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Proximate composition of selected browses and common milk supplements for camel calves in Kenya

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Abstract
A study on nutritive values of selected browses fed to camel calves and commonly used local feed supplements to milk feeding was conducted in the southern rangelands of Marsabit County. Selected browses and common supplements were analyzed for their proximate composition. In addition, commonly used supplements were analyzed for their amino acid profiles, Ca, P and tannin levels. The samples were analyzed for their potential to formulate plant-based milk replacer or starter feeds for camel calves. The study used focused group discussions (FGDs) to identify available browses and commonly used supplements. Four focus group discussions (FGDs) comprising of 12 persons per study site: Karare, Kargi, Korr and Ngurunit wards were conducted in the main camel keeping areas among the Rendille camel keeping community. A total of 10 browses, 4 grass species and 6 commonly used supplements were analyzed. This study established that CP, DM, fat, NDF, ADF, and ME composition were highly variable, with significant (P<0.05) differences among the browses and grasses. Browses like *Grewia bicolor* (24% CP) *and Justicia exigua* (20% CP) have a potential to provide recommended daily protein requirements for a camel calves (20-24% CP) as starter feeds and plant-based milk replacer. Browses which have recommended energy above 15 MJ. Kg-1 DM to meet daily energy requirement of camel calves for starter feeds and plant-based milk replacer are *Justicia exigua* (19.3 MJ. Kg-1 DM), *Acacia melliffera* (18.1 MJ. Kg-1 DM) and *Salvadora persica* (18.4 MJ. Kg-1 DM). All the four grass species evaluated (*Aristida mutabilis* (16.3 MJ. Kg-1 DM), *Cenchrus ciliaris* (17.1 MJ. Kg-1 DM), *Leptothrium senegalense* (15.3 MJ. Kg-1 DM) and *Sporobolus species* (15. 9 MJ. Kg-1 DM) have recommended energy to meet daily requirement of a camel calves (15-20MJ.Kg-1 DM). The common supplements used by pastoral camel keepers like *Acacia tortilis* pods (15.42% CP), *Tinnospora caffra* (14.05% CP) and *Prosopis juliflora* (11.08% CP) as protein sources have lower than the recommended 20-24% CP. However, the energy sources used as common supplements like sheep fat (26.87 MJ. Kg-1 DM), camel fat (28.57 MJ. Kg-1 DM) and maize meal (26. 10 MJ. Kg-1 DM) have adequate energy to meet daily energy requirements as starter feeds and plant-based milk replacer. The commonly used forage supplements i.e., *Acacia tortilis* pods, *Prosopis juliflora* and *Tinnospora caffra* are low in limiting amino acids methionine, lysine and threonine for calf nutrition, thus recommended for supplementation. Tannins concentrations of commonly used supplements were within the safe range that would not be harmful to the animals. The *Acacia tortilis* pods (Ca 3.72% and P 0.91%) and Prosopis juliflora pods (Ca 1.44% and P 0.75%) used as common supplements have sufficient Ca and P to meet daily requirements of camel calves and thus can be recommended to supply the two important minerals for the growth of the calves'. However, *Prosopis juliflora* pods should be used in grounded form because it can easily colonize rangelands through fecal propagation. It is concluded that the selected browses, grasses and commonly used supplements for camel calves have an enormous potential as ingredients for formulation of camel calves plant-based milk replacer and starter feeds when harvested at the right time. Therefore, they could reduce nutritional related mortality, enhance the camel calves' performance and result in more camel milk available for sale and home consumption.

Keywords: nutritive value, starter browses, common supplements, calf performance

Introduction
Feed inadequacy in terms of quality and quantity is the major constraint to livestock production in the Arid and Semi-Arid Lands (ASALs) of Kenya [18]. About $2 billion worth of livestock is lost annually through mortality arising from starvation, diseases and missed trade opportunities, leading to increased food insecurity in the ASALs [26] The acute shortage of forage to sustain livestock populations through the dry seasons has threatened the livelihood security of pastoral communities [23].

Camels are better adapted to the dry climate and deteriorating rangeland of Northern Kenya and other dry areas of Africa (https://infonet-biovision.org). The physiology of camels enables them to survive on very fibrous and low protein diets [12]. The height of camels allows them to utilize feed resources inaccessible to other livestock species [5]. Camels (*Camelus dromedarius*) are the source of food, cash income, means of transport and have significant cultural functions to pastoral communities dominating in the ASALs [7, 14]. Despite the socio-economic importance of the camel in the arid and semi-arid rangelands of the world, little efforts have been done to improve their productivity and nutrition.

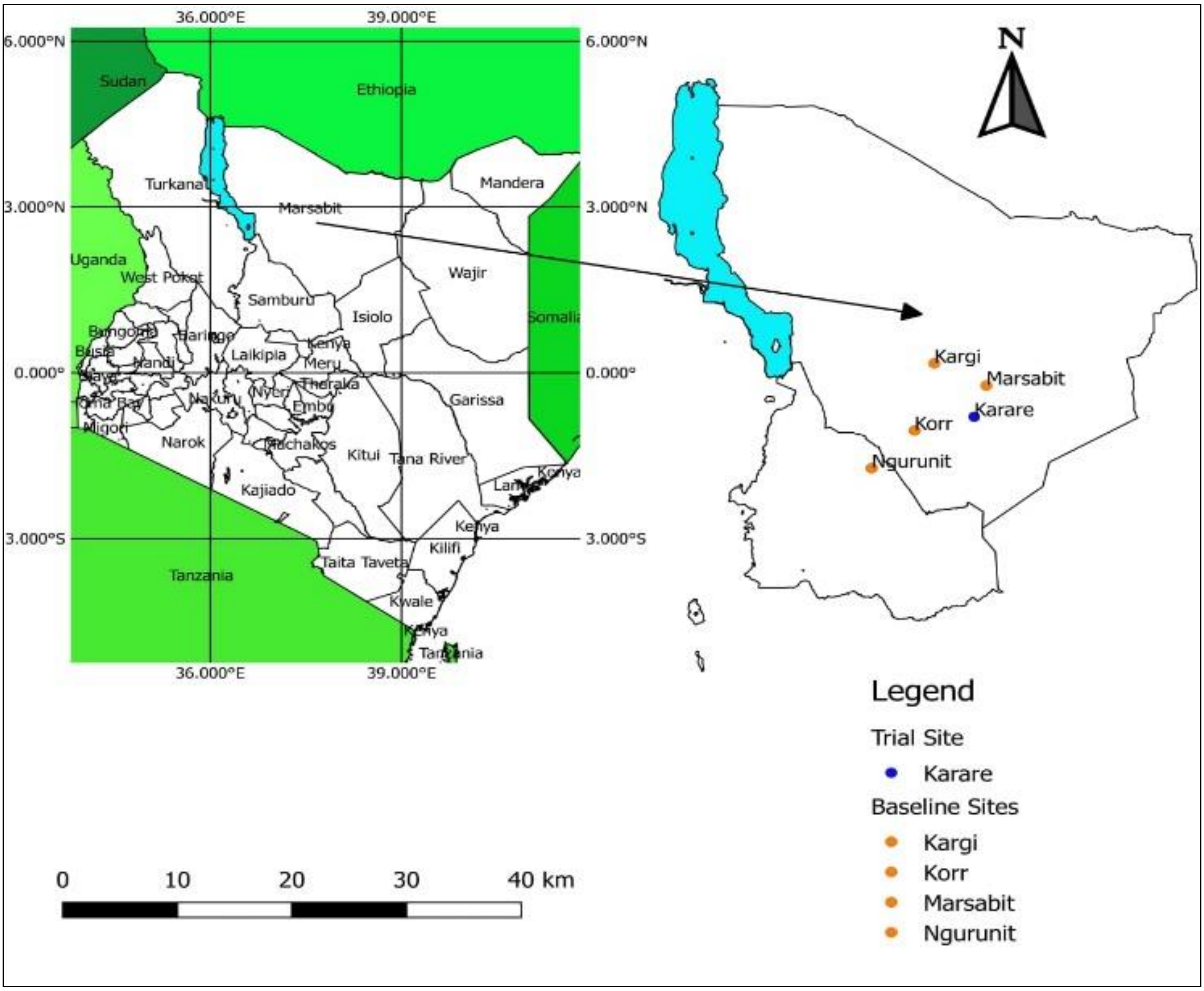
Camel calves constitute the replacement stock, without which the camel herd cannot grow nor would milk be available for the pastoralists [4]. Rearing of camel calf under traditional pastoral production systems is faced with challenges of feed deficit due to degraded rangelands coupled with competition for milk by pastoralists for household consumption and trade. Mortality rates of up to 62% have been reported in calves between birth and weaning [9, 20]. The camel is, by preference, a browser of a broad spectrum of fodder plants, including trees, shrubs, and sometimes hard-thorny, bitter and halophytic (salty) plants that grow naturally in the desert and other semi-arid areas [28, 6] Pastoralists when selecting browses for their camel calves consider: availability of the browse throughout the year, palatability and nutritive value.

Therefore, this study aimed to seek for alternative sources of feeds that will support calf growth in order to solve constraints of milk competition for households' consumption and trade.

Materials and Methods

Site Description

The study was conducted in southern rangelands of Marsabit County among the Rendille camel keeping community in Kargi, Korr, Ngurunit and Karare wards. Marsabit County is one of the ASALs Counties of Kenya, with the exception of high potential areas around Marsabit and Kulal Mountains, and the Hurri hills while the rest of the County is arid. Rainfall is usually low, highly variable and of short duration. The County experiences a bimodal rainfall regime with two peaks, in April and November. 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 34ºC, with the period between January and April being very hot.



Source: Google map (2021).

Fig 1: Map of Kenya showing the study areas

Data collection Method
A baseline survey using Focus group discussions (FGDs) comprising of 12 persons per site was conducted in the main camel keeping areas among the Rendille community in southern rangelands of Marsabit County, including Karare, Kargi, Korr and Ngurunit. The participants were purposefully selected based on their knowledge in identifying range plants species utilized by camel calves using local names and their knowledge on camel calves feeding. The study used open ended questionnaires to guide the discussion and recorded all responses on notebook and audio.

Sampling
All browses and supplements were listed and sampled (leaves, twigs and fruits) since they were fewer and specific to different study sites. At all sites three experienced elders were recruited to guide sampling of forages and supplements. The forage samples were clipped using secateurs and about 1kg of each species were collected, stored in forage bags and labeled in readiness for analysis. The samples were then kept under room temperature in open forage bags without disturbance for a period 5 days to facilitate drying. The collected forages were later ground and subjected to laboratory analysis.

Laboratory Analysis: Proximate, tannins and minerals assay of samples
Proximate analysis of local feed resources used as a starter feeds for camel calves before releasing for free range browsing and other popular supplements used by pastoral camel keepers were analyzed to determine their dry matter (DM), crude protein (CP), ether extract (EE) and ash according to the standard methods of [2]. 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 [27].
Essential amino acids profile was determined using amino acid analyzer, High Performance Liquid Chromatography (HPLC), according to the method of [2]. Phenolics were extracted using 70% aqueous acetone procedures described by [15]. The total extractable phenolics (TEPH) were determined using Folin Ciocalteu procedures as described by [8]. The condensed tannins (CT) were measured and computed as leucocyanidin equivalent, using the method of [25]. Minerals (macro and micro elements) were determined using atomic absorption spectrophotometry (AAS).

Statistical Analysis
Data collected on proximate, fiber and tannins were subjected to the analysis of variance (ANOVA) in a completely randomized design (CRD) using the General linear model procedure of statistical analysis system [31] version 9.0. Significant means were separated using Tukey's HSD (Tukey's Honestly Significant Difference Test) at 5% significance.

Results and discussion
Nutritive value of browses
The chemical composition of the browses and grasses is presented in Table 1.

Table 1: Chemical composition (% DM) of commonly used starter browsers

Samples	DM	Ash	CP	NDF	ADF	ADL	Fat	ME (MJ.Kg-1 DM)
Browses								
Lannea schweinfurthii	90.8^{e}	6.9^{i}	17.4^{d}	47.2^{h}	36.2^{i}	20.3^{e}	11.2^{b}	14.1^{f}
Grewia bicolor	92.9^{d}	8.76^{g}	24.2^{a}	47.2^{h}	30.8^{j}	10.9^{g}	8.9^{ed}	14.7^{ef}
Rhus natalensis	92.8^{d}	7.08^{i}	16.1^{ed}	61.2^{e}	51.8^{e}	29.6^{b}	9.6^{cd}	12.1^{h}
Combretum molle	93.3^{cd}	6.82^{i}	17.3^{d}	39.8^{k}	30.6^{j}	7.2^{i}	8.4^{f}	13.4^{g}
Cordia sinensis	92.1^{d}	12.1^{f}	19.3^{c}	58.9^{f}	56.8^{c}	24.5^{c}	9.1^{de}	12.2^{h}
Acacia mellifera	94.0^{cb}	8.36^{h}	20.2^{b}	44.4^{j}	34.7^{i}	6.1^{i}	9.2^{e}	18.1^{b}
Justicia exigua	92.9^{d}	8.05^{h}	20.4^{b}	43.6^{j}	42.7^{h}	22.6^{d}	8.9^{e}	19.3^{a}
Salvadora Persica	92.1^{d}	30.9^{c}	15.1^{e}	31.3^{k}	23.9^{k}	6.9^{i}	10.2^{c}	19.4^{a}
Euphorbia tirucalli	95.2^{b}	8.18^{h}	10.8^{f}	50.3^{g}	45.9^{g}	12.8^{f}	12.5^{a}	14.9^{ed}
Fiscus benjamina (leaves)	93.4^{cd}	22.3^{e}	11.8^{f}	46.2^{j}	53.2^{e}	1.2^{j}	9.8^{cd}	7.8^{i}
Fiscus benjamina (barks)	95.9^{a}	8.28^{h}	4.9^{j}	62.5^{d}	68.8^{a}	46.7^{a}	8.9^{e}	2.7^{j}
Grasses								
Aristida mutabilis	96.2^{a}	43.1^{a}	7.8^{h}	79.8^{a}	63.2^{b}	7.3i	5.2^{i}	16.3^{d}
Cenchrus ciliaris	94.8^{b}	27.8^{d}	6.1^{h}	77.8^{b}	55^{d}	7.4i	5.9^{h}	17.1^{c}
Leptothrium senegalense	96.0^{a}	30.5^{c}	8.6^{g}	79.5^{a}	58.3^{c}	18.4^{e}	5.6^{h}	15.3^{ef}
Sporobolus spp	94.9^{b}	32.1^{b}	7.4^{h}	68.1^{c}	49.6^{f}	8.8^{h}	6.9^{g}	15.9^{d}
SEM	0.186	0.217	0.209	0.291	0.308	0.261	0.177	0.189

NDF: neutral detergent fiber, ADF: acid detergent fiber, ADL: acid detergent lignin, DM: dry matter, ME: Metabolizable energy abc in columns mean values without common superscript differ at $P<0.05$.

The CP, DM, fat, NDF, ADF, and ME composition were highly variable, with significant ($P<0.05$) differences among the commonly used browses. The CP content of browses ranged from 10.8% in *Euphorbia tirucalli* to 24.2% in *Grewia bicolor* leaves and fruits. Crude protein content was very different across browses, but within browses higher protein is usually associated with higher quality. This certainly is true in forages. As forages mature, their crude protein is diluted with increasing fiber content [32]. The CP content range of commonly used browses confirms validity of indigenous technology and knowledge in selecting the right forage species as protein source for their camel calves. The content of crude protein in the fruit and leaves of the most of fodder trees and shrubs is above 10% even in the dry season when it tends to decrease [1].
Energy content is often used to compare feeds and evaluate quality. Feed energy content is not directly measured like other nutrients but is derived through regression equations. Cattle TDN values are the best estimate available and should reasonably reflect feed energy for camelids given the similarity in digestive function [32]. The ME in browses ranged from 7.8 MJ. Kg^{-1} DM in *Fiscus benjamina* to 19.32 MJ. Kg^{-1} DM in *Justicia exigua. Fiscus benjamina* is also used for its medicinal values, besides the nutrition purposes. Therefore,

these natural browses could be good sources of energy and protein to be used as ingredients for starter feeds or milk replacer for the camel calves.

Usually pastoralists harvest branches for the calves only to utilize the leaves, twigs and fruits. Such practices could be detrimental to the environment over time, especially around the sedentarized areas. Thus, there is need to capacity build pastoralists on sustainable harvesting and conservation of browser forages especially around sedentarized areas. They should only harvest the palatable parts through hand picking than cutting. The harvested parts could be dried and stored for dry season utilization.

The DM content of browses ranged from 90.6% in *Lannea schweinfurthii* and 95.2% in *Euphorbia tirucalli.* The nutrients in feeds, required by the animal for maintenance, growth, pregnancy, and lactation, are part of the DM portion of the feed. Knowing the moisture content of a feed ingredient is important because the moisture content affects the weight of the feed, but does not provide nutrient value to the animal. Although animals do have a requirement for water, providing water through an actual water source, instead of through feed ingredients, is necessary (https://dairy-cattle.extension.org). Determining the DM content of feed provides a measure of the amount of a particular feed that is required to supply a set amount of nutrients to the animal. Increases or decreases in feed DM content result in over or under feeding of nutrients. The DM in the starter forages were high due to the fact that the plants were sampled during the dry season. Unlike the conventional methods of feeding animal on dry matter basis of feeds, pastoralists feed the camel calves mostly on fresh branches without determining its DM content and they don't consider body weights of the calves as a basis of feeding and meeting the daily nutritional requirements. Therefore, there is need to capacity- build camel keepers to use DM at 3% of calf body weight as a basis of offering feed on daily basis.

Ash content of browses ranged from 6.51 in *Lannea schweinfurthii to* 30.88% in *Salvadora persica* (Table 1). Ash is simply the total mineral content of a forage or diet. High ash content in forages or TMR can skew forage energy estimates and dry matter intake. Excessive ash contents in forages could be a silent antagonist in animal nutrition [33]. This difference in proximate composition in the starter forages might be due to the difference in the constitution of species of mixed forage, soil type, location and the climate which is in harmony with findings of [3].

The portion of a forage or feed sample insoluble in neutral detergent is termed *neutral detergent fiber (NDF)*, which contains the primary components of the plant cell wall, namely, hemicellulose, cellulose, and lignin. As cell wall production increases, as occurs in advancing plant maturity, NDF content increases. As NDF content of a feed increases, dry matter intake decreases and chewing activity increases. Within a given feed, NDF is a good measure of feed quality and plant maturity. 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 [32]. Another measure of fiber is acid detergent fiber (ADF), a subset of NDF. Acid detergent fiber contains the poorly digestible cell wall components, namely, cellulose, lignin, and other very resistant substances. Due to its nature, 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. A goal would be to have < 35% ADF in either legume or grass forages quality [32]. Acid detergent lignin (ADL) is frequently a greater proportion of the acid detergent fiber (ADF) of browse leaves than of other forages. The NDF in the starter browses were all above 40% which is an indication of poor quality forages except for *Salvadora persica* which was 31.33%. This was probably due to the fact that samples were taken during dry season and *Salvadora persica* is an evergreen plant. Therefore, it is important to note that, when considering using the palatable parts of starter browses as ingredients of animals' feeds, timely harvesting is of paramount importance in order to attain high quality feeds. The ADF in all starter browses were also above recommended 35% which is an indicator of poor quality except for *Grewia bicolor, Combretum molle* and *Salvadora persica* which were in the recommended range for good quality forages.

Ether extract is a chemical method by which all lipid (fat) soluble compounds are extracted by being dissolved in ether. This technique is of little value in evaluating feed quality except in the cases of comparing feeds with high fat content [32]. Fat is important in ruminant diet, can help improve the nutritional quality of milk and meat. Fat is also an essential component of balanced diets and is often added to increase energy density crucially without increasing the acid load in the rumen [32]. Fat contains 2.25 times more energy than carbohydrate. After maximizing carbohydrate in the diet, fat is often added to meet the remainder of the energy needs. High levels of rumen available fats (above 5% of the ration DM) can decrease growth of the fiber-digesting microbes, decreasing fiber digestibility and intake. If more energy is needed beyond that supplied by carbohydrates and rumen available fats, rumen inert fats can be added. The maximum level of total fat should be 7% of the ration DM. Fats can improve reproductive performance (http://www.milkproduction.com.). Fat (EE) content of commonly used starter browsers ranged from 8.38% in *Combretum molle* to 12.54% in *Euphorbia tirucalli* which is sufficient as feedstuff ingredient.

Nutritive value of range grasses

The amount of nutrients in the forage determines the quality of livestock production. Knowledge of forage quality is necessary in planning and proper utilization of the pastures for optimum livestock performance [14]. The four rangelands grasses reported to be used as a starter feeds for camel calves across all study sites were *Aristida mutabilis, Cenchrus ciliaris, Leptothrium senegalense* and *Sporobolus spp.* Their dry matter ranged from 95.1 in *sporobolus spp* to 96.2% in *Aristida mutabilis.*

Previous studies had reported that indigenous grasses such as *Eragrostsis superba* and *Cenchrus ciliaris* had higher dry matter yields and are well adapted to the local environment under cultivation [36] The productivity potential of *Chloris gayana* has also been suggested by [37] Nevertheless, the dry matter yield from the other grass species had also potential to support livestock for considerable period of time. Considering that an animal can consume dry matter equivalent to 3% of its body weight, dry matter yield from one hectare of *Chloris gayana* can support 15 Tropical Livestock Units for 90 days, *Eragrostis superba* for 47 days and *Cenchrus ciliaris* for 26 days [36]. Therefore, propagation of adaptable grasses in arid and semi-arid lands (ASALs) to be used in feeding calves with other local feed ingredients during dry season could reduce reported high calf mortality rates in ASALs of Kenya which mostly emanates from malnutrition. The pastoralists mostly use grasses during dry season when the leaves of browses are dry and are not readily available.

The CP of the grasses ranged from 5.79% in *Cenchrus ciliaris* to 7.73% in *Sporobolus spp*. Grasses alone cannot meet the daily protein requirements of camel calves (C.P 20-24%). This is because protein requirements in ruminants include protein and or nitrogen requirements for the ruminal microbial population [39]. Although camels are classified as pseudo-ruminants, it has been previously reported that what works for cattle in nutrition also works for camels (http:om.ciheam.org). The microbial requirements are met at 6-8% CP while the animal requirements range from 7- 20% CP in the diet depending upon species, sex and physiological state [41]. [38] described 11-13% CP in the diet as adequate for maintenance and growth requirements of sheep and goats while 7-8% is enough to cover the requirements of ruminal micro-organisms.

The energy in grasses is adequate to maintain the calves and spur growth. The energy ranges from lowest in *Leptothrium senegalense* 15.25MJ to highest in Cenchrus *ciliaris* 17.11MJ. According to [21], camel calves require in their diet about 15-20MJ, C.P 20-24%, EE 10%, Ca 1.0% and P 0.7%.

Neutral detergent fibre is the major determinant of overall forage quality and digestibility, and has a direct effect on animal performance [40]. High NDF lowers the voluntary DM intake of grazing animals [42]. The higher the NDF, the lower the neutral detergent solubles i.e. starches, sugars, fats, CP. [42] described NDF range of 35-40% as within the normal range of nutritious fodders.

The NDF in the grasses used as starter feeds for camel calves ranged from 68.05% in *Sporobolus spp* to 79.84% in *Aristida mutabilis* when compared with starter browses. ADF in *sporobolus spp* was 49.63% while *Aristida mutabilis* had 63.25%. The percentages of NDF and ADF in starter grasses is an indication of low quality and digestibility. However, unlike other ruminants, camels have a higher capacity to utilize fibrous feed material by retaining it in the rumen for longer period, allowing for better digestion [12]. This unique adaptation of camels mitigates the negative effects of high fibre content in their diets. Compared to the browses, grasses had higher ash content. This study is in harmony with [10] who reported that Shrubs had a mean NDF content of 51.0+12.6% compared to 60.4+14.3% for grasses, herbs and climbers. Compared with grasses, shrubs and dwarf shrubs were lower in fibre and ash, and higher in DM and CP content. These attributes make the shrubs and dwarf shrubs more palatable, in harmony with [42] and thus preferred by the grazing camels.

Nutritive value of commonly used supplements

The chemical composition of commonly used supplements and substitutes are presented in Table 2. The DM content ranged from 90.3% in maize meal to 99.83% in Camel hump fat. The CP content ranged from 0.18% in Camel hump fat to 15.42% in *Acacia tortilis* pods. Maize meal had lower NDF compared to *Acacia tortilis, Prosopis juliflora* and *Tinnospora caffra* and sheep tail fat. Camel hump fat had higher Fat (EE) content compared to the natural browses and maize meal.

Table 2: Chemical composition of commonly used supplements and substitutes

Sample	DM (%)	ASH (%)	CP (%)	NDF (%)	Crude Fat (%)	ME(MJ/kg DM)
Acacia tortilis	93.82^{c}	21.20^{b}	15.42^{a}	61.74^{c}	6.75^{d}	5.18e
Prosopis juliflora	93.08^{c}	22.13^{a}	11.08^{c}	64.98^{a}	9.21^{c}	4.83^{e}
Tinnospora caffra	94.73^{b}	20.09^{c}	14.05^{b}	63.89^{b}	6.63^{d}	6.78^{d}
maize meal	90.13^{d}	0.32^{d}	7.11^{d}	17.68^{d}	13.14^{b}	26.10^{c}
Sheep tail fat	99.67^{a}	0.00	0.34^{e}	N/D	100.30^{a}	26.87^{b}
Camel hump fat	99.83^{a}	0.00	0.19^{e}	N/D	100.09^{a}	28.57^{a}
SEM	0.175	0.166	0.126	0.156	0.135	0.204

DM, dry matter; CP, crude protein; NDF, neutral detergent fiber; OM, organic matter; CT, condensed tannins; ME, Metabolizable energy $^{a, b, c}$ in column means values without common superscript differ at P<0.05.

Sheep tail fat, camel hump fat and maize meal had higher ME compared to the natural browses.

Acacia tortilis wholesome pods and seeds are a potentially invaluable protein concentrate for ruminants in ASALs of Kenya. Tannins in *A. tortilis* do not significantly affect digestibility of the feed and the digestibility of the seeds can be improved by grinding that removes the hard outer covering [49, 48] reported a CP of 20.16%, ash 4.50, DM of 90.90% in Acacia tortilis pod in Botswana. The factors influencing the nutritive value of range forage are many and the degree to which they are interrelated may vary considerably from one area to another. The nutritive value of range forages is affected by stage of maturity, edaphic conditions, climatic influences, plant species, animal class and range condition (https://journals.uair.arizona.edu.).

Prosopis juliflora is a shrub introduced in arid and semi-arid lands of Kenya as a way of combating desertification. However, it has colonized rangelands of Kenya in Riverines like River Tana, Perkerra and Ewuaso Nyiro. It is evergreen, fast growing and drought resistant tree/shrub reported to possess allelo chemical compounds having negative impacts on vegetation which is growing in their vicinity. *Prosopis juliflora* have biological nitrogen fixation properties type of bacterium in its roots [27, 43] in Saudi Arabia reported 15.2% crude protein, 2.61% ether extract, 18.58% crude fibre and 6.04% ash, with 5.44MJ/kg in *Prosopis juliflora* pods. Despites its nutritional values, FAO classifies it as a noxious plant species and pastoralists of northern Kenya have observed it as a threat to existence of any other rangelands forages. Therefore, if it is to be used as an animal feed, it must be ground to crush the seeds to limit its propagation.

Tinnospora caffra grows in hilly and Mountainous areas in ASALs of Kenya where its tubers are used as dry/drought season supplements for livestock, especially cattle and small ruminants. *Tinnospora caffra* is a climbing shrub producing stems up to 5 metres long that twine around other plants for support [45]. documented *Tinnospora caffra* among preferred and adaptable forage species for cattle in Marsabit County of Kenya where they with its nutritive values as: DM =97.57%, CP =3.62, NDF=76.62, Estimated MJ=2.30 MJ. Kg-1 DM, Na= 0.02% and Ca=0.16%. This study notably reported higher CP =14.05% and is comparable in DM and NDF. The differences in CP could probably be attributed to soil type, location and quality of the samples collected for laboratory analysis.

Mineral composition and Tannins levels in commonly used supplements

Mineral composition

Studies on evaluation of mineral levels in feedstuffs commonly available to camels and mineral status in camels are very scanty. Such information is important in improving camel productivity through mineral supplementation [10]. The Rendille herders appreciate the importance of mineral nutrition in camels and have developed criteria for assessing mineral deficiency. The inadequate rumen fill, reduction in milk yield and lack of frothiness, licking of urine and soil, restlessness, chewing of bones and night enclosure construction woody materials are among other signs of mineral deficiency symptoms [10].

Exact mineral requirements for camels are not well established. However, the requirements have been shown to vary with breed, locality, age, sex, nutritional and health status [1]. Camel mineral requirements varied with parity, stage of lactation and pregnancy [48, 48] observed that camels have the capacity to withstand very high levels of salts in their feeds. The recommended daily intakes are 120-140gd^{-1}.

Mineral (Ca, P) concentration among the commonly used forage supplements are presented in Table 3. From all the forage supplements species, *Acacia tortilis* was high in calcium *(*3.72%*)* and phosphorous (0.91%) compared to *Prosopis juliflora* and *Tinnospora caffra.* The *Acacia tortilis* pods and *Prosopis Juliflora* pods have sufficient Ca and P to meet daily requirements of camel calves based on [21] recommendations (Ca- 1.0% and P- 0.7% in diet daily for camel calves be it starter feeds or milk replacer).

Table 3: Mineral composition and tannins of the 3 commonly used supplements

Species	Calcium (%)	Phosphorous (%)	Total tannins (mg/g)	Condensed tannins (mg/g)
Acacia tortilis pods	3.72^{a}	0.91^{a}	50.10^{a}	1.60^{b}
Prosopis juliflora pods	1.44^{b}	0.75^{b}	25.77^{b}	9.19^{a}
Tinnospora caffra tuber	3.70^{a}	0.52^{c}	3.04^{c}	1.60^{b}
SEM	0.079	0.012	0.093	0.047

abc in columns means values without common superscript differ at P<0.05.

The most important macro and micro elements of commonly used starter browses, grasses and maize meal which is commonly used as supplements in form of porridge are presented in Table 4.

Table 4: Major and minor mineral composition of commonly used browses

species	Phosphorus %	Potassium %	Calcium %	Magnesium %	Iron mg/kg	Copper mg/kg	Manganese mg/kg	Zinc mg/kg
Lannea schweinfurthii	0.36^{b}	1.16^{g}	0.1^{k}	0.22^{f}	294.5^{h}	3.33^{k}	51.7^{c}	3.33^{k}
Grewia bicolor juss	0.28^{c}	1.55^{d}	0.39^{h}	0.12^{i}	225.5^{n}	4.77^{j}	39.6^{g}	23.3^{c}
Rhus natalensis krauss	0.32^{c}	1.65^{c}	0.94^{g}	0.66^{a}	269.5^{j}	9.17^{g}	18.3^{l}	26.7^{b}
Combretum molle	0.32^{c}	1.32^{e}	1.29^{e}	0.07^{k}	221.2^{o}	10.2^{f}	26.7^{i}	13.3^{e}
Cordia sinensis	0.32^{c}	2.44^{a}	1.62^{d}	0.07^{k}	268.7^{k}	14.5^{cb}	23.3^{k}	28.3^{a}
Acacia mellifera	0.31^{c}	1.58^{d}	1.65^{d}	0.43^{c}	233.5^{l}	13.8^{cd}	13.3^{h}	6.67^{i}
Justicia exigua	0.43^{a}	2.14^{b}	1.73^{c}	0.11^{i}	230.3^{m}	12.8^{e}	26.7^{i}	6.67^{i}
Aristida mutabilis	0.13^{f}	0.66^{j}	0.09^{k}	0.06^{lk}	565.8^{a}	15.2^{b}	43.3^{f}	14.7^{d}
Cenchrus ciliaris	0.21^{ed}	1.19^{f}	0.14^{kj}	0.07^{k}	326.3^{f}	15.1^{cd}	58.3^{b}	11.7^{f}
leptothrium senegalense	0.18^{ed}	0.93^{i}	0.09^{k}	0.31^{d}	231^{m}	10.3^{f}	29.7^{h}	1.67^{l}
Sporobolus spp	0.23^{d}	1.22^{f}	0.21^{j}	0.09^{j}	450.3^{d}	16.7^{a}	164.7^{a}	8.33^{h}
Salvadora Persica	0.22^{d}	2.11^{b}	2.27^{a}	0.19^{g}	301.3^{g}	8.33^{g}	14.7^{m}	9.7^{g}
Euphorbia tirucalli	0.32^{c}	1.35^{e}	0.12^{kj}	0.52^{b}	470.5^{c}	6.67^{h}	49.7^{d}	9.7^{g}
Fiscus benjamina(leaves)	0.21^{ed}	1.06^{h}	0.32^{i}	0.15^{h}	556.7^{b}	13.8^{cd}	48.3^{e}	13.3^{e}
Fiscus benjamina (barks)	0.16^{ed}	0.17^{k}	2.13b	0.05^{j}	225.5n	10.8^{f}	11.7^{o}	3.33^{k}
Posho meal	0.22^{ed}	0.12^{k}	1.07^{f}	0.25^{e}	415^{e}	5.7^{i}	6.67^{p}	8.33^{h}
SEM	0.017	0.009	0.008	0.003	0.119	0.164	0.200	0.141

$^{a, b, c}$ in column means values without common superscript differ at P<0.05

For all the browses species *Justicia exigua* and *Cordia sinensis* had higher calcium, potassium and phosphorous compared to the other browses. *Cenchrus ciliaris* was high in Manganese. According to [21] mineral requirements for cattle calves, is 0.58% Ca, 0.20% Magnesium,0.26% Phosphorus, 0.70% Potassium, 0.10% Sodium and 0.15% Sulphur for growing calves. Calcium and P are the most important macro elements for growing calves because they are required for bone development, muscle function and energy metabolism. Phosphorous is adequate in all the browses, grasses and maize meal while Ca is deficient in *Lannea schweinfurthii, Grewia bicolor, Euphorbia tirucalli, Fiscus benjamina* and grasses and maize meal thus need for supplementation for Ca if used as ingredients in feed formulation. For the Micro elements [21], requirements of beef cattle, growing calves require 40mg/kg Cu, 50mg/kg Iron, 40mg/kg Mn and 30mg/kg of Zn. Iron is sufficient in all the browse forages, grasses and maize meal. Copper is deficient in all, Mn is deficient in most of the browses, grasses and maize meal and Zn is deficient in all thus requires supplementation.

Tannins

[17], reported that tannins promote the formation of indigestible complexes with protein, although this varies with animal species. According to [35], condensed tannins result in low growth rates and reduced nitrogen digestibility. Drying reduces assayable tannin. Other researchers like [34] reported that there is avoidance by African ruminants of browse plants with condensed tannins higher than 60 g/kg DM. The total tannins and condensed tannins contents ranged from 3.04 to 50.10 gkg^{-1}DM and 1.60 to 9.19 gkg^{-1}DM, respectively (Fig. 4). High concentrations of anti-nutritive factors especially condensed tannins tend to lower feed intake, feed digestibility and nutrient utilization [22]. Usually tannin concentrations greater than 50 g kg^{-1} in diets may negatively affect feed intake which in the long run affects animal performance [17].

Tannins concentrations (Figure 2) were within the safe range that would not be harmful to the animals

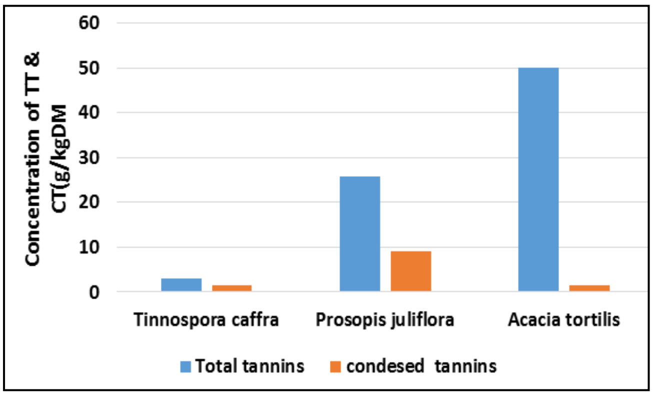


Fig 2: Total tannins (TT) and condensed tannins (CT) contents of commonly used supplements

Amino acid profile of commonly used forage supplements

Without amino acids it would have been very difficult, if not impossible, to produce the quantity of meat, milk, fish and eggs demanded by consumers. The availability of amino acids has allowed feeds to be produced using smaller quantities of protein rich raw materials allowing these limited scarce resources to be used more sparingly. Amino acids occur exclusively as structural protein units in which the amino group is bound to the α-position of the carboxylic acid group (carboxyl group). Chemically amino groups can bind in other positions, however only α-amino acids are relevant for animal nutrition [24].

Methionine and lysine are closely co-limiting amino acids in calves [19]. Lysine and Methionine are the most frequently first-limiting essential amino acids in dairy production [21]. Lysine, methionine, and threonine are the most limiting amino acids, and are related to the physiology, growth and reproductive performance of calves [13]. Individual amino acids such as lysine and methionine enhanced growth performance [30]. The amino acid profiles of the 3 commonly used supplements are presented in Tables 5. The commonly used supplements contained significant amounts of aspartic acid, glutamic acid, glycine and tyrosine. Lysine and Methionine essential amino acids necessary for calf growth were present in *Acacia tortilis pods, Prosopis juliflora pods* and *Tinnospora caffra tuber* although not in sufficient quantities and thus require supplementation.

Table 5: Analyzed Amino acid profile of the 3 commonly used supplements

Total Amino acid Concentration (mg/g)			
Amino acid	***T. caffra***	***P. juliflora***	***A. tortilis***
Aspartic acid	3.81	9.73	2.46
Glutamic acid	3.68	14.57	6.26
Serine	2.16	5.48	4.90
Histidine	0.13	1.64	0.27
Glycine	3.42	12.42	3.55
Threonine	0.89	0.60	1.61
Arginine	0.73	0.97	0.44
Alanine	1.82	5.82	2.09
Tyrosine	35.96	62.50	7.34
Valine	0.87	0.45	1.71
Methionine	1.95	3.55	2.72
Phenyl alanine	0.67	1.54	1.95
Iso-leucine	1.04	3.34	2.99
Leucine	1.08	3.90	17.91
Lysine	1.19	5.86	5.89

Feed formulations that do not meet Metabolizable amino acid requirements may lower both weight gains and the partial efficiency of energy use that affect the performance of growing calves [19]. Ability of the protein to supply sufficient amounts essential amino acids for dairy calves' growth depends on the protein amino acids profile and the protein digestibility [21, 24] reported on lysine (16 mg/g), methionine (4.7mg/g), and threonine (10.9mg/g) on limiting essential amino acids requirements (mg/d) in calves weighing (60-220kg) gaining 900g per day. Therefore, methionine, lysine and threonine in analyzed commonly used supplements (Table 5) require supplementation to promote growth and development of camel calves.

Conclusion and recommendation

- Due to the increasing pastoral sedentarization, rangelands degradation and climate change, livestock feed deficits are likely to worsen unless appropriate solution is sought. Since camels get most of their protein and energy from trees, shrubs and forbs through browsing; there is need to harvest the leaves, twigs and fruits during seasons of plenty and use them as ingredients in feed formulation. The valuable forages need to be conserved and pastoralists capacity-built on appropriate and sustainable harvesting and utilization methods.
- This study established that browses like *Grewia bicolor* (C P 24%) *and Justicia exigua* (C P 20%) have a potential to provide recommended daily protein requirements for camel calves (CP 20-24%) as starter feeds and plant-based milk replacer. Other browses recommended which have CP above 15% and could be used as protein sources are Cordia sinensis (CP 19%), *Lannea schweinfurthii (17%), Combretum molle (17%), Rhus natalensis (16%)* and *Salvadora persica (15%).*
- Browses which have recommended energy above 15 MJ. Kg-1 DM to meet daily energy requirement of camel calves for starter feeds and plant-based milk replacer are *Justicia exigua* (19.3 MJ. Kg-1 DM), *Acacia melliffera* (18,1 MJ. Kg-1 DM) and *Salvadora persica* (18.4 MJ. Kg-1 DM). All the four grass species evaluated (*Aristida mutabilis* (16.3 MJ. Kg-1 DM), *Cenchrus ciliaris* (17.1 MJ. Kg-1 DM), *Leptothrium senegalense* (15.3 MJ. Kg-1 DM) and *Sporobolus species* (15.9 MJ. Kg-1 DM) have energy to meet recommended daily requirement of camel

calves (15-20 MJ. Kg-1 DM). The common supplements used by pastoral camel keepers like *Acacia tortilis* pods (CP 15.42%), *Tinnospora caffra* (CP 14.05%) and *Prosopis juliflora* (CP 11.08%) as protein sources are lower in CP than the recommended of 20-24%. However, the energy sources used as common supplements like sheep fat (26.87 MJ. Kg-1 DM), camel fat (28.57 MJ. Kg-1 DM) and Maize meal (26.10 MJ. Kg-1 DM) have adequate energy to meet daily energy requirements as starter feeds and plant-based milk replacer.

- The acacia tortilis pods (Ca 3.72% and P 0.91%) and *Prosopis juliflora pods* (Ca 1.44% and P 0.75%) have sufficient Ca and P to meet daily requirements of a camel calves and thus can be recommended to supply the two important minerals for the calves' growth. However, *Prosopis juliflora* pods should be used in grounded form because it can easily colonize rangelands through fecal propagation.
- The commonly used forage supplements i.e., *Acacia tortilis* pods, *Prosopis juliflora* and *Tinnospora caffra* are low in limiting amino acids in calf nutrition like methionine, lysine and threonine thus recommended for supplementation. This study recommends further study in amino acid profiling, amount of greenhouse gas emission and determinations of tannins levels of selected browses and grasses used for feeding camels calves before releasing for free-range grazing.

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