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Chemical Composition, In Vitro Digestibility And Gas Production Characteristics Of Diets Containing Sweet Orange (*Citrus Sinensis*) Peel Meal

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Abstract: *The nutritive value of four diets containing different levels of sweet orange peel meal (SOPM), D_1(0%SOPM), D_2(12.5% SOPM), D_3(25% SOPM) and D_4(50% SOPM) were evaluated in terms of their chemical composition, in vitro gas production (IVGP), metabolizable energy (ME), organic matter digestibility (OMD), short chain fatty acids (SCFA) and in vitro gas production characteristics. Results showed that the in vitro gas production characteristics did not show any significant difference ($p>0.05$) among treatments. The values for potential gas production 'b' and the potentially degradable fractions 'a+b' for all the dietary treatments were similar ($p>0.05$), but absolute values of D_4(50% SOPM) for 'b' and 'a+b' (30.88 and 38.59) respectively, were higher than those of D_1, D_2 and D_3. The rate of fermention 'c' was also similar across the treatments. In vitro gas production volumes were significantly affected ($p<0.05$) among the treatments. Metaboliazable energy for D_4(6.56MJ/kgDM) was significantly higher than D_1(5.30 MJ/kgDM), D_2(5.32 MJ/kgDM) and D_3(5.39 MJ/kgDM). The OMD and SCFA followed the same trend.*
Key words: *Sweet orange peel meal, in vitro fermentation, in vitro gas production parameters, in vitro gas production characteristics,*

I. Introduction

Increasing demand and consequently high cost of conventional animal feedstuffs in the tropics has created the need for sustained alternatives, particularly natural feed resources indigenous to the region. In Nigeria, ruminants slowly gain weight in the rainy season and rapidly loose it in the dry season, yet in the traditional animal husbandary, ruminants in the tropics especially in Nigeria, are mainly fed with grasses, so that improved livestock production is not likely attainable and sustainable by grasses forage alone (Babayemi and Bamikole, 2006). Babayemi *et al*., (2003) had earlier reported that the forages are unimproved and low in nutritive values during the wet season, while during the dry season proper, they are fibrous, lignified with low protein values and even in short supply. Recently, Lamidi *et al*., (2010) agreed to this by reporting that, the available forages for most part of the year are low in protein content which leads to marked decrease in voluntary intake and digestibility, and subsequently leads to substantial weight loss of the animals during this period. The success of the livestock industry anywhere in the world depends greatly on feed quantity and quality. Ruminants do better when energy and protein rich diets are strategically combined for feeding (Adegbola and Asaola, 1986). However, the expensive nature of conventional feed as a result of competition between man and livestock (Ogunbosoye and Babayemi, 2010), makes this combination difficult. Thus, there is the need to source for locally available feedstuffs which are less expensive and viable. In Nigeria, sweet orange (*Citrus sinensis*) peels is one such agricultural by-product. *In vitro* gas production technique is a quick, cheap and accurate method of assessing nutritive values of feedstuff (Menke *et al*., 1979). It involves volumetric measurement of gas production in phosphate and bicarbonate buffered *in vitro* incubation in syringes. Although, gas produced during rumen fermentation are waste products and of no nutritive value to the ruminants, gas production tests are used routinely in feed research as gas volumes are related to both the extent and rate of substrate degradation (Blummel *et al*., 1997). This study was therefore designed to assess the chemical composition, *in vitro* gas production parameters and *in vitro* gas production characteristics of diets containing varying levels of sweet orange (C*itrus sinensis*) peel meal

II. Material and Method

Sweet orange peels were collected from sweet orange retailers who peel and sell oranges for direct consumption. They were sun-dried on concrete floor for 48 hrs and when dried, it was packed and crushed using a mortar and pestle and packed into synthetic bags. Four diets were compounded to contain 0%, 12.5%, 25% and 50% SOPM designated as treatment 1, 2, 3 and 4 respectively. Sample from each treatment was ground in a hammer mill to pass through a 1mm sieve. Each sample was analysed for crude protein, crude fibre, ether extract and ash according to the method of AOAC (1995). The *in vitro* gas production volume was determined

according to Menke and Steingass (1988). Rumen liquor was obtained from four male West African dwarf goats in the morning before feeding. 200mg of each sample was placed in a 120ml calibrated syringe in triplicates and 30ml innoculum containing cheese strained rumen liquor and buffer solution in a ratio of 1:4 was added to the 200mg of feed in the plastic syringes. Metabolizable energy (ME/MJ/kgDM) and organic matter digestibility (OMD%) were estimated as established by Menke and Steingass (1988), while short chain fatty acids (SCFA) were calculated as described by Getachew *et al*. (1998). Gas production characteristics were estimated using the equation $Y= a+b\ (1-e^{-ct})$ (Orskov and MacDonald, 1979), where Y = volume of gas produced in time t, a = gas produced from the soluble fraction, b = gas produced from the insoluble but fermentable fraction, c = gas production rate constant for the insoluble but fermentable fraction 'b' while t = incubation time. Metabolizable energy (ME, MJ/kgDM) and organic matter digestibility (OMD, %) were estimated as established by Menke and Steingass, 1988) and short chain fatty acids (SCFA) were computed as reported by Getachew *et al*. (1998).
$ME = 2.20 + 0.136GV + 0.057CP + 0.002CF$, $OMD = 14.89 + 0.889GV + 0.45CP + 0.651XA$
$SCFA = 0.0239GV - 0.0601$, Where GV, CP, CF and XA = gas production volume (ml/200mgDM), crude protein (%), crude fibre (%) and ash (%) of the incubated sample.

Data collected were subjected to analysis of variance (ANOVA) using the Minitab (1991) software in completely randomized design. Significant differences were separated using the least square difference (LSD) as outlined by Akindele (1996).

III. Results and discussion

Table 1 presents the gross and chemical composition of the four diets. Crude protein values were between 14.72-16.41%, D_1(16.41%), D_2(16.00%) and D_3(16.23%) had similar values while D_4(14.72%) was lower. This was probably so because of the higher percentage of SOPM in D_4 and also that SOPM is lower in CP than maize offal. Observed values were comparable to 16.97 -17.48% reported by Arigbede *et al*. (2010) for diets containing graded levels of cocoa yam. Crude fibre values ranged between 11.05-14.22%, while the NFE was 40.61- 45.84%. The NFE values indicated that there was sufficient fermentable carbohydrates in the diets for energy production. Nitrogen free extract values were highest in D_4(54.93) this may be as a result of the higher level of SOPM in D_4. Observed NFE values were comparable with 42.87-43.77% reported by Ukanwoko *et al.* (2009) for WAD goats fed cassava peel-cassava leaf meal, but it was higher than 28.04-32.97% reported by Maigandi and Abubakar (2004) for diets containing *Faidherbia albida* pods. Ash values which were between 9.01-9.82% indicated that, there was appreciable amount of minerals in the diets. Table 2 presents the *in vitro* gas production volumes, metabolisable energy, organic matter digestibility and short chain fatty acid of the diets containing varrying levels of sweet orange peel meal. Values of IVGP for D_4(24.67ml/200mgDM) was significantly higher ($p<0.05$) than those of D_1(15.33ml/200mgDM) D_2(17.33ml/200mgDM) and D_3(20.33ml/200mgDM). This means that more carbohydrate fermentation took place in D_4(50%SOPM) and also that D_4 had higher nutritive potentials than the other diets. The ME values were 5.30-6.50 MJ/kgDM, OMD was 40.57-49.18% and SCFA was 0.30-0.53 mmol/200mgDM. Diet 4 was significantly higher ($p<0.05$) in ME, OMD and SCFA, implying that D_4 had higher energy potentials than the other diets because high ME and SCFA implies energy availability. This agrees with the report of Sallam *et al*. (2007) that, high SCFA is an indicator of energy availability. Observed ME, OMD and SCFA values were comparable with the report of Abegunde *et al.* (2010) who reported 4.45-5.99 MJ/kgDM, 38.32-50.33% and 0.25-0.51 mmol/200mgDm for ME, OMD and SCFA respectively for *Ficus exasperata* diets. Table 3 shows the *in vitro* gas production characteristics of the experimental diets. The gas production characteristics of the diets did not show any significant difference ($p>0.05$) among the treatments. The soluble fraction 'a' (6.08-8.25ml/200mgDM) and the potential gas production 'b' (16.23-30.88ml/200mg) were all similar. This indicates that there was no difference in nutritive value among dietary treatments in the soluble carbohydrates and the insoluble but fermentable carbohydrates. The 'b' values were comparable with 19.00-26.00ml/200mgDM reported by Binuomote *et al*. (2010) for ensiled cassava tops and guinea grass mixture. The rate constant of fermentation 'c' for D_1-D_4 which ranged between 0.03-0.07ml/hr was comparable with 0.04-0.06ml/hr reported by Binuomote *et al*. (2010) for ensiled cassava tops and guinea grass mixture.

IV. Conclusion

In vitro gas production parameters improved with increasing levels of SOPM in the diets, while there was no treatment effect on the gas production characteristics. The study showed that treatment with the highest percentage of SOPM had the highest energy potential, and increasing the levels of the test ingredient in the diets did not exert harmful effect on the activities of the rumen micro-organisms so as to cause retardation.

Table 1: Gross and chemical composition of experimental diets fed to West African Dwarf goats (DM basis)

Feed Ingredients	Experimental Diets			
	D_1	D_2	D_3	D_4
Rice offal	20.00	20.00	20.00	20.00
Maize offal	48.81	42.71	36.61	24.41
Sweet orange peel meal	0	6.10	12.20	24.40
Full fat Soyabean meal	28.19	28.19	28.19	28.19
Bone ash	2.00	2.00	2.00	2.00
Common salt	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00
Determined				
Crude prorein	16.41	16.00	16.23	14.72
Crude fibre	14.22	13.16	11.05	12.27
Ether extract	9.55	7.58	8.67	6.02
Nitrogen free extract	50.81	53.84	54.93	57.93
Ash	9.01	9.42	9.12	9.82

DM= Dry matter, T1 = 0%SOPM, T2 = 12.5%SOPM
T3 = 25%SOPM, T4 = 50%SOPM

Table 2: *In vitro* gas production, metabolisable energy, organic matter digestibility and short chain fatty acid of diets containing graded levels of sweet orange peel meal

	In vitro parameters			
Diets	IVGP	ME (MJ/kgDM)	OMD (%)	SCFA (µmol/200mgDM)
D_1 (0% SOPM)	15.33^b	5.30^c	40.57^c	0.30^d
D_2 (12.5% SOPM)	17.33^b	5.52^{bc}	42.42^{bc}	0.35^b
D_3 (25% SOPM)	20.33^b	5.39^b	41.41^b	0.32^c
D_4 (50% SOPM)	24.67^a	6.56^a	49.18^a	0.53^a
SEM	2.08*	0.08*	0.51*	0.01*

a,b,c = Means on the same column with different superscripts are significantly different ($p<0.05$)
* = significant ($p<0.05$), SEM = Standard error of the mean, IVGP = *In vitro* gas production
ME = Metabolisable energy, OMD = Organic matter digestibility, SCFA = Short chain fatty acid, and SOPM = Sweet orange peel meal.

Table 3: *In vitro* gas production characteristics of the experimental diets (ml/200mgDM)

Fermentation Characteristics	Treatment diets				
	D_1	D_2	D_3	D_4	SEM
a	7.81	8.25	6.08	7.70	1.37^{ns}
a + b	24.04	27.49	23.79	38.59	10.17^{ns}
B	16.23	19.20	17.70	30.88	9.15^{ns}
C	0.05	0.03	0.07	0.05	0.01^{ns}
Lag	8.58	8.30	5.30	5.40	2.02^{ns}

^{ns} = Not significant, SEM = Standard error of the mean
a = Soluble fraction
a + b = Potentially degradable fraction
b = Potential gas production
c = Rate of fermentation constant

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