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ORIGINAL RESEARCH ARTICLE

Nutritive assessment and *in vitro* fermentation of shea nut cake at graded levels in the diets of West African dwarf goats

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ABSTRACT

The perennial problem of feed shortage during the lean period necessitated the need to screen more feedstuffs that are less competitive. Shea nut cake (SNC) is one of the agro industrial by products that abound during dry season. Hence, this study was carried out to estimate the *in vitro* gas production pattern of shea nut cake in the mixed rations (T1= (0%), T2 = (10%), T3 = (15%), T4 = (25%), T5 = (50%), T6 = (75%) with cassava peels, corn bran, cowpea husk and wheat offal to balanced up to 100 % in equal proportion to predict the degradability of SNC basal diets. The proximate composition revealed that crude protein (CP) varied from 9.18% (T4) to 11.73% (T6). Ether extract (EE), Ash and crude fibre ranged from 2.03-13.62, 16.84-19.54 and 7.08-12.11 % respectively. The samples were incubated for 24 hours. Gas volume was significantly different among the treatments ($P < 0.05$). The values ranged between 7 and 28ml /200 mg DM in diets 1 and 3 respectively. The methane production ranged from (4.0-17.0ml/200mg DM) in T6 and T1, respectively. Gas production from the soluble fraction (a) was highest in diet T1 and lowest in diet T6. The potential gas production (a+b) varied significantly from 7.00-28.00ml. The gas production rate (c) was highest for diet T1. ME (3.24-46.59MJ/kg DM), OMD (30.73-51.79%) and SCFA (0.22-0.75µmol) differed significantly ($P < 0.05$) across diets. Diet T3 had highest ME, OMD and SCFA contents. Diet (T3) gave moderate volume of methane. The results revealed that SNC at 15% inclusion can be effectively utilized by ruminants with minimum production of methane gas.

Keywords: gas production, methane, calculated parameters and SNC.

INTRODUCTION

Ruminant animals suffer a great drawback during dry season because of the drastic loss of weight being experienced by the animals. Nwaigwe *et al.* (2011) observed that this set back could be attributed to the poor quality and quantity of fodder crops in terms of protein and energy. The ever increasing prices of conventional feed stuffs such as cereals and legume grains even worsen the situation. It prohibits their wide-scale use, especially by small scale farmers. Furthermore, the competitive demand for these conventional feed resources as food between livestock and man on one hand and between monogastric animals and ruminants on the other hand limits the quantity of these conventional feeds available for ruminant feeding.

Ogunbosoye and Babayemi (2008) reported that browse plants could be harnessed as feed for ruminants but the presence of anti-nutritional factors inherent in some of them may affect the utilization of these forages. The grasses at the onset of raining season grow fast with high nutritive value but this does not last long because they flower shortly culminating into high fiber content which renders it less nutritive. At this stage the animals will not be able to efficiently derive quality nutrients from them during digestion (Khanum *et al*. 2007). It has been reported by Adegbola (2002) that poor quality roughages fed to ruminants without supplementation, especially during the dry season caused considerable weight losses and sometimes resulted in the death of the animals. Low productivity and various diseases have been the major constraints that faced sheep and goat production in Nigeria.

In view of the limitations to the use of conventional feeds for livestock feeding, it is best to resort to the use of those feed resources, which are cheap, less competitive and which the ruminant animals can convert to useful products. This will ameliorate the problems of feed shortage, high feed cost and poor quality of feed often encountered in ruminant production without a reduction in animal productivity, animal health and product quality. Shea nut cake (SNC) is one of the agro industrial by-product that greatly abounds all through the year in the North West zone of Nigeria. It constitutes a waste and nuisance to the environment wherever shea nut butter industry is located. SNC has crude protein between 15-20 % and can be produced to a large extent by various processing methods (Malede, 2012). In ruminants, according to Esien (2003), SNC can be incorporated in the diet of sheep up to 50% with wheat or rice bran and well accepted by the sheep. Salifu (2004) reported that shea nut cake may be added to the diet of sheep up to 15% without adverse effects on their performance.

In vitro gas techniques have been found to be efficient in quick evaluation of some feedstuffs at a very cheap rate to obtain the results within a short period of time. It could also be used to predict organic matter digestibility, metabolizable energy and short chain fatty acids of the feed samples (Ogunbosoye, 2016). However, there is paucity of information on the utilization of SNC by WAD goats. In an attempt to solve these afore mentioned problems, this experiment was designed to evaluate the nutritive value and *in vitro* fermentation pattern of shea nut cake at graded levels in the diets of West African dwarf goats.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Teaching and Research Farm, Kwara State University, Malete, Kwara State, Nigeria. The University is located on Lat.8.7ºN and Long. 4.5ºE in the Southern Guinea Savannah region of Nigeria.

Sources and preparation of experimental samples
Shea nut cake (SNC) was sourced for from a local shea butter processing industry in Idofian, Ilorin South Local Government area of Kwara State. SNC was sun dried for four (4) days during the dry season and milled before mixing with other ingredients which were cassava peels, corn bran, wheat offal and cowpea husk.

Formulation of experimental diets

The experimental diets: T1 (0% SNC), T2 (10% SNC and 90% other ingredients), T3 (15% SNC and 85 % others, T4 (25 % SNC and 75 % others), T5 (50% SNC and 50 % others) and T6 (75 % SNC and 25 % other ingredients) were formulated for 24 hours incubation.

Table 1: Feed composition of treatments (%)

Ingredients	T1	T2	T3	T4	T5	T6
SNC	0	10	15	25	50	75
Cassava peel	25	22.5	21.5	18.75	12.5	6.25
Corn bran	25	22.5	21.5	18.75	12.5	6.25
Cowpea husk	25	22.5	21.5	18.75	12.5	6.25
Wheat bran	25	22.5	21.5	18.75	12.5	6.25

***In vitro* gas production**

Preparation of the buffer and rumen liquor was carried out as described by Menke and Steingass (1988). The substance was placed in a calibrated gas tight plastic syringe fitted with a piston. The syringes were incubated in an incubator at 39ºC. Rumen fluid collected from three West African Dwarf (WAD) female goats that were previously fed *Gliricidial sepium* and guinea grass, sieved with a four layered cheese cloth mixed with a sodium buffer (9.8g $NaHCO_3$ + 2.77g (Na_2) HPO_4 + 0.57g KCl + 0.47g NaCl + 0.12g $MgSO_4.7H_2O$ + $CaCl_2.2H_2O$ per 1000ml) in a ratio 1:2v/v. 200mg DM of each sample plus 30ml of rumen fluid and buffer were placed in each syringe and incubated in triplicate under continuous flushing with CO_2. A blank (rumen fluid + buffer) sample was incubated at the same time. The reading of the blank was subtracted from the reading given by each of syringe while the standard sample was used as control to make sure the technique is correct. Gas production was recorded at 3, 6, 9.12,15,18,21 and 24 h and after 24 h of incubation, 4 ml of NaOH (10 M) was introduced into the incubated samples as reported (Fievez *et al*. 2005) to estimate the amount of methane produced

Proximate analysis

Dry matter, Crude protein, crude fibre, ash and ether extract of both ingredients and formulated diets were determined following procedure of AOAC (1990).

Calculation and statistical analysis

Gas production characteristics over time were as described by Ørskov and McDonald (1979) using the equation $Y = a + b\ (1 - e^{-ct})$, where a is the gas production from the soluble fraction (ml); b is the gas produced from insoluble but degradable fraction, c = gas production rate constant for b, a+b = potential gas production, t = incubation time. Graph was plotted to show the trend of the incubation. Using the procedure of Menke and Steingass (1988), Metabolizable Energy (ME (MJ) = 2.20 + 0.136GV + 0.057 CP + 0.0029 CF), organic matter digestibility (OMD in % = 14.88 + 0.889 GV + 0.45 CP + 0.651 X) and short chain fatty acids (SCFA = 0.0239 GV- 0.0601 ml/200 mg DM) were estimated, where GV, CP, CF and XA are total gas volume, crude protein, crude fibre and ash respectively. Methane (CH_4) was calculated as reported (Fievez *et al*. 2005). Data obtained were subjected to analysis of variance using SAS (2010) procedure. Significant means were separated using Duncan multiple range F-test of the same package.

RESULTS AND DISCUSSION

The proximate composition of shea nut cake (SNC) in different combinations with wheat offal, cowpea husk, corn bran and cassava peels is presented in Table 2. Significant differences ($P<0.05$) were observed in the parameters measured for the experimental diets. Wheat bran had highest crude protein (CP, 15.96 %) value and cassava peels recorded the least (4.59 %). SNC had the highest values for EE (11.84 %) and ash (16.78 %). The CP content of SNC in this study was 10.71%. These values were similar to the report of Abdul-Mumeen *et al*. (2013) who screened samples of SNC collected from different processing factories in Kumasi, Ghana. Getachew *et al*. (2004) obtained similar CP range when they evaluated some ruminant feeds. Among the ingredients, high percentage of ash in SNC is an indication of good concentration of minerals for animals' utilization for optimum performance. It also shows that little or no mineral supplementation will be needed if SNC diet is fed to animals. The high concentration of ether extract in SNC suggests that it could be included in the diet for fattening animals for short term production suggesting high energy content. Meanwhile, the parameters measured were within the range of nutrients needed to sustain ruminant animals except for cassava peels which had CP level 4.59 %. This is below minimum level (8% CP) required to meet ruminal microbial need for ammonia production (Norton, 1994). Hence cassava peels alone may not be a good source of nutrient to ruminants but must be supplemented with other ingredients that contain high level of crude protein. The ingredients may, therefore, not qualify as protein sources in a formulated feed but offers flexibility in formulating rations according to the production performance of the target animals.

Table 2: Proximate composition (%) of the ingredients and shea nut cake diets at graded of inclusions with wheat bran, corn bran, cowpea husk and cassava peels.

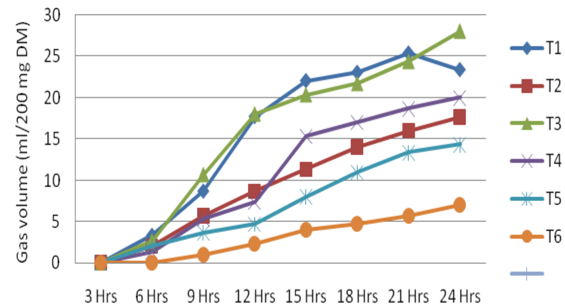
Samples	DM	CP	EE	CF	Ash
Ingredients					
Shea nut cake	94.38	10.71	11.84	7.60	16.78
Wheat offal	93.30	15.96	4.77	11.15	8.24
Corn bran	92.28	10.93	2.12	10.40	6.67
Cowpea husk	92.95	12.90	2.14	16.30	6.27
Cassava peels	93.08	4.59	1.75	9.00	4.24
Formulated diets					
T1 (0%SNC)	92.42^{b}	11.73^{a}	2.03^{c}	17.20^{b}	9.63^{bc}
T2 (10% SNC)	93.03^{ab}	$9.84b^{c}$	2.79^{c}	16.84^{b}	11.24^{a}
T3 (15 % SNC)	92.90^{ab}	9.18^{c}	2.19^{c}	19.54^{a}	12.11^{a}
T4 (25 % SNC)	93.51^{ab}	10.50^{ab}	5.30^{bc}	18.62^{a}	7.66^{c}
T5 (50 % SNC)	93.92^{a}	11.57^{a}	8.20^{b}	19.02^{a}	7.08^{c}
T6 (75 % SNC)	93.78^{a}	9.40^{c}	13.62^{a}	18.90^{a}	8.29^{bc}
SEM	0.33	0.31	1.28	0.37	0.50

abcd: means on the same column with different superscripts are different ($P<0.05$)

The CP contents of the diets decreased with inclusion of SNC but this did not follow a particular trend. The CP contents were significantly higher ($P < 0.05$) in T1, T4 and T5 than the other treatments. The EE concentration increased with SNC inclusion except in T3. CF and ash did not follow a particular pattern but ranged from 16.84 – 19.54 % and 7.08 – 12.11 % respectively. The CP content of all the diets is higher than the minimum level for maintenance (7.70%) for goats (NRC, 1981). According to Norton (1994) it was reported that the minimum level of 8% CP provides the ammonia levels required by rumen microbes for optimum activity. The moderate concentration of CP as observed in the formulated diets suggests that SNC could be a good alternative source of feedstuff to ruminant animals to mitigate shortage of feed during the dry season.

Presented in Figure 1 is the gas production of diets at various levels of inclusion of shea nut cake. Volume of gas produced was significantly different among the formulated diets and the ingredients. Gas volume produced was highest for T3 (28 ml/200mg DM) and was followed by T1 (25.33ml/200 mg DM). The least value of gas produced was found in T6 (7 ml /200 mg DM) which contains 75 % of SNC. T3 had lowest concentration of CP but highest gas volume. According to Getachew *et al*. (2004), gas production indirectly emerges from the reaction between buffer solution and acids resulting from fermentation and microbial degradation of incubated feedstuffs.

Figure 1: In vitro gas production of SNC at different combinations with wheat offal, corn bran, cassava peels and cowpea husk



The results obtained in this study was however contrary to what Hillman *et al*. (1993) and Babayemi *et al*. (2009) reported, that gas production is positively related to microbial protein synthesis. Volume of gas was reducing as the SNC level was increasing except for Diet T3. Min *et al*. (2003) reported that the action of condensed tannins in forages markedly reduced rumen proteolytic activity, bacterial growth and some proteolytic bacterial populations measured *in vivo*. This may be a great advantage to animals because these nutrients will escape microbial digestion and move to the lower gastro intestinal tract (GIT) for further digestion. However, the gas volume produced was similar to the reported value by Ogunbosoye (2016) when the foliages of some browse trees were incubated for 24 hours. .

The formulated diets did not follow a particular pattern in methane production but T3 which had highest volume of gas gave moderate level of methane (Figures 2). Methane production is an energy loss to animal. It has been reported in earlier studies that many of the available feedstuff offered to ruminants have been implicated in enhancing methanogenesis and contributing to global warming (Babayemi, 2007). High production of methane from diets could indicate an increased proportion of acetate and butyrate but decreased propionate production (Babayemi *et al*., 2004). However, the relatively lower gas production in this present study could be associated with propionic production which is carbohydrate in nature. The lower production of methane in T3 could suggest that SNC inclusion at that level will suppress methanogenesis and thereby produce better environmental condition.

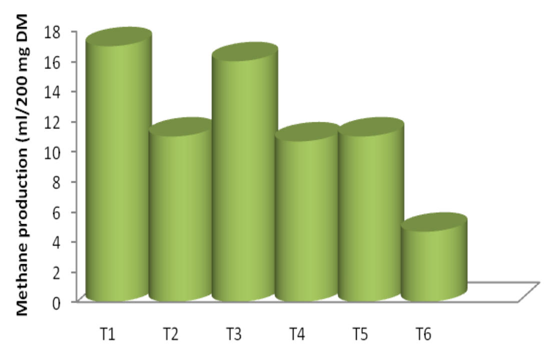


Figure 2: Methane production of SNC at graded levels of inclusion

Table 3: *In vitro* gas production characteristics of Shea nut cake in different combinations with wheat offal, corn bran, cassava peel and cowpea husk

Formulated diets	a	a + b	b	C	t	Y
T1 (0%SNC)	4.67^{a}	25.33^{a}	20.67^{ab}	0.11^{a}	13.00^{b}	20.00^{a}
T2 (10 % SNC)	3.00^{b}	17.67^{b}	14.67^{cd}	0.05^{b}	12.00^{b}	9.33^{d}
T3 (15 % SNC)	2.67^{bc}	28.00^{a}	25.33^{a}	0.07^{b}	11.00^{b}	15.67^{ab}
T4 (25 % SNC)	2.00^{bc}	20.00^{b}	18.00^{bc}	0.07^{b}	13.00^{b}	12.67^{bc}
T5 (50 % SNC)	2.00^{bc}	14.33^{c}	12.33^{d}	0.05^{b}	14.00^{b}	8.33^{d}
T6 (75 % SNC)	1.67^{c}	7.00^{d}	5.33^{d}	0.06^{b}	17.00^{a}	4.67^{e}
SEM	0.33	1.35	1.50	0.01	1.94	0.84

a,b,c,d,e: means on the same column with different superscripts are different (P<0.05)

Table 4: Metabolizable Energy, Organic Matter Digestibility and Short Chain Fatty Acids of ingredients and shea nut cake in different combinations with wheat offal, Corn bran, Cassava peel and Cowpea husk

Formulated diets	Metabolizable Energy (MJ/kg DM)	Organic Matter Digestibility (%)	Short Chain Fatty Acid (µmol)
T1 (0%SNC)	6.34^{ab}	48.79^{a}	0.67^{ab}
T2 (10 % SNC)	5.21^{ab}	42.33^{b}	0.48^{bc}
T3 (15 % SNC)	6.59^{a}	48.79^{a}	0.73^{a}
T4 (25 % SNC)	5.57^{ab}	42.37^{b}	0.54^{acd}
T5 (50 % SNC)	4.85^{ab}	37.35^{c}	0.40^{cd}
T6 (75 % SNC)	3.74^{b}	30.73^{d}	0.23^{d}
SEM	0.82	1.40	0.61

a,b,c,d,: means on the same column with different superscripts are different (P<0.05)

The values for (a), soluble fraction, (b), insoluble but degradable fraction, (a+b), potential gas production and (c), rate of gas production in the formulated diets at 24 hours incubation varied significantly (P<0.05) (Table 3). T1 produced the highest value (4.67ml) of b. This indicated an onset of fermentation and microbial attachment as reported by Aghajanzadeh-Golshanu *et al*. (2010). The values obtained for b in this study for the diets were in agreement with Getachew *et al*. (2004) but lower than values reported by Akinfemi *et al*. (2009) who evaluated some Nigerian feedstuffs. The Highest value of c measured in T6 revealed that the soluble carbohydrate fraction of this diet is readily available to the microbes for immediate degradation. The potential gas production (a+b) contents were distinctly different from the diets. There was significant decrease in the contents of a+b as the level of SNC increased but there was a little deviation in the value for T3. Nonetheless, these values were in agreement with the values obtained elsewhere (Akinfemi and Adebayo 2016). The rate of gas production (c) was similar to the value reported for tomato pomace (Mirzael- Aghasaghali *et al*. (2011) except for T1.

According to Getachew *et al*. (2004), the amount of gas produced in feeds under incubation reflects the production of short chain fatty acids, which are the main energy source for ruminants. Gas production indirectly emerges from the reaction between buffer solution and acids resulting from fermentation and microbial degradation. It was also stated that volume of gas produced during fermentation is a good measure to predict digestibility, fermentation end products and microbial protein synthesis of the substrate by rumen microbes in the *in vitro* system (Sommart *et al*. 2000). Gas volume has been observed to have correlation with *in vitro* dry matter and organic matter digestibility (Sommart *et al*. (2000), feed intake (Blummel and Becker, 1997) and growth rate in cattle (Blummel and Ørskov, 1993).

The OMD, ME and SCFA of the diets differed significantly (P<0.05) (Table 4). Among the diets, T3 produced the highest values of the three parameters. These values decreased at higher inclusion of SNC. The organic matter digestibility (OMD) signifies rate of digestibility of feedstuff. The ME obtained in this study were within the range obtained for some ruminant feeds by Getachew *et al*. (2004) while OMD and SCFA contents were well comparable to reported values by Akinfemi *et al*. (2009). Chenost *et al*. (1997) and Sallam (2005) however observed that there was significant correlation between *in vitro* gas measurement and *in vivo* digestibility. Again, the high gas production of feedstuff is a reflection of its high metabolizable energy (ME) and organic matter digestibility (OMD). Since gas production increases energy density and organic matter digestibility increases up to a certain level. (Fievez *et al*., (2005) observed that short chain fatty acid (SCFA) is an indication of energy content. SCFA as end products of carbohydrate fermentation contributes to the energy supply for the host animal. From this study, it is deduced that shea nut cake (SNC) inclusion at 15% inclusion gave the best results and could be adopted by the farmer. *In vitro* gas fermentation and nutrient composition of the feedstuffs could be very good methods to predict nutritional potential of feeds for ruminant animals and that incorporating shea nut cake in the diets of ruminants will alleviate suffering the animal generally encountered during dry season period of the year in the tropics.

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