the sensory profile investigated at the start and after the storage period of jams. The quality of jams influenced by the taste factor and jams structure. The reduction of taste is achieved by increasing watermelon rind addition at zero time. The changes in ascorbic, anthocyanins and phenolic profiles are linked by color and flavor changes.

**Table 4:** Change of sensory attributes in different treatments of strawberry jams during storage

Sample	Period storage	Taste	Flavor	Color	Mouthfeel	appearance	Consistency	Overall acceptability
Control	0 <sup>th</sup> day	7.5 $\pm$ 0.2 <sup>c</sup>	9.2 $\pm$ 0.1 <sup>a</sup>	8.9 $\pm$ 0.2 <sup>a</sup>	8.3 $\pm$ 0.2 <sup>ab</sup>	8.6 $\pm$ 0.3 <sup>b</sup>	8.0 $\pm$ 0.5 <sup>c</sup>	8.4 $\pm$ 0.4 <sup>ab</sup>
	180 <sup>th</sup> day	6.3 $\pm$ 0.3 <sup>D</sup>	8.1 $\pm$ 0.2 <sup>BC</sup>	7.2 $\pm$ 0.5 <sup>C</sup>	7.8 $\pm$ 0.2 <sup>B</sup>	8.3 $\pm$ 0.5 <sup>C</sup>	7.2 $\pm$ 0.4 <sup>C</sup>	7.5 $\pm$ 0.2 <sup>C</sup>
T1	0 <sup>th</sup> day	7.5 $\pm$ 0.4 <sup>c</sup>	9.0 $\pm$ 0.3 <sup>ab</sup>	8.7 $\pm$ 0.4 <sup>ab</sup>	8.6 $\pm$ 0.5 <sup>a</sup>	9.2 $\pm$ 0.6 <sup>a</sup>	8.6 $\pm$ 0.3 <sup>a</sup>	8.6 $\pm$ 0.3 <sup>a</sup>
	180 <sup>th</sup> day	6.8 $\pm$ 0.2 <sup>CD</sup>	8.6 $\pm$ 0.1 <sup>A</sup>	8.1 $\pm$ 0.2 <sup>A</sup>	8.1 $\pm$ 0.2 <sup>A</sup>	9.0 $\pm$ 0.4 <sup>A</sup>	8.1 $\pm$ 0.4 <sup>A</sup>	8.1 $\pm$ 0.3 <sup>A</sup>
T2	0 <sup>th</sup> day	7.9 $\pm$ 0.5 <sup>bc</sup>	9.0 $\pm$ 0.2 <sup>ab</sup>	8.5 $\pm$ 0.5 <sup>b</sup>	8.4 $\pm$ 0.3 <sup>ab</sup>	9.0 $\pm$ 0.1 <sup>a</sup>	8.4 $\pm$ 0.3 <sup>ab</sup>	8.5 $\pm$ 0.4 <sup>ab</sup>
	180 <sup>th</sup> day	7.1 $\pm$ 0.6 <sup>BC</sup>	8.4 $\pm$ 0.2 <sup>AB</sup>	7.7 $\pm$ 0.3 <sup>B</sup>	8.0 $\pm$ 0.4 <sup>A</sup>	8.6 $\pm$ 0.4 <sup>B</sup>	7.8 $\pm$ 0.2 <sup>B</sup>	7.9 $\pm$ 0.3 <sup>B</sup>
T3	0 <sup>th</sup> day	8.2 $\pm$ 0.3 <sup>b</sup>	8.8 $\pm$ 0.5 <sup>b</sup>	8.2 $\pm$ 0.6 <sup>c</sup>	8.0 $\pm$ 0.2 <sup>b</sup>	8.5 $\pm$ 0.2 <sup>bc</sup>	7.8 $\pm$ 0.2 <sup>cd</sup>	8.3 $\pm$ 0.3 <sup>ab</sup>
	180 <sup>th</sup> day	7.6 $\pm$ 0.4 <sup>AB</sup>	7.7 $\pm$ 0.4 <sup>C</sup>	7.1 $\pm$ 0.2 <sup>D</sup>	7.5 $\pm$ 0.4 <sup>C</sup>	8.1 $\pm$ 0.2 <sup>CD</sup>	7.1 $\pm$ 0.1 <sup>CD</sup>	7.5 $\pm$ 0.4 <sup>C</sup>
T4	0 <sup>th</sup> day	8.9 $\pm$ 0.3 <sup>a</sup>	8.3 $\pm$ 0.2 <sup>c</sup>	8.1 $\pm$ 0.1 <sup>cd</sup>	8.0 $\pm$ 0.1 <sup>b</sup>	8.2 $\pm$ 0.4 <sup>d</sup>	7.4 $\pm$ 0.2 <sup>e</sup>	8.2 $\pm$ 0.2 <sup>b</sup>
	180 <sup>th</sup> day	8.2 $\pm$ 0.4 <sup>A</sup>	7.2 $\pm$ 0.3 <sup>D</sup>	6.5 $\pm$ 0.3 <sup>E</sup>	7.0 $\pm$ 0.3 <sup>D</sup>	7.5 $\pm$ 0.1 <sup>E</sup>	7.0 $\pm$ 0.3 <sup>DE</sup>	7.2 $\pm$ 0.2 <sup>D</sup>

<sup>a-b</sup> Means followed by different superscript alphabets in each column are significantly different among treatments at zero time ( $p < 0.05$ )

<sup>A-B</sup> Means followed by different superscript alphabets in each column are significantly different among treatments after storage ( $p < 0.05$ )



The first fourth treatment gave a higher score of color, flavor, mouthfeel, appearance, consistency, and acceptance at zero time. According to static analysis, all sensory parameters decreased after the storage period. The findings correspond to the observations of (Yassin *et al.*, 2018) [34], which noted the same decrease in the organoleptic score of mango jam during storage at (25-30°C). Decreasing the acidity increases the acceptance of taste. Also, increasing watermelon rind increased the score of taste for acidity lower. T1 was more reddish (higher a\* values) samples, which is the most important attribute, followed by T2, and control, while T3 and T4 were lower-rated of color. A good correlation was found between a\* values and the score of color. The flavor of samples containing watermelon rind at lower concentrations such as T1, T2 recorded a higher score of flavor. T1 and T2 were superior to the other treatments of jams in terms of mouthfeel, appearance, consistency, and overall acceptability. The overall acceptability of samples containing watermelon rind except T4 excelled on control. The preference treatments in terms of sensory properties were T1 (8.1), T2 (7.9), control (7.5), T3 (7.5), and T4 (7.2) after storage periods. The previous order is compatible with optimal physicochemical characteristics and nutrient values obtained by different samples.

#### 4. Conclusion

The findings of our study illustrated that the addition of watermelon rind to strawberry jam at the ratios used in T1 (20%) and T2 (40%) improved the stability of color parameters, bioactive compounds, and sensorial quality during storage. The stability of anthocyanin was improved by using watermelon rind at 20% and 40% by store end. Therefore, we recommend adding watermelon rind to strawberry jam at the mentioned ratios to improve the color of strawberry jam produced.

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