

## Physico-chemical properties of *Syzygium cuminii* (L.) Skeels jam and comparative antioxidant study with other fruit jams

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Jamun, *Syzygium cuminii* (L.) Skeels commonly known as Indian blackberry is a widely distributed forest tree in India and other tropical and sub-tropical regions of the world. This fruit is a rich source of natural antioxidant, vitamins and minerals having good nutraceutical and medicinal value. Physical properties of jamun fruits were studied in order to facilitate its handling and processing. This work was intended to add value to these fruits in jam production. The corresponding processed jam were compared with other commercial fruit jams in terms of proximate composition, total phenolic content, antioxidant activity and viscosity to test its overall quality parameters. According to the experimental findings, the proximate composition of jamun jam was found to be equivalent with other jams and was the richest source of total phenol with 5.58 mg GAE/g. The antioxidant activities were also highest. The percent reduction of DPPH and ABTS radicals was 47.97 and 95.02, respectively and the FRAP value was 7.36 mM ferrous sulphate equivalent/g. Pseudoplastic behavior of the processed jam was determined with the help of rheometer to check its consistency which is due to the systematic trend of pH, pectin, total soluble solids and sugar concentration at the time of processing. Viscosity of jamun jam was found to be acceptable with other commercial variety jams. Results from this work revealed essential information that could promote the commercialization of jamun jam.

**Keywords:** *Syzygium cuminii*, Jamun, Indian blackberry, Jam, Physicochemical properties, Viscosity, Total phenol, Antioxidant.

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### Introduction

*Syzygium cuminii* (L.) Skeels, is a polyembryonic species belonging to family Myrtaceae. It grows equally well in both the tropical and the sub-tropical regions of the world like India, Bangladesh, Nepal, Pakistan, Sri Lanka, Philippines and Indonesia<sup>1</sup>. The fruit is commonly known as jamun in Hindi and Indian blackberry in English. The tree is valued for its medicinal and nutritional properties. Different parts of the jamun tree especially fruits, seeds and stem bark possess promising antidiabetic activity<sup>2-5</sup>. The fruits are reported to possess astringent, stomachic, carminative and diuretic properties<sup>6</sup>. They also showed anticancer<sup>7</sup> and anti-hyperlipidemic activities<sup>9-10</sup>.

Two varieties of jamun are seen in India namely “Ra Jaman” (big, oblong, deep purple fruits with pink greyish juicy sweet pulp) and another one is “Kaatha” (small fruit with acidic pulp)<sup>11</sup>. Ripe jamun fruits are available during May-July. The edible pulp is 75 % of

the whole fruit. Analysis of edible part gave the following values in g/100g edible pulp: moisture 83.7, protein 0.7, fat 0.3, crude fibre 0.9, carbohydrates 14 and ash 0.4<sup>(Ref. 11)</sup>. The mineral constituents reported to be present (mg/100g of edible pulp) are: Ca, 15; Mg, 35; P, 15; Fe, 1.2; Na, 26.2; K, 55; Cu, 0.23; S, 13 and Cl, 8. The vitamins present (in 100 g edible pulp) are: vitamin A, 80 I.U; thiamine, 0.03 mg; riboflavin, 0.01 mg; nicotinic acid, 0.2 mg; vitamin C, 18 mg; Choline, 7 mg; and folic acid 3 µg<sup>11</sup>. Raffinose, glucose and fructose are the principal sugar in ripe fruits with complete absence of sucrose<sup>12</sup>. Malic acid is the major acid (0.59 % of the weight of fruit). The purple colour of the fruit is due to the presence of cyanidin glycosides. The aglycone part of the glycoside contains petunidin and malvidin and the sugar part is mainly glucose and galactose<sup>11</sup>.

Due to the soft, juicy and perishable nature of the fruits, the post-harvest losses is very high. The market value of the fruits is also reduced due to the glut during the harvesting time. Hence, value addition through processing would be the only effective tool for economic utilization of the fruit. The shelf life of fruit can be extended by processing it to different food

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products like jam, jelly and squash. Due to its better nutraceutical property new market for export of this exotically flavoured product will be opened.

Processed products like jam contains high quantity of sugar which acts as preservative and does not allow bacteria, yeast and mould growth<sup>13</sup>. According to Bureau of Indian Standards (BIS) and Prevention of Food Adulteration (PFA) specifications, total soluble solids (TSS) of jam should be more than 68.5 % and at least 45 % of fruit. Preparation of jamun jam and its storage stability using different packaging materials and different temperatures have been reported<sup>14</sup>. However, there was no report on the antioxidant property and rheological property of jamun jam. Present study has been designed to study the antioxidant and rheological property of jamun jam and compare it with different jams available in the market.

### Materials and Methods

In the present study, ripe jamun fruits (Ra Jaman variety) were procured from New Delhi market area. The fruits were washed properly and subjected to analysis of physical properties. As per the BIS (Bureau of Indian Standards) specifications jam was prepared from these fruits and stored in dark till analysis.

#### Physical properties of jamun fruits

Jamun fruits were divided into 5 lots and 10 fruits were selected randomly from each lot to obtain 50 samples for conducting the experiments on dimensions. Measurement of all size and shape indices as well as the fruit mass was replicated fifty times. The size of fruit (length and breadth) was measured using a Vernier caliper (Mitutoyo, Japan) with an accuracy of 0.02 mm. The arithmetic and geometric mean diameters, bulk and true densities, sphericity, porosity, aspect ratio, surface area of bulk sample were calculated by using standard formulas<sup>15-18</sup>. The seed to pulp ratio was also calculated. The specific gravity was calculated as the ratio of fruit weight by fruit volume.

Reported method was applied for the extraction of juice from the fruits<sup>19</sup> and expressed as percent. The total soluble solids (TSS) of fresh juice were determined by using digital hand refractometer (Atago, Japan) at 20 °C. The pH was measured at 20 °C using a MP 220 pH meter (Mettler-Toledo GmbH, Schwerzenbach, Switzerland). Moisture content was determined using a moisture analyser

(A&D Company limited, MX-50) at 100 °C and expressed in percent. Total soluble solids were estimated by deducting percentage moisture from 100 as described by the method<sup>20</sup>. Titratable acidity was determined according to the method described<sup>13,21</sup>.

#### Preparation of jam

Healthy, undamaged jamun fruits were selected and washed thoroughly in water. The fruits were weighed and passed through a pulper to separate the seeds from the pulp. The separated pulp was weighed and used for manufacturing of jam. The pH and TSS of pulp used was 3.4 and 15° Brix, respectively. Ground, macerated fruits were heated on a hot plate in stainless steel pan at 80 °C for 10 min and TSS was checked out during heating. After that, pectin was added under manual agitation and the mixture was heated for 2 min to allow proper pectin hydration. Acidity was checked and adjusted if needed by addition of 0.3 % citric acid solution to a pH value from 3.0 to 3.2. Sugar was added and the mixture was boiled to a final concentration around soluble solids value of 68 % (approximately 105°C final boiling point). The jam was hot-packed at 85°C in 100 mL glass jars, immediately sealed with metal cover and inverted for 5 min to sterilize the glass containers. The jars of jam were stored at 20-25 °C in dark for further analysis.

#### Comparative analysis of jams

Five different jam samples (apple, pineapple, mango, pear and mixed fruit) were purchased from the market of Delhi and used for comparative study with the prepared jamun jam. Details of parameters studied and methodology followed has been described below.

#### Proximate analysis

The proximate composition of jams (total sugar %, total fat % and total solids %) were studied following standard methods<sup>14,22</sup>. Total protein % was determined using the CHN analyser (Elementar Germany, Model-Vario ELIII). The conversion factor for nitrogen to protein was 6.25. Analysis was performed in triplicate.

#### Total phenol content

Total phenol content of the jam samples were determined using Folin-Ciocalteu reagents<sup>23</sup>. Gallic acid standard solution (2.0 mg/mL) was prepared by accurately weighing 0.1 g and dissolving in 50 mL of distilled water. The solution was then diluted to give

working standard solutions of 1.5, 1.0, 0.5, 0.2, and 0.1 mg/mL. 40 µL of residue extract or gallic acid standard was mixed with 1.8 mL of Folin–Ciocalteu reagent (previously diluted 10-fold with distilled water) and allowed to stand at room temperature for 5 min, and then 1.2 mL of sodium bicarbonate (7.5 %) was added to the mixture. After standing 60 min at room temperature, absorbance was measured at 765 nm. Results were expressed as mg gallic acid equivalents (GAE)/g of sample.

#### Antioxidant activity

##### DPPH scavenging assay

Free-radical scavenging activity against 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical was evaluated from the reported method<sup>24,25</sup>. The DPPH radical (DPPH<sup>•</sup>) solution (0.004 %) was prepared in 80 % ethanol<sup>26</sup>. Sample extract 0.1 mL was added to 3.9 mL of DPPH solution and mixed thoroughly. Absorbance of the reaction mixture was measured at 515 nm against a blank after 60 min. All sample extracts were analyzed in triplicate. The results were expressed as percentage reduction of the DPPH<sup>•</sup> free radicals.

$$\text{DPPH free radical scavenging activity (\%)} = \frac{A_0 - A_c}{A_0} * 100$$

Where  $A_0$  is the absorbance of control and  $A_c$  is the absorbance of sample.

##### ABTS scavenging assay

The antioxidant activity was measured using a PerkinElmer LAMBDA 25 UV-Visible spectrophotometer following the improved ABTS method<sup>25, 27</sup>. The ABTS radical (ABTS<sup>•+</sup>) solution was prepared by the reaction of 7 mM ABTS and 2.45 mM potassium persulphate, after incubation in 23°C in the dark for 16 h. The ABTS<sup>•+</sup> solution was then diluted with 80 % ethanol to obtain an absorbance of  $0.700 \pm 0.005$  at 734 nm. ABTS<sup>•+</sup> (3.9 mL; absorbance of  $0.7 \pm 0.005$ ) was added to 0.1 mL of the test sample (10 %) and mixed thoroughly. The reaction mixture was allowed to stand at 23°C for 6 minute and the absorbance at 734 nm was immediately recorded. The measurement was performed in triplicate. The percentage decrease of the absorbance at 734 nm was calculated by the formula as below<sup>28</sup>:

$$I = \frac{(A_B - A_A)}{A_B} * 100$$

Where  $I$  = ABTS<sup>•+</sup> inhibition %,  $A_B$  = Absorbance of the blank sample ( $t = 0$  min);  $A_A$  = absorbance of the test sample at the end of the reaction ( $t = 6$  min).

##### FRAP assay

The determination of the total antioxidant activity (FRAP assay) in the jam was evaluated by a modified method<sup>29</sup>. The stock solutions included 300 mM acetate buffer (3.1 g  $C_2H_3NaO_2 \cdot 3H_2O$  and 16 mL  $C_2H_4O_2$ ), pH 3.6, 10 mM TPTZ (2, 4, 6-tripyridyl-*s*-triazine) solution in 40 mM HCl, and 20 mM  $FeCl_3 \cdot 6H_2O$  solution. The fresh working solution was prepared by mixing 25 mL acetate buffer, 2.5 mL TPTZ, and 2.5 mL  $FeCl_3 \cdot 6H_2O$ . The temperature of the solution was raised to 37°C before use. 150 µL of sample was allowed to react with 2850 µL of the FRAP solution for 30 min in the dark condition. Readings of the coloured product (ferrous tripyridyltriazine complex) were taken at 593 nm. The standard curve was linear between 200 and 1000 mM  $FeSO_4$ . Results are expressed as mM ferrous sulphate equivalent/g (mmol  $Fe^{2+}$ /g).

##### Viscosity

Viscosity measurements were carried out using modular compact rheometer (Anton Paar, USA). The experiments were carried out in the controlled stress mode to measure the viscosity of different jam having different compositions. About 10 g of jam was kept on the stationary rheometer plate. The viscosity of the products was measured at temperatures of  $25 \pm 1$ °C.

##### Statistical analysis

All data were subjected to statistical analyses. Three replicates of each treatment were examined. Values of different parameters were expressed as the mean  $\pm$  standard deviation. One way ANOVA analyses were performed to detect any statistically significant differences ( $p < 0.05$ ). The statistical software package SPSS version 16.0 was used for data analyses.

## Results and Discussion

### Physico-chemical study of jamun

Shape of fruit is an important parameter for designing of post-harvest processing equipment's and also from marketing point of view. Firmness of a healthy fruit is linked to the degree of its physiological maturation<sup>30</sup>. Chemically, the change from firm to soft condition of a fruit is largely due to the enzymatic conversion of pectic compounds present in their cell wall. The firmness of fruit determines the quality of the final product.

The shape of different cultivars of jamun varies from elliptical to ovoid to round and the colour varies

from reddish-purple to blackish-purple<sup>31</sup>. The fruits used in the present study were moderately soft, ovoid shaped, having blackish-purple colour with purple pulp. The result of physical parameters from the studied cultivar of jamun fruit has been shown in Table 1. The mean length and diameter of fruits taken for study were found to be 2.7 cm and 1.95 cm, respectively. This value was in accordance with the indigenous variety of jamun from Pakistan<sup>31</sup>. The geometric mean diameter and arithmetic mean diameter were 2.16 cm and 2.23 cm, respectively. The sphericity and aspect ratio were found to be 0.8 and 7.28, respectively. The surface areas of fruits were 14.90 cm<sup>2</sup> and the volume was 5.07 cm<sup>3</sup>. The volume of jamun fruit was found to be in accordance with the earlier result<sup>31</sup>. The density of fruits was 1.12 g/cm<sup>3</sup>. The weight of fruits (5.44 g) was slightly less than the earlier report<sup>31</sup>. The length, diameter and weight of seeds were 1.87 cm, 1.23 cm and 2.48 g, respectively. These values were high as compared to the improved

variety of jamun where the size of the seeds was quite small with length and breadth of 0.49 cm and 0.21 cm, respectively<sup>31</sup>. However the values were in accordance with the indigenous jamun variety from Pakistan with seed length and width of 1.6 cm and 0.7 cm, respectively<sup>31</sup>. Due to the bigger seed size and smaller fruit size the percentage of extractable pulp and juice was less as compared to the reported values<sup>31</sup>.

#### Preparation and analysis of jam

Jamun pulp was processed into jam to increase their shelf life and to make it available during the off season. Prepared jam as shown in Plate 1, stored in dark and the jams collected from market were analyzed for moisture content, pH, TSS and titratable acidity and the results have been given in Table 2. The moisture content of the jamun jam was found to be nearly 36.63 %. This value varied from 34.63 % (mango jam) to 38.54 % (mix fruit jam) for different jam samples studied. The TSS and pH of jamun jam was 68.3°Brix and 3.2, respectively. This value was in accordance with the value reported earlier<sup>19</sup>. However the TSS of jamun jam was significantly different from the TSS of different commercial jam samples used in the study. The TSS of mango jam was highest with

Table 1—Physical properties of jamun fruit

Properties	Delhi market
Shape	Ovoid
Colour	Blackish-purple
Firmness	Moderately soft
Length of fruit (cm)	2.7± 0.28
Diam. of fruit (cm)	1.95 ±0.24
Geometric mean diam.(cm)	2.16± 0.22
Arithmetic mean diam. (cm)	2.23±0.22
Sphericity	0.80 ± 0.06
Aspect Ratio	7.28±0.88
Surface area (cm <sup>2</sup> )	14.90 ± 3.08
Volume (cm <sup>3</sup> )	5.07 ± 1.29
True density (g/cm <sup>3</sup> )	1.12 ± 0.30
Weight of fruit (g)	5.44 ± 1.33
Length of seed (cm)	1.87 ± 0.11
Diam. of seed (cm)	1.23 ± 0.14
Weight of the seed (g)	2.48 ± 0.63
Edible pulp (%)	54.48± 4.21
Juice (%)	26.42± 1.24



Plate 1—View of prepared jamun jam

Table 2—Preliminary analysis of jam prepared from various fruits

Sample (jam)	Moisture content (%)	pH	(°Brix)	Titratable acidity (%)
Jamun	36.63±0.31 <sup>a</sup>	3.2±0.01 <sup>a</sup>	68.3±0.36 <sup>a</sup>	1.15± 0.03 <sup>a</sup>
Apple	35.75±0.34 <sup>b</sup>	3.00±0.02 <sup>b</sup>	66.13±0.25 <sup>b</sup>	1.25±0.03 <sup>b</sup>
Pineapple	36.84±0.33 <sup>a</sup>	3.6±0.012 <sup>c</sup>	70.3± 0.4 <sup>c</sup>	1.08±0.04 <sup>c</sup>
Mango	34.63±0.43 <sup>c</sup>	3.6±0.022 <sup>c</sup>	72.63± 0.15 <sup>d</sup>	1.12±0.02 <sup>a</sup>
Mixed fruit	38.54±0.37 <sup>d</sup>	3.9±0.024 <sup>d</sup>	69.60±1.08 <sup>c</sup>	1.21±0.01 <sup>b</sup>
Peach	37.01±0.15 <sup>a</sup>	3.2±0.016 <sup>a</sup>	68.40 ± 2.11 <sup>a</sup>	1.01±0.02 <sup>c</sup>

All values given are means of three determinations. Means in a column with different letters are significantly different (p< 0.05).

72.63 °Brix and it was lowest for apple jam (66.13 °Brix). TSS and pH of jam are two most important parameters as they determine the strength of the gel and hence the texture of the final product<sup>32</sup>. The codex alimentary commission<sup>33</sup> specify that the finished jam should contain more than 65 % TSS. The pH and titratable acidity of jamun jam was 3.2 and 1.15, respectively. The pH of the prepared jam was in accordance with the peach jam (3.2) and the titratable acidity was in accordance with the mango jam (1.12). The TSS and pH of jamun jam were significantly different ( $p < 0.05$ ) from other commercial jams tested. Over all the moisture content, pH, TSS and titratable acidity of the prepared jam was well within the range of specified standard<sup>22</sup>.

The proximate composition of different jams has been given in Table 3. Total sugar content of jamun jam (69.12 %) was comparable with that of peach jam (69.14 %) and was lower than all other samples except apple jam (66.84 %). This difference in sugar content can be attributed to the difference in methodology followed, quantity of sugar added and variety of fruits used. Low sugar jams can be called as better jam from health point of view.

The protein content of jamun jam (0.72) was significantly different ( $P < 0.05$ ) from the studied commercial jam samples. Highest protein content was found in peach jam (0.89 %) followed by mix fruit (0.83 %), mango (0.8 %), jamun (0.72 %), pineapple (0.48 %) and apple (0.18 %).

The fat content of jamun jam (0.15 %) was slightly more than that of pineapple jam (0.11 %) and was less than all other jam samples tested. The total solid content of jamun jam (63.65 %) was comparable with apple (63.82 %) and pineapple (63.45 %) jam. However, this value was significantly higher ( $P < 0.05$ ) than peach (62.87 %) and mixed fruit jam (61.75 %) and significantly lower ( $P < 0.05$ ) than mango jam (65.6 %).

Table 4 shows the result for total phenolics and antioxidant activity. Total phenol content of jamun jam (5.58 mg GAE/g) was highest followed by peach (4.40 mg GAE/g), mix fruit (4.16 mg GAE/g), apple (3.87 mg GAE/g), mango (2.56 mg GAE/g) and pineapple (1.98 mg GAE/g). Total phenol content of prepared jamun jam was found to be higher as compared to the earlier report of jamun jam having 355 mg GAE/100g<sup>34</sup>, date jam having 493.5 mg GAE/100g<sup>35</sup>, gabirola jam having 32.21- 72.85 mg GAE/100g and blue berry jam having 146-163 mg GAE/ 100g<sup>36</sup>. High total phenol content in the jam could have a positive effect on health. The high phenol content of the jam can be attributed to its gallic acid and anthocyanin content<sup>37-38</sup>. The anthocyanins reported in jamun fruits are delphinidin-3-gentiobioside, malvidin-3-laminaribioside, petunidin-3-gentiobioside, cyanidin-diglycoside, petunidin and malvidin<sup>39</sup>. It is well known that phenolics may prevent coronary heart disease and some cancer<sup>40</sup>. So high phenolics jams can be considered as a healthy jam.

Table 3—Proximate composition of different jam samples

Sample (jam)	Total sugar (%)	Total protein (%)	Total fat (%)	Total solids (%)
Jamun	69.12±0.61 <sup>b</sup>	0.72±0.05 <sup>d</sup>	0.15±0.03 <sup>b</sup>	63.66±0.61 <sup>a</sup>
Apple	66.84±0.54 <sup>a</sup>	0.18±0.07 <sup>a</sup>	0.20±0.08 <sup>a</sup>	63.82±0.61 <sup>a</sup>
Pineapple	72.42±0.84 <sup>c</sup>	0.48±0.04 <sup>c</sup>	0.11±0.02 <sup>b</sup>	63.45±0.52 <sup>a</sup>
Mango	72.97±0.58 <sup>c</sup>	0.80±0.01 <sup>b</sup>	0.25±0.03 <sup>a</sup>	65.60±0.66 <sup>c</sup>
Mix fruit	70.62±0.56 <sup>d</sup>	0.83±0.02 <sup>b</sup>	0.23±0.02 <sup>a</sup>	61.75±0.54 <sup>d</sup>
Peach	69.14±0.61 <sup>b</sup>	0.89±0.09 <sup>b</sup>	0.27±0.06 <sup>a</sup>	62.87±0.11 <sup>b</sup>

All values given are means of three determinations. Means in a column with different letters are significantly different ( $p < 0.05$ ).

Table 4—Total phenolics and total antioxidant activity

Sample (jam)	Total phenolics (mg GAE/g)	DPPH (%)	ABTS (%)	FRAP (mM Fe <sup>+2</sup> Eq/g)
Jamun	5.58±0.028 <sup>a</sup>	47.97±0.006 <sup>a</sup>	95.02±0.004 <sup>a</sup>	7.36±0.010 <sup>a</sup>
Apple	3.87±0.001 <sup>b</sup>	22.05±0.016 <sup>b</sup>	80.15±0.003 <sup>b</sup>	6.60±0.010 <sup>a</sup>
Pineapple	1.98±0.004 <sup>c</sup>	5.05±0.028 <sup>c</sup>	16.38±0.01 <sup>c</sup>	1.56±0.009 <sup>b</sup>
Mango	2.56±0.004 <sup>d</sup>	20.97±0.031 <sup>d</sup>	35.30±0.014 <sup>d</sup>	3.94±0.078 <sup>c</sup>
Mixed fruit	4.16±0.018 <sup>e</sup>	24.36±0.005 <sup>b</sup>	54.65±0.046 <sup>c</sup>	5.31±0.013 <sup>d</sup>
Peach	4.40±0.007 <sup>e</sup>	13.66±0.001 <sup>c</sup>	37.85±0.005 <sup>d</sup>	5.03±0.066 <sup>d</sup>

All values given are means of three determinations. Means in a column with different letters are significantly different ( $p < 0.05$ ).

The DPPH radical scavenging activity of jamun jam was highest ( $47.97 \pm 0.006$ ) as compared to other jams tested. Pineapple jam was the poorest ( $5.05 \pm 0.02\%$ ) DPPH scavenger which may be attributed to its lowest total phenol content ( $1.98 \pm 0.004$  mg GAE/g). DPPH scavenging activity of jamun jam was reported to be 20%<sup>34</sup>. This difference may be attributed to the different species of jamun and the difference in geographical region.

ABTS radical scavenging activity of jamun jam was the highest with  $95.02 \pm 0.004$  % reduction followed by apple ( $80.15 \pm 0.003$  %), mix fruit ( $54.65 \pm 0.04$  %), peach ( $37.85 \pm 0.005$  %), mango ( $35.30 \pm 0.01$  %) and pineapple ( $16.38 \pm 0.01$  %). The FRAP value determined in terms of ferrous equivalent concentration in mM was found to be in the order jamun>apple>mix fruit>peach>mango>pineapple. Overall, jamun jam was found to be the best source of total phenol with highest antioxidant activity ABTS scavenging activity of gabirola jam has been studied<sup>41</sup>. The FRAP value of different strawberry jam has been reported<sup>42</sup>.

The result of the viscosity measurement is shown in Fig 1. Viscosity of the jamun jam was found to be 500.3 poise. Trend of decreasing viscosity of jam expressed as Mango (789.8 poise)>Mix fruit (724.4 poise)>Apple (659 poise)>Peach (573.3 poise)>Jamun (500.3 poise)>Pineapple (368.2 poise). According to the experimental findings, the viscosity of prepared jamun jam was well within the range of viscosity of commercial jam samples. Earlier the viscosity of jamun jam was reported to be 47841-46093 poise (which was highly solidified in nature and extremely disliked by the tasters<sup>31</sup>). Viscosity measurement of a product is dependent upon the applied force and shear rate. In the present study, as

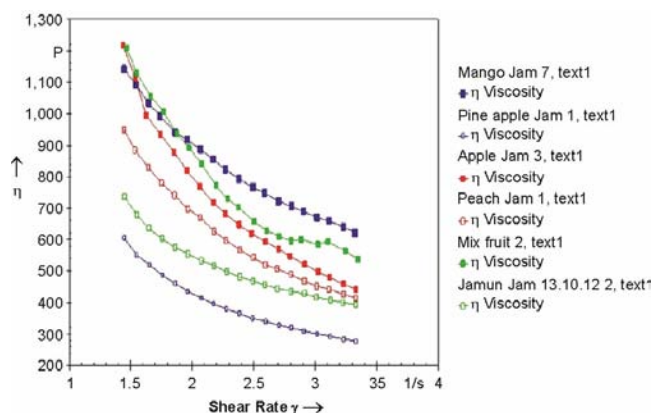


Fig. 1—Viscosity of jam changes with increasing time at controlled shear rate

the force per unit area increases with controlled shear rate the viscosity of jam decreases. This value is similar to the value reported earlier for different jamun products<sup>19</sup>. Number of factors like pH, sugar and pectin are responsible for the formation of tough gel which affects the rheological properties of jam<sup>32</sup>.

## Conclusion

The aim of this study was to prepare jam from *S. cumini* and to compare it with commercially available jams for different properties like proximate composition, total phenol, antioxidant activity and rheological property. According to the experimental findings, the jam developed from fresh jamun fruit was found to be of superior quality as compared to the commercial jams studied. The developed jam was comparatively low in total sugar and total fat and significantly high ( $p < 0.05$ ) in total phenol and total antioxidant activity as compared to the studied jam samples. Viscosity of the developed jam was well within the range of viscosity of other studied samples. So it will have good spreadability like the commercial samples. Present study shows that jamun can be successfully processed into high antioxidant jam. Jamun is a rich source of anthocyanin with documented health benefits. However, this organic source of nutraceuticals suffers from huge post-harvest losses due to its very short shelf life. Present study will help in increasing the shelf life of this precious fruits through addition of nutrition to our daily diet.

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