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ASSESSMENT OF NUTRITIVE VALUE IN MIXTURES OF OILPALM SLURRY AND CASSAVA PEELS USING IN VITRO GAS PRODUCTION TECHNIQUES

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ABSTRACT

Inadequate feed supply is a major constraint to ruminant production in the tropics. The potentials of abundantly available agricultural by-products such as Oil Palm Slurry (OPS) and Cassava Peels (CaP) were harnessed since the adoption of a mixture of these by-products as an alternative feed source. The digestibility of each Diets (A-E) and F (Control) with corresponding OPS:CaP ratios viz. 1:1, 1:2, 1:3, 1:4, 1:5 and control diet F containing 6.0 kg of CaP without oil was assessed *in vitro* to predict the potential degradability (PD), insoluble degradable fraction (IDF), rate of gas production (RGP), organic matter digestibility (OMD), metabolizable energy (ME) and short chain fatty acids (SCFA). All parameters determined varied significantly ($P<0.05$) with Diet C recording the highest values in all followed by Diet F in terms of volume of gas produced. The values of PD ranged from 56.00 - 62.50% in Diets E and C while IDF ranged from 39.33 - 48.00% in Diets A and C respectively. ME, OMD, SCFA and GP also ranged as 8.83 - 11.42 MJ/Kg DM in Diets A and C, 72.17 - 82.98% Diets E and C, 1.27 - 1.56 mmol in Diets A and C, 52.14 - 67.67 ml/200mg DM in Diets A and C respectively. It could be concluded that diet C had the best nutritive quality.

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1 Introduction

Inadequate feed supply is a major constraint to ruminant production in the tropical regions (Ogunbosoye & Babayemi, 2010). The rain forest zones of Nigeria are characterised by the first six months of lush, green and fresh grass for grazing animals, while low quality dry grass is usually a complementary problem of the last six months of the year. Makkar (2002) described the shortage of forages in Nigeria as a major constraint to ruminant production. Earlier remarks of Babayemi et al. (2003) considered the other six months of the year as a time of forage scarcity. The dry season, however, is characterised by standing hay and low quality feed that eventually culminates in growth retardation and low productivity of the animals, hence, need to source for non-conventional techniques of making feeds available to the animals during the period of scarcity. Although shrubs and many browse plants such as *Leuceanea leucocephala* and *Moringa olifera,* provide a better alternative, yet it is highly important source for cheaper alternatives in order to make choices readily available to livestock.

Agro-industrial by-products such as palm kernel meal, cassava seivate, bean seed hull, cassava peels (CaP) and oil palm slurry (OPS) are other possible non-conventional alternatives. These industrial recyclable wastes are less expensive, highly digestible and are abundantly available in their respective processing sites where they occasionally constitute social menace and environmental hazards if not properly disposed of. The production rate of OPS which is an emulsion containing 4.0-5.0% solids, 0.5-1.0% residual oil and 95.0% water (Apori, 1984), is at a ratio of 2:3 litres of finished oil (Olie & Teng, 1972). Furthermore, Webb et al. (1977) suggested that Oil palm slurry should be combined with other feedstuffs for a better utilization.

Cassava Peels are obtained from cassava processing plants. They constitute a major source of livestock feed ingredient especially in the South-west geopolitical zone of Nigeria where the crop is intensively cultivated. Okpako et al. (2008) asserted that the major limitation to the use of CaP for feeding livestock is in its low protein content and anti-nutritional constituents such as cyanide.

Feed consumption by animal particularly, the ruminant is highly dependent on the acceptability, rate of feed degradation in the rumen and the amount of energy that could be supplied by the feed (Van Soest, 1995). *In vitro* method of feed evaluation has been validated over time and adjudged as one of the means of evaluating feed degradation by animals. Gas production by *in vitro* fermentation as a process has been rated one of the most accurate methods of estimating the quality of feedstuffs (Menke & Steingass, 1988; Coelho et al., 1988; Carro et al., 1994). The process is less expensive, simple and replicable. This study aimed to determining the nutritive value of mixtures of OPS and CaP using *in vitro* gas fermentation techniques, and in addition, the acceptability by West African Dwarf (WAD) sheep on graded mixtures of OPS and CaP.

2 Materials and Methods

2.1 Formulation of Experimental diets

The experimental diet layout prescribed by Abiola-Olagunju et al. (2014) was adopted in this study. Various composition of diet is as Diet A (1.0 kg of CaP + 1.0 ltr. of OPS), Diet B (2.0 kg of CaP + 1.0 ltr. of OPS), Diet C (3.0 kg of CaP +1.0 ltr. of OPS), Diet D (4.0 kg of CaP +1.0 ltr. of OPS) and Diet E (5.0 kg of CaP + 1.0 ltr. of OPS) were formulated. Furthermore only 6.0 kg of CaP (control - Diet F) were also provided as a control diet to West African Dwarf (WAD) sheep (figure 2) .

2.2 Analytical procedure

2.2.1 In vitro fermentation of the formulated diets

The graded levels of each diet mixture i.e. Diet A, B, C, D, E and F (control) were oven dried at 105^{o}C to constant weight. 200mg of each milled sample was weighed into 120ml graduated syringe with lubricated piston. A buffered mineral solution (containing $NaHCO_3$, $NaHPO_4$, KCl, NaCl, $MgSO_4 \cdot 7H_2O$, $CaCl_2 . 2H_2O$) was mixed in ratio 1:2 (v/v) with sieved rumen liquor earlier collected from the rumens (of three female WAD sheep that were previously fed concentrate consisting 20% corn bran, 25% wheat offal, 20% palm kernel cake, 10% groundnut cake, 4% oyster shell, 0.5% common salt, 0.25% fish meal and 0.25% grower's premix) into a pre-warmed thermos flask and stirred with constant supply of CO_2 gas.

As per the method described by Adeyosoye et al. (2010), 30.0ml of buffered rumen liquor (inoculum) was ejected into a syringe containing the test diet sample. The contents were incubated at 39^{o}C. Gas production rate was recorded at 3, 6, 9, 12, 15, 18, 21 and 24 hours and each syringe was gently swirled after each reading. At the 24th hour incubation, the average volume of gas produced from the blanks was deducted from the volume of gas produced per sample. The biogas volume (ml/200mg) produced was plotted against the time (hours), and the gas production characteristics were estimated by using the mathematical function described by Orskov & McDonald (1979)

$Y= a + b^{(1- e-ct)}$ as

Where as
Y= volume of gas produced at "t"; a= intercept (gas produced from insoluble fraction); c = gas production rate constant for the insoluble fraction (b); t = incubation time

Table 1 *In vitro* Gas Production Parameters of Fermented Graded Mixtures of Oil Palm Slurry and Cassava Peel at 24hrs Incubation Period.

Fermentation Characteristics	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F (Control)	SEM
B	39.33^{f}	46.00^{c}	48.00^{a}	43.50^{d}	41.00^{e}	47.21^{b}	1.17
a+b	60.33	57.50	62.50	60.00	56.00	62.24	1.80
C	0.0553^{e}	0.0633^{d}	0.0796^{a}	0.0683^{b}	0.0671^{c}	0.0770^{a}	0.03
T	6.00	6.00	6.00	6.00	6.00	6.00	0.01
Y	35.33	35.00	37.60	35.00	36.00	36.12	1.16

Means with different superscripts across the rows are significantly different ($p<0.05$); B: Insoluble degradable fraction, a+b: potential degradability, C: rate of degradation, T: time and Y: effective degradability.

Metabolizable energy ME (MJ/Kg DM) and Organic Matter Digestibility (OMD %) were estimated by the method described by Menke & Steingass (1988) and short chain fatty acids (SCFA) were calculated by the method given by Getachew et al. (1999)

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

OMD = 14.88 + 0.889*GV + 0.057*CP + 0.0029*CF

SCFA = 0.0239*GV – 0.0601

Where GV, CP, CF and A are net gas volume (ml/200 mg DM), crude protein, crude fibre and ash of the incubated samples respectively.

2.3 Statistical analysis

Data obtained for all determined Parameters were subjected to analysis of variance (ANOVA) procedure using SAS package of (1999). Significant means were separated using Duncan multiple range test of same package.

Experimental model: Yij = u + i + Eij

Whereas Yij = individual observation; u = general mean of the population; i = treatment effect; Eij = composite error effect

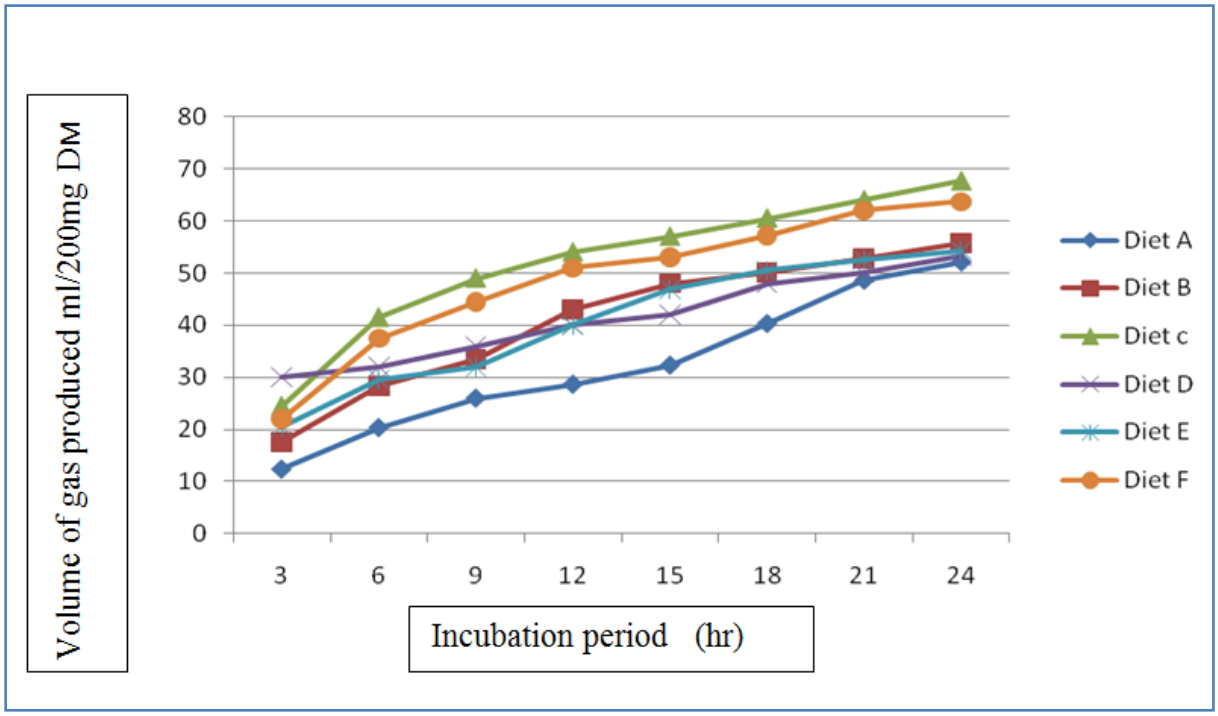

Figure 1 Hourly *in vitro* gas production of fermented graded mixtures of OPS and CaP.

Plate 1 Clarified Oil palm slurry

Plate 2 Fermented graded mixtures of OPS and CaP

Plate 3 Some sheep feeding acceptability study

Figure 2 Process of various diet composition formulation and animals feeding on this (Plate 1-3).

3 Results and Discussion

Benefits of fermentation according to Steinkraus (1995) include fortification of diet and the removal of toxins. The residual oil contained in the slurry is also an added advantage to the rate of fermentation, since oils and lipids have been found essential components of many fermentation media (Adebiyi, 2006). This can best explain why protein production was highest at 3% after fermentation as the level of CaP increased in the work of Abiola-Olagunju et al. (2014). Table 1 shows the *in vitro* gas parameters of fermented graded mixtures of OPS and CaP at 24 hrs incubation period. The *in vitro* gas production over a period of 24 hrs is as shown in figure 1. Gas production was consistently reported higher from the Diet C and it was followed by the Diet F (control) compared to other diets.

The conventional method of feed evaluation via digestibility trial using metabolic cage has been found inaccurate, expensive, laborious and unreliable *in vivo* (Tilley & Terry 1963). Therefore, a more reliable technique of estimating livestock feed is *in vitro* gas fermentation (Menke & Steingas, 1988). Although the two methods are independent of each other, however, they are inter-related. Gas production is an indication of microbial degradability of samples (Babayemi et al., 2004b; Fievez et al., 2005).

At 24 hours, high volume (48.00 ml) of insoluble but degradable fraction (b) was reported from the diet C with a combination of OPS and CaP in a ratio 1:3, could be attributed to the adequate proportion of oil to CaP in the mixture. This facilitated high rate of microbial activity by supplying the required nitrogen for their cellular protein synthesis as established by Stainer et al. (1977). The highest value 48.00l obtained for this diet could also be connected with the adequate ration of oil to cassava peel in the diet compared to other diets. The result obtained in this work agrees with the report of Jones & Porter (1998) that adequate combination of oil and carbohydrate would improve fermentation characteristics of the substrates. High concentration of oil to cassava peel in diet A inhibited the activities of microorganisms, hence the slow rate of gas production. This assertion confirmed the report of Palizdar et al. (2011) that saturated fatty acids had more inhibitory effect on rumen microbial ecosystem. Rate of gas production is directly dependent on the relative proportion of soluble, insoluble but degradable and undegradable particles of diets, mathematical description of gas production profiles allows evaluation of substrate and fermentability of soluble and slowly fermentable components of feeds (Getachew et al., 1998). The values of a+b, c, and y in the diet C were similar to diet F, but significantly higher ($p<0.05$) than other diets.

Table 2 *In vitro* gas characteristics of fermented graded mixtures of Oil palm slurry and Cassava peel at 24 hours incubation period.

Parameter	Diet A	Diet B	Diet C	Diet D	Diet E	Diet F (Control)	SEM
GV	52.14^{d}	55.71^{bc}	67.67^{a}	53.18^{c}	54.38^{c}	63.71^{b}	0.09
ME	8.83^{e}	9.04^{d}	11.42^{a}	9.47^{c}	9.76^{bc}	10.94^{b}	0.08
OMD	72.17^{c}	73.85^{c}	82.98^{a}	69.82^{d}	71.57^{bc}	79.85^{b}	0.03
SCFA	1.27^{e}	1.30^{d}	1.56^{a}	1.33^{c}	1.37^{c}	1.46^{b}	0.01

Means along the same row with different superscripts are significant ($p<0.05$); GV: Gas volume (ml/200mgDM), ME: Metabolizable energy (MJ/Kg DM), OMD: Organic matter digestibility (%), SCFA=Short chain fatty acids (mmol).

The implication of this is that, diet C which had ratio 1:3 (OPS:CaP) would enhance optimal *in vivo* degradability. The values of 'b' obtained in this study (39.33-48.00) were higher than those reported for dry matter (DM) degradation of some tropical legumes and grasses (Ajayi et al., 2007) and the value range of 9.5-32.0 ml reported for some crop residues (Babayemi et al., 2009).

The potential degradability (a+b) of a diet depicts the level at which the diet could be degraded if it were in the actual rumen of the animal (*in vivo*). This largely depends on how much of the fibre fractions (ADF and NDF) have been broken down for easy access of the microbes to the available nutrients in the diet. At 24 hrs, there were no significant variations among the diets for potential degradability which suggest that early hours of incubation and oil inclusion could not be effective for the different diets including diet F (control). A corroborative result was obtained by Jones & Porter, (1998) in which the time of oil inclusion as a determinant for facilitating degradability in the rumen was established. The rate of degradability (c) increased down the treatments except in Diets D and E, which could also be due to the different levels of oil inclusion.

Table 2 presents the gas production characteristics of fermented graded levels of oil palm slurry and cassava peels. When feedstuffs are incubated with buffered rumen fluid (inoculum) *in vitro*, gas production is basically the result of microbial degradation of carbohydrates under anaerobic condition to acetic, propionic and butyric acids (Wolin, 1960; Steingass & Menke, 1986). Gas production from protein fermentation is relatively small compared to carbohydrate fermentation.

The contribution of fat in gas production is negligible (Wolin, 1960). The highest value (1.56 mmol) of SCFA was obtained for diet C; this is in agreement with the findings of Yang & Sundaresan (2000). Oil has the ability to increase microbial growth in fermentation; it could be attributed to higher preference of the microbes for this diet due to the favourable ratio of oil to cassava peel (1:3). Furthermore, oil is considered a component of many fermentation media because of its supplemental nutrient source for microbial activity depending on its level of inclusion in the substrate (Peacock et al., 2003). Oil also acts as an adjunct to fermentation (Jones & Porter, 1998).

The organic matter digestibility (OMD) value is a good measure of the amount of feed which was accessible to the microbes in the rumen. Diet C recorded highest value of OMD (82.98%) indicating that nutrient uptake was best at this ratio. Higher levels of oil inclusion (diets A and B) might have reduced the capacity of the microbes in breaking down the lignin content due to its inhibitory effect. The findings of Phengvilaysouk & Wanapat, (2008) also supported the supplementation of cassava hay with oil. At higher levels than Diet C, the oil ratio to the cassava peel might not have been sufficient for microbial attack on the lignocellulose cell components of the mixture. This statement however is at variance with the findings of Granum et al. (2007) that OMD fermentation was best at oil supplementation level of 3% for cassava hay. Again, the detoxifying effect of the oil may be hindered due to uneven mixture that reduces microbial activity.

A correlation between metabolizable energy (ME) values measured *in vivo* and predicted from 24hr *in vitro* gas production and chemical composition of feed was reported (Menke & Steingass, 1988). The *in vitro* gas production method has been widely used to evaluate the energy value of several classes of feed (Getachew et al., 1998; Getachew et al., 2002). A direct correlation between metabolizable energy was recorded from *in vitro* gas production together with CP and fat content. This compared with metabolizable energy value of conventional feeds measured *in vivo* (Menke & Steingass, 1988). The results obtained in this study for metabolizable energy does not deviate from the report of Mako, (2009) probably because of the varying levels of oil present in each diet but however deviated from findings of Babayemi & Bamikole (2006) and Hristov et al. (2009).

Conclusion

The nutritive value assessment mimicked outside the animal environment revealed that the diets possessed enough nutrients to meet the nutritional requirements for ruminants. The Gas production kinetics also revealed that the oil acted as an adjunct to fermentation, thereby helping to break down lignocellulosic feed-stuffs into the utilizable forms. The highest *in vitro* degradation was obtained from the mixture of 1:3 of OPS and CaP as contained in diet C. Diet C is hereby recommended for feeding trials on pseudo-ruminant particularly, rabbits in subsequent studies.

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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