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Effects of feeding commercial and locally formulated milk replacers on performance of camel calves in Kenya

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Abstract
Camel calves' in pastoral production system are constrained by limited milk feeding. Their survival is important for camel herd growth and milk availability for the camel keepers. A seventy (70) days feeding trial was conducted to determine the nutritive value, dry matter intake, weight gain, feed conversion ratio (FCR), and apparent digestibility coefficients in 15 growing camel calves with a body weight of 102.3 ±1.3 Kg (mean ± SE). They were randomly assigned to plant based milk replacer (PBMR) and commercial milk replacer (CMR) diets in a randomized complete block design (RCBD) with five replications. The Crude Protein (CP), Metabolizable Energy (ME) and Dry Matter (DM) among other components were significantly (p<0.05) different between the two experimental treatments. The CP (gkg^{-1} DM) was 181.2 in PBMR and 203.1 in CMR. The DM was 93.5 gkg^{-1}DM in CMR and 88.7 gkg^{-1}DM in PBMR. The ME was 17.4 MJ/kg DM in CMR and 15.4 MJ/kg DM in PBMR. The study revealed that calves on CMR (761.4 gd^{-1}) and PBMR (566.3 gd^{-1}) had a higher ADG compared to calves on pastoral management regime (453.7 gd^{-1}). FCR was higher in CMR (14.5) compared to PBMR (13.9). It was concluded that CMR and PBMR could be used as suitable replacements to camel milk.

Keywords: Arid and semi-arid lands, camel calf, milk replacers, performance, pastoral production system

1. Introduction

Camel (*Camelus dromedarius*) provides pastoral communities with constant income, transport and social benefits such as prestige and performance of cultural ceremonies [8]. Camel production in the world has prominence due to its climate resilience and lower emission of greenhouse gases (GHG) [7]. Camel production statistics show that Kenya had 4,721,900 heads of camel [13], a growth from 2,864,732 in 2012 [5]. Camels' milk is preferred to milk of other livestock species because of its taste, nutritional value, health reasons and cultural perceptions such as preventing thirst even when walking for long distances. Due to these perceived benefits, there is a high demand for camel milk but the production cannot meet the demand [22]. Due to high market prices, there is a tendency to harvest camel milk for sale at expense of calf growth (Personal observation, 2021).

Camel calves are the foundation of a camel herd, without which the herd cannot grow and neither would camel milk be accessible for the pastoralists 16. Optimum level of calf nutrition in initial life will lead to fast growth, early maturity and optimum carcass yield [14]. Rearing of camel calves in traditional pastoral production system is faced with several constraints such as high pre-weaning calf mortality that emanates from inadequate milk for suckling to calf as a result of high competition from households for food and income, inadequate forages during dry seasons and diseases among other factors [34].

Milk replacer has been used in cattle calves for survival, faster growth rate and early reproductive maturity [33]. Although plants that may be used to formulate milk replacer could be found in camel keeping areas, little is known about their effectiveness as substitutes to feeding camel milk in improving camel calf nutrition. This study evaluated the performance of camel calves fed on locally formulated plant-based milk replacer and commercial cow milk replacer.

2. Materials and Methods
2.1 Site description
The study was conducted in Karare ward in Marsabit County among the Rendille camel keeping community. Karare is located in the southern part of Mt. Marsabit which was the main cattle keeping area before but currently with climate change, camel production is taking over. Marsabit County lies between longitude 36° 3'East and 38° 59' East and latitude 01° 15' North and 04° 27' North, (Google map, 2021). The County experiences a bimodal rainfall regime with two peaks, in April and November (Marsabit meteorological station, June 2021). The rainfall is low, erratic and unreliable, especially in the low-lying areas, with an annual range of 120-700mm. The temperatures vary from 23 to 34 °C, with the period between January and April being very hot (Martin *et al*., 1981) [20]. Karare ward is in agro-ecological zone IV with deep clay soil and the study area has diversity of natural forages for camels.

2.2 Feed Preparation
The most available forages used by camel keepers to feed their camel calves before releasing for free-range grazing and other feed supplements used during dry/drought seasons were used as ingredients to formulate plant-based milk replacer. Leaves of *Grewia bicolor* and *Lannea schweinfurthii* were harvested by hand stripping from the trees during the rainy season and *Acacia tortilis* pods and *Balanites aegyptiaca* fruits were also collected from the communal grazing rangelands in Marsabit County. After harvesting, the leaves, fruits and pods were spread on a polythene sheet and air dried under shade to avoid scorching and nutrient loss for a period of 7 days (Plate 1).

Ingredients for compounding the experimental diets were ground to pass through a 4mm sieve. Whole maize meal, premix and molasses were purchased from some reputable suppliers. Plant based milk replacer was formulated and mixed according to [24] for formulation of camel calf milk replacer (15.0-20.0 MJ/kg DM, 20-24 CP %). All ingredients used in formulation of plant-based milk replacer is what camel keepers use as starter browses before releasing camel calves for free-range browsing or supplements for feeding camel calves in northern Kenya during dry/drought season. Commercial milk replacer (Afya bora milk replacer) was purchased from Unga Feed Company limited.

Plate 1: Drying of forage leaves under shade

2.3 Experimental animals, feeding regimes and management
The experimental procedures were conducted according to the Egerton University Animal Welfare Law, the regulation on the protection of animals used for research purposes. Fifteen growing camel calves of about 3 months of age, of Somali breed and their crosses with Rendille and Turkana camels weighting approximately 102.3±1.3 Kg (mean ± SE) were randomly assigned to plant based milk replacer (PBMR**)** and commercial milk replacer (CMR) diets in a completely randomized block design where blocking was done by breed. The calves on PBMR were confined (Plate 2) throughout the experimental period and offered PBMR feed at 3% of body weight on daily basis. Calves on CMR were not confined but were fed 1 litre of commercial milk replacer (Plate 3) in the morning and 1litre in the evening as a replacement to pastoral camel milk feeding regime estimated to be fed to camel calf by pastoralists on a daily basis. One-kilogram dry matter of commercial milk replacer was mixed with 6 litres of water to prepare 6 litres of commercial milk replacer as per the manufacturers' recommendation. The daily intake and rejection of PBMR and CMR were recorded on daily basis.

Five unconfined camel calves on pastoral camel milk feeding regime were used as control (browsed during the day). In the control group, calves were allowed to stimulate the dam for milk let down, then milk was extracted from three quarters and one left for the calf to suckle. After about 30 minutes suckling, the calves were separated in the evening until the following day and the same was repeated in the morning and calves grazed the whole day on their own. The camel calves on PBMR were assigned to individual pens (Plate 2) with each treatment having 5 replicates. The experimental period was 70 days, consisting of a 14-day adaptation and 56 days' data collection periods, respectively. Before the start of the feeding trials, camel calves were weighed, treated against internal and external parasites using ivomectin sub-cutaneous injection. The five confined calves on PBMR were given free access to clean drinking water daily while those on CMR and pastoral milk feeding regime were on watering interval of five days which was according to pastoralist management regime. Weighing was done weekly, on Tuesdays from 0700hr to 0830hr throughout the experimental period. The treatment diets were:

PBMR- Plant based milk replacer
CMR- Commercial milk replacer
Control- Pastoral milk feeding regime

Plate 2: Calves feeding on plant based milk replacer

Plate 3: Calf feeding on commercial milk replacer

2.4 Grazing observation and sampling methods for preferred forages for camel calves

Calves that were on pastoral management regime (control) and those on commercial milk replacer were allowed to graze around the homestead. The calves on commercial milk replacer were only provided an equivalent of camel milk what pastoralists "claimed" to feed them on daily basis i.e., which is 2 litre of CMR per day (1litre in the morning and 1litre in the evening).

The study used focused group discussions comprising of 12 experienced camel keepers to identify important browses in their environment that camel calves utilized after releasing for free-range browsing. This was followed by field browsing observation of 15 minutes per calf where complete bites made by calf on various forages and parts eaten were recorded by the research team (Plate 4 and 5). Two experienced elders accompanied the research team for the purpose of identifying the different forage species browsed by calves. The end of a bite was marked by the time the calf raised its head for purposes of chewing and ingestion. A total of 25 calves were observed. Five calves per herd were randomly observed from a group of grazing camel calves for a period of 5 days. The grazing observation was done early in the morning between 800-1000 hours, when the calves were actively browsing. The frequencies of browsed forages were done based on number of bites and the top 11 plant species preferred by camel calves were sampled for proximate analysis.

Plate 4: Observing an individual calf

Plate 5: Group of calves browsing

2.5 Data collection

Performance was measured as weight gain calculated weekly and feed intake recorded daily. Camel calves were weighed every week after overnight fasting until the end of the experimental period. The initial weights of all the experimental calves were taken at the start of the experiment. This was followed by two weeks' adaptation period to experimental diets (PBMR and CMR). The data was collected for 8 weeks. Average Daily Gain (ADG) was calculated as the rate of weight gain over a period of one week. Feed offered and refusals were recorded every day and feed dry matter intake (FDMI) was calculated by difference between feed offered and refusal. The FCR for each calf was calculated by dividing feed intake by weight gain.

ADG = Weight gain/Period of 1 week
FCR = Feed Intake/ weight gain

2.6 Laboratory analysis: Proximate and minerals assay of samples

Proximate analysis of preferred browses was analyzed to determine their dry matter (DM), crude protein (CP), ether extract (EE) and ash according to the standard methods of [1]. The CP was calculated as (N x 6.25). Neutral detergent fiber (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were analyzed according to the procedure described by [35]. Minerals (macro and micro elements) were determined using atomic absorption spectrophotometry (AAS).

2.7 Statistical analysis

Data collected on proximate analysis, feed intake, apparent digestibility, FCR and average daily gain(ADG) were subjected to the analysis of variance (ANOVA) in a randomized complete block design (RCBD) using the General linear model procedure of statistical analysis system [29] version 9.0. Significant means were separated using Tukey's HSD (Tukey's Honestly Significant Difference Test) at 5% significance. The linear Model for RCBD used was

$$Y_{ijk} = \mu + \tau_i + \beta_j + \tau\beta_{ij} + \varepsilon_{ijk} \; i$$

Where
Y_{ijk} = observation k in treatment i and block j
μ = the overall mean
τ_i = the effect of treatment (T1...T3) i
β_j = the effect of block (Breed) j
$\tau\beta_{ij}$ = the interaction effect of treatment i and block j
ε_{ijk} = random error

3. Results and Discussion

3.1 Chemical composition

Results of the nutrient composition of experimental diets are presented in Table 1.

Table 1: Chemical composition (gkg-1DM) and Metabolizable energy (MJ/kg DM) of experimental diets

Parameters	PBMR	CMR	SEM
CP	181.2^b	203.1^a	0.166
ME	15.4^b	17.4^a	0.112
Ash (%)	7.3^b	9.7^a	0.134
EE	15.5^b	20.1^a	0.183
DM (%)	88.7^b	93.5^a	0.266
OM	185.1^b	188^a	0.214
NDF	174.8^a	128.5^b	0.195
ADF	110.8^a	85.1^b	0.183

CP=crude protein, ME= Metabolisable energy, EE= Ether extract, DM=dry matter, OM=organic matter, NDF=Neutral detergent fibre, ADF= Acid detergent fibre.$^{a, b}$ mean values in a row with different superscripts are different at $p<0.05$

The experimental diets used in the feeding trial were formulated to meet the nutrient requirements for growing camel calves (NRC, 2001) [24] where ME,15-20 $MJkg^{-1}$ DM, CP, 20 -24%, 10% EE, Ca 1%, P 0.7%). The CP, ME, ASH, EE, DM, OM, NDF and ADF composition were significantly ($p<0.05$) different between the two experimental diets **(**Table 1). The CP content (gkg^{-1}DM) was 181.2 in plant based milk replacer (PBMR) and 203.1 in commercial milk replacer (CMR). The ME contents was higher in CMR (17.4 MJ/kg DM) compared to PBMR (15.4 MJ/kg DM). The DM was 93.5% in CMR and 88.7% in PBMR. The OM content was 188 gkg^{-1}DM in CMR and 185.6 gkg^{-1}DM in PBMR. The NDF and ADF contents of CMR (128.5 and 85.1 gkg^{-1}DM), were lower compared to PBMR (174.8 gkg^{-1}DM and 110.8 gkg^{-1}DM). The EE contents were higher in CMR (20.1 gkg^{-1}DM) compared to PBMR (15.5 gkg^{-1}DM) [10] recommended 22% CP and 15.6% fat in dairy calves' milk replacer while [30] reported 94.6% DM; 20.7% CP and 17.0%. The results of this study revealed that PBMR was lower in CP (18%) while that of CMR was similar to what other authors reported. The shortfall of 2% CP in PBMR may have resulted from quality of local feed ingredients used to constitute the PBMR; thus need to set upper limit of CP (24%) requirement in future formulations to avoid such deficit while also ensuring use of high quality local feed ingredients. The energy for the two experimental diets were within the recommended range by 24NRC (2001). The CP (181.2 gkg^{-1}DM) and energy (15.4 MJ/kg DM) contents of plant based milk replacer using locally available feed ingredients indicates there is a potential of utilizing locally available feed ingredients for constituting plant based milk replacer for camel calves in ASALs of Kenya where feeds are the major constraints in camel calf rearing.

Table 2: Major and trace elements in plant-based and commercial milk replacer

Mineral elements	PBMR	CMR	SEM
Phosphorus%	0.12^{b}	0.65^{a}	0.00745
Potassium%	1.58^{a}	0.99^{b}	0.00577
Calcium%	0.78^{b}	1.58^{a}	0.00745
Magnesium%	0.32^{a}	0.11^{b}	0.00746
Iron mg/kg	547^{a}	105^{b}	0.57735
Copper mg/kg	1.67^{b}	2.67^{a}	0.00471
Manganese mg/kg	164^{a}	65.3^{b}	0.40893
Zinc mg/kg	49.0^{b}	75.3^{a}	0.14402

Competition for milk is also high in pastoral camel production systems where milk is mainly used for home consumption and trade. A cost effective milk replacer can increase both the performance of growing calves and farm profitability [10]. The two diets resulted in higher weight gains when compared with pastoral management regime (Table 5). This confirms that deprivation of milk to the calves is a reality in pastoral camel production systems thus need for camel calf supplementation to address nutrition deficit. Plant based milk replacer is usually less expensive compared to milk-based commercial milk replacers thus affordable for camel keepers. Results of the major and minor mineral elements profile of experimental diets are presented in Table 2.

PBMR- Plant based milk replacer, CMR- Commercial milk replacer

Minerals account for a very small proportion of daily calves' diets and are needed as a very small percentage of dietary nutrients, they are very important in animal function, such as bone development, immune function, muscle contractions, and nervous system function. Calves growth can be compromised if they have a deficiency of minerals. Although camels are classified as pseudo ruminants, it has been previously reported that what works for cattle in nutrition also works for camels [21]. Diets of young calves should have a crude protein (20 -28%), fat (10- 22%), crude fiber (1- 2%), calcium (1%), phosphorus (0.7%), magnesium (0.07%) and iron (100 mg/kg). In commercial milk replacer, Ca (1.58), P (0.99), Fe (105) and Mg (0.11) were all within the acceptable range reported by other authors. In the case of plant based milk replacer, P (0.99), Fe (547) and Mg (0.32) were also within the recommended range apart from Ca which was less by 0.03% and thus require supplementation to meet daily calf requirements.

According to [23], growing cattle require potassium 0.60%, zinc 75-100mg/kg, Copper 10mg/kg and Manganese 20mg/kg. Potassium and manganese levels in both diets were within the recommended levels. Zinc in the commercial milk replacer was within the recommended range but lower for plant-based milk replacer, hence required supplementation. Copper levels in the two diets were lower than the recommended levels, thus required supplementation.

3.2 Digestibility of PBMR and CMR

The two-stage [32] laboratory technique (incubation with rumen fluid followed by acid-pepsin digestion) was used to determine the *in vitro* organic matter digestibility of dried forages (Figure 1). It involved, first incubation with rumen liquor and then with acid pepsin solution. Using herbage samples of known *in-vitro digestibility* (Y), the regression equation: Y = 0.99X - 1.01 (SE=±171.803), the *in vitro* digestibilities of CMR and PBMR were calculated, where X = *in vitro* digestibility, y=82.85x.

The *in-vitro* digestibility characteristics of the experimental diets did not vary widely among the CMR and PBMR samples. The total DM digestibility (g/Kg) shown in Figure 2 show PBMR (0.469 g/kg DM) was higher compared to CMR (0.466 g/kg DM) during the trial. The higher rate of digestibility in PBMR could be due to presence of high fermentable carbohydrates important for microbial growth and accessibility of feed to microbial enzymes [6].

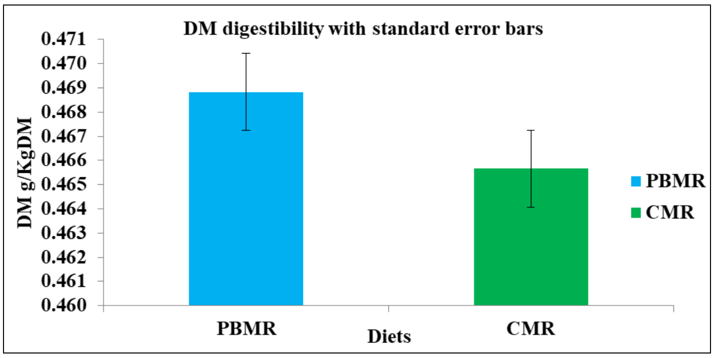

Fig 1: Tilley and Terry DM digestibility with standard error bars for PBMR and CMR

3.3 Nutritive value for most preferred forages

The nutritive values of the top 11 most preferred forages: *Acacia brevispica*, *Aspilia mossambicensis*, *Harrisonia abyssinica*, *Erucastrum arabicum*, *Duosperma eremophilum*, *Securinega virosa*, *Cordia sinensis*, *Ximenia americana*, *Rhus natalensis*, *Lannea schweinfurthii and Grewia bicolor* from northern rangelands were assessed for their potential as protein, energy and mineral sources for grazing camel calves (Table 3 and 4). The nutritional quality of forage for livestock is ultimately determined by its impact on animal performance. Thus, forage quality is evaluated in terms of the amount of milk produced, animal weight gains obtained, reproductive efficiency, and other animal responses [19]. Indigenous tree and shrub species are important feed resources for the camel pastoralists and agro-pastoralists communities [3]. The three most essential nutrients for calf growth and development are water, energy and protein. Fibre, minerals and vitamins are also needed, but play a minor role [31].

The CP (%**)** content of the preferred forages ranged from 12.61 g/kg DM in *Ximenia americana* and 24.2 g/kg DM to *Grewia bicolor*. The comparatively high CP content of the eleven selected forages showed the likely contribution of rangelands forages as protein sources. They are therefore important feed resources for utilization for camel calves' nutrition in the arid and semi-arid lands (ASALs) [11]. Evaluated the nutritive value of local browses from drylands of Kenya and reported similar result on crude protein (172.3 gkg-^{1}DM) especially in *Acacia brevispica.* The ME content ranged from 3.69 MJKg-1 DM in *Ximenia americana* and 20.46 MJKg^{-1} DM in *Aspilia mossambicensis. Aspilia mossambicensis*, *Harrisonia abyssinica*, *Erucastrum arabicum* had ME of (15.0-20.0 MJ/kg DM) that is adequate to meet daily requirement of calves [24].

Table 3: Proximate composition of preferred forages in rangelands for camel calves

Sample	DM%	Ash%	CP%	NDF%	ADF%	ADL%	Fat (gkg-1 DM)	ME(MJKg^{-1} DM)
Acacia brevispica	90.79^{e}	6.03^{i}	17.30^{e}	47.53^{d}	30.77^{c}	10.00^{g}	13.16^{d}	4.87^{i}
Aspilia mossambicensis	89.48^{h}	19.36^{a}	16.04^{g}	30.99^{i}	24.47^{d}	15.56^{d}	18.81^{a}	20.46^{a}
Harrisonia abyssinica	91.19^{c}	7.20^{f}	16.84^{f}	33.84^{h}	30.81^{c}	14.97^{e}	13.18^{d}	17.03^{b}
Erucastrum arabicum	90.65^{e}	14.01^{b}	14.77^{i}	43.37^{f}	35.90^{b}	11.45^{f}	15.87^{b}	16.91^{b}
Duosperma eremophilum	89.66^{g}	4.52^{j}	21.62^{b}	36.44^{g}	20.44^{e}	10.01^{g}	15.63^{b}	13.33^{f}
Securinega virosa	90.36^{f}	10.32^{d}	17.58^{c}	33.69^{h}	30.50^{c}	8.24^{h}	12.87^{e}	13.70^{e}
Cordia sinensis	91.92^{b}	12.93^{c}	15.57^{h}	52.56^{b}	55.24^{a}	48.43^{a}	11.70^{e}	12.88^{g}
Ximenia Americana	90.93^{d}	8.66^{e}	12.61^{j}	56.77^{a}	32.32^{c}	22.54^{b}	13.96^{c}	3.69^{j}
Rhus natalensis	90.28^{f}	6.47^{h}	12.36^{k}	49.91^{c}	36.33^{b}	13.83^{d}	13.42^{d}	9.03^{h}
Lannea schweinfurthii	90.8^{e}	6.9^{g}	17.4^{d}	47.2^{e}	36.2^{b}	20.3^{c}	11.2^{f}	14.1^{d}
Grewia bicolor	92.9^{a}	8.76^{e}	24.2^{a}	47.2^{e}	30.8^{c}	10.9^{g}	8.9^{g}	14.7^{c}
SEM	0.0267	0.0267	0.0176	0.0317	0.0374	0.0234	0.0271	0.0284

ADF= Acid detergent fibre, NDF=Neutral detergent fibre, CP=Crude protein, DM=Dry matter, EE= Ether extract, OM=Organic matter, ME= Metabolisable energy, SEM=Standard error of mean $^{a, d,c,d,e, f,g,h,i}$ mean values within a column with different superscripts differ at $p<0.05$

Fat concentrations in typical ruminants' diets without supplemental fat are usually low, ~2.5% of dry matter. Supplemental fats may be added to attain a total ration fat concentration of ~6% of dry matter. Fats in ruminant diets can induce undesirable metabolic effects, both within the rumen microbial population and within the animal. These effects include reduced fiber digestion, indigestion and poor rumen health, and suppression of milk fat concentration [31]. In calf nutrition, 10-22% of fat is recommended for inclusion in calf diets. The fat contents in preferred forages for the camel calves ranged from 8.9 to 18.81gkg-^{1}DM. Apart from *Grewia bicolor*, all other forage species had fat content adequate to meet daily requirement of camel calves. Dry matter refers to material remaining after removal of water, and the moisture content reflects the amount of water present in the feed ingredient. The nutrients in feeds, required by the animal for maintenance, growth, pregnancy, and lactation, are part of the DM portion of the feed. The DM contents of the forages ranged 89.48 to 92.9%. The DM contents of the forages ranged 89.48 to 92.9%. A Calf consumes 1.6% to 1.8% of her body weight on daily basis [31].

The ADF is often used to predict energy content of feeds. Like NDF, ADF is a good indicator of feed quality; higher values within a feed suggest lower-quality feed. For legume forages, NDF content below 40% would be considered good quality, while above 50% would be considered poor. For grass forages, NDF < 50% would be considered high quality and > 60% as low quality [27]. The NDF, ADF and ADL contents were higher in *Cordia sinensis* compared to other forage species which is an indicator of poor feed quality and most of other forages were within the recommended range of good quality forages. NDF and ADF values were similar to those reported by [2], especially for *Cordia sinensis*. The ash content in the forages ranged from 6.03%- 19.36%. Ash is the total mineral content of a forage or diet. High ash content of feeds may dilute the amount of nutrients available to the animal.

3.4 Mineral composition of most preferred forages

Mineral composition of the most preferred forages in rangelands for camel calves are presented in Table 4. All the forages were deficient in P (0.7%), but adequate in K (0.6%). *Acacia brevispica*, *Aspilia mossambicensis*, *Rhus natalensis* and *Lannea schweinfurthii* had low levels of Ca (1%), *Ximenia Americana* had Fe (100 mg/kg) within the recommended range. Only *Harrisonia abyssinica* had the recommended levels of Cu (10 mg/kg). *Harrisonia abyssinica* and *Securinega virosa* had Mn content (20 mg/kg**)** within the recommended levels and all forages were deficient in Zn. These results are in agreement with the results of [28] and [25] on the mineral content especially of *Acacia brevispica.* Results of this study are also similar to the findings reported by [2] and [12] especially on macro elements in *Cordia sinensis* and *A. brevispica.*

Table 4: Mineral composition of most preferred forages in rangelands for camel calves in peri-urban camel production system in Karare area in Marsabit County

Sample	P (%)	K (%)	Ca (%)	Mg (%)	Fe (mg/kg)	Cu (mg/kg)	Mn (mg/kg)	Zn (mg/kg)
Acacia brevispica	0.29e	0.66k	0.36h	0.08h	23.5i	1.33f	1.17j	5.00k
Aspilia mossambicensis	0.34c	2.11b	0.89g	0.14g	3.83j	8.17b	13.2c	6.83i
Harrisonia abyssinica	0.29e	1.75g	1.73c	0.30c	83.8c	11.2a	21.8b	14.2c
Erucastrum arabicum	0.34c	2.17a	1.51d	0.34b	41.5g	1.17g	2.00g	18.5b
Duosperma eremophilum	0.37b	2.04c	2.40a	0.67a	56.3e	0.83h	3.50f	10.0h
Securinega virosa	0.26g	1.78f	1.91b	0.28d	98.0b	1.17g	56.8a	5.17j
Cordia sinensis	0.39a	1.98e	1.29e	0.14g	53.7f	2.00c	11.7d	20.0a
Ximenia americana	0.29f	2.01d	1.49d	0.31c	105.5a	1.83d	1.50i	13.3d
Rhus natalensis	0.32d	1.42h	0.33i	0.16f	31.2h	1.50e	0.83k	11.3f
Lannea schweinfurthii	0.32d	0.93i	0.94f	0.14g	77.5d	0.83h	1.67h	10.3g
Grewia bicolor	0.23f	0.89j	1.28e	0.25e	83.8c	1.17g	4.50e	13.0e
SEM	0.0031	0.0032	0.0101	0.0032	0.1391	0.0169	0.0272	0.0289

3.5 *In-vitro* dry matter digestibility of the preferred forage species

The *in-vitro* DM digestibility characteristics of the preferred forage species varied widely among the nine forage species. The total DM digestibility (g/Kg) presented in Figure 3 show variations in the digestibility potential, with *Acacia brevispica* (839 g/kg DM) being the highest and *Duosperma eremophilum* (283 g/kg DM) being the lowest. *Duosperma eremophilum* ranked the lowest in *in-vitro* digestibility potential; this could be due to the high level of tannins and smell which affect nutrient utilization by the microbes [11]. The variation in gas production among the indigenous browse species might be due to the quantity of substrate fermented [26]. The *in vitro* DM digestibility (g/Kg) indicates the presence of potential degradable nutrients in most preferred forage species which underscores their importance as sources of nutrition for camel production.

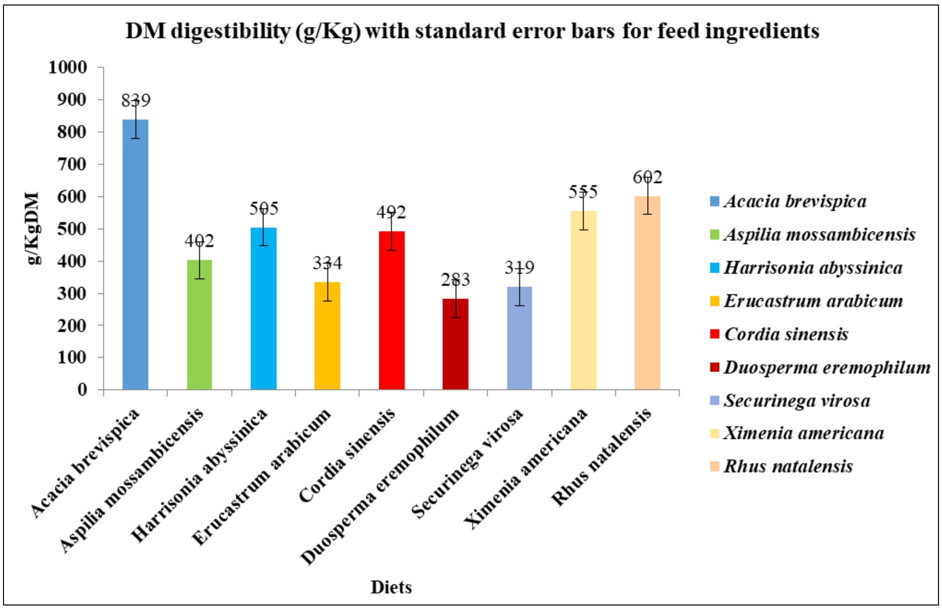

Fig 2: Tilley and Terry DM digestibility with standard error bars for most preferred forages

3.6 Feed intake, average daily weight gains, feed conversion ratio and apparent nutrient digestibility

Feed intake, average daily weight gains and apparent nutrient digestibility of camel calves fed on commercial and plant-based locally milk replacer and a control are presented in Table 5. Calves on commercial and plant-based locally formulated milk replacer had a higher ADG compared to control (Table 5 and Figure 3) perhaps as a result of the increased dry matter intake attributed to the growing camel calves getting sufficient nutrients for increase in body weight. This was similar to the results reported by [9] on average daily gain (0.77 and 0.78 kg/d) of newborn dairy calves fed on milk replacer with 20% crude protein concentrations. The results on the camel calf performance indicated significant (p<0.05) dietary treatments' effects on growth performance among the growing camel calves in the study. There were no significant interactions between block (breed) and the three experimental diets on DM intake and ADG (p>0.05). All the calves had positive weight gains. Apparent digestibility coefficient of the nutrients (g/kg^{-1}DM**)** increased significantly (p<0.05) in Control and PBMR compared to calves on CMR which could be as a result of less milk suckling among the controls and high dry matter intake among calves on plant based milk replacer. Calves on control seemed to browse more aggressively than the calf on CMR due to the limited milk suckling. In addition, calves on CMR seem to be have met their daily requirements thus browsed less during the day. Dry matter DM) intake (kg/day) in calves fed on PBMR compared to those fed on CMR were not statically different.

Table 5: Dry matter feed intake, average daily gains and apparent nutrient digestibility (g/kg DM) of camel calves fed on commercial and plant-based locally milk replacer and a control

Parameters	Control	PBMR	CMR	SEM
DM Intake (kg/day)	ND	2.41^a	2.0^a	0.0243
ADG (gd^{-1})	453.7^c	566.3^b	761.4^a	30.948
Initial weight(kg)	111.31^a	100.28^a	95.44^b	1.044
Final weight(kg)	136.66^b	132.88^b	139.38^a	1.042
FCR	ND	13.9^b	14.5^a	0.155
Digestibility coefficients (g/kg DM)				
CP	117.8^a	95.1^c	107.9^b	0.195
DM	921.1^b	932.7^a	893.9^c	0.440
ADF	98.7^a	96.4^b	92.3^c	0.701
NDF	178.7^a	153.4^b	141.3^c	0.142

ADF= Acid detergent fibre, NDF=Neutral detergent fibre, CP=crude protein, DM=dry matter, FCR=feed conversion ratio, ADG=average daily gain

Apparent digestibility coefficient provides estimates of nutrient availability in feedstuffs and is used to select ingredients that enhance nutritional value [4].The differences in apparent digestibility coefficient of ingredients may be explained by differences in chemical composition, which is determined by the processing or origin of the feed ingredients [15]. The most common measurement of feed efficiency is feed conversion ratio (FCR), which is the ratio of feed intake to live-weight gain [18]. FCR was higher in commercial milk replacer compared to plant-based locally formulated in milk replacer. Lower FCR value in PBMR indicates higher efficiency compared to CMR. Growing camels that convert at a high rate (lower FCR) are highly desirable for ideal camel production.

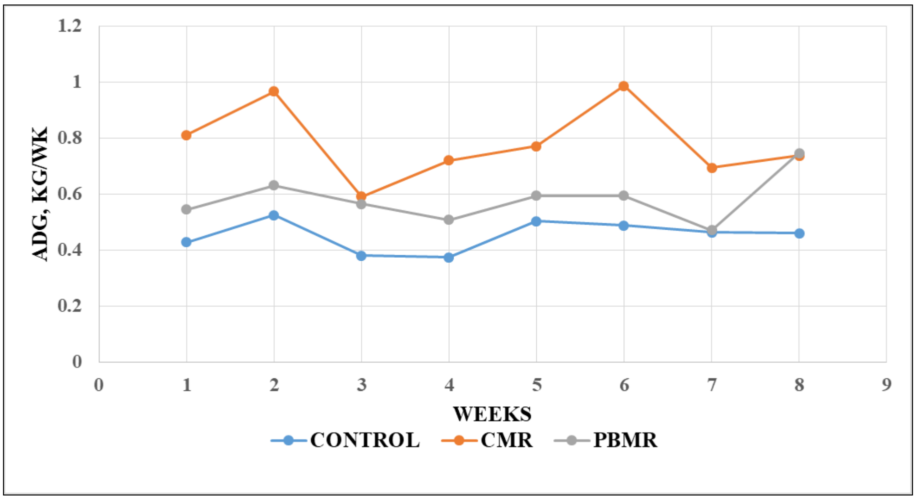

Fig 3: Effects of experimental diets on weekly average daily gains of growing camel calves

4. Conclusion

In conclusion, Dry matter DM) intake (kg/day) in calves fed on PBMR compared to those fed on CMR were not statistically different. Camels on commercial and plant-based locally formulated milk replacer had a higher ADG compared to control. FCR was higher in commercial milk replacer compared to plant-based locally formulated in milk replacer. Lower FCR value in PBMR indicates higher efficiency compared to CMR**.** Both commercial milk replacer (CMR) and locally formulated plant-based milk replacer (PBMR) could be used as replacement to camel milk feeding in Arid and semi-arid lands of Kenya to enhance calf performance and avail camel milk for income and home consumption for pastoral households'. However, the ingredients used for PBMR should be based on local availability, high quality and camel preference to ensure availability of the nutrients in the recommended quantities for formulation of milk replacers i.e., energy, protein and minerals. PBMR need some further improvements and refinements in CP (2%), Ca (0.03%) Cu and zinc and fibre in future formulations.

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6. Conflict of interest

All authors declare no competing interests.

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