Nigerian J. Anim. Sci. 2021, 23 (2): 213-221

Determining the metabolizable energy value of high quality cassava peels in roosters by a regression method

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Target Audience: *Monogastric nutritionists and researchers, Research and Development (R&D)*

Abstract

The metabolizable energy of high quality cassava peel (HQCP) - a by-product of cassava processing, was investigated in thirty-two 27 weeks old ISA brown roosters (2118.75 ± 255.82 g). High quality cassava peel was obtained from the International Livestock Research Institute, Moniya, Ibadan, and incorporated in a corn-soybean meal grower diet at 5, 10 and 15% of the diet in substitution for glucose monohydrate to create the experimental diets; HQCP-0, HQCP-5, HQCP-10, and HQCP-15, respectively and titanium dioxide included at 0.5% as an inert marker. Roosters were placed in metabolic cages (2 roosters/cage, 4 cages/treatment) and fed the experimental diets for 10 days. Excreta was collected during the last 3 days, dried at 55ºC and analyzed for dry matter, nitrogen, gross energy and titanium. Feed consumption was calculated, and nitrogen and energy utilization estimated. The metabolizable energy of the HQCP was estimated as the slope of the regression of metabolizable energy of the diets corrected for glucose contribution, against the inclusion rate of HQCP in the experimental diets. No significant ($p > 0.05$) treatment effect was observed for feed intake and weight changes of the roosters as well as nitrogen and energy retention. However, apparent metabolizable value of the diets declined significantly ($p < 0.05$) at 15% inclusion level of HQCP. Linear regression analysis ($p < 0.001$, $r^2 = 0.90$) showed that the metabolizable energy value of high quality cassava peel used in the study was 2.117 ± 0.103 kcal/g for 27 weeks old roosters.

Key words: *standard ingredient substitution method; cocks; Manihot esculenta; processing by-products*

Description of Problem

Cassava (*Manihot esculenta* Crantz) is a perennial shrub grown in the tropics and is most known for its carbohydrate-rich underground roots/tubers. Cassava roots are a major starchy staple for over 800 million people globally, and crucial to food security in parts of Africa, Asia and South America (1, 2), whilst holding promise as an energy feedstuff for livestock (3–5). Despite Nigeria's huge cassava production capacity of 59.5 million metric tonnes in 2018 (6) and potential for continued expansion (7), the inherent moisture and antinutritional factors (which include cyanogenic glycosides and phytate) in fresh cassava (*Manihot esculenta* Crantz) roots are detrimental to its shelf-life and safe consumption. In response to these challenges, processing of cassava roots is required to turn it into shelf-stable and safer forms of food for human consumption. Processing of cassava primarily involved water washing and peeling, with peels estimated to about 35% of tuber wet weight and amounting to ~ 5.2 million tonnes of wet cassava peels per annum (5, 8).

Cassava peels which are a by-product of cassava root processing, have filled a niche

in the livestock industry providing low cost energy-fibre feed resource for monogastric and ruminant animal feeding (9–12). The dehydration of cassava peels reduces its cyanogenic glycoside levels, with lower cyanogenic glycoside concentrations reported in sundried cassava peels compared with oven-dried cassava peels (13, 14). Other processing methods explored to improve the shelf-life and nutritional quality of cassava peels include solid state fermentation (15–20) and ensiling (21, 22). However, these processing methods are either heavily dependent on weather conditions (as is the case with sun-drying) or require equipment with prohibitive cost and skilled manpower which are beyond the reach of the local feed industry players.

High quality cassava peel (HQCP) is a low-cost initiative of the International Livestock Research Institute aimed at providing cheap, locally available, and shelf-stable cassava peel feedstuffs, in a bid to curb environmental pollution caused by dumping of wet cassava peels. In a multistep process, wet cassava peels are sorted (to remove stumps and large-sized woody tubers), grated, pressed in a hydraulic press (to ensure rapid dewatering), sun-dried for ~ 6 hours (to 10-12% moisture content) with subsequent sieving to obtain the HQCP (23). Despite HQCP being recommended for feeding of both monogastric (poultry and swine) and ruminant species, information on the metabolizable energy of HQCP derived from animal feeding studies are scarce. The metabolizable energy of any feedstuff is considered its potential energy having discounted the potential energy of all body wastes (estimated in the excreta of avian species) of the animal. The metabolizable energy of feedstuffs form the foundation of accurate feed formulation as dietary energy is pertinent for metabolism, physiological functions, tissue turnover and thermoregulation. Hence this study aimed to investigate the metabolizable energy of HQCP in roosters using the standard ingredient substitution method (24, 25).

Materials and Methods

The research work reported herein conforms to published guidelines for the Ethical Conduct and Reporting of Animal Research (26, 27). Methods and protocols adopted were reviewed by the Department of Animal Science at the University of Ibadan, Ibadan, Nigeria, and authors have adhered to ethical standards as stipulated on the journal's author guidelines page.

Diets and management of animals

A trial was conducted to determine the metabolizable energy of HQCP by the standard ingredient substitution method. A basal diet (Table 1) was formulated to contain 15% glucose monohydrate ($C_6H_{12}O_6 \cdot H_2O$; AMEn, 3640 kcal/kg). In a dose-response sequence, glucose monohydrate in the basal diet was substituted at 5, 10 and 15% with HQCP creating the experimental diets. The metabolizable energy content of the experimental diets was not equilibrated, and titanium dioxide was incorporated at 0.5% of the diets as an inert marker. Thirty-two 27 weeks old ISA brown roosters (2118.75 ± 255.82 g) were obtained from a previous feeding trial and housed in cages (120 cm × 69 cm × 85 cm) equipped with feeding troughs, nipple drinkers and excreta collection tray. The cages were installed in an open-sided building with temperature maintained at 26.5±2.5^{o}C throughout the study, and a 14L:10D lighting program achieved by natural illumination.

Roosters were weighed, individually identified using pre-numbered plastic leg rings and randomly allotted to sixteen cage units with two roosters per cage by weight

equalization using the Experimental Animal Allotment Program (28). During a 7-d acclimatization period, the roosters were offered a grower diet (3059 kcal/kg ME, 20.86% crude protein, 3.73% crude fibre, 48.66% starch, 1.0% calcium, 0.66% available phosphorus, 0.56% methionine, and 1.26% lysine). Post-acclimatization, each cage was randomly assigned to one of the four experimental diets for a 10-d period. Each rooster was offered a daily portion of the experimental diet and excreta was collected in the last 3 days. Daily excreta collections were pooled by cage and aliquots were dried in a forced-air oven at 55^{o}C until constant weight was obtained.

Table 1: Composition of the basal diet (on as-is basis)

Ingredient	Amount (g/1000g)
Soybean meal	320
Maize	450
Glucose•H_2O ($C_6H_{14}O_7$)	150
Fish meal, 72%	20
Soy oil	20
Titanium dioxide (inert marker)	5.0
DCP	14.0
Limestone	12.0
Vitamin-mineral premix[1]	3.0
Lysine HCl	2.0
DL-Methionine	2.0
Sodium chloride	2.0
Total	1000
Calculated Composition	
Metabolizable energy, kcal/kg	3090
Crude Protein	195.3
Fibre	33.2
Starch	369.8
Calcium	10.9
Available Phosphorus	6.1
Methionine	5.3
Lysine	12.3

[1]Optimix premix, Animal Care, Nigeria. provided the following per kg/diet: vitamin A, 20,000IU; vitamin D3, 4,000 IU; vitamin E, 20 mg; vitamin K3, 4 mg, vitamin B1, 3 mg; vitamin B2, 10 mg; niacin 16mg; calpan 16 mg; vitamin B6, 6 mg; vitamin B12, 0.03 mg; choline chloride, 200 mg; folic acid, 2 mg; biotin,0.1 mg; manganese, 120 mg; iron, 40 mg; zinc, 100 mg, copper, 10 mg; iodine, 2 mg; cobalt, 0.4 mg; selenium,0.4 mg; antioxidant, 250 mg

Chemical analyses

Moisture content of the experimental diets were determined in triplicate (NFTA, 2001) and aliquots of excreta collections were dried in a forced-air oven at 55^{o}C until constant weight was obtained. Crude protein of diets and excreta was also determined in triplicate using the Lowry's protocol (29) and nitrogen estimated by correcting the crude protein value by the standard nitrogen-to-protein conversion factor. Gross energy of diets and excreta was determined in duplicate by bomb calorimetry (30), and titanium content analyzed using spectrophotometry according to a method suggested in (31). The HQCP was assayed for moisture, crude protein, ether extract, ash, crude fibre, neutral detergent fibre (NDF) and acid detergent fibre (ADF) using previously validated methods (30, 32), and hemicellulose was determined by difference between NDF and ADF.

Calculations

The AME of the experimental diets were calculated using equations [1] (33),

$$AME = GE_{diet} - \frac{GE_{excreta} \times M_{diet}}{M_{excreta}} \quad [1]$$

where AME (kcal/kg) - apparent metabolizable energy of the diet; GE_{diet} and $GE_{excreta}$ (kcal/kg) - GE of the diet and excreta, respectively; M_{diet} and $M_{excreta}$ (%) - titanium in the diet and excreta, respectively.

The ME of HQCP was estimated as the slope of a linear regression equation derived from regressing the diet AME values less AME contributed by glucose monohydrate in the diets against the level of substitution of HQCP in the diets. (25).

Statistical analysis

All statistical analysis were done in JASP, version 0.11.0 (JASP Team, 2019). Energy and nitrogen utilization data were analyzed as one-way ANOVA, and statistically significant means were further compared with Tukey's honestly significant difference (HSD) multiple comparison procedure with statistical difference determined at $p < 0.05$.

Results and Discussion

Extensive investigations have been conducted into the prospects of cassava peels as a feeding ingredient for monogastric animals. The chemical composition and granulometry of the HQCP used in this study as well as chemical characteristics of cassava peel products assayed in similar investigations are presented in Table 2. Significant variability was observed in results from the different investigations which could be attributed to differences in physical processing of cassava peels (e.g. efficiency of the cassava peeling process, drying method, and period of drying) as well as analytical techniques employed. However, all chemical characteristics assayed in the current study fell within the range of published values in literature, except for the neutral detergent fibre which was higher than published values. Energy and nitrogen utilization of roosters fed the experimental diets are presented in Table 3. No significant effect of HQCP inclusion in the experimental diets was observed on nitrogen and energy retention of roosters when HQCP was increased from 0-150g/kg of experimental diets, however, HQCP-0 and HQCP-15 diets differed significantly in AME (3.05 ± 0.18 vs 2.82 ± 0.16 kcal/g diet; $p = 0.016$), with similar AME recorded for the HQCP-0, HQCP-5 and HQCP-10 diets. The regression of glucose-corrected apparent metabolizable energy of the experimental diets against the inclusion level of HQCP resulted in the regression equation; $y = 2.117x + 2483.8$, $R^2 = 0.90$ connoting an AME of 2.117 kcal/g HQCP (Figure 1).

Table 2: Characterization and granulometry of the high quality cassava peels (HQCP) fed to roosters (as-is-basis) and cassava peel products reported in literature

Characteristic	Concentration	Concentration in literature	Source
Moisture (g/100g)	11.5 ± 0.14		
Crude Protein (g/100g)	5.18 ± 0.46	3.12 – 6.63	(9, 35–41)
Crude fat (g/100g)	1.60 ± 0.14	0.44 - 1.18	(9, 36, 37, 39–41)
Crude Fibre (g/100g)	14.25 ± 1.20	8.3 – 21.36	(9, 36, 37, 39–42)
Ash (g/100g)	5.75 ± 0.07	5.27 - 7.16	(9, 36, 37, 39–41)
Nitrogen free extract (NFE, g/100g)	61.72 ± 0.35	66.49 - 75.80	(9, 36, 37, 39–41)
Neutral Detergent Fibre (NDF) (g/100g)	47.85 ± 0.35	15.20 – 22.50	(38, 39, 43, 44)
Acid Detergent Fibre (ADF, g/100g)	11.8 ± 0.14	13.64 – 48.10	(38, 39, 43, 44)
Acid Detergent Lignin (ADL, g/100g)	3.30 ± 0.10	2.22 – 7.80	(39, 44)
Gross Energy, kcal/g	2.937 ± 0.00	2.678 – 4.562	(36, 45–47)
Starch, %		10.26 – 18.14	(23)
Granulometry (%)			
>1.0mm	6.12		
0.60-1.0mm	35.20		
0.20-0.59mm	51.19		
<0.20mm	7.50		

Table 3: Energy and nitrogen utilization and, apparent metabolizable energy of experimental diets containing high quality cassava peel (HQCP) fed to roosters.

	Fine High Quality Cassava Peel - HQCP-F				P-value	Polynomial Contrast	
	0%	5%	10%	15%		Linear	Quadratic
Nitrogen retention, %	61.38±26.43	55.52 ± 21.04	45.49 ± 12.80	48.44 ± 14.30	0.204	NS	NS
Energy retention, %	78.67 ± 4.53	78.33 ± 4.76	78.27 ± 4.85	78.62 ± 4.59	0.995	NS	NS
AME, kcal/g DM	3.05 ± 0.18[a]	2.93 ± 0.18[a]	2.86 ± 0.18[a]	2.82 ± 0.16[b]	0.016	NS	NS

Means with different superscripts within same row differ significantly at $p < 0.05$

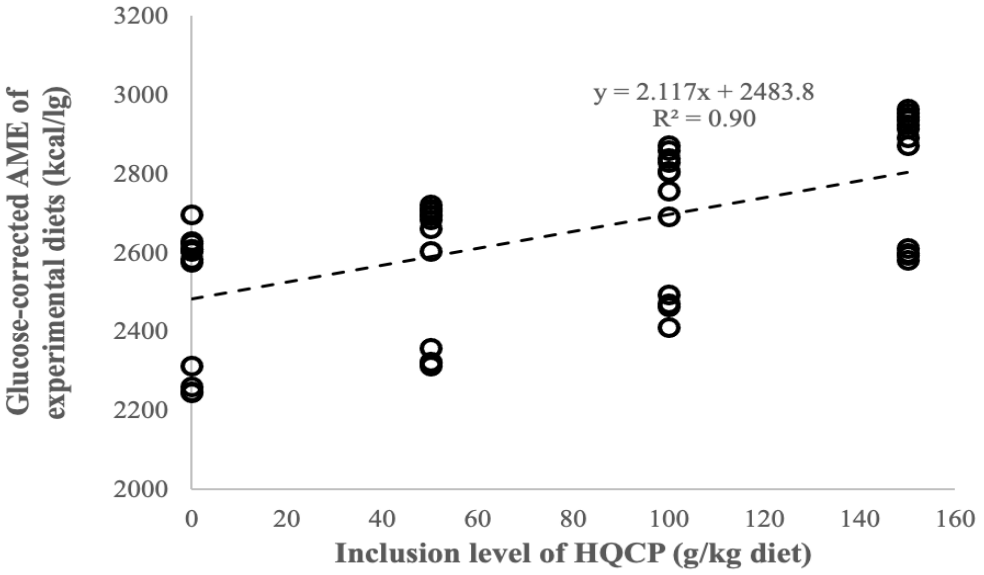

Figure 1: Regression of glucose-corrected metabolizable energy of the experimental diets (Y, kcal/kg) against the inclusion levels of high quality cassava peel (HQCP) in the diets (X, g/kg) of roosters

From the standpoint of poultry nutrition, the energy content of a diet strongly regulates feed consumption and may consequently compromise the intake of other nutrients such as proteins, minerals and vitamins; hence precise information on metabolizable energy values of individual feedstuffs is crucial for their successful incorporation in diets. Metabolizable energy values for individual feedstuffs used in feed formulation are often obtained from table values which are generated from animal bioassays or prediction equations, with a preference for the former despite their intensive cost and manpower requirement. While there exists a significant volume of research examining the feeding value of cassava peels for monogastric animals, there is a dearth of reporting of metabolizable energy values for cassava peel products derived from metabolic feeding trials. The metabolizable energy value of 2.044 kcal/g for oven dried cassava peels in growing pullets reported by (37) compares favorably with 2.117 kcal/g metabolizable energy reported for HQCP in the present study. Metabolizable energy values for dehydrated cassava peels derived from prediction

equations range between 2.651kcal/g ME and 2.686 kcal/g ME (9, 43), while a metabolizable energy value of 2.245 kcal/kg of HQCP was derived from near infrared spectroscopy (23). The metabolizable energy content of HQCP in adult roosters in the current study was observed to be ~73% of its analyzed gross energy content, and could be attributed to the significant fibrous nature of HQCP as chickens have an inherent low capacity for fibre utilization due to the absence of endogenous fibre-degrading enzymes in the foregut and limited fermentation and residence time in the hindgut.

Conclusions and Applications

1. In conclusion, the metabolizable energy value for HQCP in roosters is 2.144 kcal/g, representing ~ 73% of the potential (gross) energy in HQCP.
2. The inclusion of HQCP up to 15% of a standard diet for roosters also had no significant impact on energy and nitrogen retention of roosters, while inclusion of HQCP up to 10% of a standard roosters diet had no significant effect on apparent metabolizable energy in this study.
3. The findings from this investigation will enable efficient formulation of poultry diets using HQCP, and will go a long way in helping mainstream HQCP as a fibre and energy feedstuff in the poultry feed industry.
4. This study also confirms the suitability of a 10% inclusion of HQCP in standard grower diets for roosters without any detrimental effect on growth performance and nutrient digestibility.

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