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Nutritional composition and value added products of *Chinese ber* (*Ziziphus jujuba* Mill.) growing in Northern hill regions of India

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Present study was undertaken for assessing nutritional composition and developing different value added products from *Chinese ber* (*Ziziphus jujuba* Mill.) growing in Northern hill regions of India. Fresh fruits and processed products were analyzed for various physico-chemical, nutritional, and sensory characteristics. Fresh fruits contained 76.15-80.50 % moisture, 8.50-9.60 ^{o}B total soluble solids, 0.30-0.44 % acidity (as malic acid), and 6.80-7.20 % total sugar contents. The fruits were found to be rich in ascorbic acid (88.25-98.0 mg/100 g) and phenolic compounds (350.32-425.50 mg/100 g). Among processed products, candied *ber* contained highest total solids (89.10 %) compared to other products. Titratable acidity was maximum (2.15 %) in pickle and minimum (0.82 %) was in osmotically dried *ber*. Both osmotically dried and preserve *ber* had maximum ascorbic acid (30.15-32.50 mg/100 g). Organoleptic properties showed good score for all the products. However, highest score for taste (8.46) and flavor (8.20) was obtained by osmotically dehydrated *ber* and it was rated '*liked very much*' by the panelists compared to other products.

Keywords: *Chinese ber*, Nutraceutical properties, Osmotic dehydration, *Ziziphus jujuba* Mill.

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Introduction

The *Chinese ber* (*Zizyphus Jujuba* Mill.) belonging to the family Rhamnaceae, is also known as jujube, red date and Chinese date. It is widely cultivated in Southern Asia, between Lebanon, Iran, Pakistan, the Korea peninsula and Southern and Central China[1]. Though it can withstand wide range of temperature (below freezing to 34^{o} C), it requires a small amount of chilling to set the fruits. It is a small deciduous non-thorny tree that reaches a height of 5-10 m. The fruits are non-juicy, rich in vitamin C and eaten as dessert or dried. The fruits are also used in Chinese and Korean traditional medicine and believed to alleviate stress and act as wound healer[2]. In China, a wine is made from jujube, called *hong zao jiu*, which keep a person fresh for a long time, especially in winter[3]. Various studies made on jujube fruits and their products suggests the presence of biologically active compounds like flavonoids, vitamins, amino acids, organic acids, polysaccharides, and microelements[4,5] and have protective effects against cancer, stroke, and coronary heart diseases[6-8].

The fruits in general have low sugar content, thus not preferred as table fruit, but it has good potential for developing processed products. The quality of dried product depends upon the drying methods and pre-treatments such as blanching and sulphuring, osmosis, etc. before dehydration to improve the product quality[9-11]. Osmotic dehydration improves structure and retains large percentage of flavor volatiles of fresh fruits[12]. The fruit of *Chinese ber* as such are less suitable for pickle preparation, however, pickle with good sensory quality has been prepared by various researchers[13,14].

In India, 3 accessions of *Chinese ber* (EC27715-A, EC36768, and EC280769) were introduced from Russia and Korea and established in the field gene bank of National Bureau of Plant Genetic Resources Regional Station (NBPGR), Shimla in Himachal Pradesh (HP). Subsequently, the planting material was multiplied and distributed to different research institutes and farmers in the mid Himalayan region[2]. The trees bear heavy fruiting (Plate 1). Therefore, the present study was undertaken to assess the nutritional composition of jujube fruits and to develop different value added or functional products such as

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Plate 1—*Chinese ber* twig bearing fruits

osmotically dehydrated *ber*, preserve, candy, and pickle so as to popularize the jujube among the farmers and the industry.

Material and Methods

Raw materials

Ripe fruits were harvested from the trees established in the experimental plot of Regional Station of NBPGR at Shimla, Himachal Pradesh. The fruits were washed, packed in plastic bags, brought to laboratory and stored in refrigerator at 5-7 ^{o}C until used.

Preparation of value added products

Osmotically dehydrated ber

Ripe, firm fruits without marks or bruising were selected and dried as per standard method of Lal *et al*.[15] with some modifications. Pricking of fruit skin with stainless steel fork followed by blanching (plunging them in boiling water for 2 min), which was done to improve the uptake of sugar. Fruits were then sulphited by dipping in a solution of potassium metabisulphite (KMS) @ 0.3 % for 30 min. After this, the fruits were again washed thoroughly, drained, and submerged overnight in 60 °B sugar syrup containing 0.5 % citric acid. Next day, the fruits were removed from the syrup and drained on wire mesh trays. The fruits were then dried in mechanical dehydrator at a temperature of 55-60 ^{o}C till constant weight.

Ber preserve and candy

The preserved product made out of mature fruits is called *murabba* in India. The preserve and candy were prepared following the procedure given by Pareek[16] with some modifications. After washing and sorting the fruits, the skin was pricked with a fork. Blanching of the pricked fruits was done by plunging them into boiling water for 2 min. The softened fruits were then submerged in sugar syrup of 40 °B, whose concentration was gradually increased up to 70 ^{o}B. Citric acid (0.5 %) was added to the syrup to maintain the colour of the fruit and to reduce the pH of the syrup. For making candied ber, the pre-treated ber fruits were submerged in sugar syrup (40 °B) with slowly increasing the strength until a final concentration of 75 °B is reached.

Ber pickle

For preparation of pickle, selected fresh mature jujube fruits were weighed and washed thoroughly in cold water. The washed fruits were cut into small pieces with a stainless steel knife. The pieces were then blanched in boiling water (2 min) and air dried (10 min). Pickle was prepared as per standard method of Lal *et al*.[15] using following pre-standardized recipe:

Ber fruit pieces= 1 kg, salt= 60 g, turmeric powder= 15 g, red chilli powder= 15 g, jeera (whole)= 10 g, aniseeds= 10 g, clove (powder)= 5 g, cardamom= 5 g, ginger and garlic (grated)= 10 g each, acetic acid= 20 mL, and mustard oil= 100 mL.

The whole ingredients were mixed well and heated for 5-10 min, after which acetic acid was added and the mixture was then filled in the sterilized glass jars (500 g). Mustard oil brought to boiling and cooled to about 60 ^{o}C was added to each jar followed by storage in cool dry place.

Physico-chemical analysis

Fresh jujube fruits as well as its value added products were analyzed for different physic-chemical characteristics as per the standard methods. Random sample of 15 fruits were selected for physical parameters. The size of the selected fruits was determined by vernier calliper by measuring length and diameter. Whereas, fruit firmness, moisture, total soluble solids (TSS), titratable acidity, sugars, ascorbic acid, total phenols, crude fibers, and ash contents were estimated according to standard procedures[17,18].

Sensory evaluation fresh and value added products

Visual appearance, shape, texture and taste of the fresh jujube fruit were recorded. Whereas, sensory evaluation of the value added products was conducted by a panel of 10 semi-trained judges by using a 9-point Hedonic scale method[19]. The judges were given the coded samples of the products and were asked to evaluate on the given performa.

Statistical analysis

All the analytical parameters were recorded in triplicate and mean values with standard deviation

(SD) are presented, where applicable. Statistical analysis of data pertaining to physico-chemical parameters was carried out by completely randomised design (CRD), whereas sensory analysis by randomised block design (RBD) according to the procedure given by Cochran and Cox[20] using one factor analysis of variance (ANOVA) with the help of OPSTAT.

Results and Discussion

Proximate composition of *Chinese ber*

The proximate physico-chemical analysis of *Chinese ber* fruits given in Table 1 indicate that the fruits were ovoid and elongated in shape, weigh between 9.56-12.9 g/fruit (mean 10.90±1.43) with average pulp to stone ratio of 24.9:1. It was observed that the fruits were smooth, glossy, length varied from 15.36-34.23 mm and diameter ranged between 2.58-18.50 mm. The colour of the fruit changed from green to yellowish green with maturity and ripening, however pulp colour was greenish-white, less sweet in taste with moderate aroma. Fruit contained single stone (0.3-0.8 g) of oval to spindle shape. The firmness of fruits ranged between 18.50-23.50 lbs/in^2. Similar physical parameters of *Chinese ber* have also been reported in other studies[2,8,21].

Table 1—Physico-chemical and sensory evaluation of fruit, pulp, and seed of *Chinese ber*

Parameters	Values	
	Range	Mean*±SD
A. Physical parameters		
Weight of fruit (g)	9.56-12.9	10.90±1.43
Weight of stone (g)	0.3-0.8	0.53±0.20
Pulp (%)	92.58-96.12	94.36±1.44
Pulp: Stone ratio	24.8 : 1-26.2:1	25.3±0.63
Fruit length (mm)	15.36-34.23	27.38±8.5
Fruit diameter (mm)	2.58-18.50	11.21±6.56
Volume (cc)	9.5-20.0	15.23±4.34
Firmness (pressure), lbs/in^2	18.5-23.50	21.62±2.20
B. Visual sensory parameters		
Appearance	Fruits light green to yellowish green; flesh whitish in colour	
Texture	Smooth, glossy skinned fruits; crispy flesh; stones hard and smooth	
Shape	Fruits ovoid and elongated; stone oval to spindle	
Taste	Sub-acidic-sweet; less juicy	
C. Chemical parameters		
Moisture (%)	76.15-80.80	78.46±1.90
Total solids (%)	19.50-23.85	21.62±1.77
TSS (^{o}B)	8.50-9.60	9.1±0.45
Acidity (%, as malic acid)	0.30-0.38	0.34±0.03
Reducing sugars (%)	3.85-4.98	4.44±0.46
Total sugars (%)	6.80-7.20	7.0±0.16
Total ash (%)	0.90-1.25	1.11±0.15
Total fiber (%)	2.00-2.60	2.3±0.24
Ascorbic acid (mg/100 g)	88.25-98.0	93.58±4.03
Total phenols (mg/100 g)	388.32-425.50	406.48±15.2

*Values are in mean of three replications; SD= Standard deviation

Chinese ber is one of the most important underutilized fruit species which gives fruits with high nutritive value and health benefits. The proximate chemical and nutritional analysis of jujube fruits (Table 1) revealed that fruits contained 78.46 % average moisture content (76.15-80.50 %), 9.1 ^{o}B total soluble solids (8.50-9.60 ^{o}B) and 0.34 % titratable acidity (0.30-0.38 % as malic acid). The total sugar content varied from 6.80 to 7.20 %, whereas the reducing sugars ranged between 3.85 and 4.98 % with mean value of 7.0 and 4.44 %, respectively. The fruits were found to be very rich in ascorbic acid (88.25-98.0 mg/100 g) and also contained appreciable amount of phenolic compounds (388.32-425.50 mg/100 g). Besides, jujube fruits had good amount of minerals as evidenced by the ash content (0.90-1.25 %). The amount of fibres varied between 2.0-2.60 % with mean value of 2.40 %. The physico-chemical and nutritional characteristics of *Z. jujube* observed in the present study were in-line with the findings of other authors[8,11,22]. However, slight variations in the parameters could be due to difference in micro-climatic conditions prevailing at the growing region.

Physico-chemical and organoleptic quality of value added products

Data pertaining to physico-chemical characteristics of different value added products prepared from *Chinese ber* is presented in Table 2. All the value added products (Plate 2) differed significantly (P <0.05) for various physico-chemical attributes recorded in the present study. Highest moisture content (33.50 %) was recorded in *Chinese ber* pickle however, highest total solids (89.10 %) were found in candied *ber* compared to other products. Among different ber products, the titratable acidity ranged between 0.87 % (osmotically dehydrated) and 2.15 % (pickle). Results showed non-significant difference for titratable acidity between preserve and osmotically dried ber. Highest total sugars as well as reducing sugars (62.85 and 51.50 %) were recorded in candied *ber*, whereas minimum values were obtained in pickle (43.20 and 27.15 %), respectively (Table 2). These results are in agreement with those reported by Helmy

Table 2—Chemical quality characteristics of different value added products prepared from *Chinese ber*

Parameters	Preserve	Osmotically dried	Candy	Pickle	$CD_{0.05}$
Moisture (%)	20.75^{b}	17.50^{c}	10.90^{d}	33.50^{a}	0.25
Total solids (%)	79.25^{c}	82.50^{b}	89.10^{a}	66.50^{d}	0.28
Total soluble solids (^{o} B)	66.10^{b}	60.60^{c}	70.50^{a}	52.00^{d}	0.15
Titratable acidity (%)	0.95^{c}	0.87^{c}	1.20^{b}	2.15^{a}	0.09
Total sugars (%)	55.28^{b}	49.85^{c}	62.85^{a}	43.20^{d}	1.02
Reducing sugars (%)	40.25^{b}	37.75^{c}	51.50^{a}	27.15^{d}	0.87
Ascorbic acid (mg/100 g)	30.15^{b}	32.50^{a}	18.75^{c}	12.25^{d}	0.35

a-denotes the maximum values, d-denotes the minimum values, whereas similar letters denote non-significant difference in values for a particular parameter

Plate 2—Different value added products prepared from *Chinese ber* (*Zizyphus*)

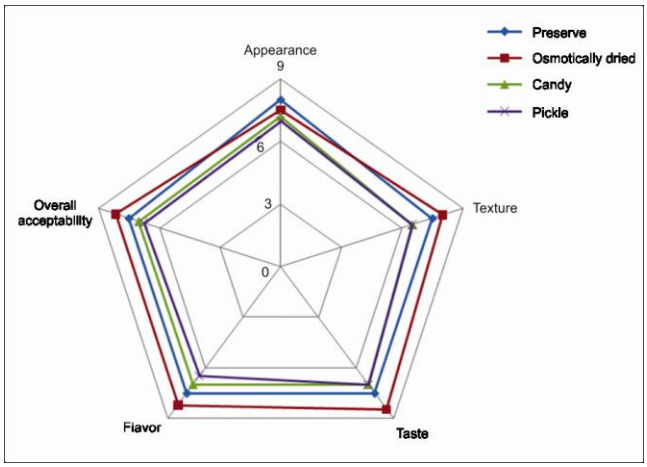

Fig. 1—Sensory characteristics of different value added products prepared from *Chinese ber*

et al.[11] and Pareek[16]. The results also showed that osmotically dried ber contained statistically (P <0.05) higher amount of vitamin C (30.15 32.50 mg/100 g) followed by the preserve (30.15 mg/100 g). The reduction in vitamin C content in processed products compared to fresh fruits may be due to heat treatment during processing[23].

Value added products prepared from jujube were also evaluated for sensory attributes like appearance, texture, taste, flavor, and overall acceptability (Fig. 1). The maximum mean value for appearance (8.0) was obtained by preserve, whereas minimum value (7.0) was recorded in pickle. Further, osmotically dehydrated Chinese *ber* samples had statistically (P <0.05) higher values of some organoleptic properties such as texture, taste, flavor, and overall acceptability being 8.00, 8.46, 8.20, and 8.15, respectively compared to other products. Results indicated that osmotically dehydrated Chinese ber was rated *liked very much*, and preferred by the sensory panelists, which might be due to their excellent taste resembling to dry dates. *Chinese ber* preserve and candied fruits were found to be statistically at par and differ significantly with that of pickle due to their better taste and flavor scores (Fig. 1). Shin *et al.*[24] investigated various processing methods for *Z. jujube* fruits and have suggested drying as a suitable method of processing *ber* fruits.

Conclusion

The present study indicates that the *Chinese ber* (*Z. jujube*) growing in Northern hill regions of India is suitable for preparing different functional products like preserve, osmotically dehydrated *ber*, candy, and pickle with good nutritional and sensory qualities. These products contain various nutraceutical compounds that are beneficial for human health. Developing value added products from these minor fruits will definitely expand their cultivation and role in fruit diversification.

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