Journal of Environment Natural Resources Management and Society (JENRS): 41-47, 2014
ISSN: 2079-8237
Published: E. U. P
Submitted: May 15, 2014 Accepted: August 1, 2014 Published: September, 2014

Chemical Composition of Cactus (*Opuntia ficus-indica*) and Prosopis Species (*Prosopis juliflora*) as Drought-resilient Feed Resources in Kenya

[1,2,3] Syomiti M., [1]Maranga E.K, [1]Obwoyere G.O, [4]Gebru G and [3]Dana H
[1]Egerton University, [2]Kenya Agricultural Research Institute, [3]Colorado State University, [4]MARIL-Ethiopia

ABSTRACT

Lack of quality feeds is a threat to pastoral production systems that are central to the livelihoods of rural communities in Kenya. Inadequate feed quantity and deficiencies in feed quality are aggravated by the current weather variability due to climate change. Prosopis and Cactus plant species are drought tolerant and can be potential alternative feed resources for pastoral communities. The current study was carried out to determine the feed value of these two plant species. Sampling was done in Baringo, Laikipia, Naivasha and Machakos counties. Different plant parts were sampled for chemical analysis using Near Infra-red Reflectance technique. Old and young leaves, a ripe and unripe fruit of different cactus species, mature and young barks, green and dry leaves and pods and seeds of *Prosopis juliflora* were sampled for analysis. Dry matter ranged from 158 to 180 g/kg DM for young and mature cladodes of spineless Opuntia, respectively and 153 to 172 g/kg DM for young and mature cladodes of spiny Opuntia, respectively. Crude fibre (CF) ranged from 134 to 305 g/kg DM for spiny young and old Opuntia, respectively and 254 to 323 g/kg DM for spineless Opuntia species (young and mature cladodes). CF content of Opuntia species increased with increase in maturity. High content of starch was observed in all the Opuntia species. Higher starch content was reported in the mature cladodes than the young ones. Spiny Opuntia had higher starch content ranging from 61 to 243 g/kg DM (young and mature cladodes respectively) as compared to spineless Opuntia which ranged from 61 to 95 g/kg DM. High contents of starch was also observed in both ripe and unripe fruits of spiny Opuntia, ranging from 136 to 146 g/kg DM (unripe and ripe spiny Opuntia fruits respectively). Mature cladodes of spiny Opuntia had higher ash contents than young shoots, ranging from 39 to 54g/kg DM (young and mature cladodes, respectively). Old barks of *P. juliflora* had the highest ash content (144 g/kg DM) as compared to other parts, with 124 g/kg DM reported for the young barks. Prosopis seed had the highest crude protein (CP) content (400 g/kg DM), and starch contents (129 g/kg DM). High CP content (150 g/kg DM and 200 g/kg DM) was reported for dry and green leaf meals respectively. The study revealed high contents of starch in Opuntia spp, high CP content in Prosopis pods, seed and leaf meals. The high energy and CP pools available in Opuntia species and *P. juliflora* can be exploited as livestock feed supplements in rangelands experiencing energy and protein imbalances due to feed quality variability and frequent droughts posed by climate change.
Key words: Resilience, Climate change, Livestock, Feeds

Corresponding Author E-mail: syomitimargaret@yahoo.com

INTRODUCTION

The declining animal feed supply and quality in arid and semi-arid regions has been aggravated by scarce and erratic rainfall that limits the growth of herbaceous species and biomass in rangelands. Thus, livestock in such regions have to survive on recurrent shortage of feed resources of insufficient nutritional value for most of the year (Robles *et al*, 2008). These drought conditions, exacerbated by climate change will force pastoral communities to look for alternative plants species as forages. Cactus species and *P. juliflora* are such lesser-known and under-utilized feed resources in Kenya.

Although Prosopis species has been reported to improve livestock production in the Kenya's rangelands, pastoral communities have perceived it as a noxious plant responsible for decay of animals' teeth, with subsequent death due to starvation. The problem of *Prosopis* species has elicited mixed reactions by the communities in Baringo County (Syomiti, Unpublished data). In the absence of concrete information about the nutritional significance of Prosopis species in addition to negative community perceptions about its forage value there are many that have expressed the need for an external support to manage its spread or eliminate it altogether and replace it with desirable plant species. However, *Prosopis* species can provide many of the needs of populations living in dry lands of the world, and have the potential to provide much more if knowledge on their utilization is expanded. For instance, a feeding trial in India on livestock using rations containing up to 45% of *Prosopis* species components yielded a 1.5% of cattle body weight with acceptable live weight gains (Tewari *et al*, 2000).

On the other hand, cactus (*Opuntia ficus-indica*) is drought tolerant and makes use of little moisture in the rainy season to produce large quantities of forage and has high carrying capacity than any other drought tolerant fodder in arid and semi-arid areas (Tegegne, 2001). It remains green and succulent during drought thus supplying the much needed energy, water and vitamins to livestock in dry periods. *Opuntia ficus-indica* withstands severe defoliation and has good regeneration ability. This plant material can be easily and inexpensively established and is quite promising because of its low maintenance costs. Due to its anatomic and physiological constitution, Cactus withstands a wide range of soil types as well as harsh climatic conditions. Thus, the development of plausible pastoral systems should incorporate Cactus establishment as a suitable soil conservation plant material. It is also a promising plant for arresting desertification (Nefzaoui and Ben salem, 2001 and De kock, 1980). The fact that Cactus combines drought tolerance and water use efficiency, it produces a large quantity of forage that remains green and succulent in dry periods and makes it the best fodder option in the changing climatic situations (Nefzaoui and Ben salem 2001. The purpose of the current study was to establish the feed value of cactus species and *P. juliflora* as potential, alternative drought- resilience feed resources in Kenya's rangelands.

MATERIALS AND METHODS

Location of the Study

The study was carried out in four pilot administrative counties of Baringo, Laikipia, Naivasha and Machakos, Kenya. Purposive selection of these study sites was used due to availability of large tracks of spiny and spineless cactus species (Plate 2) and *P. juliflora* (Plate 1). These zones are located in agro-ecological zones IV and V, with annual rainfall between 500-1000 mm and 300-600 mm respectively.

Sampling of plant materials
Different parts of spiny and spineless cactus species and *P. juliflora* sampled for nutritional evaluation were; young and mature cladodes/shoots, ripe and unripe fruits, *P. juliflora* leaves (green and dry), pods (green and dry) and bark (from a mature and young tree stem). A duplicate sample weighing 500 g was collected and dried in an oven at 60^{o}C for 48 hours, ground to pass through a 1-mm sieve and stored in plastic bottles at room temperature for subsequent chemical analyses.

Plate 1: Goats browsing on prosopis in Marigat (Source: Syomiti, Unpublished data)

Plate **2:** Cactus sampling activity in Baringo Source: Syomiti, Unpublished data

Chemical analysis

Dry matter (DM) content of the feed, crude protein (CP), crude fibre (CF), starch and ash were determined by the Near Infra Red reflectance (NIR), at Chrom Africa labs, Nairobi.

Data analysis
Statistical package for social sciences (SPSS) version 20 was used for data analysis for computation of nutrient means.

RESULTS

Cactus (Opuntia ficus-indica)
The chemical composition of different parts of Cactus species are shown in Table 1. The results indicated that chemical composition of different plant parts varied greatly between species and maturity stage.

Table 1: Chemical Composition of Different parts of Cactus and *P. juliflora* species (g/kg DM)

Species	Part	Chemical composition				
		DM	**CP**	**CF**	**Starch**	**Ash**
Spineless cactus	Mature cladodes	180	115	323	95	44
	New cladodes	158	145	254	61	26
Spiny cactus	Mature cladodes	172	120	305	243	54
	New cladodes	153	135	134	61	39
	Ripe fruit	120	111	327	146	9
	Un-ripe fruit	133	122	294	136	32
Prosopis species	Young leaves	890	263	142	110	98
	Mature leaves	900	143	192	42	20
	Mature green leaves	627	200	186	-	110
	Mature dry leaves	833	150	230	-	59
	Dry Pods meal	926	218	322	107	79
	Green pods meal	780	109	275	25	88
	Ground Seed meal	920	400	-	129	-
	Mature bark	910	0	860	126	144
	Young bark	890	33	584	79	124

The CP content of spineless Opuntia spp was higher than that of spiny Opuntia ranging from 115 to 145 g/kg DM (for mature and young cladodes respectively), and 120 to 135 g/kg DM (for mature and young cladodes) respectively. Variations were observed between CP content of young and mature cladodes of both spiny and spineless Opuntia species (Table 1). Low contents of dry matter (DM) and crude fibre (CF) were also reported in both spiny and spineless Opuntia species. Dry matter ranged from 158 to 180 g/kg DM (young and mature cladodes of spineless Opuntia respectively) and 153 to 172 g/kg DM (young and mature cladodes of spiny Opuntia species respectively). Crude fibre ranged from 134 to 305 g/kg DM for spiny Opuntia species (young and old Opuntia species) and 254 to 323 g/kg DM for spineless Opuntia species (young and mature cladodes).

Variations in CF were also observed in young and old cladodes of both spiny and spineless Opuntia species, with increase of CF content with plant maturity. However, higher content of starch was observed in all the Opuntia species cladodes. Higher starch content was reported in the mature cladodes than the young ones (Table 1).

Table 2: *Prosopis spp* pods in comparison with other sources of non-conventional animal feed ingredients

Feedstuff	ME (MJ/kg DM)	CP (%)	CF (%)	Cost (Kes/Kg)	Rank (Weighted Index)
Prosopis seed meal	9.9	399	7.3	-	1
Sunflower seed cake	7.95	27	28	24	3
Prosopis pod meal	12.95	21.8	20.1	-	4
Maize germ	11.51	12.4	10.2	21	7
Wheat bran	8.37	15.5	15	18.4	5
Molasses	9.8	2.9	0	35	10
Rice polishing	10.04	8.2	31.9	18	9
Acacia tortilis leaves	-	11.7	21	-	8
A. tortilis pods	9.19	14.5	24.7	-	6

Source: Kyuma, (2010), Syomiti, (Unpublished data)

Note: Calculation of a weighted index of the nutrient composition of key nutrients is commonly used in rating of feedstuffs

Spiny Opuntia had higher reported starch content ranging from 61 to 243 g/kg DM (for young and mature cladodes respectively) as compared to spineless Opuntia cladodes which ranged from 61 to 95 g/kg DM. High contents of starch was also recorded in both ripe and unripe fruits of spiny Opuntia species ranging from 136 and 146 g/kg DM (unripe and ripe spiny Opuntia fruits respectively). Mature spiny Opuntia cladodes had higher recorded ash contents than young shoots, which ranged from 39 to 54g/kg DM (young and mature Opuntia cladodes respectively).

Prosopis juliflora

The chemical composition of different parts of *P. juliflora* is shown in Table 1. Mature barks of *P. juliflora* had the highest ash content of 144 g/kg DM as compared to other parts, with ash content of 124 g/kg DM reported for the young barks (Table 1). Prosopis seed meal had highest reported CP content (399 g/kg DM) and starch contents of 129 g/kg DM (Table 2). Young Prosopis leaf meal had higher reported CP content of 260 g/kg DM as compared to 146 g/kg DM for older shoots.

DISCUSSION

Cactus (Opuntia ficus-indica)

Spineless Opuntia species had higher recorded levels of CP content than that of spiny Opuntia species. This can be attributed to the formation of the spines, which can be speculated that some of the plant protein is channeled to spine formation with subsequent lignifications of these spines. Variations observed between CP content of young and mature cladodes of both spiny and spineless Opuntia species (Table 1) is in agreement with Mustafa *et al (*2007) who reported higher CP content of soybean straws as the plant matured. Low contents of DM and CF reported in both

spiny and spineless Opuntia species were expected. According to Ben Salem *et al* (1996), Opuntia species is a succulent plant with approximately 90% water, which can sustain livestock without water for about 60 days in drylands which experiences water scarcity.

The reported low CF contents of Opuntia is in agreement with findings by Firew *et al.* 2007, who reported average low CF content of 14.5% in Oputnia species. Strategic supplementation of Opuntia species with high DM content feeds such as cereal straws and hay is required to control bloat and oxalate poisoning in Opuntia (Nefzaoui and Ben Salem, 2001). Higher content of starch was observed in all the Opuntia species cladodes, with higher starch content reported in the mature cladodes than the young ones (Table 1). Opuntia being a succulent drought tolerant plant with high reported starch content can be effectively utilized as non-conventional feed ingredient in ration formulation in rangelands. Spiny Opuntia species had higher reported starch content (with higher reported levels for mature spiny cladodes than young spiny cladodes) as compared to spineless Opuntia cladodes. High contents of starch were also recorded in both ripe and unripe fruits of spiny Opuntia species.

These results reveal that starch content of Opuntia species increases as the plant matures. This would be useful information with respect to domestication and agronomic management of Opuntia as livestock feed. Higher starch content in spiny Opuntia can be attributed to the spines, which upon hydrolysis can be reduced to simple sugars. However, the spines pose a limitation as livestock feed. According to Kang'ara and Gitari (2010), the spines can be eliminated by passing the cladodes through a borne fire for livestock feeding. This is in agreement with reports by Syomiti (Unpublished data), where agro-pastoral communities in Nyeri North used cactus to feed their livestock during droughts and applied fire to remove the spines.

Prosopis juliflora

Highest ash contents reported in the mature barks of *P. juliflora* is an indicator of high mineral content. Prosopis seed meal was reported to have the highest levels of CP content, which is also higher as compared to those of other conventional feed supplements such as sunflower seed cakes (Table 2). This indicates that *P. juliflora* can be a valuable non-conventional protein supplement for livestock in dry lands. However, inclusion levels in feed rations is required due to the fact that livestock, mainly small ruminants were reported to lose teeth after consuming large quantities of *P. juliflora* (Choge *et al.* 2002), with subsequent starvation to death. Reports by Kyuma (2013) indicated that pastoral communities perceived prosopis species as a noxious weed. Prosopis leaf meal had substantial CP content in both dry and green leaf meals. Although higher CP content was recorded in green leaf meal of Prosopis species, it is reported to have high anti-nutritional factors owing to mainly condensed tannins, which reduces bioavailability of this nutrient to the animals. Slow drying in a shade can reduce the tannins levels thereby increasing the feed intake (Koech *et al.* 2011).

CONCLUSIONS AND RECOMMENDATIONS

The study confirms high energy and crude protein in cactus and Prosopis species respectively, which are deficient nutrients in arid and semi-arid regions. Therefore, cactus (Opuntia) species, Prosopis seed and pod meals are ideal non-conventional feedstuffs, and are recommended as alternative feed resources for substituting

scarce conventional protein and energy feed sources in Kenya's dry lands.

ACKNOWLEDGEMENT

The authors of this manuscript are grateful to the Feed the Future Innovation Lab for Collaborative Research on Adapting Livestock Systems to Climate Change of Colorado State University, who financed the study. The reviewers of this manuscript who assisted immensely in adding value to this paper are also appreciated.

REFERENCES

Ben Salem H, Nefzaoui, A., Abdouli, H. Y Orskov, E.R. 1996. Effect of increasing level of spineless cactus (*Opuntia ficus-indica* var. *inermis*) on intake and digestion by sheep given straw- based diets. *Animal Sciences*, 62: 293-299.

Choge S. K., Ngunjiri F. D., Kuria M. W., Basaka E. A and Muthondeki J. K. 2002. Status and Impacts of Prosopis in Kenya. Technical Report produced by the Kenya Forestry Research Institute and Forest Department. 59pp (unpublished).

Firew T, Kijora C and Peters K. J 2007**.** Effects of incorporating cactus pear (*Opuntia ficus-indica*) and urea-treatment of straw on the performance of sheep. Small Ruminant Research, Volume 72, pp. 157–164

Kang'ara, J. N. N and Gitari, J. N. 2010. Exploiting fodder potentials of Cactus (*Opuntia spp*) in Kenya for pastoral livestock feeding under a changing climate. Proceedings of the 5th Annual Research week and international Conference on 21-23rd September, 2010, Egerton University, Kenya pages 15-17.

Koech O. Kipchirchir, Kinuthia R. Ngugi and R.G. Wahome. 2011. Use of Dry Land Tree Species (*Prosopis juliflora*) Seed Pods as Supplement Feed for Goats in the Arid and Semi Arid Lands of Kenya Journal of Arid Environment ,Volume 5 ,Issue 2 Pg 66-73

Kyuma R, 2013. Prosopis Utilization as animal feeds trials in Garissa – Kenya Wathajir Group Farm - Community Prosopis utilization pilot project. Proceeding of Tanzania Society of Animal Production Annual Scientific Conference. 22nd - 25th October 2013, Olasit Garden, Arusha, Tanzania

Mustafa A F, Garcia J C, Seguin P and Marois- Mainguy O, 2007. Chemical composition, ensiling characteristics and ruminal degradability of forage soybean cultivars. Canadian Journal of Animal Science. 87:623-629.

Nefzaoui, A.Y and H. Ben Salem.2001. Opuntia spp: a strategic fodder and efficient tool to combat desertification in the WANA region . In: Mondragon,C. and Gonzalez, S. (eds.). Cactus (Opuntia spp.) as forage : FAO Plant Production and protection Paper, 169 pp73-90

Tegegne F. 2001. Nutritional value of *Opuntia Ficus- indica* as ruminant feed in Ethiopia in: Mondragon, C. and Gonzalez, S. (eds.). Cactus (*Opuntia spp*.) as forage: FAO Plant Production and protection Paper, 169 pp73-90.