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Relative palatability and preference by red Maasai sheep offered brachiaria and Rhodes grass hay supplemented with calliandra leaves in Kenya

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Abstract
A study was conducted to evaluate the effect on palatability and preference of supplementing Brachiaria (*Brachiaria ruziziensis)* hay and Rhodes *(Chloris gayana)* hay with different levels of Calliandra *(Calliandra calothyrsus)* leaves on Red Maasai Sheep. Nine male sheep averaging one year and weighing (22.0 ± 2.5 kg) were used in a 3x4 factorial completely randomized design (CRD). Three animals in three replicates, were used to measure feed intake and palatability. Twelve experimental diets were formulated consisting of Brachiaria, Rhodes and a (50:50 mix) of Brachiaria and Rhodes grass hay as the basal diets, supplemented with (0%, 10%, 20% and 30%) of Calliandra leaves. Supplemental rates were used as treatments (T1, T2, T3 and T4) respectively. Treatment one (T1) served as the control. 200g of each diet was offered daily at 8:00am (East African time) with an allowance of 60 minutes feeding time. Results showed that supplementation improved ($p<0.05$) crude protein, average daily intake and palatability of the experimental diets. Brachiaria grass supplemented with 30% Calliandra emerged the most preferred with a dry matter intake (113.9 g/kg^{-1} DM) and palatability index of (RPI=100%). The relative palatability indices according to treatments were as follows: (T4>T3>T2>T1). The study concluded that Brachiaria grass supplemented with 30% Calliandra has a great potential as a forage diet for ruminants in the arid and semi-arid lands.

Keywords: Crude protein, diets, dry matter, intake

Introduction
Availability of feeds both in quality and quantity is a major challenge faced by pastoralists during the dry season in the arid and semi-arid lands (ASALs) of Kenya. During the dry season, farmers are forced to move from place to place in search of pasture or purchase feeds (mostly hay) from commercial farms. Generally, most of the hay available in the tropics is of low quality and if fed solely does not meet the basic nutrients requirements of the animals [17, 21, 20]. Protein and energy are the most deficient nutrients in the dry season, protein often being the most limiting [35, 21]. There is therefore need to look for alternative sources of protein to supplement the low quality pasture in the dry season. Leguminous fodder trees or multipurpose trees (MPT) are locally available and are rich in protein and can be used to supplement low quality pastures [1] (Rahmani, *et al.*, 2005). Apart from being rich in protein and minerals, most of the MPTs are also known to contain high levels of anti-nutritive factors (ANFs) such as alkaloids, phenolic, tannins and aromatic compounds which bind nutrients especially proteins rendering them indigestible [19, 34, 28]. Most of these ANFs are also known to affect palatability and voluntary intake due to their astringent properties [28].
Palatability and preference are parameters that can be used to evaluate the acceptability of a given feed. The term palatability refers to those characteristics of a feed that provoke a sensory response [4, 36]. Preference on the other hand refers to the choice the animal makes when offered a variety of feeds [4, 9]. Selection of feeds by animals depends on their palatability which are dependent on plant and animal factors. Plant factors that influence palatability include: species, chemical composition, physiological age, presence of ANFs. Animal factors include: species or breeds, organoleptic senses, individual differences and familiarity to the feed [4]. There are other techniques for assessing palatability such as oesophageal fistula technique and stomach content and faecal analysis [23].

However, they are not convenient because they are laborious, costly and complicated. Direct feeding on pasture or stall feeding seems to be more suitable for palatability studies [5, 13, 23].

Sheep are known to feed on a wide range of forages and select those that meet their nutritional requirements and to evade those that are toxic [31]. The objective of this study was to evaluate the effect on palatability and preference of supplementing Brachiaria *(Brachiaria ruziziensis)* hay and Rhodes *(Chloris gayana)* hay with different levels of Caliandra *(Calliandra calothyrsus)* leaves by Red Maasai Sheep in Kenya.

Materials and methods

Experimental site

This study was conducted at Kenya Agricultural and Livestock Research Organization (KALRO) Lanet in Nakuru County, in Kenya. The center lies between longitude 360° 09' E and latitude 00° 18' S at an altitude of 1920 m above sea level. The center occupies 1418 hectares of land within two agro ecological zones (AEZs), where 20% of the land lies within AEZ III and 80% in AEZ IV [10]. The region has a bimodal rainfall season with the (long rains) starting from March to June and the (short rains) falling from November to December. The annual rainfall ranges between 600-1000 mm and temperatures between 10°C and 30°C [10]. pH ranges between 5.5- 6.5. Soils are deep sandy loam with good water holding classified as humic nitosols under Food and Agricultural Organization of the United Nations (FAO) classification. The experiment was conducted in the month of March 2020.

Feed preparation

The main feed ingredients used in the study were Brachiaria *(Brachiaria ruziziensis)* hay and Rhodes grass *(Chloris gayana)* hay and Calliandra *(Calliandra calothyrsus)* leaves. Brachiaria and Rhodes grass were sourced from the KALRO, Lanet farm. Most of the Calliandra *was* sourced from local farmers since there was not enough in the institute farm. The leaves were dried in the green house, packaged and stored in a well aerated barn. Before the start of the experiment the grass hay and the dried Calliandra leaves were ground to pass through a 4mm sieve for feeding trials and 1mm for chemical analysis (AOAC 1990). The feeds were then formulated into 12 rations along a CRD (3x4) factorial design consisting of three basal diets Brachiaria grass hay, Rhodes grass hay and a (50:50 mixtures of Brachiaria and Rhodes grass hay) as the main effects and supplementation of Caliandra leaves (0%, 10%, 20%, and 30%) as interaction levels (Table 1). Treatment one (0% Calliandra supplementation) served as the control.

Table 1: Compounded treatment diets

Diets	Levels of Calliandra (C)			
	T1	T2	T3	T4
Brachiaria (B)	0% C 100% B	10% C 90% B	20% C 80% B	30% C 70% B
Rhodes (R)	0% C 100% R	10% C 90% R	20% C 80% R	30% C 70% R
Brachiaria & Rhodes (50: 50) (BR)	0% C 100% BR	10% C 90% BR	20% C 80% BR	30% C 70% BR

Experimental design, feeding and housing

Nine (n=9) male Red Maasai Sheep with an initial mean body weight (22.0 ± 2.5 kg) of about 1 years were used in a completely randomized design (CRD) replicated three times. They were confined in separate individual pens of (1.5m x 2.5m). Before the start of the experiment, sheep were treated for internal and external parasites. The sheep were fed in two phases. Phase one: fourteen (14) days for adaptation to the different feed diets. Phase two: seven (7) days data collection involving daily feed offered and left over. The palatability study was conducted in a cafeteria feeding approach as described by [1]. Each pen was provided with four feed troughs at 30cm height to accommodate each of the four treatments (T1, T2, T3 and T4) respectively (Table 1). They were offered 200g each day at 8:00am (East African time) with an allowance of 60 minutes feeding time. The refusals were collected, weighed and intake determined by difference. Each day, the physical positioning of the tested feed diets in the troughs were altered to eliminate possible biasness from the sheep' preferences for one side. The sheep were then fed with a mixture of Brachiaria and Rhodes hay for the rest of the day. Water and mineral supplements were offered ad libitum.

Data collection

To determine the amount of feed consumed each day, the feed offered and refused was weighed using a digital weigh scale (with an accuracy of 1g). This was used to determine the relative palatability of the diets. Palatability was calculated for each feed diet based on the daily feed intake divided by that of the highest feed intake and expressed as a percentage as described by [1] and then ranked in separate preference classes of high (>60%), medium (35-55%) and low palatability (<25%) [16, 25].

Chemical analysis

Samples of feeds offered and refused were collected daily and pooled for each sheep then subsampled for proximate and fibre analysis. Proximate analysis was determined according to AOAC (1990) methods. The extraction of phenolics was carried out by using 70% aqueous acetone and total extractable phenols (TEPH) determined using Folin Ciocalteu procedures as described by [11] and [8]. The concentration of TEPH was calculated using the regression equation of tannic acid standard. Condensed tannin (CT) was measured and calculated as leucocyanidin equivalent, following the method of [29].

Statistical analysis

The data was analysed by general linear model option of the ANOVA program in the SAS (2002) software (version 9.0). Means were separated using L.S.D at (P>0.05).

Results

Chemical composition

The chemical composition of the experimental diets is presented in Table 2. Dry matter (DM) content ranged from the highest 940.1 g/kg^{-1} Rhodes grass (T1) to the lowest 906 g/kg^{-1} Brachiaria and Rhodes mixture (T4). Brachiaria (T4) had the highest OM content (936 g/kg^{-1}) while Rhodes (T1) had the least (904 g/kg^{-1}). Rhodes grass (T1) had the lowest CP content (42.4 g/kg^{-1}) while Brachiaria (T4) had the highest (126 g/kg^{-1}). Rhodes grass (T1) had the highest NDF and

ADF content (724 g/kg^{-1}, and 411g/kg^{-1}) while Brachiaria (T4) had the lowest (698 g/kg^{-1} and 348 g/kg^{-1}). The concentration of condensed tannins (CT) ranged from 9.6 g/kg^{-1} to 35.4 g/kg^{-1}. The CT content ranged from 9.6 g/kg^{-1}to 35.4 g/kg^{-1} and was higher in supplemented diets than in the basal diets. The level of ether extracts (EE) ranged from (8.5 g/kg^{-1}to 72.1 g/kg^{-1}). Ash content ranged from (67.2 g/kg^{-1} to 97.7 g/kg^{-1}). Ether extract (EE) and ash content followed the same trend where their levels where higher in the supplemented diets than in the basal diets.

Table 2: Chemical composition of Experimental diets

FEED	DM g/kg^{-1}	OM g/kg^{-1}	CP g/kg^{-1}	EE g/kg^{-1}	CF g/kg^{-1}	NDF g/kg^{-1}	ADF g/kg^{-1}	ASH g/kg^{-1}	TEPH g/kg^{-1}	CT g/kg^{-1}
Brachiaria hay										
T1	930	925	58.3	8.5	392	713	388	67.2	31.2	9.6
T2	927	932	87.5	10.5	343	708	369	60.7	41.1	18.2
T3	932	932	112	45.8	342	703	356	67.2	62.5	26.4
T4	917	939	126	65.4	345	698	348	74.5	78.4	32.4
Brachiaria and Rhodes mixture (50:50)										
T1	931	915	45.2	7.8	374	722	403	84.3	31.8	10.6
T2	933	917	77.3	11.5	343	716	396	82.8	42.2	18.6
T3	927	924	94.8	46.2	342	711	378	75.7	63.5	26.3
T4	906	923	115	65.0	300	708	363	76.5	78.6	33.3
Rhodes grass										
T1	940	904	42.4	9.2	398	724	411	84.8	31.3	9.2
T2	936	915	70.0	11.8	347	721	406	85.3	40.6	17.2
T3	922	902	81.7	50.1	344	714	398	96.0	59.9	25.4
T4	932	914	99.8	72.1	307	710	369	97.7	78.9	35.4

DM: Dry Matter; CP: Crude Protein; EE: Ether Extracts; NDF: Neutral Detergent Fiber; ADF: Acid Detergent Fiber; OM: Organic Matter; CF Crude Fibre; TFPH: Total extractable Phenolic; CT: Condensed Tannins T1:(0% Calliandra); T2:(10% Calliandra); T3:(20% Calliandra); T4: (30% Calliandra).

Intake of experimental diets

Dry matter (DM) intake, palatability and preference of the experimental diets are represented in Table 3. The DM intake varied throughout the experimental period. The intake of diets T1 and T2 initially increased during the first 10 days of the experimental period but dropped drastically during the last 7 days, while the reverse trend was observed in T3 and T4. Rhodes (T1) recorded the lowest DM daily intake of 19.34 g/sheep/day. Brachiaria (T4) registered the highest daily DM intake (113.90 g/sheep/day). The level of supplementation greatly influenced feed intake in all treatments. There was an increase in intake with increased in the levels of crude protein in the diets. In this study intake was inversely proportional to the concentration of CF, NDF and ADF in that diets with high fibre registered low intake. Likewise, the Relative palatability indices followed the same trend whereby the diets with low CF, NDF, ADF were ranked high. In terms of preference, Brachiaria (T4) was ranked the highest *(*100%) and Rhodes grass (T1) the lowest (16.62%). The preference class for both Brachiaria, Rhodes and their mixture were similar at 30% supplementation with Calliandra. They were all ranked high. The lowest preference class recorded was from Rhodes (T1).

Table 3: Dry matter intake, palatability index and preference ranking of the Experimental diets

Rations/Diets	Daily intake (g/sheep/d-1 DM)	Daily intake (g/sheep/day)	RPI (%)	Preference class
Brachiaria hay				
T4	113^{a}	124^{a}	100	High
T3	73.9^{b}	79.3^{b}	63.9	High
T2	67.1^{c}	72.4^{c}	58.3	Medium
T1	49.6^{d}	53.4^{d}	43.0	Medium
Brachiaria and Rhodes mixture (50:50)				
T4	103^{a}	113^{a}	91.7	High
T3	67.0^{b}	72.3^{b}	58.3	Medium
T2	58.3^{c}	66.0^{c}	53.2	Medium
T1	38.2^{d}	52.6^{d}	42.4	Medium
Rhodes hay				
T4	101^{a}	108^{a}	87.6	High
T3	50.4^{b}	54.7^{b}	44.0	Medium
T2	35.2^{c}	25.3^{c}	20.4	Low
T1	19.3^{d}	20.6^{d}	16.6	Low
SEM	0.63	5.82	4.70	

T1:(0% Calliandra); T2:(10% Calliandra); T3:(20% Calliandra); T4: (30% Calliandra).
SEM: Standard Error of Means P: P-value.
$^{a\ b\ c\ d}$ Means with different subscript in a column differ at P<0.05
High:(>60%), Medium: (35-55%) Low palatability (<25%)

Discussion

Chemical composition

The CP contents of Brachiaria and Rhodes grass hay basal diets were consistent with values reported by [6, 22, 7, 15]. The CP content in both Brachiaria and Rhodes basal diets were below 70g/kg^{-1}DM threshold required for proper rumen function [26, 35, 21]. The low CP content of basal diets is an indicator that basal diets should be provided with protein supplements to support optimum performance of the animals. In this study the CP contend in Brachiaria improved by 45.9%

from (58.3g/kg^{-1} DM to 126.9kg^{-1}DM) after supplementation with 30% Calliandra. Likewise, the CP content of Rhodes grass and the mixture increased by 42.5% and 39.2% (from 42.4 g/kg^{-1}DM to 99.8 g/kg^{-1}DM and 45.2 g/kg^{-1}DM to 115.2 g/kg^{-1}DM) respectively. The CP content in the three basal diets supplemented with 30% Calliandra were way above the 70g/kg^{-1}DM required for proper function of rumen to meet maintenance requirement of animals [33, 20]. The higher CF, NDF and ADF content of the basal diets categorizes them as roughages of low quality since roughages with NDF content greater than 65% are considered low quality feeds [18].

Intake of experimental diets

Sheep in this study initially consumed more of the basal diets which they were more familiar to than those supplemented with Calliandra. A similar trend was also observed and reported by [23]. This pattern of intake was explained in a study by [30] which reported that ruminants prefer familiar to new or strange feeds and that they sample strange feeds with much caution. The increase in the levels of Calliandra in the diets increased DM intake and palatability [14]. This may be due to the increased level of protein in the diets. This justifies Calliandra as a forage supplement due to its influence on feed intake and efficient utilization of poor quality hay [14, 24]. Although Calliandra is regarded as highly Tanniniferous forage plants, the Condensed Tannin (CT) inclusion levels in the diets in this study were below (<50 g/kg^{-1}) normally considered detrimental to intake and palatability due to its astringent property [2, 3, 34]. This suggests that by supplementing Calliandra to low tannin basal diets, concentration of tannin in the diets decreased. This may explain why the CT content did not negatively influence intake and palatability of the diets. The order in which the diets were ranked according to treatments from the most palatable combination to the least based on daily DM intake and relative palatability index is as follows: (T4>T3>T2>T1). In this study Brachiaria grass (T4) was the most superior in terms of palatability and preference ranking while Rhodes grass (T1) had the poorest (Figure 1).

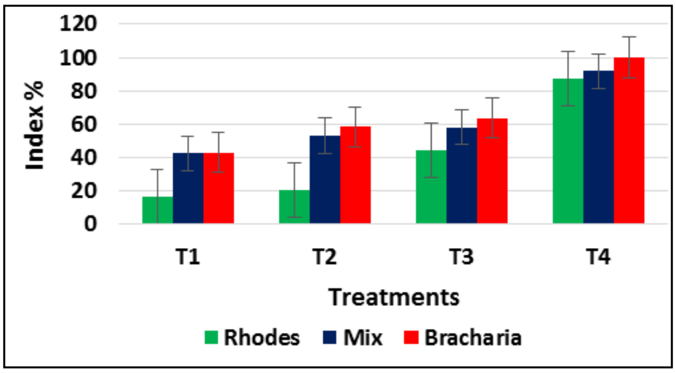

Fig 1: Ranked palatability indices of the experimental diets according to treatments

Conclusion

1. Supplementing Brachiaria and Rhodes grass with Calliandra greatly improved the CP content of the diets.
2. Supplementing Brachiaria and Rhodes grass with Calliandra greatly improved DM intake, palatability and preference
3. Brachiaria grass supplemented with 30% Calliandra emerged the highest in DM intake, palatability and preference.
4. Brachiaria grass supplemented with 30% Calliandra has a great potential as a forage diet for ruminants in the arid and semi-arid lands.

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