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Nutritional composition of jujube fruit

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Abstract

The jujube, also known as ziziphus, is grown and cultivated in India, Russia southern Europe, China and the Middle East. The fruit has been used in Chinese medicine for over 4,000 years. In India, the jujube is grown for just a few niche markets. Jujube contains potassium, phosphorus, manganese and calcium as the major minerals. There are also high amounts of sodium, zinc, iron and copper. Jujube also contains vitamin C, riboflavin and thiamine. The vitamin and mineral content of the fruit helps to support cardiovascular health and enhance metabolism. This brief review provides information on nutritional composition, changes in nutritional components with maturity and its maturity indices of Indian (*Ziziphus mauritiana* Lamk.) and Chinese (*Zizyphus jujuba* Mill.) jujube.

Key words: Chinese jujube, Indian jujube, Ber, Nutritional composition, Maturity indices

Introduction

Indian jujube (*Ziziphus mauritiana* Lamk.) is also known as ber, desert apple or Indian plum. It belongs to family Rhamnaceae. It is a tropical/subtropical fruit native to the northern hemisphere (Lyrene, 1979). The genus *Ziziphus* has 135 to 170 species (Islam and Simmons, 2006), of which 17 are native of India (Watt, 1883; Bailey, 1947; Singh et al., 2000). *Z. mauritiana* is cultivable ber in drier parts of the Indian subcontinent (Sebastian and Bhandari, 1990). Ber is also cultivated on marginal lands in some African countries (Johnston, 1972). The *Ziziphus* species are distributed throughout the tropical, subtropical and temperate regions of both the hemispheres (Rendle, 1959). Small or large plantations of ber exist in Afghanistan, Iran, Syria, Burma, Australia (Nijjar, 1975), France (Evreinoff, 1949; Munier, 1973), the United States of America (Thomas, 1924; Lanham, 1926; Riley, 1970) and the Russia (Mukherjee, 1967).

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Figure 1. External and internal of Indian jujube fruit.

Ber fruit is a drupe, globose to ovoid in shape, up to 6 x 4 cm in size; skin smooth or rough, glossy, thin but tough, yellowish to reddish or blackish; flesh white, crisp, and juicy, sub acid to sweet, becoming mealy in fully ripe fruit (Figure 1, 2). Irregular furrowed stones are found in tuberculate seed which contains 6 mm long brown kernels of elliptic shape. Ber fruit is generally eaten fresh and is a rich source of ascorbic acid, essential minerals and carbohydrates (Pareek, 1983; Abbas et al., 1988; Pareek et al., 2002). Colour of fruit is changed from green to yellow to chocolate brown with the maturity and ripening (Figure 3).

Jujube (*Zizyphus jujuba* Mill.) is cultivated from ancient time in China and reported that

cultivated for last 5000 years. Chinese jujube is found in subtropics of Asia and largely in China. Sixty lakh quintals of fruits were produced from 30,000 ha area in 2009 in China (Cui, 2009). China alone contributed 90% of world production of jujube (Li et al., 2005; Su and Liu, 2005). 'Chinese Winter Jujube', a new jujube cultivar, is known as "the king of jujube in China". This cultivar characterized with thin peel, crisp flesh and rich in nutritional components (Sun et al., 2007). Jujube fruit contains flavonoids, vitamins, amino acids, organic acids, polysaccharides, and microelements (Li et al., 2007) and found useful in spleen diseases and nourishment of blood in Chinese system of medicine (Shen et al., 2009).

Nutritional composition

Ber fruit have a high nutritive value, being a rich source of vitamin C, A, and B complex, and also of Ca, K, Br, Rb, and La (Tiwari and Banafar, 1995). In general, the fruit contain 81-83% moisture**,** 17.0% carbohydrates, 0.8% protein, 0.07% fats, 0.76-1.8% iron, 0.03% each of calcium and phosphorus, 0.02 mg/100g carotene and thiamine, 0.020-0.038 mg/100g riboflavin, 0.7-0.9 mg/100g niacin, 0.2-1.1 mg/100g citric acid, 65-76 mg/100g ascorbic acid, about 22 g/100g sugar, about 1.3 g/100g fiber, about 0.2 g/100g fat with a calorific value of 104/100g (Morton, 1987). Galactose, fructose and glucose are the major sugars found in ber fruit (Muchuweti et al., 2005). p-Hydroxybenzoic, caffeic, ferulic and p-coumaric acids are the most abundant phenolic compounds in ber with concentrations of about 366, 31, 20 and 19 mg/kg dry mass, respectively, whereas vanillic acid is the least abundant with a concentration of about 2.5 mg/kg. Guil-Guerrero et al. (2004) analyzed several ber varieties from Spain for fatty acid and carotene contents. Tryglycerides having medium chain fatty acids were most abubdant in all samples. The main fatty acids were 12:0, 10:0, 18.2n6, 16:1n7, 16:0, and 18:1n9 in total saponifiable oil. On an average 1.3 g/100g saponifiable oil was found in fruit on a dry weight basis. In comparison to other fruits, carotenes were found in appreciable amount (4 to 6 mg/100g on a dry weight basis). Citric, malonic and malic acids were identified as major organic acids in ber (Muchuweti et al., 2005). Pareek (1983) recorded 81-97% pulp in fresh, mature fruit and Jawanda et al. (1980a, b) reported a range of 91-93%. General nutritive composition of ber fruit is given in Table 1 (Morton, 1987; Pareek and Dhaka, 2008; Pareek et al., 2009).

Table 1. Nutritional composition of Indian jujube fruit (on fresh weight basis).

Constituents	Amount (per 100 g)
Moisture (g)	81.6-83.0
Protein (g)	0.8
Fat (g)	0.07
Fiber (g)	0.60
Carbohydrates (g)	17.0
Total Sugars (g)	5.4-10.5
Reducing Sugars (g)	1.4-6.2
Non-Reducing Sugars (g)	3.2-8.0
Ash (g)	0.3-0.59
Calcium (mg)	25.6
Phosphorus (mg)	26.8
Iron (mg)	0.76-1.8
Carotene (mg)	0.021
Thiamine (mg)	0.02-0.024
Riboflavin (mg)	0.02-0.038
Niacin (mg)	0.7-0.873
Citric Acid (mg)	0.2-1.1
Ascorbic acid (mg)	65.8-76.0
Fluoride (ppm)	0.1-0.2
Pectin (% dry basis)	2.2-3.4

Source: (Morton, 1987; Pareek and Dhaka, 2008; Pareek et al., 2009)

Li et al. (2007) provided the proximate composition of five cultivars of Chinese jujube. Total phenols, minerals and vitamins were also determined for fruits of 'Jinsixiaozao', 'Yazao', 'Jianzao', 'Junzao', 'Sanbianhong' cultivars. Significant variations were recorded for moisture (17.38-22.52%), carbohydrates (80.86–85.63%), proteins (4.75–6.86%), lipids (0.37–1.02%), soluble (0.57–2.79%) and insoluble (5.24–7.18%) fibres, reducing sugar (57.61–77.93%) and ash (2.26–3.01%). Fructose and glucose were identified as major soluble sugar in all the five cultivars, while rhamnose, sorbitol and sucrose contribute in lesser amount. Among the minerals K, P, Ca and Mn contributed major portion, while Fe, Na, Zn and Cu were also found in good amount. Chinese jujube is rich in ascorbic acid and it ranged from 192 – 359 mg/100g among the cultivars studied. Thiamine and riboflavin contents were 0.04–0.08 and 0.05–0.09 mg/100g, respectively. Total phenolic contents ranged from 5.18 to 8.53 mg/g (Table 2). In some cultivars of Spain triglycerides of medium chain fatty acids were present in abundant quantity. On total saponifiable oil basis 12:0, 10:0, 18:2n6, 16:1n7, 16:0, and 18:1n9 were identified as major fatty acids. On dry weight basis fruits contain 1.33 +/- 0.17 g/100 g saponifiable oil. Carotenes in these Spanish cultivars vary from 4.12 to 5.98 mg/100g on a dry weight basis. Vitamin A value was found in medium range and it was 38 µg RE/100g on a fresh weight basis (Guil-Guerrero et al., 2004).

Correlation studies suggest that there were no correlation found between antioxidants and phenolics or with ascorbic acid in Chinese jujube (Li et al., 2007).

Pareek (2001) gave details of the composition of Chinese jujube pulp. They include 9.6 – 33% sugar, 0.3-2.5% acids (Ahmedov and Halmatov, 1969), 2.9% protein and 136-363 mg/100g of vitamin C (Tasmatov, 1963; Baratov et al., 1975; Ristevski et al., 1982; Ciressa et al., 1984). The average dried *Z. jujuba* sugar content is 50.3 – 86.9 g/kg, while the protein content is 3.3 – 4.0 g/kg, and fat content is 0.2 – 0.4 g/kg. Chinese jujube also contains 18 kinds of amino acids, including eight essential amino acids, and is rich in vitamins and minerals (Annon., 1989). *Z. jujube* fruits are very rich in vitamin C, thiamin and riboflavin (Troyan and Kruglyakov, 1972; Kuliev and Guseinova, 1974). Consumption of one ber fruit in a day would meet the diet requirements for vitamin C and vitamin B complex of an adult man recommended by WHO. It is also known to have high vitamin P (bioflavonoid) content.

Fruit growth and development

Jujube fruit showed double sigmoid growth (Bal and Singh, 1978; Abbas et al., 1994; Abbas and Fandi, 2002). On the basis of diameter and weight, it has been confirmed that jujube fruit having double sigmoid growth from 40 to 88 days after petal fall (Lu et al., 2012). Cultivar differences were found for days taken to maturity e.g., 'Changhong' Jujube fruit matures in 80 days (Lu et al., 2011), whereas 'Zaytoni' took 124 days (Abbas and Fandi, 2002). Due to the rapid cell elongation and cell division (Bollard, 1970) as well as high levels of growth hormons particularly auxins, gibberellins, and cytokinins (Fandi, 1999) the first rapid growth was observed between 40 to 48 days after petal fall (Lu et al., 2012). A lag phase was observed after first rapid growth. The lag phase period was also different for different cultivars and it was more than two weeks in Indian jujube (Bal and Singh, 1978; Abbas et al., 1994) and less than two weeks in 'Zaytoni' (Abbas and Fandi, 2002) and 'Changhong' (Lu et al., 2012) jujube fruit. The occurrence of a short lag phase of growth resulting in early maturity. The fruit then entered a second period of rapid growth. This stage of fruit growth is mainly due to cell enlargement and is associated with high levels of gibberellins, whereas cytokinins are no longer detectable (Fandi, 1999).

Figure 2. Fruits of Indian jujube cultivars.

Table 2. Nutritional composition of five cultivars of Chinese jujube (on dry weight basis).

Component	Cultivars				
	Jinsixiaozao	Yazao	Jianzao	Junzao	Sanbianhong
Carbohydrate (%)	81.62	80.86	84.85	82.17	85.63
Reducing sugar (%)	57.61	60.24	77.93	58.73	67.32
Fructose (%)	19.1	18.6	42.9	25.1	22.8
Glucose (%)	22.5	26.3	19.2	19.6	27.2
Rhamnose (%)	12.2	12.5	14.1	10.5	14.7
Sorbitol (%)	2.1	0.3	1.9	2.6	3.5
Sucrose (%)	14.1	11.5	0.21	17.4	11.3
Soluble fiber (%)	2.79	1.46	1.51	1.07	0.57
Insoluble fiber (%)	6.11	7.18	5.24	5.83	5.56
Lipid (%)	0.37	1.02	0.39	0.71	0.65
Protein (%)	5.01	6.86	4.75	6.43	6.60
Moisture (%)	18.99	20.98	17.38	21.09	22.52
Ash (%)	2.26	2.78	2.41	3.01	2.56
Potassium (mg/100g)	79.2	458	375	201	344
Phosphorus (mg/100g)	110	59.3	72.3	105	79.7
Calcium (mg/100g)	65.2	91.0	45.6	118	76.9
Manganese (mg/100g)	39.7	36.5	51.2	24.6	42.1
Iron (mg/100g)	4.68	6.93	6.42	7.90	6.01
Sodium (mg/100g)	6.34	7.61	6.21	5.96	3.22
Zinc (mg/100g)	0.55	0.63	0.47	0.42	0.35
Copper (mg/100g)	0.26	0.27	0.42	0.31	0.19
Thiamine (mg/100g)	0.05	0.04	0.09	0.06	0.05
Riboflavin (mg/100g)	0.07	0.07	0.05	0.09	0.05
Vitamin C (mg/100g)	359	192	203	296	315
Phenols (GAE mg/g)	7.42	8.53	8.36	7.01	5.18
Antioxidant capacity (FRAP μmol/g)	1173	1025	794	563	342

Source: (Li et al., 2007)

Figure 3. Changes in color with maturity and ripening of Indian jujube fruits.

Changes in nutritional composition during growth and maturation

Ascorbic acid and phenolics

The ascorbic acid content of ber fruits was initially low, and continued to increase till the fruit reached physiological maturity (Abbas, 1997). The increase in ascorbic acid with the advancement of ripening was noticed in ber fruit and reached peak value i.e., 559 mg/100g on 15th day of storage (Kader et al., 1984). Bal et al. (1995) also noted the increase in vitamin C content as the maturity advanced in 'Umran' ber fruits. Highest content of ascorbic acid was observed at 56 days after petal fall and after this period it continuously decreased up to maturity (Lu et al., 2012). A significant difference in ascorbic acid was reported by various workers. Comparatively lesser amount (250-600 mg/g fresh weight) was reported by Wu et al. (2010) whereas it was as high as 721 mg/g fresh weight at 88 days after petal fall (Lu et al., 2012). Total phenols increased from 40 to 48 days after petal fall, decreased from 48 to 56 days after petal fall, again increased between 56 and 64 days after petal fall and decreased steadily after 64 days to maturity (Lu et al., 2012).

Sugars

Reducing sugars were increased from 40 days to 72 days after petal fall and then decreased until maturity and ripening (Lu et al., 2012). However, in some Indian jujube cultivars ('Zaytoni', 'Umran', 'Sanaur', and 'Kaithli') reverse trend was reported (Bal and Singh, 1978; Bal et al., 1979; Jawanda and Bal, 1980; Abbas and Fandi, 2002). Reducing sugars tended to accumulate over most of the growth period in jujube fruit cvs. 'Bambawi' and 'Mallacy' (Abbas et al., 1994). Soluble sugars content continuously increased throughout growth and development of fruit and highest increase was noticed between 40 and 48 days and 80 to 88 days after petal fall. The soluble sugars content in ripe jujube fruit was 121.58 mg/g (Lu et al., 2012) and Indian jujube was in the range 85–145 mg/g (Teotia et al., 1974). It was found as low as 58-79 mg/g in 'Mallacy' and 'Bambawi' (*Zizyphus spina-christi* L. Willd) jujube fruit (Abbas et al., 1994) and as high as 179 mg/g was found in 'Zaytoni' jujube fruits (Abbas and Fandi, 2002). Reducing and non-reducing sugars increased up to maturity (Bal and Man, 1978; Bal et al., 1979; Jawanda and Bal, 1980). Total sugars increased gradually up to certain period of growth and then increased rapidly (Bal and Singh, 1978; Bal and Man, 1978; Jawanda and Bal, 1980; Gupta et al., 1984; Bhatia and Gupta, 1985; Pandey et al., 1990; Kadam et al., 1993). In 'Umran' ber, sucrose and fructose continued to increase whereas glucose decreased slightly with advancement of ripening. The stages of harvest had a significant effect on total sugars (Kudachikar et al., 2000). Delaying the picking of fruits to later maturity stages resulted in higher sugars after ripening (Bal and Chauhan, 1981; Bal, 1986). While working on four Indian jujube cultivars ('Gaolangyihao', 'Xinshiji', 'Mizao', 'Miandianchangguo') in China, Ling et al. (2008) reported that the soluble sugar mainly consisted of sucrose, glucose and fructose. The rate of increase in sucrose accumulation was highest during mid-late growth period to ripening in all cultivars studied, however the rate of sucrose accumulation in 'Gaolangyihao' was faster than that of the other three cultivars. The cultivar difference was found in glucose and fructose content of total sugars and fructose was significantly higher than that of the glucose in 'Mizao' and 'Miandianchangguo' fruit while fructose and glucose was almost equal in'Gaolangyihao' and 'Xinshiji' (Ling et al., 2008).

Carotenoids, pH and phenols

In 'Changhong' jujube fruit, carotenoid content increased from 40 to 56 days after petal fall and staying more or less unchanged until 72 days after petal fall. At the later fruit development stage, the carotenoid content rose again (Lu et al., 2012). The pH increased at early stage and decreased at middle stage of jujube fruit development, and at maturity stage, the pH increased again (Lu et al., 2012).

The total phenols decreased with the advancement of maturity (Bal and Singh, 1978; Bal, 1981; Bal et al., 1995; Al-Niami et al., 1992). This reduction in phenolics during the ripening could be due to its hydrolysis into sugars, acids or any other compounds or owing to their transformation from a soluble into an insoluble form (Singh et al., 1981). Both on tree as well as stored 'Umran' ber fruits showed decrease in total phenols with the advancement of ripening (Sharma, 1996) and tannins also decreased (Kadam et al., 1993). Total phenolics were decreased in Chinese ber after 3 days at 20ºC and again increased on 15 days of storage period (Kader et al., 1982).

Conclusions and direction for future research

Chinese jujube is grown in temperate regions while Indian jujube is cultivated in hot arid regions of India. Both the fruits are rich in nutritive value. Vitamin C content is very high in Chinese jujube

and it is fairly high in Indian jujube fruits. More than 300 varieties are available in Indian jujube but very few are in cultivation. The complete nutritional profile is not known for both these fruits. Proximate composition, fraction of sugars, vitamins, carotenoids, minerals, amino acids, volatiles etc. should be studied in both jujube fruits for particular cultivars. Nutritional changes with the advancement of growth, maturation and ripening should be measured.

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