RESEARCH ARTICLE

Studies on the preparation of antioxidant rich ber (*Zizyphus mauritiana* Lamk.) powder burfi with coconut sugar as natural sweetener

Sonika Pandey and Amrita Poonia

Received: 18 May 2019 / Accepted: 23 November 2019 / Published online: 27 February 2020
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Abstract: Efforts were made to formulate an antioxidant rich, low sugar burfi. The burfi was enriched with different levels of ber fruit powder (5%, 10% and 15% w/w) and coconut sugar (28% w/w). Sensory scores revealed that burfi with 10% ber powder had highest overall acceptability. The optimized ber powder burfi was compared with market samples and control burfi and the physicochemical property, antioxidant activity and total phenolic content varied significantly ($P < 0.05$). Addition of ber powder significantly ($P < 0.05$) increased iron content, vitamin C content, antioxidant activity and total phenolic content of optimized burfi followed by the effect of coconut sugar incorporation. The addition of coconut sugar showed significant ($P < 0.05$) decrease in total sugar content. From the study, it was concluded that the incorporation of ber powder and coconut sugar was a great success and will be helpful for developing other value added dairy confectioneries.

Keywords: Antioxidant activity, Ber powder, Coconut sugar, Burfi, Vitamin C

Introduction

Ber (*Zizyphus mauritiana* Lamk.) is a very old fruit of India. It is also commonly called as Jujube around the world. It is an underutilized fruit in India. Ber comes from the genus *Zizyphus* of the family Rhamnaceae. The most common cultivated species of

ber fruit are *Zizyphus jujuba* and *Zizyphus mauritiana*. *Zizyphus mauritiana* is commonly grown all over the northwest of India and in the arid parts of South India (Azam et al. 2001; Kumar et al. 2011). It is called as the king of arid zone fruits (Yamadagni 1985). Ber fruits are good source of vitamin C, total phenolics ranging from 19.54 to 99.49 mg/100g and 172 to 328.6 mgGAE/100g, respectively (Koley et al. 2011). They are rich in minerals like calcium, phosphorus and iron (Yamadagni 1985; Shoba and Bharathi 2007). The major phenolics reported are caffeic acid, p-hydroxybenzoic acid, ferulic acid and p-coumaric acid (Tanmay et al. 2011; Memon et al. 2012) which justifies for its significant antioxidant activity (Krishna and Parashar 2012).

Ber fruit is seasonal as well as nutritious, so it needs to be preserved. However, the techniques to be used for preservation must sustain or improve their nutritional quality (Hsu et al. 2003). Out of the numerous processing techniques, spray drying was found to be most suitable. It is a technique useful for increasing the shelf life of the fruit. The spray drying process can form good quality powder with less water activity so that it can be easy to store and transport. The most common carrier agent used for fruit juices are maltodextrins (Cano-Chuca et al. 2005).

Coconut sugar is a natural sweetener with wonderful taste and nutritional content. It is however, less known to people. Coconut sap is converted to coconut sugar and is becoming popular worldwide because it is natural, minimally processed and healthy. One of the most important health claims is its glycemic index (GI). Foods with low GI are vital for diabetes, obesity, heart disease and hypertension (Jenkins et al. 1981). A research published that the GI of coconut sap sugar was reported to be 35, i.e. in low category (Trinidad et al. 2010). Coconut sugar consists of minerals such as iron, zinc, calcium, phosphorus, magnesium and potassium, accompanied by some short chain fatty acids. It is also good in vitamins such as vitamin C and vitamin B complex, polyphenols, antioxidants, dietary fibre and inulin (Hebbbar et al. 2015; Secretaria et al. 2007).

Burfi is one of the most popular khoa based milk product appreciated all over India. It is prepared by evaporating milk in an open pan to obtain a semi-solid product called khoa (BIS 1970).

Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221 005 Uttar Pradesh, India

Amrita Poonia (✉)

Department of Dairy Science and Food Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, 221 005 Uttar Pradesh, India

E-mail: dramritapoonia@gmail.com, Mobile: +91 9532030058

There are many types of burfi present in market viz. simple, mawa, fruit, cashewnut, almond, besan, khajoor etc. Due to its attractiveness and wide acceptance throughout India, many forms of burfi with numerous ingredients and flavours have been developed. Inventive researches are being done with burfi like herbal burfi prepared by Goyal and Shamsher (2015), Prasad et al. (2017), burfi with essential oil formulated by Prasad et al. (2018) and aloe-verapeda by Srikanth et al. (2017).

Keeping the above points in mind, the study was aimed to formulate a value-added product with high nutritional content, good antioxidant properties and low sugar content. Looking to the functional, nutritional and low sugar aspect, ber fruit powder and coconut sugar was found to be suitable for incorporation in milk based product, burfi. Hence, our present investigation was undertaken with the objective of evaluating the best ber powder burfi and the effect of incorporation of spray dried ber powder and coconut sugar on various physicochemical and antioxidant attributes of burfi samples.

Materials and Methods

Materials

Full cream milk and coconut sugar were purchased from the local market of Varanasi, India. Ber fruits were acquired from horticultural farm of Banaras Hindu University, Varanasi and the cultivar was identified by the experts of the Department of Horticulture. They identified the cultivar as Banarsi Karaka. All chemicals were obtained from Hi-media Laboratories Limited, Mumbai, India.

Production of ber fruit powder

The flowchart of the whole process is given in Figure 1. The process conditions (Inlet air temperature and maltodextrin concentration) were optimized by Response Surface Methodology using Minitab 17.1.0 software to get the finest quality of ber fruit powder. The slurry was spray dried in a lab-scale spray dryer (Model: Spray Mate - JISL Instruments Private Limited, Mumbai, India) with an inlet air temperature of 166.21°C, outlet air temperature of 80 °C, feed rate of 18 rpm, air pressure of 2 kg/cm² and aspirator speed of 1250 rpm. The spray dried fruit juice powder was collected at the bottom of the cyclone jar. The samples were then transferred to aluminium laminated polyethylene packages of size 12 cm x 9 cm and sealed immediately.

Preparation of ber burfi

The buffalo milk was standardized to 6% fat and 9% SNF. Milk was concentrated in an open karahi (pan) at boiling temperature with continuous stirring and scraping till the final stage of semi-solid consistency (khoa) is reached. The coconut sugar was added @ 28% in the burfi. The temperature was further lowered to 88-90

°C and selected levels of spray dried ber powder (0, 5, 10 and 15%) were added. Finally, this mixture was heated at low temperature with slow stirring till the desired consistency of ber powder burfi was obtained. This mixture was then spread uniformly in a tray and allowed to cool. After it has been settled, pieces of rectangular blocks were cut by knives.

The proportions of ingredients produced by the levels of ber powder addition, were considered as treatments as given below.

Treatment details:

T₀ (Control)= 0% ber powder + 100% of khoa by weight

T₁ = 5% ber powder + 95% of khoa by weight

T₂ = 10% ber powder + 90% of khoa by weight

T₃ = 15% ber powder + 85% of khoa by weight

Sensory evaluation

The sensory attributes of ber powder burfi were analyzed for colour and appearance, body and texture, flavour, sweetness and overall acceptability by a semi-trained panel of judges consisting of ten members selected from the Centre of Food Science and Technology, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India. To minimize the variances, the panellists were made familiar with the quality attributes and the flaws generally associated with burfi under study. The attributes were evaluated on the basis of 9-point hedonic scale.

Colour analysis

The colour of ber powder burfi was measured in terms of the CIE L*, a*, b* values using Color Flex EZ spectrophotometer. L* represents the lightness (L*=0 for black and L*=100 for white), a* indicates red (+) to green (−) axis, and b* represents yellow (+) to blue (−) axis (Duangmal et al. 2008).

Texture analysis

Texture profile analysis on ber powder burfi samples was performed by using the texture analyser TA.XT plus, Exponent Lite (Stable Micro Systems, Surrey, UK). A 75mm compression platen was used under 50 kg load cell. Burfi samples were cut into 1 cm³ cubes and subjected to a dual bite compression force by probe upto a 5.00mm distance at 1.0 mm/s test speed.

Proximate analysis

Moisture, fat, protein, ash, acidity, total solids, total sugar, iron and vitamin C were analyzed in ber powder burfi sample and spray dried ber fruit powder by following the AOAC (2000) methods.

Fig. 1 Process flowchart of ber fruit powder production

Free radical scavenging activity

The free radical scavenging activity was determined by using DPPH assay (Brand-Williams et al. 1995). A 3.9 mL aliquot of a 0.0634mM of DPPH solution, in methanol (95%) was added to 0.1 mL of methanolic burfi sample extract or ber powder sample extract and shaken. The samples were kept in the dark room for 30 minutes after which absorbance was recorded at 515nm. The percentage inhibition of DPPH was calculated by the following formula: %inhibition = $100 \times (A_0 - A)/A_0$ where A_0 was the control absorbance at 515 nm and A was the final absorbance of the sample extract at 515 nm. Methanol (95%) was used as a blank.

Total phenolic content

Total phenolic content was evaluated by Folin–Ciocalteu method defined by Liu et al. (2008) with some modifications. 60 µL of burfi extract or ber powder extract, 300 µL of Folin–Ciocalteu reagent and after 3 minutes 750 µL of 20% sodium carbonate in water were added in 4.75 mL of water. The mixture was kept for about 30 minutes. The absorbance was then recorded at 765nm. For blank preparation, 60µL of distilled water was taken instead of sample. Total phenol content of sample was calculated using equation of standard curve and the results are expressed as mg of GAE.

Statistical analysis

The data acquired from various experiments were recorded as mean $\pm$ standard deviation (SD). Data was statistically analyzed using one way analysis of variance (ANOVA) followed by Tukey's comparison test to find the significant differences among the mean values at 95% level of confidence using Minitab software ver. 17.0.1.

Results and Discussion

The results of sensory attributes, colour values and instrumental textural profile were discussed for different burfi samples (T_0 , T_1 , T_2 and T_3). The spray dried ber powder was analyzed for proximate parameters, antioxidant activity and total phenolic content (Table 1) which will further be used for the comparative analysis.

The optimized ber powder burfi was determined on the basis of sensory evaluation. The optimized burfi was then compared with market and control burfi (Table 5). The means were compared using Tukey's Test with confidence level of 95%. The differences were indicated as superscripts.

Sensory attributes

The sensory mean score for colour and appearance of ber powder burfi varied from 7.35 to 8.57, body and texture from 7.23 to 8.66, flavour from 7.21 to 8.83, sweetness from 7.31 to 8.48 and overall acceptability from 7.41 to 8.63. It is evident from the data presented

in Table 2 that most of the samples prepared are significantly different ($P < 0.05$) from the control sample. The overall acceptability score for the ber powder burfi prepared with 10 % ber powder was found to be most satisfactory by the panelist. This optimized burfi was finally used for further analysis in the study. This shows that ber powder incorporation improved the sensory properties of the burfi samples up to 10 % level, but further increase led to the reduction of sensory score. These results are in similarity with Bankar et al. (2013) and Khapre et al. (2015), who studied the preparation of pineapple burfi and fig fruit powder burfi respectively. Kim and Lee (2012) worked on jujube (ber) powder muffins and recommended 10 % level of jujube powder with respect to overall preference score.

Colour values

The lightness, redness and yellowness values of ber powder burfi are presented in Table 3. Lightness index ranged from 44.24 to 47.34 which is a low value. This could be due to the addition of coconut sugar which has imparted brown colour to burfi. Lightness value decreased in significant manner ($P < 0.05$) and was found lowest for 15% level of incorporation due to higher percentage of ber powder. The redness-greenness index ranged from 7.28 to 8.07 and increased significantly with increased levels of powder. They yellowness-blueness index ranged from 16.25 to 17.63 and decreased significantly. Similar results were reported by Tanuja et al. (2017) in apple pomace incorporated burfi and Kim and Lee (2012) in jujube powder muffins.

Instrumental texture parameters

The measured textural parameters of the ber powder burfi samples are given in Table 4. The value of hardness ranged from 5292.76 to 7018.78 g, adhesiveness -5.05 to -80.03 g.sec, springiness 0.23 to 0.35, cohesiveness from 0.26 to 0.34, gumminess from 1438.62 to 2205.97 and chewiness from 365.05 to 764.71.

Hardness is the most assessed characteristic in determining the texture of burfi. Addition of ber powder increased the hardness of burfi significantly ($P < 0.05$). This may be due to the lower moisture content of ber powder. The result here is in agreement with walnut powder burfi (Satav et al. 2014). Similar findings were reported by Jha et al. (2014) in lalpeda.

The sensory stickiness is due to adhesiveness. The adhesiveness of ber powder burfi decreased significantly ($P < 0.05$) because of low moisture. The result was similar to that of lalpeda reported by Jha et al. (2014). Rasane et al. (2012) reported variation in adhesiveness of market samples of burfi due to different sugar levels. A higher adhesiveness value is due to higher moisture content in peda (Londhe and Pal 2008). Cohesiveness and springiness were not much affected but showed a decreasing trend. It may be attributed with the loss of moisture content and increasing total solids. Gupta et al. (1990) reported that cohesiveness of khoa decreased with increasing total solids.

Gumminess and chewiness also decreased significantly ($P<0.05$). The textural parameters were greatly influenced by the moisture content and total solids. Similar findings were reported by Tanuja et al. (2017) in apple pomace burfi.

Effect of incorporating ber powder and coconut sugar on the physicochemical parameters of burfi and its comparison with the market burfi

The moisture content of burfi samples varied from 17.65 to 21.37% (Table 5) and decreased significantly ($P<0.05$). The optimized burfi had the lowest moisture content of 17.65%. This was because of the addition of spray dried ber powder, which had less moisture (Table 1). Results are in similarity with Kim and Lee (2012). The moisture content of the control burfi is also less than market burfi, this may be due to the fiber content of coconut sugar (Trinidad et al. 2010).

The fat content of burfi samples ranged from 19.46 to 22.60% was not much influenced by the coconut sugar addition. But it is

lowest in optimized burfi i.e. 19.46%, may be because of ber powder having very minimum fat content and also due to khoa percentage has decreased.

The protein content, titratable acidity and ash content were not much affected by addition of coconut sugar powder and ranged from 13.20 to 15.48%, 0.24 to 0.36% and 2.70 to 3.14% respectively. However titratable acidity is affected by the ber powder addition and is highest in case of optimized burfi due to the acidity of ber fruit powder (Table 1). Also the protein content and ash content decreased in optimized burfi due to low percentage of khoa. Some results here are in agreement with Bankar et al. (2013) and Goyal and Shamsheer (2015) while they worked on pineapple burfi and herbal burfi, respectively.

Total solids is significantly ($P<0.05$) influenced by addition of coconut sugar due to its minerals and fiber content (Philippine Coconut Authority) (Trinidad et al. 2010). It is highest for the control burfi, 84.25% and lowest for the optimized burfi, 80.29%. The result here is in similarity with probiotic ice cream which

Table 1 Physicochemical and antioxidant composition of spray dried ber powder

Parameters	Composition
Moisture (%)	4.85±0.05
Fat (%)	0.06±0.06
Ash (%)	0.98±0.02
Acidity (% citric acid)	0.83±0.05
Total Sugar (%)	24.00±2.00
Iron (mg/100g)	12.80±0.08
Vitamin C (mg/100g)	91.62±0.32
DPPH activity (%)	90.50±2.26
Total phenolic content (mgGAE/100g)	1133.33±2.86

Values are mean ± standard deviation (n = 3)

Table 2 Mean sensory score for burfi prepared by different levels of ber powder

Level of incorporation (%)	Colour and appearance	Body and texture	Flavour	Sweetness	Overall acceptability
0 (T_0)	7.80±0.07 ^b	7.23±0.13 ^c	7.52±0.08 ^c	7.82±0.01 ^{bc}	7.58±0.10 ^c
5 (T_1)	8.11±0.19 ^b	7.51±0.07 ^d	8.03±0.06 ^b	8.30±0.17 ^{ab}	7.97±0.12 ^b
10 (T_2)	8.57±0.25 ^a	8.66±0.12 ^a	8.83±0.20 ^a	8.48±0.40 ^a	8.63±0.10 ^a
15 (T_3)	7.35±0.10 ^c	7.80±0.01 ^b	7.21±0.12 ^c	7.31±0.11 ^c	7.41±0.10 ^c

Values are mean ± standard deviation (n = 3)

Means in the same column that do not share a letter differ significantly ($P<0.05$)

Table 3 Colour values for burfi prepared by different levels of ber powder

Level of incorporation (%)	L*	a*	b*
0 (T_0)	47.34±0.10 ^a	7.28±0.08 ^c	17.63±0.08 ^a
5 (T_1)	47.09±0.02 ^b	7.47±0.08 ^c	17.24±0.12 ^b
10 (T_2)	44.38±0.01 ^c	7.80±0.10 ^b	16.25±0.02 ^c
15 (T_3)	44.24±0.04 ^c	8.07±0.03 ^a	16.35±0.05 ^c

Values are mean ± standard deviation (n = 3)

Means in the same column that do not share a letter differ significantly ($P<0.05$)

Table 4 Instrumental texture profile for burfi prepared by different levels of ber powder

Level of incorporation (%)	Hardness (g)	Adhesiveness	Springiness (g.sec)	Cohesiveness	Gumminess	Chewiness
0 (T ₀)	5292.76±2.01 ^d	-30.50±0.25 ^b	0.25±0.03 ^b	0.27±0.02 ^b	1438.62±2.01 ^d	365.05±0.05 ^d
5 (T ₁)	6546.72±3.00 ^c	-5.05±0.10 ^d	0.35±0.01 ^a	0.34±0.03 ^a	2205.97±2.01 ^a	764.71±0.03 ^a
10 (T ₂)	6812.11±2.11 ^b	-17.88±0.31 ^c	0.32±0.06 ^{ab}	0.29±0.01 ^{ab}	1987.20±1.02 ^b	635.27±0.07 ^b
15 (T ₃)	7018.78±3.00 ^a	-80.03±0.97 ^a	0.23±0.02 ^b	0.26±0.01 ^b	1851.94±0.98 ^c	425.52±0.31 ^c

Values are mean ± standard deviation (n = 3)

Means in the same column that do not share a letter differ significantly (P<0.05)

Table 5 Physicochemical and antioxidant parameters of different burfi samples

Parameters	Market burfi	Control burfi (T ₀)	Optimized burfi (T ₂)
Moisture(%)	21.37±0.06 ^a	19.42±0.04 ^b	17.65±0.01 ^c
Fat (%)	21.50±0.02 ^b	22.60±0.01 ^a	19.46±0.01 ^c
Protein (%)	15.13±0.22 ^a	15.48±0.02 ^a	13.20±0.17 ^b
Acidity (% lactic acid)	0.24±0.02 ^b	0.25±0.006 ^b	0.36±0.01 ^a
Ash (%)	3.14±0.03 ^a	3.10±0.10 ^a	2.70±0.20 ^b
Total solids (%)	82.25±0.01 ^b	84.25±0.05 ^a	80.29±0.02 ^c
Total sugar (%)	54.13±0.03 ^a	36.04±0.19 ^c	36.86±0.02 ^b
Iron (mg/100g)	0.00±0.00 ^c	2.55±0.04 ^b	5.50±0.05 ^a
Vitamin C (mg/100g)	0.00±0.03 ^c	6.80±0.11 ^b	18.98±0.19 ^a
DPPH activity (%)	6.07±0.35 ^c	15.46±0.78 ^b	40.88±0.56 ^a
Total phenolic content (mgGAE/100g)	110.27±1.30 ^c	285.32±2.01 ^b	406.72±2.09 ^a

Values are mean ± standard deviation (n = 3)

Means in the same row that do not share a letter differ significantly (P<0.05)

showed increased total solids when the concentration of coconut sugar was increased as studied by Low et al. (2015).

Total sugar concentration showed a higher significant (P<0.05) difference among the three burfi samples. Total sugar was highest for market burfi, 54.13% and lowest for the control burfi, 36.04%. The addition of coconut sugar has pointedly contributed to the above findings. It is due to reason that coconut sugar has a total sugar concentration of 23.77-71.89% and sucrose of 49.41% as studied by Phaichamnanet al.(2010) and Somawiharja et al.(2018), respectively which is relatively lesser than the refined sugar which has a sucrose level of 99.80% (USDA). Iron content is also significantly affected by the addition of both coconut powder and ber powder (Table 1) because both are iron rich, therefore enriching burfi which does not have iron in it. The iron concentration ranged from 0.00 to 5.50 mg/100g.

The vitamin C content ranged from 0 to 18.98 mg/100g. Both coconut sugar and ber powder have contributed significantly(P<0.05) to the highest content of vitamin C in optimized burfi.

The DPPH free radical scavenging activity was also influenced by coconut sugar and ber powder. It ranged from 6.07 to 40.88%. The ber powder incorporation had the maximum significant (P<0.05) effect on the free radical capacity of optimized burfi. Ber fruit powder has free radical (DPPH) capacity of 90.50% as shown

in Table 1. These findings are in resemblance with Kavitha and Kuna (2014) who formulated ber RTS beverage. Likewise, ber juice vinegar was formed and due to its high antioxidant activity it was called as functional vinegar (Vithlani and Patel 2010).

Coconut sugar also influenced the free radical capacity significantly(P<0.05). The results in the current findings are in close similarity with Low et al. (2015) who studied the antioxidant activity of probiotic ice cream by incorporating different levels of cane sugar and coconut palm sugar.

Total phenolic content of optimized burfi was significantly higher (P<0.05) as compared to market burfi and control burfi i.e. 406.72, 110.27 and 285.32 mgGAE/100g, respectively. Both coconut sugar and ber powder have influenced phenolic content. The total phenolic content and antioxidant activity are related to each other as they have hydroxyl group in their chemical structure (Tawaha et al. 2007). Results here are comparable with Victor and Orsat (2018) who studied that palm sugar has appreciable amount of antioxidant activity and total phenolic content. Also, Koley et al. (2011) reported that 12 commercial cultivars of *Z. mauritiana* are good source of ascorbic acid, total phenolics, flavonoids, and total antioxidant activity. Further, it was also observed that even though no fruit powder or polyphenolic substrate was added to market burfi, yet it showed some amount of anti-oxidative activity, viz., total phenolic content of 110.27 mgGAE/100g and DPPH inhibition of 6.07%. This could be due to association with free

sulphahydral groups and maillard browning products which were formed during preparation of khoa (Prasad et al. 2017). Similarly, Oh et al. (2013) reported maillard browning products have DPPH free radical scavenging activity.

Conclusions

Ber fruit powder is rich in vitamin C and has good antioxidant properties. With the results mentioned above, it can be concluded that the ber powder burfi with 10% level of ber powder and 28% coconut sugar was considered best. Both coconut sugar and ber powder have significantly enhanced the physicochemical properties, free radical scavenging activity and total phenolic content of burfi. Therefore, with such an outcome our attempt to formulate a value-added burfi with good antioxidant property and low sugar has been successfully attained.

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