PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol 12(1): 1-8
https://doi.org/10.14719/pst.5124

HORIZON
e-Publishing Group
HePG

RESEARCH ARTICLE

Assessment of suitability of ber (*Ziziphus mauritiana* L.) cultivars for value addition through dehydration technology

Utpal Das[1,2], UR Nidoni[3], AR Kurubar[1], Shiva Sai Prasad[4]* & Mangalambika Balaji[2]

[1]Department of Horticulture, University of Agricultural Sciences, Raichur 584 104, India

[2]Department of Horticulture and Food Science, VIT School of Agricultural Innovations and Advanced Learning (VAIAL), Vellore Institute of Technology, Vellore, Tamil Nadu 632 014, India

[3]Department of Processing and Food Engineering, College of Agricultural Engineering, University of Agricultural Sciences, Raichur 584 104, India

[4]Department of Agriculture, Koneru Lakshmaiah Education Foundation, Green Fileds, Vaddeswaram, A.P. 522 302, India

*Email: 5257shiv@gmail.com

OPEN ACCESS

ARTICLE HISTORY
Received: 18 September 2024
Accepted: 02 January 2025
Available online
Version 1.0 : 28 February 2025
Version 2.0 : 07 March 2025

Check for updates

Additional information
Peer review: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

CITE THIS ARTICLE
Das U, Nidoni UR, Kurubar AR, Prasad SS, Balaji M. Assessment of suitability of ber (*Ziziphus mauritiana* L.) cultivars for value addition through dehydration technology. Plant Science Today. 2025; 12(1): 1-8. https://doi.org/10.14719/pst.5124

Abstract

This novel experiment assessed the suitability of twelve Indian jujube (*Ziziphus mauritiana* L.) cultivars for value addition through dehydration technology. Fresh fruit samples were collected randomly from the plants and subjected to dehydration. Five qualitative characters such as total soluble solids (TSS), pH of fruit pulp, moisture content, ascorbic acid content and phenol content were analyzed along with organoleptic evaluation of fresh and dehydrated ber cultivars. Significantly higher TSS among fresh ber was found in Chhuhara (23.96 °Brix) and dehydrated ber was in Sanaur-2 (29.91 °Brix). The highest pH among the fresh and dehydrated cultivars was recorded in Illaichi (4.73), followed by Dandan (4.70). The highest ascorbic acid content was recorded in fresh Seb (108.73 mg/100 g of fresh fruit) and dehydrated Kadaka (58.55 mg/100 g of dry fruit pulp). Significantly, the highest phenol content among fresh and dehydrated ber was in Seb 219.40 mg/100 g of fresh fruit pulp and 236.24 mg/100 g of dry fruit pulp, respectively. In the organoleptic evaluation, Kadaka ranked first, retaining a high ascorbic acid content even after dehydration. Based on the present study, Kadaka appears to be the best cultivar for dehydration, followed by Seb and Gola.

Keywords

dehydration; Indian jujube; organoleptic; qualitative characters

Introduction

Ber, also known as Indian jujube *(Ziziphus mauritiana* L.*)*, is a fruit that is commonly found in India and other parts of Southeast Asia. It belongs to the family Rhamnaceae, which consists of 550 species (1). It is cultivated in Punjab, Uttar Pradesh and Gujarat. The fruit's popularity is growing globally, particularly in the United States and Canada, due to its sweet and tangy taste. Furthermore, the Indian jujube, with its traditional medicinal uses in India and other countries, holds a significant place in cultural heritage (2). Ber plants, with their ability to withstand alkalinity and a slightly waterlogged conditions, play a crucial role in preventing soil erosion and desertification. This ecological contribution makes them not just a fruit, but a valuable asset to India and several other countries.

It also contains essential vitamins such as vitamins A, C, thiamin, riboflavin and niacin. Fruit is a good source of minerals such as calcium, iron and potassium, which are crucial for maintaining healthy bones, blood and the heart (3). Ber fruits are a magnificent source of various nutrients, providing essential minerals, nutrients, vitamins and antioxidants. It is low in calories and high in dietary fiber, making it an excellent option for weight management and digestive health (4).

The processing aspects of this crop have recently received increased attention. The preparation of value-added products from ber on a small scale can play a significant role in the proper utilization of the fruit and in reducing wastage. Therefore, the dehydration of ber fruits can be a suitable processing technique to address marketing challenges. In our country, fruits are processed into dehydrated products such as fruit candy, pulp, fermented and non-fermented beverages. The possibilities of making candy, dehydration, pickle and preservation from ber were suggested (5). At present, ber is not processed commercially, except for the drying of fruit at the home scale in some villages of Haryana and Rajasthan.

Since ber is a seasonal fruit; dehydration is the best technique for making it available throughout the year. It is an old process in our country, where ripe fruits are dried under the sun. Dehydration is the method of removing moisture under carefully controlled airflow conditions, relative humidity and temperature. The dried fruit has a prolonged shelf-life, high stability and can resist microbial and enzymatic activities. It is the cheapest preservation method and aids in a considerable reduction in transportation, handling, packaging and storage costs. The present study was undertaken to examine the effect of drying on biochemical changes in fresh and dehydrated ber cultivars.

Materials and Methods

The following research was carried out during the years of 2017-18 and 2018-19 on twelve cultivars of *Ziziphus mauritiana* L., consisting of "Umran, Kadaka, Chhuhara, Dandan, Sanaur-2, Illaichi, Seb, Jogia, Mehrun, Manuki, Gola and Sanaur-6". The cultivars Umran, Mehrun and Manuki were collected from Maharashtra; Kadaka from Uttar Pradesh; Chhuhara, Dandan, Sanaur-2 and Seb from Punjab; Jogia and Gola from Rajasthan; Illaichi and Sanaur-6 from Haryana. These cultivars were raised in the orchard of the College of Agriculture, University of Agricultural Science, Raichur, Karnataka (16° 15' N latitude; 77° 21' E longitude). During the crop period, it was noted that the average maximum temperature was 33.75°C, the average minimum temperature was 16.20°C, the average rainfall was 41.95 mm, the average relative humidity was 57.11%, the average daily evaporation was 6.64 mm and the average electrical conductivity was 0.20 dS m^{-1}.

Statistical analysis

The experiment employed a randomized block design (RBD) with three replications. The findings of the study were collected and statistical analysis was carried out according to the prescribed protocols. Results were analyzed at a 5% level of significance with analysis of variance (ANOVA) with SPSS software (6).

The space between each plant and row was kept at 7 × 7 meters. Pruning was consistently performed to promote new branches that yield flowers and fruits to remove the first-order shoots. To ensure uniform growth and development of the plants, the recommended package of practices was followed (7). Observations were recorded for various physicochemical parameters of fresh and dehydrated ber for both years. Five physicochemical properties were assessed on ten fruit samples of each cultivar, which were randomly picked from different areas of plant at the full ripening stage.

Total soluble solids (TSS)

The total soluble solids (TSS) were determined using a digital handheld refractometer (8). The instrument was calibrated by cleaning and adjusting the initial value to zero at 20°C using distilled water. An appropriate quantity of pulp sample was placed on the prism of the refractometer with the help of a glass rod and the start button was pressed to get the readings. For each sample, the instrument was recalibrated using distilled water. The reading appeared on the screen was directly recorded as total soluble solids (°Brix).

pH

The pH of prepared sample was measured using a digital pH meter (Systronics 361). After taking the readings of each sample, the electrode was removed and washed properly with distilled water. The procedure was repeated for all six samples (9).

Ascorbic acid

The ber samples were analysed for the ascorbic acid content using 2,6-Dichlorophenol indophenol dye titrimetrics, as per method suggested (10). Two grams of the sample were weighed on a weighing balance, blended with 10 mL of 4% oxalic acid and filtered through muslin cloth. An aliquot (2 mL) of the extract was titrated against 2,6-Dichlorophenol indophenol dye until the pink end point persisted for at least 15 seconds (TV 2). A similar procedure was followed for acid mixture to get blank titre value and against standard solution made in 4% oxalic acid to determine the standard titre value (TV 1). The result was expressed in terms of mg/100 g.

$$\text{Ascorbic acid (mg/100g)} = \frac{\text{Ascorbic acid in standard x TV2 x Total sample volume}}{\text{Volume taken x TV1 x Weight of the sample}}$$

Total phenol content

The phenolic content in the ber fruits was estimated using Folin-Ciocalteu (FCR) method (11). Each fruit juice sample (0.5 mL) was mixed with 2.5 mL of distilled water. To this mixture, 0.5 mL of Folin-Ciocalteu reagent (1:1) was added and incubated for 3 minutes. Then, 2 mL of 20% sodium carbonate was added to each tube and the tubes were placed in boiling water bath for 1 minute. After cooling, the absorbance of reaction mixture was measured at 650 nm in a spectrophotometer. A standard curve was plotted using different concentrations of gallic acid (standard, 0-1000 µg/mL). The total phenolic content was estimated as mg/g of fruit juice.

Moisture content

The moisture content of the ber fruit samples was determined (9). Accurately, 5 g of ber fruit sample were kept in pre-dried moisture box. The initial mass of the samples was recorded as W_1 and the boxes were placed in the hot air oven (KOS.6FD Kemi) maintained at 105°C for 24 hours. The sample boxes were then placed in the desiccators for cooling and weighed. The mass of the dried samples was recorded as W_2. The moisture content of the samples was calculated using the following equation. All the measurements were replicated thrice and the average moisture content was calculated.

$$\text{Moisture content (\%)} = \frac{W_1 - W_2}{W_2} \times 100$$

Where, W_1 = initial weight of the sample, g and W_2 = final weight of the sample, g

Solar tunnel drying (STD)

Ber fruits were dried using the STD of one-ton capacity, developed and built in the Department of Processing and Food Engineering, College of Agricultural Engineering, UAS, Raichur. The dryer (9.0 × 3.0 × 3.2 m) had a tunnel-shaped metal construction wrapped in a UV-stabilized, transparent 200-micron thermic polyethylene sheet. It was composed of a semi-circular galvanized pipe. For easy loading and unloading, the drying tunnel had a sliding door that was 1.5 m wide and 2.0 m high. At the top of the tunnel, a 110 mm-diameter PVC (polyvinyl chloride) exhaust pipe with two exits (chimneys) on either side of the drying chamber was installed. Several 12 mm diameter holes were drilled along the length of the lower side of the exhaust pipe. Two ventilators of 1.0 x 0.3 m in size, were fitted at the bottom on the rear side of the dryer to remove the moist air from the dryer by natural convection. To enhance the air circulation, one exhaust fan (250 W) was provided on the top of the dryer's front side to obtain a higher drying rate. Two 3-tier supporting structures (trolleys) on either side were fitted using a 30 x 30 mm mild steel angle iron to hold 48 trays inside the dryer.

Sensory evaluation of fresh and dehydrated ber cultivars

Sensory evaluation is a method that involves the use of human evaluators who rely on their senses of taste, sight and touch to assess the sensory qualities and consumer acceptability of food and other materials. In this study, both fresh and dehydrated STD ber fruits were evaluated by a panel of five judges, selected from the institute where the research was conducted. The judges underwent training to differentiate between fresh and dehydrated fruits and evaluated them based on taste, colour, texture, flavour and overall acceptance. Each judge was given five fruit samples and asked to rate them on a questionnaire ranging from 'extremely like' to 'extremely dislike'. After tasting each sample, the judges were given water and 'lay chips' to cleanse their palate. The average scores from the judges were calculated for each sample.

A nine-point hedonic scale was used to rate the fresh and dehydrated fruit samples. The scale ranged from 9 for 'like extremely' to 1 for 'dislike extremely', with 'like very much' rated as 8, 'like moderately' as 7, 'like slightly' as 6, 'neither like nor dislike' as 5, 'dislike slightly' as 4 and 'dislike very much' as 2. This scale was used to measure the level of liking or disliking of the fruit samples (12).

Results and Discussion

Expression of different fresh and dehydrated ber cultivars for physicochemical characters

The observations on TSS (°Brix), pH of fruit pulp and moisture content (%) as influenced by different cultivars of fresh and dehydrated ber are mentioned in Table 1. The loss of moisture in different ber cultivars during dehydration in the solar tunnel dryer is shown in Fig. 1.

TSS content

It revealed that significantly higher TSS of fresh ber was found in Chhuhara (23.96 °Brix), while dehydrated ber showed the highest TSS in Sanaur-2 (29.91 °Brix) (13, 14). These variations could be related to the cultivar's response

Table 1. Variation in the TSS (°Brix), pH of fruit pulp and moisture content among fresh and dehydrated ber cultivars

Cultivars	TSS (°Bx)		pH of fruit pulp		Moisture content (%)	
	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber
Umran	16.62^{h}	20.95^{f}	4.62^{bc}	3.83^{d}	80.25^{a}	15.69^{a}
Kadaka	18.51^{d}	22.55^{e}	3.91^{fg}	3.50^{e}	79.45^{ab}	14.80^{ab}
Chhuhara	23.96^{a}	29.38^{a}	3.86^{g}	4.01^{c}	75.43^{de}	10.81^{e}
Dandan	17.61^{f}	27.61^{b}	4.12^{d}	4.70^{a}	78.54^{bc}	14.14^{bc}
Sanaur-2	19.18^{c}	29.91^{a}	3.97^{f}	3.59^{e}	73.55^{fg}	10.40^{e}
Illaichi	18.16^{e}	27.01^{b}	4.73^{a}	3.83^{d}	73.06^{fg}	12.68^{d}
Seb	22.02^{b}	21.13^{f}	4.03^{e}	4.29^{b}	74.29^{ef}	13.94^{bc}
Jogia	18.94^{c}	21.89^{e}	4.65^{b}	4.10^{c}	77.63^{c}	13.38^{cd}
Mehrun	19.07^{c}	22.48^{e}	3.35^{h}	3.08^{f}	72.98^{g}	10.86^{e}
Manuki	18.60^{d}	25.69^{c}	3.33^{h}	3.09^{f}	75.58^{d}	11.41^{e}
Gola	17.26^{g}	24.56^{d}	4.56^{c}	3.83^{d}	78.71^{bc}	14.48^{bc}
Sanaur-6	16.60^{h}	25.69^{c}	3.87^{g}	3.42^{e}	71.36^{h}	10.80^{e}
Mean	18.88	24.90	4.08	3.77	75.90	12.78
S. Em±	0.10	0.23	0.02	0.06	0.40	0.36
C.D. at 5%	0.28	0.69	0.06	0.16	1.17	1.05
CV	0.88	1.63	0.90	2.55	0.91	4.87

S. Em±: standard error of the mean, C.D.: critical difference and CV: coefficient of variation, p = 0.05

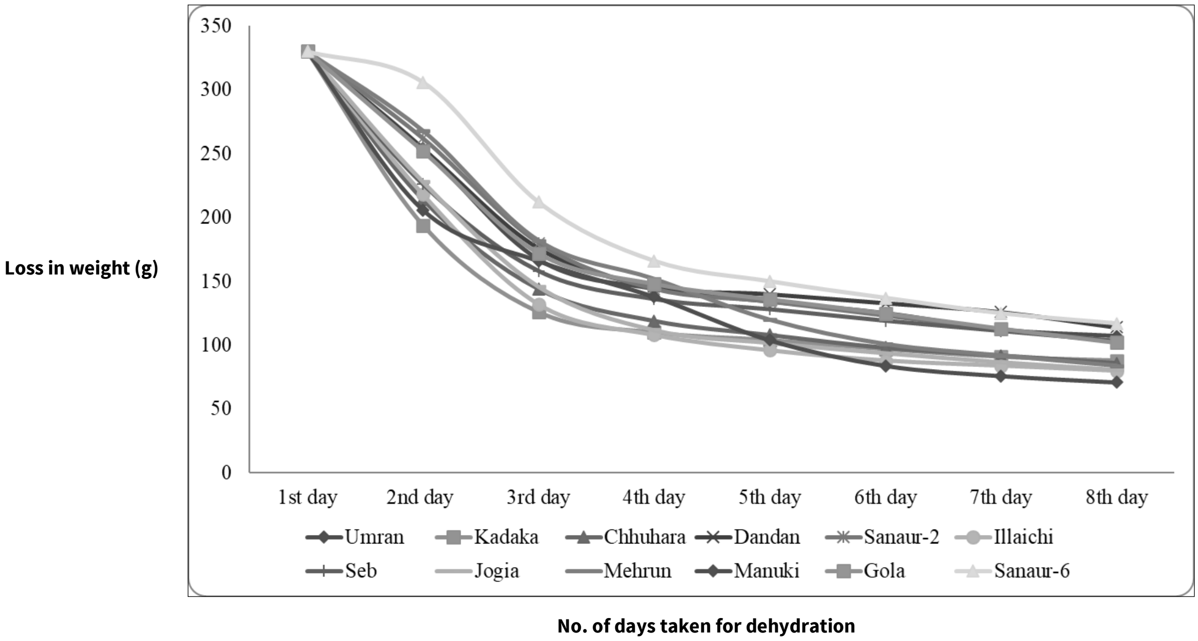

Fig. 1. Moisture loss curves of different ber cultivar during dehydration in solar tunnel dryer.

to different agro-climatic conditions, cultural techniques and crop load on the plant. Additionally, they might be due to the timing of the ripening of ber fruits under the semi-arid conditions of Raichur. Previous reports have indicated rising TSS trends during dehydration, which may be caused by evaporative losses in mango (15, 16). An increase in TSS could also be due to the conversion of primary starch and other insoluble carbohydrates into sugars (17).

pH change

The significantly higher pH in fresh fruit pulp was found in the cultivar Illaichi (4.73) and dehydrated Dandan (4.70). The pH results are consistent with the findings of previous studies (18-20). Similar results were observed for the pH of fruit pulp with values ranging from 3.12 to 3.13. It has been reported that the pH of the ber fruit's skin and pulp steadily increased (21). During the growth of the jujube fruit, the pH increased early on and decreased at the maturity stage (22).

Moisture content

The moisture of ber fruit ranged from 69.55% to 75.33%, which was in accordance with the report (23). These results are in conformity with that observed in grated carrots and in peas (24, 25). Ber reported that moisture content decreased rapidly during the initial drying stage (26).

Ascorbic acid

Data on the ascorbic acid content of fresh and dehydrated ber fruit is presented in Table 2. The fresh ber fruit of Seb recorded the significantly highest ascorbic acid content (108.73 mg), while the dehydrated ber cultivar Kadaka had the highest (58.55 mg/100 g of dry fruit). Ascorbic acid was present in adequate amounts in all the cultivars examined. The range of ascorbic acid (mg/100 g) was higher in mango, followed by papaya and guava (27, 28). Ascorbic acid has several essential functions in the human body. It acts as a reducing agent, donating electrons to other molecules and as a chelating agent, binding to metal ions (29). A high ascorbic acid content per 100 g of pulp was recorded in Umran. Its oxidation into dehydrate-ascorbic acid, which causes a reduction during storage, is one potential cause of ascorbic acid loss (30). Non-enzymatic browning of the product during storage might be one of the possible reasons for the decline in ascorbic acid. Moreover, a decline in ascorbic acid was observed as storage time increased, as mentioned in previous reports (31). The concentration of ascorbic acid in dehydrated ber is lower than in fresh ber due to its high sensitivity to temperature, which causes it to oxidise rapidly under oxygenated conditions. As a result, the ascorbic acid content may have decreased significantly or even been destroyed during the processing and subsequent storage of dehydrated ber. The loss of ascorbic acid during the preparation of aonla preserve and carrot has been reported (32, 33). During the curing process of citrus peel to make candy and store it, a reduction in ascorbic acid was also observed in the storage of the candy and in pear (34-36).

Phenol content

The highest phenol content in both fresh and dehydrated ber was recorded in the cultivar Seb (219.40 mg/100 g) and (236.24 mg/100 g), respectively. Phenolics in food, mainly fruits, are significant for consumers because they have antioxidant properties that can help prevent diseases. Apart from their ability to act as antioxidants, phenolic compounds have various biochemical properties that can be advantageous in preventing the onset of ailments such as neurodegenerative diseases (23). The fluctuation in total phenolic content (TPC) may be attributed to variations in the genetic makeup of ber plants, which exhibit considerable genetic variety due to natural cross-pollination and self-incompatibility (37). These results align with previous reports (38). It is important to observe that TPC in Indian jujube was found to be similar to that of previously known fruits (mg/100 g), such as guavas, with a TPC level ranging from 126-247 and plums with a TPC level ranging from 125-373 (28).

The rise in the TPC of dehydrated ber can be linked to an increase in phenylalanine ammonia-lyase activity. This enzyme is necessary for the synthesis of phenolic compounds in fruit tissues because it catalyzes the

Table 2. Variation in the ascorbic acid (mg/100 g in dry fruit) and phenol content (mg/100 g) among fresh and dehydrated ber cultivars

Cultivars	Ascorbic acid (mg/ 100g in dry fruit)		Phenol content (mg/ 100g)	
	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber
Umran	99.45^{e}	40.37^{de}	171.38^{d}	185.80^{cd}
Kadaka	106.48^{b}	58.55^{a}	55.71^{h}	62.08^{h}
Chhuhara	88.87^{h}	39.51^{ef}	46.76^{i}	43.60^{i}
Dandan	97.86^{f}	47.85^{c}	186.14^{c}	199.23^{c}
Sanaur-2	82.54^{i}	37.19^{g}	97.41^{g}	105.79^{g}
Illaichi	103.36^{d}	37.73^{fg}	159.07^{e}	165.05^{e}
Seb	108.73^{a}	41.16^{de}	219.40^{a}	236.24^{a}
Jogia	90.02^{g}	42.25^{d}	164.03^{de}	176.52^{de}
Mehrun	77.22^{j}	46.03^{c}	174.86^{cd}	186.94^{cd}
Manuki	82.14^{i}	52.00^{b}	104.34^{g}	224.08^{ab}
Gola	105.23^{c}	56.81^{a}	206.22^{b}	217.04^{b}
Sanaur-6	76.99^{j}	50.24^{b}	133.39^{f}	137.29^{f}
Mean	93.24	45.81	143.23	161.64
S. Em±	0.38	0.75	5.57	5.97
C.D. at 5%	1.11	2.19	16.33	17.50
CV	0.70	2.82	4.79	6.39

S. Em±: standard error of the mean, C.D.: critical difference and CV: coefficient of variation, p = 0.05

conversion of L-phenylalanine to ammonia and trans-cinnamic acid, which is the first step in the generation of polyphenols (39). The drying process could accelerate the release of associated phenolic compounds as part of the disintegration of cellular components, which could account for the increase in total phenolic content in dried samples (40). The increase in phenolic content observed in this study was likely due to the breakdown of complex phenolic tannins caused by heat and enzymatic or non-enzymatic oxidation, which released additional phenolic compounds. Furthermore, the formation of Maillard reaction products during thermal treatments could contribute to the increase in phenolic content, as new phenolic compounds can form from precursors (41).

Organoleptic evaluation of fresh fruits of different ber cultivars

The panelists judged the sensory properties of fresh ber fruits with different cultivars, as presented in Table 3 and Fig. 2. The sensory scores were evaluated, using 9 points hedonic scale, with scores given as “like extremely [9], like very much [8], like moderately [7], like slightly [6], neither like nor dislike [5], dislike slightly [4], dislike moderately [3], dislike very much [2], dislike extremely [1]” with random coding assigned to the samples. Fresh samples of ber fruits from different cultivars were served to the panelists immediately after harvesting the fruits and scores were used to judge the colour, taste, texture, flavour and overall acceptability.

Ber's acceptance among consumers is mainly influenced by its appearance and sweetness. The texture, juiciness, sweetness and market demand were therefore tested using organoleptic methods (42). The colour was rated as extremely good in Seb, Gola and Kadaka; the taste was rated as extremely good in Illaichi, Kadaka, Seb and Gola; the texture was rated very highly in Kadaka, Dandan, Seb and Gola, while the flavour was rated extremely good in Kadaka, Illaichi, Seb, Mehrun and Gola. At the same time, overall acceptability was extremely liked in Kadaka, Seb and Gola for fresh fruits from different ber cultivars (43, 44). According to a report, the maximum organoleptic scores for dried fruits with 20% moisture content were received as reported (45). Nonetheless, 15% of moisturized fruits may have a longer shelf life than 20% moisture fruits, while having a relatively poorer organoleptic score. Organoleptic evaluation of dehydrated fruits in different ber cultivars (Fig. 3). Similarly, these dehydrated fruits will have improved antioxidant content which can be used as nutraceuticals (46-48).

Table 3. Organoleptic evaluations of fresh and dehydrated fruits of different ber cultivars

Cultivars	Colour		Taste		Texture		Flavour		Overall acceptability	
	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber	Fresh ber	Dehydrated ber
Umran	7	7	8	7	7	7	7	7	7	7
Kadaka	9	7	9	6	8	6	9	7	9	6
Chhuhara	7	7	7	6	7	6	8	6	7	6
Dandan	7	7	8	8	8	7	6	6	7	7
Sanaur-2	5	4	4	4	7	7	7	7	6	5
Illaichi	8	6	9	7	7	6	9	7	8	6
Seb	9	7	9	7	8	7	9	7	9	7
Jogia	5	5	6	6	5	4	7	6	6	6
Mehrun	7	6	8	6	7	6	9	6	8	6
Manuki	7	7	8	6	6	5	8	6	7	6
Gola	9	7	9	7	8	7	9	7	9	7
Sanaur-6	6	4	4	3	6	4	5	4	5	4
Mean	7.2	6.2	7.4	6.1	7.0	6.0	7.8	6.3	**7.3**	**6.1**
C.D. at 5%	0.34	0.39	0.37	0.30	0.37	0.35	0.35	0.32	**0.37**	**0.32**

Score: like extremely-9, like very much-8, like moderately-7, like slightly-6, neither like nor dislike-5, dislike slightly-4, dislike extremely-3, dislike very much-2, dislike extremely-1

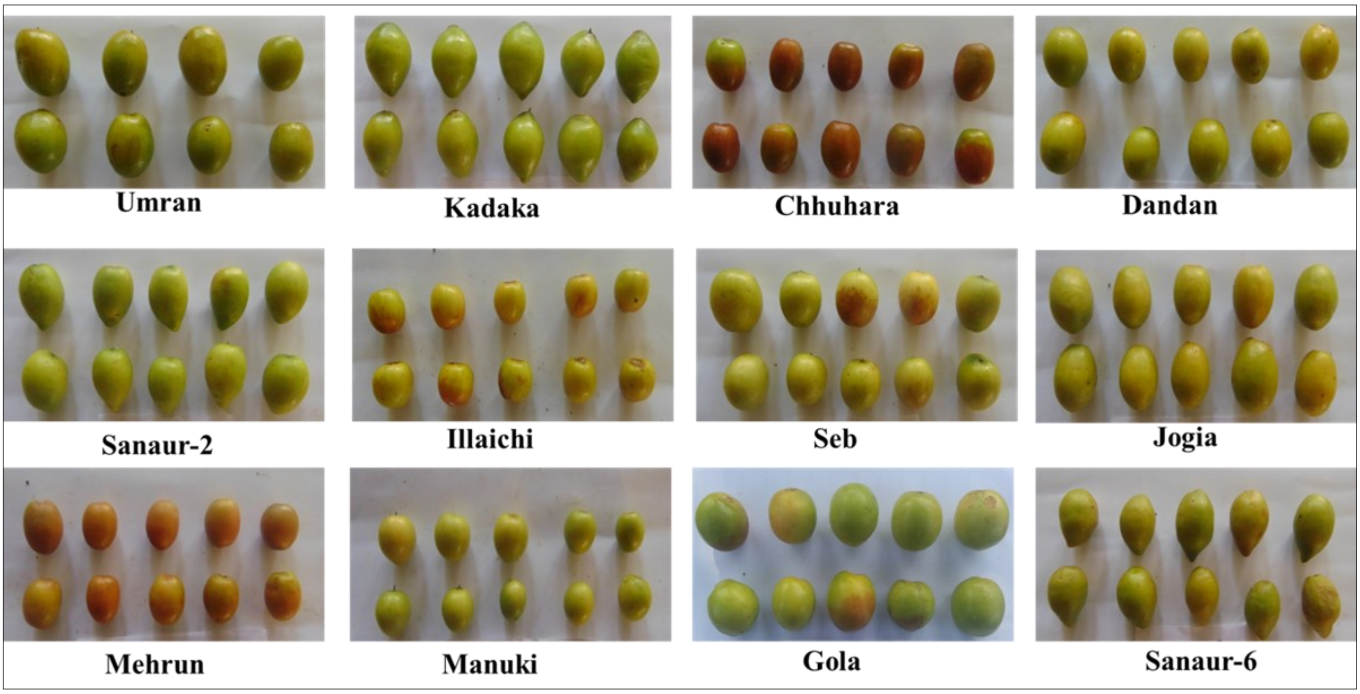

Fig. 2. Variation in ber cultivars before drying.

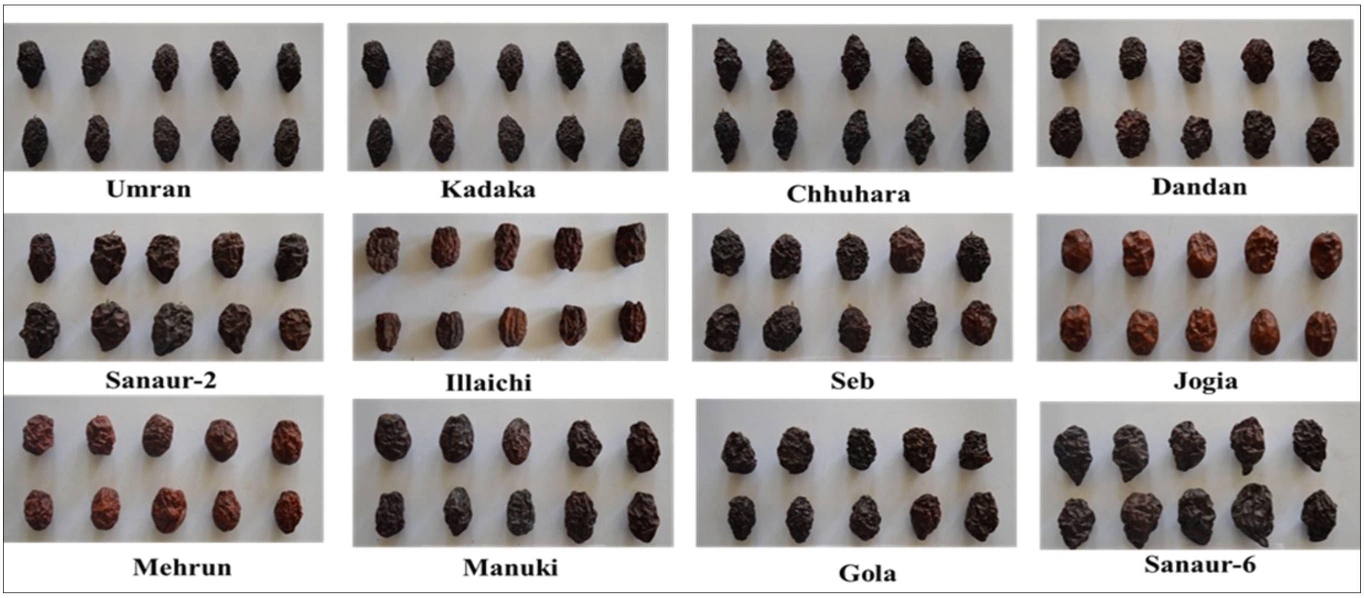

Fig. 3. Variation in ber cultivars after drying.

The colour was rated as moderately in Umran, Kadaka, Chhuhara, Dandan, Seb, Manuki and Gola; the taste was rated very good in Dandan; the texture was rated moderately good in Umran, Dandan, Sanaur-2, Seb and Gola, while the flavour was rated moderately good in cultivar Umran, Kadaka, Sanaur-2, Illaichi and Gola. Overall acceptability was rated as very good for Dandan in dehydrated fruits of different ber cultivars. The organoleptic quality of dehydrated ber also degraded with storage, as reported (16).

Conclusion

The Chhuhara cultivar, seems to be the best for biochemical characteristics. Its optimum ascorbic acid content (88.87) and TSS (23.96 °Brix) could substantiate this and could be used as research material in further crop improvement programmes. In the organoleptic evaluation, Seb stood first and its high ascorbic acid content (108.73) and phenol content (219.40), even after dehydration, can be substantiated. From the present study, Sanur-2 seems to be the best cultivar for dehydration (10.40), followed by Chhuhara (10.80) and Sanaur-6 (10.80).

Acknowledgements

The authors are very grateful to thank the Department of Horticulture and Department of Processing and Food Engineering, University of Agricultural Sciences Raichur, for their insightful discussions and research assistance.

Authors' contributions

UD experimented and drafted the primary manuscript. URN and ARK participated in the design of the study. SSP performed the statistical analysis. MB prepared the final draft. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

References

1. Ezz TM, Yousif AM, Farag ME. Morphological, physiological and biochemical genetic studies on some Indian jujube (*Ziziphus mauritiana* L.) varieties grown at El-Nubaria. Egypt J Agric Res. 2011;89(4):1499–524. https://doi.org/10.21608/EJAR.2011.179481
2. Mukhtar HM, Ansari SH, Ali M, Naved T. New compounds from *Zizyphus vulgaris*. Pharm Bio. 2004;42(7):508–11. https://doi.org/10.3109/13880200490891890
3. Tiwari RJ, Banafar RNS. Studies on the nutritive constituents, yield and yield attributing characters in some ber (*Zizyphus jujuba*) genotypes. Ind J Plant Physiol. 1995;38:88–89.
4. Kumari S, Bhat DJ, Wali VK, Bakshi P, Jasrotia A. Physico-chemical studies of different ber (*Zizyphus mauritiana* Lamk.) germplasm under rainfed conditions of Jammu. Bioscan. 2015;10(3, Suppl.):1427–30.
5. Dalal N, Neeraj, Bisht V, Raj N, Bisht V. Value added products from Ber. Int J Curr Microbiol Appl Sci. 2019;8:1603–15. https://doi.org/10.20546/ijcmas.2019.801.169
6. Panse VG, Sukhatme PV. Statistical methods for agricultural workers. 2nd enlarged Ed. New Delhi: ICAR; 1985. p.135–36.
7. Meghwal PR, Khan MA, Tewari JC. Growing ber (*Z. mauritiana* Lamk) for sustainable income and employment in arid and semi-arid regions. Extension Bulletin CAZRI. 2007; p. 26.
8. Joshi V, Sharma R, Giridhar A, Abrol G. Effect of dilution and maturation on physico-chemical and sensory quality of jamun (black plum) wine. Indian J Nat Prod Resour. 2012;3:222–27.
9. AOAC. Official method of analysis. 8th ed. Association of officiating analytical chemists. Washington DC. Method 935.14 and 992.24; 2005.
10. Sadasivam S, Manickam A. Biochemical methods. New Age International; 2008.
11. Rekha C, Poornima G, Manasa M, Abhipsa V, Devi JP, Kumar HT, Kekuda TR. Ascorbic acid, total phenol content and antioxidant activity of fresh juices of four ripe and unripe citrus fruits. Chem Sci Trans. 2012;1:303–10. https://doi.org/10.7598/cst2012.182
12. Shahnawaz M, Sheikh S, Hussain M, Razaq A, Khan SS. A study on the determination of physicochemical properties of honey from different valleys of Gilgit-Baltistan. Int J Agri Sci Res. 2013;2(2):49–53.
13. Haribabu RS, Kumar PS. Physico-chemical characters of some ber (*Ziziphus mauritiana* Lamk.) cultivars grown at Hyderabad. The Punjab Hortic J. 1987;27:17–21.
14. Chadha KL, Gupta MR, Bajwa MS. Performance of some grafted varieties of ber (*Zizyphus mauritiana* Lamk.) in Punjab. Ind J Hortic. 1972;29:137–50.
15. Gupta OP, Mehta N. Effect of post-harvest application fungicides, chemicals and pre-cooling treatments on the shelf life of ber (*Zizhiphus mauritiana* Lamk.) cv. Gola fruits. Haryana Agric Univ J Res. 1987;17:146–52.
16. Kumar A, Dhawan SS. Effect of post-harvest treatments on the enhancement of ripening of mango (*Mangifera indica* L.) fruit cv. Dashehari. Haryana J Hortic Sci. 1995;27:109–15.
17. Tandon DK, Kalra SK. Chemical evaluation of stored guava pulp in polyethylene pouches. Ind Food Pack. 1984;38:57–59.
18. Reni M, Sheela KB, Raju VK. Storage stability of pulp of different papaya varieties. Indian J Hortic. 2000;57:295– 99.
19. Kar A, Chandra P, Prasad R, Samuel DVK, Khurdiya DS. Comparison of different methods of drying for banana slices. J Food Sci Technol. 2003;40:378–81.
20. Uddin MB, Hussain I. Development of diversified technology for jujube (*Ziziphus jujuba* L.) processing and preservation. World J Dairy Food Sci. 2012;7:74–78. https://doi.org/10.5829/idosi.wjdfs.2012.7.1.62115
21. Ezhilarasi E, Tamilmani C. Influence of paddy husk on the ripening of fruit of ber (*Ziziphus mauritiana* Lamk). ARPN J Agri Bio Sci. 2009;4:29–42.
22. Lu H, Lou H, Zheng H, Hu Y, Li Y. Nondestructive evaluation of quality changes and the optimum time for harvesting during jujube (*Zizyphus jujuba* Mill Changhong) fruits development. Food Bioprocess Technol. 2012;5(6):2586–95. https://doi.org/10.1007/S11947-011-0640-5
23. Gao Q, Wu G, Yu J, Wang M, Ma Y, Li C. Textural characteristic, antioxidant activity, sugar, organic acids and phenolic profiles of 10 promising jujube (*Ziziphus jujube* Mill.) selections. J Food Sci. 2012;77:1218–25. https://doi.org/10.1111/j.1750-3841.2012.02946.x
24. Banga R, Bawa AS. Studies on dehydration of grated carrots. J Food Sci Technol Mysore. 2002;39:268–71.
25. Pradeshi IL, Arora S, Borker PA. Thin-layer drying of green peas and selection of a suitable thin-layer drying model. Drying Technol. 2009;27:288–95. https://doi.org/10.1080/07373930802606451
26. Gadakh KS, More HGU, Chobe RS. Effects of drying methods on quality of ber products and their acceptability. J Maharashtra Agric Univ. 1999;24:282–84.
27. Luximon-Ramma A, Bahorun T, Crozier A. Antioxidant actions and phenolic and vitamin C contents of common Mauritian exotic fruits. J Sci Food Agric. 2003;83(5):496–502. https://doi.org/10.1002/jsfa.1365
28. Thaipong KU, Boonprakob U, Crosby K, Cisneros-Zevallos L, Hawkins Byrne D, Boonprakob K. Comparison of ABTS, DPPH, FRAP and ORAC assays for estimating antioxidant activity from guava fruit extracts. J Food Comp Anal. 2006;19(6–7):669–75. https://doi.org/10.1016/j.jfca.2006.01.003
29. Bal JS, Jawanda JS. Studied on physico-chemical characteristic of ber cultivars grown at Ludhiana. Hortic J. 1982;42(47):65-71.
30. Pawar VD, Patil DA, Khedkar DM, Ingle UM. Studies on drying and dehydration of pumpkin. Ind Food Pack. 1985;39:58–66.
31. Patel D, Shah D, Shah M. The intertwine of band body: A quantitative analysis on how big data influences the system of sports. Ann Data Sci. 2020;7(1):1–16. https://doi.org/10.1007/S40745-019-00239-Y
32. Gupta GK, Bopaiah MG. An easy way to prepare amla murabba with high vitamin C content. Ind Hortic J. 1986;31:15.
33. Sethi V, Anand JC. Retention of nutrition in carrot and amla preserve. Ind Food Pack. 1983;37:64–67.
34. Mehta A, Ranote PS, Bawa AS. Processing of kandi lemon (galgal) peel waste for candy making. Ind Food Pack. 2005;59:67–74.
35. Gupta OP, Kainsa RL, Chauhan KS. Post-harvest studies on ber fruits *(Zizyphus mautritiana* Lamk.) in preparation of candy. Haryana Agric Univ J Res. 1980;10:163–65.
36. Rani U, Bhatia BS. Studies on Bagugosha pear for preserve and a ready-to eat product. Ind Food Pack. 1986;40:25–31.
37. Bhargava R, Shukla AK, Chauhan N, Vashishtha BB, Dhandar DG. Impact of hybridity on flavonoid spectrum of ber (*Ziziphus mauritiana* Lamk.). Environ Exp Bot. 2005;53(2):135–38. https://doi.org/10.1016/J.ENVEXPBOT.2004.03.008
38. Kamiloglu O, Ercisli S, Sengul M, Toplu C, Serc ES. Total phenolics and antioxidant activity of jujube (*Zizyphus jujube* Mill.) genotypes selected from Turkey. Afr J Biotechnol. 2009;8:303–07.

39. Alothman M, Bhat R, Karim AA. UV radiation-induced changes of antioxidant capacity of fresh-cut tropical fruits. Food Sci Emerg Tech. 2009;10:512–16. https://doi.org/10.1016/j.ifset.2009.03.004

40. Chang CH, Lin HY, Chang CY, Liu YC. Comparisons on the antioxidant properties of fresh freeze-dried and hot-air-dried tomatoes. J Food Eng. 2006;77:478–85. https://doi.org/10.1016/j.jfoodeng.2005.06.061

41. Sultana B, Anwar F, Ashraf M, Saari N. Effect of drying techniques on the total phenolic contents and antioxidant activity of selected fruits. J Med Plant Res. 2012;6(1):161–67. https://doi.org/10.5897/JMPR11.916

42. Islam SM. Study on yield and quality of different ber (*Zizyphus mauritiana* Lamk.) cultivars, Ph D [Thesis]. Dhaka. Bangladesh: Department of Horticulture and Postharvest Technology, Sher-e-Bangla Agricultural University; 2007.

43. Flora GN. Evaluation of some ber (*Zizyphus mauritiana* Lamk.) genotype for morphological and physico-chemical characters. MSc [Thesis]. Rahuri (IN): Mahatma Phule Krishi Vidyapeeth; 2014.

44. Ecevi̇t FM, Şan B, Ünal TD, Türk FH, Yildirim AN, Polat M, et al. Selection of superior ber *(Ziziphus jujuba* L.) genotypes in Çivril Region. Tarım Bilimleri Dergisi. 2008;14(1):1. https://doi.org/10.1501/Tarimbil_000000052

45. Kumar N. Study on dehydration of ber (*Zizyphus mauritiana* Lamk). Hisar, India: M Sc [Thesis]. Hissar: Haryana Agriculture University; 2005.

46. Khandare VS, Waskar DP, Kalalbandi BM, Pawar TJ. Nutraceutical composition of ber (*Zizyphus mauritiana* Lamk.) juice: Effect of enzyme-assisted processing. J Hortic Sci. 2015;10(1):54-56. https://doi.org/10.24154/jhs.v10i1.154

47. Das U, Prasad SS. Papaya waste as a nutraceuticals product. In: Nutraceuticals from fruit and vegetable waste. Wiley; 2024. p.425-39. https://doi.org/10.1002/9781119803980.ch16

48. Prasad SS, Das U, Prasad SS. Banana waste as a nutraceutical's product. In: Nutraceuticals from fruit and vegetable waste. Wiley; 2024. p.175–94.