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Nutritional potentials and in vitro estimation of composite cocoa pod husk-based diets for ruminants

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Abstract

Background: The use of cocoa pod husk in livestock nutrition is being limited because of its fibrous nature and anti-nutrients, which have detrimental effect(s) on the animals. This study was conducted to evaluate the nutritive value and effects of replacing urea-treated ensiled cocoa pod husk meal (urea-treated CPHM) with cassava peel in a complete concentrate diet (CCD) on in vitro digestibility and methane (CH₄) production.

Methods: Urea-treated CPHM was prepared by soaking the raw milled pod in 5% urea solution under anaerobic condition for 7 days, and decanted and the filtrates were further ensiled for 28 days, dried, and were replaced with cassava peel meal in CCD at 0, 5, 7.5, 10, 12.5, and 15% on part basis. Feed samples ($n = 3$) were analyzed for chemical composition, and data generated from in vitro study were subjected to statistical analysis in a completely randomized design experiment.

Results: Results revealed that the treatment significantly reduced the crude fiber, fiber fraction contents, and anti-nutrients and improved the crude protein content of the pod by 71.84%. Dry matter and crude protein of the diets ranged from 89.34–89.71% and 10.52–12.84%, respectively. The in vitro dry matter digestibility (IVDMD) increased with increasing levels of urea-treated CPHM in the diets. With increasing levels of urea-treated CPHM, CH₄ production relatively reduced as compared to diet E. Metabolizable energy (5.66 Kcal/g) of diet F was the highest. Therefore, the inclusion of urea-treated CPHM at 15% in CCDs has the potential for improving digestibility and reducing CH₄ production in ruminants.

Keywords: Cocoa pod husk, Methane, Ruminant, Urea treatment

Introduction

Livestock production is undertaken in a multitude of ways across the planet, providing a large variety of goods and services, using different animal species and different sets of resources, in a wide spectrum of agro-ecological and socio-economic conditions (Steinfeld et al., 2006). In recent years, emphases have been shifted to the use of by-products of agro-industrial origin as low-cost alternative carbohydrate sources for livestock nutrition. Sucharita et al. (1998) concluded that effective utilization of non-conventional feeds should be the major areas of research in the less developed countries due to shortage of conventional feedstuffs, ever-increasing human population and to

ensure their food security, which is dependent on the better utilization of alternative feed resources. Though ruminant animals can thrive very well on fibrous feeds to keep their rumen healthy, but higher quantities of cellulose, hemicellulose in the cell wall and presence of anti-nutritional factors usually limit efficient nutrients utilization by the ruminants (Makkar, 1993).

Consequently, cocoa pod husk which is an abundant residue generated on cocoa farmlands has been regarded as a “waste” in Nigeria, except for the negligible amount used in the manufacture of local soap. It has however been reported to contain about 80.00–88.96% DM, 6.00–9.14% CP, 24.93–35.74% CF, and 14.10–21.16% lignin (Aregheore, 2002; Ozung et al., 2016). To nutritionally upgrade the crop residue for efficient utilization by ruminant animals, urea, a non-protein nitrogen, which

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Table 2 Chemical composition of raw, urea-treated ensiled cocoa pod husk and formulated diets

Diets/level of urea-treated CPHM replacement (%)									
Parameters (%)	Raw CPHM	Urea-treated CPHM	0 A	5 B	7.5 C	10 D	12.5 E	15 F	SEM
Dry matter	88.97	89.87	89.34	89.41	89.39	89.64	89.71	89.64	0.52
Crude protein	8.31	14.28	10.52 ^d	10.87 ^d	11.35 ^c	12.53 ^b	12.67 ^{ab}	12.84 ^a	0.26
Crude fiber	33.87	23.91	17.29	17.32	17.37	17.36	17.32	17.31	1.77
Ether extract	4.92	3.82	2.33 ^d	2.67 ^c	3.07 ^b	3.15 ^a	3.17 ^a	3.16 ^a	0.22
Ash	6.25	6.05	5.47 ^a	5.33 ^{ab}	5.19 ^b	5.11 ^b	5.02 ^c	5.01 ^c	0.38
NFE	35.62	41.81	53.73 ^a	53.22 ^{ab}	52.40 ^b	51.48 ^b	51.47 ^b	51.32 ^b	1.34
NDF	63.23	52.64	73.90 ^a	72.62 ^{ab}	71.91 ^b	70.68 ^c	70.58 ^c	69.13 ^d	0.41
ADF	51.40	42.21	51.66 ^a	49.62 ^{bc}	50.83 ^{ab}	49.13 ^{bc}	49.59 ^{bc}	48.42 ^c	0.33
ADL	24.05	19.23	25.14 ^a	23.37 ^b	22.42 ^b	23.17 ^b	23.19 ^b	22.48 ^b	0.26
Calcium	0.41	0.51	0.54 ^d	0.56 ^{cd}	0.60 ^c	0.66 ^b	0.69 ^{ab}	0.71 ^a	0.02
Phosphorus	0.11	0.20	0.26 ^d	0.28 ^{cd}	0.29 ^c	0.32 ^b	0.34 ^a	0.35 ^a	0.01
Alkaloid	6.50	3.45	0.80 ^a	1.49 ^b	1.75 ^c	2.00 ^d	2.39 ^e	2.81 ^f	0.16
Theobromine	3.89	2.05	0.00 ^a	0.77 ^b	0.95 ^c	1.12 ^d	1.33 ^e	1.47 ^f	0.12

Means on the same row with different superscript letters are statistically ($p < 0.05$) different

A 0% replacement levels of urea-treated CPHM, B 5% replacement levels of urea-treated CPHM, C 7.5% replacement levels of urea-treated CPHM, D 10% replacement levels of urea-treated CPHM, E 12.5% replacement levels of urea-treated CPHM, F 15% replacement levels of urea-treated CPHM, NFE nitrogen-free extract, NDF neutral detergent fiber, ADF acid detergent fiber, ADL acid detergent lignin ($n = 3$)

effect caused the significant reduction in the crude fiber level, as 33.87% CF (raw CPHM) was reduced to 23.91% (urea-treated CPHM). Though, no significant reduction was noticed in the CF contents of the diets. The ether extract content values gradually increased across the treatment. Though, values recorded for treatment E and F were statistically ($p > 0.05$) similar. The highest EE (4.92%) and ash content (6.25%) values were obtained in raw CPHM, respectively. The value of nitrogen-free extract increased numerically from 35.62% (raw CPHM) to 41.81% (urea-treated CPHM).

The neutral detergent fiber and acid detergent fiber contents of raw cocoa pod husk were 63.23% and 51.40%, respectively, and higher compared to NDF (52.64%) and ADF (42.21%) of urea-treated CPHM. Similarly, the value of acid detergent lignin (24.05%) content of raw CPHM was the highest. The CPHM calcium and phosphorus concentrations varied positively with the treatment effect and significantly improved the Ca and P contents of the diets. The alkaloid and theobromine concentration of the pod drastically reduced, though the concentration increased with increased levels of urea-treated CPHM in the diets.

Table 3 presents the in vitro gas production of raw and replacement levels of cassava peels with urea-treated cocoa pod husk meal diets. The result showed that gas volume produced at different incubation time differed significantly ($p < 0.05$). The volume of gas produced increased with increasing incubation time (Fig. 1). The study revealed that raw CPHM produced the least gas volume (1.67 ml) at 3 h and highest (3.01 ml) at 18 h. However, gas production declined after 18th hour. Diet A (0%

replacement level of urea-treated CPHM with cassava peels in the diet) produced the least volume of gas (3.33 ml) at 3 h of incubation time, while diet F produced the highest volume of gas (9.69 ml) under the same period of incubation. Gas volume production at 3 h was least in diet A (3.33 ml) and highest in diet F (9.69 ml). Similarly, at 24 h, the highest gas volume (20.19 ml) was obtained in diet F and least (10.67 ml) in diet A at 21 and 24 h.

Means on the same row with different superscript letters are statistically ($p < 0.05$) different

CPHM cocoa pod husk meal, A 0% replacement levels of urea-treated CPHM, B 5% replacement levels of urea-treated CPHM, C 7.5% replacement levels of urea-treated CPHM, D 10% replacement levels of urea-treated CPHM, E 12.5% replacement levels of

Table 3 In vitro gas production of raw and replacement levels of urea-treated CPHM diets

Gas volume (ml)								
Diets	3 h	6 h	9 h	12 h	15 h	18 h	21 h	24 h
Raw CPHM	1.67 ^f	1.82 ^e	1.99 ^e	2.13 ^e	2.47 ^e	3.01 ^f	2.89 ^f	2.89 ^f
A	3.33 ^e	4.33 ^d	6.33 ^d	6.33 ^d	8.33 ^d	10.33 ^e	10.67 ^e	10.67 ^e
B	4.67 ^d	5.67 ^c	6.67 ^d	7.33 ^d	9.67 ^c	11.67 ^d	11.93 ^d	12.33 ^d
C	6.00 ^c	6.00 ^c	8.00 ^c	9.00 ^c	11.00 ^b	13.00 ^c	14.00 ^c	14.07 ^c
D	8.33 ^b	9.00 ^b	11.00 ^b	13.00 ^b	16.33 ^a	14.00 ^b	17.67 ^b	17.67 ^b
E	9.67 ^a	11.67 ^a	14.33 ^a	14.33 ^a	16.33 ^a	17.67 ^a	20.00 ^a	20.03 ^a
F	9.69 ^a	11.64 ^a	14.29 ^a	14.32 ^a	16.34 ^a	17.62 ^a	20.01 ^a	20.19 ^a
SEM	0.66	0.81	1.00	1.06	1.13	1.15	1.08	0.97

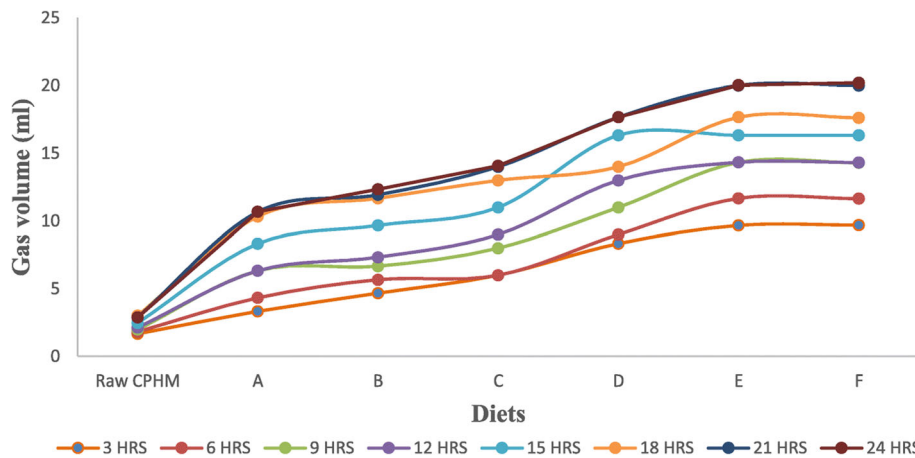


Fig. 1 Graphical representation of in vitro gas production of raw and replacement levels of urea-treated cocoa pod husk meal diets

urea-treated CPHM, F 15% replacement levels of urea-treated CPHM

Presented in Table 4 are the in vitro characteristics of raw and replacement levels of urea-treated CPHM for cassava peels. The result showed a significant ($p < 0.05$) difference for all the parameters assessed with respect to the treatments. It was noted that the least values obtained in all the parameters assessed were for raw CPHM. However, the highest volume of methane gas (5.00 ml) produced was obtained in diets E and F, while the least was observed in diets A, B, and C (3.00 ml) which were numerically and statistically ($p > 0.05$) similar. The carbon dioxide (CO_2) gas produced from the insoluble fraction increased with increased replacement levels of urea-treated CPHM for cassava peels in the diet. Diet F produced the highest volume of CO_2 gas (15.19 ml), while diet A produced the least (7.67 ml). The organic matter digestibility (OMD) obtained ranged from 32.56% (diet A) to 41.37% (diet E). The short-chain fatty acid (SCFA)

also increased with increased replacement of urea-treated cocoa pod husk meal for cassava peels in the diets; with the highest (0.42 μm) value obtained in diet F and least (0.19 μm) obtained in diet A. The metabolizable energy of the diets increased with increased replacement of urea-treated cocoa pod husk meal for cassava peels in the diets. Diets E and F had statistical ($p > 0.05$) similar values but differed numerically. The values of ME obtained ranged from 4.28 Kcal/g (diet A) to 5.66 Kcal/g (diet E). In vitro dry matter disappearance was highest (80.00%) in diets E and F and least (50.00%) in diet A.

Discussion

The 88.97% DM, 8.31% CP, and 33.87% CF contents obtained for the raw CPHM in this study (Table 2) agreed with the reported values of about 80.00–88.96% DM, 6.00–9.14% CP, and 24.93–35.74% CF by Aregheore (2002) and Ozung et al., (2016). The dry matter of the pod before and after treatment (soaking

Table 4 In vitro characteristics of raw and replacement levels of urea-treated CPHM diets

Diets	Methane (ml)	CO_2 (ml)	OMD (%)	SCFA (μm)	ME (Kcal/g)	IVDMD (%)
Raw CPHM	1.00 ^d	1.89 ^e	25.26 ^e	0.01 ^e	3.16 ^f	42.00 ^c
A	3.00 ^c	7.67 ^d	32.56 ^d	0.19 ^d	4.28 ^e	50.00 ^{bc}
B	3.00 ^c	9.33 ^c	34.15 ^c	0.23 ^c	4.53 ^d	60.06 ^b
C	3.00 ^c	11.07 ^b	35.73 ^c	0.28 ^b	4.79 ^c	60.06 ^b
D	4.00 ^b	13.67 ^{ab}	38.98 ^b	0.36 ^a	5.29 ^b	70.07 ^a
E	5.00 ^a	15.03 ^a	41.13 ^a	0.40 ^a	5.63 ^a	80.00 ^a
F	5.00 ^a	15.19 ^a	41.37 ^a	0.42 ^a	5.66 ^a	80.00 ^a
SEM	0.29	2.09	0.94	0.02	0.14	3.01

Means on the same row with different superscript letters are significantly ($p < 0.05$) different

OMD organic matter digestibility, CO_2 (carbon dioxide) gas production from insoluble fraction, SCFA short-chain fatty acid, ME metabolizable energy, IVDMD in vitro dry matter disappearance, CPHM cocoa pod husk meal, A 0% replacement levels of urea-treated CPHM, B 5% replacement levels of urea-treated CPHM, C 7.5% replacement levels of urea-treated CPHM, D 10% replacement levels of urea-treated CPHM, E 12.5% replacement levels of urea-treated CPHM, F 15% replacement levels of urea-treated CPHM

in 5% urea solution for 7 days and ensiled for 28 days) and the formulated diets were high; this could be attributed to the dried nature of the pod and casava peels, culminating in its high lignification. The CP content of the pod and invariably that of the diets was improved. The CP contents (10.52–12.84%) of the diets could adequately meet the protein requirement by ruminant animals for growth (NRC, 2007). The reduction in fiber contents could be as a result of the fermentation process during ensiling. The reduction in the alkaloid and theobromine might be traced to decanting after been soaked in urea solution and thus would make the feed more palatable to the animals. The amount of gas produced during fermentation is dependent on the nature, level of fiber, and potency of the rumen liquor used for the incubation. The result showed that gas volume produced at different incubation time differed significantly at $p < 0.05$.

The observed increase in the cumulative gas volume from 3 to 21 h (Table 3), and the gradual decline after 21 h of incubation from diets A to F could be associated to the replacement levels of urea-treated CPHM and thus predicted digestibility, fermentation end-product, and microbial protein synthesis of the diets by rumen microbes in the *in vitro* system. This also implied that digestion would take place within the normal rumen retention time at 21 to 24 h and could be an indirect measure of dry matter degradability. This trend agreed with the report of Babayemi and Bamikole (2006) when a similar method was used to evaluate the nutritive value of *Tephrosia candida* DC leaf and its mixtures with Guinea grass for ruminant feeding. From Table 4, methane gas produced was in line with the values reported by Okoruwa and Agbonlahor (2016) when they investigated the gas production characteristics of cocoa pod husk with sour sop pulp meals used in replacement for Napier grass in the diet of WAD sheep. Thus, the methane gas volume produced in this study could be traced to the gradual increment in the protein quality of the diets.

The apparently low methane gas volume produced in this study is an indication of the effective utilization of the diets. The gradual increase in the value of OMD and ME reported implied a mutual relationship exists between total methane production and ME with OMD (Babayemi and Bamikole, 2006). The low SCFA reported in this study were due to the lower methane gas production which was evident within the 24-h incubation period. The increased value of IVDMD of urea-treated CPHM-based diets over the raw CPHM could be traced to the effect of soaking in urea solution because great quantities of

cell contents were dissolved in the water. Thus, the formulated diets are rich in nutrients, highly digestible, and could meet the nutrient requirements for growth/maintenance by ruminant animals.

Conclusions

The study established that cocoa pod husk has nutritional potentials in ruminant nutrition and could be nutritionally upgraded by soaking in 5% urea solution for 7 days, ensiled for 28 days, and incorporated up to 15% replacement level in the ruminants' diets. However, *in vivo* study should be carried out to substantiate the *in vitro* study.

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Availability of data materials

The data that support the findings of this study are available from Omotoso, O. B., but restriction applies to the availability of the data, which were used under license for the current study, and so are not publicly available. Data are however available from the author upon reasonable request and with permission of Omotoso, O. B.

Author's contributions

This manuscript is a subset of my doctoral research work. I was responsible to manage all the activities of the experiment and worked in the execution of the trial and involved in the data collection and interpretation to make this manuscript. The author read and approved the final manuscript.

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