Feeding values of seven browse tree foliages mixed in varying proportions with *Panicum maximum* for feeding ruminants

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Abstract: Feeding of animals in the right proportion is a panacea to poor productivity in sub-Saharan Africa (SSA). This study was designed to evaluate the potential of seven browse tree foliages in combination with *Panicum maximum* in varying proportions as 1:3, 1:1 and 3:1 using *in-vitro* gas fermentation technique. Ground samples of the mixtures were incubated at 39°C to determine the volume of gas production at 3, 6,9,12,15,18, 21 and 24hr. Results show that CP, ash content, NDF and ADL were in the range of 10.3-23.5, 11.2-20.4, 42.6-49.4 and 8.7-13.8g/100g DM respectively. Moderate condensed tannin, oxalate, saponin and phytate were obtained in the foliages of the browse trees/shrub. Potential gas production from insoluble fraction, ***b***, was best in ratio 1:3 mixture of browse/shrub and panicum and ranged from 8.5 - 22.0 ml/g DM with lower rate of gas production. Organic matter digestibility, metabolizable energy, short chain fatty acid of the 1:3 mixture of browse tree foliages with panicum was the best compared to the 1:1 and 3:1 mixture. It is concluded that mixture of 1:3 or 25% browse tree foliages with 75% panicum would results in optimal performance of ruminants feeding on them.

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1. Introduction

In Nigeria and many other African countries where livestock sub-sector accounts for 25% of agriculture gross domestic products (GDP), livestock productivity is at its low ebb (Smith et al., 1986) because natural pastures are the primary feed sources for ruminant livestock. In addition, the production response of ruminants is constrained by inadequate forage supply accentuated by acute seasonal shortages and fluctuations' (Winrock, 1992). The magnitude of the feed supply problem from natural pastures in quality and quantity varies across ecozones as a function of season and rainfall. The nutrition from natural pastures is usually not sufficient to sustain satisfactory animal production and health even under optimal management and socking rate. This is because grasses grow rapidly during the raining season and become fibrous as it ages thereby lowering their digestibility. Consequently, productivity especially milk yield of cattle raised on these grasses rarely exceeds 3- 4kg per cow per day (Watshe, et al,. 1992).

Low quality feeds have low levels of digestibility and results in high emissions of methane per unit of forage intake; about 6% of gross energy is converted to methane in the rumen (Smith et al., 1996). Therefore increasing productivity of ruminant requires feeding high quality feeds in adequate amount. Forages legumes which are good sources of protein, vitamins and minerals are needed to supplement the poor quality grass and crop residues available for feeding animals especially during the dry season when there is acute scarcity of feedstuffs.

Multipurpose trees and shrubs could be used to improved low quality feeds or grasses used for feeding animals by incorporating in the diets as leaf meal or as fodder. The use of browse plants as supplement in the diets of livestock had proved satisfactory (Ademosun, 1994). The most commonly used ones for livestock feeding include *Gliricidia sepium* and *Leucaena leucocephala* (Sumberg, 1985); Ficus species (Bamikole et al, 2003). These browse trees and shrubs have protein, vitamins and also the mineral elements (Babayemi et al., 2004). Most browse trees and shrubs were evaluated as sole feed for ruminants and so the benefit of the browse fed may not be maximized. Efficient rumen fermentation is achieved when they are fed with grass (Ajayi and Babayemi, 2008).

The *in-vitro* gas production method has been used to evaluate the nutritive value of different classes of feed (Getachew et al., 1999, Krishnamoorthy et al., 1995). This technique is more efficient at determining feedstuffs containing tannin. The objective of this study was to determine the feeding potential of seven browse trees/shrubs mixed in different proportions with guinea grass *(Panicum maximum*), which is one of the most cherished grass by ruminants.

2. Materials and Method

2-1. Forage Tree sampling

The species of the indigenous browse plants evaluated in this study were *Kigelia africana, Moringa oleifera*, *Parkia biglobossa, Tamarin indica, Dalbergia sisso Newboulda laevis* and *Graffolia simplicifolia*. The leaves of each of these browse plants were harvested from six trees selected at random in three Agricultural research stations in Ibadan, Nigeria at the pick of the dry season. The harvested samples were pooled for each individual tree species. Similarly, *P. maximum* (panicum) was harvested at 6 wks regrowth, browse plants and panicum were oven dried at 105°C to constant weight. Samples were ground in 1.0mm sieve; sub-samples of each browse species and panicum were kept for analysis.

2-2. In-vitro gas production

Three West African Dwarf goats were fed concentrate (crude protein, 21 %; Metabolizable energy, 2600 Kcal/kg DM), *Gliricidia sepium* and panicum were fed *adlibitum* for 7 days prior to collection of their rumen liquor. The rumen liquor was collected from the goats by suction tube inserted into their rumen before feeding in the morning. The liquor was collected into a pre-warmed thermos flasks and filtered through three layers of cheese cloth, mixed and stirred with a buffered mineral solution (NaHCO3 + Na2HPO4 + KCl + NaCl +MgSO4.7H2O +CaCl2.2H2O (1.4, v/v) under continuous flushing with carbondioxide. Two hundred milligrams of ground samples of the mixture of browse plants and panicum were weighed into 100mL syringes with lubricated pistons. Thirty mLs of the mixed buffered solution and rumen liquor was added to the samples in the syringes, stirred gently, clipped and placed in the incubator at 39°C. The volume of gas produced was recorded at 3, 6,9,12,15,18,21 and 24 hour. At the end of 24 hour incubation, 4mLs of NaOH was added to the substrate in each syringe to determine the methane production. Rates and extent of gas production were determined for each substrate from linear equation $Y = a + b (1 – e^{-ct})$ described by Ørskov and McDonald (1979) where Y = volume of gas produced at time‘t’, a = intercept (gas produced from soluble fraction), b = Potential gas production (mL/g DM) from insoluble fraction, c = gas production rate constant (mL/h) for the insoluble fraction, t = incubation time. The metabolizable energy (ME) in MJ/Kg DM and organic matter digestibility (OMD %) were estimated from the volume of gas produced after 24 hr of incubation (GP, ml/200mg) and the proportion of crude protein as established by Menke and Steingass (1988):

$$OMD = 14.88 + 0.889GV + 0.45CP + 0.651 XA$$

$$ME = 2.20 + 0.136GV + 0.057CP + 0.0029CF$$

Where GV, CP, CF, and XA are net gas production (ml/200mg DM), crude protein, crude fibre and ash of the incubated samples respectively. Short chain fatty acids were calculated as described by Getachew et al. (1999).

2-3. ***Chemical Analysis***

Ground samples of browse plant species and panicum were analyzed for nitrogen by the Micro-kjeldahl method; crude protein was obtained by multiplying the nitrogen by 6.25. Dry matter, ether extract were determined according to AOAC (1990) methods.

Nitrogen free extract was obtained by calculation while neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were determined by method of Van Soest et al. (1991). Secondary metabolites were analyzed using these procedures; tannin (Makkar and Goodchild, 1996), phytate (Maga, 1982), oxalate (AOAC, 1995) and saponin (Okwu and Josiah, 2006).

2-4. ***Statistical Analysis***

Data obtained were analyzed by the analysis of variance (ANOVA) techniques using the General Linear Model procedures of SAS (2000) and significant differences between means were compared using Duncan (Duncan 1955) multiple range test with the aid of SAS/STAT program (SAS 2000).

3. Results and Discussion

Table 1 show that there are significant ($P < 0.05$) differences in the proximate composition of seven browse plant species foliages which could be used as feed resource for feeding ruminants. The dry matter content ranged from 80.5 in *M. oleifera* to 90.2 g/100g DM in *T. indica*. The highest crude protein content of 23.5g g/100g DM was observed in *M. oleifera*, followed by 21.6 g/100g DM for *T. indica.* The crude protein content of the browse plants are higher than the 8% required by ruminants for efficient microbial activity in the rumen (Norton, 1998). The ether extract values obtained for the browse plants were similar ($P >0.05$) except in *M. oleifera* which had the least value. Ash content varied from 11.2 g/100g DM in *K. africana* to 20.4 g/100g DM in *M. oleifera*. The ether extract and the ash contents obtained in this study correspond to values cited by Njidda (2010). *Newbouldia laevis* had the highest values of NDF (49.4g/100g DM) and ADL (13.8 g/100g DM) compared to other browse plants. The least values of NDF, ADF and ADL were observed in *M. oleifera.* Except, for *M. oleifera*, the NDF and ADL contents obtained in this study were higher than 43.6% and 9.3% reported (Rittner and Reed, 1992) for NDF and ADL respectively for browse trees in the humid zone of Nigeria. Browse trees are known to contain high lignin than herbaceous legumes which is a limiting factor in the digestion of legumes and is bound largely to the vascular tissue (Njidda, 2010).

The anti-nutritional factors of the browse plants evaluated differed ($P < 0.05$) significantly (Table 2). Tannin content of the browse plants ranged from 0.16 mg/g DM in *M. oleifera* to 0.31 mg/g DM in *T. indica*. Tannin has the capacity to bind protein, polysaccharide, nucleic acids, steroids, alkaloids and saponins. (Mueller-Harvey and McAllan, 1992). *Newbouldia laevis* had the highest contents of saponin (2.77 mg/g DM) followed by 2.64 mg/g DM obtained for *G. simplicifolia*. The concentrations of saponin and oxalate in *M. oleifera* were low. Oxalate contents found in the browse, though highest in *G. simplicifolia* (0.52 mg/g DM), were observed to be similar ($P > 0.05$). Dietary oxalate can be degraded in the rumen by microbes into carbondioxide and formic acid. Feedstuffs containing saponin had been shown to be a defaunating agents (Teferedegne, 2000) and capable of reducing methane production (Babayemi *et al.* 2004). Saponin in feedstuffs depresses growth rate of animal. It has been reported to alter cell wall permeability and therefore produce some toxic effect when ingested (Belmar *et al*., 1999). Similarly, except for *M. oleifera*, the browse plants were not significantly ($P > 0.05$) different in their values of phytate. Phytic acids complex certain mineral elements such as Ca, Mg, Fe and Zn and render them metabolically unavailable (Nelson et al, 1968)

The gas fermentation characteristics of mixtures of browse plants and panicum in ratio 1:3 differed ($P <0.05$) significantly among the treatments (Table 3). The volume of gas produced during fermentation ranged from 9.0 ml in mixture of *P. biglobossa* and panicum to 13 ml in *G. simplicifolia* and panicum mixture. Potential gas production from insoluble fraction, *b,* was highest in mixture of *D. sisso* and panicum. The rate of gas production, *c*, is not significantly ($P >0.05$) different among the treatments, though higher rate (0.02 ml/hr) was observed in mixtures of *K. africana* and panicum, *N. laevis* and panicum as well as *G. simplicifolia* and panicum. Lower volumes of gas were observed in this study for the browse tree than values reported (Ajayi and Babayemi, 2008), this could be as a result of the high ADL content obtained for the browse plants.

Table 4 reveals significant ($P <0.05$) differences in the characteristics of gas fermentation of mixtures of browse plants and panicum in ratio 1:1. The volume of gas produced was highest in mixture of *T. indica* and panicum (10.5 ml), the least value was obtained in the mixture of *N. laevis* and panicum (9.0 ml). Potential gas production from insoluble fraction, *b*, was observed to be highest (16.5ml/g DM) in *M. oleifera* and panicum mixture while the least value was obtained in *T. indica* and panicum mixture. Similarly, *M. oleifera* and panicum mixture was observed to have the highest rate (0.05 ml/hr) of gas production compared to other mixtures. The gas production characteristics values obtained in this mixed proportion were higher than production characteristics cited by Ajayi et al. (2011).

The gas fermentation characteristics of mixture of browse plants and panicum in ratio 3:1 differed ($P < 0.05$) significant among the treatments (Table 5). Among the mixtures, the highest and lowest gas productions were observed in mixture of *K. africana* and panicum (10.0 ml) and mixture of *D. Sisso* and panicum (8.0 ml) respectively. The gas produced from insoluble fraction, *b,* was least in mixture of *N. Laevis*/panicum (8.5ml) and was highest in *M. oleifera*/panicum mixture. The rate of gas production, *c,* ranged from 0.01 ml/hr in mixture of *T. indica* and panicum to 0.06 ml/hr in mixture of *M. oleifera* and panicum. In this mixed proportion, the gas production characteristics values are higher than values reported (Ajayi et al., 2011).

Fig. 1 shows the OMD percent of the browse plants and panicum and there were significant differences ($P < 0.05$) among the means. Mixture of 25% browse and 75% panicum had the highest digestibility and was followed by the digestibility of mixture of 50% browse plant and 50% panicum. In both mixtures, *M. oleifera*/panicum mixture had the highest OMD. The high digestibility was a reflection of the high volume of gas production observed, which agrees with reported values (Ajayi et al, 2011). The metabolizable energy (ME) of the mixtures of browse plants and panicum differed ($P <0.05$) significantly (Fig.2). The highest ME values were obtained in mixtures of 25% browse plants and 75% panicum; followed by ME values of mixtures of 50% browse plants and 50% panicum. In both of these combinations *M. oleifera*/panicum mixture had the highest ME values.

It was observed that in all the combinations, mixture of *P. biglobossa*/panicum and *N. Laevis*/panicum mixture had the lowest values of SCFA and differed ($P <0.05$) significantly (Fig 3). However, mixture of 25% browse plants and 75% panicum had the highest SCFA from which *M. oleifera*/panicum had the best SCFA (0.88μmol), followed by SCFA obtained for *T. indica* (0.62 μmol). Short chain fatty acid is a reflection of available energy in a feedstuff (Ajayi and Babayemi, 2008). This implies that the 25% browse and 75% panicum mixture would supply higher energy for the animal than other mixed proportions and the sole panicum. In all the varied proportions of browse plants and panicum, the highest methane production was observed in the 75% browse plant and 25% panicum (Fig 4) from which *T. indica*/panicum and *P.*

biglobossa/panicum mixtures had the highest methane production values which were 38.4mL and 36.0mL respectively. The higher the volume of methane observed in a feedstuff the poorer the feed quality. It implies energy loss and this is a reflection of inadequate grass in the mixed proportion. Methane production is energy loss and contributes to global warming (Babayemi and Bamikole, 2006). Sole panicum had moderate volume of methane. The least methane produced was obtained in mixture of 25% browse plant and 75% panicum from which the least value was obtained in *M. oleifera*/panicum (18.3 ml). This is because the energy source, the grass is adequate in the mixed proportion for efficient rumen function.

Table 1: Proximate composition (g/100g DM) of seven browse tree foliages for feeding ruminants

Browse species	Dry matter	Crude protein	Ether extract	Ash	NDF	ADF	ADL
K. africana	81.2^{c}	12.6^{c}	3.4^{b}	11.2^{d}	47.0^{b}	21.5^{b}	11.4^{b}
M. oleifera	80.5^{d}	23.5^{a}	5.3^{a}	20.4^{a}	42.6^{d}	18.3^{c}	8.7^{c}
P. biglobossa	86.4^{bc}	18.4^{c}	2.5^{b}	12.3^{cd}	44.3^{d}	22.8^{a}	12.5^{a}
T. indica	90.2^{a}	21.6^{b}	3.1^{b}	14.7^{c}	48.5^{a}	21.2^{b}	12.3^{a}
D. sisso	87.4^{b}	19.8^{c}	3.4^{b}	16.6^{b}	43.6^{d}	23.8^{a}	13.4^{a}
N. laevis	88.6^{b}	10.3^{c}	2.8^{b}	11.4^{c}	49.4^{a}	23.4^{a}	13.8^{a}
G. simplicifolia	84.3^{bc}	18.2^{c}	2.5^{b}	14.5^{c}	46.5^{c}	20.6^{b}	12.7^{a}
SEM	2.84	1.41	0.82	1.21	1.14	0.89	1.07

a, b, c= Means on the same column with similar superscript are not significantly different ($P > 0.05$).

Table 2: Anti-nutrient factors (mg/g) in seven browse tree foliages for feeding ruminants

Browse species	Condensed Tannin	Saponin	Oxalate	Phytate
K. Africana	0.20^{b}	2.14^{c}	0.40^{a}	0.88^{b}
M. oleifera	0.16^{c}	1.47^{d}	0.33^{b}	0.52^{c}
P. biglobossa	0.27^{a}	2.41^{b}	0.41^{a}	0.94^{ab}
T. indica	0.31^{a}	2.40^{b}	0.47^{a}	0.87^{b}
D. sisso	0.28^{a}	2.38^{b}	0.41^{a}	1.12^{a}
N. laevis	0.23^{a}	2.77^{a}	0.48^{a}	0.98^{a}
G. simplicifolia	0.20^{a}	2.64^{a}	0.52^{a}	1.10^{a}
SEM	0.03	0.17	0.07	0.04

a, b, c= Means on the same column with similar superscript are not significantly different ($P > 0.05$).

Table 3: Gas fermentation characteristics of mixtures of browse tree and *P. maximum* in ratio 1:3

Browse Mixtures	Y (ml)	b (ml)	c (h^{-1})
K. africana + P. maximum	9.5^{b}	19.5^{b}	0.02
M. oleifera + P. maximum	10.0^{c}	11.0^{c}	0.01
P. biglobossa + P. maximum	9.0^{b}	8.5^{d}	0.01
T. indica + P. maximum	10.0^{b}	20.5^{a}	0.01
D. sisso + P. maximum	11.5^{ab}	22.0^{a}	0.01
N. laevis + P. maximum	12.0^{a}	9.0^{d}	0.02
G. simplicifolia + P. maximum	13.0^{a}	20.0^{b}	0.02
P. maximum	8.3^{c}	6.3^{e}	0.01
SEM	1.35	1.87	0.005

a, b, c= Means on the same column with similar superscript are not significantly different ($P > 0.05$).
Y = Volume of gas produced at time 't', a = intercept (gas produced from soluble fraction), b = potential gas production (ml/200mg DM) from the insoluble fraction, c = gas production rate constant (h^{-1}) for the insoluble fraction, t = time of incubation.

Table 4: Gas fermentation characteristics of mixtures of browse tree and *P. maximum* in ratio 1:1

Browse Mixtures	Y (ml)	b (ml)	c (h^{-1})
K. africana + P. maximum	9.5^{a}	14.5^{b}	0.03^{ab}
M. oleifera + P. maximum	10.0^{a}	16.5^{a}	0.05^{a}
P. biglobossa + P. maximum	10.5^{a}	8.0^{cd}	0.04^{a}

T. indica + P. maximum	10.5^{a}	7.0^{d}	0.04^{a}
D. sisso + P. maximum	10.0^{a}	9.0^{c}	0.03^{ab}
N. laevis + P. maximum	9.0^{b}	10.0^{c}	0.03^{ab}
G. simplicifolia + P. maximum	9.0^{b}	10.0^{c}	0.04^{a}
P. maximum	7.8^{c}	5.5^{e}	0.02^{b}
SEM	0.55	1.8	0.01

a, b, c= Means on the same column with similar superscript are not significantly different ($P > 0.05$).
Y = Volume of gas produced at time 't', a = intercept (gas produced from soluble fraction), b = potential gas production (ml/200mg DM) from the insoluble fraction, c = gas production rate constant (h^{-1}) for the insoluble fraction, t = time of incubation.

Table 5: Gas fermentation characteristics of mixtures of browse tree and *P. maximum* in ratio 3:1

Browse Mixtures	Y (ml)	b (ml)	c (h^{-1})
K. africana + P. maximum	10.0^{a}	13.5^{a}	0.05^{a}
M. oleifera + P. maximum	12.0^{b}	17.0^{a}	0.06^{a}
P. biglobossa + P. maximum	9.5^{c}	9.5^{b}	0.01^{c}
T. indica + P. maximum	11.0^{c}	12.0^{a}	0.01^{c}
D. sisso + P. maximum	9.5^{c}	11.5^{a}	0.01^{c}
N. laevis + P. maximum	8.0^{a}	8.5^{c}	0.03^{b}
G. simplicifolia + P. maximum	10.0^{b}	10.5^{bc}	0.02^{b}
P. maximum	8.7^{c}	10.5^{c}	0.01^{c}
SEM	1.06	1.10	0.01

a, b, c= Means on the same column with similar superscript are not significantly different ($P > 0.05$).
Y = Volume of gas produced at time 't', a = intercept (gas produced from soluble fraction), b = potential gas production (ml/200mg DM) from the insoluble fraction, c = gas production rate constant (h^{-1}) for the insoluble fraction, t = time of incubation.

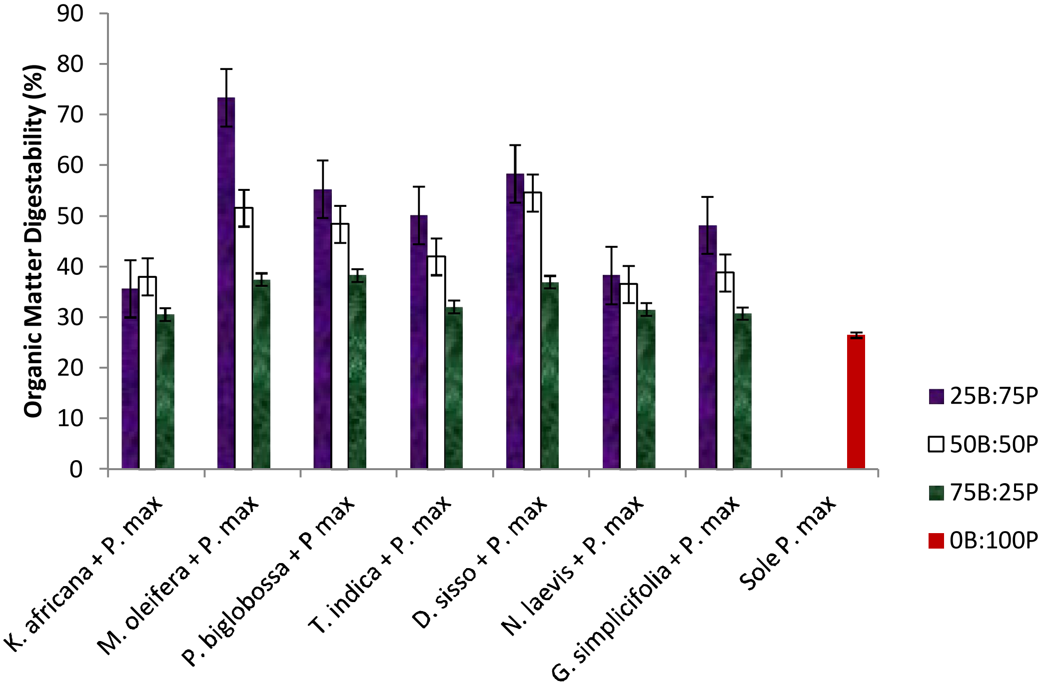

Fig. 1. Organic Matter Digestibility of mixture browse plants and *P. maximum*

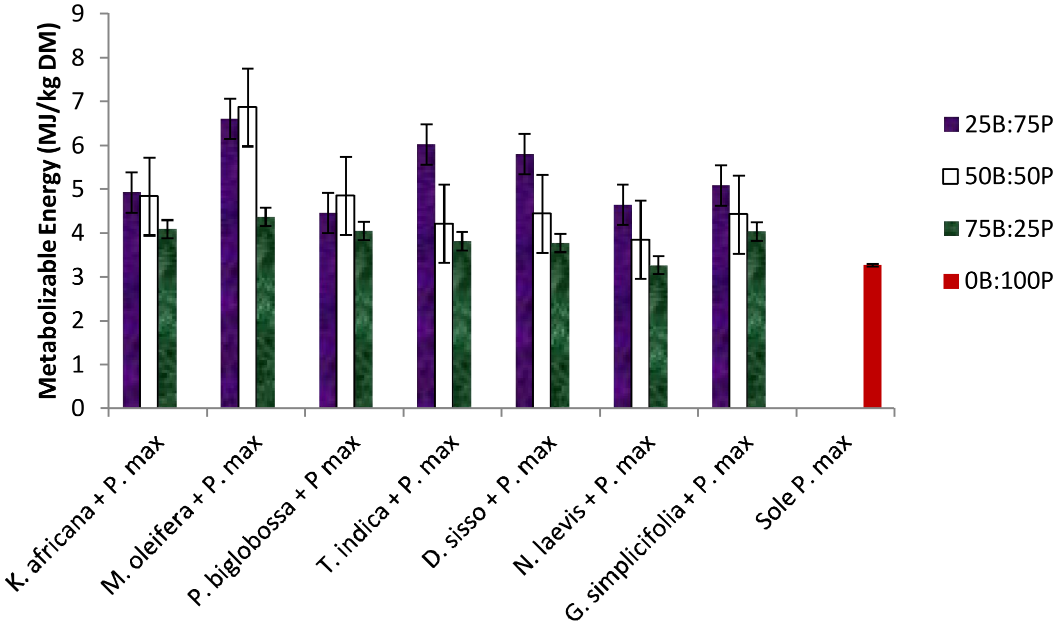

Fig. 2. Metabolizable Energy of mixture of browse plants and *P. maximum*

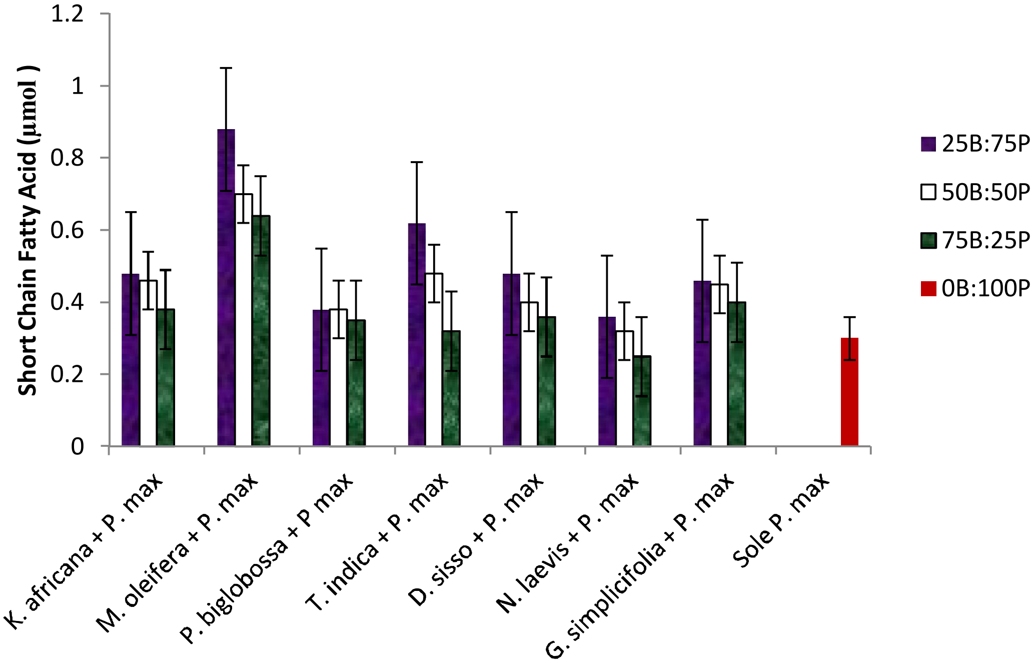

Fig. 3. Short Chain Fatty acid of mixture of browse plants and *P. maximum*

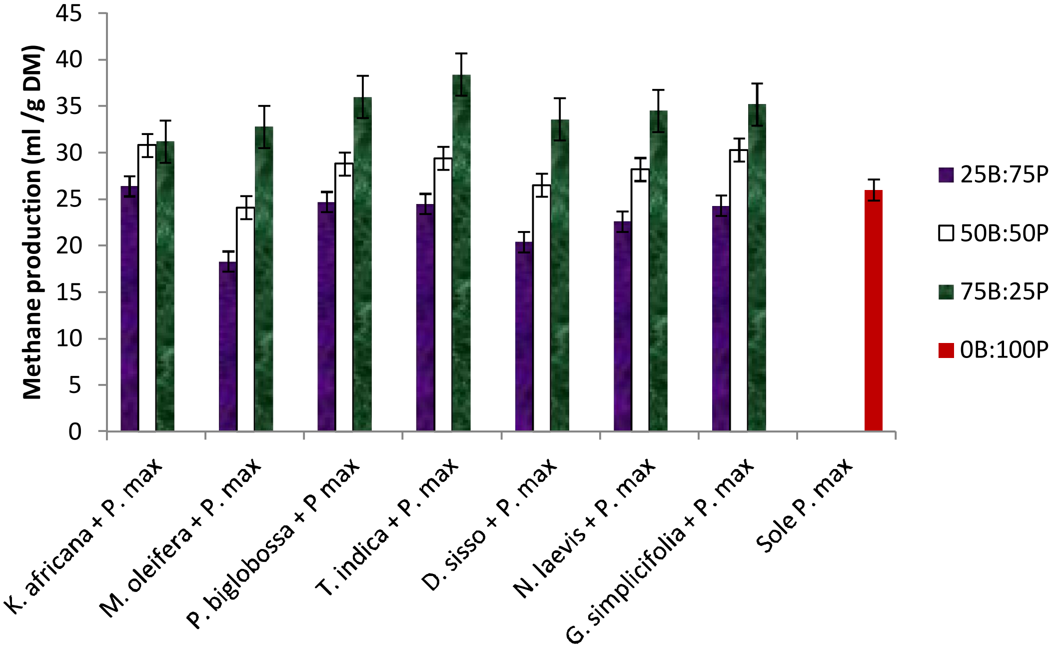

Fig. 4. Methane production of mixture of browse plants and *P. maximum*

Conclusion

This study revealed that optimal performance of ruminant livestock can be achieved when the right proportion of foliages of nutritive browse trees/shrub are fed in combination with grass. Feeding grass solely to these animals would not bring desirable output from them. The best feeding proportion is the 25% browse tree foliages with 75% panicum because it resulted to the best organic matter digestibility, metabolizable energy, short chain fatty acid or volatile fatty acid and lowest methane production. The low methane production from this combination would improve the environment and prevent global warming.

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