African Journal of Biotechnology Vol. 7 (9), pp. 1199-1203, 2 May, 2008
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2008 Academic Journals

Review

Potential for domestication and commercialization of *Hoodia* and *Opuntia* species in Botswana

Tibe, O.[1]*, Modise, D. M.[2] and Mogotsi, K. K.[1]

[1]Faculty of Agriculture, Botswana College of Agriculture, P/Bag 0027, Gaborone. Botswana.
[2]College of Agriculture and Environmental Sciences, University of South Africa, P.O. Box 392, Tshwane, 0003, South Africa.

Accepted 10 April, 2007

The species *Hoodia* (Apocynaceae) and *Opuntia* (prickly pear) (Cactaceae) are highly efficient in water use and belong to the Crassulacean Acid Metabolism (CAM) group of plants. These plant species are quite abundant in Botswana especially in the Kalahari Desert, prickly pear being the most dominant even though they have received very little commercial attention in the country. Elsewhere in the world, prickly pear has multiple uses such as their utilisation in the pharmaceutical industry, as a source of food and drink for animals in the rural communities, and are important in the weaving and clothing industry. Other important uses of the species are manufacturing of paper, making of toothpicks, needles, pins and for numerous essential products. Recently the world has been introduced to *Hoodia gordonii* or *curorri* that works as a natural appetite suppressant. This paper reviews the potential uses of *Opuntia* and *Hoodia* spp, identifies the important species used by communities in Botswana and recommends protocols and instruments for research, cultivation, and commercialization of these species in the country.

Key words: Commercialisation, communities, domestication *Hoodia, Opuntia*.

INTRODUCTION

Prickly pear also called cactus pear belongs to the *Cactaceae* family while *Hoodia* belongs to the *Apocynaceae* family. *Hoodia* spp do not belong to the cacti family despite being erroneously called *Hoodia* cactus by the public media. *Opuntia* sp. is found in arid and semi arid regions of the world while *Hoodia* sp. is indigenous to the Kalahari. They are widely distributed in desert areas and can withstand drought and high summer temperatures in Botswana much better than exotic species and are efficient in water use. Rainfall in Botswana is erratic, unreliable and scarce, so non-conventional forages are urgently required. This means plants, which can survive in drought prone areas with high summer temperatures should be integrated in Botswana farming systems. Prickly pear can therefore be a good source of food and water for livestock during dry spells (Brutsch, 1997). The mature plants though have a low nutritional value, however, can be used as an emergency supplement feed during drought seasons (Fuentes-Rodriguez, 1997). There is no evidence that the *Hoodia* species has ever been used as livestock forage and fodder. Its spiny appearance may act as a deterrent to being eaten by animals. Duru (2005) indicated that the fruit *Opuntia* can be consumed fresh after peeling the pulp, and value added by making jams, alcoholic beverages and juice. The fruits are known to act as antioxidants and can reduce degenerative diseases such as obesity, diabetes and hypertension. It is also known that the purple fruit contains belatinin pigments that are used as a natural food colorant. The immature leaves serve as a vegetable for human consumption in developing countries (El Kossori et al., 1998).

These plants are important for soil conservation, preventing soil erosion, preventing encroachment of deserts and protecting biodiversity (Tassen, 1996), encouraging arable crop diversification to ensure sustainable livelihood and food security. Research efforts would be concentrated on domestication and commercialisation of these species as one of the initiatives for diversification.

*Corresponding author. E-mail: otibe@bca.bw, Tel: ++267 365 0269, Fax: ++267 392 8755.

Botanical description of *Opuntia*

Opuntia species found in Botswana are *O. imbricata, O. ficus-indica, O. compressa,* and *O. microdasys* (National Herbarium and Art Gallery, 2007), *O. ficus-indica* being the most predominant.

The plant is evergreen, perennial, and erect with a lignified and primary stem that can reach up to a height of 5 m. Its aerial portion consists of flat green, plate-like sections, called cladodes (pads) which are circular, ovate and oblong. The size of a 2 - 3 year old cladode is usually 30 - 60 cm long, 20 - 40 cm wide and 8 - 23 mm thick with an area ranging from 462 - 796 cm^2. These plants are considered cacti because they possess spines and succulent bodies, and may also have small leaves. The spines are actually leaves of the plant, which are a few millilitres long. They have spines and glochids (Mauseth et al., 2002) on them and can change into roots and flowers. Glochids are minute hairs over the peel of the pulp. They are so tiny that if brushed or blown on the skin will cause irritation. In other countries tweezers with long handles are used to remove the hairs, the fruit is placed in a moist paper to catch the glochids. The large spines are of different lengths and colours. Since these are desert plants and surface water is always limited, the root system is not far beyond the ground but in wild plants appears extensive.

The fruit of the different species differ in shape, size, colour and quality. The peel of the fruit is usually yellow, green-yellow, yellow-red, red or purple. The shape of the fruit is cylindrical and spherical (Reyes-Aguero et al., 2005). The pulp of the fruit is formed from the papillary cells of the dorsal epidermis of the funicular involucre and the funicle while the epicarp comes from the receptacle, the vegetative tissue surrounding the ovary. The seeds are embedded inside the pulp, ranging from 100 to 400 per fruit, about 3 - 4 mm in diameter. The fruit grows and increases in fresh weight.

The flowers are yellow, brown and orange in colour. These are distinct from the areolas arranged along the upper margin of the corona of 1 year-old pads. They usually have visible sepals and petals of different colours, the yellow colour being the most dominant. Numerous stamens surround the gynoecium, which is a pistil surmounted by a multiple stigma. The ovary is inferior, uniocular, containing several ovules in laminal placentation. Self-pollination and cross-pollination can co-exist and several species are characterised by pre-anthesis cleistogamy, as the stigma can be receptive before the flower opens.

Distribution

The *Opuntia* sp. is a common crop in North America and South America. It is now widely distributed in the world. It is becoming neglected in Botswana as it multiplies quickly and considered to be weed. It is a very efficient crop in water use and the pads can be used as a livestock fodder. In fact, these countries produce a reasonable amount of animal fodder from *Opuntia*.

Table 1. Chemical composition of *Opuntia ficus-indica* (fruit and cladodes)

Parameter	Fruit	Cladodes
Moisture content (%)	85-90	88.3-92.7
Crude Protein (%)	5.1-12	4.5-5.5
Sugar (%)	6-14	-
Ash (%)	0.44	13.1
Fat (%)	0.09-0.7	1.4
Crude Fibre (%)	0.02-3.1	17.6
Nitrogen Free extract (%)	-	77.1
Acid detergent fibre (%)	-	12.0-16.0
Neutral detergent fibre (%)	-	22.7-27.1
K (mg/100mg)	90-217	-
Na (mg/100g)	0.6-1.1	0.1
Ca (mg/100g)	12.8-59	1.4
Mg (mg/100g)	16.1-98.4	-
P (mg/100g)	15- 32.8	0.2
Fe (mg/100g)	1.5	-
Mn (ppm)	2.9	-
Zn (ppm)	0.3-0.4	-
Vitamic C (mg/100g)	1-41	12.7

(Source: Duru and Turker, 2005; Guevera et al., 2004; El Kossori et al., 1998; Piga, 2004; Fuentes-Rodriguez, 1997; Stuart, 2003; Flachowsky and Yami, 1995)

Table 2. Amino acids composition of *Opuntia ficus-indica* fruit

Parameter	Range (mg/L)
Proline	1768.7
Glutamine	574.6
Taurine	572.1
Serine	217.5
Alanine	96.6
Glutamic acid	83.0
Methionine	76.9
Lysine	53.3

(Source: Piga, 2004)

Chemical composition

The nutritive value in food and forages is primarily determined by the reserves of carbohydrate and protein content. The nutritional composition of *O. ficus-indica* is shown in Table 1 and 2. The prickly pear is a succulent, so it contains about 85 % water, an indication of water used as dry matter where water is scarce.

The nutritional composition of *Opuntia* fruit has high glucose and fructose content while the protein content is very low. *Opuntia* has a low protein content (3.2% to 5.0% on dry matter basis), high fibre content; NDF ranges from 22.7 to 27.1 % and ADF 12.0 % to 16.0% (Guevera et al., 2004). Glucose and fructose content lies in the range 6-8 %, ascorbic acid 23 mg/100g. It is rich in macro-minerals such as potassium, calcium, phosphorus and magnesium. The chemical composition can be enhanced through the application of fertilisers. The composition is variable depending on the genetic characteristics of the species, age, location, soil fertility and climate. Young cladodes have high protein content than the mature ones.

The chemical composition of cladodes (on dry matter basis): moisture content 85-90%, crude protein content 5-12 %, dry matter digestibility 62-76%, and carbohydrate content 2-6 % (Stuart, 2003). It has nutritional composition that is similar to other leafy vegetables.

Potential uses of *Opuntia*

Opuntia is a multipurpose plant and its uses are discussed below. It consists of roots, pads, spines and fruits. In Botswana, the plant is mainly reared for providing a live fence or hedge in homes and provision of fruit; however, other uses have not been explored.

Fruit and vegetables

The fruit can be consumed fresh after removing the outer skin using a sharp instrument. The fruit is a good source of protein, minerals and vitamins (El Kossori et al., 1998). The plant is very efficient in water use. It remains green throughout the year through the CAM photosynthetic pathway. The high water efficiency emanates from this pathway. The uptake of carbon dioxide at night by this pathway is converted to crassulacean acid, which is further changed to sugars. Even if the plate-like sections may appear shrivelled, the fruit remains healthy. The small spines cause irritation on the skin, as they are blown away by the wind during removal. However, the spines could be removed by placing the fruit in water. The presence of spines in the fruit is variable from one plant to another. The purple fruit has fewer spines than the yellow one. Tender pads are sliced and used as a vegetable in Mexico and the United States (El Kossori et al., 1998). The pads can be pound-ed and dried, and the strong fibers made into baskets, mats, fans and fabrics (Soberon et al., 2001). The large spines are used as needles, toothpicks and pins.

Animal fodder

Livestock plays a major role to the Botswana economy. The fresh pads of *Opuntia* are a good source of water and food for livestock (Flachowsky and Yami, 1995) during the dry seasons. It has a high biomass yield, high digestibility, palatability, and moisture content (Nerd et al., 2005). The pads are heated to remove spines and cut to be made into fodder.

Cosmetics and agro-industry

Value adding had led to the production of jams, gums, resins, dyes (Soberon et al., 2001). Vigueras and Portillo (2001) stated that the pulp of the plant is used as an ingredient in making face and body lotions, hair gels and shampoos.

Medicinal uses

The consumption of fruit and pads is associated with reduction of different ailments such as diabetes, obesity and cholesterol concentrations (Vigueras and Portillo, 2001). The flowers are used for the treatment of the urinary discomfort in men, diarrhoea, arthritic and asthmatic problems and so on. The plant part responsible for therapy is administered in pills or capsules.

Although intensive research is still to be performed, the plant *Opuntia* has a huge potential for food, cosmetics, and medicinal properties irrespective of its negligence as weed in other countries. Besides these uses, the seeds are a good source of oil and can also be used for water purification (Vigueras and Portillo, 2001), the wood as a source of fuel and live fence (Brutsch, 1997).

Propagation and cultivation

Its propagation is simple. The pads are placed on a slightly moist ground to absorb water and nutrients and allowed to obtain root and leaves. Vegetative bud sprouting begins to develop from areoles which are not in contact in the soil and new individual cladodes develop. The seeds of the fruit can be used for growing the plant. However, asexual reproduction is more efficient than sexual reproduction. Suitable soil for cultivation is about 20 - 40 cm deep or medium texture. The pH value should be between 5.0 and 7.5.

No major pests or diseases are associated with this plant. However, an exotic pest *Cactoblastis cactorum* has been found in Mexico (Garrett, 2004).

HOODIA

Distribution

Hoodia sp. are mainly distributed in Southern Africa. They are extremely rare natural crops found in the dry and drought prone areas of Botswana, South Africa,

Namibia and Angola. In Botswana, *H. gordonii* grows in the Central Kalahari Game Reserve, Xai National Park and Makgadikgadi national parks. *H. currorri* susp.*lugardii* occurs only in Botswana, some parts of Zimbabwe and the Limpopo province of South Africa (Court, 1981). Road construction, physical infrastructure and mining may have impacted negatively on the population of *Hoodia* sp. A survey by Frank Barsch (2005, unpublished) has indicated that these species are sparsely populated in Botswana as such cannot be economically viable unless cultivated in large scale in farms or plantations.

Botanical description

The plant has minute hard spines, perennial, erect and firm, and grows slowly (Innes, 1977). It can also be a habitat for small animals. *H. gordonii* can grow up to a height of 450 mm with brown-spined stem angles. The stems are a greyish brown and the new growth is usually light green. It has a spiny appearance analogous to that of a cactus.

Its flowers are saucer-shaped with a diameter of 70 - 100 mm. They are pale purple in colour with small dark red papillae in the centre. The flowers are foul-smelling and smell like a stinking feet. They are insect pollinated and flies are attracted to the foul smelling flowers.

Chemical composition

There is no published data in the literature on the nutritional composition of *H. gordonii* and *H. curorri*.

Propagation and cultivation

Hoodia can be propagated by seeds, tissue culture and cuttings. It survives well in hot areas and light shade. It can rot due to overwatering and if rot occur detritus should be removed from the healthy parts of the plant by cutting away. The cut portion is then sealed or ash from a fireplace can be applied on the wound to prevent onset of micro-organisms.

H. gordonii and *H. curorri* are usually attacked by mealy-bug on the roots. The plant is cultivated in South Africa but it has not been harvested. It is reported that it has been cultivated in Chile.

Development of *H. gordonii* in Southern Africa

H. gordonii contains the active ingredient for natural appetite suppressant (CITES, 2004), which has been named “P57 molecule”. Trials suggest that the P57 molecule targets the satiety centre of the brain and reduce appetite. The mechanism behind suppressing appetite is due to the molecule fooling the body into thinking that it is full. They are also used for cultural and horticultural purposes (Hargreaves, 2004).

South African Scientists have licenced the rights of development and production of *H. gordonii* to Pythopharm in the United Kingdom. Their aim is to increase the production of the raw material. Phytopharm currently grows the plant in two sites in South Africa, but it will need to significantly increase the supply of the raw material before it can enter into agreements with other giant manufacturing companies. Obesity could be seen to be soaring at an alarming rate within a single generation unless an urgent action is taken. Child obesity has now become a major worldwide concern in developed and developing countries. No much work has been done in Botswana on *H. gordonii* and *H. curorri*, which are known for weight reduction.

Uses of *Hoodia* in Botswana

The San of the Kalahari desert are known to have been using this succulent by cutting off part of the stem and chewing the plant to stave off hunger and thirst during their long hunting trips (Wynberg, 2004). Pharmaceutical companies now use this traditional knowledge of the San for reduction of obesity and heart related diseases. The plant has many medicinal applications because it is used for treating ailments such as abdominal cramps, haemorroids, tuberculosis, indigestion, hypertension and diabetes. This suggests that men relied on plants surrounding them and through trial and error discovered plants for treating various diseases. The Council of Scientific and Industrial Research (CSIR) in South Africa and Phytopharm have patented the active ingredient (Wynberg, 2004). It is ascertained that the local communities in which these species are present use it as a vegetable and a source of energy.

Natural bioresources in Botswana are getting lost to the international corporate world. If no immediate action is taken and policy reforms, protocols are put in place, the species would become extinct. This calls for multidisciplinary research to be done to avoid the risk of over-exploitation, extinction and illegal trade of natural resources such as *Hoodia* used for food and medicine. It is imperative that the resources are used sustainably by the present generation without jeopardising with the needs of the future generations (Our Common Future 1987).

H. gordonii is under threat and is one of the species protected by CITES (Convention of Illicit Trade of Endangered Species) which means that the gathering and selling without a permit is prohibited (CITES, 2004).

PROSPECTS

The nutritive value and medicinal properties of these species offer a potential for commercialization in order to

improve food security and diversify the economy of Botswana. *Opuntia* sp. is already in great demand on the South Africa, Canada, Japan and European Market (Duru and Turker, 2005). Much work on this plant has not been done in Botswana.

H. gordonii has been listed as a CITES Appendix II plant. Hence there is need to cultivate more species for commercialization as harvesting of wild resources cannot be recommended. This would also enhance conservation on the wild resources. *H. gordonii*, *curorri* and *Opuntia* sp. have a great potential to generate income and employment for the San and the nation at large. *Hoodia* sp. especially the *H. gordonii* is demanded in large quantities in the international market due to its hunger depressant properties.

Baseline work needs to be done on the uses and value of these species by the local community in Botswana. There is no published data on the uses of these species. Research on the ecological adaptation outside their normal habitats, chemical composition and biological interactions should to be undertaken.

Policies and protocols for conservation, domestication and commercialisation of these species need to be put in place. Strategies for commercialisation will include supply of germplasm for cultivation and propagation, expanding local, regional and international market, value adding, multidisciplinary research, and sourcing funding, public education, collaboration with private sectors and NGOs etc.

REFERENCES

Brutsch MO (1997). The Beles or Cactus Pear (*Opuntia ficus-indica*) in Tigray, Ethiopia. JPACD. pp. 130-141.

CITES (2004): Inclusion of H*oodia* spp. In Appendix II, designating all parts and derivatives except those bearing the label “Produced from *Hoodia* spp material obtained through controlled harvesting and production in collaboration with CITES management. Authorities of Botswana, Namibia and South Africa.

Court D (1981). Succulent Flora of Southern Africa: A comprehensive and authoritative guide to 164 genera in nine family groups. AA Balkema. Cape Town. p. 202.

Duru B, Turker N (2005). Changes in physical properties and Chemical Composition of Cactus Pear (*Opuntia ficus-indica*) during maturation. J.PACD, pp. 22-23.

El Kossori RL, Villaume C, El Boustani E (1998). Composition of pulp, skin and seeds of prickly pears. Plant Foods Hum Nutr. 52: 263-270

Flachowsky G, Yami A (1995). Composition, Digestibility and Feed Intake of *Opuntia ficus-indica* by Ogaden sheep. Arch Tierernahr. 35(8): 599-606.

Fuentes-Rodriguez J (1997). A comparison of the nutritional value of *Opuntia* and Agave plants. J. PACD, pp. 20-24.

Garrett L (2004). Center for Plant Health Science and Technology, USDA. A White Paper Economic Impact from Spread of Cactoblastis Cactorum in the United States. pp. 1-9.

Guevera JC, Colomer JHS, Esterez OR (2004). Nutrient Content of *Opuntia* Forage Clones in the Mendoza Plain, Argentina. J. PACD, pp. 62-77.

Hargreaves B (2004). In litt. to IUCN/TRAFFIC Analyses Team. Cambridge. UK.

Innes C (1977). The complete handbook of Cacti and Succulents: A comprehensive guide to cacti and succulents in their habitats, to their care and cultivation in house and indoor and to the genera and their species. Van Nostrand Reinhold Company. New York, p. 138.

Mauseth JD, Kieslag R, Ostoloza C (2002). A Cactus Odyssey: Journeys in the wilds of Bolivia, Peru, and Argentina. Timber Press. Oregon. pp. 1-33.

Nerd A, Degen AA, Pasternak D, Benjamin R (2005). A five year project pre-proposal. Ben-Gurion University of the Negev. Israel.

Reyes-Aguero JA, Aguirre-Rivera JR, Hernandez HM (2005). Systematic notes and a detailed description of *Opuntia ficus-indica* (L.) Mill (Cactaceae). Agrociencia 39(4): 395-408.

Soberon J, Golobov J, Sarukhan J (2001). The importance of Opuntia in Mexico and routes of invasion and impact of Cactoblasts Cactorum (Lepidopterra: Pyralidae). Florida Entomol. 84(4): 486-492.

Stuart AG (2003). Pricly pear cactus. Submitted for a PhD thesis. The World Commission on Environment and Development. Our Common Future (1987). Oxford University Press. Oxford and New York.

Vigueras GAL, Portillo L (2001). Uses of *Opuntia* species and the potential impact of *Cactoblastis Cactorum* (Lepidoptera pyralidae) in Mexico. Florida Entomol. 84(4): 493-498.

Wynberg R (2004). Rhetoric, Realism and Benefit Sharing: Use of traditional Knowledge of Hoodia Species in the Development of an appetite Suppressant. J. Intellectual Property. 7(6): 851-876.

Yassen Y, Barringer SA, Splittstoesser WE (1996). A note on the uses of *Opuntia* spp. In Central/ North America. J. Arid Environ. 32(3): 347-353.