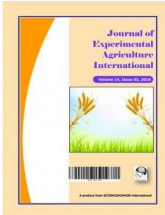

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Feed Intake, Growth Performance and Carcass Characteristics of West African Dwarf Sheep Fed *Moringa oleifera, Gliricidia sepium* or Cassava Fodder as Supplements to *Panicum maximum*

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Authors' contributions

This work was carried out in collaboration between all authors. Authors AAF and JAA designed the study. Author AAF wrote the protocol and the first draft of the manuscript. Authors ANF and JAA reviewed the experimental design and all drafts of the manuscript. Author AAF collected the data and performed the laboratory analyses of the study. Authors GEO and AAF performed the statistical analysis and interpreted the results. All authors read and approved the final manuscript.

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ABSTRACT

The performance and carcass characteristics of West African dwarf (WAD) sheep fed *Panicum maximum* supplemented with *Moringa oleifera, Gliricidia sepium* or cassava fodder, were investigated in a randomized complete block and completely randomized design experiments respectively. Twenty four growing WAD sheep (10.7 kg average live weight) were randomly allotted to four dietary treatments: 1: 100% *P. maximum* (control), 2: 75% *P. maximum* + 25% *M. oleifera*, 3: 75% *P. maximum* + 25% *G. sepium*, 4: 75% *P. maximum* + 25% Cassava leaves. Dry matter

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(DM) intake (g/kgW$^{0.75}$/day) ranged between 74.6 for treatment 4 and 92.7 for treatment 3. Crude protein (CP) intake in treatment 3 was higher than in treatments 1 and 4. Growth rate ranged between 6.53 g/day to 12.74 g/day for treatments 1 and 4 respectively while treatments 2 and 4 had better feed conversion ratio than treatment 1. Average dressing percentage was 33.9% and there was no significant difference in the carcass characteristics among the various treatments. It was concluded that *Moringa oleifera* is a suitable alternative to *Gliricidia sepium* as supplement in small ruminant diets.

Keywords: Supplement; browse plants; sheep intake; weight gain.

1. INTRODUCTION

In most developing countries, the major feed resources for ruminant animals are natural grasslands which are becoming increasingly unavailable due to land-use and unpredictable drought which constrain the animals to the insufficient, low-quality available herbage. The use of crop residues and agro-industrial waste and by-products as supplements to natural grazing are of great importance in these areas but this is limited by the nutritive characteristics of these feeds. They have high fibre content, low metabolizable energy, low levels of crude protein and mineral nutrients as well as low to moderate digestibility. Their daily intakes are often limited to less than 10g dry matter/kg live weight [1]. The ability of the ruminant animal to meet its energy and protein requirements from such low quality and relatively indigestible feed is thus greatly impaired. This factor coupled with the poor genotypic characteristics of tropical breeds is largely responsible for the low productivity of indigenous breeds of small ruminants in less developed countries.

Leng [2] have proposed that ruminant feeding systems based on poor quality tropical forages, crop residues or agro-industrial waste and by-products, in which protein is one of the major limiting factors, may require supplementation with protein-rich feeds to maintain an efficient rumen ecosystem that will stimulate nutrient intake and improve animal performance. Foliage of some browse trees and shrubs have been identified as having the potential to serve as supplementary feeds in small ruminant feeding systems. This is because they grow all year round and their nutritive values do not fluctuate as much as that of grasses in different seasons. The potentials of trees and shrubs as alternative fodder resources in livestock nutrition have thus attracted the attention of researchers worldwide.

Gliricidia sepium is one of the browse species which have been well studied for its potentials as supplement in sheep and goats diets. However, its limitations as ruminants fodder resource are also well documented [3,4,5]. Foliage of cassava *(Manihot esculentum)* is produced abundantly in Nigeria and is rich in protein (25%), ash (9%) and fat (12.7%) but low in crude fibre (11%); the protein is of good quality, and the amino acid profile apparently compares favourably with that of soybean meal [6]. However, risk of cyanide toxicity and lack of adequate information on the effect of frequent foliage harvest on tuber yield has hindered its effective integration into ruminant feeding systems.

Moringa oleifera is a promising new species with potential for supporting improved small ruminant productivity due to its palatability, high nutritive value and precocious growth [7]. Another distinct advantage of *Moringa* is that it doubles as forage for animals and vegetable for human, thus the chances of its adoption especially in areas where it is relished as food is very high compared with strictly forage plants like *Gliricidia.* However, there are few reports in the literature on feeding trials with small ruminants using the species [8]. This study is therefore conducted to compare the performance of WAD sheep fed *Panicum maximum* supplemented with *M. oleifera, G. sepium* or cassava foliage with a view to discovering a feeding strategy that will enhance intake, weight gain and lean production by the animals.

2. MATERIALS AND METHODS

The experiment was carried out at the Federal College of Agriculture, Akure (7°16´N, 5°12´E) located in the rain forest ecological zone of Nigeria. Twenty four growing West African Dwarf (WAD) sheep (12 males and 12 females) with an average initial weight of 10.7 kg were used in the study. They were quarantined for four weeks during which period they were treated against ecto-parasites using diazintol, dewormed with broad spectrum anthelminthics (Levamisole) and Ivomec (against mange) and prevented against infections using antibiotic injection (Kepro-oxytet

LA) and Peste de petits ruminantes (PPR) vaccine. After the quarantine period the animals were housed individually in concrete floored pens measuring about 1.8 m^2 with provision for feeding and watering troughs. Wood shaving was spread on the floor as litter which was changed every 2 weeks.

The feeding trial was a randomized complete block experiment while the carcass characteristics study was a completely randomized design experiment. After balancing for sex and body weight, the animals were divided into four groups of six animals (3 males and 3 females) each. Each group was randomly allotted to one of the following dietary treatments:

- Treatment 1: 100% *Panicum maximum* (control)
- Treatment 2: 75% *P. maximum* + 25% *M. oleifera*
- Treatment 3: 75% *P. maximum* + 25% *G. sepium*
- Treatment 4: 75% *P. maximum* + 25% Cassava leaves

Fresh *Panicum, Gliricidia* and *Moringa* foliage were harvested from established pastures and cassava leaves from the arable crop farm of the Federal College of Agriculture, Akure. They were allowed to wilt overnight after which *Panicum* was chopped to a length of about 10 cm before being fed to the animals. Each day, weighed quantities of feed were given to the animals and the left-over measured the following day to determine the voluntary feed intake. Salt lick was also provided ad-libitum throughout the duration of the experiment which lasted nine weeks comprising one week adaptation and eight weeks collection periods.

Feed offered and left over were sampled daily and bulked together for chemical compositions according to A.O.A.C. [9]. All the animals were weighed at the beginning of the trial and subsequently at weekly intervals. Weighing was carried out with the aid of a mobile metallic weighing crate on which a standard 100 kg Salter scale was mounted. Data collected was used to calculate the average daily weight gains for individual animals.

On the last day of the growth trial, three rams from each treatment were slaughtered. They were previously starved overnight and were weighed on the day of and just before slaughter. Thereafter the carcasses were flayed and eviscerated using sharp knives and then washed. The head and legs (trotters) were removed and weighed. The dressed carcasses were also weighed to obtain the warm dressing percentage and then divided into the primary cuts [10] namely shoulder, rack, loin, breast, flank and leg. These and other body organs were weighed. Dressing percentage was also calculated for each animal.

The data collected were subjected to analysis of variance using the general linear model (GLM) procedure of MINITAB [11] to determine the effects of sex and dietary treatments on the various parameters studied. Where significant F-values for treatment effects were found, means were compared by Fisher's Pairwise Comparism in the MINITAB software.

3. RESULTS AND DISCUSSION

In Table 1, Crude protein (CP) content was higher for the browse species and cassava leaves than for *P. maximum* while crude fibre (CF) content of *P. maximum* was more than double that for *Moringa* and *Gliricidia* and more than triple that in cassava foliage. This is in agreement with Leng [2] who stated that roughages such as grasses contain greater quantities of structural components and therefore more fibre than other livestock feed resources. On the other hand, nitrogen free extract (NFE) content was highest in cassava leaf suggesting that it could be a better source of readily fermentable carbohydrates than the other forages used in this study. The higher CP content of *P. maximum* than values given by other authors [12,13] could be due to the fact that this present study was carried out during the early rainy season (April – July) when tropical grasses are known to contain higher crude protein.

According to Table 2, *Panicum* intake by animals fed browse supplements were statistically similar ($P>0.05$) but supplement intake was higher ($P<0.05$) for *Gliricida* than *Moringa* and cassava foliage supplemented groups. This is probably because the animals were more familiar with *Gliricidia* which is commonly fed to small ruminants in the locality where the animals were purchased, since according to Ikhimioya [14], small ruminants readily accept feeds with which they have had previous experience.

Table 2 also shows that the ratios of grass to supplement intake were higher for animals fed cassava and *Moringa* foliage than animals supplemented with *Gliricidia* and that while the proportion of grass relative to *Moringa* and cassava foliage consumed were respectively higher than the proportion offered, that of grass relative to *Gliricidia* was lower. Based on the assertion of Jayasuriya [1] that ideal supplements should not reduce intake of the basal diet but instead have the potential for enhancing it, *Moringa* and cassava foliage therefore seem to have better value than *Gliricidia* as supplements to poor quality ruminant feeds.

Total DM intake was similar for all the treatments except treatment 4 which was significantly lower ($P<0.05$) than treatment 3. The least DM intake recorded for cassava foliage was probably because the animals took longer time to adapt to this feed and this could probably indicate that longer time is required for the rumen flora to become adapted to metabolizing the cyanide presumably librated in the rumen [15]. DM intake (g/kg$W^{0.75}$/day) which ranged between 74.6 for treatment 4 and 92.7 for treatment 3 is lower compared to 87.1 – 107.8 reported by Adegbola et al. [16] but it is higher than the ranges 49.0 – 64.0, 49.5 – 61.2 and 59.0 – 74.0 reported by Adeleye et al. [17], Sarwatt et al. [18] and Tuah et al. [19] respectively. According to Oladotun et al. [20], variations in feed intake can be attributed to differences in breed, body weight, type of diet and length of time spent on the diet. Matthewman [21] also stated that feed intake is greatly influenced by the palatability of the feed and animals' level of productivity. Type of diet seems to be the major difference in the reports cited above and that in the present study. Therefore the higher DM intake recorded by Adegbola et al. [15] followed by that in this study could be attributed to higher palatability of the diets used in the two studies than those in the other works cited.

DM intake as percent live weight which ranged between 4.03 and 5.02% compares favourably with 4.5% average reported by Mejia et al. [22] which according to the authors is at the high end of the range of expected values for tropical hairy sheep. According to Preston and Leng [23], a high intake is an indication that the diet is giving rise to an adequate balance of nutrients at the site of metabolism. It can be inferred therefore that the supplementation employed in this study, at about 25% of the total dietary DM, was adequate in ensuring an optimum feed intake for normal growth and development of small ruminants.

As shown in Table 3, CP intake in treatment 3 was higher than composite values in treatments 1 and 4. This suggests that diets supplemented with *Gliricidia* and *Moringa* were capable of furnishing the animals higher quantities of CP than the ones supplemented with cassava leaves and the non-supplemented (control) diet. The highest CP intake recorded in treatment 3 could also explain the highest DM intake obtained in animals on this treatment (Table 2) because dietary protein supplementation is known to improve DM intake by increasing the supply of N to the rumen microbes [18]. This has a positive effect of increasing microbial population and efficiency thus enabling them to increase the rate of breakdown of the digesta. As the rate of breakdown and passage of the digesta increases, feed intake increase accordingly [24].

CF and ash intake were not significantly different ($P>0.05$) probably because of the higher CF and ash contents of *P. maximum* and its much higher inclusion levels in the experimental diets compared to the other feedstuffs. EE intake was also similar and this could be due to the similarity in the EE composition of the feedstuffs (Table 1). On the other hand, NFE intake in treatment 3 was significantly different ($P<0.01$) from the other treatments. This suggests that fibrous diets supplemented with *Gliricidia sepium* could be a potential source of fermentable carbohydrates which according to Leng [2] are needed in the rumen to provide energy for growth of microbial cells to enhance degradation of fibrous feed materials.

Values of live weight changes of the animals shown in Table 4 are generally low compared with those reported elsewhere for WAD sheep [16,17,20,25,26,27]. The reason could be because all these authors fed supplementary compounded rations which were probably more palatable and digestible than the 100% forages offered in this present study resulting in higher intake and better growth performance of the animals. However, at 9.73 g day^{-1}, overall average growth rate in the present study almost triple the 3.5 g day^{-1} obtained by Tuah et al. [19] who offered graded levels of palm kernel cake as replacement for cassava peels to WAD sheep. The authors adduced the low performance of the animals to dietary deficiency of rumen degradable nitrogen due to the low intake of the supplement. This is probably not applicable in this present study.

According to Ogebe et al. [28], growth rate is influenced by a combination of factors which include management type, season of the year, age and physiological state of the animal. The low growth rates recorded in the present study could therefore be attributed to the management system of total confinement which the animals, purchased from the open market, probably found difficult to adapt to. Wilson [29] stated that the average daily weight gain of sheep was better under farm rearing conditions than on station most probably because of heavier parasitic burden and related health and productivity problems due to the confined husbandry in station. It is conceivable that this problem is more acute in the rainforest zone particularly during the rainy season when this study was carried out. However this season coincides with the period of abundant availability and higher nutritive value of tropical forages. This is probably why animals on the control (sole *Panicum*) diet gained weight (though marginally) contrary to Ademosun [30] who stated that the use of grass such as *P. maximum* or *Cynodon nlemfuensis* alone was not adequate to allow optimum production in sheep and goats and that the animals lose weight unless they have access to supplementary feeds. This was corroborated by Alli-Balogun et al. [31] who recorded a growth rate of -30.5 g/day in Yankasa/WAD sheep crosses fed sole gamba grass (*Andropogon gayanus*).

Table 1. Chemical composition of *Panicum, Moringa, Gliricidia* and cassava leaves

Composition (%)	*P. maximum*	*M. oleifera*	*G. sepium*	Cassava leave	SEM
Dry matter*	24.27	21.48	31.60	17.60	5.12
Organic matter	88.08	92.46	91.00	93.86	2.14
Crude protein	12.17	29.68	24.38	22.40	4.14
Crude fibre	37.37	16.98	14.00	9.55	8.17
Ether extract	4.07	5.78	3.00	4.40	0.99
Ash	11.92	7.54	9.00	6.14	2.14
Nitrogen free extract	34.47	40.11	49.62	57.51	8.83

**Dry Matter, % in fresh sample, others % in Dry Matter*

Table 2. Effect of feeding *Moringa, Gliricidia* or cassava foliage as supplements to *Panicum maximum* on voluntary feed intake in WAD sheep

Treatment	Sex	Grass intake (g day^{-1})	Supplement intake (g day^{-1})	DM intake (g day^{-1})	DM intake (g/day/kgW$^{0.75}$)	DM intake (% LW)	Ratio of voluntary grass to supplement intake
1	F	535.70	-	535.70	82.83	4.78	100:0
	M	509.60	-	509.60	80.40	4.39	100:0
	Mean	522.65^{a}	-	522.65^{ab}	81.62	4.56	100:0
2	F	351.90	110.25	462.15	83.44	3.84	76.1:23.9
	M	433.10	126.90	560.00	85.94	4.77	77.3:22.7
	Mean	392.50^{b}	118.58^{b}	511.08^{ab}	84.69	4.31	76.8:23.2
3	F	393.20	162.07	555.27	90.70	5.14	70.8:29.2
	M	411.60	183.80	595.40	94.73	4.89	69.1:30.9
	Mean	402.40^{b}	172.93^{a}	575.33^{a}	92.72	5.02	69.9:30.1
4	F	380.10	104.83	484.93	74.75	4.01	78.4:21.6
	M	372.30	96.25	468.55	74.54	4.04	79.5:20.5
	Mean	376.20^{b}	100.54^{b}	476.74^{b}	74.65	4.03	78.9:21.1
Stat. significance							
Dietary effect		**	***	*	NS	NS	
Sex effect		NS	NS	NS	NS	NS	
Diet x sex effect		NS	NS	NS	NS	NS	

*a, b Means within the same column with different superscripts are significantly different (**P<0.01, ***P<0.001); Means±S.E, F=Female, M=Male, NS=Not significant (P>0.05), LW=Live weight*

Table 3. Effect of feeding *Moringa, Gliricidia* or cassava foliage as supplements to *Panicum maximum* on nutrient intake in WAD sheep

Treatment	Sex	CP Intake (g day^{-1})	CF Intake (g day^{-1})	NFE Intake (g day^{-1})	EE Intake (g day^{-1})	Ash Intake (g day^{-1})
1	F	65.19	200.19	184.66	21.80	63.86
	M	62.02	190.44	175.66	20.74	60.74
	Mean	63.61^{b}	195.32	180.16^{b}	21.27	62.30
2	F	75.55	150.23	165.52	20.69	50.26
	M	90.37	183.40	200.19	24.96	61.19
	Mean	82.96^{ab}	166.82	182.85^{b}	22.83	55.73
3	F	87.36	169.63	215.96	20.87	61.46
	M	94.90	179.54	233.08	22.27	65.60
	Mean	91.13^{a}	174.59	224.52^{a}	21.57	63.53
4	F	69.74	152.05	191.31	20.08	51.74
	M	66.87	148.32	183.69	19.39	50.29
	Mean	68.31^{b}	150.19	187.50^{b}	19.74	51.02
Stat. significance						
Dietary effect		**	NS	**	NS	NS
Sex effect		NS	NS	NS	NS	NS

*a, b Means within the same column with different superscripts are significantly different (**P<0.01); F=Female, M=Male, NS=Not significant (P>0.05)*

Table 4. Growth rate, feed conversion ratio (FCR) and mortality in WAD sheep fed *Moringa, Gliricidia* or cassava leaves as supplements to *Panicum maximum*

Treatment	Sex	Initial Liveweight	Final Liveweight	Weight Gained	Growth Rate	FCR	Mortality
		(Kg)	(Kg)	(Kg)	(g day^{-1})	(g/W$^{0.75}$Feed:gGain)	(n)
1	F	11.65	12.05	0.40	4.76	17.40	**1**
	M	11.03	11.73	0.70	8.30	9.69	**0**
	Mean	11.34	11.89	0.55	6.53^{b}	13.55^{a}	**-**
2	F	9.00	9.80	0.80	9.52	8.76	**0**
	M	11.07	12.17	1.10	13.10	6.56	**0**
	Mean	10.70	11.49	0.95	11.31^{ab}	7.66^{b}	**-**
3	F	10.33	11.20	0.87	10.36	8.75	**0**
	M	11.07	11.60	0.53	6.31	15.01	**0**
	Mean	10.70	11.40	0.70	8.34^{b}	11.88^{ab}	**-**
4	F	10.47	12.10	1.63	19.44	3.85	**0**
	M	11.10	11.60	0.50	5.96	12.51	**1**
	Mean	10.78	11.85	1.07	12.74^{a}	8.18^{b}	**-**
Overall Mean		10.88±0.27	11.66±0.22	0.82±0.20	9.73±2.44	10.32±2.48	
Stat. significance							
Dietary effect		NS	NS	NS	*	*	
Sex effect		NS	NS	NS	NS	NS	
Diet × sex effect		NS	NS	NS	NS	NS	

*a, b Means within the same column with different superscripts are significantly different (*P<0.05); Means±S.E; F=Female; M=Male; NS=Not significant (P>0.05)*

Average growth rates of animals on treatment 4 were significantly higher than treatments 1 and 3 but were comparable with treatment 2. Moreover, treatments 2 and 4 showed the least feed conversion ratio although comparable with treatment 3, suggesting that the animals probably utilized the supplemented diets better than the control. These results could be an indication that *Moringa* and cassava fodder are probably suitable alternatives to *Gliricidia* leaves as supplements to poor quality fibrous feeds. The results presented in Table 4 also show that female animals had better growth rates than the males under study (11.0 versus 8.4 g day^{-1}), although the difference was not statistically significant (P>0.05). This contradicts an earlier finding [32] that male sheep usually grow faster than their female counterparts.

Average mortality in this study at 8.3% is lower than the range of 10 – 30% typical of traditionally managed flocks in the tropics [32]. The fact that mortality were recorded in treatments 1 and 4 and none in treatments 2 and 3 is probably an indication that supplementation with either *Moringa* or *Gliricidia* is capable of sustaining a favourable health status in small ruminants whereas feeding grass supplemented with cassava leaves or sole grass which is the typical diet of traditionally managed sheep and goats in parts of Nigeria could predispose the animals to varying degrees of mortality probably because of deficiency of critical nutrients and/or presence of anti-nutritional factors.

The data presented in Table 5 showed that there were no significant differences (P>0.05) in the carcass parameters examined in this study. In numerical terms however, slaughter weight was highest in treatment 2 followed by treatment 4, dressed weight was highest in treatment 4 followed by treatment 2, while warm dressing percentage was least in treatment 1 and highest in treatment 4. The average dressing percentage of 33.9% was lower than 43.6% reported by Wilson [29]. This could be due to differences in live weight which was 11.3 kg in this study compared with 19.6 kg in the report cited.

The relative contribution of various organs to dressed weight as shown in Table 6 is similar (P>0.05) across the treatments. In a study with Malawian sheep, Kamwanja et al. [33] reported a value of 3.5% lung, lower than the average of 4.46% recorded in this study. The same authors obtained 5.1% liver, 2.5% heart and 4.4% testes, higher than obtained in this present study. These variations could be due to breed differences and age of the animals.

Table 5. Carcass characteristics of WAD sheep fed *Moringa, Gliricidia* or cassava foliage supplements

Parameters	Treatments				Mean	SEM	SS
	1	2	3	4			
Live weight (kg)	10.90	12.10	10.65	11.60	11.31	0.57	NS
Slaughter weight (kg)	9.25	10.40	8.70	10.20	9.64	0.69	NS
Dressed weight (kg)	3.55	4.00	3.55	4.25	3.84	0.30	NS
Warm dressing (%)*	32.57	33.06	33.33	36.64	33.90	1.44	NS
Head (%)	23.38	29.00	23.66	24.24	25.07	2.29	NS
Feet (%)	9.30	9.50	8.73	8.00	8.88	0.58	NS
Skin (%)	25.35	27.25	23.10	21.18	24.22	2.29	NS
Neck (%)	8.45	7.25	10.42	8.94	8.77	1.14	NS
Shoulder (%)	21.13	23.25	22.25	24.00	22.66	1.08	NS
Rack (%)	9.58	8.75	6.48	10.12	8.73	1.39	NS
Loin (%)	9.01	9.50	8.17	7.76	8.61	0.68	NS
Leg (%)	29.86	32.00	29.58	32.94	31.10	1.42	NS
Breast (%)	7.61	9.25	10.99	9.88	9.43	1.22	NS
Flank (%)	2.82	3.50	3.10	3.53	3.24	0.29	NS

**Warm dressing, % live weight, others % dressed weight; Mean±S.E, NS = Not Significant*

Table 6. Relative organ characteristics* of WAD sheep fed *Moringa, Gliricidia* or cassava foliage supplements

Parameters	Treatments				Overall	SEM	SS
	1	2	3	4	Mean		
Liver (%)	4.07	5.54	4.98	4.08	4.86	0.61	NS
Kidney (%)	0.99	1.31	1.29	1.14	1.18	0.13	NS
Lung (%)	5.36	3.91	4.34	4.22	4.46	0.54	NS
Spleen (%)	0.53	0.48	0.52	0.40	0.48	0.05	NS
Heart (%)	1.48	1.47	1.72	1.62	1.57	0.10	NS
Testes (%)	1.49	3.44	2.75	2.25	2.48	0.71	NS
Stomach** (%)	11.25	12.24	11.32	10.66	11.37	0.57	NS
Small intestine (%)	6.76	7.18	7.31	5.56	6.70	0.69	NS
Large intestine (%)	4.18	3.18	3.89	3.02	3.57	0.48	NS
Caecum (%)	1.55	1.48	1.60	1.47	1.53	0.05	NS

**As % dressed weight; **Stomach = rumen+reticulum+omasum+abomasum; SEM = Standard error of mean; SS = Statistical significance; NS = Not Significant*

4. CONCLUSION

Results obtained in this study showed that the dry matter intake and growth performance of WAD sheep supplemented with *Gliricidia sepium* are comparable with those supplemented with *M. oleifera.* However, the highest growth rate recorded for animals on cassava leaves supplementation is rather inconsistent with the low dry matter intake and incidence of mortality. It is therefore concluded that at 25% level of supplementation, *Moringa oleifera* is probably a better alternative than cassava leaves to *Gliricidia sepium* in small ruminant diets.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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