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Effect of preservative level and packaging material on nutritional quality of jamun juice during storage

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Abstract
The research was undertaken to study the physicochemical properties of Jamun fruits and study the storage behavior and sensory properties of Jamun juice during storage. The uniform size, well-matured, and healthy Jamun fruits of Cv. Local with firm textures were selected. The pulp was extracted by a brush-type pulp extractor. The preservative i.e., sodium benzoate with levels 200, 300, 400, 500, and 600 ppm was added followed by pasteurization of juice at 90 °C for 5 minutes. Pasteurized juice was filled in pre-sterilized PET and glass bottles, filled bottles sterilized, and stored at room temperature. The experiment was planned with 10 treatment combinations with three replications and FCRD design was used to check the statistical significance. The average weight of the fruit was 9.20g. The average pulp and seed were found to be 71.30 and 28.7%, respectively. The fresh Jamun juice had 81.32% moisture content (wet basis), 13.75 °Brix total soluble solid, 1.12% acidity, 3.80 pH, 9.76% total sugars, 8.27% reducing sugars, and 216.0 mg/100mL anthocyanin. TSS, acidity, total sugars, and reducing sugars were increased whereas pH and anthocyanin were decreased with the storage periods advancement. A gradual decrease was observed in scores for color, flavor, taste, and overall acceptability during storage. Among different treatment combinations, treatment of 600 ppm preservative and packed in a glass bottle followed by treatment with 500 ppm preservative and packed in a glass bottle was found to be more suitable for Jamun juice storage for 90 days in respect of chemical properties and sensory properties.

Keywords: Extractor, flavour, jamun juice, pasteurize, sensory, sodium benzoate

Introduction
India is the largest producer of fruits in the world with an annual production of 88977 million tonnes. Jamun (*Syzygium cumini* L.) fruit is an important member of the family Myrtaceae. India is the second largest country in Jamun fruit yield. It is considered indigenous to India and the West Indies, being cultivated in the Philippines, West Indies, and Africa. Its tree is tall, evergreen, and generally grown in India as an avenue or as a windbreaker. In India, the maximum number of jamun trees are found scattered throughout the tropical and subtropical regions. It is also found in the lower range of the Himalayas up to an elevation of 1300m and in the Kumaon hills up to 1600m. It is widely grown in large parts of India from the Indo-Gangetic plains in the North to Tamil Nadu in the South (Patel *et al.*, 2012) [1].
The most common type of jamun grown in North India is known as Ray Jamun. This is a large-fruited type with oblong deep purple colors (Having small seeds) available in June- July. The fruits are highly perishable and cannot be stored for more than 24 hours at room temperature (Baraiya *et al.*, 2015) [2]. Very little information is available on the processing of jamun, although it is known to be used for making juice, jam, jelly, beverages, wine, vinegar, and pickle. Jamun was used for juice, syrup, and squash preparation (Marimutha and Thirumaran, 2000) [3]. In India, there is wide scope for fruit-based fermented beverages (Joshi *et al.*, 2012) [4].
A large quantity of marketable surplus fruit is available in all jamun growing regions which needs to be processed and converted into value-added products (Patel *et al.*, 2012) [1]. Jamun fruits are a very rich source of antioxidants and have numerous health benefits. The fruit and the seed contain a biochemical called Jamboline. Different parts of the tree such as bark, fruit, and seed possess medicinal and therapeutic values (Kirtikar *et al.*,1991) [5]. Its fruits are known for medicinal value like anti diabetic, astringent, stomatic, carminative, antiscorbatic and diuretic. The pulp of a jamun contains appreciable amounts of fermentation sugar, which can be used for alcoholic fermentation (Gaikwad *et al.*, 2016) [6]. Jamun fruits are highly seasonal from May to June, highly perishable, and short storability (up to 2-3 days under ambient temperature), due to these reasons this fruit is considered an unexploited fruit crop in India

(Devi and Shenbagaveni 2014) [7].

The demand for jamun fruit and its processed products like juice, squash, and seed powder is on increasing trend both in metropolitan and small cities. There is great scope for processed products, not only because of their exotic flavor but also due to their nutraceuticals and therapeutic values. The fruit is highly perishable and can be stored only for 2-3 days under ambient conditions. Thus, processing jamun into value-added products results in a wide variety of exotically flavored products with better nutritional and sensory qualities and can unveil new export markets.

In view of the medicinal and therapeutic properties of jamun fruit, its short availability period, and short shelf life an attempt has been made to study the storage behavior jamun juice with the following objectives to study the physicochemical properties of jamun fruits and identify the effect of preservative levels and packaging material on physicochemical and sensory properties of jamun juice during storage.

Material and Methods

Fruit material and sample preparation

Jamun fruits of Cv. Local were freshly harvested, uniform size, well matured, and healthy jamun fruits of local variety were directly procured from farmers. After weighing fruits of jamun cv. local were washed with clean tap water. The pulp was extracted by brush type extractor. The juice was separated from the pomace with the help of muslin cloth and filtered through four layers of muslin cloth. The preservative i.e., sodium benzoate in different levels of 200, 300, 400, 500, and 600 ppm was added followed by pasteurization of juice at 90°C for 5 minutes. Pasteurized juice was filled in 200 mL sterilized PET and glass bottles using a crown cork machine. The filled bottles were sterilized in boiling water and stored at room temperature. The experiment was planned with ten treatment combinations with different preservative levels *viz*. 200 (T_1), 300 (T_2), 400 (T_3), 500 (T_4), and 600 (T_5) ppm and packaging materials *viz*., glass bottle (P1) and PET bottle (P2).

Determination of weight, moisture, and TSS

The freshly harvested jamun fruits weighing using a digital display electronic weighing balance having a 2.5 kg capacity with the least count of 0.01g (Make: Indosaw, Haryana). For determination of moisture content fruits were cut into small pieces and kept in Petri dishes and dried in a hot air oven for 24 hours at temperature. The pulp of jamun fruit was strained through muslin cloth and used for determining TSS. A refractometer (Erma, Tokyo, Japan) was used for the measurement of the total soluble solids of jamun juice. The prism of the refractometer will wash with water and wipe to dry after each reading (A.O.A.C. 1990) [8].

Determination of Titratable acidity

The titratable acidity was determined by the procedure as reported by Ranganna (1986) [9]. One ml of fresh sample was taken in a 100 mL volumetric flask and the volume was made up to 100 mL with distilled water. From this 10 ml was taken in a conical flask and titrated against standard 0.1N sodium hydroxide solution using phenolphthalein as an indicator, until faint pink color persisted for 15 sec. The titratable acidity was calculated and expressed in terms of anhydrous citric acid in percent.

$$\text{Titratable acidity (\%)} = \frac{(Normality\ of\ NaOH\ x\ Titre\ x\ 0.64\ x\ 100)}{Volume\ of\ juice\ taken}$$

Determination of total sugars

Total sugars were determined by the volumetric method as reported by Ranganna (1986) [9]. In a 100 mL volumetric flask, 10 mL of juice was taken. In this 2 mL concentrated HCL was added and the flask was kept in the hot water bath at 70-80 °C for 30 min. After cooling the hydrolysate was neutralized by adding a pinch of sodium carbonate till the formation of effervescence stopped. The volume of the neutralized hydrolysate was made to 100 mL with distilled water. The total sugar in the neutralized hydrolysate was determined in the same way as described under reducing sugars.

$$\text{Total sugars (\%)} = \frac{(Factor\ x\ volume\ made\ up\ x\ 100)}{(Titre\ x\ Wt.of\ sample\ taken)}$$

Determination of reducing sugars

The reducing sugars were estimated by the volumetric method as reported by Ranganna (1986) [9] as follows. Ten ml of juice was taken in 100 mL volumetric flask. Then 40 mL of distilled water was added and content was neutralized with 1N sodium hydroxide solution (colourless). Two ml lead acetate (45%) was added and kept for 10 min followed by the addition of 10 ml potassium oxalate solution (22%). The volume was made to 100 mL with distilled water and then filtered through filter paper. The filtrate was further used for titration against Fehling's A and B solutions. Five ml of each Fehlings ‘A’ and ‘B’ solution were pipetted in 250 ml conical flask and diluted to about 50 ml with distilled water. The mixture was heated to boiling. During boiling, a clarified sample of juice was added carefully through the burette until the brick red color appeared. Finally, 2-3 drops of methylene blue indicator were added and titration was continued until a brick-red precipitate was formed. The reducing sugars content was calculated and expressed in percentage.

$$\text{Reducing sugars (\%)} = \frac{Factor\ x\ Volume\ madeup\ x\ 100}{Titre\ x\ Volume\ of\ sample\ taken}$$

Anthocyanin content

Total anthocyanin content was estimated as per the procedure described by Ranganna (1986) [9]. Total anthocyanin content was calculated by using molecular extinction coefficient values. Exactly 10g of arils were taken and macerated in mortar and pestle using 75 millilitre of ethanolic- 1.5N HCL (85:15) and transferred to a 250 millilitre volumetric flask using few millilitre of ethanolic-HCL for washing. The volumetric flasks were kept overnight in a refrigerator. The solution was filtered under a vacuum through a Whatman No. 1 paper using a Buchner funnel. The Paper and funnel were washed repeatedly with ethanolic-HCL and the volume was made to 250 millilitre. To determine the optical density measurements within the optimum range of the instrument, 10 millilitre aliquot of the filtrate was diluted with ethanolic-HCL making 100 millilitre volume stored in dark for 2 hours and the color was read at 535 nm on Spectronic-20 and O.D. values were recorded for quantitative measurement of the total anthocyanins expressed as mg/100g fresh weight.

Sensory evaluation

The sensory evaluation was carried out by procedure given by

Amerine *et al.*, (1979) [10] on nine-point hedonic scale. The sensory evaluation was performed by a panel of trained judges for color, taste, and overall acceptability of jamun juice.

Statistical analysis
The experiment was planned using a factorial completely randomized design (FCRD) with three replications. The data obtained for chemical composition and sensory parameters will be analysed for statistical significance according to the procedure given by Panse and Sukhatme (1985) [11].

Results and Discussion
Physico-chemical Properties of Jamun Fruits
The measured physico- chemical properties of jamun fruits (cv. Local) as following average weight of fruits was 9.20 g. The average pulp and seed were found to be 71.30 and 28.70%, respectively. The fresh jamun juice had 81.32% moisture content on wet basis, 13.75°B total soluble solids, 1.12% acidity, 3.80 pH, 9.76% total sugars, 8.27% reducing sugars and 216.0 mg/100mL anthocyanin. The results were in agreement with Garande (1992) [12], Patel *et al.,* (2012) [1] and Rakesh and Shivanna (2015) [13] for jamun fruit.

Chemical Compositions of Jamun Juice
The data for changes in the chemical composition of jamun juice subjected to different preservative levels, packaging materials, and storage periods are given and discussed below.

Total soluble solid (TSS)
The data on changes in total soluble solids of jamun juice during storage is presented in Fig 4.1. The individual effect of packaging materials i.e., glass bottle and PET bottle on the TSS content of jamun juice was statistically significant. There was a significant increase in the TSS content of jamun juice from 13.75 to 14.23˚B in a glass bottle (P1) and from 13.75 to 14.73˚B in a PET bottle (P2) during 90 days of storage. The effect of preservative levels on the TSS of jamun juice was statistically significant. The TSS was increased during 90 days of storage. The minimum increase in TSS as 14.27˚B was observed in treatment T5 i.e., 600 ppm preservative level and the maximum was 14.69˚B in T1i.e. 200 ppm preservative level during 90 days of storage.

The interaction effect of different packaging materials and preservative levels on TSS content was increased during the advancement of the storage period in all the treatment combinations. At the end of 90 days of storage, the minimum increase in TSS was observed in treatment P1T5(14.10˚B) followed by P1T4(14.17˚B). Whereas a maximum increase in TSS was observed in treatment P2T1(15.03˚B) followed by P2T2(14.96˚B). The data revealed that TSS content increased during the storage period, which might be due to the reduction of moisture content, conversion of insoluble carbohydrates into soluble sugar, and increasing the total sugar content of juice during storage. These results are in accordance with the results observed by Khurdiya and Roy (1985) [14] in jamun RTS beverage, Palaniswamy, and Muthukrishnan (1974) [15].

Titratable Acidity
There was a non-significant difference in the acidity of jamun juice during 90 days of storage subjected to different packaging materials and preservative levels. The acidity of jamun juice increased during 90 days of storage. During storage, the increase in acidity of jamun juice might be due to a decrease in pH. The individual effect of packaging materials i.e., glass bottle and PET bottle on the acidity of jamun juice was statistically non-significant. There was an increase in the acidity of jamun juice from 1.120 to 1.196% in a glass bottle and from 1.12 to 1.207% in a PET bottle during 90 days of storage shown in Fig 4.2.

The effect of preservative levels on the acidity of jamun juice was statistically non-significant. The acidity was increased during 90 days of storage. The minimum increase in acidity at 1.184% was observed in treatment T5 i.e., 600 ppm preservative level and the maximum was 1.223% in T1 i.e. 200 ppm preservative level. The interaction effect of different packaging materials and preservative levels on acidity was increased during the storage period in all the treatment combinations. At the end of 90 days of storage, the minimum increase in acidity was observed in treatment P1T5(1.183%) followed by P1T4(1.186%) whereas a maximum increase in acidity was observed in treatment P2T1(1.237%) followed by $P2T_2$ (1.212%).

The results of increased acidity are in accordance with the results observed by mixed fruit RTS beverage (Krishnaveni and Manimegalai, 2001) [16], and jamun beverage (Khurdiya and Roy, 1985) [14]. Similar observations were also reported in fig jam (Kad *et al.*, 2011) [17], sapota pulp (Kute *et al.,* 2000) [18], and guava pulp (Tondon and Kalra, 1984 [19]; Pandey *et al.*, 1999 [20]).

Total sugars
The increase in the total sugar content of jamun juice extracted by the pulper machine method subjected to different packaging materials, preservative levels, and storage periods are recorded in Fig 4.3 a**.** The individual effect of packaging materials on total sugars of jamun juice was statistically non-significant. There was an increase in total sugar content of jamun juice from 9.76 to 10.83% in glass bottle and 9.76 to 10.97% in PET bottle during 90 days of storage. The effect of preservative levels on the total sugars of jamun juice was statistically non-significant. The total sugar content was increased during 90 days of storage. The minimum increase in total sugars at 10.46 percent was observed in treatment T5 i.e., 600 ppm preservative level, and the maximum 11.24% in T1 i.e. 200 ppm preservative levels during 90 days of storage.

The interaction effect of the different packaging materials and preservative levels on total sugar content was increased during the storage period in all the treatment combinations. At the end of the 90 days of storage, the minimum increase in total sugars content was observed in treatment $P1T_5$ (10.42%) followed by P1T4 (10.65%) followed by $P2T_5$ (10.51%) whereas, the maximum increase in treatment $P2T_1$ (11.36%) followed by P2T2 (11.20%). Similar results of an increase in total sugars during storage have been reported in stored jamun juice (Khurdiya and Roy, 1985) [14]. Observations similar to these findings were also reported in citrus juices (Lee and Nagy1988) [21], orange juice (Wibowo *et al.,* 2015 [22]), and sapota pulp (Kute *et al.*, 2000) [18].

Reducing sugars
The data revealed that changes in reducing sugars of jamun juice during storage are presented in Fig 4.3 b. It was shown that the increase in reducing sugars during storage period which might be due to the hydrolysis of non-reducing sugars to reducing sugars. The increase in reducing sugars was more

in less preservative levels and in PET bottles. The statistical analysis of data shows that the increase in reducing sugars of the jamun juice during storage period in a glass bottle and PET bottle was statistically non-significant. There was an increase in reducing sugars content of jamun juice from 8.27 to 8.31% in glass bottle (P1) and from 8.27 to 8.32% in PET bottle (P2) during 90 days of storage.

The effect of preservative levels on reducing sugars of jamun juice was non-significant and increases during 90 days of storage. The minimum increase in reducing sugars as 8.29% was observed in treatment T5 i.e., 600 ppm preservative level, and maximum of 8.33% in T1 i.e. 200 ppm preservative level. The interaction effect of different packaging materials and preservative levels on reducing sugars was increased during storage period in all the treatment combinations. At the end of 90 days of storage, the minimum increase in the reducing sugars was observed in treatment P1T5 (8.29%) followed by P1T4 (8.30%) and P2T5 (8.30%), and maximum increase in reducing sugars was observed in treatment P2T1(8.33%) followed by P2T2 (8.32%). These results are in accordance with the results observed by Priyanka *et al.*, (2015) [23] in jamun juice. The same results were also observed in mango RTS beverage (Sakahle *et al.*, 2012) [24], citrus juices (Lee and Nagy,1988) [21], sapota pulp (Kute *et al.*, 2000) [18], custard apple pulp (Kolekar, 2002) [25] and different fruits like mango, apple, guava, and peach (Rehman *et al.*, 2014) [26].

Anthocyanin content

The variation in data for anthocyanin of jamun juice subjected to different packaging materials and preservative levels during storage period are presented in Fig 4.4. The results showed that there was a significant decrease in anthocyanin during storage period due to anthocyanin pigments of jamun juice being destroyed at high storage temperatures and the refrigerated storage has to stabilize effect on the anthocyanins of juices (Ponting *et al*. 1952). The individual effect of packaging materials on anthocyanin of jamun juice was statistically significant. There was a decrease in anthocyanin in jamun juice from 211.80 to 197.02 mg/100mL in a glass bottle and from 210.35 to 193.19 mg/100mL in a PET bottle during 90 days of storage.

The effect of preservative levels on anthocyanin of jamun juice was statistically significant. The anthocyanin was decreased during advancement of storage. The minimum decrease in anthocyanin as 198.01 mg/100mL was observed in treatment T5 i.e., 600ppm preservative level and maximum as 191.92 mg/100 mL in T1 i.e. 200 ppm preservative levels at the end of 90 days storage. The interaction effect of different packaging materials and preservative levels on anthocyanin decreased during storage in all the treatment combinations. At the end of 90 days of storage, the minimum decrease in anthocyanin was observed in treatment P1T5(200.45mg/100 mL) followed by P1T4(199.79mg/ 100 mL) whereas a maximum decrease in anthocyanin was observed in treatment P2T1(190.42mg/100mL) followed by P2T2(191.99mg/100mL). These results are in accordance with the result observed by Khurdiya and Roy (1984) [27] in jamun juice and Do *et al.*, (1976) [28] in sour cherry juice. It was reported that anthocyanin in pigments of fruit juices is destroyed at high storage temperatures and the refrigerated temperature has stabilizing effect on anthocyanins (Singh *et al.*, 2013) [29]. Same results were observed in pomegranate juice during storage (Alighourchi & Barzegar, 2009) [30].

Sensory Evaluation of Jamun Juice During Storage Period

Color

The data on the color score of jamun juice is presented in Fig 4.5 a. Individually, packaging materials had a non-significant effect on color score of jamun juice during the storage period of 90 days except for fresh and at 30 days of storage. A gradual decrease in color score of jamun juice from 8.50 to 7.06 in a glass bottle and 8.50 to 6.88 in a PET bottle was observed during 90 days storage period. From a statistical point of view, the effect of preservative levels on treatment T5(7.19) was superior over the other treatment with the highest score followed by treatment T4(7.10). The interaction effect on color score was found to be superior in treatment P1T5 (7.25) followed by P1T4 (7.17) and P2T5(7.13). Singh and Chandra (2012) [31] estimated that color of guava carrot jelly decreased with storage period. Similar results were also reported by Pérez- Vicente *et al.*, (2004) [32] on pomegranate juice. The results obtained in the present study are also in conformity with the observation of Kamble and Soni (2010) [33] for custard apple pulp.

Taste

The data on the taste score of jamun juice is presented in Fig 4.5 b. Individually, packaging materials had a significant effect on taste score of jamun juice during storage period of 90 days except for fresh juice. A gradual decrease in taste score of jamun juice from 8.36 to 7.05 in a glass bottle and 8.17 to 6.80 in a PET bottle was observed during 90 days storage period.

The effect of preservative levels on treatment T5 (7.35) was superior over the other treatment with the highest score followed by treatment T4 (7.14). The interaction effect on taste score was found to be superior in treatment P1T5 (7.45) followed by P1T4 (7.28) and P2T5 (7.26). Garande (1992) [12] reported that the flavor scores were decreased continuously in jamun juice with advancement of storage period. Similar results were also reported by Suryawanshi *et al.*, (2007) [34] a decrease in taste score of pomegranate juice during storage period.

Overall acceptability

The data on the overall acceptability score of jamun juice is presented in Fig 4.5 c. Individually, packaging materials had significant effect on overall acceptability score of jamun juice during 90 days of storage except for fresh juice. A gradual decrease in overall acceptability score of jamun juice from 8.37 to 7.05 in a glass bottle and 8.25 to 6.78 in a PET bottle was observed during advancement of storage period.

The effect of preservative levels on treatment T5 (7.25) was superior over the other treatment with the highest score followed by treatment T4 (7.09). The interaction effect on overall acceptability score was found to be superior in treatment P1T5 (7.33) followed by P1T4 (7.20) and P2T5 (7.16). Garande (1992) [12] reported that the overall acceptability scores were decreased continuously in jamun juice with advancement of storage period. Similar results were observed by Kute *et al.*, (2000) [18] in sapota pulp, Kedar, (2007) [35] in pomegranate juice and orange juice (Ros-Chumillas *et al.*, 2007) [36].

Conclusion

The chemical properties i.e., TSS, acidity, total sugars, and reducing sugars were found to be increased whereas pH and anthocyanin were decreased with advancement of storage period. A gradual decrease was observed in score for color, flavor, taste, and overall acceptability during 90 days of storage. The best quality jamun juice in respect of chemical and sensory properties was found to be superior in treatment P1T5 i.e., with 600 ppm preservative level and packaging in glass bottle for 90 days storage period at room temperature. Followed by P1T4 i.e., 500 ppm preservative and sample packed in glass bottle was found to be superior among all other treatments.

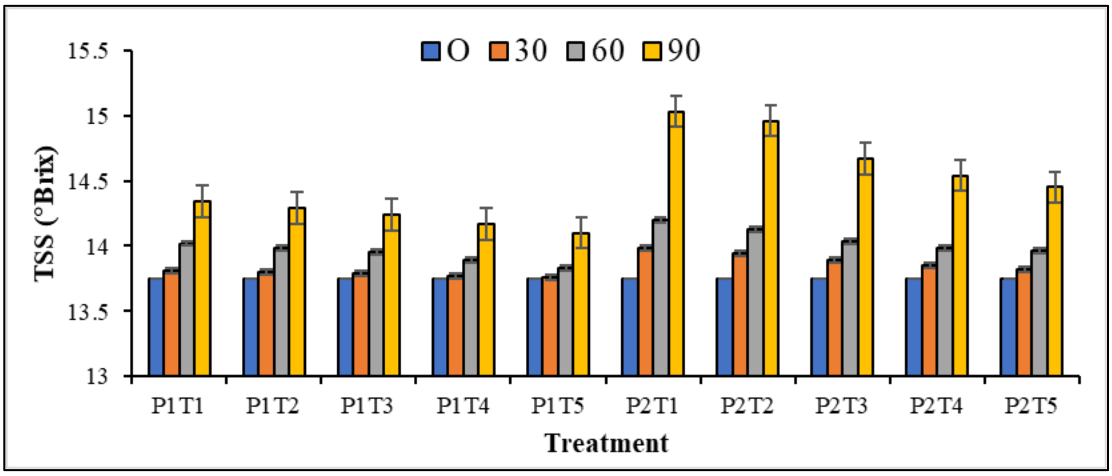


Fig 1: Effect of packaging materials and preservative levels on TSS of jamun juice during storage

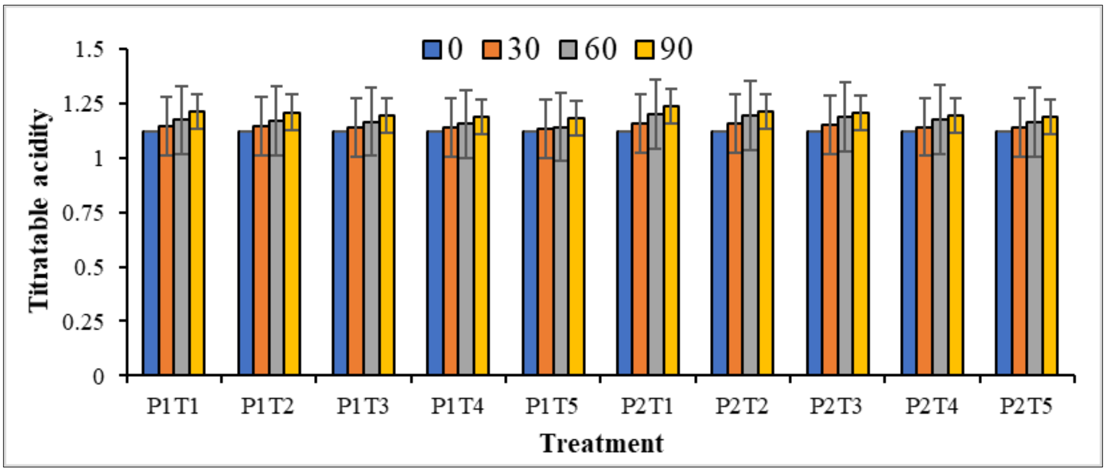


Fig 2: Effect of packaging materials and preservative levels on titratable acidity of jamun juice during storage

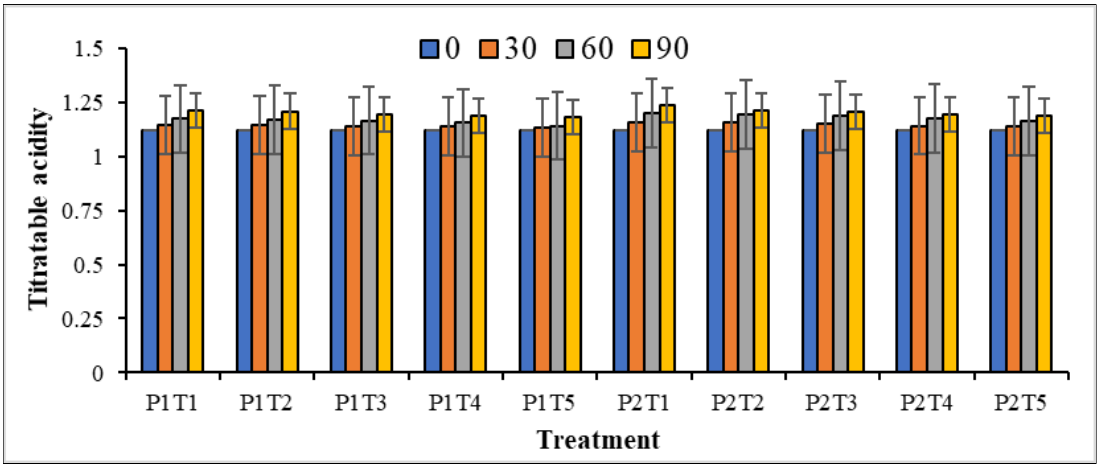


Fig 3: Effect of packaging materials and preservative levels on (a) total sugar content and (b) reducing sugar content of jamun juice during storage

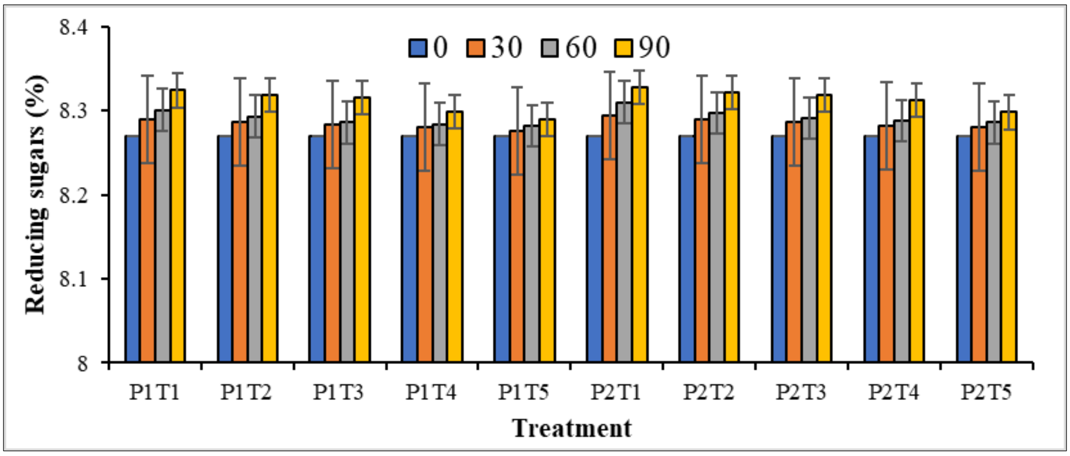


Fig 4: Effect of packaging materials and preservative levels on anthocyanin content of jamun juice during storage

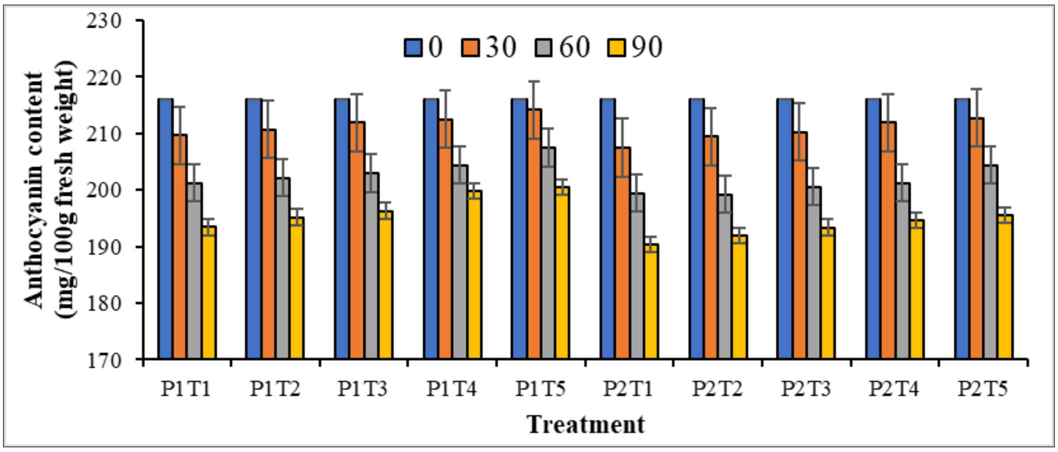
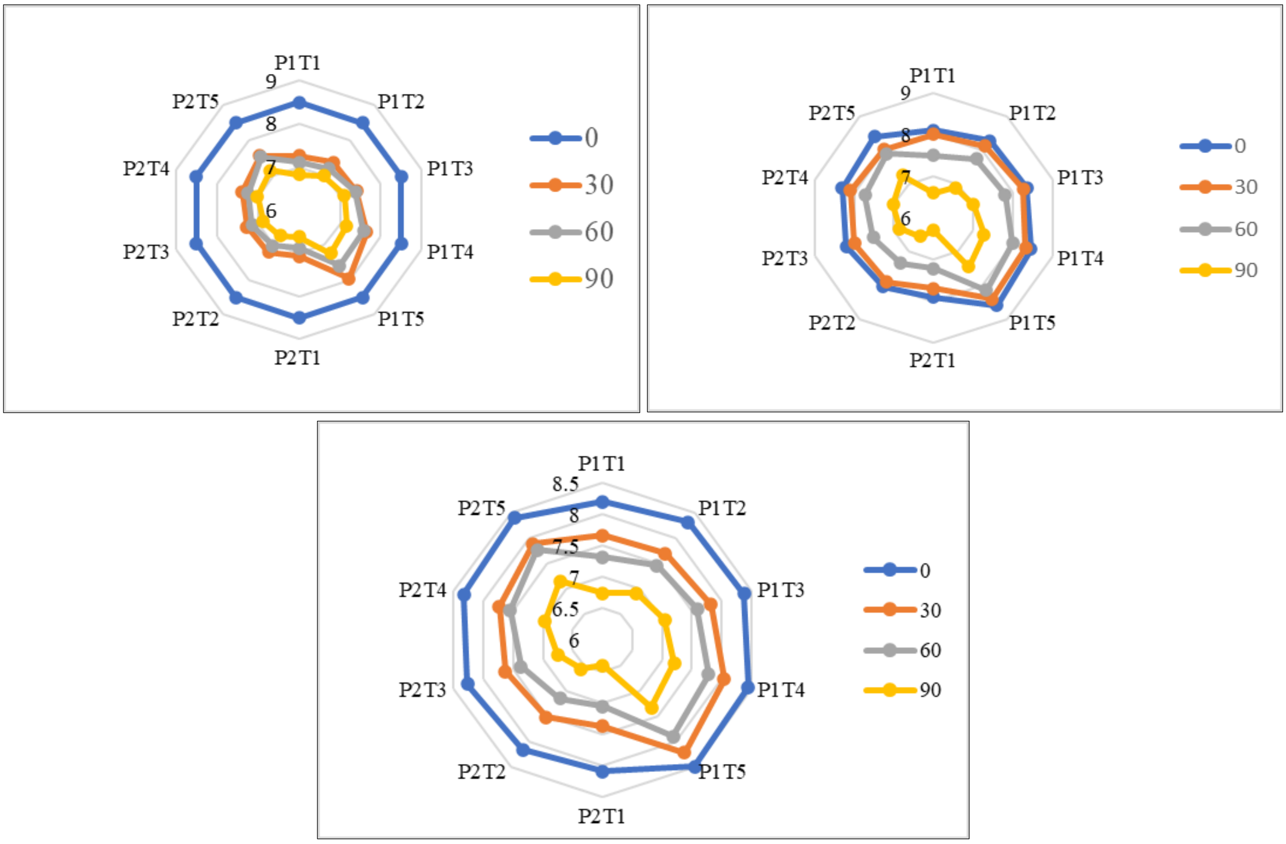


Fig 5: Effect of packaging materials and preservative levels on sensory quality of jamun juice during storage (a) color, (b) taste, (c) overall acceptability



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