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Cactus as a fodder and beyond

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Last month, FAO jointly with ICARDA (International Centre for Research in Dry Areas) and University of Chile organized 9th International Congress on "Cactus pear and cochineal" in Coquimbo, Chile. At this congress FAO and ICARDA released a document entitled "Crop ecology, cultivation and uses of cactus pear". From mainly the animal feed perspective, this short article aims to provide a brief summary of this document and also presents salient points that emerged from the International Congress.

Against the backdrop of ongoing climate change, frequent and long droughts, and land degradation, cactus has a special place in future sustainable food production systems in dry areas. Among various cacti, cactus pear (*Opuntia ficus-indica*) has drawn extensive attention because of its multi-uses and being free of spines (thorns). Furthermore, it is highly resilient, and has high water use efficiency and

Figure 1. Cactus cultivation on a rocky soil in Chile (Photo credit: Harinder P.S. Makkar)

capability to grow in poor and degraded soils where other plants fail to grow (Figure 1). Mexico is considered as the centre of cactus origin. Cactus is vegetatively propagated and cladodes are used for this purpose. This method of propagation preserves the genetic characteristics of the plant.

Cactus pear (*O. ficus-indica*) is a CAM (crassulacean acid metabolism) plant which offers it tolerance to water scarcity and enhances its survival in harsh climates. The CAM mechanism enables nocturnal CO_2 uptake. Cactus pear opens its stomata at night to fix CO_2 and accumulate and store malate in vacuoles of chlorenchyma cells. Due to low temperatures and high humidity during nights, the transpiration of this plant is 3–5 times lower than C3 and C4 plants, which gives this plant the ability to thrive in semi-arid environments and makes it highly efficient in water use.

Cactus is available in a range of environments, from sea level in the Californian deserts to an altitude of 4 700 m (mean sea level) in the Peruvian Andes, and from tropical areas of Mexico with temperatures greater than 5° C to parts of Canada where temperatures reach as low as -40° C. While its productivity is high in fertile soils and with irrigation, it also grows in poor soils and with little water. It does need well-drained soils and does not tolerate salinity.

Global production scenario

It is cultivated in America, Asia, Africa, Europe and Oceania. Argentina has approx. 1 650 ha under cactus cultivation, Brazil has a cactus production area of 500 000 ha, Chile covers 935 ha; while, Mexico has a cultivated area of approx. 54 000 ha and a large area (3 million ha) is under cactus in the wild as natural plantation. Other countries in America that have cactus plantation are Peru and Bolivia. Brazil and Bolivia use cactus mainly as a fodder crop; while, Chile, Argentina and Mexico use it for fruit production. Cactus in Peru is used mainly (60%) for production of red dye and the remaining (40%) is used for fruit production. Cactus production in Mexico has started using more intensive production practices, lately; for example, adoption of drip irrigation, and cultivation in more benign areas with better quality soil and good rainfall conditions, and use of mechanical fruit-cleaning. In Africa, cactus is cultivated in Algeria (30 000 ha), Ethiopia (360 000 ha, 66% being spiny cactus) and Morocco (120 000 ha). South Africa has approx. 4 500 ha for fruit (33%) and fodder (rest 67%) production, and an estimated 150 000 ha of original cactus infestation is largely used for fruit production for sale in the local market. Cactus area covered in Tunisia is approximately 600 000 ha, mainly for fruit production. In West Asia, Jordan (300 ha), Lebanon (area not known), Syria (area not known), Gulf countries (Oman, Qatar, Saudi Arabia, the United Arab Emirates and Yemen; area not known) and Israel (350 ha) cultivate cactus. In Europe, it is cultivated in Italy (15 000 ha), Portugal (200 ha) and Spain (small orchards; area not known). In some countries cactus cladodes obtained on pruning the cactus orchards established for fruit production are also used for livestock feeding. This has enabled integration of livestock into the cactus production, which brings back nutrients and organic matter to cactus cultivation through manure and also complements farmers' income. Due to lack of information on the area under cactus cultivation it is difficult to assess precisely the importance of cactus in different livestock production systems.

Cactus as animal feed

For sustainable food production systems including livestock production systems, cactus cultivation has a special place in drylands. Water scarcity and rangeland degradation are threatening livestock production in dry areas. Adapted perennial species such as cactus offer opportunities for improving fodder availability in such area. Cactus can produce a biomass from 20 tonnes dry matter (DM)/ha/year to 200 tonnes DM/ha/year. Being rich in water (*ca* 90%), it represents a cost-effective option for water provision to livestock in dry areas. With such high biomass yield (*ca* 60-fold increase over rangeland productivity), it is possible to produce sufficient forage to sustain 4–5 cows per year. A small intensively cropped cactus plantation can produce sufficient fodder, reducing the pressure on overstocked rangelands. The water footprint of cactus is also very low, approx. 250 litres/kg DM. For cactus production systems and agronomical practices for

Figure 2. Harvesting, transporting, processing and feeding cactus in NE Brazil. Photo credit: Jose Dubeux

production of cladodes as animal feed, readers are referred to the references provided in "Further Reading".

Besides water, cactus (*Opuntia* spp.) cladodes are high in sugars, ash and vitamins A and C, but are low in crude protein (CP; 3–5%) and fibre. Most of the nitrogen is present as non-protein nitrogen. The older the cladode, the lower its CP content. The cladodes are highly palatable. They have a high Ca:P ratio. The nutritive value of cladodes varies with species and cultivars. It also varies according to season, agronomic condition, soil, rainfall, fertilization, among others. One- to three-year old cladodes are high in water during winter and spring (85–90%), low in summer (75–85%); and the younger the cladode, the higher is its water content. Provision of chemical fertilizers (ammonite and superphosphate) increased CP content of cladodes from 45 to 105 g/kg DM. Breeding has also been used to increase the CP content of cladodes to 10%. The carbohydrates content is approx. 60%, β-carotene level is approx. 0.65 mg/100 g DM and mucilage is high (6–13 g/kg fresh material). Mucilage concentration in summer is almost 2-fold higher than in winter. It reduces salivation in ruminants, which avoids a rapid decrease in rumen pH. Other soluble carbohydrate-rich feedstuffs, such as molasses, cause acidosis in the ruminant, because they are low in or free of mucilage. The neutral detergent fibre content varies from 18 to 30%. Acid detergent fibre and acid detergent lignin contents are from 12–20% and 1.5–4.0% respectively.

Use of cladodes as a feed can solve the problem of livestock watering, but attention should be paid to their high water content. Ruminants should not consumes large quantities of cladodes, which may lead to diarrhoea. It is therefore recommended to associate a fibrous feedstuff. Also, since cladodes are low in nitrogen and high in energy, it is vital to supplement them with sources rich in nitrogen. Inclusion of nitrogenous supplements (*Atriplex nummularia* foliage, oilseed meals, urea) in cactus-containing diets is currently the most widely adopted option and good productivity responses have been observed in ruminants animals.

Unlike other fodder and forage crops which need to be stored as hay or silage, cactus is an evergreen crop and can be used round-the-year. Cactus cladodes can

be cut and fed directly to animals. Cut-and-carry is the most commonly used technique for cactus feeding. It prevents wastage and excessive grazing. Cactus being rich in water, plays a crucial role in arid environments as a replacement for drinking water. In dry areas there is a scarcity of water and use of cactus as a feed synergises livestock production in such harsh environments.

Silage-making or drying is feasible, but entails additional costs in terms of handling, energy and labour. In South Africa, the focus of research has been on silage making or drying to make a feed for use as a component by the feed manufacturing industry; while in other countries such as Brazil and Tunisia, the use of fresh cactus for animal feeding is being promoted. Wasted cactus fruits could also be incorporated into the silage, which gives a better quality silage due to sugars present in them. Studies in South Africa showed that feeding dried (sun drying) cactus to beef animals does not affect carcass quality; and in Brazil feeding of a diet containing approx. 70% cactus and 30% concentrate can maintain a cow with daily milk yield of 20 litres. Cactus feeding has been shown to affect fatty acid composition of milk – reduced proportion of stearic and oleic acids, but did not affect other long chain fatty acids, such as linoleic (C18:2) and linolenic (C18:3) acids. Some evidence exists that cactus feeding to small ruminants resulted in increased proportions of linoleic, linolenic and conjugated linoleic acid in meat. Higher proportion of polyunsaturated fatty acids (PUFA) and higher PUFA to saturated fatty acids (SFA) ratio have also been observed. All these changes are considered to have human health benefitting effects.

The blocks containing urea as a source of nitrogen could also be made using cactus fruits and cladodes. These may be stored for use as animal feed during the summer periods when there is scarcity of feed. These blocks could also be used during emergency periods of severe droughts. A number of feeding studies have shown that cactus can improve the nutritive value of poor-quality diets for example crop residue based diets because of its high content of soluble carbohydrates. It also increases weight gain in small ruminants and heifers fed on crop residues or poor-quality pastures, provided that a small amount of a nitrogen source is included in the diet. Studies that replaced 12, 25, 38 and 51% of cracked corn and Cynodon hay by cactus in the diets of dairy cattle showed that cactus can totally replace cracked corn and partially replace the hay (*ca* 40%) without any significant effect on milk production (*ca* 20 litres per day). When cladodes are fed to sheep or cattle with a protein-rich feedstuff, they may replace barley grains or maize silage without affecting body weight gains of the animals.

Further information on feeding of cactus-containing diets and their impact on animals in different production systems is provided in the presentation (made at the International Congress), available as a video at https://youtu.be/u0CxxfaWvVs.

Figure 3. Cactus potential in semiarid regions (picture taken in São Bento do Una, Pernambuco, Brazil). Photo credit: Jose Dubeux

Ecosystem services provided by cactus

In North Africa cultivation of cactus has been practiced for many decades with the aim to improve rangeland. Cactus can prevent soil erosion particularly when established along contours. In Tunisia and Brazil, experiments have shown that cactus in agroforestry systems is more efficient for soil and water conservation than the conventional land uses. The ecosystem goods and services provided by cactus include soil and water erosion control, biodiversity conservation, change in micro-environment especially increase in moisture that promotes growth of adjoining plants and microbiomes, and provision of habitat to wild life, carbon sequestration both above and below soil and enhancement of aesthetic beauty of landscape by greening of dry areas. A holistic approach that integrates environmental conservation, farming system production and socio-economic development through cactus plantation has been suggested.

Other uses of cactus

Besides use of cactus cladodes and waste fruits as a feed for animals and food for humans, cactus has a number of other uses. For over 12 000 years, fresh nopal cactus and its fruits have been consumed by the Mesoamerican civilizations for its nutritional and healing properties. Cactus (*O. ficus-indica*) cladodes, flowers and fruits have been used as a natural medicines in many countries. Fruits are good source of nutrients and antioxidants such as flavonoids, vitamin C and pigments named betalains. Flowers also contain flavonoids and betalains. Betalains is a natural dye and has potential to use as an additive in food products. Cladodes are rich in mucilage and chlorophyll derivatives; while, oil extracted from cactus seeds is rich in unsaturated fatty acids, mainly linoleic acid and phytosterols. Many of the medicinal properties have recently been verified by modern research tools. Cladodes have antiulcer and antiviral effects, protective effect against gastric lesions as well as anti-inflammatory activity. Supplementation of diets with cactus fruits in healthy individuals has shown to improve overall antioxidant status and decrease the oxidative stress. The fruits have also been investigated as cancer preventive using ovarian and cervical epithelial cells, as well as ovarian, cervical, and bladder cancer cells. Feeding of cladodes shows a marked decrease in blood cholesterol and triglycerides levels. Experiments in diabetes mellitus non-insulin-dependent patients have confirmed the hypoglycemic effects of the cladodes. Moreover, the consumption of cactus young cladodes has been shown to reduce obesity and blood glucose. Cactus flowers are dried to prepare infusions, used to prevent prostate cancer. The flowers are also considered to have diuretic and depurative effects, and they are considered to help in removal of kidney stones. Seeds are rich in unsaturated fatty acids, tocopherols and phytosterols. Wound healing properties of oil and cladodes have also been reported.

Juices, marmalades, candies, liquors and syrups are prepared from cactus fruits. A number of functional foods, nutraceutical and cosmetic products from cactus plants are currently available in the global market. Cactus pads, flowers and seed oil are also used to produce soaps, shampoo and cosmetics. Cactus seed oil is used as a cosmetic product – as an anti-wrinkle and anti-aging agent. Cactus cladodes, mixed with animal manure are also good source of biogas production. Cochineal is an insect that thrives on *Opuntia* cactus plant, and is used as a source of carminic acid – a pigment used in food colouring, cosmetics, drugs and fabrics. For further information on medicinal, nutraceutical and food applications of cactus products, readers are referred to FAO-ICARDA (2017) and FAO-ICARDA-ISHS (2017).

Cactus offers the possibility for the local development of industries to manufacture high added value products which are demanded in the global market.

What next

The potential of cactus as a feed in semi-arid areas is underutilized. To further enhance cactus utilization as animal feed, it is imperative to disseminate knowledge on multi-functionality of this crop for dryland areas; and develop it as a sustainable crop, for example by following agro-ecological principles.

The food consumption pattern is changing – there is increase in consumption of animal products, vegetables and fruits. The livestock feed market is increasing at a very high rate and it involves fewer risks than the fruit and vegetable market, giving it a potential for entrepreneurial activity. Need is to develop business models around exploitation of various goods and services that cactus provides to an array of stakeholders from farmers to industries. It means involvement of all stakeholders in the livestock production chain, including producers, suppliers, retail stores, research and extension institutions, and policy-makers. There are tremendous opportunities to develop cactus-based livestock production systems. Cactus production and its use as animal feed provides win-win situations in all the sustainability dimensions. It has potential to contribute positively to addressing sustainability and climate change challenges, and to substantially contribute in achieving Sustainable Development Goals of the United Nations. Strong political will would act as a catalyst in transforming this potential to a reality. Policy-makers and donors must be made aware of the benefits of this multi-purpose "wonder" plant.

Sources and further reading

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