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IMPACT OF SUPPLEMENTATION OF *MORINGA OLEIFERA* AND *LEUCAENA LEUCACEPHALA* TREE FODDER ON THE PRODUCTION PERFORMANCE OF INDIGENOUS GOATS IN MOZAMBIQUE

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Abstract

This study was conducted to assess the effect of supplementation with *Leucaena leucacephala* (LL), and *Moringa oleifera* (MO) tree leaves on growth and reproduction performance of indigenous goats in southern Mozambique. Fifty-six indigenous goats with an average age of 8 months and a body weight of 17.57 ± 3.97 kg were randomly divided into seven treatments groups of 4 castrated males and 4 females each. Treatment 0 served as the control group (Co), and these animals only grazed on natural pasture without any supplementation. In addition to the natural pasture, three groups received 50 g (LL_{50}), 75 g (LL_{75}) and 100 g (LL_{100}) of *L. lecocephala* dried leaves, respectively while groups 4 to 6, received 40 g (MO_{40}), 60 g (MO_{60}) and 80 g (MO_{80}) of M. oleifera dried leaf meal, respectively. *Leucaena leucocephala* contained 23.7% crude protein (CP) and 11.05 MJ/kg DM of metabolizable energy (ME), while *M. oleifera* leaves contained 28.8% CP and 7.61 MJ/kg DM of ME. The study lasted for 16 months from July of 2015 to November of 2016. Compared to the control, treatment supplementation of the tree leaves, irrespective of level, had a significant effect ($p < 0.05$) on the overall body weight gain and the final body weight of the bucks but did not significantly affected the does ($p > 0.05$). No difference could be detected between the final body weight and overall average daily gain ($p > 0.05$) based on the supplementation source (*Leucaena Lecocephala* versus *Moringa oleifera* dried leaf). Average daily gain (ADG), during the dry season, ranged from -7.85 to 10.42 g/day for goats fed LL leaves and from -7.92 to 13.33 g/day for goats fed MO and these values were higher ($p < 0.05$) compared to values recorded for the control goats (-36.11 to -20.74 g/day). All female reproduction efficiency parameters measured such as birth rate, twinning rate, birth weight and weaning were significantly ($p < 0.05$) higher in supplemented goats compared to the control goats. Body weights at birth and weaning weight of the offspring of supplemented goats were however not significantly ($p > 0.05$) affected by supplementation. The highest survival rate (100%) was observed in goats supplemented with *Moringa oleifera* (MO_{40}), while the lowest was recorded in goats supplemented with *Leucaena leucocephala* leaves (LL_{75}). The results of this study suggest that *L. leucacephala* and *Moringa oleifera* tree leaves could be used as supplementation to goats to

overcome the adverse effects of seasonal fluctuations in feed quality on growth and reproductive performance.

Keywords: Fodder trees, Growth, Reproductive, Smallholder, Goats, Supplementation

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1. Introduction

The global goat population has increased during the last decade and currently exceeds 1 billion goats with approximately 95% of those found in developing countries (FAOSTAT, 2014). Goats play an essential role for the smallholder farmer, mainly as a source of income and animal protein (Osaer et al., 1999; Peacock, 2005), but also contributing to the livelihoods of the poor through risk mitigation and accumulation of wealth (Casey and Webb, 2010; Hossain et al., 2015; Ouchene-Khelifi et al., 2015).

In the (sub)tropics, goat farming is limited by several factors which adversely affect its productivity. Nutrition, based mainly on natural pasture, poses the most severe problem since the composition of natural pasture species and levels of nutrients show significant seasonal variation (Hove et al., 2001; Berihu et al., 2015). During the dry season (April to September), the natural pasture becomes scarce and poor in quality and consequently does not sustain the energy and nitrogen requirements of ruminants for maintenance and other physiological functions (Silanikove et al., 1996; Oni et al., 2010). Due to poor nutrition goats may lose up to 20 – 40% of the body weight (Clariget et al., 1998; Faftine and Zanetti, 2010), have reduced performance and productivity (Lusweti, 2000) and become more susceptible to diseases (Kanani et al., 2006).

Supplementation during the dry season represents a valuable economic alternative to improve the quality of diet and reduce nutritional problems for smallholder goat production compared to purchased concentrates or agro-industrial by-products (Getu, 2006; Kanani et al., 2006; Place et al., 2009). In Mozambique, the alternative feed resources available in communal zones include crop-residues from maize, rice, cowpea and groundnut (Preston, 1987; Faftine and Zanetti, 2010). Moreover, supplementation with cultivated legumes such as *L. leucocephala* has been studied in the feeding system of goats (Muir and Massaete, 1996; Faftine and Zanetti, 2010). Fodder trees and shrub forages are considered to be good and cheap sources of protein and micronutrients that can be used to increase the quality and availability of feeds for ruminants during the dry season (Manaye et al., 2009; Moyo et al., 2012; Bebeker and Abdalbagi, 2015, Babiker et al., 2017). It has multiple advantages for resource-poor smallholder farmers as it can be grown locally, propagated efficiently and are less demanding regarding the use of fertilisers, pesticides or advanced technology (Mendieta-Araica et al., 2011).

Leucaena leucacephala and *Moringa oleifera* are important sources of energy and protein in the tropics. *Leucaena leucacephala* is a drought-resistant leguminous tree (Devendra and Burs 1993), and its leaves are readily consumed and nutritious (Yami et al., 2000). It provides highly nutritious forage with an average crude protein content of 237g/kg of dry matter (Damothiran and Chandrasekaran, 1982; Kanani et al., 2006), but its use as feedstuff for livestock is limited by the presence of the toxic amino acid, mimosine. However, *L. leucocephala* has been used to feed ruminants without adverse effects because of the presence of ruminal micro-flora capable of degrading mimosine (Kanani et al., 2006). In tropical agroforestry systems, it is frequently used for a variety of purposes including as provision of forage and shade for livestock, fuelwood, soil stabilisation and fertility improvement (Kang et al., 1984; Brewbaker, 1987). When intercropped in a pasture forage program, it can provide a balanced diet of protein and carbohydrates derived from the grasses (Robert et al., 1996). Its potential benefits on goat production have been confirmed in studies conducted in tropical regions, which reported improvements in body weight gain when it was used as a supplement to poor pasture (Aletor and Omodara 1994; Kanani et al., 2006; Rubanza et al., 2007; Mohamed et al., 2015).

Moringa oleifera is an ideal protein supplement for livestock that can be quickly grown, even under drought condition (Oduro et al., 2008). Its leaves are nutritious with a crude protein content ranging from 225 to 400 g/ kg DM, and it has therapeutic and prophylactic properties (Moyo et al., 2011). This fodder tree is also rich in vitamins A, B and C, and contain a higher level of calcium than milk (Fahey, 2005; Midcap and De Witte, 2006; Mendieta-Araica et al., 2011; Gopalakrishnan et al., 2016). *Moringa oleifera* seems to be readily accepted by animals, and no toxic effect from its use has been reported. Sánchez et al. (2005, 2006) showed the beneficial effects on intake, digestibility, milk production and composition of dairy cows fed different levels of foliage of *M. oleifera.* Several other studies conducted to investigate the use of *M. oleifera* as a source of protein in goats also reported improvements in feed intake, nutrient digestibility, growth performance and milk yield. This suggests that *M. oleifera* could be used as a low-

cost alternative protein supplement for goat production (Kanani et al., 2006; Asaolu et al., 2011; Moyo et al., 2012; Bebeker and Abdalbagi, 2015; Kholif et al., 2018).

The use of locally available fodder trees and shrub forages represents a useful and cost-effective source of protein and micronutrients for goats. In Mozambique, the use of these alternative feed resources for goats is poorly documented and has not been disseminated among smallholder farmers. This study aimed to evaluate the effect *L. Leucacephala* and *M. oleifera* leaves supplementation, during the dry season, on indigenous goat production in a subtropical environment in southern Mozambique

2. Material and Method

2.1. Study Setting

The study was conducted at the University Center of Changalane, located in the district of Namaacha, in the Maputo province of southern Mozambique. The Namaacha district covers an area of 2196 km^2 and is characterized by a humid tropical climate with an average annual rainfall of 751 mm. However, the district has been experiencing a substantial decrease in rainfall over the last few years, having received an annual rainfall of only 260 mm in 2015 and 471 mm in 2016 (National Institute of Meteorology of Mozambique, 2015-2016).

Most parts of the district are classified as semi-arid, with visible desertification due to poor management caused by overgrazing (MAE, 2005). In this district, the average maximum annual temperature varies between 23° and 24 °C, with maximum highs of 36 °C. The rainy season is from October to March and the dry season ranges from April to September.

2.2. Experimental Design

2.2.1. Pre-experimental period

Before the onset of the experiment, goats were ear tagged and de-wormed against gastrointestinal nematodes and external parasites. The goats were submitted to a 21-days adaptation period to feeding and housing and were allowed to graze during the daytime and access water *ad-libitum*.

2.2.2. Experimental period

Fifty-six 8-month-old indigenous goats, consisting of 28 females and 28 castrated males with an average body weight (BW) of 17.4 ± 0.7 kg were randomly selected and divided into seven groups of 8 animals each (4 females and four males). The groups were then randomly allocated to one of seven treatments consisting of a natural pasture diet combined with different levels of *L. lecocephala (LL)* or *M. oleifera (MO).* Treatment 0 served as the control group (Co) and consisted of a natural pasture diet with no supplementation. In Treatment 1 to 3, the goats grazed the natural pasture with daily supplementation of 50 g (LL_{50}), 75 g (LL_{75}) and 100 g (LL_{100}) of *L. lecocephala* leaf meal respectively. Treatments 4 to 6 included a daily supplementation of 40 g (MO_{40}), 60 g (MO_{60}) and 80 g (MO_{80}) of *M. oleifera* leaf meal to goats on natural pasture. Two bucks, previously selected and evaluated for their reproduction capacity (Nöthing, 2000) joined the females during the natural grazing period in order to guarantee mating.

During the dry season, the experimental groups were provided with the respective levels of supplementation at 8:00 in the morning before grazing. Each goat was fed its supplement in an individual box. The individual boxes fulfilled the welfare standards, and the quantities of supplement provided for each goat were adjusted monthly according to body weight. The experiment was conducted from July 2015 to November 2016.

2.3. Preparation of Leaf Meals

The leaves of *L. lecocephala* and *M. oleifera* were manually harvested from mature trees at the Boane district and Changalane village, in Maputo Province, during the summer period when they are more readily available. They were separated from branches cut from trees, air-dried under shade by spreading them on clean plastic sheets and turning several times for 72 h. Thereafter, the dried leaves were cut into small pieces and stored in sisal bags until use.

2.4. Chemical Analysis of the Feeding Diets

To establish the supplementation levels of *L. lecocephala* and *M. oleifera*, the dry and fresh forms of leaves were analysed to determine the metabolizable energy (ME), crude protein (CP), calcium (Ca) and phosphorus (P) content. The analyses were carried out at the UP *Nutrilab,* Department of Animal and Wildlife Sciences, Agricultural Sciences Building – University of Pretoria.

2.5. Traits measured

2.5.1. Growth performance

Goats were weighed at the beginning of the experiment and then fortnightly until the end of the experimental period using a commercial scale. Weighing was performed in the morning before supplementation was given. Average daily gain (ADG) was calculated by subtracting the initial body weight from the final body weight and divided by the number of experimental days.

2.5.2. Reproductive performance and growth performance of kids

The reproductive traits considered were the birth rate, litter size, twinning rate and survival rate. These traits were calculated as follow (Sen and Onder, 2016);

Birth rate = (number of does giving birth/number of does mated) × 100

Litter size = (number of kids born/number of a does giving birth)

Twinning rate = (number of twin kids/number of does giving birth) × 100

Survival rate = (number of kids alive at weaning/number of kids alive at birth) × 100

All kids were weighed at birth to determine the birth weights and at four months of age to obtain the weaning weights.

2.6. Statistical Analysis

Data were analysed using the statistical package SPSS release 20 (IBM Corp, 2011). Analysis of BW and ADG were

performed using Analysis of Variance (ANOVA) for a completely randomised design, using the GLM procedure. Treatment and sex were entered into the model as independent variables while initial weight was considered as a linear covariate to control variation. When treatment effects were significant ($p < 0.05$) on the ANOVA, the effect of type and level of supplementation were determined by orthogonal contrast testing. A 5% significance level was adopted. The following statistical model was used: $Y_{ij} = \mu + T_i + \gamma_j + \beta(x_{ij} - \bar{x}) + \epsilon_{ij}$, where μ is the general mean effect, T_i is the effect of treatment, γ_j is the effect of sex, β is the linear regression coefficient, x_{ij} is the value of covariate variable, $\bar{x}$ is mean value of the covariate, and ϵ_{ij} is the random error effect.

3. Results

3.1. The Chemical Composition of The Feeder Tree Leaves

The chemical analyses of *L. lecocephala*and *M. oleifera* dried leaves on ME, CP, Ca and Pare presented in Table 1. A higher concentration of CP and P was observed in *M. oleifera* than in *L. lecocephala* leaves, while on the contrary the observed ME and Ca was lower than that of *L. lecocephala*.

Table 1. Chemical analyses of *L. lecocephala* and *M. oleifera* dried leaves

Feeder trees	DM (g/100)	Nutrient contents (on Dry Matter basis)			
		ME (MJl/kg)	CP (g /100g)	Ca (g /100g)	P (g /100g)
L. leucacepha	100	11.05	23.7	3.26	0.15
M. oleifera	100	7.61	28.8	2.21	0.24

3.2. Growth performance

Table 2 presents the results of the growth performance of the goats throughout the study period. Final body weight was influenced by dietary supplementation with either *L. lecocephala,* or *M. oleifera* leaves. Generally, supplemented bucks had higher ($p < 0.05$) final BW than control bucks. Although higher levels of *L. lecocephala*or *M. oleifera* supplement showed higher weight gains compared to the control animals, the average final BW was not significantly different among the supplemented goats.

Table 2. Effect of supplementation with *L. lecocephala* and *M. oleifera* on growth performance of indigenous goats

Trait	Treatments							SEM*	p-value
	Control	LL_{50}	LL_{75}	LL_{100}	MO_{40}	MO_{60}	MO_{80}		
Initial BW (kg)									
Bucks	17.4	17.9	21.3	21.2	21.3	21.2	22.2	0.560	0.162
Does	16.3	14.9	14.2	14.3	14.3	14.3	14.9	0.491	0.956
Final BW (kg)♣									
Bucks	24.2^{b}	31.8^{ab}	35.8^{a}	34.9^{a}	31.3^{ab}	36.0^{a}	34.1^{a}	1.221	0.001
Does	21.3	22.5	25.4	24.2	21.6	24.9	22.6	0.594	0.461
ADG (g/day)									
Bucks	6.9^{b}	21.9^{ab}	30.2^{a}	28.6^{a}	21.4^{ab}	30.7^{a}	27.1^{a}	1.747	0.001
Does	10.0	15.1	21.9	19.4	14.2	20.7	14.9	1.521	0.437

♣Adjusted body weight, *SEM = standard error of mean, $^{a-b}$Means in a row without a common superscript letter differ ($p < 0.05$)

Supplementary diet was only provided during the dry season. Results of the average daily weight gain (g/head/day) of goats fed *L. lecocephala* or *M. oleifera* leaf meals in two consecutive dry seasonsare presented in Table 3. Generally, supplementation of goats with either *L. lecocephala* or *M. oleifera* leaves, irrespective of level, had a significant effect ($p < 0.01$) on weight gain. In year 2, all goats lost weight during the dry season, but it was significantly lower in supplemented goats compared to control goats. In the same year the ADG did not differ significantly ($p > 0.05$) between goats supplemented with *L. lecocephala* and *M. oleifera* leaf meals.

Within *L. Leucaena* supplemented goats during the first dry season of the study (year 1), a linear increasing of ADG was observed with increasing levels of supplementation with *L. lecocephala*, though increasing from 75 g to 100 g did not increase the ADG significantly. In contrast, during the last dry season of the study (year 2), increasing levels of supplementation with *L. leucacepha* had no significant effect on ADG, though a quadratic trend was observed. On the other hand, during the first dry season, supplementation with *M. oleifera* at 60 g significantly increased the ADG compared to 40 g supplementation, while increasing from 60 g to 80 g did not resulted in benefit as the goats lost on average 5.69 g/head/day. A similar trend on ADG, though not significant, was observed during the second dry season with increasing levels of *M. oleifera* supplementation.

Table 3. Average daily weight gain (g/head/day) of goats fed diets contained leaves of *L. lecocephala* (LL) or *M. oleifera* (MO) in two consecutive dry seasons.

Diet	Season			
	Dry 1	Rainy 1	Dry 2	Rainy 2
Co	-20.74	10.06	-36.11	2.60
LL_{50}	-6.25	9.54	-7.85	1.86
LL_{75}	10.42	10.00	-3.06	0.93
LL_{100}	2.22	10.58	-6.46	2.31
MO_{40}	-4.72	10.73	-7.92	1.90
MO_{60}	13.33	10.93	-4.03	2.29
MO_{80}	-5.69	10.14	-7.08	2.36
SEM	2.377	0.263	1.737	0.248
Contrasts				
A	<.010	0.773	<.001	0.417
B	0.031	0.303	0.282	0.630
C	0.264	0.170	0.754	0.649
D	0.280	0.727	0.444	0.979
E	0.020	0.470	0.382	0.299
F	0.897	0.891	0.851	0.128
G	0.014	0.558	0.491	0.621

Co = Control, LL_{50} = Grazing + 50 g of *L. leucacepha*; LL_{75} = Grazing + 75 g of *L. leucacepha*; LL_{100} = Grazing + 100 g of *L. leucacepha* MO_{40} = Grazing + 40 g of *M. oleifera*; MO_{60} = Grazing + 60 g of *M. oleifera*; MO_{80} = Grazing + 80 g of *M. oleifera*

SEM = standard error of the mean.

A = control vs pooled Leucaena and Moringa treatments; B = LL_{50} compared to LL_{75}; C = LL_{50} compared to LL_{100}; D = LL_{75} compared to LL_{100}; E= MO_{40} compared to MO_{60}; F = MO_{40} compared to MO_{80}; G = MO_{60} compared to MO_{80}

To investigate if goats regardless of the season had different growth performance throughout the study period, body weights along the experimental period were compared among treatments (Figure 1).

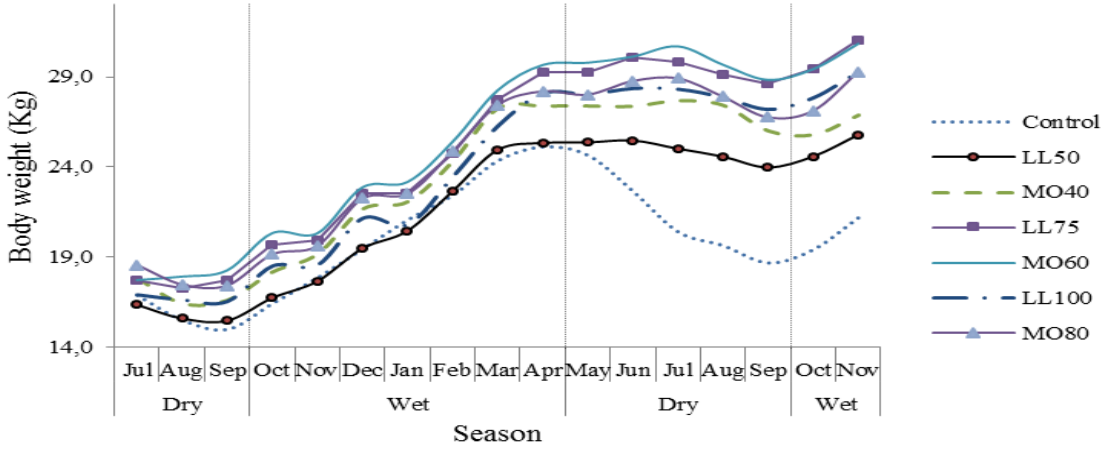

Figure 1. Body weight (kg) of goats fed diets contained leaves of *L. lecocephala*(LL) and *M. oleifera* (MO) in two consecutive dry seasons (the year 2015 to 2016).

There was a tendency toward heavier weights when goats were supplemented with either *L. lecocephala or M. oleifera* compared to control goats. Between supplemented groups, goats fed 60 g *M. oleifera* and 75 g *L. lecocephala* leaf meals had heavier weights compared to goats fed other supplement levels, but there were no significant differences on weight gains resulting from both diets. Control goats always showed the lowest weight gain compared to supplemented goats, though no significant effects of diets on weight gains were observed during the rainy season. The goats in the control group didn't show compensatory growth during the rainy season as the weight gain level during the rainy season was not significantly different from the rest of the treatment groups.

3.3. Reproductive Performance and Growth Performance of Kids

The results of some reproductive traits of does and growth performance of newly born kids are presented in Table 4. All does conceived during the experimental period, and the birth rate of supplemented goats (100%) was higher compared to control goats (75%). The twinning rate ranged from 25 to 75% in does supplemented with *L. lecocephala* or *M. oleifera* leaves. Live body weights at birth and weaning weight were not significantly ($p > 0.05$) affected by the type of supplement. However, increasing levels of supplementary diets irrespective of source had a linear effect ($p < 0.01$) on the weight of kids before

weaning. Birth type and pre-weaning survival rate of the kids varied among supplementation levels. Goats fed higher level of supplement, except for LL_{100} group, had higher rates of twin births and lower pre-weaning survival rates of the kids compared to other levels of supplementation. The pre-weaning survival rate of the kids was higher in supplemented goats when compared to control goats, though 71.4% of the kids died from the LL_{75} group.

Table 4. Effect of diet on some reproductive traits and growth performance of goat kids

Diet	Birth rate (%)	Age at first kidding (years)	Litter size	Twinning rate (%)	Survival rate (%)	Birth weight (kg)	Weaning weight (kg)
Co	0.75	2.30±0.10	1.00±0.00	0.0	50.0	1.60±0.70	7.05±0.05
LL_{50}	100	2.15±0.10	0.75±0.50	0.0	75.0	2.23±0.13	9.30±0.15
LL_{75}	100	2.17±0.08	1.75±0.50	75.0	28.6	2.09±0.16	10.15±0.35
LL_{100}	100	2.13±0.09	1.00±0.00	0.0	75.0	2.00±0.08	9.37±0.35
MO_{40}	100	2.10±0.12	1.00±0.00	0.0	100	2.33±0.15	8.65±0.88
MO_{60}	100	2.24±0.09	1.25±0.50	25.0	80.0	2.14±0.14	9.13±0.43
MO_{80}	100	2.10±0.14	1.25±0.50	25.0	60.0	2.12±0.20	9.53±0.64

4. Discussion

The chemical composition of *L. lecocephala* and *M. oleifera* leaves used in this experiment have shown similar values to those reported in other studies (Ndemanisho, 1996; Ben Salem and Makkar, 2009; Gopalakrishnan et al., 2016). Concerning dried *L. lecocephala* leaves in term of ME, CP and P, the values were within the range reported by Ocran (1994) and Ndemanisho (1996), while ME, CP and Ca in dried *M. oleifera* leaves were similar to those values reported by Ben Salem and Makkar (2009) and Gopalakrishnan et al. (2016).

The positive effect of supplementation with either *L. lecocephala* or *M. oleifera* on growth performance observed in this study was due to the supply of high-quality energy and protein from these feed sources, compared to natural pasture which showed deficiency during the dry season. This result is corroborated by findings of Garcia et al.(1996), Muamba et al. (2014), Hassan et al. (2015), Moyo et al. (2016) and Damor et al. (2017) in goats supplemented with *L. lecocephala* and *M. oleifera* during the dry season. Also, Faftine and Zanetti (2010) reported that the low productivity observed in goats fed natural pasture could have resulted from the low efficiency of utilization of fibrous feeds due to the low content of nitrogen, minerals and vitamins and high levels of lignin during the dry season. Moreover, Payne (1990) reported that forage species, in the tropics and sub-tropics, mature and become fibrous rapidly, resulting in poor quality forage. However, the non-significant differences on growth between the control and other treatment groups observed during the rainy season may probably be due to reduced feed intake of the supplemented goats. Similarly, Toukourou and Peters (1999) who studied the impact of feed restriction on the growth performance of goat kids found no difference in body weight gain among the restricted and control groups. Generally, animals are able to grow rapidly and recover body weights after periods of restrictions, and this ability varies according to several factors, such as species, breed, adaptability to harsh conditions, the nature and severity as well as the duration of feed restriction (Yagoub and Babiker, 2009; Onder et al., 2015).

Leucaena leucocephala is considered rich in nutrients with the potential to sustain microbial growth and subsequently allowing higher animal performance (Aletor and Omodara, 1994). However, in the present study, a quadratic effect on weight gain was observed with increasing levels of supplementation, suggesting that beyond certain levels, *L. leucocephala* supplementation may lower the growth performance of goats, probably as result of the presence of limiting factors. Anti-nutritional compounds have been identified in fodder trees (Simbaya, 2002), and among them, tannins and mimosine are present in *L. lecocephala* (Simon, 2012; Adedeji et al., 2013). These compounds depending upon the situation can have beneficial or deleterious effects on animals consuming them (Kumar, 1992). The detrimental effect of anti-nutritional factors in ruminants may range from reduced animal performance to neurological problems and death of the animal (D'Mello, 1992; Aemiro et al., 2004; Assefa, 2007; Sen and Onder, 2016). Several studies have associated the consumption of *L. leucocephala* leaves with lower growth performance in ruminants by limiting nutrient utilisation of ingested feed material (Kumar, 1992; Leng, 1997). However, other studies have reported that diets of moderate to high levels of *L. leucocephala* could be fed to goats without adverse effects on weight gain, as goats were capable of degrading mimosine, and were very well adapted to increase their productivity rate (Kumar and Ashwani, 1998; Yami et al., 2000).

On the other hand, goats fed *M. oleifera*meal had a relatively higher growth performance compared to goats fed *L. leucocephala* meal. The positive effect resulting from *M. oleifera* supplementation was due to the high protein contents. Several studies (Arivazhagan et al., 2000; Moyo et al., 2012; Aboh et al., 2012; Asaolu et al., 2012; Dougnon et al., 2012; Moyo et al., 2016) have reported improvements in growth performance of goats fed diets

containing *M. oleifera* leaves. Increasing levels of *M. oleifera* resulted in increased weight gain, though a decrease was observed between 60 g and 80 g supplementation levels, suggesting that a higher beneficial effect was achieved at 60 g supplementation level. Similarly, Bebeker and Abdalbagi (2015) fed goats with three different levels of *M. oleifera* leaves and observed that moderate levels of supplementation resulted in rapid growth performance and could sustain and improve livestock productivity.

Concerning reproductive performance, the higher birth rate observed in goats fed *L. leucocephala,* or *M. oleifera* leaf meals may have resulted from the use of these supplements in animal feed. Supplementary feed rich in energy and protein has a significant positive effect on reproduction in general and ovulation rate in particular (Blache et al., 2008). Previous studies reported increased ovulation rates (Rhind, 1992; Akingbade, 2002) and the incidence of twins (Isaacs et al., 1991; Rhind, 1992) in does feed high protein diets.

Birth weight and weaning weight did not vary significantly among treatments, but kids born from supplemented does had relatively heavier weights compared to those from the control group. Heavier birth weight and weaning weight of kids may have resulted from heavier weights of does at kidding and milking phase, therefore reflecting a positive effect of supplementation. Similar results were observed in other studies conducted for goats under different production systems (Soundararajan et al., 2006; Bushara and Abu Nikhaila, 2011). In contrast, the lower birth weight and weaning weight observed in the control group may be due to the effect of poor quality feeding during the dry season. According to Deminicis et al. (2009), insufficient energy supply is considered to be the primary obstacle in the production of small ruminants, resulting in reduced growth and reproductive performances.

While the high twinning rate observed in goats fed 75 g of *L. leucocephala* leaf meal seems to be due to the positive effect of supplementation, the survival rate of kids was the opposite. This may be indicative of either lower milk produced by does for offspring or a consequence of lighter birth weights of twins, which may contribute to reduced resistance to adverse conditions, such as climate. The lower survival rate observed is in agreement with the results presented by Akingbade et al. (2001) in South Africa, Peacock (1982) in Kenya and Mackinnon and Rocha (1985) in Mozambique, where individual twin goats had a higher mortality rate. Also, *L. leucocephala* leaves have some compounds that act as limiting factors (Ben Salem et al., 2001), affecting the reproductive tract either by their toxicity or by interference in the reproductive control mechanisms, which may result in weak offspring (Kumar, 1992; Leng, 1997).

However, offspring born to goats feed *M. oleifera* leaves had high survival rates. This result may have been influenced by the presence of compounds with therapeutic properties in *M. oleifera* leaves (Bebeker and Abdalbagi, 2015), in addition to the positive effects of supplementation on the does. Similar results were also reported by Qwele et al. (2013) who showed that consumption of a diet supplemented with *M. oleifera* could be a useful source to protect the animals from oxidative stress-induced diseases.

Age at first kidding was not affected by the supplementation with either *L. lecocephala* or *M. oleifera* and ranged between 780 to 690 days. Similar results were reported by Wilson et al. (1989) who found age at first kidding of 693 ± 36.3 days in Mozambique goats. Also, Mackinnon and Rocha (1895) on their study with indigenous goats in Mozambique showed similar results with an average age at first kidding of 738 days.

5. Conclusion

Supplementation with *L. leucacepha* and *M. oleifera* leaves during the dry season had a positive effect on the growth rate and reproductive performance of goats. Moderate levels of supplements (LL_{75} and MO_{60}) yielded better results and can be used to overcome shortages of good quality feeds. Therefore, *L. leucacepha* and *M. oleifera* represent a good alternative to commercial supplements that can be used by smallholder farmers for feeding goats during periods of feed shortage.

Conflict of Interest

The authors declare that there is no conflict of interest.

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