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Effect of different processing methods on chemical composition and *in vitro* gas production of some browse plants for ruminant feeding

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Target Audience: Livestock farmers, Ruminant Nutritionists

Abstract

Chemical composition and in vitro gas production parameters of four differently processed browse plants (Gmelina arborea, Leucaena leucocephala, Mangifera indica and Moringa oleifera) was investigated. The leaves of each plant were subjected to three processing methods; sun-drying, air-drying and fermentation. Chemical composition and in vitro gas production analyses were carried out. Results showed that processing methods had significant effect (p < 0.05) on all the parameters considered under chemical composition. Air dried and sun dried browse plants had higher (p < 0.05) dry matter content (89.68 and 89.75% respectively). Highest crude protein was recorded in air-dried browse plants (26.20%). Moringa oleifera recorded higher (p < 0.05) crude protein, ether extract and ash contents (35.60%, 14.17% and 13.50% respectively). Fermented browse plants had the lowest amount of tannin and saponin. Air-dried browse plants had higher gas production throughout the incubation period. Among the browse plants, the highest gas production (p < 0.05) was obtained in Moringa oleifera. Air and sun-dried browse plants recorded higher values for OMD (51.39%; 44.80%) and SCFA (0.46mmol; 0.35mmol). Air drying was the best method for maintaining nutrient content of forages while fermentation was the best for reducing anti-nutritional factors.

Keywords*:* Processing methods, chemical composition, in vitro gas production, browse plants

Description of Problem

In Nigeria ruminants are important sources of animal protein where they contribute to the cultural and socio-economic life of people (1). However their productivity is affected by seasonality in the availability of grass which forms the bulk of their feed. According to (2) their productivity is limited by non-availability of good pasture as well as by the low quantity, quality and regularity of supplements provided. Changes in weather conditions have been reported to affect the nutrient quality of forages consumed by ruminant livestock, especially during the up to, six months of dry season in some parts of the country with the crude protein of grasses falling below 6% (3). Attempts have been made by animal nutritionists to supplement dry season grazing with browse plants and agro-industrial by-products (4).

A number of browse plants worldwide serve as alternative feedstuffs for livestock (5; 6; 7). This is due to their abundant biomass and availability all year round. Browse plants are considered palatable, highly digestible and as a result improved animal performance (8). However, most of these forages contain anti-nutritional substances which might affect their digestibility and availability of nutrients. (9) had reported that tropical browses contained varying quantities of condensed tannin and other anti-nutritional substances which affect their utilization by animals. Processing methods such as sun-drying, shade drying and others are means by which these anti-nutritional factors in forages can be lowered or eliminated (10; 11)

Browse plants can be fed to ruminants fresh or processed into different forms such as hay or silage. The utilisation of browse is however limited by the high lignin content and the presence of anti nutritional factors, which may be toxic to ruminants. It is therefore necessary to process them before feeding them to animals. This study therefore assessed the chemical composition and *in vitro* gas production parameters of differently processed browse plants for ruminant feeding.

Materials and methods

Location, sample collection and preparation

The study was carried out at the Laboratory of Animal Nutrition Department, Federal University of Agriculture, Abeokuta, Ogun State. It lies within latitude 7°10'N longitude 3° 2'E and altitude 76m. It is located in climate with the derived savannah zone of South-Western Nigeria. It has a humid climate with mean annual rainfall of 1073mm and temperature of about 34.7°C (12).

Four (4) different browse plants were used for the experiment namely: *Gmelina arborea, Leucaena leucocephala*, *Mangifera indica* and *Moringa oleifera.* The browse plants were sourced for within the University premises. About 10kg leaves of each browse plant was harvested and subjected to three different processing methods. The methods were sun-drying (the leaves were spread under direct sunlight for 72 hours), air-drying (the leaves were spread under a shed to avoid direct sunlight and were allowed to air-dry for 72 hours) and fermentation (the leaves were allowed to undergo natural fermentation by wetting with little water inside a black polythene under anaerobic condition for 72hours and was later spread under direct sunlight for another 72 hours).

Chemical analyses and in vitro gas production studies

The differently processed browse plants wereoven-dried at 60°C until constant weight was achieved for dry matter determination. The oven-dried samples were later milled and made to pass through 1mm screen after which they were analysed for crude protein, crude fibre, and ether extract and ash contents according to (13). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were also determined (14).

The *in vitro* gas production of each browse plant was determined following the procedure of (15). Rumen fluid (which was kept under a continuous flow of carbondioxide) was collected from six West African dwarf goats (fed 40% concentrate feed and 60% *Panicum maximum* grass) with the use of suction tube as described by (16). It was collected in the morning before feeding, pooled and strained through four layers of cheese cloth. Glass syringes (100mL) were used where 200mg of milled samples was introduced and thereafter the syringes filled with 30 mL of medium (consisting of buffer solution and rumen fluid in the ratio 2:1). Each sample was measured in triplicates and the syringes were tightly capped and carefully arranged in an incubator maintained at 39±1 ºC along with three blank syringes containing 30 mL of medium (inoculums and buffer) only as control. Gas production was monitored and recorded between 3 to 48 hours incubation process. Post incubation parameters such as organic matter digestibility, short chain fatty acid, metabolisable energy were calculated.

Statistical Analysis

Data collected were subjected to one way analysis of variance in 3x4 factorial arrangement. Significant means were separated using Duncan's Multiple Range Test (17).

Table 1: Effect of processing methods on the chemical composition (%) of different browse plants

Processing methods	Browse plants	DM	CP	EE	ASH	NDF	ADF	ADL	Tannin	Saponin
Air drying	*G. arborea*	89.40^{ab}	21.36^{h}	8.50^{h}	14.00^{b}	52.00^{e}	48.00^{c}	15.00^{b}	0.005^{g}	1.73^{j}
	L. leucocephala	88.70^{b}	32.56^{b}	8.00^{i}	12.00^{e}	47.00^{i}	39.00^{h}	15.00^{b}	0.015^{a}	6.67^{a}
	M. indica	90.80^{ab}	23.82^{f}	6.00^{k}	6.50^{l}	51.00^{f}	46.00^{d}	9.00^{e}	0.011^{c}	3.77^{c}
	M. oleifera	89.80^{ab}	36.22^{a}	12.50^{d}	10.00^{i}	45.00^{j}	38.00^{i}	5.00^{h}	0.007^{f}	3.14^{d}
Sun drying	*G. arborea*	88.70^{b}	20.32^{i}	10.00^{g}	11.00^{g}	56.00^{d}	41.00^{f}	17.00^{a}	0.008^{e}	2.12^{g}
	L. leucocephala	89.20^{b}	22.10^{g}	11.50^{e}	13.47^{c}	57.00^{c}	34.00^{j}	10.00^{d}	0.007^{f}	4.18^{b}
	M. indica	89.90^{ab}	22.12^{g}	10.00^{g}	7.50^{k}	53.00^{e}	49.00^{b}	7.00^{f}	0.011^{c}	2.92^{f}
	M. oleifera	86.70^{c}	29.42^{d}	16.00^{a}	20.00^{a}	53.00^{e}	46.00^{d}	2.00^{i}	0.0114^{b}	3.08^{e}
Fermenting	*G. arborea*	91.50^{a}	18.92^{j}	7.00^{j}	8.50^{j}	49.00^{h}	45.00^{e}	11.00^{c}	0.004^{h}	1.51^{j}
	L. leucocephala	90.00^{ab}	27.32^{e}	11.00^{f}	11.50^{f}	61.00^{b}	51.00^{a}	9.00^{e}	0.009^{e}	1.98^{h}
	M. indica	91.00^{a}	14.00^{k}	13.50^{c}	12.50^{d}	50.00^{g}	40.00^{g}	5.00^{h}	0.009^{d}	2.09^{g}
	M. oleifera	85.70^{c}	30.16^{c}	14.00^{b}	10.50^{h}	64.00^{a}	48.00^{c}	6.00^{g}	0.006^{f}	0.92^{k}
SEM		0.32	25.78	0.49	0.57	0.90	0.85	0.75	0.0004	0.25

Means along the same column with different superscripts are significantly different ($p<0.05$)

Results

The chemical composition of browse plants with different processing methods is presented in Table 1. Processing methods had significant effect ($p < 0.05$) on all the parameters considered. Dry matter content was significantly different ($p < 0.05$) and higher in air-dried and sun dried browse plants (89.68 and 89.75% respectively). Air-dried browse plants had the highest ($p < 0.05$) crude protein value while sun-dried browse plants had the least. Ether extract and ash contents were higher in sun-dried browse plants compared to air-dried and fermented browse plants. Air-dried browse plants contained more ($p < 0.05$) NDF, ADF and ADL contents than other processing methods. Tannin and saponin values were highest in air-dried browse plants and lowest in fermented samples.

There was no significant difference ($p > 0.05$) in the dry matter content of the different browse plants considered. *Moringaoleifera* recorded higher ($p < 0.05$) crude protein, ether extract and ash contents (36.22%, 14.17% and 13.50% respectively) followed by *Leucaena leucocephala*. Neutral detergent and Acid detergent fibre were higher in *L. leucocephala* and *M. indica* respectively. *Gmelina arborea* contained more ADL and NFE compared to others. *Gmelina arborea* had the least content of tannin. Saponin value was highest in *L. Leucocephala* and lowest in *Gmelina arborea.*

Table 2: Post incubation parameters of differently processed browse plants

Processing methods	Browse plants	OMD	ME	SCFA	IVDMD	Methane
Air drying	*G. arborea*	46.19^{b}	7.75^{bcd}	0.35^{b}	43.33^{abcd}	24.60^{ab}
	L. leucocephala	54.52^{ab}	8.27^{bcd}	0.51^{ab}	54.33^{a}	30.80^{ab}
	M. indica	33.07^{b}	5.92^{d}	0.18^{b}	36.67^{cd}	15.27^{ab}
	M. oleifera	71.78^{a}	11.58^{a}	0.80^{a}	50.00^{abc}	35.67^{a}
Sun drying	*G. arborea*	45.00^{b}	7.57^{bcd}	0.32^{b}	41.67^{abcd}	22.53^{ab}
	L. leucocephala	45.00^{b}	7.67^{bcd}	0.34^{b}	51.67^{ab}	23.29^{ab}
	M. indica	35.75^{b}	6.47^{cd}	0.23^{b}	38.33^{bcd}	12.00^{b}
	M. oleifera	53.62^{ab}	9.22^{abc}	0.50^{ab}	45.00^{abcd}	26.43^{ab}
Fermenting	*G. arborea*	34.87^{b}	6.72^{cd}	0.18^{b}	36.67^{cd}	16.50^{ab}
	L. leucocephala	36.06^{b}	6.94^{cd}	0.21^{b}	42.00^{abcd}	17.27^{ab}
	M. indica	31.28^{b}	5.60^{d}	0.16^{b}	36.00^{d}	13.22^{ab}
	M. oleifera	48.89^{ab}	9.91^{ab}	0.39^{b}	51.67^{ab}	30.33^{ab}
SEM		2.63	0.35	0.04	1.45	2.01

Means along the same column with different superscripts are significantly different ($p<0.05$)
OMD-Organic matter digestibility (%), ME- Metabolizable energy (MJ/Kg DM), SCFA- Short chain fatty acids (mmol/Kg), IVDMD- *In vitro* dry matter digestibility (%), Methane (mL/ 200mg DM)

The post incubation parameters of different browse plants as affected by processing methods are shown in Table 2. Organic matter digestibility and short chain fatty acids were significantly affected ($p < 0.05$) by the processing methods used. Air and sun-dried browse plants had the higher values for OMD and SCFAs while fermented browse plants had the least values.

Moringa oleifera had ($p < 0.05$) higher OMD, ME and SCFA compared to other browse plants. Higher IVDD was observed in *Moringa oleifera* and *L. leucocephala* plants. *Mangifera indica* recorded the least value ($p < 0.05$) for methane production.

Figure 1 shows the volume of gas produced by different browse plants as affected by processing methods used. Air-dried browse plants had higher gas production throughout the incubation periods followed by sun-dried browse plants while fermented browse plants had the least gas production.

Moringa oleifera had the best gas production compared to other browse plants as shown in figure 2. *Gmelinaarborea* and *Leucaena leucocephala* produced similar gas volume while *Mangifera indica* had the least.

Discussion

Higher dry matter content observed in air-dried and sun-dried browse plants could be as a result low moisture content of the samples compared to fermented plants. Lower dry matter content of fermented browse plants could be partly due to addition of water during ensiling or loss of soluble carbohydrate during fermentation as reported by (18). The dry matter obtained for air dried (89.68%) and sun-dried (89.75%) browse plant in this study was lower than those reported by (19) and (20) for air-dried and sun-dried *Clotalaria retusa* and air-dried *Gmelina arborea* leaves respectively. Crude protein content was higher in air-dried browse plants followed by fermented plants and lowest in sun-dried plants. The low crude protein value recorded for sun-dried browse plants could be attributed to the influence of the sun on the protein which perhaps might have been denatured. However, the range of crude protein obtained for all processing methods (14.00-36.22%) used in this study was far above 8% crude protein required to satisfy the maintenance of ruminants (21). Lower ash content of fermented browse plants compared to others might be due to the loss of minerals in effluent (22). However, range of ash content obtained was higher than those reported in the previous findings (19; 20). Partial degradation of cell walls by silage microorganisms as well as hydrolysis of hemicelluloses and cellulose by organic acids during ensiling could have been the cause of lower NDF content in fermented browse plants (22) compared to air-dried and sun-dried browse plants. Fermented browse plants had the least content of saponin and tannin and this might be due to degradation of the anti-nutritional factors by microbes.

The dry matter content of all the browse plants considered in this study was in the range reported in the previous studies (23; 24; 19). The crude protein was highest in air dried *Moringa oleifera* plant (36.22%). The observed value was higher than the reported values of 20.50% by (25) and 22.23% by (26) but comparable to 25% to 32% reported by (27). *Gmelina arborea*, *Leucaena leucocephala* and *Magnifera indica* contained approximately 20% and above crude protein. This agrees with the findings of (28) that the leaves of multipurpose trees contained more than 20% crude protein. The range of crude protein observed was also above the minimum level required by rumen microorganisms to provide sufficient nitrogen for optimum activity (23). It has been shown that with low crude protein (less than 10%), intake of forages is limited (29). This implies that the browse plants considered in this current study can improve intake when fed alone or as supplement to low protein diets such as crop residues.

The ash content of all the browse plants was considered high when compared with values obtained elsewhere (27; 26). This indicates that the plants contained substantial amount of inorganic elements which are critical in the formation and function of blood and bones (30). The high ether extract content of *Leucaena leucocephala* and *Moringa oleifera* is comparable with the range of values (12.29-16.41%) reported for Moringa, Leucaena and Gliricidia leaf meal by (27). The NDF, ADF and ADL contents reported for the browse plants in this study was similar to those in previous studies (26; 24). The tannin and saponin contents of the browse plants were generally low (1.79 - 4.28%) compared to 60-

100g/kg DM that could depress feed intake and growth in ruminants (31)

In-vitro gas production was highest in air dried browse plant and lowest in fermented plants. The difference in the gas production may be attributed to the different processing methods which might have affected their chemical composition and hence their digestibility. Nutrient composition of feedstuffs is known to influence *in-vitro* gas production and related parameters (32). Lowest gas production observed in fermented browse plants was contrary to the report of (33) that cell wall component has negative correlation with gas production. According to (34), gas production is related positively to microbial synthesis, this might also be the reason for increased gas production obtained in air dried browse plant as it contained the highest crude protein content which is critical to microbial synthesis.

Moringa oleifera produced the highest gas throughout the incubation period; this is in line with the report of (35) which could be as a result of higher crude protein content of *Moringaoleifera*. However, the result contradicts the observation made by (33) that fibre components negatively affect gas production. Observed differences in the gas production parameters in this study could be partly due to variation in the chemical composition of the different browse plants and processing methods used. Organic matter digestibility and short chain fatty acids were highest in air dried browse plants. This might be attributed to the higher crude protein content which also reflected in the gas production. It supported the claim of (32) that chemical composition of feed materials affected their *in vitro* gas production parameters

Conclusions and application

(1) Method of processing plant materials prior to feeding is a critical factor to be considered in livestock nutrition as it affects chemical composition and digestibility. This may have significant effect on the overall performance of the animals.

(2) Air dried browse plants had highest crude protein content while sun drying and fermentation reduced the crude protein of the plants.(3) Fermentation and sun drying methods however reduced the tannin and saponin content of the browse plants.(4) *In vitro* gas production was also highest in air-dried browse plants.(5) Hence, to preserve the crude protein of browse plants, air drying should be employed but to solve the problem of anti-nutritional factors especially saponin and tannin in browse plants for ruminants, fermentation or sun drying method can be used.

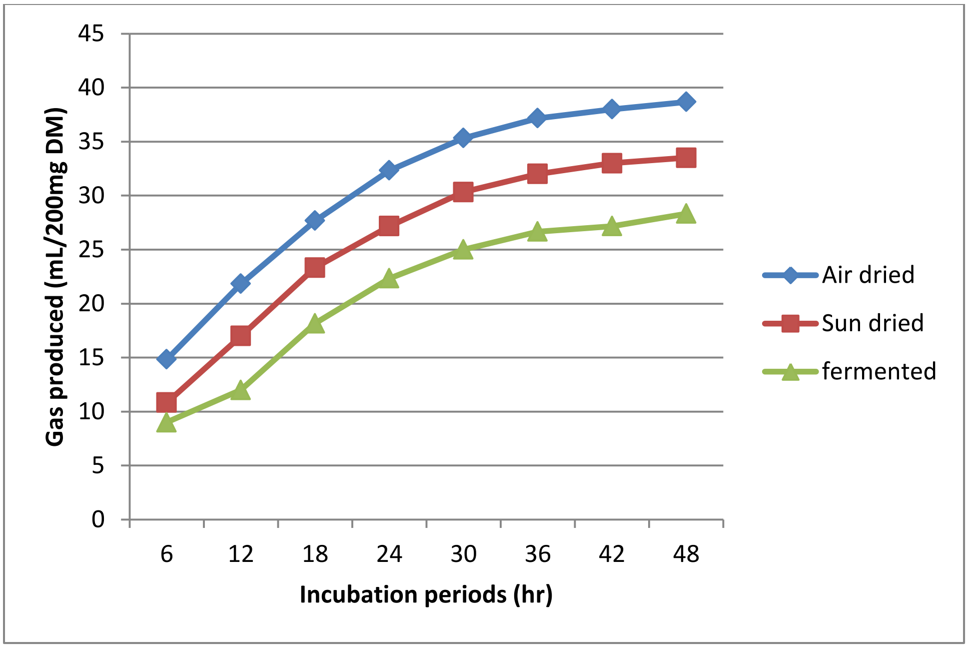

Figure I: Gas production of different browse plants as affected by processing methods

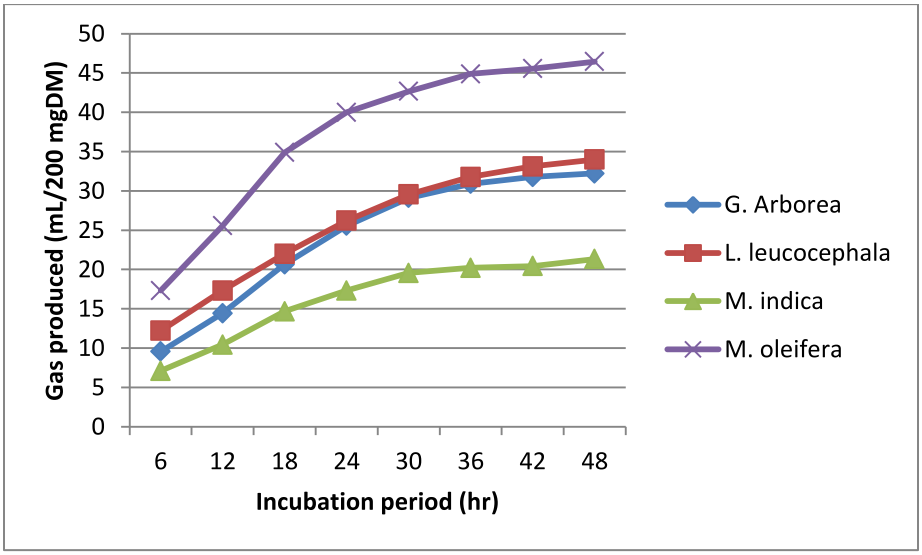

Figure 2: Gas production of different browse plants

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