Prickly Pear Cactus (*Opuntia Ficus-Indica*) the Beles in Ethiopia: A Review on Nutritional Aspects and Health Benefits

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Abstract

Background: Prickly Pear Cactus (*Opuntiaficus-indica*) is the cactus species of greatest agronomic importance, due to its delicious fruits, stems (cladodes), which are used as fodder for livestock as well as a fruit and vegetable for human consumption. This cactus was introduced in Ethiopia 150 yrs before, locally known as Beles. The chemical, nutritional composition, and health benefits of cactus pears have been extensively studied. But the documented research evidence related to the nutrient content of the Ethiopian variety is very less and the study on health benefits is almost nil. Climate changes, drought, high temperatures, and changes in soil productivity are threatening human civilization in terms of food scarcity in Ethiopia. In this context, there is an urgent need to re-explore and promote Ethiopian Prickly Pear, an indigenous cactus as a supportive food for drought-prone areas in Ethiopia with enlightening the potential health benefits of cactus fruit and stem.

Method: This work is based on the reports of the United Nations, local Government, and Non-Government organizations, research articles, conference proceedings, books, and unpublished theses.

Conclusion: The review identified the gap between the knowledge and the practice in the use of this cactus in Ethiopia. It is recommended that along with administrative and social support; production and utilization can be enhanced to address human and livestock needs.

Keywords: *Beles, Ethiopia, Health Benefits, Nutritional Aspects, Prickly Pear Cactus.*

Introduction

Cactus pear, *Opuntiaficus-indica* (L.) is a CAM (Crassulacean Acid Metabolism) plant cultivated in a wide range of environments and most agro-economically important cactus crop species, out of about 150 species in the genus *Opuntia.* The ecological success of *O. ficus-indica*, like other CAM plants, is due to their peculiar daily pattern of carbon uptake and water loss mostly at night. The crop originates in Mexico and still the largest producing and consuming country in the world. Now, it is cultivated in America, Africa, Asia, Europe, and Oceania[1]. In addition to its resilience as a crop to restore degraded land, the cactus pear is also increasingly consumed by human (fruit and young cladodes part); as fodder in sub-Saharan Africa and South Asia. Other non-food uses like biofunctional, medicinal, nutraceutical, and cosmetic properties are already promoted and some are yet to be explored[2]. "Green gold", "fruit for the poor", "treasure under its spines", "world vegetable dromedary", "future plant", "sacred plant" and "monster tree" are just some of the names used for the plant and the fruit [3], which convey the importance of opuntias to poor people for their survival.

Tigray is a region of Ethiopia bordering on Eritrea; where more than 80% live in rural areas and agriculture is the mainstay of the people. But production is very less due to infertile soil and erratic rainfall. The cactus pear or "beles" (as it is known here), plays an important economic and cultural role, which is reflected in traditional songs and sayings, as in the following translation by Abay (1997) [4]: *"Oh my beles you spare me this summer till barley has cheerfully come to rescue me".* Increasing humans and livestock growth, combined with a decline in soil productivity and recurrent episodes of drought and famine, there is increasing reliance on cactus pear to minimize risk, ensure crop and food security in this part

of Ethiopia. Along with that, both spiny and spineless cactus is used as a source of livestock feeding in Tigray region[5]. Despite the great extent and importance of cactus pear in Ethiopia, there is a lack of awareness of mass and interest of scholars on cactus pear.

Based on the current birth rate, countries having arid and semi-arid areas are mostly under the category of the fastest-growing populations; are going to face difficulty in food production by 2050 [6]. In this context, Cactus Pear (Beles) can be promoted as an alternative crop with improved drought tolerance and water-use efficiency in the arid and semiarid part of Ethiopia with special emphasis on its medicinal properties. Same time, the attention required in research and development sectors of nutritional aspects and health benefits of crop and its productivity management.

Materials and Method

This work is based on the reports of the United Nations, local Government, and Non-Government organizations, research articles, conference proceedings, books, and unpublished theses. The search words include Prickly Pear Cactus, Beles, Nutritional aspects, Health benefits, Ethiopia, etc. The review covers all the documented information available in the above-mentioned sources up to November 2020.

Discussion

History of Cactus Pear in Ethiopia: Long before the Spaniards arrived in America, the Opuntias were in use and cultivated. The Indian chroniclers were the first to record these plants and their fruits, which were carried to Spain and initially used as ornamental plants [1]. There is evidence for the use of *Opuntia* in the human diet at least 9000 years ago[7] or even as early as 12,000 years ago[8,9].

It has been given many names in its native range and in the regions where it has been introduced. The name "tuna" is of Caribbean origin and "Nopal" is a Mexican name derived from the Nahuatl Nopalli[10]. In other languages, it is called figo da India (Portuguese); Indian fig (English); figuierd'Inde (French); Indianische Feige (German); fico d'India (Italian)[11].

Beles was introduced between 1848 and 1870 by Catholic Missionaries in Tigray region, Ethiopia. One priest brought three spineless cladodes from Mexico and planted one cladode in Alitena (Erob), the second one planted in Golea (Gantaafeshum), and the third one planted in Lehe (Eritrea). After that, the plant was distributed throughout the region and beyond. This information was supported by Kibra (1992) [12] and Neumann (1997) [13]. However, Habtu (2005)[14] reported that Muslim pilgrimages to Mecca (Saudi Arabia) introduced cactus pear to the lowlands of the southern Tigray in 1920.

About Structure, Component and Nutritional Aspects of Fruit, Cladodes & Seed:

Cladodes: They are modified flattened stems with a characteristic ovoid or elongated shape. Young tender cladodes, called nopalitos [Fig 1, 3], are consumed as fresh vegetables; they are used as an ingredient in a wide range of dishes, including sauces, salads, soups, snacks, pickles, beverages, confectionery, and desserts. Besides the direct consumption of tender shoots, mature cladodes are ground to make flour and other products. Nopal flour is a rich source of dietary fibre reaching up to 43% (dry basis)[15]. The major components of cladodes are carbohydrate-containing polymers, comprising a mixture of mucilage and pectin. In addition,

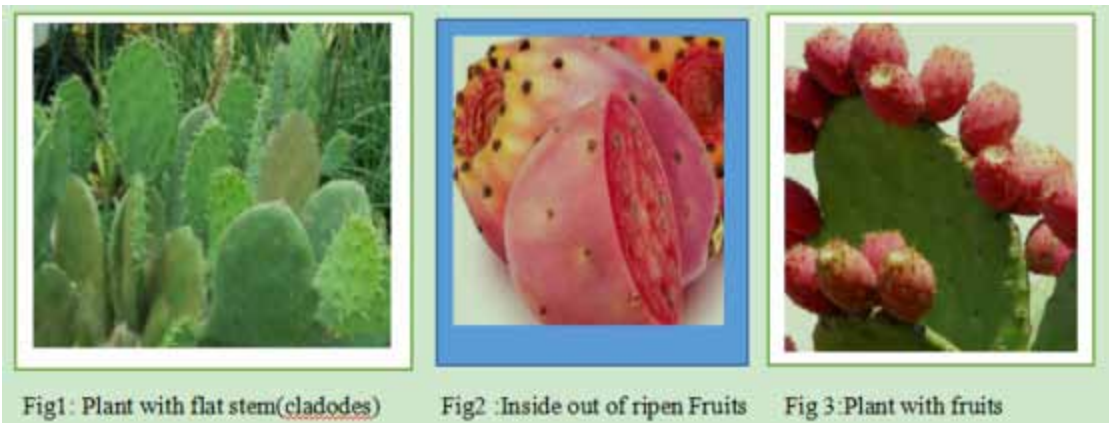

Fig1: Plant with flat stem(cladodes) Fig2 :Inside out of ripen Fruits Fig 3:Plant with fruits

100g of cladodes contain 11mg vitamin C and 30µg of carotenoids. The dried mucilage comprises on average: 5.6% moisture; 7.3% protein; 37.3% ash; 1.14% nitrogen; 9.86% calcium; 1.55% potassium [16]. The presence of five major flavonoids (isoquercitrin, nicotiflorin, rutin, isorhamnetin-3-O-glucoside, and narcissin) was observed by Guevara Figueroa et al,(2010)[17]. Cactus cladodes contain phytochemicals with no apparent detrimental effects on livestock. Negesse et al. (2009)[18] determined the content of some anti-nutritive factors in mature and young cladodes of spineless cactus (*O. ficus-indica*) growing in Ethiopia and reported their total tannin content as 21 and 42g equivalent tannic acid/kg(dry matter) respectively.

Fruit: It is an oval, elongated shape, and is technically a fleshy berry form. *O. ficus-indica* fruit grows vigorously in terms of length, width, weight, and volume in the first 20-30 days after anthesis and grows approximately up to 59-90 days. Generally, cactus pear fruits may be divided into three components: seeds (some varieties with few or no seeds), peel, and pulp [Fig 2, 3]. The presence of a high number of normal seeds in the fruit is considered an obstacle to its commercialization. Other than consumed as fresh fruit, it can be used to prepare a large number of products like jams, liqueurs, vinegar, sauces, juice concentrates, and canned products. This fruit constitute sugars, fibre, mucilage, and pectins as major; and proteins (specially amino acids like alanine, arginine, and asparagine), vitamins and minerals as the minor components[19]. Cactus pear fruits present high antioxidant activity, due to the presence of vitamin C, carotenoids, flavonoids and betalains[20,21]. Betalains are the main pigments responsible for the ripe fruit (peeled and unpeeled) colours like green, yellow, orange, red, purple and, therefore, they are a major factor in consumer acceptance. Kuti (1992)[22] reported an antioxidative effect due to the major flavonoids found in cactus fruits (e.g. quercetin, kaempferol, and isorhamnetin derivatives). The nutrient concentrations remain in the fruit without significant changes throughout storage; although some changes in vitamin C content have been reported, depending on the storage conditions[23]. Irrespective of the origin or variety, the fruits are a good natural reservoir of micronutrients like magnesium, calcium, potassium, phosphorus, and vitamin C, so they can be used as food supplements. Based on the low acidity, high sweetness, and attractive stable color, Opuntia fruits could be very suitable as a natural additive or substituted material in the production of many foodstuffs. The fleshy prickly pear fruits have a short shelf life, varying from 2-3 and up to 4weeks [24], which making marketing and long-term storage and worldwide distribution of fruits difficult [25]. The absence of toxic elements like lead and cadmium is indicating that the fruit is safe as food[26].

Table 1 showing the nutrients present in 100gm of fruit from two sources: one from Ethiopian Food Composition Table[27] and another from USDA Database(2019)[28]; both sources are only providing fruit nutrient content with some variations. Differences may be due to many factors: species; variety; environmental factors, such as the climatic and edaphic conditions; crop management, including fertilization and post-harvest treatment; and maturity status.

Table 1: Nutrient Content of *O. ficus-indica* fruit (raw), per 100gm of edible portion

Nutrients Type	Energy (kcal)	Protein (gm).	Fat (g)	CHO (gm)	Fiber (gm)	Calcium (mg)	Iron (mg)	Zinc (mg)	Ascorbic Acid (mg)
Ethiopian Beles(EHNRI,1998)[27]	55	1.10	0.8	15.4 (including fiber)	4.6	122.8	1.0	1.2	14.20
Prickly Pears, Raw, (USDA Database, 2019)[28]	41	0.73	0.51	9.57	3.6	56	0.3	0.12	14

Seed: According to Tewelde and Mulubrhan(2019)[29], the seed of Ethiopian Beles contains 392.84 kcal/100g energy on a dry weight basis. The dietary Ca, K, P, Fe, and Zn contents of the sample accounted for 390.14mg, 446.46mg, 206.18mg, 4.37mg, and 2.01mg per 100 g, respectively. Despite the high phytate content (259.20mg/100g), the seed had an appreciable amount of antioxidant capacity (43 to 95% of inhibition).

The nutritional and chemical properties of the prickly pear may not provide the required balanced diet for human nutrition, like rice, wheat, legumes, but, the

prickly pear fruit and derivative properties can act as a supplement towards human nutritional requirements due to having some promising nutraceuticals.

About Health Benefits of Cactus Pear

Health Benefits of Fruits: Cancer protective effects *O. ficus-indica* fruits aqueous extracts have been documented by Zou et al.,(2005) [30] for ovarian, cervical, and bladder cancer. Siriwardhana et al., (2006)[31] studied human peripheral lymphocytes and stated that *O. ficus-indica* fruit extract can reduce DNA damage. Tesoriere et al. (2003, 2004, 2005b)[32, 33, 34] reported that cactus pear fruit ingestion produced a decrease in oxidative stress markers, inhibited low-density-lipoprotein (LDL) oxidation, and increased resistance to oxidative hemolysis red blood cells in ex vivo experiments. The anti-ulcerogenic and anti-gastritis effects of *O. ficus-indica* fruits were studied in rats by Lee et al. (2001)[35]. Hepatoprotection of *O. ficus-indica* fruit juice and the extract was demonstrated in rats [36,37]. Kim et al.(2006) [38] demonstrated the neuroprotective action of *O. ficus-indica* fruit extracts against neuronal oxidative injuries induced by excitotoxins in mice cortical cells. Hypoglycemic action and antidiabetic effects of cactus fruit were observed in rats [39].

Health Benefits of Cladodes: Diuretic effect has been reported by feeding of *O. ficus-indica* cladodes in rats[40]. The anti-ulcerogenic and anti-gastritis effects of *O. ficus-indica* cladodes were studied in rats[40,41]. Opuntiaficus-indica plant extract can alleviate alcohol hangover symptoms in humans[42]. The protective effect of *Opuntiaficus-indica* cladode juice against oxidative damage reported by Ncibi*et al.* (2008)[43] and Zourgui*et al.* (2008)[44]. Healing properties of *O. ficus-indica* cladodes in human has been identified by Hegwood(1990)[45]. Frati Munari et al.(2004)[46] studied in human that Opuntia sp. cladode can act as an anti-obesity factor. An anti-hyperlipidemic effect was observed in rats by feeding of *O. ficus-indica* cladodes [47]. Antiviral action of Opuntia sp. cladodes reported in guinea pigs[48]. A study on Mexican adult women revealed that the intake of dehydrated nopal at a high stage of maturity in the premenopausal stage could improve bone mineral density and calciuria and thus prevent osteoporosis[49].

Health Benefits of Seed: According to Tewelde and Mulubrhan (2019)[29], the seed of Ethiopian Beles had an appreciable amount of antioxidant capacity (43 to 95% of inhibition).

Although the medicinal properties of cactus have been known since ancient times, recently some of them have been scientifically proven. But the study explicitly on Ethiopian variety is scanty.

Development & Uses of Belesin Ethiopia: Tigray region covers about 80,000 km2 and is estimated to have about 360,000 hectares of cactus pear, about two-thirds of which are spiny plants. Approximately half the existing area of opuntias was planted; the rest has been invaded by naturalized cactus. Here, it is used as food, livestock feed, cash income, environmental protection, fence, firewood, cochineal production, and bee forage[50]. Two Ethiopian organizations that play an important role in the expansion of cactus acreage are the Relief Society of Tigray (REST) and the Tigray Regional Natural Resource Conservation and Development Bureau. The Cactus Fruit Development Project (CFDP) has promoted the selection, production, and distribution of cactus varieties, identification of diseases, and design of erosion control measures as part of its strategies [51]. Various projects have been developed to raise awareness of the uses of cactus by local communities. Cactus pear is mainly used for fruit production, with still limited knowledge of nutritional aspects and human health benefits.

Food and Agriculture Organization of the United Nation (FAO) cooperation projects in the area, carried out by International Cactus Pear Network (Cactus Net) members, have introduced nopalitos (Cladodes) in regional diets and the NGO “Mums for Mums” in Tigray region, Ethiopia promotes the use of nopalitos at the community level. This project used to have a public awareness nutritional program through which they spread about the nutritional value of cactus fruit. They also provided facilities for program participants to experiment with different cactus recipes. They published a beautiful little cactus recipe book, which is available to the public. Along with that, this NGO promoted small-scale enterprise development based on cactus pear. But, their adoption has been limited due to the presence of thorns, the abundance of mucilage, and the lack of organoleptic appeal of cooked nopalitos. In this area, “Himbasha” (traditional bread) prepared with Beles seed and wheat flour(ratio of 85:15%) is another form of consumption of this cactus.

Conclusion

In Ethiopia, this "Beles" is considered as the 'Bridge of life' by storing large quantities of water in the stems, like fruit, and providing both feeds for cattle and farmers during prolonged drought due to global warming[51]. Again, this fruit and stem can be considered as a promising future crop for commercial food applications. But the production challenges of this environmentally friendly crop are there due to a lack of research related to reproductive biology, plant productivity, and orchard management. One of the biggest challenges is the structural improvement of fruit, specifically the creation of large, tasty, seedless fruits of higher quality. In addition to that, Beles is confined only into local markets due to ineffective marketing strategies. Large-scale commercial production and export for Tigrean cactus pears have to be promoted by establishing enterprises, or co-operatives. Consequently, pharmacological potential in human nutrition and health issues are being under exploited due to research challenges in terms of low political, social attention on Cactus. Public policies and credit are essential in order to increase the cultivation of this important plant in the arid and semi-arid regions. Scientists must identify the traits for use in intensive breeding programs helpful for coping with drought, diseases, and improving nutritional content. Collaboration between interdisciplinary teams from all cactus-pear-producing countries is advisable.

Despite the efforts of the last 20 years, current knowledge remains scarce and only limited scientific information is available to producers and users. Tigray Region is among the most drought-prone areas of Ethiopia, and households in these areas mostly depend on food and cash assistance for their survival. If edible cactus grows abundantly in these parts of the country, they can be used to address human and livestock needs. Along with administrative and social support; International collaboration needs to be encouraged, with sharing expertise, genetic resources, and facilities for new varieties of cactus, which will benefit cactus pear cultivation for a country like Ethiopia. Lastly, the commercial production and use of spineless cactus for forage and almost seedless fruit for humans need to be encouraged at the community level.

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