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Overview of Cactus (*Opuntia Ficus-Indica* (L): A Myriad of Alternatives

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ABSTRACT The paper reviewed in detail the following for *Opuntia ficus-indica* including the origin and varieties, the morphology, the success and the potential limitations, nutritional qualities of cactus, constituents of the seeds/ fruits, storage of *Opuntia* fruits, consumption, nutritional qualities, health implications, mineral element composition including Crude Protein (CP), Acid Detergent Fiber in cactus (ADF), Neutral Detergent Fiber (NDF) Cellulose, Hemicellulose, Lignin, Non Fiber Carbohydrates (NFC), ether extract, minerals, phosphorus, potassium, calcium, magnesium, sodium, elemental concentration and the ecological and environmental usefulness. The paper concluded that the fortified and high-energy, nutrient-endowed cacti stands as a myriad of alternatives protecting the already ailing and depleted natural resources, providing farmers and livestock with a definite source of water during period of water stress, and serving as medicinal, food and vegetables for humans. As the intuition and consciousness of these benefits spreads, cactus-producing countries should be encouraged to improve their cultivation practices for these valuable plants of cacti.

INTRODUCTION

The quest for drought resistance fodder crops has been the ultimate concern for nutritionists. Losses incurred as a result of drought, exacerbated by concomitant weather vagaries have been substantial in the livestock sector. In order to ameliorate the effect of drought in arid and semiarid regions, the cultivation of drought resistance fodder crops becomes imminent. Generally, the cactus plant has exhibited ideal characteristics of being a drought tolerant plant species. The cactus (*Opuntias ficus-indica*) originated from Mexico and later extended to Central America, and the southern part of United States of America. It later spread to Africa, Asia and southern Europe (USDA 2009). The cactus is cultivated and used as fodder crops and medicinal plants in more than 30 countries but regarded as a toxic weed in South Africa and Australia. In Chile, Algeria, Mexico and Brazil, large areas are used for the cultivation of cactus. It is regarded as an alternative or backup feedstock in periods of drought as cacti remain succulent and fresh for longer periods (Houerou 1992). The paper reviewed in detail the origin and varieties, the morphology, the success and the potential limitations, nutritional qualities of cactus, constituents of the seeds/fruits, storage of *Opuntia* fruits, consumption, nutritional qualities, health implications, mineral element composition including Crude Protein (CP), Acid Detergent Fiber in cactus (ADF), Neutral Detergent Fiber (NDF) Cellulose, Hemicellulose, Lignin, Non Fiber Carbohydrates (NFC), ether extract, minerals, phosphorus, potassium, calcium, magnesium, sodium, elemental concentration and the ecological and environmental usefulness of *Opuntia ficus-indica* was also discussed. The paper therefore, critically examined the potential benefits and limitations of cacti within the contemporary societal spectrum.

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Objectives of the Study

The paper examined in detail, firstly, the morphology, the nutritional qualities of cactus, health implications, mineral element composition, and secondly, the ecological and environmental usefulness of *Opuntia ficus-indica*.

METHODOLOGY

Varieties of Cactus

The paper reviewed the commonly cultivated types of cactus, which include *Opuntia ficus-indica* (L) or cactus decumanus wild, *cactus ficus-indica* L., *Opuntia amyclaea* Ten., *Opuntia cordobensis* Speg., *Opuntia gymnocarpa* F.A.C. Weber., *Opuntia hispanica* Griffiths, *Opuntia maxima* Mill., *OpuntiaMegacantha* Salm-Dyck., and *Opuntia paraguayensis* k, Schum (USDA 2009). The Oputia ficus-indica is well adapted to arid regions and its one of the most important cactus specie. It is use as food, fodder, dye, a source of energy and can also assist in ecosystem preservation (Small and Catling 2004). The botanical classification of cactus is given in Table 1.

Table 1: The botanical classification of cactus

Kingdom	*Plantae*
Division	Magnoliophyta
Class	Magnoliopsida
Order	Caryophyllales
Family	Cactaceae

The Morphology of Cactus

Cactus is generally called prickly pears with approximately 130 genera and 1,500 species. The cactus is a perennial shrub with a varying height depending on the variety. The tallest species, which is the *pachycereus pringlei* grows to a height of 19.2 meters and the smallest specie is *Blossfeldia liliputiana*, with only 1 cm diameter at maturity. It has a horizontal root system, which ramifies into the soil. The stems are thick, succulent and oblong shaped. It has a thick waxy epidermis with a property of repelling water and also reflecting sunlight. Most of the leaves are thorny and some varieties are without thorns or spines. Flowering of cactus occurs on the clados, which is about 1-2 years old, and flowers opens up in the morning (Ecocrop 2009; ICARDA 1993). The fruit, which is edible, is succulent, reddish and ellipsoid with a length of approximately 7 cm. The *Opuntia* variety of cactus are edible and are cultivated in most countries for its nutritional and agronomic benefits, such as higher yield output, higher protein content, resistance to insects and cold condition. However, the spineless varieties are extensively used for fodder (Mondragon-Jacobo et al. 2001). The cactus yield output is between 5 to 6 tons per hectare annually with 40 tons of dry matter achievable and fruit yield may be up to 20 ton per hectare (Reynolds 2001). *Opuntia* do not tolerate salinity and water logging, but thrive well in dry conditions, uneven rainfall and poor soil (Orwa et al. 2009) (Fig. 1).

Fig. 1. Pictographic view of the morphology of cacti plant

OBSERVATIONS AND DISCUSSION

Cactus: The Success and the Potential Limitations

Opuntia are mostly eye-catching as fodder for animals because of its inherent efficiency in the conversion of water to dry matter (DM). Cactus has the potential of not only decreasing the carbon dioxide (CO_2) levels in the atmosphere through the gas exchange pattern referred to as Crassulacean Acid Metabolism (CAM) but also assists in the control of soil erosion by providing cover and enhancing afforestation. They also assist in the conservation and protection of local fauna by surviving in arid conditions (Reynolds et al. 2001). The rapid spread of cactus and its rigorous adaptability is however worrisome, as it stands a threat to the native plants, which have lead countries like South Africa and Australia to adopt biological control measures to curtail the spread (Reynolds et al. 2001). The presence of spines and stiff bristles on the surface of the cladode has been attributed to irritations in livestock and spines may also cause injuries when taken by livestock (Greenberg 2003). The presence of oxalate crystals in cactus reduces the presence of calcium in the body of the animal (Barceloux 2008). However, Nobel (2002) posited that by counter balancing the calcium to phosphorus ratio, and the use of phosphorus and nitrate lick, the non-availability of calcium in the body of the animals that consumes cactus fodder has been a thing of the past. Instances are abound, where cases of diarrhea have been reported in livestock because of excess intake of cactus as fodder, although with provision of fiber in the diet of the livestock have proven to be good remedy to the prevalence of diarrhea (Nefzaoui et al. 2001). In addition, the problem experienced in feeding animals with cactus may be exposure to laxative syndrome. The laxative symptom exhibited by animal fed with cactus is not a disease condition but the only disadvantage is that there is faster passage of food through the digestive tract, thus reducing digestibility. Measures to reduce the laxative effect is to allow animals fed with cactus access to grazing veld or the addition of roughages or the inclusion of lime at the rate of three percent to the ration of the animal to counteract the laxative condition (De Kock 2001). This is another motive why the inclusion of lucerne to the diet of animal fed with cactus is very critical (De Kock 1980). In humans, the occurrence of dermatitis and conjunctivitis has also been reported following the consumption of cactus (David et al. 1990).

Nutritional Qualities of Cactus

Cactus is an important fodder for livestock in areas where water is a limiting factor in pasture cultivation and also acts as an emergency source of water and feed (Dos Santos et al. 2001). Cactus has a high level of calcium and carbohydrates (energy) with digestibility of more than seventy percent. The succulent spineless cactus with high moisture content can be helpful during dry periods when water becomes scarce for livestock. Succulent spineless cactus pad contains approximately ninety percent of moisture and ten percent dry matter (De Kock 1998). The succulent pads usually serve as sources of drinking water for livestock. However, studies have shown that sheep kept in kraal can perform without water for more than 500 days if they have daily intake of enough quantities of spineless cactus (Potgieter 2007). This is further substantiated by another study, which posited that sheep fed on succulent spineless cactus pads barely drink any water and the high moisture content of succulent cactus limits the amount of cactus intake by sheep that is provided with water (De Kock 1983). In Tunisia, a study shows that lambs that were fed on straw supplemented with cactus and saltbush grew at the rate of 80 grams per day and dairy cattle in Brazil, after been fed with a complete mixed ration made up of sixty percent grounded cactus cladodes, twenty percent chopped hay, and twenty percent protein-rich concentrate, yielded around 25 liters of milk per day (ICARDA 1993). In South Africa, lambs fed on a ration of sundried cactus cladodes mixed with lucerne, yellow maize, sunflower olive cake meal, and molasses perform in growth at similar rate with those on conventional ration (ICARDA 1993).

Though cactus fruits are used in most pharmaceutical industries and as a health support in most traditional societies, the vegetative parts are seldom used in modern nutrition and medicine (Stintzing and Carle 2005). The peyote extracts (*Lophophora williamsii*) obtained from cactus is a famous psychoactive agent used by Native Americans southwest of USA. The pey-

ote has been linked to the regulation of blood pressure, sleep, hunger and thirst, and also acts as a stimulant to the central nervous system (Franco et al. 2003). Cactus pear fruit extract is used extensively as a traditional medicine for healing of first degree skin burned wound, and also for the treatment of edema and constipation in human (Choi et al. 2002).

According to study, the anti-oxidative and DNA damage-reduction activities are enhanced with increased cactus pear fruit extract (CPFE). This phenomenon shows that the anti-oxidative and DNA damage-reduction effectiveness of CPFE constituents as conceivable sources of raw material for pharmaceutical and food processing industries (Siriwrdhana et al. 2006). It has also been discovered that Arizona cactus pear extracts have the potential attributes of inhibiting cell growth in cancer cell cultures, reduce the growth of tumor in nude mice and also assist in changing the tumor-linked genes. However, Zou et al. (2005) posited that the cancer-remedy effects of cactus have to be examined in details. The seeds that emanates from cordon cactus (*Pachycereus Pringlei*) are well known to be edible and nutrient based and the plant itself is used in parts or as a whole in traditional medicine (Holgiun et al. 1993). Among other species of Cacti such as the prickly pear, Hylocereus, *Opuntia tuna*, *streptacantha*, *cardona*, *Hylocereus undatus Carnegiea gigantea*, and *Escontria chiotilla* are also considered widely as edible while Mytillocactus geometrizans are displayed for sale in Mexican markets tagged as Garambullos (Strit et al. 2004). In another study, a food product made from *Opuntia ficus-indica* called "NeOpuntia" manufactured by Bio Serae Laboratories were found to contain hypolipaemic properties, which assist humans suffering from lipid metabolism disorder (Ennouri et al. 2007).

The Constituents of *Opuntia* Seeds/Fruits

Opuntia cacti fruits were found to contain minerals, vitamins, sugars and amino acids at varying levels. However, the weight of cacti varies from 80 grams to 140 grams with average edible part as 54.18 percent (Bekir 2006). The ascorbic acid and beta-carotene content of cacti were in varying proportion of 14.7 mg/100g and 334.0 mg/100g correspondingly (Bekir 2006). The range of pectin content of cacti varies from 5.32 to 14.19 percent (Ghaleb et al. 2003), and in contrast to mucilage, which vary from 3.78 and 8.5 percent (Pena and Sanchez 2006). The cactus spear fruit is made up of vitamin C and its consumption affects the redox balance of the body, reduces the oxidative damage to lipids and improves antioxidant levels of humans (Tesoriere et al. 2004; Nalin and Jeon 2004). It has also been discovered that cactus fruits contains belatins pigments and cactus fruit concentrates, which are useful in the preparation of yoghurt and ice cream (Stintzing and Carle 2006). Some of the cactus that are purple also contains belatins, which are potential antioxidants and colorants similar to the pigment found on red beet used extensively in food industries (Saenz 2006). A research study portrayed that cactus pear oil extracts and cactus pear seeds are invaluable in the reduction of serum cholesterol level (Ennouri et al. 2007). The cactus cultivar called *gialla* has 13 types of betaxanthins (Kugler et al. 2007). Opuntia undulata and *Opuntia ficus-indica* species contains betacyanins and betaxanthins respectively, while the fresh fruit of *Opuntia stricta* shows a higher level content of betanin and isobetanin of 80mg/100g (Casteller et al. 2003).

Storage of *Opuntia* Fruits

Despite the inherent benefits associated with cactus, low acidity and soluble solids contained in the fruits renders the fruits vulnerable to the growth of microorganisms, thus requiring a thermal handling to control the microbial activities. The fruit stored in cold condition enhances its suitability, reduces water loss and fungal development (Ochoa et al. 2006). The stem of cactus can be preserved up to 32 days in a Modified Atmosphere Package (MAP) by allowing CO_2 concentration of 20 KPa thus the quality remains intact. A freshly chopped cactus has a shelf life of 20 days when packed in bidirectional polypropylene bags and stored at a temperature of 4^{o} C (Corrales et al. 2006). In contrast, slightly processed cactus especially the *Opuntia ficus-indica* cladodes have a shelf life of 1-2 days at room temperature, and with increase temperature to 5^{o} C, the shelf life will be extended to 7 days. Browning and mucilage secretion shortens the shelf life of cactus cladodes (Quevedo et al. 2005) (Fig. 2).

Consumption of Cacti as a Vegetable

Cactus vegetables are well known and used extensively in Mexico and some Central Ameri-

Fig.2. Pictographic view of the fruiting period of cacti

Fig. 2. Pictographic view of the fruiting period of cacti

can countries and other parts of Europe, Middle East, India, North America and Australia, while its popularity and use is gaining momentum in the United States. The edible cactus that serves as vegetables are mostly of the *Opuntia ficus-indica* varieties. Edible cactus is made up of fleshy oval leaves referred to as pads or sometimes called paddles. The nopal or nopalito is the name given to the vegetative part (young cladode or pad). The entire parts of *Opuntia* spp are edible, the parts the fruit commonly referred to as prickly pear (Russell and Felker 1987). The dietary nutrient values found in Nopales (Opuntia ficus-indica) are listed in Table 2. Table 2 illustrates a detailed composition of nutrients available in Nopales (*Opuntia ficus-indica)*, in nutrition value per 100g and Recommended Daily Allowance (RDA).

The Health Implications of Consuming Cacti

The soft paddles are good sources of nutritional fiber and it contains pectin, mucilage and hemicellulose. These substances that are present assist in lowering body weight, cholesterol and blood glucose levels in the human body (Hahm 2010; Wolfram et al. 2003). Consuming nopales not only lower blood sugar level in diabetic patients but also assist in the protection of liver from fatty liver disease (Frata-Munari et al. 1989; Hahm 2010; Moran-Ramos 2012). The medicinal properties of cactus are numerous, and research has shown that the fruits are effective in the reticence of cancer growth (Zou et al. 2005) and against colon and prostate cancer cells (Chavez-Santescoy et al. 2009). Nopales vegetables from cacti are noted to possess very low calorie. About 100g of freshly prepared vegetable leaves provide just 16 calories. However, the leaves (paddles) have many vital phytochemicals, fiber, anti-oxidants, vitamins, and minerals that are of benefits to health (Kuti et al. 2004; United State Department of Agriculture (USDA) as illustrated in Table 2.

Studies also show that the ration containing cacti assist in the prevention of skin cancer (Lee 2013). Additionally, liquid extracted from the nopales has the properties of acting as an immune booster and also the daily consumption of nopales in any form improves the functioning of the blood platelet (Wolfram et al. 2003). Recent studies also exemplified the remedial medi-

Table 2: Nutrient composition of *Opuntia ficus-indica*

Nutrients	*Nutrient value*	*Percentage of RDA*
Energy	16 Kcal	≤1
Carbohydrates	3.33 g	2.56
protein	1.32 g	2
Total fat	0.09 g	≤ 1
Cholesterol	0 mg	0
Dietary fibre	2.2 g	5.5
Vitamins		
Folates	3 µg	≤ 1
Niacin	0.410 mg	2.5
Pantothenic acid	0.167 mg	3
Pyridoxine	0.070 mg	6
Riboflavin	0.041 mg	3
Thiamine	0.012 mg	1
Vitamin C	9.3 mg	15.5
Vitamin A	457 IU	15
Vitamin E	0.00 g	0
Vitamin K	5.3 µg	4.4
Electrolytes		
Sodium	21 mg	1.5
Potassium	257 mg	5.4
Minerals		
Calcium	164 mg	16
Copper	0.052 mg	6
Iron	0.59 mg	7
Magnesium	52 mg	13
Manganese	0.457 mg	20
Phosphorus	16 mg	3
Selenium	0.7 µg	1
Zinc	0.21 mg	5
Phytonutrients		
Carotene-β	250 µg	
Carotene-α	48 µg	
Lutein-zeaxanthin	0 µg	

cal characteristics of cactus fruit in the healing of alcohol related damages to the system (Alimi et al. 2012).

Mineral Element Composition of Cactus

The Crude Protein (CP)

The Crude Protein (CP) content of many varieties of Opuntia cladodes ranges from 3.66 percent to 8.08 percent on dry matter basis as exemplified in the study by Mciteka (2008). The *Opuntia engelmannii, Opuntia stenopetala* and Australian variety have 3.32 percent, 8.84 percent and 6.82 percent of crude protein, respectively (Tegegne 2001; Pretorious et al. (1997). These differential levels of crude protein content recorded could be attributed to climatic variations coupled with soil condition and the level of fertilization. Generally, with the exception of the Morado variety a good number of *Opuntia* variety has a low crude protein content and thus microbial growth are inhibited. However, the use of cactus cladodes as animal ration has been criticized mainly because of the low level of CP (Pretorius et al. 1997). Other studies claim that some variety, which exhibited CP levels of 9.2 percent and eleven percent and are high enough to enhance microbial growth. Nevertheless, the inclusion of protein supplements remains critical when cacti are used as animal ration (Gregory and Felker 1992).

Acid Detergent Fiber in Cactus (ADF)

Acid Detergent Fiber (ADF) is a representation of the crude lignin, silica and cellulose proportion of a given plant material (Van Soest 1967). The proportion of ADF in most Opuntia varieties falls within the average range of 13.66 percent for *fusicaulis* and 17.36 percent for *Castello*. In a study by Ben Thlija (1987), average ADF levels of 15.89 percent were recorded for *Opuntia engelmannii, Opuntia filipendula, Opuntia versicolor, Opuntia polyacantha* and *Opuntia fragilis* on the basis of a dry matter. However, cactus hay may not be fed solely to animals because of its low level of ADF content, and hence the inclusion of other plant material becomes critical.

Neutral Detergent Fiber (NDF)

The Neutral Detergent Fiber (NDF) measures the level of cellulose, hemicellulose, lignin silica, tannins and cutins in plants. These components enhance plant rigidity and assist the plant for support as it grows. The breakdown of cellulose and hemicellulose by microbial bacteria in the rumen of ruminants assist in the release of energy to the animals (Schroeder 1994). The results from the study by Schroeder (1994) showed that *Opuntia* varieties have varied NDF percentages.

Cellulose

The principal component of the cell wall of plants generally is cellulose. The availability of this cellulose is more pronounced in fibrous seeds. It records a very low level of digestibility and may hinder the digestibility of other nutrients. Livestock partially digest cellulose and there is substantial evidence from research suggesting that there are chemical links between

cellulose and hemicellulose and as well as between cellulose and lignin. The average cellulose content of *Oputia* varies according to varieties (Thlija 1987).

Hemicellulose

The alkali-soluble cell wall polysaccharide usually linked with cellulose is referred to as hemicellulose. However, critics like McDonald et al. (1991) asserted that the name hemicellulose is ambiguous because by implication, hemicellulose is eventually converted to cellulose. Hemicellulose is structurally made up of D-glucose, D-galactose, D-mannose, D-xylose and L-arabinose units linked together in diverse combinations and in many glycosidic linkages with uronic acid combined. Nonetheless, studies from literature shows that the hemicellulose that is present in different *Oputia* is at variance.

Lignin

Lignin is described as that part of the plant material, which is indigestible and also impacts the digestion of plant cells wall material adversely. The lignin is a component of Neutral Detergent Fiber (NDF) and accounts for about thirty to eighty percent of organic matter in forage crops. It has been observed that ruminant animals that exhibit microbial fermentation are well adjusted in the use of plant fiber for energy (Schroeder 2004). The higher NDF in forage indicates a higher lignin content, which in turn reduces digestibility and less forage consumption (Schroeder 2004). However, the *Castello* variety of *Oputia* has the lowest ligin content.

Non-Fiber Carbohydrates (NFC)

The Non-Fiber Carbohydrates (NCF) are present in varying proportions in different varieties of *Opuntia*. The study by Mciteka, (2008) reveals that *Opuntia* varieties like the *Montery, Castello, Rubasta, Chicco, fusicaulis,* and *Morado* has the following percentage content of 33.7 percent, 48.64 percent, 48.64 percent, 48.43 percent, 34.28 percent 45.41 percent and 33.37 percent, respectively. The NFC is known as a non-cell wall portion (such as starch, sugar and pectin) that is made up of highly digestible energy source, which is required together with degraded protein for microbial activities. NFC portions are fermented by bacteria in the rumen of ruminant animals and are utilized as a source of ammonium or peptide (Russell et al. 1992). In contrast, the NFC content of Opuntia varieties were noted to be lower than that of barley, which stands at sixty-five percent and maize at seventy-five percent on dry matter level (Dupchak 2005). In the study by Mciteka (2008), the NFC compositions of Opuntia varieties were observed to be higher than that of good quality roughages from maize and Lucerne (Dupchak 2005).

Ether Extract

The Ether Extract (EE) is also referred to as Crude Fat (CF), which encompasses all substances that are soluble in ether. The EE also has lipids content, which provide energy and other fat-soluble constituents like chlorophyll and fat-soluble vitamins. However, higher fat levels in the ration of animals reduces feed intake in ruminant animals and obstructs the functioning of the rumen (AOAC 1990). The EE levels of different *Opuntia* varieties are different as per percentages (Zeeman 2005).

Minerals

Opuntia varieties contain mineral elements in varying proportion as exemplified by many studies. The main mineral elements, which are notable, are phosphorus, potassium, calcium, magnesium, sodium, nitrogen and sulphur.

Phosphorus

The element phosphorus assists in the metabolism of energy based food substances and in the formation of strong bones and teeth formation. It is also a protein component in the soft tissues of plants and animals. However, the overall average phosphorus content of many *Opuntia* varieties were noted to be between 0.1 percent and 0.5 percent (Lopez et al. 1988) as cited by Tegegne (2001). The differential levels of phosphorus composition could perhaps be as attributed to varying degrees of soil fertility, cladode age and climatic conditions (Lopez et al. (1988) as cited by Tegegne (2001).

Potassium

The potassium average composition of different *Opuntia* varieties are pronounced at 3.02

percent Dry Matter (DM). Essentially, potassium is important for osmotic regulation and water balance, electrolyte, muscle contraction in animals and nerve impulse conduction (Maynard 1979). Retamel et al. (1987) asserted that the age of cactus cladodes has effects on the percentage of potassium availability.

Calcium

Similar to phosphorus, calcium is also present in *Opuntia* in the form of oxalate crystals and druses, and it also assists in the hydrolysis of ATP and phospholipids. It also helps in building of bone and teeth formation, blood coagulation and transmission of nerve impulses (McDonald et al. 1981). Most Opuntia varieties contain calcium levels, which apparently are above that which is required for the optimal performance of sheep and cattle put at 0.18-0.66 percent of Dry Matter (DM) (NRC 1989). In their study, Nefzaoui and Ben Salem (1998) opined that the prevalent high level of calcium in *Opuntia* varieties maybe as a result of the cladodes possessing a high level of oxalates content of thirteen percent where forty percent is in soluble form bound to calcium.

Magnesium

The quantity of magnesium present in *Opuntia* species is relatively high and it increases with the age. Magnesium assists and plays a role in protein synthesis, fats and carbohydrates metabolism and enzymes activator (McDonald et al. 1995). There is however, low absorption of magnesium exacerbated by the presence of potassium, which reduces the efficacy of absorption and transportation in the walls of the rumen against the electro-chemical gradient.

Sodium

The prevalent of the element sodium in *Opuntia* is low as compared to other elements. Retamel et al. (1987) observed that the low level of sodium in *Opuntia* was likely due to low genetic ability for accumulation and low requirement for growth and development or its low availability in the soil. However, the importance of sodium in the ration of farm animals cannot be underestimated, as it is responsible for the acid-base balance, muscle shrinkage and contraction, and nerve transmission. It is also important for glucose absorption and the transportation of amino acid (McDonald et al.1995). Sodium (Na) is also responsible for acid-base balance, muscle contraction and nerve transmission. From the review of elemental composition of *Opuntia*, (Calderon 1995) most varieties have higher moisture content and this justifies the assertion that during droughts, *Opuntia* becomes a valuable source of water, and energy. Seemingly, the CP content of *Opuntia* is low but with a higher percentage of ash and the minerals like Mg, K, and Ca remains relatively in abundance.

Opuntia has other further uses in the likes of the preparations of mock-gherkins, jams and soap from its leaves, fermented into alcoholic drinks, with seeds converted for honey and cheese production. Some varieties like the cactus spear are used as red colorant (Casteller et al. 2003). According to studies, the mucilage from prickly pear cactus apart from been edible also act as preservative in extending the shelf life of strawberries (Del-Vale et al. 2005). The mucilage found in cactus contains diverse and varying fractions of "L-arabinose, D-galactose, L-rhamnose, D-xylose and galac-turonic acid". Studies reveal that cactus mucilage is used locally in the purification of drinking water and also assists in the improvement of house paint. Lately, a cactus cladode extract was confirmed to enhance water infiltration into the soil (Saenz et al. 2004). *Opuntia* especially the spines varieties are frequently used for fencing in local areas (Table 3).

Table 3: Elemental concentration of *Opuntia*

Source	*Concentration (g/m³) Nutrient*	
Potassium nitrate	150-250	N
Phosphoric acid	40	P
Potassium sulphate	289.4-350	K
Calcium nitrate	210	Ca
Magnesium Sulphate	40	Mg
Ferrous sulphate	12	Fe
Copper sulphate	0.1	Cu
Zinc sulphate	0.2	Zn
Boric acid	0.6	B

Ecological and Environmental Usefulness

The hedges of cacti are physical barriers, which assist in the control of wind and soil ero-

sion and land partitioning. The cultivation of cactus helps in maintaining soil fertility through their geo-biogene and microelement cycling activities (Orwa et al. 2009). The spiny varieties of *Opundia* such as the *Amyclaea* and *Forma Elongata,* make good and durable fence for gardens and orchards in some parts of Italy, Spain and North America. It is also often used to demarcate land borders.

CONCLUSION

Organizations such as the International Center for Agricultural Research in Dry Areas (ICARDA), whose primary mandate amongst others is to oversee the collection, publication, distribution of relevant information related to cacti cultivation must incorporate local and international partners with a view of enhancing the technical capabilities of emerging farmers in the production and cultivation of cactus. In sum, concrete and anecdotal evidences are abound to substantiate that cacti generally are potential fodder alternative to livestock nutrition given the immense contribution of cactus to livestock production and human development. Known for their high water retention efficiency and ability to tolerate dry conditions, cacti are progressively being recognized as a more sustainable alternative to local livestock fodder in arid areas.

RECOMMENDATIONS

The fortified and high-energy, nutrient-endowed cactus stands as a myriad of alternatives protecting the already ailing and depleted natural resources, providing farmers and livestock with a definite source of water during period of water stress, and serving as medicinal and food and vegetables for humans. Based on the extensive reviewed literature on cacti, the paper recommends that since the intuition and consciousness of the benefits of cacti plants spreads, producing countries should be encouraged to improve their cultivation practices for these valuable plant cacti.

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