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SHORT COMMUNICATION

Nutritional Composition of Composite Diets Using In Vitro Gas Production Technique

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Abstract

Waste from rumen, poultry and cassava processing when not transformed are sources of environmental pollution in most cities and rural communities in developing nations. This study was therefore carried out to investigate the nutritive value of composite diets comprising of rumen waste (RW), poultry waste (PW) and cassava peels (CP) using in vitro gas production technique.

Four experimental diets were formulated in which diet 1 was a standard diet (control), diets 2, 3 and 4 contained the three wastes in varied proportions of 5, 15, and 25% respectively. Two hundred milligram each of the diets was incubated at 39^{0}C in a 100mL syringes containing a buffered solution of rumen fluid for 24 hours. Total gas production, Methane production, Dry matter digestibility (DMD), Short Chain Fatty Acids (SCFA) production, Organic matter digestibility (OMD) and Metabolizable energy (ME) production were determined. Samples of the diets were also analysed for chemical composition.

The result showed that diets 2 and 3 have the highest values for total gas production (31.00 mL/200 mg DM and 28.50ml/200mg DM respectively), OMD (69.93% and 70.87% respectively), SCFA (0.68 Mmol and 0.62 Mmol respectively) and ME (6.87 MJ/Kg DM and 7.28 MJ/Kg DM respectively). While diet 1 and 2 had the highest DMD (37.10% and 40.82% respectively) and Methane (3.17 mL/200mg and 3.50mL/200mg). Thus, diets 2 and 3 have higher nutritive value and better potential and could therefore be fed to ruminant animals were found in large amounts rather than polluting the environment.

Keywords: cassava peel, rumen waste, poultry waste, nutritional value, *in vitro technique,*

Composition nutritionnelle de rations composites a l'aide de la technique de production de gaz in vitro

Résumé

Les déchets de rumen, de volaille et de transformation du manioc, lorsqu'ils ne sont pas valorisés, sont des sources de pollution environnementale dans la plupart des villes et communautés rurales des pays en développement. Cette étude a donc été réalisée pour évaluer la valeur nutritive de rations composites comprenant des déchets de rumen (DR), des déchets de volaille (DV) et des épluchures de manioc (EM) en utilisant la technique de production de gaz in vitro. Quatre régimes expérimentaux ont été formulés : le régime 1 était un régime standard (témoin), tandis que les régimes 2, 3 et 4 contenaient les trois déchets en proportions variées de 5, 15 et 25 % respectivement. Deux cents milligrammes de chaque régime ont été incubés à 39 °C dans des seringues de 100 mL contenant une solution tamponnée de liquide ruminal pendant 24 heures. La production totale de gaz, la production de méthane, la digestibilité de la matière sèche (DMS), la production d'acides gras volatils (AGV), la digestibilité de la matière organique (DMO) et la production d'énergie métabolisable (EM) ont été déterminées. Des échantillons des régimes ont également été analysés pour leur composition chimique. Les résultats ont montré que les régimes 2 et 3 présentaient les valeurs les plus élevées pour la production totale de gaz (31,00 mL/200 mg MS et 28,50 mL/200 mg MS respectivement), la DMO (69,93 % et 70,87 % respectivement), les AGV (0,68 mmol et 0,62 mmol respectivement) et l'EM (6,87 MJ/kg MS et 7,28 MJ/kg MS respectivement). Alors que les régimes 1 et 2 présentaient les DMS (37,10 % et 40,82 % respectivement) et teneurs en méthane (3,17 mL/200 mg et

3,50 mL/200 mg) les plus élevées. Ainsi, les régimes 2 et 3 ont une valeur nutritive et un potentiel plus élevés et pourraient donc être utilisés pour l'alimentation des animaux ruminants, là où ces déchets sont disponibles en grande quantité, plutôt que de polluer l'environnement.

MOTS-CLÉS : épluchure de manioc, déchet de volaille, valeur nutritionnelle, technique in vitro

Introduction

Production of animal feed from agricultural wastes is one of the alternatives that make use of inexpensive local materials and at the same time help to dispose of these materials in an economical and environment friendly manner (Oman, 2010). When wet, these wastes constitute breeding ground for microbes and maggots, thereby posing an environmental health hazard to people living in such environment.

In most developing countries of the world, the use of conventional feed ingredients such as carbohydrate and protein concentrates is fast becoming uneconomical for local farmers. The cost of feed has become really high due to high cost ingredients in the formulation and production of livestock feeds (Osanyinlusi & Williams, 2024). This is due to exorbitant cost of these concentrates (maize, sorghum, wheat, soya beans, cowpea, etc.) occasioned by scarcity of these concentrates due to its high demand for human consumption (Martins, 2024). There is therefore an urgent need for farmers to seek alternative feed ingredients affordable and available for farm animals. Agro industrial wastes and crop residues have become imperative as an alternative to conventional feed ingredients in the developing nations of the world (Shoyombo *et al*., 2025) . Waste from rumen, poultry and Cassava processing are readily available and inexpensive for farmers' usage in most urban and peri-urban cities in Nigeria. Harnessing them as ruminant feed could largely reduce production cost for local livestock farmers.

This study was carried out to investigate the nutritional value of composite diets containing different proportions of rumen wastes, poultry droppings and cassava peels using *in vitro* gas technique.

Materials and Methods

The experiment was carried out at the Small Ruminant Unit University of Benin Farm Project. Rumen contents, poultry waste and cassava peels were déchet de rumen collected and sundried on concrete slabs until it was gritty to touch with moisture content of about 10%, after which they were milled and bagged separately.

Four feed types were formulated with mixtures of dried rumen contents, poultry wastes and cassava peels at 0, 5, 15 and 25% inclusion levels respectively. About 200mg of each experimental diet formulated in three replicates were milled and weighed into incubation bags, sealed and put into 100mL calibrated syringes containing 30mL of goat rumen liquor and buffer. *In vitro* incubation was carried out for 24 hours and gas production recorded at 3hours intervals (i.e. 3, 6, 9, 12, 15, 18, 21 and 24 hours). Dry matter digestibility was calculated using the following formula:

$$\% \text{ DMD} = \frac{\text{Wt. of sample before incubation} - \text{Wt. of sample after incubation}}{\text{Wt. of sample before incubation}} \times \frac{100}{1}$$

Metabolizable energy, Short chain fatty acid and organic matter digestibility (OMD %) were estimated using the equation established by Menke and Steingass (1988) and Getachew *et al.*, (1999) as follows:

$$\text{SCFA} = 0.0239\ \text{GV} - 0.0601; \quad \text{OMD}\ \% = 14.88 + 0.88\ \text{GV} + 0.45\text{CP} + 0.651\text{XA};$$

ME = 2.20 + 0.136 GV + 0.057 CP + 0.00029 CF; Where, GV = net gas production (ml/200 mg DM) at 24 hour incubation time, CP = crude protein sample at 24 hour incubation time; XA = ash of the incubated sample; CF = Crude Fibre

Samples of the four diets were weighed and oven dried at 65^{0}C for a period of 24 hours to a constant weight for determination of dry matter and chemical composition (AOAC, 2000). Data obtained were analysed using statistical analytical system software (SAS, 2000) and variations among treatment means that are significant were computed using Duncan Multiple Range Test (1955).

Results and Discussion

The results from Table 1 showed diet 1 as control diet, with conventional feed ingredients, while diets 2, 3 and 4 had varied proportions of the wastes, with Brewer Dry Grain (BDG) serving as a basal ingredient to all the diets. Chemical composition of the diets were presented in table 2, with diet 3 having the highest crude protein (CP) value of 21.00%, which was not significantly ($P > 0.05$) different from the CP (16.98%) of diet 4, while diet 1 and 2 had lower ($P < 0.05$) and similar CP of 14.53% and 14.00% respectively. Also, diet 3 had the highest Neutral Detergent Fibre (NDF) value of 61.00%, which was significantly ($P < 0.05$) higher than NDF for diets 1, 2 and 4.

Table 3 showed that the combination of waste from rumen, poultry and cassava processing resulted in a higher gas production in diets 2 (31.00 mL/200 mg DM) and 3 (28.50mL/200mg DM), which was significantly ($P < 0.05$) higher than gas production from diets 1 (23.83 mL/200mg DM) and 4 (23.67 mL/200mg DM); thus suggesting a relatively better degradation of cell wall solubles and other degradable carbohydrates in diet 2 and 3. As seen in table 3, Dry matter digestibility (DMD) of diet 2 (40.82%) was the highest ($P < 0.05$), while the Organic matter digestibility (OMD) of diet 2 (69.93%) and 3 (70.87%) were both higher ($P < 0.05$) than OMD of diets 1 (61.63%) and 4 (64.46%). Basically gas production during fermentation in ruminants as seen in *in vitro* technique depend essentially on actual chemical composition and structure of diet. Blummel and Becker (1997) asserted that gas production is a function of and a mirror of degradable carbohydrate and therefore, the amount depends on the nature of the carbohydrate. It has been reported that gas production was negatively correlated with less degradable carbohydrate or NDF and positively correlated with starch (De Boever *et al*., 2005). This observation was also corroborated by Njidda and Nassiru (2010) that cell wall content (NDF and ADF) are negatively correlated with gas production at all incubation times and estimated parameters. However, the similarities of gas production characteristics reported in this study for diet 1 and 4 may be partly due to similarities in crude protein, NDF and ADF contents.

Also, diet 2 and 3 had higher values for short chain fatty acid (0.68 Mmol and 0.62 Mmol respectively), metabolizable energy (6.87 MJ/Kg DM and 7.28 MJ/Kg DM respectively) and Net Gas volume (17.00 MJ/Kg DM and 14.15 MJ/Kg DM respectively). While diets 1 (control) and diet 4 had lower values for these parameters. However, there was no significant ($P > 0.05$) difference between the values. Indicating that diet 4 (25% CRC, 5% PD and 15% CP) compares favourably well with the control diet which is a conventional diet for ruminants. It could possibly serve as potential feed for ruminant animals.

Methane production was highest in diet 2 (3.50 ml/200 mg DM), though similar to diet 1 (3.17 ml/200 mg DM) and diet 4 (3.00 ml/200 mg DM), implying that the combination of the wastes did not reduce methane production. Methane production signifies a considerable loss of energy (Johnson & Johnson, 1995) in the diets and largely indicates a poor feed quality. Moreover, it is 25 times more potent greenhouse gas than carbon dioxide (Pachauri *et al*., 2014), so there is a need to minimize its production. Therefore, diet 3 with a high gas production, DMD, OMD, SCFA and lower methane production can be recommended as a potential feed for ruminant animals.

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Table 1: Composition of Dietary Treatments (g/kg)

Ingredients	Diet 1	Diet 2	Diet 3	Diet 4
Cattle rumen waste	-	5.00	15.00	25.00
Poultry waste	-	15.00	25.00	5.00
Cassava peels	-	25.00	5.00	15.00
Palm kernel meal	23.00	-	-	-
Wheat offals	18.00	-	-	-
Maize	4.00	-	-	-
Brewer Dried Grains	51.00	51.00	51.00	51.00
Bone meal	1.00	1.00	1.00	1.00
Limestone	1.00	1.00	1.00	1.00
Common Salt	0.50	0.50	0.50	0.50
Vit./Min Premix	1.50	1.50	1.50	1.50
Total	100.00	100.00	100.00	100.00

Table 2: **Chemical composition (%) of experimental diets**

Variables	[1]Diet 1	[2]Diet 2	[3]Diet 3	[4]Diet 4	SEM
DM (%)	88.08a	81.71a	84.33a	79.92a	8.94
OM (%)	70.41a	62.73b	67.04ab	67.06ab	6.05
CP (%)	14.53a	14.00a	21.00b	16.98b	5.12
NDF (%)	51.00a	52.00a	61.00b	51.00a	3.38
ADF (%)	27.00a	40.00b	39.00b	33.00ab	10.12
ASH (%)	29.05a	31.27a	32.96a	32.94a	3.06
ME(MJ/kg DM)	7.05a	3.91b	5.65c	5.99c	1.27

ME (MJ/Kg DM) = 13.5 — 0.15 X ADF% ÷ 0.14 + CP% — 0.15 × ASH% (MAFF, 1984)
DM - Dry Matter, OM - Organic Matter, CP - Crude Protein
NDF - Neutral Detergent Fibre, ADF - Acid detergent Fibre, ME – Metabolizable Energy
SEM – Standard error of mean;
a,b,c,d – means along the rows with the same letters are not significantly different
[1]Diet 1- Control
[2]Diet 2- 5% Cattle Rumen Content, 15% Poultry Droppings, 25% Cassava Peels
[3]Diet 3 - 15% Cattle Rumen Content, 25% Poultry Droppings, and 5% Cassava peels
[4] Diet 4 - 25% Cattle Rumen Content, 5% Poultry Droppings, and 15% Cassava Peels

Table 3: *In vitro* gas production parameters of the experimental diets

Variables	[1]Diet 1	[2]Diet 2	[3]Diet 3	[4]Diet 4	SEM
TGV(ml/200mg DM)	23.83a	31.00b	28.50b	23.67a	2.23
AVG (ml/200mg DM)	2.98a	3.88b	3.56ab	2.96a	0.74
Methane(ml/200mg DM)	3.17ab	3.50a	2.67b	3.00ab	0.55
DMD (%)	37.1a	40.82b	31.11a	23.59a	7.96
OMD (%)	61.63a	69.93b	70.87b	64.46a	1.96
SCFA (Mmol)	0.51a	0.68a	0.62a	0.51a	0.05
ME (MJ/Kg DM)	3.46a	6.87bc	7.28b	6.39c	0.33
Net GV (ml/200g DM)	9.83a	17.00b	14.50b	9.67a	2.33

DMD - Dry matter digestibility; OMD – Organic matter digestibility; SCFA - Short chain fatty acid;
ME - Metabolizable energy; GV - Gas volume; AVG – Average gas volume.
a,b,c,d - means along the rows with the same letters are not significantly different