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Effect of storage condition on physiochemical and sensory properties of papaya jam

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Abstract

The objective of present study was to evaluate the effect of storage condition on physiochemical and sensory properties of jam prepared from ripe and unripe papaya. Jam was prepared by traditional Open Kettle method. Jams were stored at ambient condition and low temperature for 60 days. Results exhibited that moisture, TSS, pH, total sugar and phenolics content of jam gradual changed during storage. There was decrease in the moisture, pH and phenolics content during storage period. However, TSS and total sugar content increased during the 60 days of storage period. Papaya jam also exhibited changes in sensory characteristics. There was gradual decrease in taste, flavor and overall acceptability during storage. Jams stored at ambient condition exhibited more significant changes in physiochemical and sensory properties than jams stored at low temperature. Thus, suggesting that jam prepared from ripe and unripe papaya cannot be stored for long period at ambient condition. Storage not only brings about physiochemical changes but also influence sensory characteristics of papaya jam.

Keywords: Papaya, jam, storage, phenolics content, overall acceptability

Introduction

Fruits are vital constituents of our daily diet. They serve as an important source of vitamins, minerals, fibers and carbohydrates for mankind. Daily consumption of fruits has been linked to several health benefits [2, 21]. Man prefers eating fresh fruits. However, fresh fruits are liable to deteriorate owing to high ambient temperature and humidity, pest and disease infestation, improper handling and poor storage facilities [22]. One of the most handy, attractive and effective method of reducing loss is to process and preserve fruits in durable edible forms [12]. Converting fruit to preserves, jams, sauces, pickles and chutneys is an age-old Indian tradition. Fruit preservation not only reduces fruit loss but also increases availability of fruit-based products during off-season [12, 15].

Preservation of fruits in the form of jam is very attractive and popular among consumers. Generally, jam preparation involve cooking fruits with sugar and other additions such as pectin and citric acid [10]. A good quality jam must be bright color with intermediate consistency and texture. Jam must also impart distinct flavor of original fruit [15, 19]. Processing method and conditions has tremendous influence on quality parameters and self-life of jam [22]. Storage condition influences several quality parameters (such as color, texture, total phenolics content, total soluble solids, anti-oxidant activity and anthocyanin content) of jam [12, 15, 19]. Thus, proper selection of ingredients, storage condition, processing methods and condition is of utmost importance for the production of good quality jam [12, 15, 19].

Papaya (*Carica papaya* L.) is one of the most popular tropical fruit owing to high nutritional content and immense commercial importance [2]. Papaya fruits are good source of vitamins, minerals, carbohydrates and dietary fibers [2, 21]. It also contains many bioactive phytochemical with potential health benefits [2]. Papaya fruits are available throughout the year in India. People prefer consuming papaya fresh or in the form of processed and preserved product. Both ripe and unripe papaya fruits can be utilized for preparing various preserved product.

Jam is the most preferred means of preserving papaya [19]. Like several other preserved product, papaya jam also undergo changes during storage [19, 20]. There are very few reports showing influence of storage temperature on physiochemical and sensory parameters of papaya jam [19, 20]. Thus, the present study reports changes in the physiochemical and sensory parameters during storage at low and ambient temperature. Jam used in the study was prepared from fully ripe and unripe papaya fruits.

Materials and methods**Materials use in the study**

The present investigation was carried out at Sant Baba Bhag Singh University, Khiala, India during 2020-2021.

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The papaya fruit used in the study was procured from kitchen garden located at SBS Nagar, India. Injury and disease free papaya (fully ripe and unripe) of nearly equal size was selected randomly during month of November 2020. Visual inspection was used for deciding on the ripening status of papaya. Fully ripe papaya was yellow in color while unripe papaya was green in color. Lemon used in the study was purchased from local vegetable market. Food grade ingredients were used for jam preparation. Chemical and reagents used for biochemical analysis was purchased from nice chemicals Pvt Ltd., India and Avarice Industries Pvt Ltd., India.

Pulp preparation

Papaya collected from kitchen garden was washed thoroughly with distilled water to remove all the dust. Excess of water present on the surface of fruit was removed by drying it in the open air. Thin layer of skin was removed from fruit by help of Potato Peeler. Peeled papaya was sliced in small pieces of nearly 2 cm with help of sharp kitchen knife. Seeds were removed manually. The small pieces of papaya were grinded with help of Mixer-Grinder (Philips Ltd. India) to prepare pulp. Papaya pulp was immediately used for making the jam.

Processing of papaya pulp for jam preparation

Traditional Open Kettle method of jam manufacturing was used in the present study^[10]. Ripe and unripe papaya jam was prepared by mixing 0.5 kg of papaya pulp with 0.4 kg sugar and 50 ml water. All the ingredients were mixed thoroughly and heated to remove excess of moisture. During heating mixture was stirred regularly. After excess moisture removal, 5 ml fresh lemon juice, followed by pectin was added and further allowed to boil till achieving optimum point. Heating of mixture was stopped after removal of excess water and attainment of desirable TSS of 68.0 ± 1.0 %. After reaching end point heating was turned off. Jam was filled in cleaned glass bottles while still hot (temperature above 82°C) and inverted to sterilize the lids. After 5 minutes in inverted position, bottles were turned upright and immersed in gradually cooling water. Figure 1 show important step involved in preparation of jam from ripe and unripe papaya. Bottles containing jam was stored at low and ambient temperature. Low temperature storage was achieved by keeping bottles in Refrigerator (Godrej Conglomerate Company, India). Ambient temperature was achieved by storing bottle in proper ventilated room.

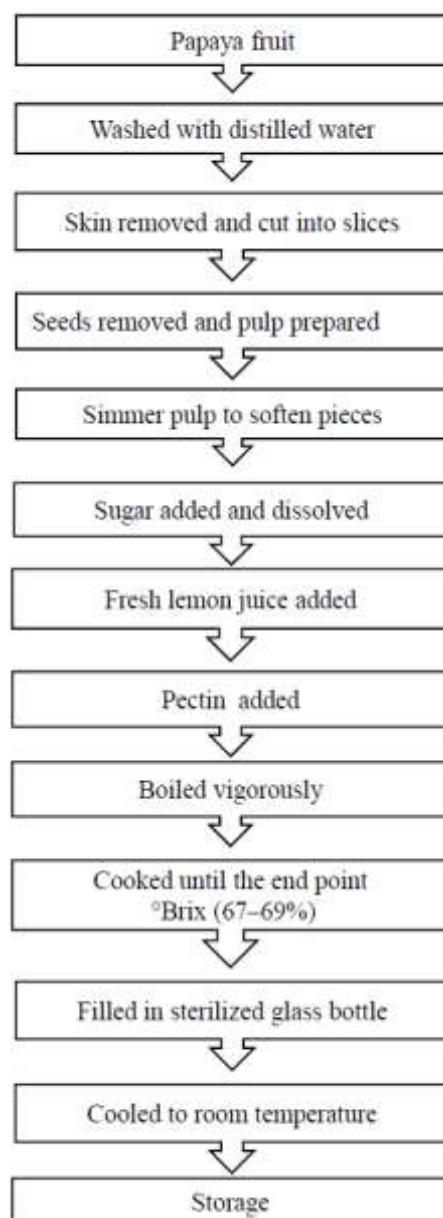


Fig 1: Flow chart showing important steps of papaya jam preparation.

Determination of moisture content in jam

Moisture percentage of papaya jam was determined on 0th day and 60th day of storage. About 10 gm of sample was measured into a previously weighed crucible. The crucible plus sample was transferred into the oven set at 80°C to dry the content. After 24 hours, the crucible plus dehydrated sample was removed from the oven and transfer to the desiccators. Cooled crucible plus sample was weighed with help of Digital Electronic Precision Balance (Aczet, Thailand Co. Ltd. Bangkok, Thailand). The moisture percentage was calculated with help of following equation:-

$$\text{Moisture (\%)} = \frac{(W_1 - W_3)}{(W_1 - W_0)} \times 100$$

Where, W₀ is the weight of empty crucible; W₁ is the crucible plus sample weight and W₃ is the weight of crucible plus oven dried sample.

Biochemical analysis of jam

Biochemical analysis of papaya jam was performed on 0th day and 60th day of storage. For biochemical analysis 10 gm of jam was mixed with 100 ml of distilled water. The content was boiled and centrifuged to obtain clear supernatant. Supernatant was used for estimating total soluble solid (TSS), pH, total sugar, and total phenolic content of jam.

Estimation of total soluble solid (TSS)

Supernatant obtained from papaya jam was poured over the window of hand Refractometer (ERMA Inc. Tokyo Japan) and readings were recorded. Refractometer was calibrated with standard sugar solution to ensure precision in the analysis. TSS of supernatant of jam was reported as °Brix at room temperature.

The pH of jam

The pH of jam was measured at room temperature by digital pH meter (Comsys Technologies, India). Before experiment the pH meter was calibrated with standard pH buffers (pH 4.0, pH 7.0 and pH9.0).

Estimation of total sugars

Total sugar content of papaya jam was determined by phenol-sulphuric acid method. An aliquot of 1ml was taken from the supernatant in the test tube. To the supernatant 1 ml phenol solution (5% w/v) and 5 ml sulphuric acid was added. After cooling the test tube at room temperature, absorbance was taken at 490 nm using Microprocessor UV-VIS single beam spectrophotometer (Advance Lab Equipment's PVT LTD, India). The concentration of total sugar was calculated from dextrose standard curve.

Estimation of total phenolic content

Total phenolic content in the supernatant was determined according to the earlier reported methods [3, 16]. In brief, 100 µl supernatant was transferred into a test tube, and then mixed with 0.4 ml of 10% Folin-Ciocalteu reagent. After 3 min, 0.8ml of a 10% Na₂CO₃ was added. The tubes were allowed to stand for 1 h at room temperature, and the absorption was measured at 725 nm using Microprocessor UV-VIS single beam spectrophotometer (Advance Lab Equipment's PVT LTD, India). Gallic acid was used as calibration standard, and the results were calculated as gallic acid equivalent (GAE).

Sensory evaluation

Sensory evaluation of jam samples were determined by using nine point Hedonic scale [1]. For the test, ten members panel

was constituted and asked to score the samples by allotting numbers between 9 to 1. Ten samples of ripe and unripe papaya jam were equally divided among the panel members. Members were asked to award the numbers from 1 to 9 as a score for each sample. The scores stand as 9- extremely desirable, 8-very much desirable, 7-moderately desirable, 6-slightly desirable, 5-neither desirable nor undesirable, 4-slightly undesirable, 3-moderately undesirable, 2-very much undesirable and 1-extremely undesirable.

Microbiological analysis

Microbiological analyses were performed to detect mold, yeast and bacterial load in the jam. Total viable count (cfu/ml) of mold, yeast and bacteria was determined by serial dilution method on PDA (Potato Dextrose Agar) and NA (Nutrient Agar) plates.

Data analysis

All statistical parameters were estimated using Graph Pad Prism 8.0. The variation in the observation was recorded as means ± standard deviation of 5 replicates. Changes observed during storage were considered significant ($p < 0.05$) on basis of Sidak's multiple comparison test.

Results and discussion

Physical appearance of jam and chutney

Physical appearance of food serves as one of the most important parameters that determine consumers demand and liking. Papaya jam exhibited intermediate consistency after proper cooking. Jam prepared from unripe papaya exhibited rough texture as compared to products prepared from ripe papaya. Visual inspection of jam over period of 60 days did not exhibit any significant change in the color for jam stored at low temperature. Contrary, jam stored at ambient temperature exhibited change in color from light yellowish to intense yellow tones.

In one of the study, Touati *et al.*, (2014) [23] reported significant change in the color of jam after 21 days of storage. On storage jam lost its particular color from initial yellow to reddish tones. This may be attributed to the formation of brown pigments by Maillard reaction [23]. In another study, Vukoja *et al.*, (2019) [24] reported that storage of jam at room temperature changed color from initial most reddish to yellowish tones due to decrease in anthocyanin content and formation of brown pigment by Maillard reaction [24].

Moisture content of jam

The moisture content of jam is very important parameter influencing storage and self-life of processed product. Higher moisture content reduces self-life of processed product [14]. In the present study, the moisture content of freshly prepared papaya jam was in the range of 12% to 16% (Table 1). Jam stored at ambient temperature exhibited more prominent decrease in the moisture content as compared to one stored at low temperature.

There are reports that storage of jam can decrease the moisture content [7, 12]. Chavan and Shaik (2015) [7] reported that moisture loss is more rapid under ambient condition than under refrigerated condition. Loss of moisture during storage can be due to the evaporation of water from processed product. In one of the study, Kumar *et al.*, (2017) [12] observed non-significant change in the moisture content of fruit bar prepared with the papaya pulp. Moisture content of papaya fruit bar changed from 15.05% to 15.02% during storage period of 60 days. Generally, high moisture content of valued

added product attracts microbial contamination and reduces storage life [17].

The pH of jam

The pH value plays key role in maintaining self-life, color, texture, flavor and taste of processed food [17]. The optimum pH inhibits the microbial activity and help in increasing the self-life of processed food [12]. In the present study, addition of acid in the form of lemon juice reduced pH value of papaya pulp below 4.8. The pH value of ripe papaya jam and unripe papaya jam was 3.6 ± 0.3 and 3.8 ± 0.3 before the storage period, respectively. However, pH value of ripe papaya jam decreased to 3.4 ± 0.2 and 3.4 ± 0.4 after 60 days of storage at low and ambient temperature, respectively. Similarly, unripe papaya jam stored at ambient temperature changed its pH from 3.8 ± 0.3 to 3.0 ± 0.1 . Unripe papaya jam stored at low temperature changed its pH from 3.8 ± 0.3 to 3.4 ± 0.4 .

Earlier, Rababah *et al.*, (2011) [15] has reported significant decrease in the pH values of cherry fruit pulp after jam preparation. The pH value changed from 3.66 to 3.31 after processing of cherry fruit pulp. Storage of cherry fruit jam decreased pH value from 3.31 to 3.20 [17]. Decrease in the pH value has also been reported in guava and papaya mixed fruit bar [4]. The pH of guava and papaya mixed fruit bar decreased from 3.54 to 3.41. Decrease in the pH value during storage can be attributed to conversion of sugar into acid [4, 16].

TSS of jam

TSS indirectly demonstrate amount of sugar present in the processed products. The TSS of freshly prepared ripe and unripe papaya jam was 63.0 ± 2.0 % and 67.0 ± 2.0 %, respectively (Table 1 and 2). On storage there was significant increase in TSS value in the jam. Change in TSS was more prominent in the jam stored at ambient temperature.

Similar findings have been reported by Bisen *et al.* (2020) [4], Rababah *et al.* (2010) [15], and Touati *et al.* (2013) [23] in mixed fruit bar, cherry fruit jam and apricot jam, respectively. Prior to storage, the TSS value of apricot jam was 64.42° Brix. However, storage of apricot jam at room temperature increased TSS value to 67.30° Brix [23]. The mixed fruit bar prepared from 40% papaya pulp and the 60% of guava pulp exhibited TSS of 75.39° Brix prior to storage. However, storage of more than 60 days increased TSS to 80.05° Brix [12]. During storage TSS value increases because polysaccharides undergo acid hydrolysis to release simple soluble sugar into products [4, 15]. Longer period of storage bring about considerable increase in the sugar content. Decrease in the moisture content can also contribute towards increase in TSS value [4]. An ideal fruit preserves or preserves must contain TSS of more than 60° Brix soluble solids (Codex Alimentarius standard, CODEXSTAN, 2009). In this regard, jam prepared from ripe and unripe papaya, both served as a better papaya preserve.

Table 1: Changes in physiochemical and sensory properties of ripe papaya jam during storage

Parameters	Storage Period		
	0 Day	60 Days (LT)	60 Days (AT)
Moisture Content (%)	14.0 ± 2.0^a	10.0 ± 1.0^b	8.4 ± 0.5^c
pH	3.6 ± 0.3^a	3.4 ± 0.2^a	3.2 ± 0.4^a
TSS ($^\circ$ Brix)	63.0 ± 2.0^a	65 ± 1.0^a	68.3 ± 1.2^b
Total sugar content (mg/g)	66.8 ± 2.1^a	68.2 ± 1.6^a	70.4 ± 3.2^b
Total phenolic content (mg GAE/100 g)	52.7 ± 1.2^a	50.0 ± 1.0^a	45.7 ± 1.5^b
Bacterial Load (cfu/g)	20 ± 3^a	22 ± 2^a	25 ± 4^a
Yeast Load (cfu/g)	4 ± 1^a	7 ± 2^a	8 ± 2^a
Taste	8.4 ± 0.5^a	7.6 ± 0.2^b	7.0 ± 0.3^c
Flavor	8.6 ± 0.2^a	7.5 ± 0.4^b	7.0 ± 0.2^c
Overall acceptability	8.2 ± 0.4^a	7.7 ± 0.3^b	6.8 ± 0.2^c

LT- low temperature; AT- ambient temperature
 Values given are mean \pm standard deviation of 5 replicates. Different letter in row indicates significant ($p < 0.05$) change during storage period on basis of Sidak's multiple comparison test.

Total sugar content of jam

The taste and consumer liking for the proceed fruit product is directly influenced by total sugar content. The unripe and ripe papaya pulp had 36.8 ± 2.1 mg/g and 48.8 ± 3.5 mg/g total sugar content. Earlier, Gomez *et al.* (2002) [11] have reported similar findings. According to Gomez *et al.* (2002) [11] starch and fibers are important contributor sugar in the papaya. Addition of sugar during preparation of jam increased the overall sugar content. The sugar content also increased during storage. Total sugar content of ripe papaya jam increased from 66.8 ± 2.1 mg/g to 68.2 ± 1.6 mg/g during 60 days of storage at low temperature. Similarly, in the unripe papaya jam, total sugar content increased from 64.8 ± 2.2 mg/g to

67.5 ± 1.6 mg/g during 60 days of storage at low temperature. In ripe and unripe papaya jam, storage at ambient temperature increased total sugar content to 70.4 ± 3.2 mg/g and 72.1 ± 1.8 mg/g, respectively.

Kumar *et al.*, (2020) [12] has reported increase in total sugar and reducing sugar content upon storage of guava-papaya jam for three months at room temperature. The increase in total sugar content can be attributed to hydrolysis of polysaccharides into sugars and inversion of sugars [12]. Similar result has been reported by Brandao *et al.* (2018) [5] and Rahman *et al.* (2018) [16] in mixed cerrado fruit jam and guava jam, respectively.

Table 2: Changes in physiochemical and sensory properties of unripe papaya jam during storage

Parameters	Storage Period		
	0 Day	60 Days (LT)	60 Days (AT)
Moisture Content (%)	15.0 ± 1.0^a	12.0 ± 0.5^b	10.2 ± 1.0^c
pH	3.8 ± 0.3^a	3.4 ± 0.4^a	3.0 ± 0.1^b
TSS ($^\circ$ Brix)	67.0 ± 2.0^b	69.0 ± 1.0^b	71.0 ± 1.0^c
Total sugar content (mg/g)	64.8 ± 2.2^a	67.5 ± 1.6^a	72.1 ± 1.8^b
Total phenolic content (mg GAE/100 g)	55.4 ± 1.5^a	53.8 ± 3.6^a	48.7 ± 2.5^b

Bacterial Load (cfu/g)	16 ± 4 ^a	18 ± 2 ^a	20 ± 2 ^a
Yeast Load (cfu/g)	4 ± 2 ^a	8 ± 2 ^a	9 ± 2 ^a
Taste	7.8 ± 0.4 ^a	7.2 ± 0.2 ^b	6.8 ± 0.4 ^c
Flavor	8.8 ± 0.2 ^a	7.5 ± 0.4 ^b	6.5 ± 0.5 ^c
Overall acceptability	8.4 ± 0.4 ^a	7.1 ± 0.5 ^b	6.8 ± 0.2 ^c

LT- low temperature; AT- ambient temperature

Values given are mean ± standard deviation of 5 replicates. Different letter in row indicates significant ($p < 0.05$) change during storage period on basis of Sidak's multiple comparison test.

Total phenolic content of jam

Fruits are important source of dietary phenolics for human. Phenolic components of fruits are known to have antioxidant activity [9]. Eberhardt *et al.*, (2000) [8] suggested that the antioxidant activity of fruits is primarily due to the presence of polyphenol and flavonoid compounds. Amount of phenolics compounds may vary in the range of 38.6 mg GAE/100 g FW to 60.20 mg GAE/100 g FW with average value of 50.79 ± 11.12 mg GAE/100 g FW in fresh papaya fruit [9]. The accumulation of phenolics compounds in fruits is primarily influenced by physiological status of fruits. Unripe papaya fruit have more phenolics than ripe papaya fruit [8]. This is also evident in the present study. Jam prepared from unripe fruits has more phenolics content than ones prepared from ripe papaya. During 60 days of storage at ambient temperature, total phenolics content of ripe papaya jam decreased from 52.7 ± 1.2 mg/g to 45.7 ± 1.5 mg/g. Similarly, in unripe papaya jam, total phenolics content decreased from 55.4 ± 1.5 mg/g to 48.7 ± 2.5 mg/g during 60 days of storage at ambient temperature. Total phenolic content of ripe and unripe papaya jam decreased to 50.0 ± 1.0 mg/g and 53.8 ± 3.6 mg/g, when stored at low temperature, respectively.

Earlier, Kumar *et al.* (2020) [12] have observed significant decrease in the total phenolic of guava-papaya jam during storage at room temperature. Decrease in total phenolic content was also reported by Lafarga *et al.* (2018) [13] in blueberry jam. Phenolic component of fruits are easily oxidized during storage resulting in gradually decrease in concentration. During processing of jam, the cell structure gets disrupted as a result phenolic component of fruits became more prone to non-enzymatic oxidation [12].

Microbial load of jam

Presence of microorganisms in food items usually hastens quality degradation process. In severe cases, even makes preserve food items unsuitable for human consumption. As evident from table 1 and 2, both bacteria and yeast were detected in the jam prepared from ripe and unripe jam. However, the microbial load was within recommended safety limits [18]. As evident from table 1 and 2, during storage no significant increase in microbial load was observed in the jam.

Organoleptic attributes of jam

Organoleptic test is also referred as sensory analysis. In this test the qualities of the food ingredients and spices are determined by the sensory properties such as taste, smell, color and touch [20, 23]. Organoleptic properties of jam are influenced by several parameters such as taste, flavor, appearance and texture. The salt, sweet and sour are the main taste which are predominantly observed in the jam.

The sensory profile of the ripe and unripe papaya jam was evaluated in terms of taste, flavor and overall acceptability. The average scores of sensory attributes during storage of ripe and unripe papaya jam are reported in table 1 and table 2, respectively. As evident from table 1 and table 2, there was gradually decrease in organoleptic properties of ripe and unripe papaya jam.

In one of the study, Touati *et al.* (2014) [23] reported decreases in overall acceptability of commercial apricot jam during storage at 37 °C. Chauhan *et al.* (2012) [6] observed that the sensory characteristics for color, appearance, flavor and overall acceptability of the coconut jam samples showed a decreasing trend throughout the storage period.

Conclusions

Jam prepared from ripe and unripe papaya exhibited gradual change in moisture, TSS, pH, total sugar and phenolics content. During 60 days of storage period, there was decrease in the moisture, pH and phenolics content. However, TSS and total sugar content increased during the storage period. Storage of jam prepared from ripe and unripe papaya also exhibited changes in organoleptic characteristics. There was gradual decrease in taste, flavor and overall acceptability. Changes in physiochemical and sensory characteristics were more prominent in jams stored at ambient condition. Thus, suggesting that jam prepared from ripe and unripe papaya must be stored at low temperature for increasing the self-life of jam. Storage not only induced the physiochemical changes but also influenced sensory characteristics of jam. Prolong storage at ambient condition should be avoided as it bring about unfavorable changes in physiochemical and sensory characteristics of jam.

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