Antioxidant components and physico-chemical characteristics of *jamun* powder supplemented pear juice

Swati Kapoor¹ · Pushpinder Singh Ranote¹

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Abstract Studies were conducted to develop *jamun* powder supplemented pear juice. Two drying methods (Hot air cabinet drying and freeze drying) were used to prepare *jamun* pulp powder. *Jamun* powder was then blended with pear juice at 1, 2, 3, 4 and 5 % levels for preparation of *jamun* powder supplemented pear juice. Among the drying methods used, freeze dried powder retained better bioactive compounds and possessed higher antioxidant activity as compared to hot air dried *jamun* powder. Analysis of color properties (L^* , a^* , b^*) revealed lower L^* , b^* values and higher a^* values with progression of supplementation levels indicating decreased brightness of product. Pear juice supplemented with 4 % *jamun* powder received highest overall acceptability scores and was chosen for development of final product. Physico-chemical characteristics of control pear juice did not vary much from when compared to *jamun* powder supplemented pear juice. Bioactive components mainly total phenols enhanced (9.24 % higher) with addition of *jamun* powder in pear juice. Addition of anthocyanins from *jamun* powder to pear juice upon blending improved antioxidant activity of the final product. Supplemented pear juice had 18.13 % higher antioxidant activity than pear juice without supplementation. Storage period of 6 months resulted in significant ($p < 0.05$) decrease of bioactive compounds and antioxidant activity in *jamun* powder supplemented pear juice.

Keywords *Jamun* powder · Pear juice · Freeze drying · Hot air cabinet drying · Storage

Introduction

Fruits and vegetables and their products are extremely important in human nutrition. Natural bioactive compounds such as polyphenols, anthocyanins and carotenoids derived from fruits offers health benefits such as protection against cancer, cardiovascular diseases, age related macular degeneration and other diseases of modern lifestyle (Ajila et al. 2008). Fruit powders obtained from fruit pulp represent an interesting market as their physical form provides a stable, much longer shelf life and easily dosable ingredient that may be used to impart color and taste to food products (Bhandari et al. 1993). Food powders have many benefits and economic potential over their liquid forms such as reduced volume and packaging; easier handling and transportation (Sarabandi et al. 2014). Among various drying techniques, freeze dried powders have garnered much attention due to high retention of nutrients, color and flavors of the original fruit. Kapoor and Aggarwal (2015) studied the effect of different drying methods on bioactive compounds of carrot slices and found that freeze drying better retained bioactive compounds and antioxidant activity of carrot slices than hot air drying. In addition to providing foods and beverages with real fruit juice solids, freeze dried powders have numerous functional and nutritional benefits. The synergistic, multifunctional properties of these juice powders can be used to optimize number of ingredients in a formula (Francis and Phelps 2003).

Jamun also known as Indian Blackberry belongs to the family *Myrtaceae* and is indigenous to India and West Indies (Patil et al. 2012). The ripe *S. cumini* fruit has many therapeutic properties such as liver stimulation, digestive, carminative, coolant and hypoglycaemic effects (Paganga et al. 1999). The fruit has been recognized as a nutraceutical due to presence of phytonutrients such as anthocyanins, tannins, alkaloids, terpenoids and various minerals (Chaudhary and Mukhopadhyay 2012). *Jamun* fruit pulp has been used to prepare different

✉ Swati Kapoor
swatikapoor74@yahoo.com

¹ Department of Food Science and Technology, Punjab Agricultural University, Ludhiana, India

processed food items, however, astringent flavour is sometimes not preferred by the consumers, and thus, can be blended with other fruits to enhance acceptability of the product. *Jamun* pulp has a short shelf life and can be processed to form powder to increase its longevity. *Jamun* powder can be utilized in preparation of fruit beverages that form a major segment of food industry and serve as dietary supplements, rich in vitamins, minerals and vital micronutrients. Blending of different fruits is practiced to overcome the high cost of some exotic fruits, scarcity or seasonal availability, balancing of strong flavours, high acidity, astringency, or bitterness, improving total soluble solids, bland flavour, improving and stabilizing colour (Balaji and Prasad 2014).

Pear fruit contains good amount of carbohydrates, minerals, vitamins and polyphenol (Kumar and Ghuman 2007) however; pear juice has low acidity and insipid flavour, which is a constraint for its large scale processing. Blending of *jamun* powder with pear juice can help in optimizing sensory and nutritional quality. However, no reports are available regarding the supplementation of *jamun* powder in the aforementioned fruit beverage. Therefore, the present investigation aimed to study the blending of *jamun* powder with pear juice to further augment the phytonutritional status of the developed products. Hence, the objective of the study was to prepare *jamun* powder using hot air and freeze drying technique, to develop *jamun* powder blended pear juice beverage; to assess the antioxidant and physico-chemical properties of the developed products and to study its storage stability.

Materials and methods

Jamun (*Syzygium cuminii* L. Skeels) fruit was obtained from local market, Ludhiana, Punjab, India and Pear fruit was procured from Department of Fruit Science, Punjab Agricultural University (PAU), Ludhiana, Punjab, India.

Hot air drying and freeze drying of *jamun*

Fresh and fully ripe *jamun* fruits were washed thoroughly under running tap water. *Jamun* fruits were gently heated in its own juice on hot plate maintained at 60 °C for 10 min. Seeds were removed manually and uniform pulp was collected by passing the seedless material through fruit strainer. The pulp was spread as a thin layer on trays of dimension 40 × 80 cm and dried in cabinet hot air drier (Frederick Herbert-Design 20, Bombay, India) at 40 ± 5 °C for 8 h. The position of trays was interchanged periodically and the material was dried till constant weight was attained. In the second lot, the pulp was spread as thin layer on stoppering trays of freeze drier (Freezone freeze dry systems, Labconco, Kansas, USA). The pulp was dried at -30 °C temperature and 0.004

mBar pressure for 60 h. The conventional hot air dried (CD) and freeze dried (FD) material was grounded finely, packed in aluminium laminates and stored at refrigeration temperature for further studies.

Product preparation

Figure 1. Flowchart for preparation of *jamun* powder supplemented pear fruit juice.

Sensory evaluation

Jamun powder supplemented pear juice was served at low temperature to panelist and evaluated for sensory attributes such as appearance/color, flavour, body/texture and overall acceptability using 9- point hedonic scale (Lamond 1970). Seven semi-trained panellists in the age group of 22–55 years having no medical disorder from the Department of Food Science and Technology, PAU, Ludhiana were selected to evaluate the sensory properties of *jamun* powder supplemented pear juice.

Colour analysis

Colour analysis was performed using Hunter Lab Colorimeter, MiniScan XE Plus (Hunter Lab, Reston, VA). Colour readings were expressed by Hunter values for L*, a* and b*. The a* value ranged from -100 (greenness) to +100 (redness), the b* value ranged from -100 (blueness) to +100 (yellowness), whereas L* value, indicating the measure of lightness, ranges from 0 (black) to 100 (white) (Hutchings 1999). Hue angle was calculated using the formula $\tan^{-1} b^*/a^*$.

Proximate composition of *jamun* powder supplemented pear juice

Pear juice blended with *jamun* powder was analyzed for Total soluble solids (TSS) using refractometer (Erma, Tokyo). Titratable acidity was evaluated by titrating known volume of aliquots against 0.1 N NaOH and expressed as percent malic acid (Ranganna 1986); pH was measured using digital pH meter (MAX electronics, India). Total sugars and reducing sugars of *jamun* powder supplemented pear juice were estimated as per Lane and Eynon method (AOAC 2000). Crude fibre was estimated by acid-alkali method (Fibertec, FOSS) (AOAC 2000). Total ash and crude protein content was estimated as per Association of Official Analytical Chemists (AOAC 2000).

Bioactive composition of *jamun* powder supplemented pear juice

Bioactive components of *jamun* powder supplemented products were evaluated for ascorbic acid, total anthocyanins and total

Fig. 1 Flowchart for preparation of *jamun* powder supplemented pear fruit juice

phenols. Ascorbic acid was determined using direct colorimetric method (Ranganna 1986) and expressed as mg/100 g. Ascorbic acid from the dried *jamun* powder was extracted using 2 % metaphosphoric acid and filtered followed by volume make up. Dye solution was prepared by mixing 100 mg 2, 6-dichlorophenol-indophenol dye with 84 mg NaHCO₃ and volume made to 100 ml. The dye solution was diluted with water in 1:20 before use. 1 ml aliquot was taken in glass cuvettes along with 10 ml of dye solution and reading was taken immediately at 518 nm (Spectronic 20, Bausch & Lomb, USA). Total anthocyanins content was determined by spectrophotometric method (Srivastava and Kumar 1994) and expressed as mg/100 g. Control pear juice and *jamun* powder blended pear juice samples were mixed with ethanolic HCl (85 ml 95 % ethanol: 15 ml 1.5 N HCl) followed by volume make up with ethanolic HCl. The

contents were allowed to stand overnight at 4 °C and absorbance was recorded at 530 nm. Total anthocyanins were then calculated using following formula:

$$\text{Total O.D./100ml} = \frac{\text{O.D} \times \text{Volume made up} \times 100}{\text{Volume of juice taken}}$$

$$\text{Total anthocyanin (mg/100ml)} = \frac{\text{Total O.D./100ml}}{87.3}$$

Total phenolic content of methanolic extract of *jamun* powder and supplemented products were determined according to Folin-Ciocalteu spectrophotometric method (Gao et al. 2002). Methanolic extract was prepared by refluxing suitable amount of control pear juice and *jamun* powder blended pear juice with 80 % methanol for one hour in a round bottom flask

followed by filtration of the extract and volume made to 100 ml with 80 % methanol. The results were expressed as g Gallic acid Equivalent (GAE)/100 g for *jamun* powder and mg GAE/100 g for supplemented products by taking gallic acid (100 µg/ml) as reference material to prepare standard curve.

Antioxidant activity

Antioxidant activity of *jamun* powder and supplemented fruit beverage was determined by di phenyl picryl hydrazyl

(DPPH) method according to Brand-Williams et al. (1995) with some modifications. Methanolic extract of samples was taken for antioxidant activity analysis and calculated according to the following formula. The assay contained 2 ml of sample aliquot, 2 ml of tris HCl buffer (pH 7.4) and 4 ml of 0.1 mM DPPH. The contents were mixed immediately and the degree of reduction of absorbance was recorded continuously for 30 min. at 517 nm (Spectronic 20, Bausch & Lomb, USA).

$$\text{Radical scavenging activity (\%)} = \frac{\text{Control OD (0min)} - \text{Sample OD (30min)} \times 100}{\text{Control OD (0min)}}$$

Storage test

Control pear juice and *jamun* powder blended pear juice was stored in glass bottles (200 ml ca.) at room temperature to evaluate storage effect on product quality.

Statistical analysis

All analyses were carried out using three independent determinations and expressed as mean value $\pm$ standard deviation (SD) except for sensory evaluation where seven independent observations were expressed as mean value. Student's t-test and Duncan's test was used to calculate the means and their 95 % confidence intervals for *jamun* powder and *jamun* powder supplemented pear juice, respectively using the SPSS software, version 18.0 (Statsoft Inc. USA).

Results and discussion

Physico-chemical properties of *jamun* powder

Physico-chemical properties of hot air dried and freeze dried *jamun* powder has been depicted in Fig. 2. The values for total solids were established as 91.43 and 91.87 % in hot air and freeze dried *jamun* powder, respectively. Titratable acidity was recorded slightly more in freeze dried *jamun* powder (4.18 %) compared to hot air dried powder (4.12 %). Slightly higher total sugars and reducing sugars were observed in freeze dried samples (56.52 % and 51.59 %, respectively) than in hot air dried samples (55.08 % and 49.78 % respectively). Ali et al. (2013) reported 52.48 % of total sugars in dried *jamun* pulp. Crude fibre was slightly more in freeze dried samples (2.57 %) than hot air dried samples (2.47 %). Similarly, total ash content which represents mineral matter was higher in freeze dried samples (2.97 %) than hot air dried samples (2.85 %) signifying *jamun* fruit as an important

source of minerals. Protein content was at par in both the hot air dried and freeze dried samples (1.75 and 1.82 %) respectively. Overall, it was established that *jamun* powder obtained from both the drying methods did not varied much from each other with respect to physico-chemical properties.

Bioactive components of *jamun* powder

Jamun fruit has been recognized as a nutraceutical fruit due to presence of antioxidants such as ascorbic acid, anthocyanins and total phenols. Ascorbic acid content of hot air dried samples was recorded as 25.61 mg/100 g and that of freeze dried sample was 36.95 mg/100 g (Table 1). Lower ascorbic acid retention in hot air dried *jamun* powder was due to oxidation of ascorbic acid in the presence of air and high temperature. Leoni (2002) reported that Vitamin C is destroyed mainly due to oxidation reactions and heat applied in the presence of air while Shofian et al. (2011) revealed that freeze drying process exerted minimal effect on the deterioration of Vitamin C. Anthocyanin was also found to be higher in freeze dried samples (305.47 mg/100 g) than in hot air dried samples (Table 1). Temperature is one of the factors that affects the stability of anthocyanins and degradation of anthocyanins occurs with increase in temperatures (Kopjar et al. 2009). Total phenols and antioxidant activity of freeze dried *jamun* powder was 4.16 g/100 g and 88.34 %, respectively (Table 1). Hot air dried *jamun* powder had comparatively low content of total phenols (3.67 g GAE/100 g) and lower antioxidant activity (83.53 %). A study reported that due to absence of liquid water during freeze drying there was minimal loss of anthocyanins and polyphenols retaining more bioactive components in freeze dried powder (Mitra et al. 2013). Low antioxidant activity of hot air dried *jamun* powder may be due to lowest retention of bioactive compounds. Overall, freeze dried powder was found to retain better bioactive components than hot air drying and could be used to preserve heat labile nutritional components.

Fig. 2 Physico-chemical properties of hot air and freeze dried *jamun* powder

Sensory evaluation

Differences were established among the appearance/colour, flavour, body/texture and overall acceptability scores of conventional hot air dried (CD) and freeze dried (FD) *jamun* powder incorporated pear juice have been depicted in Table 2. The overall acceptability scores were significantly ($p \leq 0.05$) affected with the supplementation of *jamun* powder from 1 to 5 % in pear juice. Appearance scores were in the range of 7.60–7.80 for conventional hot air and freeze dried *jamun* powder supplemented pear juice. Increased darkness in the product was observed with increased supplementation levels of *jamun* powder. Flavour was found to have predominant effect in determining acceptability of the final product. Maximum flavour values were noted for both hot air and freeze dried *jamun* powder incorporated at 4 % level in pear juice (8.20) and minimum values were noted at 5 % supplementation level. Similarly, maximum scores for mouth feel were found at 4 % supplementation level of hot air and freeze dried *jamun* powder. Overall acceptability scores were in the range of 7.56–8.13. Highest scores for sensory characteristics were found in pear juice containing 4 % of *jamun* powder from both the drying methods and lowest for 5 % supplementation level. Pear juice containing *jamun* powder at higher levels was slightly astringent. Therefore, optimum sensory properties were established at 4 % level.

Color analysis

Effect of hot air and freeze dried *jamun* powder supplementation on colour values of (L^* , a^* , b^*) and hue angle of pear juice has been elucidated in Table 3. The L^* , a^* , b^* and hue angle values for control pear juice was noted as 42.47, 0.45, 5.38 and 85.16, respectively. Huang and Hsieh (2005) found L^* values for pear fruit leather in the range of 41.55–56.07 for different percentage of pectin and corn syrup supplemented. Statistically, significant ($p \leq 0.05$) difference was observed in L^* value of *jamun* powder supplemented pear juice with increasing supplementation levels. Increase in supplementation levels of *jamun* powder from both the drying methods resulted in decreasing L^* values from 42.47 to 31.44 and 42.47 to 31.38 in CD and FD *jamun* powder supplemented pear juice, respectively, indicating decreased brightness of the product.

The a^* value that indicate redness/greenness of the product followed an increasing trend with increase in supplementation level of *jamun* powder. Marked increase in a^* values was found at 3 % supplementation level in case of freeze dried *jamun* powder (2.28) and at 4 % supplementation level in case of hot air dried *jamun* powder (2.68). The following observation indicated higher retention of anthocyanins in freeze dried *jamun* powder than hot air dried *jamun* powder as a^* values have been positively correlated with anthocyanins (Camire et al. 2007). However, a^* values of pear juice containing CD and

Table 1 Bioactive components of hot air and freeze dried *jamun* powder

Drying methods	Ascorbic acid (mg/100 g)	Anthocyanin (mg/100 g)	Total phenols (g GAE/100 g)	Antioxidant activity (%)
Hot air dried	25.61 ^a ± 0.29	259.89 ^a ± 0.48	3.67 ^a ± 0.49	83.53 ^a ± 0.34
Freeze dried	36.95 ^b ± 0.17	305.47 ^b ± 0.50	4.16 ^b ± 0.28	88.34 ^b ± 0.49

GAE- Gallic acid equivalent; means with different letters in the same column are significantly different for $p \leq 0.05$, student's t-test

Table 2 Effect of different supplementation levels of *jamun* powder on sensory scores of pear juice

Supplementation (%)	Appearance/Colour		Flavour		Mouth feel		Overall acceptability	
	CD	FD	CD	FD	CD	FD	CD	FD
Control	7.60 ^a ± 0.41	7.60 ^a ± 0.43	7.70 ^{ab} ± 0.44	7.70 ^{ab} ± 0.27	7.70 ^{bc} ± 0.44	7.70 ^{bc} ± 0.44	7.66 ^b ± 0.39	7.66 ^{bc} ± 0.36
1	7.60 ^a ± 0.41	7.70 ^a ± 0.44	7.80 ^{ab} ± 0.57	7.70 ^{ab} ± 0.27	7.90 ^{abc} ± 0.22	7.80 ^{bc} ± 0.44	7.76 ^{ab} ± 0.25	7.73 ^{bc} ± 0.14
2	7.70 ^a ± 0.44	7.80 ^a ± 0.27	7.70 ^{ab} ± 0.44	7.80 ^{ab} ± 0.44	8.00 ^{ab} ± 0.35	8.10 ^{abc} ± 0.41	7.79 ^{ab} ± 0.36	7.89 ^{bc} ± 0.19
3	7.80 ^a ± 0.57	7.80 ^a ± 0.27	8.10 ^{ab} ± 0.41	8.00 ^a ± 0.35	8.00 ^{ab} ± 0.35	8.20 ^{ab} ± 0.37	7.96 ^{ab} ± 0.31	7.99 ^{ab} ± 0.20
4	7.80 ^a ± 0.27	7.80 ^a ± 0.41	8.20 ^a ± 0.27	8.20 ^a ± 0.27	8.30 ^a ± 0.27	8.40 ^a ± 0.22	8.09 ^a ± 0.14	8.13 ^a ± 0.13
5	7.60 ^a ± 0.41	7.70 ^a ± 0.27	7.50 ^b ± 0.50	7.40 ^b ± 0.41	7.50 ^c ± 0.35	7.60 ^c ± 0.41	7.56 ^b ± 0.25	7.59 ^c ± 0.25

Means with different letters in the same column are significantly different ($p \leq 0.05$)

CD- Conventional hot air drying FD- freeze drying

FD *jamun* powder were found at par at 5 % level (Table 3). The overall range of a^* value for different supplementation levels was found to lie between 0.84–3.17. Increasing supplementation level of CD and FD *jamun* powder resulted in reduction of b^* values from 4.75 and 4.47 at 1 % supplementation level to 1.92 and 1.75 at 5 % supplementation level, respectively. Decreasing b^* values showed increase in blue coloration of the samples due to increasing anthocyanin content with increase in pulp concentration.

Statistically significant ($p \leq 0.05$) decrease was observed in hue angle of the pear juice with increasing supplementation level. The values of hue angle were noted in the range of 79.88–31.45 and 77.50–28.93 in hot air and freeze dried *jamun* powder supplemented pear juice, respectively. Hue angle and L^* values are well correlated depicting sample darkness with progression in supplementation levels (Cliff et al. 2007).

Physico-chemical composition and storage of *jamun* powder supplemented pear juice

On the basis of sensory evaluation and colour characteristics, 4 % supplementation level of *jamun* powder in pear juice was

chosen for further studies. Physico-chemical composition of *jamun* powder blended pear juice has been listed in Table 4. Total soluble solids (TSS) of control and supplemented pear juice were 14°B. Slight increase in TSS was observed with progression of storage period of 6 months. TSS increased from initial values of 14°B to 14.20°B, both in hot air and freeze dried *jamun* powder supplemented pear juice during storage period. Increase in TSS values might be attributed to breakdown of the complex carbohydrates into simple soluble carbohydrates (Raj et al. 2011). Titratable acidity after processing of pear juice was noted as 0.28 % for control juice and 0.33 % for both the CD and FD *jamun* powder supplemented pear juice (Table 4). Increase in acidity from 0.33–0.37 % was observed in CD and FD *jamun* powder supplemented pear juice after termination of storage period of 6 months which might be due to chemical interaction between the organic constituents of the product. Similar trend of increasing acidity with storage period was reported by Raj et al. (2011) in sand pear-apple juice blends.

Reducing and total sugars content of *jamun* powder supplemented pear juice differed slightly from the control samples (Table 4). Control samples were found to have 7.81 and 10.24 % of reducing and total sugars, respectively. Pear juice

Table 3 Colour analysis of *jamun* powder supplemented pear juice

Supplementation (%)	L^*		a^*		b^*		Hue angle (°)	
	CD	FD	CD	FD	CD	FD	CD	FD
Control	42.47 ^a ± 0.56	42.47 ^a ± 0.56	0.45 ^c ± 0.12	0.45 ^c ± 0.12	5.38 ^a ± 0.33	5.38 ^a ± 0.33	85.16 ^a ± 0.56	85.16 ^a ± 0.44
1	41.06 ^b ± 0.87	40.28 ^b ± 0.41	0.84 ^d ± 0.08	0.98 ^d ± 0.04	4.75 ^b ± 0.37	4.47 ^b ± 0.48	79.88 ^b ± 0.67	77.50 ^b ± 0.78
2	39.26 ^c ± 0.57	38.74 ^c ± 0.56	1.11 ^d ± 0.10	1.13 ^d ± 0.05	4.10 ^c ± 0.12	3.84 ^c ± 0.34	74.79 ^b ± 0.95	73.53 ^b ± 0.95
3	36.65 ^d ± 0.58	36.77 ^d ± 0.58	1.88 ^c ± 0.19	2.28 ^c ± 0.33	3.17 ^d ± 0.22	2.90 ^d ± 0.22	59.35 ^c ± 0.49	51.84 ^c ± 0.65
4	33.14 ^e ± 0.56	33.07 ^e ± 0.07	2.68 ^b ± 0.32	2.84 ^b ± 0.12	2.50 ^e ± 0.22	2.20 ^e ± 0.21	43.33 ^d ± 0.56	37.72 ^d ± 0.43
5	31.44 ^f ± 0.64	31.38 ^f ± 0.54	3.15 ^a ± 0.26	3.17 ^a ± 0.05	1.92 ^f ± 0.12	1.75 ^e ± 0.21	31.45 ^e ± 0.76	28.93 ^e ± 0.77

Means with different letters in the same column are significantly different ($p \leq 0.05$)

CD- Conventional hot air drying FD- freeze drying

Table 4 Effect of storage on physico-chemical characteristics of *jamun* powder supplemented pear juice

Storage months	TSS (°B)		Titratable acidity (% malic acid)				Reducing sugars (mg/100 g)			
	C	CD	FD	C	CD	FD	C	CD	FD	FD
0	14.00 ^a ± 0.00	14.00 ^b ± 0.00	14.00 ^b ± 0.00	0.28 ^b ± 0.03	0.33 ^c ± 0.01	0.33 ^c ± 0.01	7.81 ^b ± 0.50	7.96 ^b ± 0.53	7.98 ^b ± 0.52	
2	14.00 ^a ± 0.00	14.06 ^{ab} ± 0.11	14.06 ^{ab} ± 0.11	0.29 ^{ab} ± 0.02	0.35 ^b ± 0.01	0.34 ^{bc} ± 0.03	8.01 ^{ab} ± 0.58	8.18 ^b ± 0.41	8.22 ^b ± 0.42	
4	14.13 ^a ± 0.11	14.06 ^{ab} ± 0.11	14.13 ^{ab} ± 0.11	0.31 ^{ab} ± 0.02	0.36 ^{ab} ± 0.01	0.35 ^b ± 0.01	8.52 ^{ab} ± 0.05	9.31 ^a ± 0.22	9.37 ^a ± 0.28	
6	14.13 ^a ± 0.11	14.20 ^a ± 0.00	14.20 ^a ± 0.00	0.32 ^a ± 0.01	0.37 ^a ± 0.00	0.37 ^a ± 0.01	8.83 ^a ± 0.17	9.78 ^a ± 0.23	9.81 ^a ± 0.18	
Storage months	Total sugars (mg/100 g)		Total ash (%)				Crude protein (%)			
	C	CD	FD	C	CD	FD	C	CD	FD	FD
0	10.24 ^a ± 0.57	10.34 ^a ± 0.10	10.39 ^a ± 0.10	0.43 ^a ± 0.02	0.45 ^a ± 0.01	0.45 ^a ± 0.00	0.12 ^a ± 0.02	0.13 ^a ± 0.03	0.14 ^a ± 0.03	
2	10.15 ^a ± 0.50	10.26 ^a ± 0.43	10.32 ^a ± 0.49	0.43 ^a ± 0.01	0.44 ^a ± 0.01	0.45 ^a ± 0.01	0.11 ^a ± 0.02	0.13 ^a ± 0.01	0.13 ^{ab} ± 0.01	
4	9.92 ^a ± 0.70	10.01 ^a ± 0.56	10.08 ^a ± 0.57	0.39 ^b ± 0.02	0.40 ^b ± 0.01	0.41 ^a ± 0.01	0.11 ^a ± 0.01	0.12 ^a ± 0.01	0.12 ^{ab} ± 0.02	
6	9.70 ^a ± 0.53	9.83 ^a ± 0.70	9.93 ^a ± 0.72	0.38 ^b ± 0.01	0.39 ^b ± 0.01	0.40 ^a ± 0.00	0.09 ^b ± 0.03	0.10 ^a ± 0.02	0.09 ^b ± 0.02	

Means with different letters in the same column are significantly different ($p \leq 0.05$)

C- Control CD- Conventional hot air drying FD- freeze drying

extracted from different varieties of pear was reported to have total sugars in the range of 8.09–9.0 % (Zhang et al. 2005; Chen et al. 2005). Gradual increase in reducing sugars was observed with progression of storage period. Reducing sugars increased significantly ($p < 0.05$) from initial values of 7.96 and 7.98 % to 9.78 and 9.81 % in CD and FD *jamun* powder supplemented pear juice, representing an increase of 22.86 and 22.93 %, respectively after storage period of 6 months. The increasing trend could be attributed to the inversion of non-reducing sugars to reducing sugars upon prolonged storage under ambient conditions and acid content of the product. The results corresponded to the findings of Kumar and Manimegalai (2001) in pineapple-pear-pomegranate blended RTS. Gradual decrease in total sugars content was noted in control and *jamun* powder supplemented pear juice samples. Total sugars decreased by 5.56, 5.18 and 4.63 % in control, hot air and freeze dried *jamun* powder supplemented pear juice, respectively, upon termination of storage period (Table 4). Such decline in total sugars might be ascribed to conversion of sugars into monosaccharide by acid hydrolysis and copolymerization of sugars in presence of acids as reported by Khurana and Anand (1980) and Saini and Grewal (1995).

Total ash content in control pear juice was noted as 0.43 % which reduced to 0.38 % after 6 months of storage (Table 4). Hot air and freeze dried *jamun* powder supplemented pear juice had 0.45 % of total ash that reduced to 0.39 and 0.40 %, respectively after termination of storage period. Minor losses were observed in ash content with progression of storage which can be attributed to binding of certain minerals with organic substances (Gopalan et al. 1993). Protein content ranged between 0.12–0.09 % in control and in supplemented samples, it varied from 0.14–0.09 %. Storage period had non-significant ($p \leq 0.05$) effect on the protein content of control and blended samples.

Bioactive composition and storage of *jamun* powder supplemented pear juice

Bioactive composition and storage studies of control and *jamun* powder supplemented pear juice are detailed in Table 5. Ascorbic acid content of control, hot air and freeze dried *jamun* powder supplemented pear juice was at par. Sumaya-Martinez et al. (2011) also reported 92 mg/L of ascorbic acid in white pear fruit. Upon perusal of the results, it was observed that ascorbic acid content decreased from 8.64 to 4.14 mg/100 g in control samples, 8.69 to 4.96 mg/100 g in hot air dried and 8.83 to 5.51 in freeze dried *jamun* powder supplemented pear juice. The per cent retention in ascorbic acid content was noted as 47.91, 57.07 and 62.40 in control, hot air and freeze dried *jamun* powder supplemented pear juice, respectively. Pear-*jamun* blended juice exhibited better retention of ascorbic acid which might be due to the antioxidant properties of phenolic compounds (anthocyanins) in *jamun*

Table 5 Effect of storage on bioactive components and antioxidant activity (%) of *jamun* powder supplemented pear juice

Storage months	Ascorbic acid (mg/100 g)			Anthocyanins (mg/100 g)			Total phenols (mg GAE/100 g)			Antioxidant activity (%)		
	C	CD	FD	C	CD	FD	C	CD	FD	C	CD	FD
0	8.64 ^a ± 0.51	8.69 ^a ± 0.49	8.83 ^a ± 0.51	-	6.89 ^a ± 0.20	7.82 ^a ± 0.33	112.44 ^a ± 0.70	120.37 ^a ± 0.54	125.29 ^a ± 0.65	68.94 ^a ± 0.24	80.26 ^a ± 0.46	82.63 ^a ± 0.46
2	6.86 ^b ± 0.29	6.90 ^b ± 0.29	7.93 ^b ± 0.30	-	4.78 ^b ± 0.48	5.89 ^b ± 0.55	104.96 ^b ± 0.56	116.63 ^b ± 0.79	123.71 ^a ± 0.85	65.14 ^b ± 0.18	77.03 ^b ± 0.88	80.53 ^b ± 0.40
4	5.98 ^c ± 0.19	5.99 ^c ± 0.20	7.03 ^c ± 0.21	-	3.64 ^c ± 0.47	4.17 ^c ± 0.42	98.73 ^c ± 0.67	114.15 ^c ± 0.23	120.23 ^b ± 0.58	61.27 ^c ± 0.44	75.87 ^b ± 0.56	77.30 ^c ± 0.82
6	4.14 ^d ± 0.28	4.96 ^d ± 0.29	5.21 ^d ± 0.28	-	2.17 ^d ± 0.33	2.68 ^d ± 0.45	96.14 ^d ± 0.72	109.59 ^d ± 0.80	116.63 ^c ± 0.51	59.13 ^d ± 0.33	73.58 ^c ± 0.49	75.21 ^d ± 0.44

GAE- Gallic acid equivalent; means with different letters in the same column are significantly different for $p \leq 0.05$

C- Control CD- Conventional hot air drying FD- freeze drying

powder (Zheng and Wang 2001). Losses of ascorbic acid during storage were attributed to oxidation of dehydroascorbic acid which was directly affected by temperature and light exposure. Reduction in ascorbic acid content was observed by Chakraborty et al. (2011) in blended *jamun*-litchi nectar at the end of storage period.

Pear juice supplemented with freeze dried *jamun* powder secured little higher values of anthocyanins content (7.82 mg/100 g) than juice supplemented with hot air dried *jamun* powder (6.89 mg/100 g) and no anthocyanins were detected in control pear juice (Table 5). During storage period of six months, there was gradual decline in anthocyanins content from 6.89 to 2.17 mg/100 g and 7.82 to 2.68 mg/100 g in CD and FD *jamun* powder supplemented pear juice representing per cent reduction of 68.50 and 65.72 %, respectively. This might be due to hydrolysis of protective 3-glucoside linkages to give unstable anthocyanins as reported by Kannan and Thirumaran (2004) in *jamun* RTS beverage, squash, syrup and jam.

Total phenolic content of control pear juice was noted as 112.44 mg GAE/100 g (Table 5). The results are in accordance with the one reported by Cansino et al. (2013) where it was noted 98.22 mg GAE/100 g of total phenols in pear juice. Pear juice containing freeze dried *jamun* powder had 4.08 % higher total phenols than juice containing hot air dried *jamun* powder which may be due to initially high concentration of total phenols in freeze dried *jamun* powder. Polyphenols retained better in freeze dried powder due to absence of liquid water during freeze drying that exerted minimal degradation on polyphenols retaining more bioactive components in freeze dried powder (Mitra et al. 2013). Storage period resulted in significant ($p \leq 0.05$) decrease in total phenolic content of control and supplemented pear juice. The decrease in phenolic content from initial values were recorded as 8.95, 6.91 and 14.49 % in pear juice supplemented with *jamun* powder from hot air drying, freeze drying and without supplementation respectively, after six months of storage. Decrease in total phenolic content with progression of storage period might be attributed to the volatile nature of phenolic compounds which gets easily oxidized (Ranganna 1986).

The antioxidant capacity of fruits and vegetables largely depends upon a plethora of individual antioxidants or combined effect of antioxidants (Rai et al. 2011). Many authors have reported that antioxidant effect is mainly due to radical scavenging activity of phenolic compounds (Matsukawa et al. 1997; Rahman and Moon 2007). In order to evaluate free radical scavenging capacity of control and supplemented pear juice, DPPH assay was conducted and the results are presented in Table 5. Antioxidant activity of supplemented samples was recorded maximum in FD *jamun* powder supplemented pear juice (82.63 %), followed by CD *jamun* powder supplemented pear juice (80.26 %) and minimum in control juice (68.94 %). This trend can be explained on the basis that supplemented samples

constitute higher amount of bioactive components such as ascorbic acid, total phenols and additionally presence of anthocyanins in blended juice. Antioxidant activity showed positive correlation with phenolic compounds (Duddone et al. 2009), ascorbic acid (Teixeira et al. 2009) and concentration of total anthocyanins (Jakobek et al. 2007). Storage period resulted in significant ($p \leq 0.05$) reduction of antioxidant activity from 68.94 to 59.13 % in control pear juice. It was observed that scavenging activity decreased by 8.32 and 8.97 % in hot air and freeze dried *jamun* powder supplemented pear juice respectively, after storage period of 6 months. The decrease in the antioxidant activity could be linked to a decrease in phenolic compounds and vitamin C during storage (Klimczak et al. 2007).

Conclusion

The present investigation with regards to physico-chemical and bioactive composition of *jamun* powder supplemented pear juice suggests the potential use of *jamun* powder for improving antioxidant status of fruit beverages low in bioactive components. Among the drying methods, freeze drying was found better in retaining bioactive components than hot air drying. The overall acceptability scores were highest for pear juice containing 4 % *jamun* powder from both the drying methods. Colour characteristics were significantly affected with increasing supplementation level from 1 to 5 %. Physico-chemical characteristics of pear juice were not affected much by incorporation of *jamun* powder. Blending of *jamun* powder with pear juice resulted in enhanced ascorbic acid content, total phenolics and addition of anthocyanins. Supplemented pear juice had 18.13 % higher antioxidant activity than pear juice without supplementation. During storage period all the bioactive compounds and antioxidant activity decreased significantly ($p \leq 0.05$) in control and supplemented samples. Conclusively, *jamun* powder can be successfully blended with pear juice having improved functional and bioactive properties of the resultant beverage. The future possibilities lie in utilizing *jamun* fruit powder in processed fruit products to boost nutritional components and to encourage the utilization of minor fruit crops.

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