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Bioactive compounds, medicinal benefits and value added products of ber fruit: A review

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Abstract
Ber fruit belongs to family *Rhamnaceae* and genus *Zizyphus*. *Zizyphus mauritiana* Lamk. is commercially important in India. It is considered as an underutilised crop. Ber fruit is normally eaten fresh are highly nutritious, rich in ascorbic acid, carbohydrates and contain fairly good amount of vitamin A and B complex, minerals like calcium, phosphorus and iron. Predominant phenolics found in Ber relates to its major antioxidant activity, reducing power activity and scavenging of free radical activity. Fruit has great medicinal value, considered to purify blood and aid digestion. Ber fruit is mainly eaten fresh and in a dehydrated form. The fruits are greatly seasonal and available in plenty at particular times of the year. During peak season, the price decreases and their surplus amount in the market may result in the spoilage of large quantities, to avoid this spoilage; the fruits can be processed into various products like ber fruit powder, candy, jelly, jams etc. These value added products contribute significantly to the therapeutic as well as nutritive value.

Keywords: Ber, nutritive value, antioxidant activity, medicinal value, value added products

Introduction
The Jujube or the Ber (*Zizyphus mauritiana* Lamk.) is a very old fruit of India and China. Ber belongs to the genus Zizyphus of the family Rhamnaceae. *Zizyphus jujuba and Zizyphus maurtiana* are the most important cultivated species of ber. *Z. jujuba* is deciduous, has glabrous leaves and is known as Chinese jujube or Chinese date whereas, *Z. mauritiana* is evergreen, has pubescent leaves and is commercially the most important in India. This is called as Ber or Indian jujube (Yamdagni, 1985) [57]. It has been one of the most prominent fruits since the vedic age in ancient India. Ber fruit is generally available in the market from November– March, when other main fruits are less available. Ber is widely cultivated in different states of India, i.e. Madhya Pradesh, Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Maharashtra and to limited extent in several other states (Samant *et al.*, 2008) [46]. It is cultivated in semi arid regions. The main constriction for fruit production in arid and semi-arid regions is water. The ber tree is, however, drought hardy and can grow under the most hazardous conditions of soil, water and climate. The cultivation requires perhaps the least inputs and care. It gives good production even without irrigation (Kumar *et al.*, 2008, Dayal *et al.*, 2010) [28], [9]. Ber fruit is commonly used for direct consumption. The blend of a sweet and sour taste makes this an appealing fruit. Ber fruits are very nutritious and are rich in vitamins C, A and B-complex. This fact is of great significance to fight against the existing malnutrition among the masses as for a good health, the balanced diet is necessary. It is a good source of income, provide nutrition at low cost therefore, within the reach of the poor people. It is thus known as a poor man's fruit.

Traditional Importance
Ber is a semi arid underutilized fruit. These fruits alongwith Jamun, Aonla, Bael, Karonda, Ker, Khirni etc. were largely used by tribals for the source of nutrition as well as natural medicine mainly in form of fresh fruits, powder, fruit juice and drugs. However in present scenario people are less aware of such fruits due to their busy lifestyle and therefore they are leading towards nutritional deficiencies. Besides their nutritional importance they are also the household income of the poor or the tribals (Goyal and Sharma, 2009) [12]. Ber fruit has a great antioxidant activity and also rich in phenolics including caffeic acid, p-hydroxybenzoic acid, ferulic acid and p-coumaric acid (Tanmay *et al.*, 2011) [53]. It has medicinal properties too. Its seeds, roots and stem also have medicinal uses (Kumar, 2011) [29]. In West Africa wild *Z. mauritiana* fruits are used to produce an alcoholic drink (Hutchinson and Dalziel, 1958) [18]. In India, ripe ber fruits are mostly consumed raw but can be stewed also. The unripe fruits are often eaten with salt. Different products are made from ber fruit (Table 1).

One of the easy way to process is dehydration. The dried fruits are sometimes ground to powder so that they can be easily stored when they are out-of-season. Dried, fresh or powdered ber can be used further for processing purpose. Pre-treatments used such as blanching or sulphuring before dehydration improve the product quality (Ali *et al.*, 2006) [2]. To maintain the neutraceutical properties of fruits and to avoid their degradation, the fruits are processed into various products like fruit powders, jams, jellies, bars, candy, preserves, syrups, squashes, ready to drink products etc. Ripe fruits when crushed in water form a very popular cold drink. The sweet and fleshy *Z. mauritiana* fruits are used in India to prepare jujube tea which is very healthy. The tea is enriched with vitamins and nutrients. The tea has natural sugar, vitamin A, B_1 and C and is commonly used to treat various, health ailments ranging from sore throat to anaemia (Meena *et al.*, 2014) [32].

Table 1: Types of Ber fruit products around the world

S. No	Species	Uses	Places	References
1	*Z. nummularia*	Churan (dried fruit powered with spices)	Western India	[43]
2	*Z. mauritiana*	Eaten fresh, as dry powder used in baking and to prepare jam	Zimbabwe, Africa	[31]
		As a traditional loaf		[20]
		Kachaso, a crude spirit		[3]
		An alcoholic drink is also made in Malawi		[10]
3	*Z. jujuba*	Fruits are used to make a liqueur called 'crema de ponsigue'	South America	[36]
4	*Z. spina-christi*	As food	Cental Sudan	[11]
5		Fruits including kernels are ground to produce an edible mealy substance which is either eaten raw or cooked in water, milk or buttermilk	Oman	[37]
6	*Z. jujuba*	Red date	China	[56]
		Zongzi Red dates are placed in the middle of sweet rice, which is then wrapped by bamboo or reed leaves and cooked for 2 to 3 h. After the cooking process, the red date is sweet, tasty, and gives the surrounding glutinous sweet rice great flavor.		
		Smoked/Roasted jujube		
7	*Z. mauritiana*	Jujube tea	India	[32]

Nutritional Composition

Fresh mature ber fruits contain 81-97% pulp which is rich source of nutrients. Ber fruit is richer in protein, phosphorous, calcium, carotene and vitamin C than apple and also exceeds oranges in phosphorous, iron and vitamin C (Pareek, 2001) [44].

Chandra *et al.*, (1994) [6] reported 0.8% protein, 17.0% carbohydrate, 0.3% fat, 0.02mg/100g Vit.B_2, 0.02 mg/100g Vit.A, 76.0mg/100g Vit.C, 4.0mg/100g calcium, 9.0mg/100g phosphorous, 1.8mg/100g iron and 73.9 Kcal/g energy in the ber fruit. The ber cv. Gola fruits have an average weight of 20g and are very attractive, yellow colored and round in shape. The fruit pulp consist of a TSS of 17 to 19% and 0.46 to 0.51% acidity. The ratio of pulp to stone is 14 (Azam-Ali *et al.*, 2001) [1].

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 was also reported in the ber fruit (Morton, 1987) [35].

Z. mauritiana fruits are also known in Zimbabwe and called as Masau fruit. Nyanga *et al.* (2013) [42] studied the nutritional content of the fruits and also their contribution to the diet. Samples of fruit were collected in two seasons (August 2006 and August 2007). Both macronutrients and micronutrients were determined. Dry matter content ranged from 21.1 ± 0.2 to 24.1 ± 0.3 g per 100 g of edible portion of the sweet and sour fruits, and 84.8 ± 0.2 to 87.2 ± 0.2 g per 100 g for the dried fruit. Crude protein per 100 g edible portion of dry weight ranged between 7.9 ± 0.0 and 8.7 ± 0.0 g, crude fat from 0.8 ± 0.0 to 1.5 ± 0.0 g, crude fibre from 4.9 ± 0.0 to 7.3 ± 0.0 g, ash between 3.0 ± 0.0 and 4.3 ± 0.0 g and carbohydrate between 79.5 ± 0.0 and 83.2 ± 0.0 g. The fruits were rich in vitamin C (15.0 ± 0.0–43.8 ± 0.02 mg per 100 g) and the energy values ranged between 1516.0 ± 1.73 and1575.0 ± 2.3 kJ per100 g. Also, the fruits contained (mg/ 100 g of dry weight) potassium from 1865.0 ± 1.3 to 2441.0 ± 1.1, calcium from 160.0 ± 0.3 to 254.0 ± 0.1, sodium between 185.0 ± 0.1 and 223.0 ± 0.2, magnesium between 83.0 ± 0.0 and 150.0 ± 0.13 and phosphorous from 87.0 ± 0.1 to 148.0 ± 0.5. Manganese and copper contents ranged between 0.7 ± 0.03 and 1.6 ± 0.03, while iron and zinc ranged between 2.1 ± 0.43 and 4.3 ± 0.1, and 0.6 ± 0.0–0.9 ± 0.0 mg /100 g of dry weight, respectively. Therefore masau fruit is a good potential source of both the macronutrients and micronutrients.

Ber fruits also consists of some major sugars like galactose, fructose and glucose are (Muchuweti *et al.*, 2005) [38].

Guil-Guerrero *et al.* (2004) [13] analyzed some ber varieties from Spain for fatty acid and carotene contents. It was found rich in tryglycerides having medium chain fatty acids. 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 reported in fruit on a dry weight basis.

In contrast 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 recognized as major organic acids in ber (Muchuweti *et al.*, 2005) [38].

Mature and ripened ber fruits of cultivars Kaithali, Umran and Ponda were analyzed for different physico-chemical analysis on many parameters. In all the cultivars most of the physico-chemical parameters increased precisely with the advancement of ripening of the fruits whereas parameters like acidity, protein, moisture and rehydration ratio decreased. Highest moisture content (82.40%) was recorded in mature fruits of Umran whereas lowest (79.00%) in Ponda. With the increase in ripening total soluble solids, ascorbic acid, total sugars, reducing sugars, non-reducing sugars, ash content and non-enzymatic browning increased but acidity, fat and protein content decreased with the progress of ripening in all the three cultivars analyzed. Total soluble solids (18.5ºB), total sugars (11.02%), reducing sugars (6.50%) and non-reducing sugars (4.52%) were recorded highest in Umran whereas TSS (14.1ºB), total sugars (8.12%), reducing sugars (4.71%) and non reducing sugars (3.41%) were lowest in Ponda. Ascorbic acid was observed highest (117.5 mg/100 g) in ripe fruits of Kaithali whereas lowest in Ponda. Highest ash content (0.54%) was observed in Ponda and lowest (0.42%) in Umran. Fat content was highest (0.170%) in mature fruits of Kaithali followed by mature fruits of Umran (0.163%). The highest protein content (0.42%) was reported in mature followed by ripe fruits of Ponda (0.41%). Non-enzymatic browning was recorded highest (0.97) in ripe fruits of Kaithali and lowest (0.67) in mature fruits of Ponda (Kumar *et al.*, 2016) [26].

Memon *et al.* (2012) [33] did the GC-MS analysis of the TMS derivative of ber fruit extract that showed the presence of following compounds: propanoic, hexanoic, heptanoic, octanoic, nonanoic, decanoic, dodecanoic, n-pentadecanoic, hexadecanoic, benzoic and trihydroxybenzoic acids. Also, D-fructose, galactofuranoside, gluconic acid, and β-sitosterol were detected. In seed oil of ber, the fatty acids such as, hexanoic, octanoic, 7-octadecenoic, 9,12-octadecendoic, eicosanoic, 11-eicosenoic, and docosanoic acid with 7-octadecenoic acid, were found to make up 55% of total fatty acids. Squalene, γ-tocopherol and stigmasterol were identified as minor constituents in the unsaponifiable fraction of seed oil.

Role of Bioactive Compounds

1. Antioxidant Activity

Reactive oxygen species (ROS), such as superoxide anion radicals (O_2-), hydrogen peroxide (H_2O_2), hydroxyl radicals (OH-) and singlet oxygen (O_2) initiates the oxidative stress. At a high concentration, ROS can be toxic leading to a number of diseases like arthritis and connective tissue disorders to carcinogenesis, Cardiovascular diseases (CVD), physical injury, infection and acquired immunodeficiency syndrome (Glucin *et al.*, 2004 a, b) [14], [15]. Antioxidants can eliminate ROS which causes the oxidative stress.

Koley *et al.* (2011) [24] evaluated 12 commercial cultivars of *Z. mauritiana* for their ascorbic acid (AA), total phenolics (TPH), flavonoids (TF), and total antioxidant activity (AOX) and the results indicated that Indian jujube is a good source of ascorbic acid and total phenolics ranging from 19.54 to 99.49 mg/100 g and 172 to 328.6 mg GAE/100 g, respectively. Total AOX ranged from 7.41 to 13.93 and 8.01 to 15.13 l mol Trolox/g in ferric reducing antioxidant power (FRAP) and cupric reducing antioxidant capacity (CUPRAC), respectively.

Sangeethapriya and Siddhuraju (2014) [47] studied the composition of *Zizyphus mauritiana* mucilage (ZMM) and several properties related to its nutritional quality. The ZMM has the strong antioxidant potency against ABTS (16,587.32 mmol trolox equiv./g), DPPH (5.27 g mucilage/g DPPH), hydroxyl (76.13%) and superoxide (85.12%) radicals due to the presence of polyphenols (25.54 mg GAE/g mucilage).

Kavitha and Kuna (2014) [21] reported that fresh ber fruits has 78.57±0.16% inhibition DPPH scavenging radical activity, 3.51±0.05 absorbance reducing power activity, 74.0±2% super oxide anion radical activity, 232.84±3.06% (Thiobarbituric acid reactive substances)TBARS activity, 94.7±0.27 (μg of PE) total phenolic content and 7.48±0.01 μg of RE total flavonoid content. Blanching of ber fruits increased the total flavonoid content and super oxide anion radical activity but also reduced the scavenging radical activity, reducing power activity and total phenolic content compared to fresh fruit. Secondary processing of ber fruits to some extent slowed down the scavenging radical activity, reducing power activity, total flavonoid content and total phenolic content but raised the super oxide anion radical activity in RTS Ber beverage. TBARS activity of fruit also increased 29% on blanching and 52% in RTS ber beverage. This promotes the importance of ber fruit and also its use in value added products.

During the ripening stages phenolic compounds from ber fruits and related antioxidant activities were studied. Three different antioxidant assays, including oxygen radical absorbance capacity (ORAC), FRAP and DPPH, were estimated in crude jujube extract (CJE). Three selective fractions of fruits were taken into account F1, F2, and F3. But, only the FRAP assay gave the relative antioxidant activity for the three fractions. In addition, to identify the compounds in each purified fraction, high performance liquid chromatography–electrospray ionisation-tandem mass spectrometry (quadrupole-time-offlight) (HPLC–ESI-MSMS (Q-Tof) and GC–MS were used. FRAP, F1 mainly composed of lipids, showed the lowest antioxidant activity (0.080 ± 0.015 mmol trolox/100 g, $p < 0.05$). F2, rich in flavanols, displayed 50-fold higher activity (4.27 ± 0.11 mmol trolox/100 g). Surprisingly, F3 with an high content of condensed tannins (polymeric proanthodelphinidins), exhibited the highest antioxidant activity (25.4 ± 0.35 mmol trolox/100 g).The results proved that the phenolic profiles of the fruits were inclined towards their developmental stage. Furthermore, during ripening, the antioxidant activity may be more affected by the flavanols and condensed tannins. The purified condensed tannins of ber fruits may be utilised as natural antioxidant extracts (Zozio *et al.*, 2013) [59].

Krishna and Parashar (2013) [25] observed twenty-eight varieties of Indian jujube for various health promoting compounds such as ascorbic acid, total flavonoids, flavanol, O-dihydric phenol and total phenolics. The antioxidant capacity was also measured by CUPRAC, FRAP and DPPH assays. The ascorbic acid content varied from 47.81 to 160.12 mg/100 g, total phenolics from 48.69 to 196.34 mg/100 g, total flavonoids from 60.32 to 173.11 mg/100 g, flavanol from 25.21 to 70.59 mg/100 g and O-dihydric phenol from 5.03 to 19.26 mg/100 g fresh weight. The average antioxidant activities were 1.6–6.33 and 1.22–5.49 mM TE/g as determined by the CUPRAC and FRAP assays, respectively. Equally, according to the results obtained, cv. ZG-3 was found to exhibit the strongest DPPH free radical scavenging activity followed by Katha Phal and Thar Sevika. The study also revealed a considerable amount of variation among the genotypes tested in relation to their phenolic content and antioxidant activity.

A study on the effect of gamma irradiation (0.25 to 1.0kGy) on antioxidant properties of ber fruit was done. The determination of antioxidant properties of ber fruits was done by scavenging DPPH radical activity, reducing power assay, super oxide anion radical activity, TBARS, total phenolic content and total flavonoid content. Gamma irradiation treatment up to 1.0kGy increased the Scavenging DPPH radical activity (9 %), super oxide anion radical activity (26 %) and total flavonoid content (208 %) compared to fresh ber fruit. On the other hand it brought down the reducing power activity (65 %) and total phenolic content (18 %) as compared to raw fruit. The TBARS activity statistically increased upon irradiation of ber fruit. It indicated that total antioxidant activity decreased as TBARS value increased. Therefore 0.25 to 0.5kGy is better dose to retain the natural antioxidant in fruit (Kavitha *et al*., 2014) [22].

In Bangladesh Bhuiyan *et al.*, (2009) [4] studied the antioxidant activities of the two varieties of fruits of *Zizyphus mauritiana*. Ethanolic extracts of fruits powder were characterized using DPPH free radical solution. It is found that the fruit extracts have notable antioxidant activities. The $IC_{50's}$ (inhibition concentration 50) of the ethanolic extracts of *Zizyphus mauritiana* (Local) and *Z. mauritiana* (Narikeli kul) were 72 and 250 µg/ml respectively. The local variety showed higher antioxidant activities. Therefore, the research indicates local variety of *Zizyphus mauritian*a is very beneficial for human health.

2. Phenolic Compounds

Phenolic acids occur in free and conjugated forms (soluble and insoluble) with sugars, acids, and other biomolecules (Shahidi & Naczk, 1992)[48]. Precise estimation of total phenolic acids in a plant mainly requires either base, acid, or enzymatic hydrolysis (Stalikas, 2007) [[51]].

Four species of ber (*Ziziphus mauritiana* Lamk.) fruits were studied for the flavonoid profile. The 12 flavonoids identified were quercetin 3-O-robinobioside, quercetin 3-O-rutinoside, quercetin 3'-O-galactoside, quercetin 3'-O-glucoside, quercetin 3'-O-rhamnoside, quercetin 3'-Opentosylhexoside, quercetin 3-O-6'malonylglucoside, quercetin 3'-O-malonylglucoside, luteolin 7-O-6'malonylglucoside, luteolin 7-O-malonylglucoside, myricetin 3-O-galactoside, and naringenin tri glycoside. Also three different base hydrolysis techniques were compared namely ultrasonic assisted base hydrolysis (UABH), microwave assisted base hydrolysis (MWABH), and pressurised liquid assisted base hydrolysis (PLABH) for the quantification of total phenolic acids. Nine phenolic acids, protocatechuic acid, p-hydroxybenzoic acid, ferulic acid, chlorogenic acid, vanillic acid, caffeic acid, vanillin, ortho- and paracoumaric acids, were identified and quantified. The three major phenolic acids identified in all four ber species were p-coumaric acid, vanillin and ferulic acids. Higher amounts ($p < 0.05$) of total phenolic acids in all cultivars were obtained with the PLABH technique as compared to other two procedures (UABH and MWABH) (Memon *et al*., 2013) [34].

Muchuweti *et al.*, (2005) [38] identified two phenolic compounds by TLC (thin layer chromatography) i.e. caffeic acid and p-coumaric acid. Phenolic compounds were also quantified using HPLC. Twelve peaks of phenolic compounds were detected. Among these, p-hydroxy benzoic acid, caffeic, ferulic acid and p-coumaric acid were the most abundant with concentrations of 365.94, 30.76, 19.64 and 19.28 mg/kg dry mass respectively, whereas vanillic acid was the least abundant with a concentration of 2.52 mg/kg.

This study was done to evaluate the antioxidant activity and phenolic content of the fruit. The edible portion of the fruit was extracted with 60% aqueous methanol by sonication and then assayed for total phenolic content, antioxidant activity, and individual phenolic compounds by HPLC-DAD. The total phenolic content of the fresh fruit was 12.8 mg/g as gallic acid equivalent, with an antioxidant activity of 0.5 µmol/g as quercetin equivalent by Folin-Ciocalteu and DPPH assays respectively. Hydroxybenzoic acid, vanillin, *ortho*- and *para*-coumaric acid, epicatechin, quercetin, and naringenin were identified by matching retention time and UV spectra with those of commercial reference standards (Memon *et al.*, 2012) [33].

Medicinal Benefits

Rathore *et al.* (2012) [45] reported that different secondary metabolites present in ber fruit like flavonoids, glycosides, saponins, lignins, sterols and phenols, extracted through methonol, 95% ethanol and distilled water extraction method. These secondary metabolites show very effective function against pathogens. Therefore, ber fruit can be used in the treatment of liver diseases according to their function and also used in cancer treatment. In addition to fruit, different parts of plant like root, bark, leaves, flowers, seeds are used in Ayurvedic and Yunani medicines for treatment of diarrhoea, ulcer, billousness, indigestion, cough, headache, bleeding gums, asthma. It is also used as blood purifier and appetizer (Baloda *et al.*, 2012) [5].

1. Anticancer Activity

The in vitro cytotoxicities of the triterpenoic acids extracted from *Z. jujube* were tested against tumour cell lines. The lupane-type triterpenes showed high cytotoxic activities. The cytotoxic activities of 3-O-p- coumaroylalphitolic acids were found to be better than those of non-coumaroic triterpenenoids. These results suggest that the coumaroyl moiety at the C-3 position of the lupane-type triterpene may play an important role in enhancing cytotoxic activity (Lee *et al.*, 2003) [30].The triterponic acid, betulinic acid, extracted from *Z. jujuba* and *Z. mauritiana,* showed selective toxicity against cultured human melanoma cells (Kim *et al.*,1998) [23].

2. Antidiabetic Activity

Significant antihyperglycemic and hypoglycemic activities were exhibited by the aqueous extract and the non-polysaccharide fraction of the aqueous extract of fruits of *Z. mauritiana* (Jarald *et al.*,2009) [19]. The petroleum ether extract exhibited only an antihyperglycemic effect. When the diabetic rats were treated with petroleum ether extract, aqueous extract, and non polysaccharide fraction of this plant, it restored the elevated biochemical parameters, glucose, urea, creatinine, serum cholesterol, serum triglyceride, HDL, LDL, hemoglobin, and glycosylated hemoglobin significantly to the near normal level. As a result, the non-polysaccharide fraction of the aqueous extract was found to be more effective, followed by the aqueous extract, and the petroleum ether extract.

3. Hepatoprotective Activity

The aqueous extract of *Z. mauritiana* fruit was evaluated for its protective activity against CCl_4 induced liver damage. 250, 500 mg/kg fruit extract or 100 mg/kg silymarin (standard) were administered to different groups of rats prior to CCl_4 administration. Both 250 and 500 mg/kg of fruit extract significantly reduced (dose dependently) the levels of enzymes and non-enzymes markers of tissue damage when compared to rats given CCl_4 only. These findings were supported by liver histology and suggest that fruit possessed reach hepatoprotective principles that inhibited the toxicity of CCl_4 against the liver (Dahiru *et al.*, 2010) [7].

4. Antimicrobial Activity

Z. mauritiana was most effective against *Pseudomonas aeruginosa* and produced the largest zone of inhibition (27.67 ± 0.57 mm), while the smallest zone of inhibition (12.17 ± 0.76 mm) was observed against *Chromobacterium violaceum*

(Tanvir *et al.* 2014). Nyaberi *et al.* (2010) [40] reported that the antibacterial activity of methanol extract of Kenyan jujube against *Staphylococcus aureus* at concentration of 200 and 100 mg/mL and the observed zone of inhibition was 15.6 mm and 9.0 mm, respectively. Antibacterial activity against pathogenic *Staphylococcus aureus* strain has also been observed in both green and ripe Indian *Z. mauritiana* (Das 2012) [8]. Other jujubes derived from the same species, such as *Z. spina-christi* fruits, also showed antibacterial activity against *Bacillus subtilis*, *E. coli* and *Streptococcus pyrogenes* (Nazif 2002) [39] and *Z. jujube* showed activities against *E. coli*, *Klebsiella pneumonia* and *Sa. typhi* (Kumar and Begum 2002) [27]. As *Z. mauritiana* inhibited *Salmonella paratyphi* to a similar extent as streptomycin and showed robust antibacterial activities against a wide spectrum of bacteria, it can be postulated that *Z. mauritiana* can be used against both grampositive and gram-negative bacterial infections of the skin, gut, intestine, lung and urinary tract.

5. Anti-inflammatory Effect

The compound prescription of Huangqin Tang contains the fruit of *Z. jujuba* showed marked anti-inflammatory effect (Huang *et al.*, 1990) [17].

6. Antispastic Effect

Huangqin Tang is the compound prescription which contains the fruit of *Z. jujube* that possessed significant antispastic/antispasmodic effect (Huang *et al.*, 1990) [17].

7. Antiallergic

The anti-allergic activity of aqueous extracts of *Z. jujuba* was studied by measuring its inhibitory effect on hyaluronidase (bovine testes) activation in vitro. *Z. jujuba* was shown to have strong anti-allergic activity (Su *et al.*, 2000) [52].

Value Added Products

Singh and Pathak (2016) [50] formulated ber candy from different varieties. They studied the physico-chemical characteristics of different cultivars viz., Illaichi, Ponda, Umran, Gola, Banarsi Karaka and Narendra Ber Sel-2. Both the physico-chemical composition of ber fruit and organoleptic quality of candies Banarsi Karaka was found the best among all cultivars for making of candy. Storage studies indicated that LDPE film was better in comparison to glass jar and plastic jar for packaging of ber candy at ambient temperature and candy was found in good condition after 9 months of storage period in LDPE film.

Helmy *et al.* (2012) [16] aimed his research to prepare several new products from ber fruits (local and Chinese) varieties such as beverage, combot, jam, dried candy and syrup also, to study the nutritional analysis and sensory characteristics for these products. The physicochemical constituents, vitamin C, phenolic content and antioxidant activity were determined for the product. Minerals, color values and organoleptic properties were also measured. The results showed that Chinese ber jam had high values of TSS% (72.87%), protein (3.34%), fat (0.91%) and ash (3.06%). Acidity (as malic acid) and total sugars% reached to their maximum values in Chinese ber beverage and syrup being (2.41% and 70.61%) respectively. The contents of vitamin C, phenol and total antioxidant activity (DPPH%) ranged from 48.25-191.65mg/100g, 2.40-7.14mg GAE/gm and 76.95-89.95% respectively. Potassium and calcium were the most predominant minerals and ranged from (203.68-548.71mg/100g and (74.92-419.13mg/100g) respectively. High score values for the tested organoleptic properties were present in all ber products prepared from Chinese ber fruits.

Z. mauritiana in Zimbabwe is called as Masau. These fruits form part of the family diet and generate additional income by selling at local markets. Excess fruits are sun dried and can be converted into various products such as porridge, traditional cakes, mahewu, and also fermented to produce a spirit called Kachasu. Fermented fruit pulp contains ethanol ranged from 2.1 – 3.7 mL $100mL^{-1}$, whereas the traditionally made distillate contained 23.8 – 45.6 mL 100 mL^{-1}. Nayanga *et al.*,(2008) [41] did a survey of the traditional processing techniques of masau using a questionnaire and two focus group discussions in Mudzi, Mt. Darwin,and Muzarabani districts in Zimbabwe.

Kavitha and Kuna (2014) [21] studied the effect of processing on antioxidant activity of ber fruit and also formulated ber beverage. Blanching of ber fruits increased the total flavonoid content and super oxide anion radical activity but, at the same time, it reduce the scavenging radical activity, reducing power activity and total phenolic content compared to fresh fruit. Therefore, optimization of blanching time and temperature for ber fruits is necessary. Secondary processing of ber fruits slightly slowed down the scavenging radical activity, reducing power activity, total flavonoid content and total phenolic content but raised the super oxide anion radical activity in RTS Ber beverage. TBARS activity of fruit increased 29% on blanching and 52% in RTS ber beverage. This shows that value addition of ber fruits can improve the economy and health benefits by reducing the post harvest loss, establishment of agro process industry and promoting the importance of functional products from ber fruit.

Younis and Siddiqui (2014) [58] studied the production of wine from ber fruits using *Saccharomyces cerevices* Var.HAU 1. The juice of ber fruit was extracted and analyzed for TSS, pH, total Sugar and reducing sugar. Further the juice was adjusted with different TSS as 10, 15, 20, 25 and 30% by adding cane sugar in powder form and samples were fermented at 30 °C by using *Saccharomyces cerevices* var HAU 1. It was observed that juice having TSS 15% showed higher ethanol production as compared to juice at other TSS. 15% TSS juice was further adjusted with different pH by using diluted NaOH & H_2SO_4 and kept for fermentation at 30°C. It was observed that ber juice having pH 4 yield higher alcohol as compared to samples at other pH.

Sharma and Rana (2016) [49] studied that *Z. jujube* growing in northern hill area region suitable for preparing different functional products like preserve pickle, dehydrated ber, candy with good nutritional and sensory properties. These products contain nutraceutical compounds that are beneficial for health. Developing value added products from these minor fruits will definitely expand their cultivation and role in fruit diversification.

Ber fruit juice was also used for the preparation of vinegar. It was produced by fermentation by two step process i.e. alcohol and acetic acid fermentation which was later analysed for physico-chemical properties. Due to its high antioxidant activity it is known as functional vinegar (Vithlani and Patel 2010) [55].

Conclusion

The present investigation about the underutilised fruit crop Ber, gives a deep insight of its origin, traditional importance, physico-chemical properties and uses. The fruit is eaten raw, dry or fresh and it can be processed into various products which include non-alcoholic and alcoholic beverages, traditional cake, porridge and jam. These products are highly nutritious and boon for undernourished mass. This fruit plays an important role in food security and poverty alleviation. Therefore, it can be an alternative source of livelihoods of people leaving in arid and semi-arid areas. Income from these fruits can be improved through value addition.

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