Development and Quality Evaluation of Papaya Jam with Blended Carrot

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Abstract: The study was undertaken with the objective of evaluating jam with enhanced nutritional properties and acceptable sensory attributes. Jam samples were developed from *Carica papaya* and carrot pulp in different ratios of 50:50, 25:75 and 75:25 (*Carica papaya*: Carrot pulp) and were labeled as sample A, B and C. The raw samples and the jam thus prepared were analyzed for physio-chemical properties and the jam samples were also evaluated sensorily on a 9-point hedonic scale. The proximate composition of the formulated jam samples ranged from 31.40% to 30.34% for moisture, 0.41% to 0.22% for ash, 0.92% to 0.69% for protein, 0.35% to 0.31% for fat, 0.96% to 0.76% for fiber and 67.48% to 66.34% for carbohydrate. The antioxidant activity was found to be 40.9%, 39.65% and 25.7% in sample A, B and C respectively while the total phenolic content of different formulated jam varies from 6.58802 to 2.239 mg GAE/100 gm. The physicochemical characteristics of the carrot and papaya pulp jam samples were also evaluated. The pH of raw papaya and carrot pulp was 5.8 and 5.3 while the pH of the jam samples was 3.4, 3.2 and 3.5 respectively. The overall acceptability of the formulated jam samples was 7.5, 7.2 and 7.4 for sample A, B, and C respectively. The results suggest that papaya jam developed from 50% papaya and 50% carrot blend may be an acceptable jam for consumers.

Keyword: Papaya, Carrot, jam, quality, evaluation, acceptability, composition

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1 Introduction

Papaya (*Carica papaya* L.) is cultivated in the tropics and subtropics worldwide. It is one of the leading fruits in the acreage and per hectare production in Bangladesh. About 1.25 lac metric tons of papaya were produced from an area of approximately 1.24 thousand hectares of land with an average yield of 7ton ha^{-1} in Bangladesh (BBS, 2011). Papaya yields are currently much smaller in Bangladesh relative to other countries in the world (Chowdhury et al., 2008). Papaya fruit losses in Bangladesh were estimated at approximately 39.9 percent post-harvest and 15.64 million US dollar reflects the amount of post-harvest losses of papaya fruits (Hassan, 2010). Fungal diseases are one of the key factors for the post-harvest failure of papaya production. All around the world, mature papayas suffer from numerous post-harvest diseases. Fruit rots result in a significant loss in the fruit industry after harvest, causing price rises (Uddin, 1995). In Bangladesh yield of papaya, truth be told, is far underneath contrasted with different nations of the world (Chowdhury et al., 2008). The accessibility of the natural product is decreased because of significant level of post-harvest loss (Mondal et al., 1995).

Carrots (*Daucus carota* L.) are among the main root vegetables in the *apiaceae* family are developed

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around the world. As a vegetable carrot is highly perishable food materials coupled with difficulty and high cost of transportation from production areas to consumers areas; there is a lot of waste especially in rural areas, where there is no facilities for agro processing activities. These facts indicate that there is a necessity for the development of appropriate technology to cope with these problems. Jam making is the most suitable method for preservation. Jam is defined as fruits or vegetables pulp or juice to which sugar, pectin and citric acid are added. The mixture is usually boiled until reaches reasonable consistency (Saeed and Elmubarak, 1974). It involves the reduction of as much water as possible from the fresh fruit to arrest enzymatic and microbial activities; hence, stopping deterioration (Teshome, 2010). Great jam has a delicate, even consistency without particular bits of natural product, a splendid tone, a decent natural product flavor and a semi-jellied surface that is not difficult to spread yet has no free fluid (Berolzheimer et al.,1959).

The availability of raw materials and additional components such as sugar, citric acid, pectin, and jam jars at acceptable costs are required for jam production. In isolated areas, where making of proper number of fruits and vegetables jam may contribute to some extent in solving the problem of losses of fresh fruits and vegetables. This research was performed for the following reasons, taking into account the nutritional content of jam:

To assess and optimize product consistency.

To analyses the product's chemical and nutritional properties.

To access the product's acceptability.

2 Materials and methods

The present research work was conducted at Nutrition and Food Technology laboratory, Jashore University of Science and Technology. The quality of fresh fruits and processed jam were evaluated by the determination of nutritional analysis, texture and physio-chemical analyses. Finally, sensory evaluation of jam was conducted. The experimental site, materials utilized, and procedures employed in various operations throughout the experiment, as well as data collecting, are all explained here under the following sub-section:

2.1 Collection of samples

Fresh and fully ripe papaya, fresh carrot, sugar, citric acid, pectin powder, and different flavors were purchased from a local market in Jashore, Bangladesh.

2.2 Tool and equipment

Knife, Plate, Weight machine, Pan, Muslin cloth, Wooden spoon, Tea spoon, Mixer grinder, Thermometer, Glass bottle, Glass jar, PH meter, Refractometer, Burette, Pipette, Analytical balance, Oven dryer, Petridish, peeler, muffle furnace, crucible, beaker, Soxhlet apparatus, Thimble, Heating mantle, Glass rod, Desiccator, filter paper, Cotton plugs, Kjeldal tube, Spectrophotometer.

2.3 Methods

The present investigation used the following methods, each of them was for specific purposes.

(1) Extraction of fruit pulp as described by Ullah et al. (2018)

(2) Preparation of jam as described by Awan and Rehman (1999)

(3) Assessment of jam quality as described by AOAC (2012)

2.4 Product formulation

The following different ratios were maintained in preparing the jam.

Sample A: papaya pulp (50%) + carrot pulp (50%).

Sample B: papaya pulp (25%) + carrot pulp (75%).

Sample C: papaya pulp (75%) + carrot pulp (25%).

2.5 Pulp extraction

Matured and fully ripe papaya fruits were peeled, and the seeds removed manually, while the carrot was also peeled and chopped manually into tiny pieces as presented in Figure 1. The size reduced fruits were then ground individually with a grinder

until the pulp was homogeneous and uniform. The ground pulps were also properly strained.

2.6 Preparation of jam

Figure 1 Small pieces of carrot and papaya pulp

2.6.1 Cooking and addition of sugar

Jam was prepared by placing the fruit pulp and sugar in a heavy-bottomed stainless-steel pan and heating it to 100 ℃ on an induction cooktop (Figure 2). To avoid pectin clotting, the mixture was continuously stirred after being allowed to come to a boil before being added with 0.1 g of pectin powder. The mixture was left to cook for a few minutes while being stirred every so often at a temperature of 130 ℃. The induction cooktop temperature was set at 130 ℃, but jam was cooking at 105 ℃ at this time. For the jam to cook quickly, the temperature (105 ℃) was applied for several minutes. By cooling a small sample and measuring its TSS with a refractometer, the endpoint of jam production was identified. The heat was turned off when the mixture reached a Brix TSS consistency of 65 °.

Figure 2 Jam preparation

2.6.2 Pouring and storing of jam

After jam had been made, samples were immediately placed in clean, previously sterile glass jars and allowed to cool at room temperature (Figure 3). Jar underwent sterilization to remove any potentially dangerous microorganisms. After cooling, the jars were sealed with their lids and kept in the fridge. The prepared jams were placed in pre-sterilized glass bottles and given time to acclimate to room temperature. They were then placed in the refrigerator for storage.

Figure 3 Jam stored in jar

2.7 Determination of pH

The pH was determined with a glass electrode pH meter (Figure 5). First at pH 4.0, then at pH 7.0, the pH meter with buffers was calibrated. When the glass electrode was put in the filter to test the pH, constant measurement was carried out. The glass electrode was cleaned with distilled water after reading and washed dry with soft tissue paper to ensure accuracy.

2.6.3 Process diagram of jam preparation

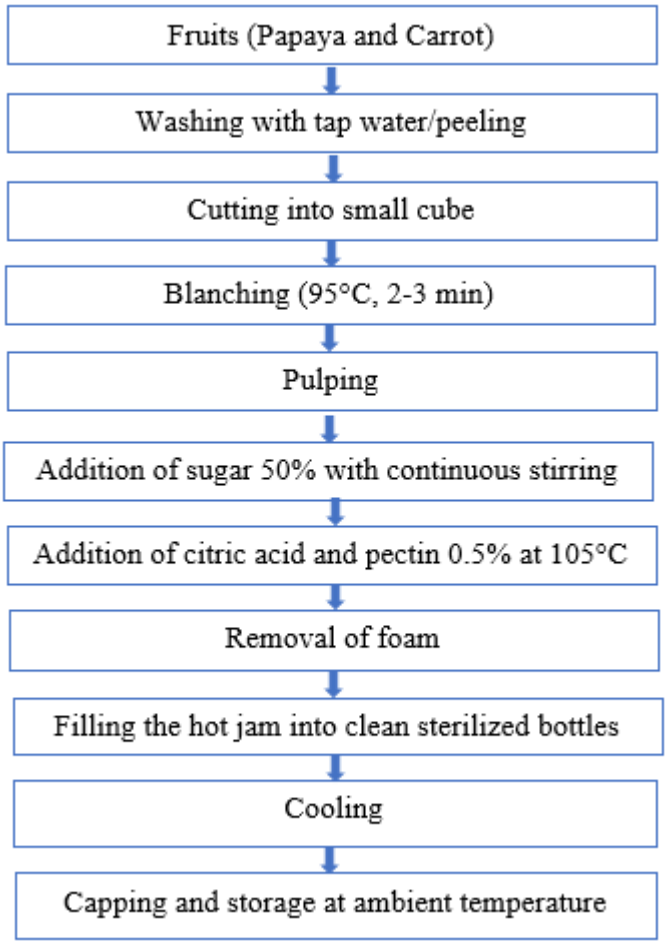

Figure 4 Flow chart for jam preparation

Figure 5 pH meter

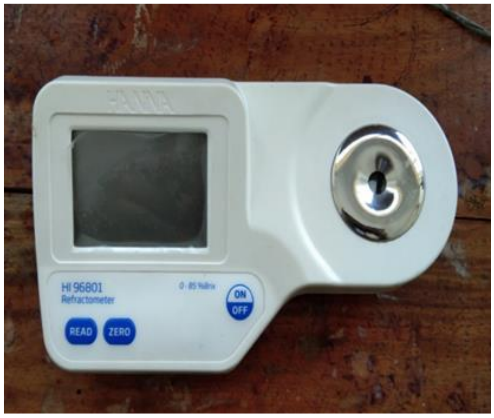

Figure 6 Refractometer

2.8 Determination of total soluble solids

A digital refractometer was used to determine the jam's total soluble solids (TSS) concentration (Figure 6). The remaining of the sample was used to measure the TSS. Before to testing to provide a 0% value the refractometer was calibrated with pure water. Approximately 1 or 2 drops of the sample were put in the refractometer prism glass to get the %TSS read. Finally, this reading was recorded.

2.9 Proximate analysis of formulated jam

2.9.1 Determination of moisture content (AOAC, 2005)

The oven-dry method is one of the most often used methods for measuring moisture content. In this procedure, 5 grams of sample were collected (Figure 7), the precise weight was established, and the sample was dried in an oven for 24 hours at the temperature of 105℃. The sample was then weighed, and the

moisture loss was calculated by subtracting the oven-dry weight from the moist weight.

Figure 7 Sample in Petridis

Figure 8 Ash in crucible

The moisture content is represented in the oven-dry weight as a percentage.

Calculation

$$\%Moisture = \frac{W1-W2}{W1-W} \times 100 \quad (1)$$

Where,

W is the weight of petridis, g

W_1 is the weight of petridis plus sample, g

and W_2 is the weight of petridis plus oven dried sample, g.

2.9.2 Determination of ash content (AOAC, 2005)

Accurately 5 g of sample was weighted in a crucible (Figure 8). Then the sample was transferred to the muffle furnace and increased the temperature step wise to 550℃ ± 5℃. The temperature was maintained for 8 hours or until white ash was obtained. After removing the crucible from muffle furnace then the crucible was placed into a desiccator. Finally, the crucible was removed from the desiccator and weighted soon after cool.

The percentage ash content (wet weight basis) was calculated as follows:

$$\%Ash = \frac{m2-m1}{ms} \times 100 \quad (2)$$

Where,

m_1 is the weight of empty crucible (g),

m_2 is the weight of crucible with ash (g),

and m_s is the weight of sample (g).

2.9.4 Determination of protein content (AOAC, 2005)

It can be divided into 3 major process steps:

(a) Digestion of the samples with sulphuric acid

(b) Distillation of the digestion solution with steam

(c) Titration of the distillate and calculation of the result

Reagents

Kjeldahl catalyst: Mix 6 g of potassium Sulphate with 0.4g copper sulphate

Sulfuric acid

40% Sodium Hydroxide (NaOH)

0.1N HCl solution

4% Boric acid

Indicator solution: Mix 100 mL of 0.1% methyl red (in 95% ethanol) with 200 mL part of 0.2% bromocresol green (in 95% ethanol).

Procedure

Accurately 0.5 g of sample was weighted and placed the sample in digestion flask (Figure 9). 6 g K_2SO_4 and 0.4 g $CuSO_4$ and 20 mL of conc. H_2SO_4 were added. A tube containing the above chemical except sample was prepared as blank. The flask was then heated in a digestion chamber at 380℃ for 1 hr and 30 min and then cooled the flask. The flask placed in distillation chamber and added boric acid then added methyl red indicator and added distilled water for dilution. Then added sodium hydroxide into digested sample and distillation for 5 minutes. Finally titrated the sample with the HCl until the solution became colorless. The burette reading was recorded.

Figure 9 Protein determination

$$\text{Protein}(\%)=\frac{(A-B)\times N\times 1.4007\times 6.25}{W} \quad (3)$$

Where,

A is the volume of 0.1N HCl used sample titration (mL),

B is the volume of 0.1N HCl used in blank titration (mL),

N is the normality of HCl,

W is the weigh (g) of sample,

14.007 is the atomic weight of nitrogen, and

6.25 is the protein conversation factor.

2.9.5 Determination of fat content (AOAC, 2005)

Reagent: n-Hexane

Procedure

2 g of the material was put into the extraction thimble and gently placed in the extractor after the extraction flask was precisely weighed (Figure 10). Next extraction flask was connected to the extractor carrying the thimble and 25 mL of n-hexene was added into the extractor. The extractor was connected to the condenser and flask was heated on a heating mantle for 6 hours. The solvent is vaporized and condensed by the heat and the condenser respectively. The condensed solvent is poured into the thimble drop by drop. The solvent removes the fat found in food. The flask was then gently removed. The extract was placed into a conical flask and the solvent was heated until evaporated. Weighed after cooling in desiccators. The weight was finally recorded. The extract percentage was determined by multiplying the weight increase of the extraction flask by 100.

Figure 10 Fat extraction

$$\text{Fat}(\%)=\frac{weight\ of\ extracted\ fat\ (g)}{weight\ of\ original\ sample\ (g)}\times 100 \quad (4)$$

2.9.6 Determination of Crude Fiber (AOAC, 2005)

After crude fat determination, 2 g of dried, fat free residue was weighted accurately and moved into the conical flask (Figure 11). In a beaker 200 mL dilute sulphuric acid (1.25%) was taken and boiled 30 min on the hot plate. Then the sample was filtered with muslin cloth and washed with hot water until the washing was no longer acid to litmus. The entire residues were transferred in the same beaker. Then 200 mL of NaOH (1.25%) was added to the beaker and boiled 30 min. Filtered the residue with muslin cloth and the residue was washed thoroughly with boiling water till free from alkali and again washed with 95% ethanol. The residue in a crucible was transferred to an oven dryer which temperature was maintained at 105˚C and kept there the sample overnight for drying. Then removed the crucible and kept it in the desiccator for cooling. Then the sample was weighed to the crucible with residue. The crucible and its contents were transferred in a muffle furnace and ignited at 600˚C for 2 hours. Finally, the crucible was removed and cooled in desiccators. Then, the ash was weighed.

Figure 11 Fiber determination

$$\%\ Crude\ fiber = \frac{A-B}{C}\times 100 \quad (5)$$

Where,

A is the weight of crucible with dry residue (g),

B is the weight of crucible with ash (g) and

C is the weight of sample (g).

2.9.7 Determination of Carbohydrate

Total carbohydrate content was determined by subtracting the total of the percentages of moisture, ash, fat, protein from 100.

Percent of carbohydrate = 100 – [Moisture (%) + Crude fiber (%) + Ash (%) + Fat (%) + Protein (%)] (6)

2.10 Determination of antioxidant activity

2.10.1 Extract collection

10 gm of sample and 30 mL of acidified methanol were shaking together 30 min. Then it was centrifuged for 20 min at 4000 rpm and filtered. The resultant supernatants were finally utilized as test samples.

2.10.2 Scavenging of DPPH (1, 1-diphenyl-2-picrylhydrazyl)

24 mg of DPPH was dissolved in 100 mL of methanol and protected from light by covering it with aluminum foil. A blank solution of pure methanol was utilized. In a test tube, 100 μL of extract sample was placed, along with 3 mL of DPPH, and the test tubes were covered with aluminum foil. The solution was incubated for 30 minutes at room temperature and the absorption measured by means of a spectrophotometer was 517 nm.

The following formula was used to determine the free radical scavenging activity (FRSA) (% antioxidant activity).

$$\text{DPPH scavenging effect (\%)} = \frac{AC_0-AC_t}{AC_0}\times 100 \quad (7)$$

Where,

AC_0 is the absorbance of the control DPPH solution at 0 min and AC_t is the absorbance of test samples. The simplified shape for determining percent DPPH formula is as under,

$$\%\text{DPPH} = \frac{control\ absorbance-sample\ absorbance}{control\ absorbance}\times 100 \quad (8)$$

2.11 Determination of phenolic content

Reagent: Folin- ciocalteu

Accurately weighted 100 μL sample from extract in a test tube and 1 mL methanol was added. Then 3.1 μL distilled water was poured into the test tube. Next added 200 μL Folin-ciocalteu reagent and waited for 10 minutes. 10% sodium carbonate was added and incubated at 40℃ for 30 minutes. Finally, the absorbance of the samples, standard and blank was read at 765 nm using a Spectrophotometer. The absorbance of the blank was subtracted from all readings and a calibration curve was created using the standard. Total phenolic content was calculated as gallic acid equivalent based on the gallic acid calibration curve.

2.12 Sensory evaluation of jam

The produced papaya-carrot jams were presented to a group of 30 semi-trained panelists for evaluation of color, consistency, flavor, taste, and general acceptability on a 9 point hedonic scale with values ranging from 9 to 1 representing like extremely and dislike extremely. The three assessments' mean scores were obtained after the quality parameters were quantified.

3 Results

The results of the analyses of variance in respect of all the parameters studied in the present investigation are presented and discussed in this section. The results on the different parameters are presented in tables for ease of discussion under the following sub-headings and possible interpretations are also given whenever necessary.

From Table 1, the pH of raw papaya and carrot pulp was found to be 5.8 and 5.3 while the TSS was 9.2% and 9.8% respectively. The proximate composition recorded for papaya was 90% for moisture content, 0.27% for ash content, 0.77% for protein content, 0.23% for fat content, 1.23% for fiber content and 7.5% for carbohydrate content. Carrot pulp was found to contain 87% moisture, 0.6% ash, 1.60% protein, 0.30% fat, 1.20% fiber and 9.3% carbohydrate.

Table 1 Proximate composition of the ripe papaya and fresh carrot

Sample	pH	TSS (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
Papaya	5.8	9.2	90	0.27	0.77	0.23	1.23	7.5
Carrot	5.3	9.8	87	0.60	1.60	0.30	1.20	9.3

Table 2 Proximate composition of formulated jam

Sample	pH	TSS (%)	Moisture (%)	Ash (%)	Protein (%)	Fat (%)	Fiber (%)	Carbohydrate (%)
A	3.4	68.8	30.60	0.26	0.92	0.31	0.96	66.95
B	3.2	68.2	31.40	0.22	0.81	0.35	0.88	66.34
C	3.5	68.6	30.34	0.41	0.69	0.32	0.76	67.48

Table 3 Mean score for smell, taste, sweetness, texture, appearance and overall acceptability for jam sample

Sample	Appearance	Texture	Sweetness	Taste	Smell	Overall acceptability
A	7.6	7.4	7.5	7.3	7.7	7.5
B	7.5	6.6	6.5	7.2	7.3	7.2
C	7.2	8.0	7.0	7.6	7.2	7.4

Note: Where, 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; 9= like extremely.

Table 4 Antioxidant activity of formulated jam (%)

Sample	Absorbance	Antioxidant activity
A	0.588	40.9
B	0.601	39.65
C	0.740	25.7

Table 2 revealed that, sample A pH was 3.4, 68.8% TSS, 30.60% moisture, 0.26% ash, 0.92% protein, 0.31% fat, 0.96% fiber and 66.95% carbohydrate while sample B with pH 3.2 contain 68.2% TSS, 31.40% moisture, 0.22% ash, 0.81% protein, 0.35% fat, 0.88% fiber, 66.34% carbohydrate. Sample C recorded a pH of 3.5 and with 68.6% TSS, 30.34% moisture, 0.41% ash, 0.69% protein, 0.32% fat, 0.76% fiber, 67.48% carbohydrate. The mean scores for smell, taste, sweetness, texture, appearance and overall acceptability are shown in Table 3.

From Table 4 we can see that, absorbance of sample A (0.588), B (0.601), C (0.740) and their antioxidant activity are 40.9%, 39.65% and 25.7% respectively.

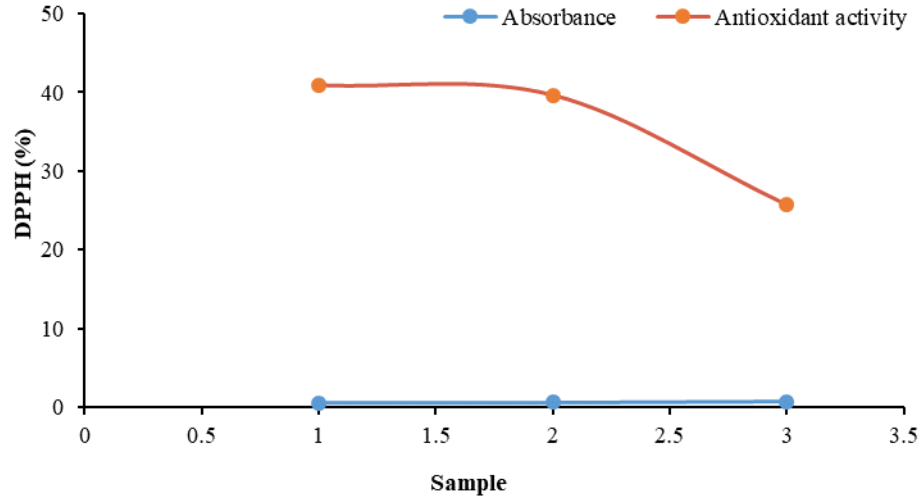

Figure 12 Graphical view of DPPH

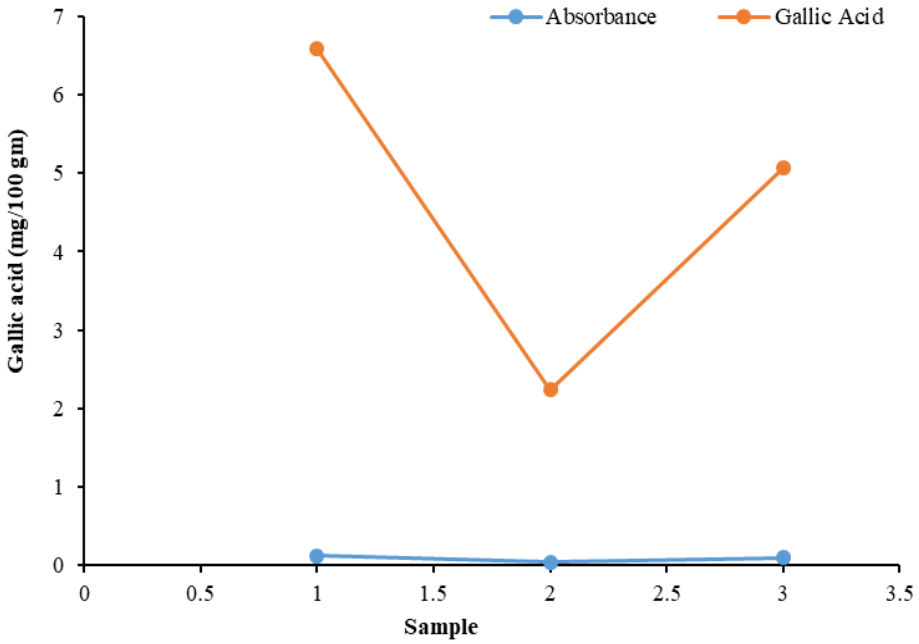

Figure 13 Standard curve of gallic acid

The antioxidant activity was determined by the percentage of DPPH. Antioxidant activity of sample A, B and C was found to be 40.9%, 39.65% and 25.7% respectively as presented in Table 4. The result of antioxidant activity is significantly higher in sample A (40% probability level), while the lowest content was found in sample B and sample C respectively (Figure 12). This suggests that the shelf life of sample A will be longer than sample B and C. Table 5 shows that the total phenolic content of different formulated jam varies from 6.58802 to 2.239 mg GAE/100 gm. Sample A exhibits good amount of gallic acid (Figure 13), which indicates good source of antioxidants to maintain color, flavor,

and nutritional values of the fruits. Being an antioxidant, it can also act as a natural preservative by inhibiting the growth of certain microorganisms that can spoil the jam.

Table 5 Amount of Gallic acid in extract of sample

Sample	Absorbance	Amount (mg/100 gm)
A	0.118	6.58802
B	0.038	2.239
C	0.09	5.06595

4 Discussion

From the comparison of the formulated jam samples (A, B, C) with previous research in this category, it can be observed that the total soluble solids (°Brix) of the formulated jam samples are higher than the raw papaya and jam. Sample A has the highest percentage (68.8), while sample B has the lowest (68.2). This finding is consistent with the observations made by Khan et al. (2017) in their study on pear apple jam (68.5 °Brix-71.2 °Brix) and Ehsan et al. (2003) in their study on fruit jam (66.5-68.8 °Brix). Similarly, Hussain and Shakir (2010) found a TSS range of 70 °Brix to 70.8 °Brix in watermelon and lemon jam.

Regarding the pH values, the formulated jam samples have lower pH compared to the raw papaya and carrot. Sample C has the highest pH value of 3.5, while sample B has the lowest pH value of 3.2. This finding aligns with the research of Hussain and Shakir (2010), who observed decreasing trends in the pH of watermelon lemon jam samples over time. However, Anjum et al. (2000) reported somewhat higher pH values in their study on apple and apricot jam. The decrease in pH values during storage can be attributed to the formation of acidic compounds and microbial activities, as supported by previous literature (Aina and Adesina, 1991; Fasoyiro et al., 2005).

The moisture content of the formulated jam samples is lower compared to ripe papaya and fresh carrot. High sugar content in jams can make moisture unavailable for the growth of microorganisms, thus improving the shelf life of the product. Fluctuations in moisture content can be influenced by microbial activity and enzymatic reactions. The moisture content of the jam samples in this study is lower compared to jams made from blends of African star apple and tamarind, as well as jams from dry dark red roselle calyx stored at ambient temperature (Ashaye et al., 2006).

The ash content, which indicates the mineral content of the jam samples, is lower in samples A and B compared to ripe papaya and fresh carrot. Ash content can affect the physiological functioning of metabolic processes in the body. The ash content reported in this study is higher compared to jams made from fresh dark red roselle calyx stored at ambient temperature and dry light red roselle calyx stored at cold temperature. However, it is within a favorable range compared to jams made from blends of African star apple and tamarind (Ashaye et al., 2006).

The crude protein and fat content of the jam samples vary compared to ripe papaya and fresh carrot. Sample A has the highest crude protein content (0.92%), while fresh carrot has the highest crude protein content (1.60%). Sample B has the highest fat content (0.35%), whereas fresh carrot has a slightly higher fat content (0.30%). The fiber content of the jam samples is lower compared to ripe papaya and fresh carrot.

In terms of sensory evaluation, sample A received the highest ratings for hedonic aspects, texture, sweetness, taste, fragrance, and overall acceptability. On the other hand, sample B received the lowest ratings in these categories. This indicates that sample A is preferred over the other samples.

Lastly, from the analysis of Table 5, it can be observed that the antioxidant activity of the sample extract increases as the absorbance decreases. This suggests a higher antioxidant potential in the formulated jam samples.

5 Conclusion

It may be concluded from the results that the addition of papaya with carrot in jam making can enhance the food quality and dietary diversity. It was revealed that equal proportions of papaya and carrot pulp in combinations are suitable for preparation of jam of acceptable quality with attendant benefits in terms of nutritional value with regards to fiber, carbohydrate and anti-radical activity. It will also lower the risk of various types of cancer and can also play an important function in liver health and vision. Therefore, the formulated papaya-carrot jam may be incorporated in the daily diet of people of all ages to improve nutritional intake and protection against illness.

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