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Nutritive Value Assessment of Four Crop Residues by Proximate Composition and *In Vitro* Rumen Fermentation Techniques

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Abstract

This study estimated the proximate composition and in vitro gas production parameters of rice husk, bean waste, citrus pulp and maize stover, in a rumen incubation system. The incubation was for 24 h with measurement of gas production volume over incubation periods of 3, 6, 9, 12, 15, 18, 21 and 24 hours. The crude protein ranged 1.92 to 11.75% and the crude fibre ranged between 9.68 and 45.09%. The potential gas production (a+b) was rated highest in both citrus pulp and maize stover (48.33 ml), next was bean waste (42.00 ml) and lowest was rice husk (25 ml). The ranges of values of metabolizable energy (ME), organic matter digestibility (OMD) and short chain fatty acids(SCFA) were 6.33 to 9.24 MJ/kg DM, 52.70 to 64.69 % and 0.94 to 1.09 µmol respectively. The values of ME, OMD and SCFA ranked as, citrus pulp > maize stover> bean waste > rice husk. The higher values obtained for the potential gas production (a+b), ME, OMD and SCFA in citrus pulp and maize stover could imply higher nutrient availability for the rumen micro-organisms. The results revealed that citrus pulp and maize stover could be of higher nutritional value in ruminants feed than bean waste, while rice husk was lowest.

Keywords: *Crop residues, in vitro incubation, West African Dwarf goats*

Introduction

The livestock industry in Nigeria has contributed substantially to the national wealth and well-being of the populace. There is regular supply of different kinds of animal protein sources. The keeping of sheep and goats in rural communities is an age long practice in Nigeria. The West African Dwarf (WAD) goats are very common in the South-Western Nigeria. They can subsist on household leftovers, are resistant to trypanosomosis, and are known to have high productivity as they usually give birth to twin kids (Belewu, 2006).

However, there is usually inadequate supply of forage for ruminants in Nigeria, particularly during the dry seasons, when most pasture deteriorate rapidly and are converted to standing hays. This coupled with high cost of conventional feed supplements have led to the search for non-conventional feed ingredients which are not normally used in commercially produced rations for livestock. Agricultural farms and industries generate large quantities of crop residues which though fibrous, could be digested by ruminants with the aid of micro-organisms that are present in their rumen. There has been previous research on the use of crop residues (Akinfemi *et al*., 2009)

in the feeding of livestock in Nigeria. These crop residues could be used as supplements to forages in ruminants feeding. The *in vitro* gas production method provides a quick assessment of nutritional value (Babayemi and Bamikole, 2006; Tona *et al*., 2013).

This research is therefore designed to investigate the potential nutritive values of rice husk, bean waste, citrus pulp and maize stover based on their proximate composition and *in vitro* fermentation characteristics.

Materials and methods

Experimental site, sample collection and processing

The experiment was carried out at the Small Ruminant Unit and Laboratory, LadokeAkintola University of Technology (LAUTECH), Teaching and Research Farm, Ogbomoso, Nigeria between January and April, 2014. The *in vitro* gas production experiment was carried out at the Animal Science Laboratory, University of Ibadan, Ibadan, Oyo State, Nigeria. Fresh samples of rice husk, bean waste, citrus pulp and maize stover were collected from Adeseun farms in Ogbomoso, Nigeria and sun-dried.

Sample preparation, chemical analysis and experimental design

Samples of rice husk, bean waste, citrus pulp and maize stover were weighed and oven dried at 65^{o}C for 48 hours to a constant weight for proximate analysis. Dry matter was determined by oven drying samples at 105^{o}C for 24 hours to a constant weight. Ash content was determined by igniting the samples in a muffle furnace at 600^{o}C for 8 hours. Nitrogen, crude fibre and ether extract were determined according to the methods of AOAC (2005). Crude protein was calculated (N x 6.25) and NFE was also calculated (100 – (% CP + % CF + % EE + % Ash + % moisture). There were four dietary treatments with three replicates per treatment in a completely randomized design.

In vitro gas production experiment

Rumen fluid was obtained with suction tube from three female WAD goats that were previously fed (two days prior) with rice husk, bean waste, citrus pulp and maize stover at 5% of their body weights. The dietary treatment samples previously oven dried at 65^{o}C for 24 hours to a constant weight, milled, well labelled and stored were used. Two hundred (200) mg of diet samples labelled (D1- D4) were placed in triplicates in 120 ml calibrated syringes, 30 ml inoculums containing (cheese-cloth) strained rumen liquor and buffer solutions (1:4 v/v) under constant flushing with CO_2 were incubated. Ingredients of the buffer solution are shown in Table 1. Incubation was carried out at 3, 6, 9, 12, 15, 18, 21 and 24 h at 39^{o}C. At post incubation period, the gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24 h. Thereafter, 4 ml of NaOH (10 M) was introduced to estimate the amount of methane produced as reported by Fievez*et al*. (2005). Average volumes of gas produced from the blanks were deducted from the volume of gas produced per sample. (The blanks contained only the inoculums and buffer). The volume of gas production characteristics were estimated using the equation $Y = a + b (1 – e^{-ct})$ (as described by Orskov and McDonald (1979). Where: Y = volume of gas produced at time 't'; a = intercept (gas produced from the soluble fraction); b = potential gas production (ml/ g DM) from the insoluble fraction; c = gas production rate constant (h^{-1}) for the insoluble fraction (b); t = incubation time. Metabolizable energy (ME, MJ/Kg DM) was calculated as ME = 2.20 + 0.136 GV + 0.057 CP + 0.0029 CF (Menke and Steingass, 1988). Organic matter digestibility (OMD%) was estimated as OMD = 14.88 + 0.889 GV + 0.45 CP + 0.651 XA (Menke and Steingass, 1988). Short chain fatty acids (SCFA) as SCFA = 0.0239 GV – 0.0601 (Getachew*et al*., 1999). Where GV, CP, CF and XA are total gas volume, crude protein, crude fibre and ash respectively of the incubated samples.

Table 1: Ingredients of the buffer solution (g/liter)

$NaHCO_3$	Na_2HPO_4	KCl	NaCl	$MgSO_4.7H_2O$	$CaCl_2.2H_2O$
9.8	2.77	0.57	0.47	2.16	0.16

Source: *Menke and Steingass (1988)*

Statistical analysis

Data from the experiment were subjected to one way analysis of variance (ANOVA) procedure of SAS (2000). Significant means were ranked using the Duncan's multiple range test of the same package. Mean differences were considered significant at $P<0.05$.

Results and discussion

Proximate composition of crop residues

The proximate composition of the treatment diets, rice husk, bean waste, citrus pulp and maize stover is shown in Table 2. The results showed that there were variations in the values of the CP, CF and Ash. Crude protein contents for rice husk (1.92%) and for maize stover (4.71%) were below the minimum levels of 7.7 % CP for maintenance for goats (NRC, 1981); and 8% CP required to provide the minimum ammonia levels required by rumen micro-organisms for optimum rumen activity (Norton, 2003). However, the CP contents of bean waste (7.71%) and citrus pulp (11.75%) were within the above mentioned required limits. In this study the range of values obtained for ether extract (2.12 – 4.23 %) are lower than 10.00% EE content of rice husk observed in the study by Aderolu*et al.* (2007). Babayemi and Bamikole (2006) stated that low ether extract content of the diet could imply that the incubated diets were low in energy and thus need to be supplemented with other energy sources such as grasses, legumes or concentrates, when animals are reared under zero grazing.

***In vitro* gas production characteristics, metabolizable energy, organic matter digestibility and short chain fatty acidofrice husk, bean waste, citrus pulp and maize stover**

The *in vitro* gas production characteristics, metabolizable energy, organic matter digestibility and short chain fatty acidofrice husk, bean waste, citrus pulp and maize stover are presented in Tables 3 and Table 4. Figure 1 shows the *in vitro* incubation gas production pattern and Fig. 2 represent the methane production of the experimental diets. There were significant ($P<0.05$) variations among the *in vitro* gas production values of the experimental diets. The potential gas production (a + b) was highest (48.33 ml) for both citrus pulp and maize stover, this is followed by the value for bean waste (42.00 ml), while the lowest potential gas production of 25.00 mls was recorded for rice husk. The total volumes of gas produced from the experimental diets during incubation (Y values) was highest ($P<0.05$) for maize stover. The range of the volume of gas produced (Y) of 16.00 – 22.67 ml/200 mg DM observed in this study is comparable to 6.52 – 22.88 ml/200 mg DM reported for *Panicum maximum* and legume forage mixtures (Ajayi and Babayemi, 2008).The ME, OMD and SCFA values observed in this study were higher ($P<0.05$) for maize stover, citrus pulp and bean waste but lowest for rice husk. The following range of values were recorded in this study: 6.33 to 9.24 MJ/kg DM (ME), 52.70 to 64.69% (OMD) and 0.54 to 1.09 µmol (SCFA). These values were lower than 7.25 to 10.10 (ME, MJ/kg DM); 51.87 to80.19 (OMD %) and 0.74 to 1.22 (SCFA, µmol) recorded for some forages (Yusuf *et al*., 2013). The presence of the short chain fatty acids or volatile fatty acids (VFA) such as acetate and butyrate suggest a potential to make energy available to ruminants (Yusuf

et al., 2013). Methane production was highest (P<0.05) for citrus pulp and lowest for rice husk (see Fig. 2). Previous researchers (Babayemi and Bamikole, 2006; Silivong *et al*., 2013) reported that high methane production connote a significant energy loss to the ruminant and this could contribute negatively to global warming.

Table 2: Proximate composition ofcrop residues

Composition (%)	DM	CP	CF	EE	Ash	NFE
Rice husk	90.52	1.92	45.09	2.24	14.44	26.93
Bean waste	95.55	7.71	9.68	2.12	5.18	70.86
Citrus pulp	93.50	11.75	21.55	4.23	15.86	40.11
Maize stover	93.25	4.71	18.30	3.83	0.42	72.74

DM = Dry matter, CP = Crude protein, CF = Crude fibre, EE = Ether extract, NFE = Nitrogen free extract

Table 3: *In vitro* gas production characteristics ofrice husk, bean waste, citrus pulp and maize stover

Treatment	a	a + b	b	c	t	Y
Rice husk	3.00^{c}	25.00^{c}	22.00^{b}	0.09^{a}	13.00^{a}	17.67^{b}
Bean waste	4.00^{b}	42.00^{b}	38.00^{a}	0.05^{b}	11.00^{ab}	19.00^{b}
Citrus pulp	7.33^{a}	48.33^{a}	41.00^{a}	0.03^{c}	9.00^{b}	16.00^{b}
Maize stover	4.33^{b}	48.33^{a}	44.00^{a}	0.05^{b}	12.00^{ab}	22.67^{a}
SEM	0.47	3.34	3.27	0.02	1.12	2.48

^{a,b,c} Means on the same column with different subscripts are significantly different (P<0.05). Y = volume of gas produced (ml/200 mg DM) at time 't', a = gas production (ml) from the soluble fraction, b = gas production (ml) from an insoluble fraction , c = gas production rate (h^{-1}) constant from insoluble fraction 'b', a + b = potential gas production (ml), t = incubation time; SEM=standard error of mean

Table 4: Metabolizable energy, organic matter digestibility and short chain fatty acid of rice husk, bean waste, citrus pulp and maize stover

Treatment	ME (MJ/Kg DM)	OMD (%)	SCFA (µmol)
Rice husk	6.33^{c}	52.70^{b}	0.54^{c}
Bean waste	8.15^{b}	62.47^{ab}	0.94^{b}
Citrus pulp	9.24^{a}	64.69^{a}	1.09^{a}
Maize stover	9.09^{a}	60.24^{ab}	1.09^{a}
SEM	0.45	2.96	0.08

^{a,b,c} Means on the same column with different subscripts are significantly different (p<0.05). ME = metabolizable energy, OMD = organic matter digestibility, SCFA = short chain fatty acid; SEM=standard error of mean

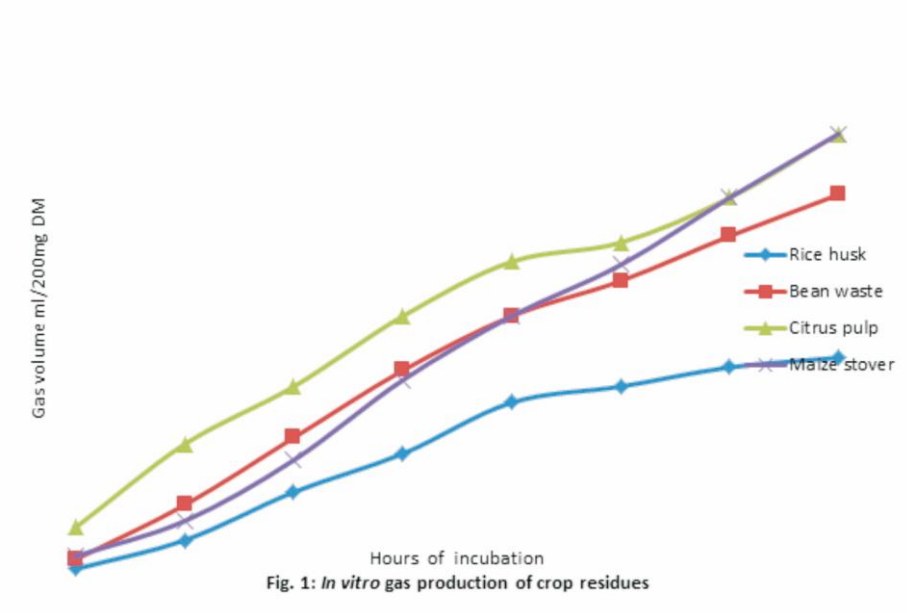

Fig. 1: *In vitro* gas production of crop residues

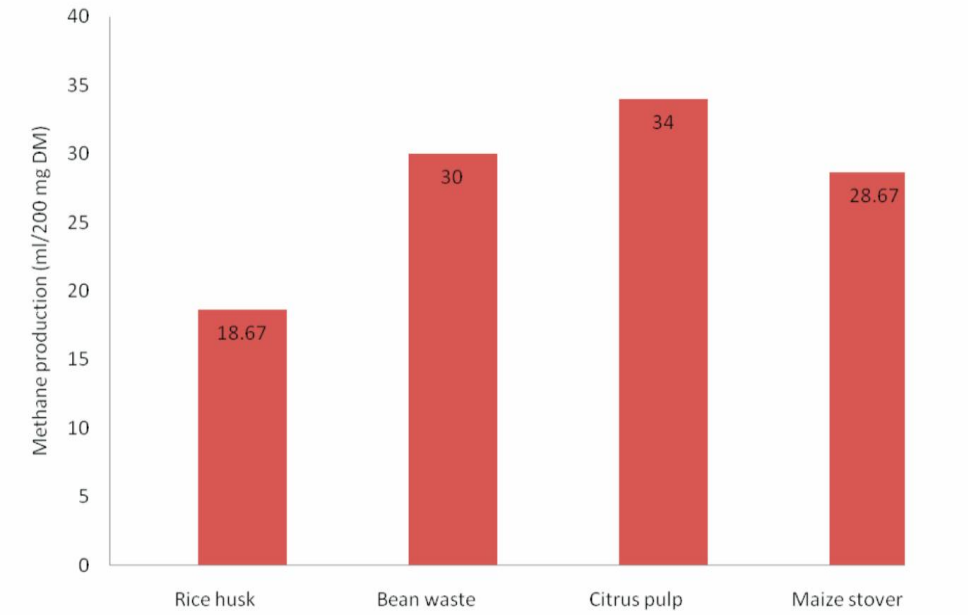

Fig. 2: Methane production of crop residues

Conclusion

The results revealed that citrus pulp and maize stover could be of higher nutritional value when included in ruminants feed than bean waste, while rice husk was of the lowest value.

However, these diets would considerably be of beneficial effect to ruminants when fed in combination with other protein sources such as legume forages and concentrates.

Also, more work is required in this research with the use of live animals.

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