Journal of Applied and Natural Science 7 (1) : 309 – 315 (2015)

JANS

Antioxidant potentials and quality aspects of *Jamun* (*Syzygium cumini* L.) supplemented unleavened flat bread (*Indian chapatti*)

Swati Kapoor*, **Pushpinder Singh Ranote and Savita Sharma**

Department of Food Science and Technology, Punjab Agricultural University, Ludhiana-141004 (Punjab), INDIA
*Corresponding author. E-mail: swatikapoor74@yahoo.com

Received: November 19, 2014; Revised received: March 25, 2015; Accepted: April 22, 2015

Abstract: Enriched *chapattis* prepared by supplementing whole wheat flour with *Jamun* (*Syzygium cumini* L.) pulp at 5, 10 and 15% were assessed for antioxidant activity and quality. *Jamun* pulp supplementation enhanced the bioactive composition of *chapatti* in terms of increased anthocyanins, total phenols and antioxidant activity. Total phenolic content and antioxidant activity increased 99.73% and 44.38%, respectively after incorporation of *Jamun* pulp (15%) to whole wheat flour *Indian chapatti*. Anthocyanins were not observed in control *chapatti* and in *Jamun* supplemented *chapatti* the range was 1.41-2.64 mg/100g content for 5-15% supplementation level. Qualitative evaluation revealed non-sticky behavior of dough supplemented with *Jamun* at 5 and 10% level and slight stickiness at 15% level. *Chapattis* exhibited full puffing at all supplementation levels. Sensory scores were highest for 10% *Jamun* supplemented *chapatti*. Crude fiber content improved significantly (13.77% increase) in *chapattis* on supplementation of *Jamun* pulp. The study concluded that supplementation of wheat flour with *Jamun* pulp improved nutritional and antioxidant status of *chapatti*.

Keywords: Antioxidant activity, *Chapatti*, Colour, *Jamun* (*Syzygium cumini* L.), Texture

INTRODUCTION

Jamun (*Syzygium cumini* L.) known as Indian blackberry has long been used as a traditional medicine to cure various lifestyle diseases such as diabetes, cardiovascular diseases, age related macular degeneration and others (D'Mello *et al*., 2000; Sagrawat *et al*., 2006). Use of fruits and vegetables as an ingredient in processed food products is garnering attention worldwide due to rise in importance of the concept of "phytochemicals" as they have the ability to combat and prevent the development of deadly diseases such as cancer and cardiovascular diseases. *Jamun* fruits are rich in vitamins, minerals and carbohydrates (Sharma *et al*., 2012). The main phytochemicals found in *Jamun* fruit are anthocyanins, tannins and other phenolic compounds. Anthocyanins have shown antagonistic activity to some bacteria, virus and fungi and also protect food from microbial spoilage (Chattopadhyay *et al*., 2008). *Chapatti* along with other bakery products can be used as a cost-effective carrier of phytochemicals derived from fruits and vegetables. The upcoming trends in the food industry focus on the theme of health and wellness, thus, food scientists are exploring the opportunities to combine various food sources and develop a wholesome healthy product. Incorporation of real fruit in cereal products creates excellent opportunities for new product development and among this *chapatti* represents one of the routinely consumed cereal product in Indian diet.

Jamun fruit has been processed in various ways such as jams, jellies, squash, vinegar, wine in order to preserve and relish it round the year as it is seasonal in nature being very short duration crop. The era of amalgamation of cereal-fruits and vegetable is rising in view to enhance the antioxidant status of cereal based products. Cereal products are high in protein content compared to fruits and vegetables whereas fruits and vegetables are high in bioactive compounds such as carotenoids, ascorbic acid and phenolic acids (anthocyanins, tannins). Therefore, combination of the two can serve the dual purpose in a diet making the diet rich in proteins as well as phytochemicals in the finished product (Francis and Phelps, 2003).

Chapatti, unleavened flat bread is one of the staple diets of Indian people and about 85% of wheat in India is consumed in the form of *chapattis* (Kadam *et al*., 2012). Incorporation of processed *Jamun* pulp in the whole wheat flour can help improve the nutritional status of masses by increasing the antioxidant status of the *chapatti*. Therefore, the present investigation has been done to study the utilization of processed *Jamun* (*Syzygium cumini* L.) pulp in whole wheat flour and to assess the antioxidant, qualitative and physico-chemical properties of *Jamun* pulp supplemented *Indian chapattis*.

MATERIALS AND METHODS

Raw materials: *Jamun* (*S. cumini* L.) fruit and whole wheat flour was obtained from local market, Ludhiana, Punjab, India.

Processing of *Jamun* fruit into pulp: *Jamun* fruit was processed into pulp by heating gently for 10 min. at 60˚C in its own juice. Seeds were removed manually and pulp was collected by passing the seedless material through fruit strainer. Pulp was further heated to 82˚C for 3 min., filled hot in pre-sterilized clean glass bottles (200 ml) and processed in boiling water for 20 min. and then cooled to room temperature. The bottles were stored at 4-7˚C till further use.

***Chapatti* preparation:** Unleavened flat bread or *chapatti* was prepared following the procedure described by Austin and Ram (1971). Processed *Jamun* pulp was blended with the whole wheat flour (50g) at the levels of 5, 10 and 15% and mixed with desired quantity of water. The water required to form viscoelastic dough was reported as water absorption (%). Manual kneading was done for 2.5 minutes for dough development and dough was rested for 30 min. at 30˚C and 85 % RH (relative humidity). Dough was divided into four equal parts and rounded manually followed by sheeting/ rolling on smooth surface to obtain circular *chapattis* of 15 cm in diameter. The raw *chapatti* was immediately placed on an open hot girdle and baked on one side and then inverted and baked on the other side followed by final baking on the first side. Final product was optimized on the basis of quality (puffiness and stickiness) and sensory evaluation score for different attributes.

Quality evaluation of *chapatti*: Comparative evaluation of cooled *chapattis* was done by observing stickiness, puffing and sensory quality (Dar *et al*., 2014). Dough handling characteristics such as non-sticky, sticky, slightly sticky and very sticky parameters along with puffing characteristics of *chapatti* such as full, partial and nil were observed during *chapatti* making.

Sensory evaluation: *Jamun* supplemented *chapattis* were evaluated for sensory attributes (appearance, colour, flavour, texture and overall acceptability) using 9- point hedonic scale (Larmond, 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, Punjab Agricultural University, Ludhiana were selected to evaluate the sensory properties of *chapattis*.

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 ranges from −100 (greenness) to +100 (redness), the b^* value ranges from −100 (blueness) to +100 (yellowness), whereas the L^* value, indicating the measure of lightness, ranges from 0 (black) to 100 (white) (Hutchings, 1999). Hue angle was calculated using the formula $\tan^{-1} b^*/a^*$.

Texture analysis: The texture of *chapatti* was analyzed using Texture Analyzer (Stable Micro Systems, Model TA-HDi, UK). Strips measuring 4 cm × 2 cm were cut from each *chapatti*. One strip at a time was placed on the centre of the sample holder and the Warner wratzler blade was allowed to cut the *chapatti* strip. The force (N) required to cut *chapatti* strip into two pieces was recorded. The speed was maintained at 1.70 mm/s (Dar *et al*., 2014).

Proximate composition: Fresh *Jamun* fruit and processed *Jamun* pulp was evaluated for total solids and ash (AOAC, 2000). Total sugars and reducing sugars were estimated using Lane and Eynon method (AOAC, 2000). Crude fibre of prepared *chapattis* was estimated using Fibertec (FOSS) (AACC, 2000).

Bioactive composition: Ascorbic acid has been determined using direct colorimetric method (Ranganna, 1997) and expressed as mg/100g. The samples were analyzed for total anthocyanins content by spectrophotometric method (Srivastava and Kumar, 1994) and expressed as mg/100g.Total phenolic content was determined according to Folin-Ciocalteu spectrophotometric method (Gao *et al*., 2002). Sample (5 g) was mixed with 80% methanol (50ml) and refluxed for 2hours. Aliquot was (0.2ml) was added to 0.8ml of distilled water. Thereafter, 5 ml of fresh Folin- Ciocalteu reagent (10 fold dilution) was added and the mixture was allowed to equilibrate for 8 minutes followed by addition of 4 ml saturated sodium carbonate solution. The mixture was incubated in dark at room temperature for 60 minutes, the absorbance of the mixture was then observed at 765nm (Spectronic 20, Bausch & Lomb, USA). The results were expressed as mg GAE/100g by taking gallic acid as reference material to construct standard curve.

Antioxidant activity: Antioxidant activity was determined by DPPH (2, 2 di phenyl picryl hydrazyl) method according to Brand-Williams *et al.* (1995) with some modifications. Briefly, samples (5 g) were extracted with 80% methanol for 2 hrs and filtered; aliquot collected and made volume to 100ml with 80% methanol. The assay contained 2 ml of sample aliquot, 2 ml of tris HCl buffer (pH 7.4) and 4 ml of 0.1mM 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). Antioxidant activity was calculated according to following formula.

Antioxidant activity (%) = Control Absorbance (0 min) – Sample Absorbance (30 min) × 100 / Control Absorbance (0 min)

Statistical analysis : The results were expressed as mean ± standard deviation (SD) (n=3). Data were analyzed by student's t-test for fresh and processed *Jamun* pulp and data collected from *Jamun* pulp supplemented *chapattis* were subjected to variance (ANOVA) analysis and their comparison were done through Duncan's multiple range test with $p \leq 0.05$significance level on SPSS 18.0 statistical software (SPSS Inc.).

RESULTS AND DISCUSSION

Bioactive composition of fresh *Jamun* and processed *Jamun* pulp: The bioactive composition of fresh *Jamun* and processed *Jamun* pulp are given in table 1.

The results revealed ascorbic acid content 21.77 mg/100 g for fresh *Jamun* and 18.29 mg/100 g for processed *Jamun* pulp. Ascorbic acid is a reducing agent and is vulnerable to light induced oxidation in addition to thermal degradation that may have occurred during processing of *Jamun* pulp. The anthocyanin content of fresh *Jamun* and processed *Jamun* pulp was found as 126.54 mg/100g and 112.56 mg/100g (Table 1). Chowdhury and Ray (2007) depicted 140 mg/100g anthocyanins in *Jamun* fruit. Temperature is one of the factors that affect the stability of anthocyanins and degradation of anthocyanins occurs with increase in temperatures (Kopjar *et al*., 2009). Total phenolic content of processed *Jamun* pulp was noted to be slightly lower than fresh fruit (Table 1). Fresh *Jamun* had 91.83% antioxidant activity and processed *Jamun* pulp was found to have 88.68% antioxidant activity. The results of our study corroborates with Ali *et al*. (2013) who reported 85.22% of free radical scavenging capacity in *Jamun* pulp. Processing altered the antioxidant activity of fresh *Jamun* which may be due to degradation of ascorbic acid, anthocyanins and phenolic compounds on processing.

Physico-chemical composition of fresh *Jamun* and processed *Jamun* pulp: Physico-chemical composition of fresh *Jamun* and processed *Jamun* pulp is depicted in fig. 1. Total soluble solids for fresh *Jamun* fruit was 10.2˚B and for processed *Jamun* pulp it was 11.9 ˚B. Total solids of fresh and processed *Jamun* pulp that comprised mainly of reducing and total sugars, acids, crude fibre, protein and ash were found to be 12.62% and 13.37 %, respectively. Increased total solids of processed *Jamun* pulp compared to fresh *Jamun* fruit may be due to concentration of pulp during processing. Total sugar values correspond to 16.92% and 15.33%, respectively for fresh *Jamun* and processed *Jamun* pulp. The results are in line with Joshi *et al*. (2012) who reported 12.44% of total sugars in *Jamun* fruit. Crude fiber and ash content of fresh *Jamun* was found to be 0.86% and 0.32%, respectively. Similarly, for processed pulp it was 0.64% and 0.27%, respectively. An appropriate amount of crude protein content in fresh *Jamun* fruit and processed *Jamun* pulp was observed as 0.87 and 0.84 %, respectively. Shahnawaz *et al*. (2009) reported slightly lower values of protein (0.72%) for freshly extracted *Jamun* pulp. The difference may be due to different cultivars.

Quality assessment: Qualitative characteristics of *chapatti* supplemented with *Jamun* pulp at 5, 10 and 15% levels have been tabulated in table 2. Statistically significant ($p \leq 0.05$) variation was observed for water absorption of unsupplemented and supplemented whole wheat flour. Water absorption of control whole wheat flour for dough making was 66.29%. Less water was required for dough development with increase in supplementation level of pulp from 5 to 15%.

Dough handling characteristics of *Jamun* pulp supplemented *chapatti* did not show significant variation, however, dough at 15% supplementation level showed slightly sticky behaviour than control, 5 and 10% supplementation level. Puffing is one of the most desired quality characteristics of *chapatti* and influences the consumer acceptability. Control and supplemented *chapattis* exhibited full puffing. Significant ($p \leq 0.05$) differences were established among the appearance, colour, flavour and overall acceptability scores that are listed in Table 2 whereas, non-significant effect of different supplementation levels on texture was observed. Sensory evaluation studies reported highest overall acceptability scores for 10% *Jamun* pulp supplemented *chapatti* mainly on the basis of appearance and flavour. *Jamun* supplemented *chapattis* at 5 and 15% were also highly acceptable.

Colour and texture analysis: The colour and texture values of *Jamun* supplemented *chapattis* have been elucidated in table 3. Statistically significant ($p \leq 0.05$) difference was observed in L* (Lightness) value of

Table 1. Bioactive composition of fresh *Jamun* and processed *Jamun* pulp.

Parameters	Ascorbic acid (mg/100g)	Anthocyanin (mg/100g)	Total phenols (mg GAE/100g)	Antioxidant activity (%)
Jamun fruit	$21.77^{a}\pm0.25$	$126.54^{a}\pm0.67$	$2250.91^{a}\pm0.55$	$91.83^{a}\pm0.57$
Processed *Jamun* pulp	$18.29^{b}\pm0.36$	$112.56^{b}\pm0.62$	$2158.89^{b}\pm0.64$	$88.68^{b}\pm0.51$

GAE: Gallic acid equivalent; means with different letters in the same column are significantly different ($p \leq 0.05$).

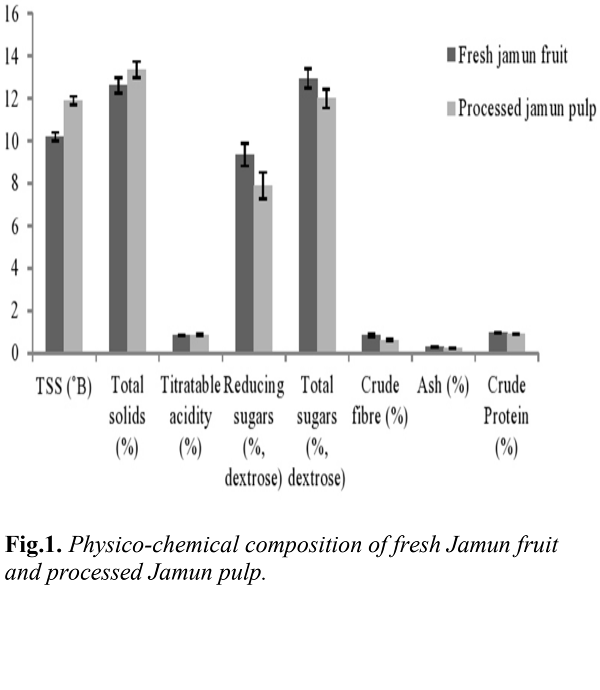

Fig.1. *Physico-chemical composition of fresh Jamun fruit and processed Jamun pulp.*

Table 2. Quality evaluation of *Jamun* supplemented *Indian chapatti*.

Supplementation (%)	Water absorption (%)	Dough handling	Puffing	Appearance	Colour	Flavour	Texture	Overall acceptability
Control	$66.29^{a}\pm0.34$	NS	FP	$8.1^{b}\pm0.22$	$8.2^{b}\pm0.27$	$8.1^{b}\pm0.22$	$8.1^{a}\pm0.22$	$8.12^{b}\pm0.17$
5	$63.18^{b}\pm0.21$	NS	FP	$8.2^{b}\pm0.27$	$8.3^{ab}\pm0.27$	$8.2^{b}\pm0.27$	$8.2^{a}\pm0.27$	$8.22^{b}\pm0.10$
10	$60.70^{c}\pm0.29$	NS	FP	$8.8^{a}\pm0.27$	$8.6^{a}\pm0.22$	$8.6^{a}\pm0.41$	$8.3^{a}\pm0.27$	$8.57^{a}\pm0.16$
15	$54.42^{d}\pm0.27$	SS	FP	$8.1^{b}\pm0.41$	$8.1^{b}\pm0.22$	$7.9^{b}\pm0.22$	$8.1^{a}\pm0.22$	$8.04^{b}\pm0.18$

NS- Non sticky, SS- Slightly sticky, FP- Full puffing; means with different letters in the same column are significantly different ($p\leq0.05$).

Jamun supplemented *chapattis*. L* value lowered with increasing supplementation levels resulting in darker *chapattis*. L* values of control *chapatti* was found to be 74.76 and for 5, 10 and 15 % supplementation level it was found to be 70.79, 68.95 and 67.45, respectively leading to decreased brightness with increasing supplementation levels. The data in Table 3 depicts that a* (Redness) value increased with increase in *Jamun* supplementation level in *chapatti*. The b* (Blueness) value reduced gradually from 16.14 at 0% supplementation level to 14.25 at 15% supplementation level with increasing supplementation level indicating an increase in blueness of supplemented samples that might be due to increase in anthocyanin content in increasing supplementation levels of *Jamun* pulp. The results are in agreement with the study of Camire *et al.* (2007) where the authors reported lowest L* and b* values (darker and more blue) in breakfast cereal supplemented with blueberry fruit powder and highest a* value in red raspberry powder incorporated breakfast cereal indicating positive correlation between anthocyanin content and a* values and negative correlation between anthocyanins and L*, b* values. Similarly hue angle reduced with increasing supplementation levels from 80.11 at 0% supplementation level to 71.60 at 15% supplementation level. Total anthocyanins were found to have correlation with L* (r^2 = -0.83), a* (r^2 = 0.63) and hue angle (r^2 = -0.74) as lower anthocyanin content resulted in lower degree of redness and higher L* and colour hue values (Cliff *et al.*, 2007) in different varieties of red wine.

Textural studies of *chapattis* signify texture of the *chapattis* and it stimulates the biting action of the human teeth on *chapattis* (Sidhu *et al.*, 1988). Significant ($p>0.05$) effect of *Jamun* pulp supplementation levels on cutting force of *chapattis* was found (Table 3). Minimum cutting force was required for 15% *Jamun* pulp supplemented *chapatti* (0.25 kg) and maximum was required for control *chapatti* (0.31 kg) depicting increase in softness of *chapattis* with increasing supplementation levels. Cutting force of 5% and 10% *Jamun* pulp supplemented *chapatti* was found to be 0.29 and 0.27 kg, respectively.

Bioactive and physico-chemical composition of *Jamun* supplemented *chapatti*

Physico-chemical composition: Physico-chemical composition of *Jamun* pulp supplemented *chapatti* is depicted in Table 4. Supplemented *chapatti* at 5% level did not differ significantly ($p>0.05$) from control for moisture content but at 10 % level significant ($p\leq0.05$) effect was found. Moisture content of *chapatti* was 34.99% at 0% supplementation levels and in the range of 35.07- 35.55% at 5-15% level. The increase in moisture content may be due to presence of fruit fibres in *Jamun* pulp, as these fibres are reported to contain more pectin and have a higher water binding capacity than those of the cereal and legume fibres (Chen *et al.*, 1984). Protein content did not differ much with

Table 3. Colour and texture (kg) of *Jamun* supplemented *Indian chapatti.*

Supplementation level	Lightness (L*)	Redness (a*)	Blueness (b*)	Hue angle (°)	Cutting force
Control	74.76^{a} ± 0.72	2.81^{b} ± 0.30	16.14^{a} ± 0.28	80.11^{a} ± 1.21	0.31^{a}±0.01
5%	70.79^{b} ± 0.76	4.38^{a} ± 0.37	16.01^{a} ± 0.22	74.69^{b} ± 1.43	0.29^{ab}±0.00
10%	68.95^{c} ± 0.82	4.61^{a} ± 0.26	15.05^{b} ± 0.18	72.97^{bc}± 0.71	0.27^{bc}±0.01
15%	67.45^{d} ± 0.63	4.74^{a} ± 0.28	14.25^{c} ± 0.25	71.60^{c} ± 0.71	0.25^{c}±0.01

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

Table 4. Physico-chemical characteristics of *Jamun* supplemented *Indian chapatti.*

Supplementation (%)	Moisture (%)	Protein (%)	Ash (%)	Crude fibre (%)	Fat (%)
Control	34.99^{c} ± 0.10	11.98^{a} ± 0.09	1.45^{a} ± 0.03	1.67^{c} ± 0.02	1.30^{a}± 0.03
5	35.07^{c} ± 0.07	11.88^{b} ± 0.03	1.47^{a} ± 0.06	1.78^{b} ± 0.06	1.28^{a} ± 0.03
10	35.31^{b} ± 0.04	11.74^{c} ± 0.01	1.49^{a} ± 0.02	1.83^{ab} ± 0.05	1.28^{a} ± 0.01
15	35.55^{a} ± 0.13	11.66^{c} ± 0.04	1.53^{a} ± 0.03	1.90^{a} ± 0.03	1.27^{a} ± 0.03

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

Table 5. Bioactive composition of *Jamun* supplemented *Indian chapatti.*

Supplementation (%)	Anthocyanin (mg/100g)	Total phenols (mg GAE/100g)	Antioxidant activity (%)
Control	nd	68.03^{d} ± 0.51	56.59^{d} ± 0.55
5	1.41^{c} ± 0.10	76.09^{c} ± 0.42	68.80^{c} ± 0.56
10	2.30^{b} ± 0.07	91.67^{b} ± 0.38	74.98^{b} ± 0.64
15	2.64^{a} ± 0.07	135.88^{a} ± 0.61	81.71^{a} ± 0.63

nd: not detected; means with different letters on the same column are significantly different ($p \leq 0.05$).

increasing supplementation level but had significant effect. Control *chapattis* had protein content of 11.98% and in supplemented *chapattis* it was 11.88, 11.74 and 11.66% at 5, 10 and 15% level, respectively. Paucean and Man (2014) incorporated pumpkin pulp in wheat bread at concentrations of 15, 30 and 50% reported decrease in protein content of wheat bread with increase in supplementation level of pumpkin pulp. *Jamun* pulp significantly ($p \leq 0.05$) enhanced the fibre content of supplemented *chapattis*. Control *chapatti* was found to have 1.67% crude fibre which increased to 1.90% at 15 % supplementation level. There was non-significant ($p > 0.05$) effect of supplementation levels on ash and fat content of *Jamun* pulp supplemented *chapattis*. Kulkarni and Joshi (2013) replaced 2.5% of refined wheat flour with pumpkin powder in the biscuit and reported higher crude fibre and ash content in the optimized product over control samples whereas fat content remained same in both the samples.

Bioactive composition: The bioactive profile of control and *Jamun* pulp supplemented *chapattis* is detailed in table 5. Anthocyanin content increased linearly from 1.41mg/100g at 5% to 2.64mg/100g at 15% level. Similar trend was found for total phenolics that were found to be highest in 15% *Jamun* pulp supplemented *chapatti* (135.88mg GAE/100g) and control *chapatti* had 68.03mg GAE/100g total phenols. The higher value of total phenols in supplemented *chapattis* compared to control *chapatti* may be due to addition of anthocyanins from *Jamun* pulp into *chapattis*. Estimation of antioxidant activity revealed that 15% *Jamun* supplemented *chapatti* had highest antioxidant activity (81.71%) followed by 10%, 5% and control *chapatti*. A positive correlation coefficient ($r = 0.989$, $p < 0.01$) was observed between anthocyanins and antioxidant activity (Fig. 2) and also between total phenolic content and antioxidant activity ($r = 0.877$, $p < 0.01$) (Fig. 3) that shows that phenolic compounds and anthocyanins might be the main components responsible for antioxidant activity of *Jamun* pulp supplemented *chapattis*. Jakobek *et al.* (2007) also found positive correlation of total phenolic content with antioxidant activities ($r = 0.97$, $p < 0.01$) of red fruit juices rich in anthocyanins. Sonawane *et al.* (2013) reported that incorporation of 3% *Jamun* powder in milk *kulfi* increased total phenolic content, anthocyanin and antioxidant activity (DPPH) by 78.68, 100 and 91.22%, respectively. Thus, supplementation of *Jamun* powder in whole wheat flour showed value addition in the *chapattis* with respect to increased phenolic content and antioxidant activity.

Conclusion

Incorporation of *Jamun* (*S. cumini* L.) pulp in whole wheat flour enhanced anthocyanin, total phenolics and antioxidant activity of *Indian chapatti* with increasing supplementation level. Colour characteristics of *chapatti*

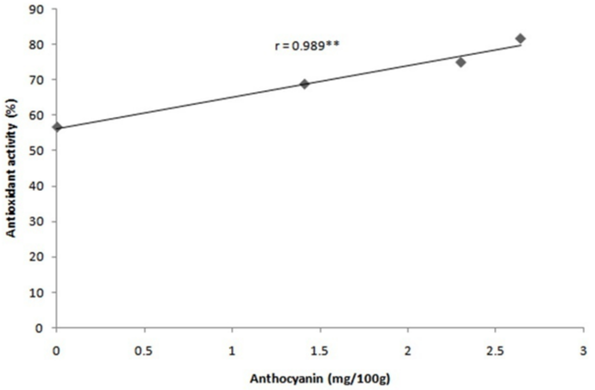

Fig. 2. *Correlation plots between total anthocyanins and antioxidant activity of Jamun pulp supplemented chapattis. The correlation coefficients (r) are marked in each plot; significant correlations are marked with asterik (**= significance at p≤0.01).*

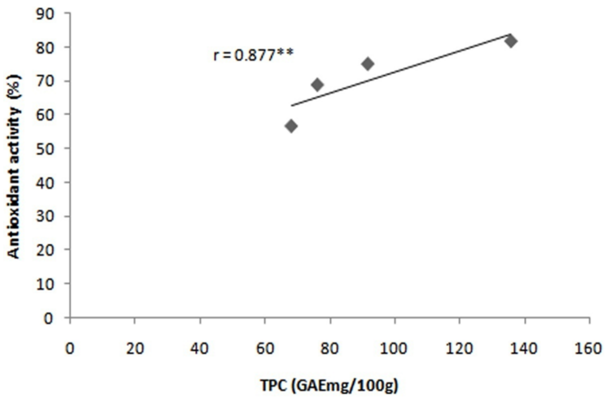

Fig. 3. *Correlation plots between total phenolic content (TPC) and antioxidant activity of Jamun pulp supplemented chapattis. The correlation coefficients (r) are marked in each plot; significant correlations are marked with asterik (**= significance at p≤0.01).*

were affected by increasing levels of supplementation. *Jamun* pulp in whole wheat flour help improved texture of *chapattis*. Moreover, fibre content also increased in supplemented *chapattis* with increasing levels. The sensory attributes showed that 5, 10 and 15% *Jamun* pulp supplemented *chapattis* were acceptable, however, 10% received highest overall acceptability scores. Thus, potential use of *Jamun* pulp in whole wheat flour can be successfully done to improve functional and bioactive properties of the *chapattis*. The future possibilities can be to combine antioxidant rich fruits with cereal products in order to achieve well balanced antioxidant rich foods.

ACKNOWLEDGMENTS

Ministry of Science and Technology (Department of Science and Technology), Government of India, New Delhi is acknowledged for rendering the financial support under INSPIRE (DST/INSPIRE Fellowship/2012, 292) Programme to carry out the present work.

REFERENCES

AACC (2000). Approved Methods. American Association of Cereal Chemist, 10th ed. AACC, St. Paul Minnesota, USA.

Ali, S., Masud, T., Abbasi, K.S., Ali, A. and Hussain, A. (2013). Some compositional and biochemical attributes of *jaman* fruit (*Syzygium cumini* L.) from Potowar region of Pakistan. *Res. Pharm*., 3: 1-9.

AOAC (2000). Official Methods of Analysis, Association of Official Analytical Chemists, Gaithersburg, Maryland, USA.

Austin, A. and Ram, A. (1971). Studies on *chapatti* making quality of wheat: Tech Bull 31. Indian Council of Agricultural Research, New Delhi, pp 108.

Brand-Williams, W., Cuvelier, M.E. and Berset, C. (1995). Use of a free radical method to evaluate antioxidant activity. *LWT-Food Sci.Technol*., 28: 25-30.

Camire, M.E., Dougherty, M.P. and Briggs, J.L. (2007). Functionality of fruit powders in extruded corn breakfast cereals. *Food Chem*., 101: 765-770.

Chattopadhyay, P., Chatterjee, S. and Sen, S.K. (2008). Biotechnological potentials of natural food grade colourants. *Afr. J. Biotechnol*., 7: 2972-2985.

Chen, J.Y., Piva, M. and Labuza, T.P. (1984). Evaluation of water binding capacity (WBC) of food fibre sources. *J. Food Sci*., 49: 59–63.

Chowdhury, P. and Ray, R.C. (2007). Fermentation of *Jamun* (*Syzgium cumini* L.) fruits to form red wine. *ASEAN Food J*., 14: 15-23.

Cliff, M.A., King, M.C. and Schlosser, J. (2007). Anthocyanin, phenolic composition, colour measurement and sensory analysis of BC commercial red wines. *Food Res. Int*., 40: 92-100.

D'Mello, P.M., Jadhav, M.A. and Jolly, C.I. (2000). Free radical scavenging activity of *Syzygium cumini* and *ficus bengalensis*- Plants used in *Ayurveda* for diabetes mellitus. *Indian Drugs*, 37: 518-520.

Dar, B.N., Sharma, S., Singh, B. and Kaur, G. (2014). Quality assessment and Physico-chemical characteristics of bran enriched chapattis. *Int. J. Food Sci*., 2014: 1-6.

Francis, D. and Phelps, S.K. (2003). Fruit and Vegetable juice powders add value to cereal products. *Cereal Foods World,* 48: 244-246.

Gao, L., Wang, S., Oomah, B.D. and Mazza, G. (2002). Antioxidant activity of wheat millstreams. Wheat quality elucidation, St. Paul, MN: AACC International.

Hutchings, J.B. (1999). Food Color and Appearance, Springer, Windsor, CT.

Jakobek, L., Seruga, M., Medvidovic-Kosanovic, M. and Novak, I. (2007). Anthocyanin content and antioxidant activities of various red fruit juices. *Dtsch. Lebensm. Rundsch*., 103: 58–64.

Joshi, V.K., Sharma, R., Girdher, A. and Abrol, G.S. (2012). Effect of dilution and maturation on physico-chemical and sensory quality of *Jamun* (Black plum) wine. *Indian J. Nat. Prod. Resour*., 3: 222-227.

Kadam, M.L., Salve, R.V., Mehrajfatema, Z.M. and More, S.G. (2012). Development and evaluation of composite flour for *missi roti* /*chapatti*. *J. Food Process. Technol*., 3: 1-7.

Kopjar, M., Pilizota, V., Subaric, D. and Babic, J. (2009). Prevention of thermal degradation of red currant juice anthocyanins by phenolic compounds addition. *Croat.*

J. Food Sci. Technol., 1: 24-30.

Kulkarni, A.S. and Joshi, D.C. (2013). Effect of replacement of wheat flour with pumpkin powder on textural and sensory qualities of biscuit. *Int. Food Res. J*., 20: 587-591.

Larmond, E. (1970). Methods of Sensory Evaluation of Food, 2nd Ed. Food Research Institute, Canada Department of Agriculture, Ottawa.

Paucean, A. and Man, S. (2014). Physico-chemical and sensory evaluation of wheat bread with pumpkin (*Cucurbita maxima*) pulp incorporated. *J. Agroaliment. Proc. Technol*., 20: 26-32.

Ranganna, S. (1997). Handbook of analysis and quality control for fruit and vegetable products, 2nd Ed. Tata McGraw Hills Publ Co. Ltd. New Delhi.

Sagrawat, H., Mann, A. and Kharya, M. (2006). Pharmacological Potential of *Eugenia Jambolana*: A Review. *Pharmaco-genesis Magazice*, 2: 96-104.

Shahnawaz, M., Sheikh, S.A. and Nizamani, S.M. (2009). Determination of Nutritive Values of *Jamun* Fruit *(Eugenia jambolana)* Products. *Pak. J. Nutr.*, 8: 1275 -1280.

Sharma, S., Mehta, B.K., Mehta, D., Nagar, H. and Mishra, A. (2012). A review on pharmacological activity of *Syzygium cumini* extracts using different solvent and their effective doses. *Int. Res. J. Pharm*., 3: 54-58.

Sidhu, J.S., Seibel, W. and Brummer, J.M. (1988). Measurement of *Chapatti* texture using wick universal testing machine. *Food Sci. Technol*., 21: 147–152.

Sonawane, S.K., Arya, S.S. and Gaikwad, S. (2013). Use of *jambhul* powder in the development of bioactive components enriched milk *kulfi*. *J. Microbiol. Biotechnol. Food Sci*., 2: 2440-2443.