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EFFECT OF SUPPLEMENTING RHODES GRASS HAY WITH DRIED CALLIANDRA LEAVES AND COMMON VETCH HAY ON THE PERFORMANCE OF GROWING DAIRY GOAT CROSSES IN KENYA

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ABSTRACT

A study was conducted to determine the effect of supplementing basal Rhodes grass hay with dried Calliandra leaves and common Vetch hay on growing dairy goats on voluntary feed intake and growth rate under a confined feeding system. A total of twelve weaned male Toggenburg crosses aged between 3 and 4 months were randomly allocated to 3 dietary treatments in a randomized complete block design. T1: Rhodes grass hay as the control, T2: 30% Calliandra + Basal diet, T3: 30% Vetch + Basal diet. The initial 10 days were allowed for adaptation to the diets and data collected for 8 weeks. The result of this study showed that live weight gain and average daily gain for supplemented goats was significantly different ($p<0.05$) for the supplemented goats compared to those fed on the control diet which gained 3.4 Kg and 2.9 Kg and average daily gain of 60.9 and 51.1 g/day for goats supplemented with Calliandra and Vetch respectively. The un-supplemented goats lost 1.09 Kg and had a negative daily gain. This study suggests that the Toggenburg crosses performed better when dried Calliandra leaves and common vetch hay were used as protein supplements on basal Rhodes grass hay.

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INTRODUCTION

In Kenya, the livestock industry plays an important role in food and nutrition security, employment creation and income generation through sale of livestock and animal products, especially for the rural communities. It is reported that 60-80% of rural households keep livestock to supplement their food needs and income (Asseya and Mbugua 2019). Sheep and goats contribute about 30% of the total red meat consumed in the country and about 17% of the total milk production (ICPALD, 2013). The exotic breeds that include; Saanen, Toggenburg, Alpine and the Anglo-Nubian have been used to cross with the local goats to get better adapted and higher yielding goats than the local goat (FAO, 2010). Currently, there is insatiable demand for both pure and improved dairy goat (crosses) breeds hence there is an urgent need for a significant scaling up of the current goat development activities to meet this rising demand (Peacock, 2008, Reddy, 2018). An increase in milk production from local goats has been reported from an average of 0.25 L per goat per day to 1.0 –4.2 L/doe per day for the improved goats (Mburu *et al*., In spite of its enormous potential, the dairy goat industry is faced with major challenges that include among others inadequate nutrition, poor quality breeds, shortage of quality breeding and replacement stock and inappropriate management resulting to an overall performance often below optimum levels (Marete *et al*., 2011; Mbinyo *et al*., 2017). Among these factors, nutritional constraint is the most critical (Nsahlai *et al*., 2000). Feeding of protein rich forages (PRFs) like the browses and fodder trees as supplements to low quality basal forages is commonly practiced by small scale livestock farmers in tropical areas. *Calliandra calothyrsus* and the common vetch have gained popularity in dairy goat feeding in recent years as they are easy to grow and manage. However, despite their common use by farmers, not much has been done to evaluate the effects on the performance of goats. Compared to sheep, fewer management (mainly nutrition) and production related research projects have been undertaken with goats (Solomon *et al*., 2014). The present study, therefore aimed at supplementing Rhodes grass (*Chloris gayana*) hay with dried Calliandra (*Calliandra calothyrsus* leaves and the Common vetch (*Vicia sativa*) hay on the performance of growing dairy

MATERIALS AND METHODS

Study site: The study was conducted at Tatton Agricultural Park (TAP), Egerton University, Njoro. The farm is located in the Rift Valley region on the Eastern slopes of Mau Escarpment of the Great Rift Valley of East Africa, Njoro Sub-County in Nakuru County of Kenya. It is lies within latitude 0º 23'S and longitude 35º 57'E at an altitude of 2200 and 2280 Metres above sea level. The area has a bimodal rainfall pattern with long rains in March to May, and sometimes extending to June and short rains in September to November.

Animals and dietary treatments: Twelve (12) male cross-bred (Toggenburg x Small East Africa goat) weaned goats aged between 3-4 months and an initial weight ranging between 11.5-12.6 Kg were used as experimental animals in the study. The initial weight for each goat was identified by taking weight for each goat for three consecutive days and the mean weight taken. Rhodes grass (*Chloris gayana*) hay was used as the basal diet, while dried Calliandra (*Calliandra calothyrsus*) leaves and common vetch (*Vicia sativa*) hay were used as the supplemental diets. Rhodes grass hay (basal diet) was used as the control (T1) and supplemented with dried Calliandra leaves (T2) and common vetch hay (T3). Dry matter intake (DMI) was estimated at 5% of the live weight of each goat being the higher DMI value reported for goats (Kieser, 2010). Each of the supplemental diets was fed at 30% of the total estimated DM intake for each goat, while the basal diet was availed *ad libitum*. The amount fed was adjusted at the beginning of each week to cater for the changes in live weight during the study period. A randomized complete block design (RCBD) and three dietary treatments were used. The three dietary treatments were randomly allocated to the animals in each of the four blocks. Blocking was based on live weight of the animals. There were four animals for each of the three dietary treatments. The animals were confined in individual pens that were slatted and well-ventilated. Clean water and mineral lick were availed *ad libitum* to the animals. The goats were drenched with an anti-helmintics (10% albendazole®) for the control of endo-parasites while ecto-parasites were controlled fortnightly using an acaricide (stelladone®). The initial 10 days were allowed for adaptation to the diets and then data collected for a period of 8 weeks.

The feeds were offered twice a day at 07:30 and 14:00 hr. The whole portion of the supplement was offered first as a priority at 07:30 hr, while the basal diet was offered immediately the goat finished the supplement. At 14:00 hr, additional basal diet was offered depending on the morning intake. Rhodes grass hay was offered *ad libitum* so as to allow for about 10% refusals and as a way of ensuring that intake was not constrained by unavailability of the basal diet. The intake of both the basal and supplement for each animal was calculated and recorded daily. Refusals from the previous day's offer were collected from each goat, weighed and recorded. It was then sub-sampled, bulked and stored for further chemical analyses at the end of the collection period. At the end of every week on a designated day, each goat was weighed in the morning before feeding at 07:00 -07:30 hr and the weight of each goat recorded.

Chemical analyses of experimental diets: The three experimental diets were subjected to proximate analysis where dry matter (DM), Crude protein (CP), Ether extract (EE), organic matter (OM) and ash content were determined according to the procedures outlined in (AOAC, 1990). Neutral detergent fibre (NDF), Acid detergent fibre (ADF) and Acid detergent lignin (ADL) were determined by the method of Goering and Van Soest (1991) in determining the cell wall constituents (CWC) and cell contents (CC) of each diet.

***In-vitro* gas production and rumen liquor collection:** Rumen liquor was collected from the goats 2 days before the end of the feeding trial using a stomach tube early in the morning before feeding the animals. The pH of each rumen fluid sample collected was measured immediately using a pH meter. In *vitro gas* production was conducted for all the experimental diets according to procedure of Menke and Steingass (1988) to estimate apparent digestibility. Feed samples of Rhodes grass hay, dried Calliandra leaves and common vetch hay were incubated *in-vitro* with rumen fluid-buffer mixture in 100 ml calibrated glass syringes. The rumen liquor collected was properly mixed and filtered through a metallic sieve (1 mm sieve). A stream of carbon dioxide gas (CO_2) was passed through the sieved rumen liquor until the completion of inoculation. Incubation was conducted using three replicates per treatment. 100 ml capacity calibrated glass syringes were used and the piston of the syringes was lubricated with Vaseline Jelly for easy movement. Feed samples were weighed each containing 0.2 g. The piston was withdrawn and later inserted after introduction of the feed samples. The inoculum of 30 ml was introduced through the silicon tube fitted into the top of the syringe containing 200 mg the test sample. The content was agitated while the piston of the syringe was pushed off to eliminate the air bubbles and after which the silicon tube was tightened with metal clip, leaving a 2-cm length of the silicon tube above the clip. The prepared syringes were placed in the incubator maintained at 39^0C. Readings of gas produced were recorded at 0, 3, 6, 9, 12, 24, 48, 72 and 96 hr. after incubation. Cumulative gas production data were then fitted in the model of Ørskov and McDonald (1979). The exponential equation $Y= a+b\ (1-e^{-ct})$, where Y is the gas produced at the time t and a+b is the potential gas produced (ml), c is the gas production rate constant and t is the incubation time. A graph was plotted to show the trend of the incubation for the *in-vitro* gas production characteristics of the basal diet (Rhodes grass hay) and supplemental diets. The gas produced provided a useful basis from which Metabolizable energy (ME) and organic matter digestibility (OMD) were calculated.

Statistical analysis: The data collected from the experiment was subjected to analysis of variance (ANOVA) using the General linear model (GLM) procedures of statistical analysis SAS (2008). An F-test at 5% probability level was used to test for significance and means separation was done by least significance difference (LSD).

Statistical model

$Y_{ij}= \mu + \alpha_i + \beta_j + \varepsilon ij$

Where: -

Y_{ij} = observation of i^{th} dietary treatment in the j^{th} block.
μ= Overall mean
α_i= effect of i^{th} dietary treatment, where I = {1, 2, 3}
β_j= effect of j^{th} block, j = {1, 2, 3,4}
ε_{ij}= random error component

RESULTS AND DISCUSSIONS

Chemical ccomposition of the basal and supplemental diets: The proximate chemical composition of Rhodes grass hay (basal diet) and supplemental diets used is given in Table 1. Calliandra and Vetch had higher and similar crude protein (CP) content while Rhodes grass hay the basal diet had the lowest. Common Vetch hay had the highest ash content followed by Rhodes grass hay with Calliandra which had the lowest ash content. There was a similar trend for the ether extract with Vetch hay having the highest and Calliandra the least content. Rhodes grass hay had the highest NDF and ADL, while common vetch hay had the lowest ADL content.

Table 1. Proximate Chemical Composition of the basal Rhodes grass hay and supplemental diets of dried Calliandra leaves and common Vetch hay (gkg^{-1} DM)

Parameter	Rhodes grass	Calliandra	Vetch
DM	931	893	858
OM	825	834	746
CP	79.5	230	227
Ash	114	66.2	131
EE	65.3	52.5	78.7
NDF	691	243	418
ADF	368	230	311
ADL	130	108	71.2
Hemicellulose	323	12.4	107
Cellulose	238	123	240

DM=Dry matter, OM=Organic matter, CP=Crude protein, EE=Ether extracts, NDF=Neutral detergent fiber, ADF=Acid detergent fiber, ADL=Acid detergent lignin.

The DM content of the Rhodes grass hay observed in this study was highest, comparable to that reported by Biwott, (2000) and that for dried *Calliandra calothyrsus* leaves was close to that reported by others (Kaitho and Kariuki 1998; Wambui *et al*., 2006) while that of common Vetch was also similar to a previous study (Heúze *et al*., 2015). The CP content of Rhodes grass hay in the study was similar to those reported in earlier studies (Biwott, 2000; Kinuthia *et al*., 2007) but differed with that reported by Woyengo *et al*., 2004. The CP content of the supplements was similar to those from other reports (Rebole *et al*., 2004; Rybiński *et al*., 2015). However, Wambui *et al*., 2006 reported a lower CP content (189 gKg^{-1} DM), while Kaitho et al (1993) reported higher CP content (280 gKg^{-1} DM). Rhodes grass hay had the highest NDF and ADL content with *Calliandra calothyrsus* having the lowest. Previous studies recorded higher NDF for Calliandra (Wambui *et al*., 2006; Kaitho, (1997). This could be associated with the stage of growth since the more mature a forage is, the higher the cell wall content. The NDF values for common vetch hay in this study are in agreement with that reported in literature (Heúze *et al*., 2015) but higher than that reported in a previous study (Rebole *et al*., 2004). Among the diets, the NDF content for Calliandra was within the range of 200-350 gKg^{-1} DM reported by Norton (1994) within which digestibility is enhanced.

Voluntary feed intake and pH of rumen liquor: The pH of rumen liquor extracted from goats in T2 was higher than that of T1 and T3. However, the pH for all the treatments was consistent with earlier studies and is within the normal range of 6.0-7.0 which is considered optimal for rumen function (Muia, 2000; Woyengo *et al*., 2004). The TDMI and CPI showed that goats supplemented with dried Calliandra had the highest TDMI followed by those supplemented with common Vetch hay. The un-supplemented goats recorded the lowest TDMI. There was significant ($p< 0.05$) basal DMI, TDMI and feed intake relative to the live weight for the supplemented goats compared to those fed basal diet only (Table 2). However, the basal DMI, TDMI and the feed intake relative to the live weight among the supplemented goats was not significantly different ($p>0.05$). Supplementation enhanced both the CP intake and the basal feed intake significantly ($p<0.05$) in the present study. The basal feed intake increased by 24.2% and 16.9% for those goats on Calliandra (T2) and Vetch hay (T3) respectively compared to those on basal diet.

Table 2. Total Dry Matter Intake (TDMI), Crude Protein Intake (CPI) and pH of rumen liquor for dairy goats fed Rhodes grass hay supplemented with dried *Calliandra calothyrsus* leaves and *Vicia sativa* hay

	Dietary Treatments			
Parameter	T1(Control)	T2	T3	SEM
DMI (g/day)				
Basal diet (Rhodes grass hay)	290^{a}	361^{b}	339^{b}	11.2
Supplement (Calliandra & vetch)	0.0	166	153	7.9
TDMI (g/day)	290^{a}	527^{b}	492^{b}	23.5
TDMI as % Lwt	2.8^{a}	3.3^{b}	3.4^{b}	0.2
CPI (g/day)	23.1^{a}	66.9^{b}	61.8^{b}	2.8
pH of rumen liquor	6.9	7.0	6.8	0.2

^{ab} means with different superscripts within a row differ significantly at $p<0.05$. TI = Basal diet of Rhodes grass hay; T2= Rhodes grass hay supplemented with *Calliandra calothyrsus* dried leaves; T3= Rhodes grass hay supplemented with Vetch hay; SEM=Standard Error of the Mean.

The present study showed that higher intake (TDMI) was observed for supplemented goats than those fed the basal diet. This was consistent with earlier reports (Osuga *et al*., 2012; Ondiek *et al*., 2013) but differed with others reported earlier (Asaolu *et al*., 2011; Sultana *et al*., 2012). Supplementation enhanced the basal diet and crude protein intake significantly due to the improved rumen fermentation environment. This agrees with findings by Kaitho (1997) that supplementation can maintain or enhance feed intake. The enhanced intake can be attributed to the additional supply of rumen degradable N supplied by the PRFs which enhance the activities of the microorganisms in the rumen thus increasing organic matter digestibility and therefore higher basal forage intake.

***In-vitro* gas production:** *In-vitro* gas production for the experimental diets is shown in Table 3. Vetch hay had a notable initial gas production followed by Rhodes grass hay with Calliandra recording the least. The same trend was on the net gas produced with Vetch hay producing the highest net gas. Vetch hay had the highest organic matter digestibility amongst the diets. At 48 hr of incubation, gas production for Calliandra overtook that of Rhodes grass hay as that of Vetch hay continued to lead (Figure 1). Menke and Steingass, (1988) indicated that the quantity of gas produced during an *in-vitro* incubation of a substrate is closely related to its digestibility and consequently to its energetic value, thus Vetch hay could have had the highest digestibility in the present study and the least digestible being Calliandra. The low digestibility of Calliandra is consistent with earlier studies (Tuwei *et al*., 2003). *Calliandra calothyrsus* is reported to contain a wide variation of condensed tannins ranging between 1.5 to 19.4% and high levels of over 11% may reduce digestibility of protein in livestock (Fact Sheet, 2016). It is significant to note that despite the indication of low digestibility of *Calliandra calothyrsus*, the present study showed the best performance of goats supplemented with dried *Calliandra calothyrsus* leaves in both total DM intake and ADG which has also been reported in previous studies (Dey *et al*., 2008; Pathak 2010).

Table 3. *In Vitro* gas production (ml/200 mgDM) of Rhodes grass hay, Dried *Calliandra calothyrsus* leaves and common vetch hay and calculated ME and OMD

	Gas production (hr)					Degradation constants				ME	OMD	RSD
	6	24	48	72	96	a	b	c	a+b	(MJ/Kg DM)	(%)	
Rhodes grass	8.6	23.9	30.0	31.8	33.9	3.0	5.1	5.8	8.1	14.2	46.2	7.8
Calliandra leaves	7.8	22.2	33.4	39.3	41.1	0.8	4.2	6.5	5.0	14.4	49.4	3.9
Vetch hay	13.1	34.6	41.9	43.8	45.3	4.4	4.8	10.9	9.2	14.2	57.2	3.8

a, b, c are constants: a=Initial gas production, b=Gas produced during incubation, c=Gas production rate constant (Fraction/hour), a+b=Net gas produced in the equation (Ørskov and McDonald, 1979), RSD=Residual Standard Deviation, calculated ME (MJ/kg DM) =14.78-0.0147ADF and OMD48: Organic matter digestibility calculated from the equation; OMD (%) =18.53+0.9239(gas produced at 48hr) + 0.054CP (Menke and Steingass, 1988).

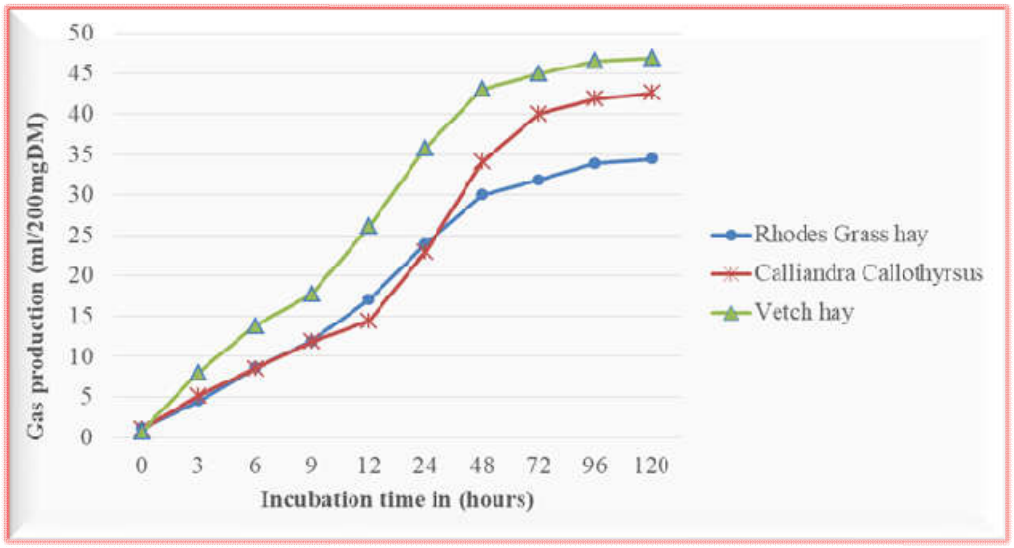

Figure 1. In-Vitro gas production on Rhodes grass hay, *Calliandra calothyrsus* dried leaves and common vetch hay in buffered rumen fluid

Table 4. Total live weight change and Average Daily weight gain (ADG) of weaned dairy goats fed Rhodes grass hay and supplemented with dried *Calliandra calothyrsus* and *Vicia sativa* hay

Dietary Treatments				
Parameter	T1	T2	T3	SEM
Initial body weight (Kg)	11.5	12.6	12.2	0.3
Final body weight (Kg)	10.4^{a}	16.0^{b}	14.7^{b}	0.6
Live weight change (kg)	-1.1^{a}	3.4^{b}	2.9^{b}	0.5
ADG (g/day)	-19.5^{a}	60.9^{b}	51.1^{b}	9.4

^{ab} means with different superscripts within a row are significantly different at ($P<0.05$). SEM=Standard Error of the Mean. ADG=Average Daily Gain.

This cannot be well explained but it can be associated with the presence of condensed tannins which may prevent excessive rumen degradation of dietary protein hence increasing the proportion of protected (by-pass) protein which are utilized in the lower gut (Tandon and Siddique, 2016). Pathak (2013) concluded that low to moderate (1-4% DM) use of condensed tannins supplementation improves nutrient utilization, productive performance and immunological response in small ruminants. Most of these positive effects in ruminant nutrition are associated with great affinity of the leaf portion by condensed tannins after mastication which increases the amount of undegradable dietary protein reaching the small intestines where it is digested and absorbed and therefore available for tissue metabolism (Ramírez-Restrepo *et al*., 2005). The ME of Calliandra (14.4 MJ/Kg DM) was consistent with earlier studies (Wambui *et al*., 2006) and was higher than that of Rhodes grass hay; therefore, more energy was available to the supplemented goats than those on basal diet. The ADG of goats supplemented with Calliandra was in agreement with results reported earlier (Kinuthia *et al*., 2007; Wambui *et al*., 2006). The overall loss of weight by the un-supplemented goats was consistent with report by Wambui *et a*l (2006) and (2000) that basal roughages alone are not sufficient to support optimal growth due to low levels of ingested protein and energy. Anya *et al*., (2011) also reported a loss of 1.48 Kg live weight for West Africa Dwarf goat kids not supplemented, whereas the supplemented animals gained 1.1 Kg live weight. A live weight loss of 20 g/day was also reported in Zambia on goats fed control basal diet of low quality grass and a gain of 24 g/day when supplemented with 140 g/day of Calliandra leaf (Sebsibe and Mathur 2000).

Conclusion

Supplementation of Rhodes grass hay with dried *Calliandra calothyrsus* leaves and common Vetch (*Vicia sativa*) hay on growing dairy goats improved voluntary feed intake of basal diet of Rhodes grass hay, increased total live weight gain and average daily gain thus improving the overall production performance of the growing dairy goats. This study suggests that the Toggenburg crosses performed better when dried *Calliandra callothyrsus* leaves and common Vetch hay were used as protein supplements. However, dried *Calliandra callothyrsus* leaves are superior to common vetch hay. The

researchers, animal nutritionists and any other interested stakeholder involved in dairy goat development.

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