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RESEARCH ARTICLE

Preparation of Strawberry Jam and Estimation of its Nutritive Value during Storage

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ABSTRACT

The processing of jam from strawberry was studied during storage and found successful from the sensory evaluation the mean score showed that T_2 (pulp to sugar ratio 1:1.25) was most preferred considering all the characters as colour, flavour, sweetness and overall acceptability followed by T_1. After 2, 4 and 6 month of storage the moisture content had slightly increased. The initial TSS and total sugar content of strawberry jam were maximum in T_3 (67.25 % and 41.50 %, respectively) while these were minimum in T_1 (66.12 % and 40.07 %, respectively). This study revealed at the end of storage 0.29 to 1.00 % TSS and 5.14 to 5.89 % total sugar were reduced. At initial stage titratable acidity and pH level were found higher in T_1 (0.65 % and 2.81, respectively) and at the end of 6 months of storage titratable acidity and pH of this treatment were 0.69 % and 2.78, respectively. Ascorbic acid content of strawberry jam was found very low (14.75-17.49 mg 100 g^{-1}). This study revealed ascorbic acid content of strawberry jam decreased during storage. After 6 month of storage the maximum reduction of ascorbic acid was noted in T_3 (14.44 %), while minimum in T_2 (11.06 %). Just after cooking *β*-carotene content of strawberry jam was found higher at T_1 (1.81 µg 100 g^{-1}), and at the end of storage period it was 1.69 µg 100 g^{-1}. During 6 months of storage, maximum reduction of *β*-carotene was recorded in T_1 (6.6 %), while minimum in (3.5 %) from T_3. Considering sensory evolution, nutrients content and storage study jam prepared form 1:1.25 pulp to sugar ratio i.e.T_2 formulation was found better.

Keywords: Strawberry, Processing, Jam, Storage, Sensory evaluation, ascorbic acid

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INTRODUCTION

Strawberries (*Fragaria x ananassa* Duch.) are highly perishable, with short storage life due to their soft texture, high softening rate and high susceptibility to fungal attack and mechanical injury (Shin *et al.*, 2008). The fresh fruits of strawberry cannot be stored for long time due to their inherent compositional and textural characteristics. The alternate way of extending their shelf life and availability in off-season and reduction of post harvest losses is processing. Processing of fruits reduces postharvest loss and provides nutrients from these fruits. The basic principle of preserving foods by heat is known as "Processing". The method of processing varies from food to food (Singh *et al.*, 2007). Processing had an adverse effect on nutrient content of products. Generally, temperature, duration of boiling, pasteurization, sugar and acid content, cultivar and degree of fruit ripeness as well as storage conditions of products are the most important factors determining the nutrition and quality of products (Kim and Zakour, 2004; Garcia-Viguera *et al.,* 1998, 1999). It is necessary to ensure quality, because it is of utmost importance to understand the scientific basis for producing a superior product which must meet the fundamental

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characteristics like, pH, TSS, sugars and nutritional quality to ensure the standard excellence of the product (Shahnawaz and Shiekh, 2011). Strawberry is a commercial fruit having a great potential for processing and is widely used for preparation of purees, squash, juice, jams, preserves, candy, and alcoholic beverages (Sharma *et al.*, 2009).

Jams are prepared by boiling the fruit pulp with sufficient quantities of sugar to a reasonably thick consistency, and thus were firm enough to hold fruit tissues in position (Carbonell et al., 1991). The large amount of sugar with the fruit pulp allowed taking advantage of its preservative effect. Sugar in jam helped in the sweetening, gel formation and colour retention of the jams (Sugawara *et al.*1982). But the processed products are not shelf-stable and standard in quality. To explore the potentiality of processing of strawberries into jam this study was, therefore, undertaken.

MATERIALS AND METHODS

Site and duration of the experiment

The experiment was conducted at the laboratory of Postharvest Technology Division, BARI, from February 2014 to May 2016.

Materials

Matured fruits of BARI Strawberry-1 grown in the experimental field of Horticulture Research Center, BARI, Gazipur, Bangladesh were used for processing. Sugar, citric acid, pectin, potassium meta-bisulphite (KMS), sodium benzoate, calcium lactate, and other necessary materials viz. paraffin, glass bottles, saucepan, stirrer, spoon, blender, balance etc. were used to perform smoothly the processing of jam, squash and candy.

Preparation of strawberry jam, squash and candies

Ripe, healthy and fresh strawberries were collected. The sepals were removed and berries were separated. The fruit was washed thoroughly with pure water. The fruits were crushed with a blender (Joypan, Osaka, Japan) for collecting pulp. The pulp thus collected was used for jam and squash preparation. On the other hand, for preparation of strawberry candy $1/3^{rd}$ matured, $2/3^{rd}$ matured and fully matured fruits were used as the treatments denoted as T_1, T_2 and T_3. Fruits were as much as possible uniform in size, shape and colour. The fruits were analyzed to determine the moisture, TSS, total sugar content, titratable acidity, pH, ascorbic acid and β carotene. The chemical composition of the extracted pulp was presented in Table 1.

Table 1. Chemical composition of fresh pulp of strawberry

Sl. No.	Parameters	Quantity
1.	Moisture (%)	91.5
2.	TSS (%)	8.50
3.	Total sugar (%)	3.37
4.	Acidity (%)	1.02
5.	pH	3.44
6.	Ascorbic acid (mg 100 g^{-1})	61.65
7.	β carotene (µg 100 g^{-1})	2.19

Treatment of the experiment

The experiment consisted of the following treatment:

Table 2. Treatment combination for preparation of strawberry jam

Treatment	Jam
T_1	1:1.00 pulp to sugar ratio
T_2	1:1.25 pulp to sugar ratio
T_3	1:1.50 pulp to sugar ratio

Calculation for preparation of strawberry jam

At first the percentage of soluble solids of the pulp was determined. Then the theoretical output of recipe was calculated (Hossain, 2011). To calculate the theoretical output, the following formula was used:

The theoretical output of jam (%) "W" = $\frac{A}{S} X 100$

Where,

S = the required soluble solids of the finished product

A = the total weight of soluble solids contained into recipe.

Weight of required pulp into recipe 'P' $= R_1 \, x \, \frac{W}{R_1 + R_2}$

Weight of required sugar into the recipe 'S_1' $= R_2 x \frac{W}{R_1 + R_2}$

Where,

W = weight of the finished product (g)

R_1 = ratio of the pulp contained into recipe

R_2 = ratio of the sugar contained into recipe

Soluble solid derived from the pulp 'S_2' $= \frac{P \, x \, b_1}{100}$

Where,

P = weight of the required pulp into the recipe (g)

b_1 = per cent soluble solids of the pulp

Pectin required into the recipe 'pectin' $= \frac{S_1}{100}$

Where,

S_1 = weight of the required sugar into the recipe (g)

Acid required into the recipe 'A$_1$' $= \frac{ac_1 \times W}{100}$

Where,

ac_1 = desired acidity of the product (%)

W = weight of the finished product (g)

Acidity contributed by the pulp 'A$_2$' $= \frac{ac_2 \times P}{100}$

Where,

ac_2 = per cent acidity of the pulp

P = weight of the pulp

Acid to be added into recipe $= A_1 – A_2$

Sugar to be added $= S_1 – S_2$

The basic recipe is

- As an illustration, let us consider the manufacture of 5 kg of strawberry jam.
- Strawberry (Pulp) containing 8.5 % refractometric solid and 1.02 % acidity.
- The pH of final product 3.5 and final TSS 65 %.

Processing

The jam produced from strawberry was done through several steps (Figure 2). All the ingredients were weighed separately. Sugar and pectin were mixed with the fruit pulp. The mixture was cooked slowly with occasional stirring till the cooking mass approached the desired consistency. When the mass became sufficiently thick in consistency, a spoon was dipped into it and allowed the product to run off the sides of the spoon. If on cooling the product fell off in the form of a sheet instead of flowing readily in a single stream, it was assumed that the end point had been reached and the product was ready for filling into container. Citric acid was added at the later stage of processing for preventing too much hydrolysis of the sugar. Boiling was continued till the sheet test was satisfactory (up to 65^0B). The clean and sterilized dry bottles were filled with hot jam and kept in a cool place for 8-12 hours for jam setting. After setting, a thin layer of melted wax was given on the top of the jam and closed the cap tightly and stored.

Flow diagram for jam preparation

Strawberry jam is prepared by following the flow diagram as given below:

Harvesting of 80 % ripe fruits
↓
Selection and preparation of fruit
↓
Pulping (blending) and weighing
↓
Addition of sugar
↓
Cooking the pulp (slow cooking with continuous stirring)
↓
Addition of pectin
↓
Addition of citric acid + salt (1pinch)
↓
Judging the end point (TSS-66.5%)
↓
Determining the end point of cooking
↓
Bottling (filling the clean, dry and sterilized glass bottles with hot jam)
↓
Cooling and waxing
↓
Storing in clean and dry place

Figure 1. Flow diagram for preparation of strawberry jam

Table 3. Ingredients in different treatments of strawberry jam

Sl. No.	Ingredients	Treatment (pulp to sugar ratio)		
		T_1 (1:1)	T_2 (1:1.25)	T_3 (1:1.5)
1.	Strawberry pulp (g)	2500	2500	2500
2.	Sugar (g)	2287.50	2912.5	3537.5
3.	Citric acid (g)	7	7	7
4.	Pectin (g)	25	31.25	37.5
5.	KMS (g)	5	5	5

Figure 2. Photograph showing the processing techniques of strawberry jam.

Experimental design

The experiment was carried out in a Completely Randomized Design (CRD) with four replications.

Storage studies

The strawberry jam wese processed and filled in sterilized glass jar, bottle and polypropylene bags, respectively. The james were stored for 6 months and the chemical composition and nutritive value were determined according to following schedule during the storage period at room temperature and calculated the change over storage.

Table 4. Observation schedule of strawberry jam, squash and candy for chemical and nutritiv values during storage

Products	1st observation	2nd observation	last observation
Jam	2 months	4 months	6 months
Squash	20 days	40 days	60 days
Candy	3 months	6 months	9 months

Collection of data

Data were collected on the following parameters for evaluating fresh and stored jam, squash and candy processed from strawberry:

(i) Sensory evaluation of freshly processed products: The sensory evaluation of the processed strawberry jam, squash and candy were carried out. A panel of judges consisted of 10 members (5 men and 5 women) evaluated the processed products on the basis of colour, flavour, sweetness, texture, taste and overall acceptability using a 9 points Hedonic scale viz. 1= Dislike extremely, 2= Dislike very much, 3= Dislike moderately, 4= Dislike slightly, 5= Neither like nor dislike, 6= Like slightly, 7= Like moderately, 8= Like very much and 9= Like extremely described by Wills *et al.*, (1990). The score given by the judges for every parameter were calculated and average was taken there after.

(ii) Moisture content: Hundred grams of fresh sample was taken. These samples were taken in porcelain crucible in triplicate and oven dried at 80 ^{0}C till the weight become constant. Per cent moisture content was calculated according to the following formula:

$$\text{Moisture (\%)} = \frac{I-F}{I} \times 100$$

Where, I = Initial weight of sample

F= Final weight of sample

The data on (iii) total soluble solids (TSS), (iv) total sugar, (v) titratable acidity, (vi) pH and (vii) ascorbic acid were recorded following the same methods as in experiment number 1.

(vii) *β*-carotene: The estimation of *β*-carotene was done by the extraction of 3g of sample with acetone (Fisher Scientific Ltd., UK) and petroleum ether. It was further purified with acetone, methanolic KOH and distilled water. The resulting solution was filtered with anhydrous sodium sulphate and read on a spectrophotometer (T-80, PG Instrument Ltd., UK) at 451 nm against petroleum ether as a blank. A standard graph was plotted using synthetic crystalline *β*-carotene (Fluka, Germany) dissolved in petroleum ether and its optical density was measured at 451 nm (Alasalvar *et al.*, 2005).

Statistical analysis

The data were subjected to analysis of variance (ANOVA) using the Crop State Statistical Software version 6.2. The results showing significant differences were then subjected to mean separation using Least Significant Difference (LSD) Test.

RESULTS AND DISCUSSION

Sensory evaluation

The organoleptic attributes of the strawberry jam were evaluated. Comparative sensory evaluation of different quality attributes of the strawberry jam are presented in Fig. 3. The mean score showed that T_2 (Jam of 1:1.25 pulp to sugar ratio) was most preferred considering all the points as colour, flavour, sweetness and overall acceptability followed by T_1. The jam of T_1 scored the highest points for flavour, texture and taste followed by T_2. While T_3 (1:1.5 pulp to sugar ratio) scored the lowest for most of the attributes.

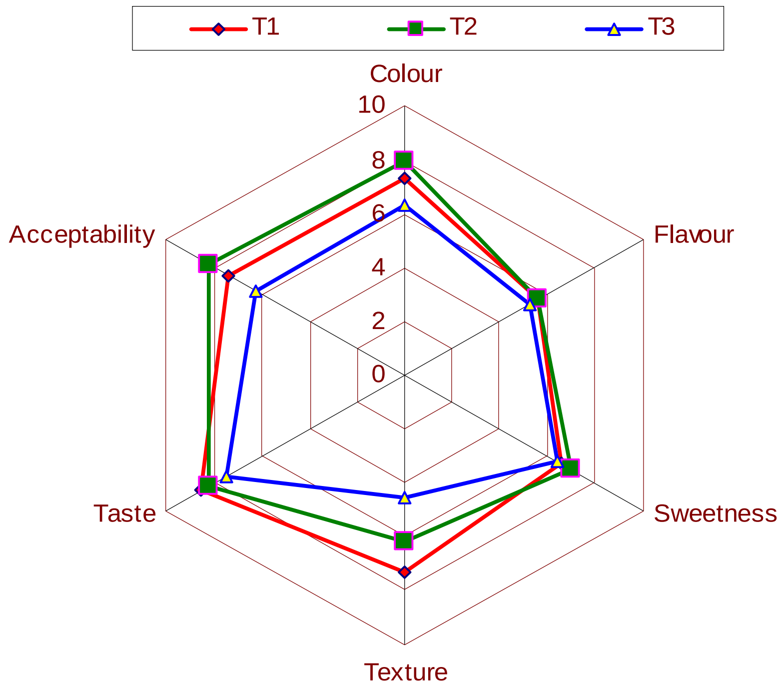

Figure 3. Rader diagram of selected sensory attributes of strawberry jam prepared from different pulp and sugar ratio.

The score of colour in the 9-point Hedonic scale was 7.95 in T_2, indicating that the colour of Jam under this treatment liked very much, while in T_3 it was 6.33which means that it was liked slightly. The flavour scored 5.23-5.60, indicates neither liked nor disliked. This was caused because attractive flavour of strawberry was lost due to heating at high temperature. It requires 103-105^{0}C temperature for gel formation. The sweetness scored 6.35-6.95 and revealed liking slightly to moderately. Resende *et al.* (2008) found Hedonic scale for flavour of different strawberry jam ranging from 2.05 to 2.32, which was lower than the present finding. This may be due to difference in processing method. The texture attribute of T_1 was 7.28, which indicates gel formation in this treatment was satisfactory, while T_3 had the lowest score (4.55) which indicate this treatment was disliked by the judges. The taste of jam in T_1 scored 8.48, which indicated that it was liked very much, while in T_3 it was 7.43, which was liked moderately. The overall acceptability of jam in T_2 scored 8.20, indicated that it was liked very much, and in T_3 it scored 6.25, indicated that it was liked slightly. Among the strawberry jam T_2 formulation scored the highest points in most of the sensory attributes and ranging from 5.58 to 8.20 which was suitable for jam preparation as per judges' opinion. Resende *et al.* (2008) found that the scores for appearance of jam produced from different strawberry cultivars varied from 5.79 to 7.38 Hedonic scale. Sinhg *et al.* (2009) evaluated some jams, for appearance, colour, flavor and texture and found that, papaya-pineapple jam was most preferred in overall appearance, colour and flavor.

Moisture content

The initial moisture content of strawberry jam ranged from 25.78 to 29.67 % in T_3 and T_1, respectively, and after 2, 4 and 6 months of storage the moisture content slightly increased (Table 5), which might be due to moisture absorbed by sugar component of jam. At the end of the storage period moisture content was the highest in T_1 (29.93 %), while the lowest in T_3 (26.11 %). After 6 months of storage the amount of gained moisture content was 0.88 % in T_1 and 1.28 % in T_3. Hossain (2011) found 1.00 % moisture increase in jackfruit jam during 6 months storage. This finding was corroborate with present results.

Table 5. Moisture content of strawberry jam and its change during storage

Treatment	**Pulp : Sugar**	**Moisture content (%)**				**Per cent change over time**
		Initial	**Month-2**	**Month-4**	**Month-6**	
T_1	1 : 1.00	29.67	29.65	29.87	29.93	0.88
T_2	1 : 1.25	26.75	26.81	26.91	27.05	1.12
T_3	1 : 1.50	25.78	25.83	25.96	26.11	1.28
LSD (1 %)		**1.629**	**-**	**1.350**	**1.603**	**-**
Level of significance		**	**ns**	**	**	**-**
CV (%)		**2.27**	**2.56**	**1.78**	**1.05**	**-**

Total soluble solids

The initial total soluble solids (TSS) content of strawberry jam varied from 66.12 to 67.25 % which was in standard range (Table 6.). Due to high TSS content the produce turns into sticky which is not preferred by the consumers (Hossain, 2011). During storage the TSS content slightly decreased. The initial TSS content in strawberry jam was the maximum in T_3 (67.25 %) and at the end of storage period it became 66.58 %, while the minimum TSS content was recorded in T_1 (66.12 %), which decreased to 65.93 % at the end of the storage period. Present findings are partially in agreement with those of Taufik and Karim (1992), who reported that maintaining Brix of 68 to 70 % not only gives taste but also protects jam from deterioration because microorganisms cannot grow at 70 % sugar concentration. This study revealed a decreasing trend of TSS content in strawberry jam. This trend was more or less similar and at the end of storage period the TSS was reduced up to 0.29 to 1.00 %. The decrease in TSS might be due to either conversion of sugar or absorption of moisture through sugar component during storage. Garcia-Viguera *et al.* (1999) found that TSS showed a constant value (<65 %) for all samples and slightly decreased during storage, which was in agreement with present finding. This result is also in agreement with that of Hossain (2011), who found 1.00 % decrease in TSS content after 6 months of storage in jackfruit jam. Singh *et al.* (2009) found that initial TSS of pineapple, orange and pineapple + orange jam were 72.5, 74.0 and 72.5 %, respectively. The TSS content of those product change during storage and attained at 74.0, 74.0 and 72.0 %, respectively after 60 days of storage. Shakir *et al.* (2008)

reported that trend of TSS content of fruit jam increased from 68.5 to 71.2^{0}Brix during 3 months of storage. There was an increase in TSS of aonla jam during storage (Diwate *et al.*, 2004). There was no significant change in TSS during the storage period of wood apple jam (Vidhya and Narain, 2011), and pomegranate jam (Pota *et al.*, 1987). The TSS of the products is the index of sweetness. In most cases it is correlated with the maturity and ripeness of fruits (Jain and Agawal, 2005).

Table 6. The TSS content of strawberry jam and its change during storage

Treatment	Pulp : Sugar	TSS content (%)				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	66.12	66.08	66.00	65.93	0.29
T_2	1 : 1.25	66.72	66.55	66.47	66.40	0.48
T_3	1 : 1.50	67.25	67.03	66.92	66.58	1.00
LSD (1 %)		**0.423**	**0.524**	**0.537**	**0.332**	-
Level of significance		**	**	**	**	-
CV (%)		**1.24**	**1.30**	**1.31**	**1.19**	-

Total sugar content

The total sugar content in strawberry jam ranged from 40.07 to 41.50 % at fresh, which was affected by temperature during storage (Table 7.). Total sugar content decreased in all the time of the strawberry jam throughout the storage period. At fresh condition the total sugar content was high in T_3, which decreased gradually and finally reached 39.08 %. Although, minimum total sugar content of fresh jam was found in T_1 (40.07%), during storage it decreased slowly and attained 38.01 % during 6 months of storage. Maximum total sugar loses was recorded in T_3 (5.89 %), while the minimum was observed in T_1 (5.14 %). This result is in agreement with that of Hossain (2011), who found 3.81 % decrease in total sugar content after 6 months of storage in jackfruit jam. Decrease in total sugars in the strawberry jam was observed by Mir and Nath, (1993). This might be due to the significant increase in reducing sugar. Rao and Ray (1980) explained the decrease in total sugar content due to hydrolysis and thereby inversion of sugar components. Biswal and Bozorgmehr (1991) reported that the maximum sucrose concentration that can be achieved in the liquid phase of the jam product. However, higher total sugar quantities found in jam is explained by increased reducing sugar solubility, resulting from sucrose inversion. Sinhg *et al.* (2009) observed that total sugar contents of different jams differed significantly; storage period did not affect its contents in the jams. The interactive effect between pulp combinations and storage periods significantly changed the total sugars (invert) and the total sugar of different jams ranged from 31.7 to 57.9 % at 30 days, and from 33.3 to 51.2 % at 60 days of storage. Saikia and Saikia (2002) reported that initial total sugar percentage ranged at day 0 was 26.54 to 48.48 % which increased to 31.15 to 55.05 %, after 60 days of storage. Shakir *et al.* (2008) reported an increasing trend of reducing sugars from 16.55 to 47.30 % during 3 months of storage.

Table 7. Total sugar content of strawberry jam and its change during storage

Treatment	Pulp : Sugar	Total sugar content (%)				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	40.07	39.88	39.21	38.01	5.14
T_2	1 : 1.25	41.00	40.90	40.03	38.89	5.15
T_3	1 : 1.50	41.50	41.10	40.20	39.08	5.89
LSD (1 %)		**0.287**	**0.262**	**0.439**	**0.203**	**-**
Level of significance		**	**	**	**	**-**
CV (%)		**1.27**	**1.25**	**1.42**	**1.20**	**-**

Titratable acidity

At initial stage titratable acidity was 0.65 % in T_1 and at the end of storage period it was 0.69 %. While lower titratable acidity was found in jam produced from T_3 (0.61 %), which reached up to 0.64 % at the end of 6 months storage. During storage period of strawberry jams, the maximum 5.80 % titratable acid was gained by $T_{1,}$ followed by T_3 (4.70 %), while the minimum (4.40 %) was occurred in jam of T_2 (Table 8.). Titratable acidity is an important quality factor related to flavour. If the acid level is too low, the product may be bland and unappealing (Kramer and Twigg, 1970). Acidity is the measure of shelf-life of the product (Vidhya and Narain, 2011). Titratable acidity studied to ensure physico-chemical changes during preparation (Sandhu *et al.*, 1998) and during storage (Kalra and Tandon, 1985). Titratable acidity of strawberry jam stored at ambient temperature increased steadily and varied significantly among the treatments. The titratable acidity of present investigation increased significantly during storage period and was partially corroborates with that reported by Hossain (2011). In his study titratable acidity in jackfruit jam increased from 0.35 % to 2.8 % after 6 months of storage. Sinhg *et al.* (2009) found that the acidity increased from the initial adjusted value up to 0.5 % after 30 days of storage. This findings are strongly in agreement with the present findings. Increase in acidity of fruit jams was reported earlier to be a result of ascorbic acid degradation or hydrolysis of pectin (Sogi and Singh 2001). Shakir *et al.* (2008) found that an increase was noted in acidity from 0.60 to 0.78%, during 3 months storage. The gradual increase in acidity might be due to the formation of acidic compounds by degradation or oxidation of reducing sugars present in the drink by the breakdown of peptic bodies (El-Warraki *et al.,* 1976). In wood apple jam, acid content was found to be decreased during storage (Vidhya and Narain, 2011).

Table 8. Titratable acidity of strawberry jam and its change during storage

Treatment	Pulp : Sugar	Titratable acidity (%)				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	0.65	0.68	0.68	0.69	5.8
T_2	1 : 1.25	0.65	0.67	0.68	0.68	4.4
T_3	1 : 1.50	0.61	0.63	0.64	0.64	4.7
LSD (1 %)		**0.026**	**0.026**	**0.026**	**0.026**	-
Level of significance		**	**	**	**	-
CV (%)		**2.98**	**2.22**	**2.15**	**2.30**	-

The pH level

The pH level of strawberry jam decreased slowly during storage and varied significantly (Table 9). Just after processing pH of strawberry jam was 2.81 in T_1, which decreased to 2.78 at the end of storage period. The lowest pH 2.77 was found in T_3, which was reduced to 2.73 at the end of storage period. During storage, the maximum retention of pH was observed in T_2 (2.10 %) followed by T_3 (1.44 %), while the minimum (1.07 %) reduction of pH was observed in T_2 after 6 months. The decreasing trend of pH might be due to increasing trend of acidity during storage of jam. Rababah *et al.* (2011) stated that after processing, the pH of fruit jams became 2.71, and during storage it did not change significantly, which is partially in agreement with present results. Garcia-Viguera *et al.* (1999) found that pH of strawberry jam varied significantly ranging from 2.98 to 3.39 during jam preparation, and revealed a steadily decrease during storage. These findings were similar with the present findings. The pH of the samples decreased due to an increase in acidity during storage period (Murtaza *et al.*, 2004). A similar decreasing trend in pH during storage was observed in jackfruit jam by Hossain (2011) and in mixed fruit jam by Shakir *et al.* (2008).

Table 9. The pH levels of strawberry jam and its change during storage

Treatment	Pulp : Sugar	pH level				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	2.81	2.79	2.78	2.78	1.07
T_2	1 : 1.25	2.80	2.77	2.75	2.74	2.10
T_3	1 : 1.50	2.77	2.75	2.74	2.73	1.44
LSD (1 %)		**0.028**	**0.026**	**0.026**	**0.026**	-
Level of significance		**	**	**	**	-
CV (%)		**1.10**	**1.13**	**1.10**	**1.11**	-

Ascorbic acid content

Ascorbic acid content of the jam was found very low and ranging from 14.75 to 17.49 mg 100 g^{-1} just after processing (Table 10.) in contrast to 61.65 mg 100 g^{-1} of ascorbic acid in strawberry pulp (Table 1.). Due to the most of the ascorbic acid present in the pulp was destroyed during heating at higher temperature (Ihekoronye and Ngoddy, 1985). Fresh strawberry jam of T_1 treatment contained the maximum ascorbic acid (17.49 mg 100 g^{-1}), whilst T_3 contained the minimum (14.75 mg 100 g^{-1}). After 6 months of storage, ascorbic acid content of strawberry jam was found to be decreased and varied significantly. At the end of 6 months of storage the highest ascorbic acid content was found in the treatment T_1 (15.37 mg 100 g^{-1}), and the lowest in T_3 treatment (12.62 mg 100 g^{-1}). The maximum reduction in ascorbic acid content was noted in T_3 (14.44 %) followed by T_1 (12.12 %), while the minimum (11.06 %) in T_2 after 6 month of storage. This result partially agreed with that of Hossain (2011), who found a reducing trend in ascorbic acid of jackfruit jam and it decreased 18.79 % during 6 months of storage. Shakir *et al.* (2008) reported that ascorbic acid content decreased from 17.40 to 9.19 mg 100 g^{-1} in mixed fruit jam during 3 months of storage. A substantial reduction in ascorbic acid content of the sample during storage could be due to both oxidative and non oxidative changes as described by Eskin (1979) and Land (1962). According to Klopotek *et al.* (2005), the heating has reducing effect on vitamin C. Vitamin C, which is unstable to heat and oxygen, is oxidized to non antioxidant effective substances. According to Otta (1984) the decrease in ascorbic acid was due to prolong storage at high temperature. In addition, time-consuming treatments such as fermentation of the mash and centrifugation of the juice also reduced the vitamin C content because enzymes and oxygen are capable of attacking and inactivating vitamin C (Mankar et al., 2015).

Table 10. The ascorbic acid content of strawberry jam and its change during storage

Treatment	Pulp : Sugar	Ascorbic acid (mg 100 g^{-1})				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	17.49	16.37	15.60	15.37	12.12
T_2	1 : 1.25	15.91	15.01	14.67	14.15	11.06
T_3	1 : 1.50	14.75	13.91	12.94	12.62	14.44
LSD (1 %)		**1.526**	**1.795**	**1.890**	**1.258**	**-**
Level of significance		**	**	**	**	**-**
CV (%)		**3.63**	**4.45**	**5.08**	**5.56**	**-**

β-carotene content

The *β*-carotene content of strawberry jam decreased bit by bit during storage and varied significantly (Table 11). Fresh strawberry jam of T_1 treatment contained the higher *β*-carotene content. Just after cooking *β*-carotene content of strawberry jam in T_1 was 1.81 µg 100 g^{-1}, and at the end of storage period it was 1.69 µg 100 g^{-1}. While the lower *β*-carotene content was found in T_3 i.e. 1.70 µg 100 g^{-1}, which decreased to 1.64 µg 100 g^{-1} at the end of storage. During storage, the maximum retention of *β*-carotene was observed in T_1 (6.60 %) followed by T_2 (4.50 %), while the minimum (3.50 %) in T_3 after 6 months. It might be due to sugar pulp ratio that prevents *β*-carotene from destruction during storage. The reduction could be due to both oxidative and non oxidative changes in *β*-carotene in products as described by Eskin (1979) and Land (1962). Such changes altered the colour of the product and lowered the flavour and nutritive value.

Table 11. The *β*-carotene content of strawberry jam and its change during storage

Treatment	Pulp : Sugar	*β*-carotene content (µg 100 g^{-1})				Per cent change over time
		Initial	Month-2	Month-4	Month-6	
T_1	1 : 1.00	1.81	1.79	1.76	1.69	6.6
T_2	1 : 1.25	1.76	1.75	1.72	1.68	4.5
T_3	1 : 1.50	1.70	1.69	1.68	1.64	3.5
LSD (1 %)		**0.083**	**0.083**	**0.026**	**0.026**	-
Level of significance		**	**	**	**	-
CV (%)		**2.37**	**2.36**	**1.78**	**2.25**	-

Conclusion

Considering the sensory evaluation, nutritive value and physio-chemical changes during storage the treatment combination T_2 that is 1: 1.25 pulp to sugar ratio of strawberry jam could be selected for commercial processing. After 6 months of storage under room temperature, the quality and the nutritional changes of strawberry jam was found satisfactory. For this regards it was concluded that strawberry jam may be stored up to 6 months at room temperature.

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