Chemical composition and *in vitro* evaluation of the nutrient content of *Panicum maximum*-*Moringa oleifera* diets.

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Abstract

The ruminants in the tropics are slow growing, arising from low quality feed. The use of indigenous legume trees and Guinea grass is a good strategy for an improved livestock performance. The study determined the chemical composition, anti-nutritional factors and *in vitro* gas production characteristics of *Panicum maximum*-*Moringa oleifera* mixed diets. Five diets were formulated such that *Panicum maximum* was substituted with *Moringa oleifera* at ratio 0, 25, 50, 75 and 100% in diets A, B, C, D and E respectively and they were incubated for 48 hr using *in vitro* gas production technique. The proximate composition, fibre fraction, anti-nutrient, mineral contents and *in vitro* characteristics of the *P. maximum*-*M. oleifera* mixed diets were determined and all data collected were subjected to one way analysis of variance and where there were significant ($P < 0.05$) differences, means were compared using Duncan multiple range F-test. The results revealed that the observed values were significantly ($p < 0.05$) influenced by the inclusion of *Moringa oleifera* in the diets with the exception of dry matter and gross energy. Dry matter values (87.00–89.72g/100g) decreased with the increased inclusion of *Moringa oleifera* in the diets, while protein content (9.26–26.68g/100g) increased with the increased inclusion of *Moringa oleifera* in the diets. It implied that the diets could be good sources of protein and energy that would meet the requirement of small ruminants for growth and production. Neutral detergent fibre and Acid detergent lignin values decreased with the increased inclusion of *Moringa oleifera* in the diets. However, the values of acid detergent fibre, hemicelluloses and cellulose ranged from 20.13 to 43.44g/100g, 6.88 to 14.45g/100g and 14.65 – 31.48g/100g respectively. Anti-nutrient values were significantly ($p < 0.05$) influenced by the treatment. Tannin concentrations in these diets were below the 6.00g/100g toxic level for small ruminants. The concentrations (g/100g) of Ca (0.12 – 2.74), P (0.05 – 0.12), K (0.17 – 2.78), Na (0.07 – 0.27), Fe (0.07 – 0.17) and Zn (0.04 – 0.16) varied significantly ($p < 0.05$), the observed values were higher in diet E that contained 100% *Moringa oleifera* leaves than other diets. The high contents of these minerals in *Moringa oleifera* indicated that the requirements of sheep and goats for these minerals could be met if the plant is fed with grass *ad libitum*. There were significant ($p < 0.05$) differences among the treatment means of metabolizable energy (ME 3.44 – 5.58 MJ/kg DM), organic matter digestibility (OMD 30.96 – 43.65 g/100g), short chain fatty acids (SCFA 0.05 – 0.26 μ mol) and methane (2.00 – 6.00 ml). Total gas and methane production increased with incubation period and the highest values of OMD was observed in the 48th hour of incubation. It can be concluded that with the enhanced values of crude protein, gross energy, metabolizable energy, short chain fatty acids and low methane production, the *Panicum maximum*-*Moringa oleifera* diets have potential that would meet the nutrient requirements of small ruminants in the tropical regions particularly during the dry season.

Keywords: Gas production, *in vitro*, nutrients, *Moringa oleifera*, *Panicum maximum*

Introduction

A major constraint to small ruminants production in Nigeria is the scarcity and fluctuating quantity and quality of the year-round feed supply (Fajemisin *et al.*, 2013). Tchinda *et al.* (1993) reported that native pastures are the most widely available low cost feeds for ruminants in the tropics. The native pastures deteriorate rapidly in the dry season. This calls not only for identification and introduction of new and lesser-known plants capable of growing in poor soil of Nigeria but which can also play a vital role in control of soil erosion in addition to providing industrial raw materials, food and feed. The potentials of multipurpose trees and shrubs as alternative fodder resources in ruminant nutrition have attracted the attention of researchers worldwide. Several indigenous and exotic browse species have been investigated and evaluated for inclusion in ruminant feeding systems in Nigeria. Unfortunately, the adoption of most of these species by farmers has been faced with several challenges such as pests and diseases attack and presence of anti-nutritional factors. There is therefore the need for continuous screening of browse plants to identify those with good potentials as livestock's fodder and which could serve as supplement or substitute to the poor quality and available grasses. *Panicum maximum* is one of the common grasses in the derived savannah region of Nigeria. Under good conditions, its nutritional value is high having 9-12.5% crude protein, total digestible nutrients (TDN) of 10.2%, calcium of 0.05% and magnesium of 0.06% (McDonald, *et al.*, 1995). However, these values reduced during the dry season because of poor soil fertility and low rainfall which reduces the growth rate of the grass resulting into high cell wall contents and thereby lowering the quality of the forage. According to (Andera

and Pablo, 1999), a sustainable way of improving the feeding value of poor quality pastures is through supplementation with browse plants. Browse plants are edible parts of trees, shrub/bushes and other woody-stemmed plants which are available for animal consumption, mainly leaves, fruits and shoots. These plants include, *Moringa oleifera*/ *Morus alba*, *Gliricidia sepium* and *Leucaena leucocephala*. They can be fed to small ruminants at varying levels with *Panicum maximum* especially during the dry season as source of supplementary protein. This is because they survive long dry season by the possession of deep rooting habit, low transpiration xerophytic foliage and often have good water-harvesting architecture. These makes browse plant remain green in the dry season when other vegetation has senesced. *Moringa oleifera* which has its origin in Agra and Undih, a member of monogeneric family of shrubs and a novel browse plant has better potential than other known browse plant in ruminant feeding system because its nutritional characteristics are excellent so it can easily be used as fresh forage materials. It is a multipurpose tree plant, leaves are rich in crude protein (26 %), NDF (23.70 %), Acid detergent insoluble protein - ADIP (30.00 g kg⁻¹), tannin (12.00 g kg⁻¹), carotene, iron and ascorbic acid and the pod is rich in the amino acid lysine (Hoffman *et al.*, 2001). It has high productivity of fresh biomass yield per unit area compared with other forage crops (Fadiyimu *et al.*, 2010). Therefore, there is necessity for knowing the nutritive value of browse plants because they are very valuable for supplementation in ruminant animals' feed during the dry season. There are different methods of assessing nutritive value of plants, these include chemical analyses, in-vitro digestibility and feeding trial.

The *in vitro* degradability method is a laboratory estimation of rate and extent of nutrient disappearance in livestock feed sample for the purpose of assessing the potential nutritive value of the feed. It is also a method that is reproducible and parameters obtained correlate well with *in vivo* trials (Fajemisin, 2002). *In vitro* gas degradability method has the advantage of not only being less expensive and less time consuming but it allows for more precision in experimental conditions than the *in vivo* method (Makkar, 2002). It is convenient, fast and allows a large number of samples to be handled at a time. It is based on the quantification of substrate degraded and of gas or short chain fatty acid produced in rumen fermentation system (McDonald *et al.*, 1995). Thus, this study was designed to evaluate the nutritional composition of *Panicum maximum* substituted with *Moringa oleifera* using the *in vitro* gas production technique.

Materials and Methods

Site of the experiment

The experiment was carried out at the Teaching and Research Farm and Nutrition laboratory of Department of Animal production and Health, Federal University of Technology, Akure Nigeria.

Collection of *Panicum maximum* and *Moringa oleifera*

Samples of *Panicum maximum* were harvested after 5th week of re-growth and *Moringa oleifera* leaves were collected fresh from a pruned year old *Moringa oleifera* plants at the pasture unit of the Teaching and Research farm, Federal University of Technology, Akure Nigeria. The *Panicum maximum* and *Moringa oleifera* samples were air-dried in the laboratory at room temperature for seven days and milled to pass through 1mm mesh and stored in different air-tight labeled

container.

Experimental diets preparation

Five experimental diets were formulated such that *Panicum maximum* was substituted with *Moringa oleifera* at ratio: 100% *Panicum maximum* (A), 75% *Panicum maximum* + 25% *Moringa Oleifera* (B), 50% *Panicum maximum* + 50% *Moringa oleifera* (C), 25% *Panicum maximum* + 75% *Moringa Oleifera* (D) and 100% *Moringa oleifera* (E) respectively.

Chemical analysis

The air-dried samples of browse plants were oven dried at 60°C for six hours to a constant weight for dry matter determination; crude protein, crude fibre, ether extract and ash were analyzed according to (AOAC, 1995). Neutral detergent fibre, Acid detergent fibre and Acid detergent lignin were determined as described by (Van Soest *et al.*, 1991). The samples were also analyzed for minerals after wet digestion of samples with a mixture of perchloric acid and concentrated nitric acid (1:4 v/v) and some minerals (calcium, magnesium, potassium, sodium, iron and zinc) in the digest were determined by atomic absorption spectrophotometer (AAS) model 490 Gallenkamp, London, while phosphorus was determined by the phosphovanadomolybdate method (AOAC, 1995). Anti-nutrients (phytate, oxalate, tannin, phenol, saponin and alkaloid) were also analyzed using methods of Wheeler and Ferrel (1971), Makkar and Goodchild (1996) and Teferedegne (2000).

In vitro gas production study

The *in vitro* gas production study was carried out at the Nutrition laboratory, Department of Animal Production and Health, Federal University of Technology, Akure Ondo State, Nigeria. Rumen fluid was obtained from three West African Dwarf rams through suction tube before the morning feed. These animals were fed

sufficient quantity of *Panicum maximum* and 300 g of cotton seed cake as supplement. They also have free access to water and salt lick. Incubation was carried out as reported by Menke and Steingass (1988) using 100 ml calibrated syringes in three batches. To 200 mg each of the samples in the syringes was added 30 ml inoculums containing cheese cloth-strained rumen liquor and buffer (9.8 g NaHCO_3 , 2.77 g Na_2HPO_4 + 0.57 g KCl + 0.47 g NaCl + 0.12 g $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ + 0.16 g/litre $\text{CaCl}_2 \cdot \text{H}_2\text{O}$) (1:4, v/v) under continuous flushing with CO_2 . The incubation was carried out at $39 \pm 1^\circ\text{C}$ and the volume of gas production was measured at 3, 6, 9, 12, 15, 18, 21, 24 and 48 hr. After 24 and 48 hr at post incubation period, 4 ml of NaOH (10 M) was introduced to estimate methane production as reported by (Fievez *et al.*, 2005). The NaOH (10 M) was introduced using 5 ml capacity syringe through the silicon tube which was fastened to the 100 ml capacity syringe. The clip was then opened while the NaOH was gradually released. The content was agitated while the plunger began to shift position to occupy the vacuum created by the absorption of CO_2 . The volume of methane was read on the calibration. To determine the actual gas produced, the average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample. The average volume of gas produced from the blanks was deducted from the volume of gas produced per sample. The volume of gas produced at intervals was plotted against the incubation time and form the graph.

Calculations and statistical analysis

The post incubation parameters such as metabolisable energy (ME; MJ/Kg DM) and organic matter digestibility (OMD %) were estimated as established by (Menke and Steingass, 1988) and short chain fatty

acids (SCEA) was obtained as reported by (Getachew *et al.*, 1999): $\text{ME} = 2.20 + 0.136 \cdot \text{Gv} + 0.057 \cdot \text{CP} + 0.0029 \cdot \text{CF}$; $\text{OMD} = 14.88 + 889 \cdot \text{Gv} + 0.45 \cdot \text{CP} + 0.651 \cdot \text{XA}$; $\text{SCEA} = 0.0239 \cdot \text{Gv} - 0.0601$; where Gv, CP, CF and XA are net gas production (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

Gross energy content was estimated using the equation $\text{GE (KJ/100gm DM)} = (\% \text{CP} \times 16.7) + (\% \text{EE} \times 37.7) + (\% \text{Carbohydrate} \times 16.7)$ of (Ekanayake *et al.*, 1999). All data obtained were subjected to one way analysis of variance (ANOVA) and significant differences among treatment means were compared using (Duncan, 1955) multiple range F-test.

Results and Discussion

Proximate composition

The results of proximate composition shown in Table 1 revealed that there was significant ($P < 0.05$) variation in the values of determined nutrients with exception of dry matter (DM) and gross energy (GE). The DM of the test diets ranged from 87.00 (diet E) to 89.72 g/100g (diet A) while CP of the diets ranged from 9.26 (diet A) to 26.69 g/100g (diet E). The improved crude protein values observed agreed with the findings of (Ezenwa and Aken'ova, 1988) that the effect of legume components in a grass-legume mixture would increase the protein quality of the mixture. The CP value (26.68%) recorded for *M. oleifera* was lower than the value (29.68% CP) reported by (Fadiyimu, 2009). However, the CP of diets B, C and D was improved by substituting *P. maximum* with *M. oleifera* at 25, 50 and 75% respectively, this observation agreed with the earlier report of (Salihu, 2009) and the CP values were comparable to those values reported by (Aregheore *et al.*, 1998) when nutritive

potentials of some multipurpose trees in Nigeria were evaluated. Thus, where growing of browse plants are not favoured possibly as a result of the prevailing climatic conditions in some parts of Nigeria, *Moringa oleifera* leaves and stem could be used as dry season feedstuffs if properly made into hay.

The crude fibre values observed in this study ranged from 16.98 (diet E) to 27.23g/100g (diet A) and these were consistent with previous values (17.01 - 33.53%) reported by Fadiyimu (2009) however, these values were lower than the values (47.80-51.20%) reported for other forage leguminous plants (Ifut, 1987). The diet B had the highest ash value (13.29g/100g) which was more than the value reported by (Kwashima *et al.*, 2002). The lowest NFE value (30.02g/100g) was observed in 100% *M. oleifera* diet but this value was significantly ($p < 0.05$) different from the values (32.72 - 36.54g/100g) recorded for other *Panicum maximum-Moringa oleifera* diets. However, the

values were favourably compared to the values (34.79 - 58.21%) reported by (Fajemisin *et al.*, 2015) when cassava peels was substituted with *Cajanus cajan* hay in the diets of WAD goats, it implied that the soluble carbohydrates (NFE) could support the production of volatile fatty acids in the rumen during fermentation (Blummel *et al.*, 1997). The gross energy contents observed in the diets ranged between 13.85 and 15.10 KJ/100gDM, these values were comparable to the values reported by (Fajemisin *et al.*, 2010) when *Musa sapientum* was substituted with *Gliricidia sepium* in the diets of West African Dwarf goats

The Neutral detergent fibre (NDF), Acid detergent fibre (ADF), Acid detergent fibre (ADL), hemi-cellulose and cellulose contents were presented in Table 2. The observed NDF, ADF, hemicellulose and cellulose values were significantly ($P < 0.05$) higher in diet A than the values observed in diets B, C, D and E while the least values of hemicelluloses and cellulose were observed in sole *M. oleifera* diet. The

Table 1: Proximate composition (g/100g) of *Panicum maximum-Moringa oleifera* diets

Parameters	Diets					SEM
	A	B	C	D	E	
Dry matter	89.72	88.60	88.12	87.53	87.00	0.60
Organic matter	77.80 ^{ab}	75.63 ^b	77.89 ^{ab}	81.22 ^a	79.46 ^{ab}	0.79
Crude protein	9.26 ^d	13.17 ^c	19.92 ^b	21.49 ^b	26.68 ^a	1.70
Crude fibre	27.33 ^a	20.50 ^b	22.23 ^{ab}	17.74 ^{bc}	16.98 ^c	1.24
Ether extract	4.70 ^b	5.42 ^b	3.02 ^c	7.32 ^a	5.78 ^b	0.41
Ash	11.92 ^{ab}	13.29 ^a	10.23 ^{bc}	6.31 ^d	7.54 ^{cd}	0.77
Nitrogen free extract	36.51 ^a	36.54 ^a	32.72 ^b	34.67 ^{ab}	30.02 ^c	0.73
Gross energy (KJ/100gDM)	13.98	13.85	13.97	15.10	14.49	0.28

abc = Means in the same row with the same superscripts are significantly ($P > 0.05$) different.

Table 2: Fibre fractions (g/100g) of *Panicum maximum-Moringa oleifera* diets

Parameters	Diets					SEM
	A	B	C	D	E	
Neutral detergent fibre	62.00 ^a	51.50 ^b	50.62 ^a	42.28 ^c	26.01 ^d	3.34
Acid detergent fibre	43.44 ^a	37.05 ^b	43.66 ^a	39.04 ^b	20.13 ^c	2.37
Acid detergent lignin	23.44 ^a	15.25 ^b	12.18 ^c	11.08 ^c	5.48 ^d	1.61
Hemicellulose	12.56 ^b	14.45 ^b	8.96 ^c	7.24 ^d	6.88 ^d	0.82
Cellulose	20.00 ^{bc}	21.80 ^{bc}	31.48 ^a	27.96 ^{ab}	14.65 ^c	1.87

abc = Means in the same row with the same superscripts are not significantly ($P > 0.05$) different.

reason for the variation might be due to differences in maturity, stage of growth and lignin content of the plants (Fadiyimu *et al.*, 2011, Promkot and Wanapat, 2004). The NDF values however, fell within the range of 25-71 % reported for some valuable multipurpose trees that are fed to sheep and goats in Nigeria (Larbi *et al.*, 1993).

Table 3 shows the anti-nutrients content of the *P maximum-Moringa oleifera* diets and the observed values varied significantly ($P < 0.05$). The highest value of saponin (36.16g/100g) was observed in diet D, Phytate (6.01g/100g) in diet C, while phenol (0.32g/100g) and Tannin (1.02g/100g) were observed in diets A and E respectively. However, the presence of tannin and saponin could enhance the quality of the *P maximum-M.oleifera* being beneficial for ruminants nutrition. Feedstuffs containing saponin had been shown to be defaunating agents (Teferedegne, 2000) and capable of reducing methane production (Babayemi *et al.*, 2004). The tannin level in these diets is below the 6.00% toxic level for small ruminants and it could be an added

advantage as a natural additive in the diet of ruminants, since forages or feeds containing tannin have potential of forming complexes with protein as by-pass protein in the rumen (Barry and McNabb, 1999) by diminishing rumen protein digestibility, thus improving on the availability of protein to ruminants at the lower gut.

The macro and trace mineral concentrations of the *P maximum-Moringa oleifera* diets were shown in Table 4. There were significant ($P < 0.05$) differences among the calcium (Ca), phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), iron (Fe) and zinc (Zn) contents of *P maximum-M.oleifera* diets. However, Ca, P, K, Na, Fe and Zn values are apparently higher in *M.oleifera* than the concentration observed in *P. maximum*, diets B, C, and D. The high contents of these minerals in *M.oleifera* indicated that the requirements of sheep and goats for these minerals could be met (McDowell, 1992) if the plant is fed with grass *ad libitum*.

The *in vitro* gas production pattern of *Panicum maximum - Moringa oleifera* mixed diets at 24 and 48 hr shown in

Table 3: Anti-nutrient contents (g/100g) of *Panicum maximum-Moringa oleifera* diets

Parameters	Diets					SEM
	A	B	C	D	E	
Tannin	0.71 ^b	0.16 ^d	0.41 ^a	0.09 ^e	1.02 ^a	0.09
Saponin	21.94 ^c	25.50 ^b	26.14 ^b	36.16 ^a	14.02 ^d	2.82
Phenol	0.32 ^a	0.06 ^d	0.18 ^c	0.14 ^c	0.24 ^b	0.02
Oxalate	2.06 ^d	4.95 ^c	7.01 ^b	9.52 ^a	5.85 ^{bc}	0.69
Phytate	4.20 ^b	2.72 ^c	6.01 ^a	2.92 ^{bc}	2.60 ^c	0.38

abc = Means in the same row with the same superscripts are not significantly ($P > 0.05$) different.

Table 4: Mineral contents (g/100g) of *Panicum maximum-Moringa oleifera* diets

Parameters	Diets					SEM
	A	B	C	D	E	
Calcium	0.51 ^b	0.12 ^c	0.13 ^c	0.13 ^c	2.74 ^a	0.27
Phosphorus	0.05 ^b	0.09 ^{ab}	0.10 ^{ab}	0.09 ^{ab}	0.12 ^a	0.01
Magnesium	0.15 ^b	0.26 ^a	0.19 ^{ab}	0.27 ^a	0.07 ^a	0.02
Potassium	0.52 ^b	0.17 ^b	0.17 ^b	0.21 ^b	2.78 ^a	0.29
Sodium	0.21 ^{ab}	0.17 ^{ab}	0.15 ^b	0.18 ^{ab}	0.28 ^a	0.02
Iron	0.09 ^{ab}	0.08 ^{ab}	0.07 ^b	0.09 ^{ab}	0.17 ^a	0.01
Zinc	0.13 ^a	0.06 ^b	0.05 ^b	0.04 ^b	0.16 ^a	0.01

abc = Means in the same row with the same superscripts are not significantly ($P > 0.05$) different.

Figures 1 and 2 indicated that more degradation of dry matter were still possible beyond 48 h. The situation here depicted that of typical during dry season in Nigeria, when most of the forages are fibrous and therefore take longer time to degrade in the rumen. The highest gas production obtained at 24 and 48 hr was from *Moringa oleifera* while the least gas was observed in *Panicum maximum* forage. In this study, it appeared that the crude protein in the forage diets enhances microbial multiplication, which in turn determines the extent of fermentation.

Methane (ml/200 mg DM) production (Figure 3) range from 2 to 6 among the *Panicum maximum* – *Moringa oleifera* diets, the least and the highest being from 100% *Panicum maximum* and 100% *Moringa oleifera* diets respectively. In most cases, feedstuffs that show high capacity for gas production are also observed to be synonymous for high methane production. Methane production indicates an energy

loss to the ruminant and many tropical feedstuffs have been implicated to increase methanogenesis (Babayemi *et al.*, 2004) as an integrated part of carbohydrate metabolism (Demeyer and Van Soest, 1975). However, the methane production from the forage diets fermented in this study was low compared to methane production values (18–24 ml/200 mg DM) reported by Babayemi (2007) when *in vitro* degradation and acceptability by WAD goats of some dry season forages were evaluated.

The results of metabolizable energy (ME), organic matter digestibility (OMD), short chain fatty acids (SCFA) and methane (CH_4) are presented in Table 5. The ME, SCFA, OMD and CH_4 (24hr) values of the *P maximum-M oleifera* diets were significantly ($P<0.05$) differed, while the values of CH_4 observed at 48hr were similar ($P>0.05$). Although, gas produced is a nutritionally wasteful product (Mauricio *et*

Figure 1: In vitro total gas production of incubated *Panicum maximum-Moringa oleifera* diets at 24hr

Nutritional evaluation of *Panicum maximum*-*Moringa oleifera* diets

Figure 2: In vitro total gas production of incubated *Panicum maximum*-*Moringa oleifera* diets at 48hr

Figure 3: Methane gas production of incubated *Panicum maximum*-*Moringa oleifera* diets

al., 1999) but provides a useful basis from which ME, OMD and SCFA may be predicted. In this study, the higher preponderance of SCFA in diets D and E probably showed an increased proportion of acetate and butyrate but may mean a decrease in propionate production (Babayemi *et al.*, 2006). However, the ME values that averaged 4.48 (24hr) and 4.94 (48hr) MJ/KgDM in the *P. maximum*-*M. oleifera* diets suggest a potential to make energy available to the ruminants. Thus, the *P. maximum*-*M. oleifera* have an advantage of being used as feed for small ruminants especially during the dry season.

Conclusion

The observed result of nutrients composition (9.26–26.68 g/100g CP, 26.01–62.00 g/100g NDF, 30.02–36.72 g/100g and 13.85–15.10 KJ/100gDM) of *Panicum maximum* substituted with *Moringa oleifera* leaves revealed that the diets will be useful sources of protein and energy in ruminant feeding. The presence of tannin (0.09–1.02 g/100g) and saponin (14.02–36.16 g/100g) below toxic level in the diets exhibited the tendency to suppress methanogenesis and improve the availability of protein to ruminant at the lower gut. The enhanced values of crude protein, gross energy, metabolizable energy

Table 5: Metabolizable energy (ME) (MJ/Kg DM), organic matter (OMD) (g/100g), short chain fatty acids (SCFA) (μ mol) and methane (ml) of *Panicum maximum-Moringa oleifera* diets

Diets	Production parameters				parameters			
	In vitro	gas	24hr	CH ₄	ME	OMD	SCFA	CH ₄
A	3.44 ^a	30.96 ^a	0.05 ^b	3.0 ^a	4.26 ^a	36.30 ^a	0.20	5.0
B	4.23 ^a	37.46 ^a	0.16 ^a	1.0 ^b	4.60 ^b	39.83 ^{ab}	0.22	5.0
C	4.72 ^b	39.10 ^{ab}	0.17 ^a	1.0 ^b	4.94 ^{ab}	40.58 ^{ab}	0.21	4.0
D	4.87 ^{ab}	37.85 ^b	0.19 ^a	3.0 ^a	5.31 ^a	40.51 ^{ab}	0.26	5.0
E	5.13 ^a	40.69 ^a	0.18 ^a	2.0 ^{ab}	5.58 ^a	43.65 ^a	0.26	3.0
SEM	0.16	0.92	0.02	0.29	0.15	0.80	0.01	0.42

abc = Means in the same column with the same superscripts are not significantly ($P > 0.05$) different.

and short chain fatty acids in the *Panicum maximum-Moringa oleifera* diets connote the diets' ability to meet nutrient requirements of small ruminant in the tropical regions particularly during the dry season.

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