EVALUATION OF NUTRITIVE VALUE OF SOME AGRICUTURAL BY-PRODUCTS AS OFF SEASON FEED SUPPLEMENTS FOR RUMINANTS

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ABSTRACT

This study assessed the nutritive value of some selected agricultural by-products (ABPs) using In vitro gas production (IVGP) method on cowpea (Vigna unguiculata) husk, cocoa (Theobroma cacao) pod and corn (Zea mays) cob. Two experiments were conducted. Experiment 1, determined the chemical composition of cowpea husk (CH), cocoa pod (CP) and corn cob (CC). In experiment 2, the nutritive value of these agricultural wastes was assessed by in vitro gas production method for total gas production over a period of 24 hours and to predict organic matter digestibility (OMD), metabolizable energy (ME) and short chain fatty acid (SCFA). Methane volume (CH4) was measured after 24hr incubation period. The in vitro gas production characteristics: soluble degradable fraction (a), insoluble degradable fraction (b), potential degradability (a+b) and rate of degradation (c) were also predicted. Results revealed that the chemical composition of CH, CP and CC varied significantly ($p<0.05$). The crude protein values ranged from 4.83 - 6.69% in CC and CH, while neutral detergent fibre ranged from 52.85 - 60.39% in CC and CP respectively. The IVGP parameters differed significantly ($p<0.05$) except methane production that was similar. IVGP characteristics were also significantly ($p<0.05$) different. It was concluded that CH, CP and CC are potential feed in ruminant nutrition, if treated to improve the nutrient content.

Key words: Agricultural wastes, Chemical composition, *In vitro* gas production, Nutritive value, Ruminant.

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INTRODUCTION

In Nigeria, large quantities of agricultural residues and agro-industrial wastes are generated and most of these are regarded as wastes and non-conventional feed stuffs (Sadh *et al*., 2018). They generate huge volumes of solid wastes which are allowed to accumulate thereby constituting menace to the environment (Bracco *et al*., 2018). Among the common agro wastes in Nigeria are rice bran, maize husk, corn cobs, cassava peels, palm kernel wastes, cocoa pods and shells and cowpea husk (or shell). Unfortunately, the mismanagement of these volumes of crop residues are the cause of human and environmental health challenges and are also one of the major causes of elevated CO_2 emissions, adding up to the global warming issues experienced all over the world today. (Kolawole *et al.,* 2024). It also poses threat to food and energy security (Babu *et al.*, 2022). Maize residues were estimated to be about 4.11 million tonnes, often consists mainly of straw, husk, skins and trimmings, cobs and bran. These residues which are often either burned or plough into the soil account for almost 25% of the total energy suitable for ruminant livestock (Akinfemi *et al.,* 2009). On one hand, Cocoa by-products consist of cocoa pod husk (CPH), cocoa shell, and pulp, of which about 70 % of the fruit is composed of CPH, a renewable resource, rich in dietary fiber, lignin, and bioactive antioxidants like polyphenols that are being underutilized. (Anoraga *et al.,* 2024). On the other hand, research reveals that Nigeria is the largest producer and consumer of cowpea with a total of 68% production in Africa and leading with a 58% production in the world, generating a volume of waste totaling 58% of cowpea husk waste. Yet, this waste is still being underutilized (Alayande *et al.,* 2011). A successful exploitation of agricultural wastes as livestock feed supplements will not only remove the menace of disposal, greenhouse gas emission and improve environmental sanitation but also provide economically utilizable products (Scarlet *et al.*, 2015). While disposal of many of these wastes in the years past has been a thorny issue for environmentalists (Abiola-Olagunju *et al.,* 2020). In Nigeria, research has been conducted on the use of this enormous agricultural waste by several researchers, but there are little or no practical conversion of this agricultural waste to useful products on a commercial scale (Kolawole *et al.,* 2024). Therefore, there is the need to determine the nutrient components of these wastes or by products. This study aimed at determining the nutritive value of cowpea husk, cocoa pods and corn cobs as off- season feed for livestock.

MATERIALS AND METHODS

Sample Collection

Dry samples (2-3kg) of corn cobs, were randomly collected from maize farm at the Teaching and Research farm of the College of Agriculture and Hospitality Management, Tai Solarin University of Education, Ijagun, Ogun State, Nigeria, while same quantity of dry samples of cocoa pods and cowpea husk were purchased from Oke-Aje market in Ijebu-Ode also in Nigeria.

Sample Preparation

The cocoa pods, cowpea husk and corn cobs were cleaned by dusting, then pulverized using a hammer mill, then dried by aerating at room temperature of 25^0C. Then 2kg of each sample was packaged in an air tight container and taken to the laboratory for Chemical analysis.

In vitro gas fermentation Procedure

Rumen fluid was obtained from three West African Dwarf female sheep through suction tube before the morning feed. The animals were fed concentrate consisting of 40% corn bran, 35% wheat offal, 20% palm kernel cake, 4% oyster shell, 0.5% salt and 0.5% grower premix for three days prior to the collection of rumen liquor. Incubation was as described by (Menke and Steingass, 1988) using 120 ml calibrated syringes in three batch incubation at 39^0C. 30 ml inoculums was introduced into 200 mg samples in the syringes containing cheese cloth strained rumen liquor and buffer ($NaHC0_3 + Na_2HP0_4 + KCl + NaCl + MgS0_4. 7H_20 + CaCl_2. 2H_20$) · (1:2, v/v) under continuous flushing with $C0_2$. Gas production was measured at 3, 6, 9, 12, 15, 18, 21 and 24, after 24h of incubation, 4 ml of NaOH (10 M) was introduced to estimate the amount of methane produced. The average of the volume of gas produced from the blanks was deducted from the volume of gas produced per sample. The volume of gas produced at intervals was plotted against the incubation time, and from the graph, the gas production characteristics were estimated using the equation Y= a+b (1-e-ct) described by Orskov and McDonald (1979) where: Y=

volume of gas produced at time 't', a = intercept (gas produced from insoluble fraction), c = gas production rate constant for the insoluble fraction (b), t = incubation time, metabolizable energy (ME, MJ /Kg DM) and organic matter digestibility (OMD, %) were estimated as established by Menke and Steingass (1988) and short chain fatty acids (SCFA, umol) was calculated as described by Getachew *et al*. (1999)

- ME = 2.20 + 0.136*GV + 0.057*CP + 0.0029*CF
- OMD = 14.88 + 0.889GV + 0.45CP + 0.651XA
- SCFA = 0.0239*GV – 0.0601

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

Chemical Analysis

Proximate component such as crude protein, crude fiber, ether extract and total ash of samples were analyzed in triplicate using standard procedure of AOAC (2012). The crude protein was determined with the micro kjeldahl distillation apparatus, while chemical component of neutral detergent fiber, and acid detergent fibre and lignin were determined by Van Soest method (1995).

Mineral Analysis

A total of eight minerals were assayed. All the three (3) samples (cowpea husk, cocoa pod and corn cobs) were digested with HNO_3, $HClO_3$ mixture (nitric acid, perchloric acid) (20:5v/v).The digest was made up to 100ml in standard volumetric flask with deionizer water. Ca, P, K, Mn, Zn, Mg, Fe, and Cu in the digest were determine with the atomic absorption spectrophotometer model 420 (Gallenk CMP and CO LTD) while phosphorus in the digest was estimated with vanadomolybrate solution. The color so developed was read with spectrophotometer at 420m/u.

Statistical Analysis

Data obtained were subjected to analysis of variance procedure (ANOVA) of SAS (2012). Means were separated using Duncan's multiple range test of the same software package.

RESULTS AND DISCUSSION

Proximate Composition of Selected Agricultural By-products

The proximate composition (%) of some selected agricultural by-products is as shown in Table 1 below. It was observed that all parameters analyzed ranged significantly (P<0.05) among treatment means. The highest (92.40 %) value for dry matter was recorded for cocoa pod, while the lowest (91.33 %) was recorded for corn cobs. This result is in agreement with the findings of Ettu and Mako (2020) who reported values of 85.55 to 92.18 % dry matter for some crop residues (Yam peel, Maize chaff and Rice straw). Crude protein (CP) content of these agricultural by-products ranged from 4.83% in corn cobs to 6.69 % in cowpea husks. These results are is in agreement with the findings of Ettu and Mako (2020) who reported a value range of 4.00 – 5.10 % for Yam peel, Maize chaff and Rice straw, but lower than the value range of 13.80 – 30.12 % reported for corn bran, soybean cheese waste, shea nut cake and rice bran (Ogunbosoye and Salau, 2020). It was observed that the CP content of all agricultural by-product analyzed are low and fall below the 7-8% recommended level for microbial activity (NRC, 2002). However, these wastes can be subjected to treatment to improve the nutrient content. Mako *et al.* (2019) degraded water hyacinth with white rot fungi to improve the nutrient content. The ether extract, ash and NFE content ranged from 1.18 to 1.88 % in CH and CP; 6.24 to 15.39% in CC and CP; 52.00 to 66.88% in CP and CC respectively.

These values are within the value range reported by Ettu and Mako, (2020).

Fibre fractions of selected agricultural by-products

The fibre factions of agricultural by-products are represented in Table 2. It was observed that all parameters analyzed ranged significantly (p<0.05) among treatments. Neutral detergent fibre (NDF) ranged from 52.85 to 60.39 % in corn cobs and cocoa pods respectively, same trend was observed for Acid detergent fibre (ADF) and Acid detergent lignin (ADL). These values are higher and at variance with the values reported for corn bran, soybean cheese waste, shea nut cake and rice bran (Ogunbosoye and Salau, 2020). However, the values are within recommended level 55-60 % that will enhance feed intake and increase productivity of ruminants (Messiner, 1991).

Table 1: Chemical composition (%) of selected agricultural by-products

Samples	DM	CP	CF	EE	ASH	NFE
Cocoa pods	92.40[a]	6.16[b]	24.58[a]	1.88 [a]	15.39 [a]	52.00[c]
Cowpea husk	91.92[b]	6.69[a]	21.21[b]	1.18[c]	8.21[b]	62.73[b]
Corn cobs	91.33[c]	4.83[c]	20.37[c]	1.62[b]	6.24[c]	66.88[a]
SEM	0.05	0.02	0.02	0.01	0.03	0.05

[a-c]Means on the same column differ significantly(p<0.05)
SEM = Standard error of means; DM=Dry matter, CP = Crude protein, CF = Crude fibre; EE = Ether extract; NFE = Nitrogen free extract.

Table 2: Fibre fraction (%) of selected agricultural by-products

Sample	NDF	ADF	ADL
Cocoa Pod	60.39[a]	47.09[a]	23.18[a]
Cowpea husk	53.47[b]	33.48[b]	14.69[b]
Corn cobs	52.85[c]	31.92[c]	13.53[c]
SEM	0.11	0.01	0.07

[a-c]Means on the same column with different superscript differ significantly (p<0.05)
NDF = Neutral detergent fibre; ADF = Acid detergent fibre; ADL = Acid detergent lignin; SEM = Standard Error of Mean.

Macro and Micro Mineral Content of Agricultural By- products

Table 3 presents the macro (g/100g DM) and micro mineral (mg/kg) contents of selected agricultural by-products. It was observed that all minerals analyzed varied significantly (p < 0.05) amongst the treatment means. Calcium (Ca) ranged from 0.285 in cocoa pod to 0.306 g/100g DM in cowpea husk. The same trend was observed for phosphorus (P), potassium (K) and magnesium (Mg) that ranged from 0.372 to 0.383; 0.678 to 0. 944 and 0.301 to 0.318 g/100g DM respectively. The cowpea husk recorded the highest micro minerals content in all the minerals analyzed, expect for copper. It ranged from 53.47 – 57.47; 63.43 – 67.57 and 137. 47 - 143.27 mg/kg in corn cobs and cowpea husk for manganese, zinc and iron respectively. The macro and micro mineral content obtained here compared well with findings of Abubarkar *et al*., (2016), and are within the required level that meets the requirement of sheep and goat (NRC, 2002).

In-vitro gas production parameters of selected agricultural by-products

Table 4 presents the *in-vitro* gas production parameters of agricultural by-products. It was observed that all parameters analyzed varied significantly (p < 0.05). OMD, ME and SCFA ranged from 28.52 to 34.78% in cowpea husk and cocoa pod, 3.47 to 3.71 MJ/kg DM in corn cobs and cocoa pods; 0.083 to 0.139 mmol in corn cobs and cowpea husk respectively. These values are lower and at variance with the value range 35.13 to 64.14%, 5.32-11.12 MJ/kg DM and 0.50 to 1.12 mmol respectively, reported for yam peel, maize chaff and rice bran by Ettu and Mako, 2020. The metabolizable energy and organic matter digestibility are sources of energy to animals. Feed samples that possess some anti-nutritional factors have been reported to be low in ME and OMD (Aregheore and Abdulrazak, 2005), this might be responsible for the fairly low ME and OMD obtained in this study. The short chain fatty acids are the primary end-products of fermentation of non-digestible carbohydrates (NDC) that become available to the microbiota, it is also a source of energy to ruminant animals.

Table 3: Macro (g/100g DM) and Micro(mg/kg) mineral contents of agricultural by-products

Agricultural by-products	Macro-minerals (g/100g DM)				Micro-minerals (mg/kg)			
	Ca	P	K	Mg	Mn	Zn	Fe	Cu
Cocoa pod	0.285^{b}	0.372^{b}	0.678^{c}	0.310^{a}	56.80^{a}	64.97^{b}	141.73^{b}	19.60^{a}
Cowpea husk	0.306^{a}	0.383^{a}	0.944^{a}	0.318^{a}	57.47^{a}	67.57^{a}	143.27^{a}	19.47^{a}
Corn Cobs	0.293^{b}	0.375^{b}	0.932^{b}	0.301^{b}	53.47^{b}	63.43^{c}	137.47^{c}	18.47^{b}
SEM	0.002	0.010	0.081	0.001	0.113	0.096	0.129	0.079

$^{a-c}$Means on the same column with different super scripts differ significantly (p<0.05).
SEM= Standard error of mean.

Table 4: *In-vitro* gas production parameters of selected agricultural by-products

Samples	ME (MJ/Kg DM)	OMD (%)	SCFA (mmol)
Cocoa Pod	3.71^{a}	34.78^{a}	0.131^{a}
Cowpea husk	3.67^{ab}	28.52^{b}	0.139^{a}
Corn cobs	3.47^{b}	28.57^{b}	0.083^{b}
SEM	0.04	0.26	0.01

$^{a-c}$Means on the same column with different super scripts differ significantly (p<0.05), ME = Metabolizable energy (MJ/Kg DM); OMD = Organic matter digestibility; SCFA = Short chain fatty acids (mmol); SEM = Standard error of mean.

In vitro gas fermentation characteristics of selected agricultural by-products

Table 5 presents the *in vitro* gas fermentation characteristics of selected agricultural by products. It was observed that the ‘a’ fraction (soluble degradable) and ‘b’ (insoluble degradable) fractions were significantly (P<0.05) different among the treatment means. Similar values of 0.67 ml were obtained for ‘a’ fraction for cocoa pods and cowpea husk. This value is lower than the value range of 5.67-12.33 ml/200mg DM reported for corn bran, soybean cheese waste, shea nut cake and rice bran (Ogunbosoye and Salau, 2020). This fraction is the fraction that the rumen microbe ferment first to obtain energy.

The ‘b’ fraction is the fraction that is insoluble but degradable. The value range of 6.00 to 7.67ml/200mg DM obtained here are also within the value range of 6.00-15.00 ml/200mgDM reported by Ogunbosoye and Salau (2020) for corn bran, soybean cheese waste, shea nut cake and rice bran. Cowpea husk recorded the highest value for fractions ‘a’ and ‘b’ (0.67 and 7.67 ml) respectively, this indicates its fast degradability among the agricultural wastes investigated. The lowest values of both parameters were recorded for corncobs.

The a+b indicates the potential degradability of the wastes and significant variation was observed for this parameter, with cowpea husks recording the highest value of 8.33ml/200mg DM while the lowest value 6.00ml/200mgDM was obtained for corn cobs. The rate of degradation did not vary significantly among treatment means here, the low degradability of these wastes is an indication of the presence of some anti-nutritional factors like theobromine in cocoa pods, lectins, tannins and oxalate in cowpea husk and phytate in corn cobs which can inhibit microbial activity in fermentation, protein breakdown, methane synthesis and the ability to reduce food-borne pathogens (Addisu, 2016). This will negatively impact nutrient availability, digestibility and utilization.

Table 5: *In-vitro* gas production characteristics of some agricultural by-products

Samples	A	B	a+b	C
Cocoa Pod	0.67^{a}	7.33^{ab}	8.00^{ab}	0.05
Cowpea husk	0.67a	7.67^{a}	8.33^{a}	0.05
Corn cobs	0.01^{b}	6.00^{b}	6.00^{b}	0.05
SEM	0.157	0.369	0.294	0.008

$^{a-c}$Means on the same column with different super scripts differ significantly (p<0.05), 'a'=soluble degradable fractions (ml/200mgDm);'b'= insoluble but degradable(ml/200mgDm); a+b= potentials degradability(ml/200mgDm); c =rate of degradation ml/hr; SEM = Standard error of mean.

Cumulative in vitro gas production of selected agricultural by products

Figure 1 presents the cumulative *in vitro* gas production of selected agricultural by products. It was observed that gas production varied significantly (p<0.05) among the wastes investigated. The highest (8.33ml) gas was produced by corn cobs at 24hrs, while the least (6.00ml) was produced by cowpea husk at 24hrs.The rate and extent of gas production can be considered a good indicator of the digestibility and fermentation of feeds and microbial protein synthesis (Elghandour *et al.,* 2015). Gas production is an indication of feed stuff degradation (Arifuddin *et al.,* 2016), therefore the degradation observed in the agricultural wastes investigated here is an indication that cowpea husk, cocoa pods and corn cobs are potential feed supplement for ruminants especially during off seasons.

Methane Production of Cowpea husk, Cocoa pods and Corn cobs

Figure 2 presents the methane produced from the selected wastes investigated. Significantly variation (p<0.05) was observed. It ranged from 2.00 ml in corn cobs to 3.00 ml in cowpea husks. This result is lower than the range of 2.5 to 5.5ml reported by Ogunbosoye and Salau, (2020) for some selected agro-industrial by products. Methane production is of no use to ruminants, it is a waste of energy and contributes to green- house gas emission (Yaman, 2020) in which its production into the atmosphere depletes the ozone layer which is a factor in climate change.

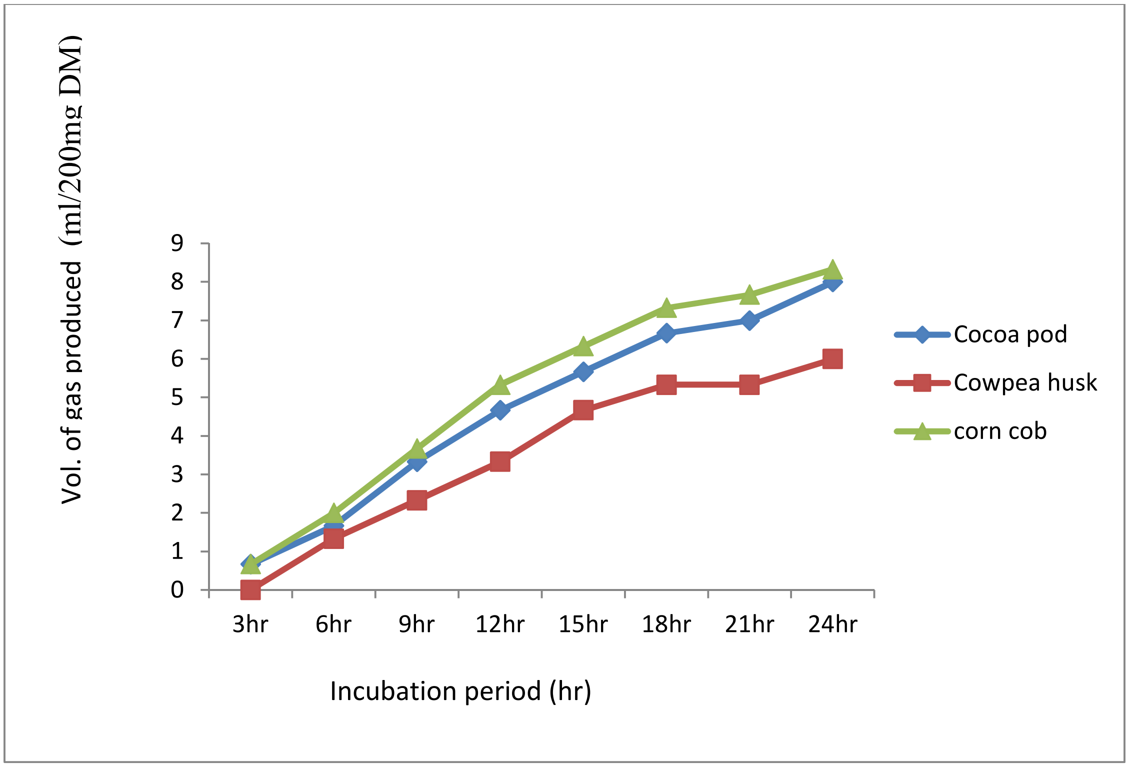

Figure 1: *In vitro* gas production (ml/200mg DM) of agricultural by-products

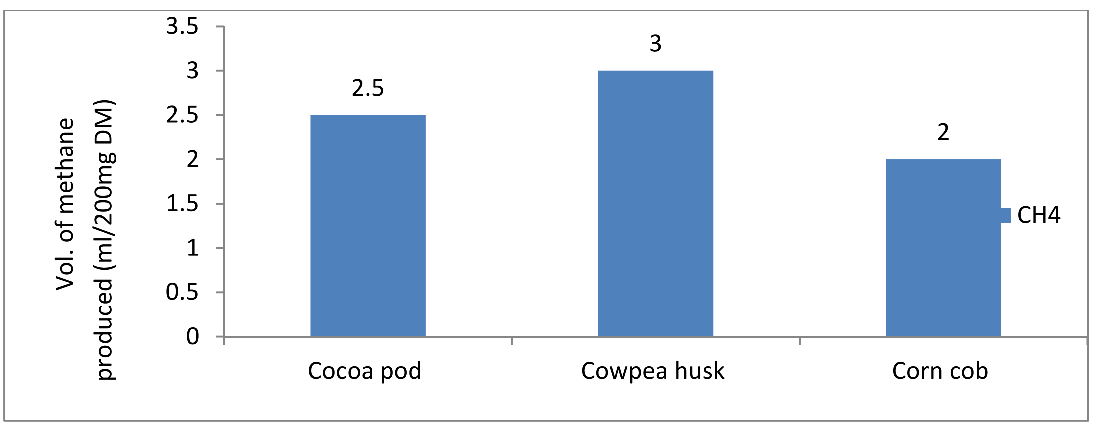

Figure 2: Methane production (ml/200mg DM) of agricultural by products

CONCLUSIONS

- The nutrient content and gas volume of individual ingredient is an indication that these agricultural wastes could be potential feed resources for improved ruminant production.
- The CP content of all wastes is below recommended value of 7% that can provide the minimum requirement for microbial activity.
- It is therefore not suitable to feed any of these ingredients solely, but probably in combination with other feed resources for efficient and increased production.

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