Indian J. Anim. Nutr. 2020. 37 (3): 218-226
doi: 10.5958/2231-6744.2020.00035.3

Indian Journal of Animal Nutrition

Nutritive Value of Selected Preferred Forage Species by Lactating Camels in the Peri-urban Area of Marsabit Town, Kenya

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ABSTRACT

The arid and semi-arid lands are the major camel keeping areas in Kenya. However, these areas are largely constrained by year-long shortage of feeds leading to poor performance of grazing camels, particularly during the dry season. Therefore, there is need to determine the nutritive value of the available forage during different seasons in order to conserve the nutritious ones for sustainable peri-urban camel production system. The objective of this study was to assess the chemical composition and *in vitro* digestibility of the most preferred forages by grazing lactating camels in the peri-urban area of Marsabit town. Twenty multiparous (parities 2 and 3) lactating Somali camels in early stage of lactation (1-4 weeks post-partum) and were recruited from large local herds for the study and were grouped into 4 groups comprising of 5 camels each based on initial live weight. The camels were allowed to browse in the communal field for 8 hours daily. The most selected forage species were identified through direct observation of 2 browsing camels for 30 minutes each in the morning between 09.00 a.m to 10.00 a.m at an interval of 7 days for a total period of 90 days. Using the tallying list of most selected browse species, 20 forage species were sampled in short rains and dry seasons and analysed for proximate composition, detergent fibre and *in-vitro* dry matter digestibility. The crude protein content of preferred forages during the short rains and dry season ranged from 9.64 to 17.71 % dry matter and 6.87 to 16.81 % dry matter for tree species and 9.73 to 12.19 % dry matter and 8.92 to 10.66 % dry matter for shrubs, respectively. The neutral detergent fibre content during the short rains and dry season was in the range of 24.5 to 48.2% and 21.7 to 42.5% for tree species and, 40.4 to 41.4% and 35.4 to 39.8% for shrubs, respectively. The *in-vitro* dry matter digestibility during the short rains and dry season was in the range of 35.3 to 74.4% and 33.5 to 66.4% for tree species and, 51.1 to 59.2% and 45.5 to 58.3% for shrubs, respectively. It was concluded that there were species and seasonal differences in preferences and that the selected species were high in crude protein content and *in-vitro* dry matter digestibility.

Key words: Chemical composition, Dry matter digestibility, Grazing camels, Preferred forages, Seasonal variation

INTRODUCTION

Camel keeping in the peri-urban areas of Kenya is increasing due to sedenterization and urbanization of an increasing number of the local population. Hence, a ready market for camel milk is expanding (Noor *et al.,* 2012). Performance of grazing camels in these areas is poor due to inadequate and low quality of feed resources, particularly during the dry season (Aregawi *et al.,* 2008; Noor, 2013; Dokata, 2014). Grazing of camel herds in peri-urban areas is concentrated around the urban settlements so as to remain closer to the milk market (Shibia *et al.,* 2013). The natural vegetation found in these areas is usually of poor quality and camels are not supplemented with concentrates except salt and/ or mineral soil (Seifu, 2009). Previous studies in Marsabit County have concentrated in identifying and determining the quality of feed resources for camels kept under pastoral system (Lusigi and Nkurunziza, 1984; Kuria *et al.,* 2004; Kuria *et al.,* 2005; Lengarite *et al.,* 2013). Such studies were undertaken in the pastoral rangelands of Korr, Kargi and Ngurunit areas of Marsabit County, Kenya by Kuria *et al.* (2004). There is therefore need to identity feed resources available in the peri-urban area, assess their nutritive and

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digestibility value in order to conserve the nutritious and highly digestible ones for the sustenance of peri-urban camel production. This study was conducted to assess the nutritive value and digestibility of the most selected forages by grazing lactating camels in the peri urban area of Marsabit town.

MATERIALS AND METHODS

The study area lies between latitude 02° 19' North and 02° 11' North and longitude 37° 89' East and 37° 76' East with a mean elevation of 874 m above sea level. The area receives bi-modal rainfall pattern, and ranges between 200 mm and 1,000 mm per annum on the plains and foot slopes of the mountainous areas, respectively. Rainfall patterns are relatively stable in the mountainous areas but low and unpredictable in the lowlands. Rainfall is distributed between two seasons, long rains falling from March to May, and the short rains occurring from November to December followed by the long dry season occurring between June to September. The area experiences tropical climatic conditions with temperatures ranging from a minimum of 10.1°C to a maximum of 30.2°C with an annual average of 20.1°C.

Herders were used to identify the forages preferred by camels by local names which were then matched to scientific names. This was done by following the animals for 30 minutes once weekly during the short rains season (December 2018 to January 2019) and the dry season (February to March 2019) recording bites for each plant species based on which the most preferred forage species were determined. Feeding observations were done through observing 2 camels of the 20 camels in the morning hours between 0900-1000 hours weekly for twelve consecutive weeks by the same persons. Bites made on a particular plant species by different camels were summed up to get the weekly totals. The forages were ranked according to the number of bites which reflected the feeding preference by the camels. Based on the number of bites, ten most preferred forages were identified for each season.

The ten most selected forages identified during the grazing observations were sampled by hand plucking along the grazing path. The forage samples corresponding to parts consumed (leaves, young twigs and flowers) were collected along the grazing path during the short rains season (December 2018-January 2019) and in the dry season (February-March 2019). For each selected forage species, 5-10 plants were hand plucked to give representative sample of 500 to 1000 grams and placed in labelled sampling paper bags.

Forage samples were first oven dried at 60°C for 48 hours to determine dry matter and thereafter preserved. The forage samples were then ground using a Wiley mill (Type: WRB80C/2Q) to pass through 1 mm screen size and stored in labelled sample bottles for laboratory analysis. The dry matter (DM), ash and crude protein (CP) content of the feeds were determined by drying the samples in an oven set at 105°C for 12 hours, ashing in muffle furnace at 600 °C and the Kjeldahl procedure (AOAC, 1995), respectively. The ether extract (EE) was obtained by Soxhlet extraction method, crude fibre (CF) was determined as per AOAC (1995). Nitrogen free extract (NFE) was determined mathematically by subtracting the sum of percentages of all the nutrients already determined from 100 (AOAC, 1995). Fibre fractions; neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined following procedure of Van Soest *et al.* (1991). The *in-vitro* dry matter digestibility (IVDMD) was determined using the two- stage technique for digestion of forage samples (Tilley and Terry, 1963). Data were analyzed using standard statistical procedures.

RESULTS AND DISCUSSION

The nutrient composition and *in-vitro* dry matter digestibility (IVDMD) of the most selected browse species during the short rains and dry season are presented in Tables 1, 2 and 3. There were differences in nutrient composition and IVDMD between the preferred forage species. The preferred forages had an overall mean CP content of 13.06 and 8.98 % DM during short rains and dry seasons, respectively. The CP content of the tree forage species ranged

from 9.64 % in *Olea africana* to 17.71 % in *Albizia antihelmintica* during the short rains season. Corresponding values for tree forages for the dry season ranged from 6.87 % in *Rhus natalensis* to 16.81 % in *Albizia antihelmintica*, respectively. Among the shrub species, *Aspilia mossambicensis* had a CP content of 12.19 % while *Maytenus heterophylla* had CP content of 9.73 %. Tree forages had higher CP content compared to shrubs during the short rains season (Table 1).

The mean ash content of the forages was 8.41 and 8.38 % during the short rains and dry season, respectively. The ash content ranged from 3.48 % in *Acacia nilotica* to 16.95 % in *Opilia campestris* during the short rains season. Corresponding ash content during the dry season ranged from 5.54 % in *Olea africana* to 16.72 % in *Duosperma eremophilum*, respectively. The ether extract content of the forages averaged 3.35 and 3.32 % during the short rains and dry season, respectively.

The crude fibre content of preferred forages was 25.65 and 24.74 % during short rains and dry season, respectively. During the short rains season, *Olea africana* had the highest CF content of 32.22 % while

Table 1. Nutrient composition (%DM) of most preferred forages by grazing camels during the short rainy and dry season

		% DM				
Short rain season forage	**DM (%)**	**Ash**	**CF**	**CP**	**EE**	**NFE**
Acacia mellifera	67.5^{f}	7.38^{c}	28.34^{bcd}	14.14^{cd}	3.21^{bcd}	42.17^{de}
Acacia nilotica	70.4^{e}	3.48^{h}	15.28^{h}	10.36^{gh}	3.98^{b}	58.90^{a}
Acacia senegal	69.3^{e}	10.45^{b}	27.66^{bcd}	16.28^{ab}	3.40^{bc}	37.13^{fg}
Acacia tortilis	66.5^{f}	6.71^{cd}	27.11^{cd}	13.60^{de}	2.84^{bcd}	39.91^{ef}
Albizia antihelmintica	54.7^{h}	6.49^{cd}	29.02^{b}	17.71^{a}	3.05^{bcd}	35.35^{g}
Aspilia mossambicensis	66.3^{f}	16.84^{a}	18.68^{g}	12.19^{ef}	5.60^{a}	38.31^{f}
Maytenus heterophylla	69.6^{e}	6.28^{cde}	23.11^{f}	9.73^{h}	3.20^{bcd}	53.83^{b}
Momordica spinosa	74.4^{c}	3.97^{gh}	28.41^{bc}	11.68^{fg}	3.84^{b}	48.41^{c}
Olea africana	73.1^{d}	5.53^{def}	32.22^{a}	9.64^{h}	2.36^{cde}	42.26^{de}
Opilia campestris	57.7^{g}	16.95^{a}	26.68^{d}	15.33^{bc}	2.06^{de}	29.24^{h}
Mean	66.9	8.41	25.65	13.06	3.35	42.55
S.E	0.34	2.28	3.01	2.944	2.2	5.23
Dry season forage	DM	Ash	CF	CP	EE	NFE
Acacia nilotica	66.5^{c}	8.88^{b}	21.59^{gh}	7.76^{e}	3.63^{bc}	58.03^{d}
Acacia tortilis	64.5^{e}	7.58^{c}	31.63^{b}	8.80^{d}	3.69^{bc}	48.18^{g}
Albizia. antihelmintica	57.1^{i}	9.46^{b}	32.74^{a}	16.81^{a}	3.77^{b}	36.95^{h}
Duosperma eremophilum	65.1^{d}	16.72^{a}	23.25^{f}	10.66^{c}	1.64^{de}	47.54^{g}
Harrisonia abbysinica	59.7^{h}	5.86^{d}	18.88^{i}	7.15^{ef}	3.77^{b}	64.21^{a}
Maytenus heterophylla	60.6^{g}	8.75^{b}	24.05^{e}	8.92^{d}	2.98^{c}	55.03^{e}
Olea africana	60.5^{g}	5.54^{d}	30.21^{c}	7.62^{e}	2.02^{d}	54.19^{ef}
Rhus natalensis	56.7^{i}	7.07^{c}	23.49^{ef}	6.87^{f}	1.58^{de}	60.69^{b}
Ximenia americana	61.2^{f}	7.02^{c}	15.22^{j}	7.53^{ef}	4.34^{b}	65.40^{a}
Zanthoxylum chalybeum	61.6^{f}	6.91^{c}	26.31^{d}	7.70^{e}	5.82^{a}	53.09^{f}
Mean	61.4	8.38	24.74	8.98	3.32	54.33
S.E	0.117	1.84	1.37	1.307	1.3	2.74

^{a,b} Column means with different superscripts within a season are significantly different (P≤0.05)

Acacia nilotica had the lowest CF content of 15.28%. Among the preferred species during both seasons, high CF content was observed in *Acacia nilotica* (21.59 %), *Acacia tortilis* (31.63 %) and *Albizia antihelmintica* (32.74 %) during the dry season. The high CF content of *Olea africana* was also reflected in its high content of NDF, ADF and ADL (Table 2).

The mean IVDMD was 54.8% during the short rains season and 49.0 % during the dry season, respectively, implying that forages were more digestible during the short rains season compared to the dry season. The IVDMD of forage species during the short rains season ranged from 35.3% for *Olea africana* to 74.4% for *Opilia campestris*. The highest IVDMD during the short rains season was recorded in *Opilia campestris* (74.4%) followed by *Albizia antihelmintica* (68.3%) while the lowest values were recorded for *Olea africana* (35.3%) and *Momordica spinosa* (41.6%), respectively. During the dry season, the highest IVDMD content was recorded for *Harrisonia abbysinica* (66.4%) followed by *Duosperma eremophilum* (58.3%) while the lowest values were recorded in *Olea africana* (33.5%) and *Acacia tortilis* (37.8%). *Olea africana* recorded the lowest *in-vitro* dry matter digestibility during the short rains and dry season.

The nutrient and fibre content of the selected

Table 2. The fibre content of plant species preferred by camels during the short rainy and dry season (%DM)

Forage species short rains	%NDF	% ADF	% ADL
Acacia mellifera	45.5^{ab}	28.6^{b}	8.8^{bcd}
Acacia nilotica	24.5^{c}	16.8^{d}	5.5^{e}
Acacia senegal	48.2^{a}	26.3^{bc}	6.5^{cde}
Acacia tortilis	39.3^{b}	30.4^{ab}	9.9^{ab}
Albizia antihelmintica	43.7^{ab}	29.7^{b}	6.0^{de}
Aspilia mossambicensis	41.4^{b}	27.2^{bc}	6.1^{de}
Maytenus heterophylla	40.4^{b}	25.2^{bc}	5.8^{e}
Momordica spinosa	40.2^{b}	29.0^{b}	6.4^{cde}
Olea africana	45.1^{ab}	36.0^{a}	12.0^{a}
Opilia campestris	44.6^{ab}	27.8^{bc}	9.0^{bc}
Means	41.3	27.7	7.6
S E	1.29	1.22	0.56
Forage species dry season	%NDF	% ADF	% ADL
Acacia nilotica	28.7^{h}	20.1^{e}	8.8^{abcd}
Acacia tortilis	37.7^{d}	28.3^{b}	8.5^{cd}
Albizia. antihelmintica	42.5^{a}	29.5^{b}	7.9^{d}
Duosperma eremophilum	35.4^{e}	22.8^{c}	9.4^{abc}
Harrisonia abbysinica	23.5^{j}	18.5^{ef}	6.5^{ef}
Maytenus heterophylla	39.8^{c}	27.6^{b}	9.8^{a}
Olea africana	35.6^{e}	27.5^{b}	6.6^{e}
Rhus natalensis	32.0^{f}	22.5^{c}	5.6^{f}
Ximenia americana	21.7^{k}	17.6^{f}	9.5^{ab}
Zanthoxylum chalybeum	41.2^{b}	34.5^{a}	6.9^{e}
Means	33.8	24.9	7.9
S E	0.15	0.43	0.19

[a,b]Column means with different superscripts during different seasons are significantly different (P<0.05)

forage species in the study area were significantly different. The disparities in nutrient content of forages was expected and could be attributed to genetic diversity of the plant species and edaphic factors as reported by Le Houeroue, (1980) and Minson, (1990). Similarly, seasonal differences in nutrient content of forages selected by camels can result in changes in the diet quality directly affecting camel performance (Kuria *et al.,* 2005). The mean CP content of 13.06 % and 8.98 % in forage species during the short rains and dry season, respectively was higher than the critical level of 7.00 % for temperate forages (Mc Donald, 2003) and 6.00 % for tropical forages (Minson, 1990), below which the feed intake of the animal is compromised. The high CP content during the short rains season could have been due to a period of active plant growth when grazing camels would have been actively selecting for leafy, green plant material as observed by Tessema, (1986). Other studies have shown that amount of rainfall in the rangelands affects the growth and development of plant species which is reflected in the variations in the nutritive quality of forages between seasons (Abebe *et al.,* 2012).

The CP content of *Albizia antihelmintica* (17.71 %) during the short rains season in this study was lower than 19.50 and higher than 14.82 % during wet season as reported by Azim *et al.* (2011) and Dougal *et al.* (1964) in Ethiopia and Kenya, respectively. CP content of *Olea africana* (9.64 %) as observed in this study was lower than 12.20 % reported by Girma *et al.* (2015) in the rangelands of Ethiopia but comparable to 8.90 and 7.00 % reported by Shenkute *et al.*(2012) and Lebopa *et al.*(2011) in Ethiopia and South Africa, respectively. The CP content of 17.30 and 21.60 % for *Aspilia mossambicensis* reported by Muya and Ogute (2000), and Kapinga *et al.* (2018) in Kenya and Tanzania, respectively, was higher than 12.19 % observed in this study. The corresponding dry season value of the same species reported by Roothaert, (2000) and Mwilawa *et al. (*2000) was 12.70 % and 7.95 % in Kenya and Tanzania respectively. The CP content of 9.73 % of *Maytenus heterophylla* was lower than 20.50 % obtained by Shenkute *et al.* (2012) in the Ethiopian rangelands.

During the dry season, *Albizia antihelmintica* had the highest CP content of 16.81 %, but had declined

Table 3. The *in vitro* dry matter digestibility of plant species preferred by camels during the short rainy and dry season (%DM)

Short rains season		Dry season	
Plant species	**% IVDMD**	**Plant species**	**% IVDMD**
Acacia mellifera	60.1^{cd}	*Acacia nilotica*	56.4^{c}
Acacia nilotica	54.9^{de}	*Acacia tortilis*	37.8^{f}
Acacia senegal	60.8^{c}	*Albizia. antihelmintica*	56.4^{c}
Acacia tortilis	42.3^{f}	*Duosperma eremophilum*	58.3^{bc}
Albizia antihelmintica	68.3^{b}	*Harrisonia abbysinica*	66.4^{a}
Aspilia mossambicensis	59.2^{cd}	*Maytenus heterophylla*	45.5^{d}
Maytenus heterophylla	51.1^{e}	*Olea africana*	33.5^{g}
Momordica spinosa	41.6^{f}	*Rhus natalensis*	40.6^{e}
Olea africana	35.3^{g}	*Ximenia americana*	39.2^{ef}
Opilia campestris	74.4^{a}	*Zanthoxylum chalybeum*	56.3^{c}
Means	54.8		49.0
S E	1.04		0.445
LSD (P<0.05)	3.21		1.37

^{a,b,c,d,e}Column means with different superscripts in different seasons are significantly different (P≤0.05)

from 17.71 % recorded during the short rains season while *Rhus natalensis* recorded the lowest CP value of 6.87 %. Among the shrub species, *Duosperma eremophilum* had the highest CP content of 10.66% and *Maytenus heterophylla* having the lowest content of 8.92. In agreement with this findings, Ndungu (1996) and Noor (2013) reported that most camel browse species were lower in CP content during the dry season compared to the wet season. Similarly, studies by Van Soest, (1982) and Tessema, (1986) reported that dry season is a period of nutrient deprivation for grazing ruminants due to decline in quality, often to levels that cannot support the energy requirements of animals.

During both seasons, camels preferred browsing on leaves and twigs of *Olea africana, Acacia nilotica, Albizia antihelmintica* and *Acacia tortilis* (Tables 1 to 3) in which, *Albizia antihelmintica* had a high CP content of 17.71 and 16.81 %, CF of 29.02 and 32.74 %, respectively. *Olea africana* had the lowest CP content of 9.64 and 7.62 %, and highest crude fibre content of 32.22 and 30.21 % in the short rains and dry season, respectively. Despite the fact that *Olea africana* had poor nutrient content, it was ranked among the most preferred species by grazing lactating camels. This might have been attributed to the leafy nature of the plant during both seasons (Personal observation).

The 4 forage species preferred during both seasons namely; *Olea africana*, *Acacia nilotica, Albizia antihelmintica* and *Acacia tortilis,* respectively had high ash content of 5.54, 8.88, 9.46 and 7.58 %, respectively, during the dry season implying that the forage species had adequate concentration of minerals which is vital for camels as most forage species are deficient in minerals during dry spell. The ash content of 8.88 % in *Acacia nilotica* and 7.58 % in *Acacia tortilis* as recorded in this study were higher than the ash content of 6.07 % and 6.66 %, respectively reported by Abebe *et al.* (2012) in camel browse species in Southern Ethiopia. Generally, shrubs had higher ash content compared to trees during the dry season. Sanon *et al.* (2008) reported that dry matter increases with maturity of forages. However, mean dry matter content of 61.4% recorded during the dry season compared with 60.8% reported by Kuria *et al.* (2005) in the same study County, though under pastoral camel production system.

The NDF and ADF contents were higher during the short rains season while the ADL was higher during the dry season. The increase in structural constituents during the short rains season compared to the dry season could have been due to seasonal effect. Abdullah *et al.* (2017) who reported that detergent fibres of a plant may vary depending on the time and season of the year when they are harvested. The NDF content of 45.1% observed in *Olea africana* was similar to 45.0% obtained by Lebopa *et al.(*2011) but was higher than 40.3 and 36.2% reported by Girma *et al.*(2015) and Shenkute *et al.* (2012) in Ethiopian rangelands, respectively.

Higher IVDMD values were observed during the short rains season compared to the dry season (Table 3). The higher digestibility was attributed to the fact that during this time, dietary CP content was high with growth of young shoots of high nutritional quality as reported by Kibet, (1984) and Kidake *et al.* (2016). Other researchers have reported higher digestibility during the wet season compared to the dry season as pasture quality and quantity change with seasons (Karue, 1975; Kayongo and Field, 1983; Kidake *et al.,* 2016). Over 70% of the plant species had *in-vitro* dry matter digestibility of 50.0% and above. With the exception of *Olea africana,* all other forage species had an IVDMD in the range of 36 and 69.5% for good quality tropical browse species as suggested by Milford and Minson, (1968), implying that the browse species evaluated were more digestible.

The % IVDMD of *Olea africana* obtained in this study during the short rains and dry season was 35.3 and 33.5%, respectively and was lower than 68.8% obtained by Karabulut *et al.* (2006). The digestibility of *Harrisonia abbysinica* was higher than 43.0 and 17.73% obtained by Field and Rose (1976) and Onyango *et al.* (2019) in Narus valley areas of Uganda and Kenyan rangelands, respectively. According to studies of Zinn *et al.* (2004) and Mohammadabadi *et al. (*2019), high NDF content in forages limits energy intake and

reduces nutrient digestibility thus affecting animal performance. The IVDMD of *Opilia campestris* of 74.4 % was similar to 74.1% obtained by Boufennara *et al*. (2012). Among the four most selected tree species during both seasons, *Albizia antihelmintica* had the highest IVDMD of 68.3 and 56.4 % followed by *Acacia nilotica* with 54.9 and 56.4 %, respectively. *Olea africana* had the least and poorest IVDMD of 35.3 and 33.5% during short rains and dry seasons, respectively.

Both *Albizia antihelmintica* and *Acacia nilotica* had a high CP content of 17.71 and 10.36 %, and 16.81 and 7.76 % during the short rains and dry season, respectively and this was reflected in their higher IVDMD. This was in agreement with the findings of Tessema (1986), who reported that there is high correlation between dietary CP content with digestibility Kidake *et al.* (2016), reported that in the arid and semi-arid regions during the wet season, dietary CP content and digestibility of plant species and grasses was high and the degree of lignification was lower since forage plants and grasses were young. This observation is in agreement with the current study as plants high in CP content were also high in IVDMD. The differences in IVDMD may be due to variations in maturity status of the plant, low CP, as well as regional differences in terms of edaphic factors and rainfall patterns (Le Houeroue, 1980; Shaltout *et al.,* 2008). The seasonal influence on chemical composition and digestibility of the most selected forage species was consistent with previous findings by Karue (1974) and Tekletsadik *et al.* (2004) Irrespective of the season, leguminous species were high in crude protein, *in vitro* dry matter digestibility and ether extract content.

CONCLUSION

It was concluded that there were species and seasonal differences in forage preferences and that the preferred species were high in crude protein content and *in-vitro* dry matter digestibility.

ACKNOWLEDGEMENTS

The authors are thankful to United States Agency for International Development/ Kenya Agricultural and Livestock Research Organization (USAID / KALRO) for provision of funds and technical support that led to the success of this work.

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Received on 13-09-2-2020 and accepted on 12-10-2020