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In Vitro Fermentation Characteristics of Some Chaffs, Leaves and Peels as Potential Feedstuffs for Ruminants

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Abstract

Alternative feedstuffs are necessary due to the stiff competition between man, animal and the industries for the limited conventional feedstuffs. This also leads to ruminants losing the weight they gained in the rainy season. To achieve sustainable animal agriculture in Africa through (sustainable development goals) SDGs 1, 2, 3 and 6, the *in vitro* gas production at 24 hours (IVGP), metabolizable energy (ME), organic matter digestibility (OMD) and short-chain fatty acids (SCFA) of seven chaffs, four leaves and nine peels which are mainly 'waste' were studied. These materials were subjected to *in vitro* fermentation using rumen fluid from goats before their morning feeding. The rumen liquor was collected into the thermos flask pre-warmed to a temperature of 39ºC. Feedstuffs and inoculums were incubated using 120 ml syringes. ME, OMD, IVGP and SCFAs were estimated at 24 hours post gas collection according to standard procedures. A completely randomized design (CRD) was used. Data were subjected to a one-way analysis of variance (ANOVA). Means with significant differences were separated using Duncan Multiple Range Test contained in SPSS version 20. *In vitro* gas production (%) from chaffs ranged from (12.0-36.67), leaves (18.0–29.33), and peels (13.33-38.67), while the highest value was discovered in mango peels and the lowest was in groundnut testa. The values for ME (MJ/kg DM), OMD (%), and SCFA (μmol) ranged from 4.71-8.0, 31.83–53.91, and 0.23-0.86, respectively. The values showed a significant difference ($p < 0.05$), with the highest ME and OMD found in orange peels while the lowest was in groundnut shells, which may be due to the anti-nutritive factors present in them. Mango peel gave the highest SCFA, while the lowest was in groundnut testa. The high gas production, ME, and OMD observed in the feedstuffs may be because of the high crude fiber and crude protein in them, which is indicative of the nutritive value of the residual feedstuffs and could serve as potential supplement for ruminants. It is concluded from this study that the feedstuffs studied are rich enough to meet the nutrient requirements of ruminants when fed to them.

Keywords: Ruminants; Chaff; Leaves; Peels; Metabolizable energy

Abbreviations: IVGP: *In vitro* Gas Production; ME: Metabolizable Energy; OMD: Organic Matter Digestibility; SCFA: Short-Chain Fatty Acids; CRD: Completely Randomized Design; ANOVA: Analysis of Variance

Introduction

In the tropical region of Africa, malnutrition is one of the factors that affect livestock productivity, which is generally due to inadequate availability of the required feeds and feedstuff especially during the dry season. This period is characterized by insufficient feeds and consequently limited forage and fibrous hay for ruminants' nourishment [1]. Many negative effects had been observed in these stressful circumstances of the animal, such as increase in mortality rate, loss of weight, reduction in the milk production, and disease transmission because of low immunity of the livestock due to inadequate nutrition [2]. This situation had necessitated the herders to travel far distances in search of green pastures for their livestock [3], which has made them incur so many losses of the animal. During this dry season that is usually long and characterized with inadequate forage or fibrous hay, there is need to supplement the livestock feeds with byproduct feedstuffs like residual chaff, peels and leaves. By-product feedstuffs that are readily available locally are frequently a practical alternative for feeding ruminants because the rumen microbial ecosystem can use the feedstuffs, which usually contain high levels of structural fiber, to meet their nutrient needs for upkeep, growth, reproduction, and production [4]. Livestock feeding on these alternate feedstuffs reduces their dependent on grains that could be consumed by human and eliminate the need for expensive waste management programs, which has grown increasingly crucial in recent years as the global population has grown and the volume of agricultural and food byproducts has increased, especially in developed nations [4]. Despite the importance of these alternative feedstuffs in livestock feeding, there is still paucity of research to evaluate the nutritive value of most of them. Therefore, emphasis should be placed on the protein value and the indigestibility of these feedstuffs to obtain better predictions on their nutritive potentials from the laboratory analysis [5]. There is a great deal of information accessible on grasses and legumes but limited to alternate feedstuffs.

In vitro fermentation procedure is the rapid method of evaluating and confirming the nutritional qualities of feedstuffs [4]. *In vitro* gas production is a reliable approach for predicting feed intake, digestibility, microbial nitrogen supply, and animal performance [6]. With the values of crude protein, crude fat, crude fiber, and crude ash in the feedstuffs, the assessment system uses the volume of gas produced in a stipulated time from the specified quantity of dry matter to determine the amount of metabolizable energy [5]. Methane is a vital gas produced by the ruminants at fermentation and it has been reported by researchers to be an energy loss to the animal and when released to the environment, it contributes to ozone layer depletion [2]. But this *in vitro* fermentation technique could be used to determine the volume of methane discharged by the ruminants. This study therefore focuses on evaluating and validating the nutritive value of different samples of leaves, chaff, and peels from a range of fruits, seeds, root and tuber plants commonly available in Nigeria and using the *in vitro* fermentation techniques to investigate the *in vitro* gas production, metabolizable energy, organic matter digestibility, and short chain fatty acids of the alternative feedstuffs. This will provide valuable insights into the potential of these underutilized feed alternatives as supplements for ruminants during the dry season, contributing to improved animal performance and sustainable livestock farming practices.

Materials and Methods

Collection of Samples

The leaves, chaff and peels were collected when the dry season was highly intense, between the months of February and March 2022 from Teaching and Research Farm, University of Jos, Nigeria. The location is 9° 57′ N and 8° 53′E at altitude 1238.1 above the sea level; mean temperature of 27.5 °C to 30.5 °C and average rainfall of 2000mm. The leaves were gotten from the growing plant in the Faculty of Agriculture University of Jos, farm site. After collection from the farm, they were thoroughly washed and cut into smaller sizes to hasten sun-drying. After complete drying, they were crushed, sieved, and the finer particles were collected into transparent containers for analysis. The chaffs were gotten from the Katako market in Jos, and they were subjected to similar processing of cutting to smaller sizes, sun-drying, crushing, and sieving to obtain finer particles for laboratory analysis of several parameters, while the peels were obtained from the tubers and fruits on the farm site. Then, a clean knife was carefully used to strip the peels off the tubers or fruits. After which, the peels were washed, sun-dried, crushed using a mortar and pestle, sieved, and the smooth-textured powder packaged into transparent containers and labeled to avoid mix-up. These materials were subjected to *in vitro* fermentation using rumen fluid collected from goats before their morning feeding.

In vitro fermentation parameter

In vitro fermentation techniques were carried out in this experiment and the following parameters were measured:

i. First gas (a)
ii. Potential gas production (b)
iii. Potential degradable fractions (a+b)
iv. Rate of gas production (c)
v. Organic matter digestibility (OMD)
vi. Metabolisable energy (ME)
vii. Short chain fatty acids (SCFAs)
viii. Methane (CH_4) production
ix. *In vitro* gas production

In vitro Gas Fermentation Procedure.

Rumen fluid was collected from goats before their morning feeding as described by Babayemi and Bamikole [7], using suction tube. The collected rumen fluid was filtered using a cheese cloth into a pre-warmed thermo flask to a temperature of 39oC. The buffer solution used consists of (g/litre) 9.8 $NaHCO_3$ + 2.77 NaPO4 + 0.5 KCl + 0.47 NaCl + 2.16 $MgSO_4.7H_2O$ + 0.16 $CaCl_2.2H_2O$. Incubation procedure was as reported by Menke and Steingass [8] using 120ml calibrated transparent glass syringes fitted with silicon tube. 200 mg of each sample (in triplicates) was loaded in the syringes. The rumen fluid and the buffer were mixed in ratio of 1:4 (v/v). The 30 ml of the inoculums was drawn into 50 ml glass calibrated syringes; this was then dispensed into the calibrated transparent glass syringes containing the feed samples under continuous CO_2 flushing. Air bubbles were removed from the syringe by gently tapping the syringes and pushing the piston upwards to expel the air. The silicon tubes on the syringes were properly clipped to prevent escape of gas before placement in the incubator. The glass syringes were placed in the incubator at a temperature of 39°C for 24 hours. Gas production was measured

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at 3, 6, 9, 12, 15, 18, 21 and 24 hours. At post incubation period, 4 mL of NaOH (10M) was introduced to estimate methane production as reported by Fievez et al. [9] ME (MJ/Kg) and OMD were estimated as established by Menke and Steingass [8], and SCFAs were calculated as reported by Getachew et al. [10] using 24 hours post incubation. The formulae used for calculations were:

$$ME = 2.20 + 0.136Gv\ 0.057\ CP + 0.0029CF$$

$$OMD = 14.88 + 0.889Gv + 0.45CP + 0.0651\ XA$$

$$SCFA = 0.0239Gv\ 0.0601$$

Where: Gv = Net gas production (ML/ 200 mg DM)

CP = Crude protein

CF = Crude fibre

XA = Ash

Other parameters such as: a, b, a+b and c were derived by calculation, where.

a = First gas

b = potential gas production.

a + b = Potential degradable fractions.

c = Rate of gas production.

Experimental Design and Statistical Analysis

A completely randomized design was used. Data obtained were subjected to Analysis of Variance (ANOVA) and means that were significantly different were separated using Least Significant Difference (LSD), both contained in SPSS for Window, version 20 not 16.

Table 1: IVGP, ME, OMD and SCFA of chaffs as feed resources for ruminants.

	CHAFF								
Parameters	OR	BKT	MO	MC	RMW	GT	PKC	SEM	LoS
IVGP (ml/200mg DM)	36.67^{a}	23.33^{bc}	31.33^{ab}	20.67^{cd}	16.00^{cd}	12.00^{d}	23.33^{bc}	2.00	**
ME (MJ/Kg DM)	7.74^{a}	6.41^{ab}	7.49^{a}	5.65^{bc}	4.96^{c}	4.79^{c}	6.55^{ab}	0.27	**
OMD (%)	51.85^{a}	43.83^{ab}	50.94^{a}	38.01^{bc}	34.39^{c}	34.10^{c}	44.89^{ab}	1.75	**
SCFA (µmol)	0.82^{a}	0.50^{bc}	0.69^{ab}	0.43^{cd}	0.32^{cd}	0.23^{d}	0.50^{bc}	0.05	**

Abbreviations: OR: Orange Residue, BKTW: Burukuru Waste; MO: Maize Offal; MC: Maize cob; RMW: Rice Milling Waste; GT: Groundnut Testa, PKC: Palm Kernel Cake; IVGP: I*n Vitro* Gas Production (at 24hrs); ME: Metabolisable Energy; OMD: Organic Matter Digestibility; SCFA: Short Chain Fatty Acids

Results and Discussion

In Table 1, the *in vitro* gas production, metabolizable energy, organic matter digestibility and the short chain fatty acids values of the different chaff samples are shown. The least (12 ml/24hr) and highest (36.67 ml/24hr) *in Vitro* gas production was in groundnut testa and orange residue respectively. Organic matter digestibility has all high values ranged from (34.10 - 51.85%) which is like the values reported [2]. The metabolizable energy was observed to be least also in ground testa (4.79 MJ/kg DM) and highest in orange residue (7.74 MJ/kg DM) while the short chain fatty acids were generally low in all the samples with the least recorded likewise in groundnut testa. The general low values of ME, OMD & SCFA in groundnut testa could be because of the anti-nutritional factor in it, which also correlates with the report of [11], that low metabolizable energy and organic matter digestibility were generally observed in feedstuffs that are intrinsic with certain anti-nutritional factors. The parameters studied were highest in orange residue and these were also reported [2]. There were significant differences ($p<0.05$) in the ME, OMD and SCFA of the samples studied. However, values for palm kernel cake and burukutu waste were the same for gas production and short chain fatty acids of 23.33 (ml/24hr) and 0.50(µml) respectively.

Table 2 below presents the *in vitro* gas production, ME, OMD and SCFA of different leave samples. The highest (29.33 ml) and least (18.0ml) gas production were observed in maize and cassava leaves respectively, while maize leaves also had the highest value of metabolisable energy, and short chain fatty acids. However, Sweet potato leaves were observed to have the highest organic matter digestibility (50.08%) and the same metabolizable energy value with maize leaves (7.14 MJ/kg DM). Generally, the leave samples have low short chain fatty acids while cassava leaves had the lowest values (0.37%), which is due to the level of anti-nutritional factors i.e. cyanide and tannin etc. Figrue 1 presents the *in vitro* gas production, metabolizable energy, organic matter digestibility and short chain fatty acids of different peels as stated in Table 3 above. As observed in Figure 1, mango peel was discovered to have the highest gas production of 38.67ml/24hrs, though the gas produced by orange peel is very close in value (38ml/24hrs) to it, while the least was found in groundnut shell (13.33ml/24hrs). The metabolisable energy, organic matter digestibility, and short chain fatty acids followed the same trend, with highest values of 8.0MJ/kg DM, 53.91%, and 0.85 µml respectively in orange peels while the least values 4.71 MJ/kg DM, 31.83%, and 0.26 µml respectively were observed in groundnut shell. Generally,

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there were significant differences ($p<0.05$) in gas production, metabolisable energy and short chain fatty acids, amidst the peels studied. The organic matter digestibility obtained in this study for orange peel was relatively high but not as high as the one found previously [5]. The high anti-nutritional factors i.e. phytate and oxalate in groundnut shell could be responsible for the low values in the gas production and likewise in other parameters. This is an important factor as it determines the extent of their fermentation in the rumen of the ruminant [2], because the anti-nutritional factors dissuade bacteria action in the rumen. According to Aregheore and Abdulrazak [11], feedstuffs with certain anti-nutritive characteristics have poor levels of metabolizable energy and organic matter digestibility.

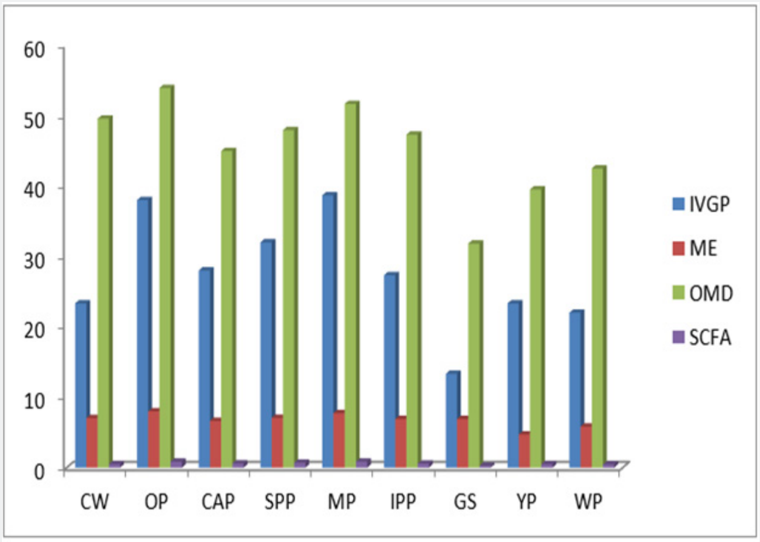

Figure 1: IVGP, ME, OMD and SCFA for peels as ruminant feeds.

Abbreviations: CW: Cabbage Waste; OP: Orange Peel; CAP: Cassava Peel; SPP: Sweet Potato Peels; MP: Mango Peel; IPP: Irish Potato Peels; GS: Groundnut Shell; YP: Yam Peel; WP: Watermelon Peel/Rind; IVGP: *In Vitro* Gas Production (at 24hrs); ME: Metabolisable Energy; OMD: Organic Matter Digestibility; SCFA: Short Chain Fatty Acids.

Table 2: IVGP, ME, OMD and SCFA of leaves as feed resources for ruminants.

LEAVES						
Parameters	ML	CL	SPL	CARL	SEM	LoS
IVGP (ml/200mgDM)	29.33	18.00	24.67	24.00	2.35	NS
ME (MJ/KgDM)	7.14	4.91	7.14	6.85	0.39	NS
OMD (%)	48.85	33.22	50.08	47.82	2.74	NS
SCFA (µmol)	0.64	0.37	0.53	0.51	0.06	NS

Abbreviations: ML: Maize Leave; CL: Cassava Leave, SPL: Sweet Potato Leave; CARL: Carrot leaves; IVGP; *In Vitro* Gas Production (at 24hrs); ME: Metabolisable Energy; OMD: Organic Matter Digestibility; SCFA: Short Chain Fatty Acids

Table 3: IVGP, ME, OMD and SCFA of peels as feed resources for ruminants.

PEELS											
Parameters	CW	OP	CAP	SPP	MP	IPP	GS	YP	WP	SEM	LoS
IVGP (ml/200mgDM)	23.33^{bc}	38.00^{a}	28.00^{ab}	32.00^{ab}	38.67^{a}	27.33^{ab}	13.33^{c}	23.33^{bc}	22.00^{bc}	1.89	**
ME (MJ/KgDM)	7.04^{ab}	8.00^{a}	6.65^{ab}	7.07^{ab}	7.74^{ab}	6.91^{ab}	4.71^{c}	5.84^{bc}	6.16^{abc}	0.24	*
OMD (%)	49.57^{ab}	53.91^{a}	44.96^{ab}	47.63^{ab}	51.66^{ab}	47.30^{ab}	31.83^{c}	39.52^{bc}	42.49^{abc}	1.62	*
SCFA (µmol)	0.50^{bc}	0.85^{a}	0.61^{ab}	0.70^{ab}	0.86^{a}	0.59^{ab}	0.26^{c}	0.50^{bc}	0.47^{bc}	0.05	**

Abbreviations: CW: Cabbage waste; OP: Orange peel; CAP: Cassava peel; SPP: Sweet potato peels; MP: Mango peel; IPP: Irish potato peels; GS: Groundnut shell; YP: Yam peel; WP: Watermelon peel/rind; IVGP: In vitro Gas Production (at 24hrs); ME: Metabolisable Energy; OMD: Organic Matter Digestibility; SCFA: Short Chain Fatty Acids

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Conclusion

The present study demonstrated significant variations in the nutritive parameters among the different samples of chaff, leaves and peels. The high value of *in vitro* gas production, ME, OMD and SCFA observed in the residual feedstuffs are indicative of their potential as viable supplements for ruminants in Nigeria. The richness in crude fiber and crude protein content contributes to their overall nutritive value. Moreover, the higher short-chain fatty acid production observed in mango peels further underscores their potential as a valuable feed option [12-14]. By utilizing these alternative feedstuffs during the dry season, ruminant farmers can mitigate the weight loss typically experienced during this period due to a lack of adequate feed. The utilization of residual chaff, peels, and leaves from various sources offers a sustainable approach to provide additional nutrition to ruminants, thus improving their productivity and overall well-being, and also providing a promising solution to address the feed scarcity challenges faced by ruminant farmers in Nigeria and potentially in similar regions. By so doing, (sustainable development goals) SDGs 1,2,3 and 6 can be met. However, further research is suggested to investigate the specific anti -nutritive factors present in certain feed materials and the strategies to mitigate their effects are essential for optimizing their utilization.

Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

1. Babayemi OJ (2007) *In vitro* fermentation characteristics and acceptability by West African dwarf goats of some dry season forages. Afr J Biotech 6(10): 1260-1265.
2. Babayemi OJ (2006) Anti-nutritional Factors, Nutritive Value and *in vitro* Gas Production of Foliage and Fruit of Enterolobium cyclocarpum. World Journal of Zoology 1(2): 113-117.
3. Iyayi EA, Okoruwa VO, Babayemi OJ, Busari AA, Peters OF (2003) Livestock production pattern of agro-pastoralists in peri-urban centres of southwest Nigeria. Nig J Anim Prod 30(1): 87-92.
4. Bampidis VA, Robinson PH (2006) Citrus by-products as ruminant feeds: A Review. Anim Feed Sci Tech 128: 175-217.
5. Megı´as M, Herna´ndez F, Madrid J, Martı´nez-Teruel A (2002) Feeding value, digestibility and gas production of different by-products for ruminant nutrition. J Sci Food Agric 85(5): 567-572.
6. Blümmel M, Ørskov ER (1993) Comparison of *in vitro* gas production and nylon bag degradability of roughages in predicting feed intake in cattle. Anim Feed Sci Tech 40(2-3): 109-119.
7. Babayemi OJ, Bamikole MA (2006) Effects of Tephrosia candida DC leaf and its mixtures with Guinea grass on *in vitro* fermentation changes as feed for ruminants in Nigeria. Pak J Nutrition 5(1): 14-18.
8. Menke KH, Steingass H (1988) Estimation of the energetic feed value from chemical analysis and *in vitro* gas production using rumen fluid. Anim Res Devt 28: 7-55.
9. Fievez V, Babayemi OJ, Demeye D (2005) Estimation of direct and indirect gas production using syringe: A tool to estimate short chain fatty acids production that requires minimal laboratory facilities. Animal Feed Sci Tech 123-124: 197-210.
10. Getachew G, Makka HPS, Becker K (1999) Stoichiometric relationship between short chain fatty acid and *in vitro* gas production in presence and absence of polyethylene glycol for tannin containing browses, EAAP Satellite Symposium, Gas production: fermentation kinetics for feed evaluation and to assess microbial activity, Wageningen, The Netherlands.
11. Aregheore EM, Abdulrazak SA (2005) Estimation of organic matter digestibility and metabolizable energy content of agro-industrial wastes using *in vitro* gas production. Nig J Anim Prod 32 (1): 79-87.
12. AOAC (1990) The Official Methods of Analysis. Association of official Analytical Chemists, (15th edition), Washington DC.
13. Babayemi OJ, Demeyer D, Feivez V (2004) *In-vitro* rumen fermentation of tropical seeds in relation to their content of secondary metabolites. J Anim Feed Sci 13(1): 31-34.
14. Durmic Z, Hutton P, Revell DK, Emms J, Hughes S, et al. (2010) *In vitro* fermentative traits of Australian woody perennial plant species that may be considered as potential sources of feed for grazing ruminants. Anim Feed Sci Tech 160: 98-109.

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