academicJournals

Vol. 12(21), pp. 3309-3312, 22 May, 2013
DOI: 10.5897/AJB12.2631
ISSN 1684-5315 ©2013 Academic Journals
http://www.academicjournals.org/AJB

African Journal of Biotechnology

Full Length Research Paper

Chemical and nutritional content of *Opuntia ficus-indica* (L.)

Rose Chiteva* and Norman Wairagu

Kenya Forestry Research Institute (KEFRI), Forest Products Research Center, Karura,
P. O Box 64636, 00620, Nairobi, Kenya.

Accepted 8 May, 2013

***Opuntia ficus-indica* (L.) fruit pulp was analyzed for its chemical and nutritional content and the results compared with those of the same species from other parts of the world. The analysis included those for: Moisture and ash contents, crude fibre, energy values, non-reducing sugars, crude protein and vitamin C. Total carbohydrates were obtained by calculation. Results show no major variation in moisture content, amount of ash except in the Kenyan sample (A), which had a high value of 4.03 ± 0.52)%. Vitamin C varied from the three reported sources whereas crude fat was the same in all except 0.40% in sample A. Crude fiber varied and calorific value only reported in A was 3.77 kcal/g. Carbohydrates varied widely between 12 to 92%. All analyzed minerals varied, but Pb and Cd were absent. From this study, it is evident that the nutritional composition of *Opuntia ficus-in*dica (L.) varies in regards to age and season. However, irrespective of the origin or variety, these fruits are a good natural reservoir of energy whose nutritive components and antioxidants such as vitamin C, can be used as a food supplement.**

Key words: Kenya, nutritional composition, *Opuntia ficus-indica* (L.) fruits.

INTRODUCTION

Prickly pear cacti produce cactus fruit also called cactus figs or *Opuntia ficus-indica.* The fruits are purple, fleshy and oval in shape, measuring between 1 and 3 cm in length. The Opuntia species is a xerophytes of about 200 to 300 species ((Moβhammer et al., 2006). This is adapted to arid zones, characterized by drought conditions, erratic rainfall and poor soils subjected to erosion (FAO, 2001). The plant has a shallow root system and this enables it to accumulate elements. .

The *Opuntia* plant provides water, vitamins, carbohydrates, and calcium that are required in the animal diet (Rodriguez-García et al., 2007) This plant survives the drought due to its succulent leaves. It is attractive as food due to its efficiency in converting dry matter and thus provide digestible energy. The succulent pads of *Opuntia* species serve as a source of water for livestock in dry regions around the world and provide an important feed source of fodder (Gabremariam et al., 2006).

The *Opuntia* fruits are the main food source during the drought season in the community adjacent to Mukogodo forest where people and domestic animals feed on them. They are also a rich source of natural antioxidants for food as a result of their flavonoid, ascorbic acid and carotenoid contents (Kuti, 2004). Being fleshy and sweet, they are also taken as source of refreshment, used to make jams and juices (Broihier, 1999). Nowadays, there is an interest to obtain ethanol by fermentation of various cactus material (Retamal et al., 1987; Turker et al., 2001), and a kind of beer has been obtained from Opuntia plant (Shi et al., 2004).

Many different species of *Opuntia* are grown in Mexico for fruit production whereas in Italy and the Mediterranean region in general, *O. ficus-indica* is cultivated. The lack of a well defined standard for varieties has led to

*Corresponding author. E-mail: rchiteva@yahoo.com. Tel: +254 20 2011628/9.

clonal populations being developed in producer countries, mostly distinguished on the basis of some morphological features of the fruit and cladodes. Thus, in Italy and Spain, three main varieties have been produced; the colour of the fruit determining the denomination. In South Africa varieties, cladodes of different shapes can be found while in Chile the most common variety has fruit which is green even when ripe. Other characteristics (vegetative vigour, sugar and protein content, cladode fibre, among others) determine how the variety can be utilized (Chessa and Nieddu, 1997).

Recent studies in the varieties of European and Asian cactus pears have shown notable antioxidant activities that significantly reduce oxidative stress in patients and may help in preventing chronic pathologies. Betalain pigments contained in these cactus pears have shown beneficial effects on the redox-regulated pathways involved in cell growth and inflammation (Wolfram et al., 2003; Tesoriere et al., 2004; Tesoriere et al., 2005a; Siriwardhana et al., 2006). Betalains are water-soluble pigments. Two betalain derivatives are present in cactus-pears: betacyanin, which gives the red-purple color, and betaxanthin, which gives a yellow-orange color. These pigments show important antioxidant activities without toxic effects in humans (Castellar et al., 2003; El-Samahy et al., 2006; Livrea and Tesoriere 2009).

A multi-ingredient fruit such as *O. ficus-indica* (L.) holds promising answers for tailor-made nutraceuticals and functional foods by embracing essential ingredients such as: taurines, amino acids, readily absorbable carbohydrates, minerals, vitamin C and soluble fibres (Stintzing et al., 2000; Stinzing et al., 2001). Currently a lot of work has been done on the cladodes, (Rodriguez-Felix and Cantwell, 1988; Gallegos-Infante et al., 2009; Gabre-mariam et al., 2006) but not enough has been done on the effect of variation in fruit nutrition with respect to location, variety climate and age.

In this study, we analyze the chemical and nutritional composition of *O. ficus-indica* (L.) from Kenya. Results were compared with those of other varieties studied in Ethiopia (Tegegne, 2001), Egypt (El Samahy et al., 2006) and USA (Feugang et al., 2006). These results give informative profile not only on the effect of variety, location and other parameters on the fruit quality of Opuntia species, but also for future work in product development and value addition. The fruit can be used as a food supplement, thus addressing the food security issue, especially in arid and semi - arid areas where it grows.

MATERIALS AND METHODS

Reagents

Analytical grade solvents and reagents were used to perform analyses and were purchased from Sigma-Aldrich chemical (Sternhem, Germany). Bi-distilled de-ionized water was used and all reagents were of suitable analytical purity.

Sample preparation

Ripe fruits were collected in the month of September from Mukogodo division of Laikipia County, Central Kenya. Only the purple ones (the first change in skin color) were considered ripe and picked. The fruits have no season and ripen all year through. Fruits were sampled randomly from the wild removing spines manually.

Washing and drying

The fruits were washed with distilled water and disinfected using 10% sodium hypochlorite solution to eliminate microorganisms. They were then dried using a vacuum system for 12 h at 10^{-2} Torr, and 45°C, in order to avoid protein and carbohydrate damage and eventually powdered using a mill (PULVEX 200, Mexico) equipped with 0.5mm screen (Rodriguez-García et al., 2007).

Chemical analyses

Analysis was done on the edible portion in triplicates. Moisture content was determined by desiccation at 40°C for 24 h, according to the 934.01 method as described in the Association of Official Analytical Chemists (AOAC, 2000) techniques. Mineral ash content was evaluated with the 942.05 method (AOAC, 2000) using 100 g samples, determined at 550°C for 24 h in order to remove organic material. The samples were placed in shallow, relatively broad ashing dishes that had been ignited. The samples were then cooled in desiccators, and weighed once they reached room temperature. Nitrogen (N) concentration was ascertained by applying the Kjeldahl method 2001.11 (AOAC, 2000) using a 100 g sample. The carbohydrate free nitrogen extract, was determined by calculating the differences in 100 g of all the components using AOAC official method 986.25 1986 (AOAC, 2000). Crude fiber was determined according to the 991.42 and 993.19 AOAC methods. Fat was analyzed by petroleum ether extraction using a Soxhlet apparatus according to the 920.39 AOAC methods (2000). Vitamin C content was determined using 2, 6-dichlorophenol indophenol titrimetric method (AOAC, 2000); whereas energy were determined by bomb calorimeter.

Atomic absorption spectroscopy (AAS)

The Ca, Mg, K, Na, Mn, Fe, Zn, Cu, P, Pb and Cd contents were determined using the dry-ashing procedure 968.08 (AOAC, 2000). Their ion concentrations were measured with a double beam Atomic absorption spectrometer, (Shimadzu, AA - 630 - R). The organic components were previously eliminated at 550°C for 24 h.

RESULTS AND DISCUSSION

Proximate composition

The proximate composition of *O. ficus-indica* from Laikipia, Kenya is given in Table 1. These were compared with results from Ethiopia (Tegegne, 2001), Egypt (El Samahy et al., 2006), and USA (Feugang et al., 2006). There was no major variation in moisture content which ranged between 84 to 90% (Feugang et al., 2006) and the highest value of 92% obtained by Tegegne (2001). This is just an indication of the succulent nature of the fruit pericarp. The small variation may result from

Table 1. Proximate composition of *Opuntia ficus-indica* (L.) fruits with spines.

Sample	Composition
Moisture content (%)	87.07 ± 0.86
Ash (%)	4.03 ± 0.52
Vitamin C (mg/100 g)	5.17 ± 0.06
Protein (%)	1.03 ± 0.0.06
Crude fat (%)	0.40 ± 0
Crude fibre (%)	1.37 ± 0.06
Calorific value (Kcal/g)	3.77 ± 0.06
Sugars (NR) (%)	59.40 ± 0.10
Carbohydrates (%)	92.57 ± 0.99

Table 2. Mineral composition of Opuntia *ficus-indica* (L.) fruit samples (mg/100g, dry matter).

Mineral	Composition
Mg	63.4
Na	18.7
K	108.8
Ca	316.5
Mn	37.8
Fe	25.9
Zn	12.6
Cu	0.01
P	0.05
Pb	0
Cd	0

difference in season whether wet or dry. Sample A was lowest since it was collected during the driest month of the region when temperatures were over 26°C in September. A high value of 4.03 ± 0.52% ash content was recorded from the Kenyan sample whereas all the others gave an average of 0.3%. Ash content depends on the age of the fruit (Hernandez-Urbiola et al., 2010) and season Retamal et al., 1987). Sample A was collected during a dry season. Vitamin C varied from the 3 recorded sources with the highest value of 13.7 mg/100g by El Samahy et al. (2006) and the lowest value of 5.17 ± 0.06 mg/100g from the Kenyan sample. The higher the intensity of light during growing season, the higher the vitamin C content (Lee et al., 2000). Other favourable conditions include less irrigation, low temperatures during harvesting and storage. Physically damaged fruits also recorded low vitamin C content (Lee et al., 2000). Proteins ranged between 0.2 to 2.0%, the low values expected since very few fruits have proteins. Crude fat was less than 0.1% except in A (0.40 ± 0)%. The low levels indicate that the fruits are not a good source of energy (Samson, 1986). Crude fiber ranged from 0.002% as the lowest and 3.15% as the highest value both reported by Feugang et al. (2006), however calorific value only reported in A was 3.77 kcal/g a low energy value as indicated by the low crude fat. Sugars varied in the reported samples with El Samahy et al. (2006) giving the lowest value of 0.11% and the highest value of 59.40 ± 0.10% from the Kenyan sample. These values depend on season (Retamal et al., 1987). The lowest value of 12 to 17% carbohydrates probably indicates the sample was collected during a drier season (Retamal et al., 1987).

Mineral composition

The mineral composition reported (Table 2) varied appreciably from those by Tegegne (2001) which reported the highest value of 140 mg/100 g Mg and 16.1 mg/100 g as the lowest reported by Feugang et al. (2006). Tegegne (2001) reported the highest value of 450 mg/100 g sample Ca, 316.5 mg/100 g from the Kenyan sample and 12.8 mg/100 g by Feugang et al. (2006). K registered high values of 220 mg/100 g from the report by Feugang et al. (2006). The lowest value of 40 mg/100 g K was reported by Tegegne (2001) indicating the fruits were mature (Hernandez-Urbiola et al., 2010); however Na was low with values ranging from 0.6 mg/100 g (Feugang et al., 2006) to 70 mg/100 g (Tegegne, 2001). The Kenyan sample reported high values of transition metals, Mn (37.8 mg/100 g) compared with 0.35 mg/100 g reported by Jana (2012), Fe (25.9mg/100g) compared with 0.4 mg/100 g (Feugang et al., 2006) and Zn (12.6 mg/100 g) compared with 1.0 mg/100 g (Jana, 2012). Toxic elements like Pb and Cd were absent.

Conclusions

The trend towards product development from natural sources has increased. The data obtained as well as that of already published work are an important indication of a potential food and economic utility of *O. ficus-indica* (L.). From this study, it is evident that the nutritional composition of *O. ficus-indica* (L.) varies with respect to age, postharvest handling and season; however, irrespective of the origin or variety, the fruits are a good natural reservoir of minerals such as Mg, Ca and K whose nutritive components and antioxidants such as vitamin C 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. Toxic elements such as lead and cadmium are absent, indicating the safety of the fruit as food.

ACKNOWLEDGEMENTS

We would like to acknowledge the contribution of the community from Mukogodo in Laikipia district for their information concerning these fruits and our partners, Forest Service, Nanyuki and African Wildlife Forum (AWF) for their support on the ground, KEFRI for provision of technical support, and finally USAID for provision of funds.

REFERENCES

AOAC (2000). Official Methods of Analysis, 17th Ed. Association of Official Analytical Chemists, Gaithersburg, USA. Broihier K (1999). The Phyto-chemical Renaissance. Food Processing. 44:46-48.

Castellar R, Obón JM, Alacid M, Fernández-López JA (2003). Color properties and stability of betacyanins from *Opuntia* fruits. J. Agric. Food Chem. 51:2772-2776.

Chessa I, Nieddu G (1997). Descriptors for Cactus pear (opuntia spp.). In: Newsletter CACTUSNET, FAO, Special issue, p. 39.

El-Samahy SK, Abd El-Hady EA, Habiba RA, Moussa TE (2006). Chemical and rheological characteristics of orange-yellow cactus pear pulp from Egypt. J. Prof. Assoc. Cactus Dev. 8:39-51.

FAO (2001). Cactus (*Opuntia spp*.)as forage. Plant Production and protection paper 169. Rome Italy. p. 91.

Feugang MJ, Konarski P, Zou D, Stintzing FC, Zou C (2006).Nutritional and medicinal use of Cactus pear (Opuntia spp.) cladodes and fruits. Frontiers in Bioscience 11:2574-2589.

Gabremariam T, Melaku S, Yami A (2006). Effect of different levels of Cactus (*Opuntia ficus - indica)* inclusion on feed intake, digestibility and body weight gain in tef (*Eragrostis tef*) straw - based feeding of sheep. Anim. Feed Technol. 131:43-52.

Gallegos-Infante JA, Rocha-Guzman NE, González-Laredo RF, Reynoso-Camacho R, Medina-Torres L, Cervantes-Cardozo V (2009). Effect of air flow rate on the polyphenols content and antioxidant capacity of convective dried cactus pear cladodes (*Opuntia ficus indica*) Int. J. Food Sci. Nutr. 60 suppl 2:80-87.

Hernández-Urbiola MI, Contreras-Padilla M, Pérez-Torrero E, Hernández-Quevedo Rojas-Molina JI, Cortes ME, Rodríguez-Garcia (2010). Study of Nutritional composition of different maturity stages. The open Nutritional Journal 4:11-16.

Jana S (2012). Nutraceutical and functional properties of catus pear (Opuntia spp.) and its utilization for Food Applications. JERS 3(2):60-66.

Kuti OJ (2004). Antioxidant compounds from four *Opuntia* cactus pear fruit varieties. Food Chem. 85(4):527-533.

Lee KS, Kader AA (2000). Preharvest and Postharvest factors influencing Vitamin C content of horticultural crops. Postharvest Biol. Technol. 20: 207-2010.

Livrea MA, Tesoriere L (2009). Antioxidative effects of cactus pear [*Opuntia ficus-indica* (L) Mill] fruits from Sicily and bioavailability of betalain components in healthy humans. Acta Horticult. 811:197-204.

Moβhammer MR, Stintzing FC, Carle R (2006). Cactus pear fruits (Opuntia spp.): A review of processing technologies and current uses. J.PACD.

Retamal N, Duran JM, Fernández J (1987). Seasonal variations of chemical composition in prickly pear [*Opuntia ficus - indica* (L.) Miller]. J. Sci. Food Agric. 38:303-311.

Rodriguez-Felix A, Cantwell M (1988). Developmental changes in composition and quality of prickly pear cactus cladodes (nopalitos). Plant Foods Hum. Nutr. 38:83-93.

Rodriguez-Garcia ME, de Lira C, Hernández-Becerra E, Cornejo-Villegad MA, Palacios-Fonseca AJ, Rojas- Molina I, Reynoso R, Quintero LC, del Real A, Zepeda A, Muňoz-Torres C (2007). Physicochemical characterization of Nopal pads (*Opuntia ficus indica*) and dry vacuum nopal powder as a function of the maturation. Plant Foods Hum. Nutr. 62(3):107-112.

Samson JA (1986). Tropical Fruits. Longman Group Limited, London p. 336.

Shi H, Chen K, Ren S, Wang X (2004). Development of *Opuntia dillenii* Haw beer. In: Chin with Engl. Abstr. Food Sci. Technol./Zhonggio Shipin (2):79-81.

Siriwardhana N, Shahidi F, Jeon YJ (2006). Potential antioxidative effects of cactus pear fruit (*Opuntia ficus-indica*) extract on radical scavenging and DNA damage reduction in human peripheral lymphocytes. J. Food Lipids. 13:445-458.

Stintzing FC, Schieber A, Carle R (2000). Cactus pear - a promising component to functional food. Vegetable and potato Processing 85:40-47.

Stintzing FC, Schieber A, Carle R (2001). Phytochemical and nutritional significance of Cactus Pear. Eur. Food Res.h and Technol. 212:396-407.

Tegegne F (2001). Nutritional value of *Opuntia ficus - indica* as a ruminant feed in Ethiopia. In: Cactus (*Opuntia* spp.) as forage. FAO Plant Production and Protection Paper 169. FAO, Rome. pp. 91-99.

Tesoriere L, Butera D, Allegra M, Fazzari M, Livrea MA (2005a). Distribution of betalain pigments in red blood cells after consumption of cactus pear fruits and increased resistence of the cells to *ex vivo* induced oxidative hemolysis in humans. J. Agric. Food. Chem. 53:1266-1270.

Tesoriere L, Butera D, Pintaudi AM, Allegra M, Livrea MA (2004). Supplementation with cactus pear (*Opuntia ficus-indica*) fruit decreases oxidative stress in healthy human: A comparative study with vitamin C. Am. J. Clin. Nutr. 80:391-395.

Turker N, Coskuner Y, Ekiz HI, Aksay S, Karababa E (2001). Effect of fermentation on the stability of yellow - orange pigments extracted from cactus pear (*Opuntia ficus - indica*). Eur. Food Res. Technol. 212:213-216.

Wolfram R, Budinsky A, Efthimiou Y, Stomatopoulos J, Oguogho A, Sinzinger H (2003). Daily prickly pear consumption improves platelet function. Prostaglandins Leukot. Essent. Fat. Acids. 69:61-66.