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Chemical Composition and Estimation of Metabolizable Energy Values of Sun-dried, Fermented and Rumen Digesta-Ensiled Cassava Root Meal in Poultry

O. A. Akapo[1*], W. A. Olayemi[2], R. A. Olorunsola[3], A. O. Oso[1], O. O. Akapo[4], A. M. Bamgbose[1] and A. O. Mafimidiwo[2]

[1]Department of Animal Nutrition, College of Animal Science and Livestock Production, University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria.
[2]Yaba College of Technology, P.M.B. 2011, Yaba, Lagos, Nigeria.
[3]Department of Biological Science, Ondo State University of Science and Technology, Okitipupa, Nigeria.
[4]Department of Animal Breeding and Genetic, College of Animal Science and Livestock Production, University of Agriculture, P.M.B. 2240, Abeokuta, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Author OAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors WAO and RAO managed the analyses of the study. Author AOO managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The experiment was carried out to investigate the chemical analysis, fibre fractions and mineral composition of cassava. Detailed chemical analysis of raw cassava root (RCR) and processed cassava root meal (PCRM) was assayed. Results obtained were Subjected to analysis of variance (ANOVA) as applicable to a completely Randomized Design (CRD).Significant means were separated using Duncan's Multiple Range Test. (RDECRM) had the highest crude protein content

**Corresponding author: E-mail: aolajetemi@gmail.com;*

(27.10%) while raw cassava root meal had the lowest crude protein content (15.00%). The crude fiber (CF) content of the processed cassava ranged from 83.50% in sun dried, fermented 84.60% to 92.00% in rumen digesta ensiled cassava root meal. Metabolizable energy of processed cassava were significantly different (*P=.05*). AMEn reduced with the inclusion level from (12.32^{a} -11.11^{c}), all other parameters were not affected. The neutral detergent, acid detergent lignin and cellulose were not significantly influenced (*P=.05*) by the different processing methods. Acid detergent fibre and hemicellulose of raw and processed cassava were significantly different (*P=.05*) the values ranged from (15.70 -13.17%) and (10.10 - 8.57%) The rumen digesta ensiled cassava root meal proved to be superior to sun dried and fermented cassava.

Keywords: Cassava; rumen digesta; fermentation; sun-drying; broiler.

1. INTRODUCTION

Inadequacy and unavailability of conventional cereal grains, most especially maize in developing countries such as Nigeria has been a major interest to the animal scientist. This scarcity of cereals grains has created a food-feed competition between man and livestock [1]. There is therefore a need to explore alternative energy feed ingredient that could comfortably replace conventional cereal grains. Cassava has been reported to replace maize in most poultry feed [2]. Cassava is taught to have a relative advantage due to its high energy, calorie yield and drought tolerant nature [2]. Cassava productivity in terms of calories per unit land area per time is significantly higher than other staple crop as cassava can produced $250x10^{3}$ calories/ha/day compared with other crop like maize [3,4].

Traditionally, cassava is processed before consumption, this is necessary for several reasons.

The two most widely used processing methods are sun-drying and ensiling. However, through simple processing, the disadvantage of perishability and cyanide can be overcome. Moreover with different processing methods employed in this study, (Sun-drying, Fermentation and Ensiling) cassava can play a significant role in stemming this tide of maize shortage, thereby leads to increase in animal protein [5]. It serves as means of removing or reducing the potential toxic cyanogenic glucosides present in fresh cassava, (ii)it also serve as a means of preservation, (iii)it yields product that has different attributes which creates variety in cassava diets [6].

1.1 Fermentation

Fermentation is an important method common in most processing. While there are many fermentation techniques for cassava, they can be broadly categorized into solid state and sub-emerged fermentation [7]. Sub-emerged fermentation involves the soaking of whole cassava peeled, or whole unpeeled cassava roots in water for various period of time. Traditionally, cassava is fermented for 4 to 6 days in order to effective sufficient detoxification of the roots. Fermentation less than 4 days can attributes to food poisoning [8].

1.2 Ensiled

Cassava ensilation is a technology that could be used as a means to assist the development of poultry feedstuff production, but also as an alternative means of encouraging the utilization of cassava, by offering market options in tropical environment, where processing for export is limited, or other market are non –existent [9]. However the high water content of the root and its loss during the processing require that special consideration should be taken. Solid, non-absorbant material should be used in order to prevent excessive liquid losses [9]. Ensiling reduced HCN of cassava root to a greater extent compared to sun-drying and fermentation [9]. Ensiled cassava root is palatable and poultry consume it more without problem. Ad-libitum systems are probably the most appropriate means of feeding ensiled cassava [9].

Metabolizable energy is a concept used in measuring or characterizes the nutritional value of animal feedstuff. It is used to estimate the energy available to an animal from digestion of a feed material, expressed in units of MegaJoule per kilogram of feed (MJ/kg DM), [10,5,11]. A limited number of directly determined metabolizable energy of poultry birds are available. The main advantages of ME energy are using less feed and its simplicity, (Silbbald 1975a). This study was conducted to determined, gross energy, nutritive values, HCN, mineral

content and metabolizable energy values of cassava root meal fed broiler birds.

2. MATERIALS AND METHODS

2.1 Processing of Cassava Root Meal

2.1.1 Sun dried cassava root meal

Freshly harvested matured cassava tubers (TMS-30573) were purchased from local farmers within Abeokuta metropolis, Ogun State. Harvesting and processing was done during dry season (September–December, 2012) to enhance proper drying. Cassava tubers were washed in clean water to remove dirt and subjected to the following processing methods: sun drying (fresh cassava were washed, chipped manually into smaller sizes, sun dried to obtain 10% moisture content, and milled to obtain the sundried cassava root meal (SDCRM).

2.1.2 Fermented cassava root meal

Fresh unpeeled cassava tubers were manually chipped into smaller sizes, washed in clean water and soaked in water at a ratio of 1 kg fresh cassava tuber/1 Lt of water in an air tight, plastic container for 3 days. At the expiration of fermentation period, fermenting water was decanted while the soft pulp was placed in a jute sac and screw-pressed for 12 hours prior to sun-drying. The dried fermented chips were milled to obtain the fermented cassava root meal (FCRM).

2.1.3 Rumen digesta-ensiled cassava root meal

Adequate quantity of fresh rumen digesta obtained from cattle abattoir located in Abeokuta, (South-West Nigeria) were collected at the point of slaughter in a plastic container. The fresh digesta was mixed thoroughly with freshly sliced cassava root manually (at a ratio of 2 kg freshly sliced cassava root: 1 kg digesta) and placed in an air tight sealed container for 21 days. At the expiration of ensiling period, the final product was sun dried and milled to obtain rumen-digesta ensiled cassava root meal (RDECRM). All the processed cassava meal were bagged separately and kept in a dry and ventilated store till the time of usage.

2.2 Chemical Analysis of Processed Cassava Root Meal

Representative samples (n = 4) of the processed cassava root meals and fresh cassava root were analyzed for crude protein (N × 6.25) in an automatic analyzer (Kjeltech Auto 147 1013 Analyzer, Tecator), ash (method no. 984.13) and ether extract (method no. 920.39) according to the procedures of [12]. Fibre fractions (NDF, ADF, ADL, Hemicellulose and Cellulose) of the samples were determined according to the standard method of [13]. Gross energy of the cassava meals was determined in a ballistic bomb Calorimeter. The cyanide content of the processed meals was analyzed using methods described by [14]. Tannin content was determined according to the methods of [15] while saponins content were analyzed using Spectrophotometric methods of Association of Analytical Chemists [12]. Mineral analysis, samples were dried in a hot air oven (at 105℃ for 8 h) and ground to pass through 0.5 mm sieve. Samples were ignited at 400℃ for 4 h in a muffle furnace. The ash was treated with HNO_3 under mild heat and digested. Analyses of constituent minerals were estimated using the Flame Atomic Absorption Spectrophotometer (Analyst 100, US). Zinc, iron and phosphorous content of raw and processed cassava flour samples were determined according to the method of [16].

2.3 Estimation of Metabolizable Energy of Processed Cassava Meals in Poultry

2.3.1 Experimental birds and management

A total of thirty nine (39) broiler chickens of Marshall breed (4 weeks old, of average weight 1.7 kg) were used for this study. The birds were randomly distributed into 3×3 factorial arrangement of 9 treatments consisting of 3 processed cassava root meal (SDCRM, FCRM, REDCRM) included at 10, 20 and 30% respectively. There were 4 birds per treatment. Each treatment was replicated four times with 1 bird per replicate. Birds were adjusted for three days prior to the commencement of 7 days feeding trial. Birds were fed with experimental diets while total excreta collection was done daily for 7 days. Daily feed offered was measured and excreta voided were collected. Daily excreta per bird was pooled for the collection period and dried in oven at 60℃ for 18 hours. Excreta samples were analysed for proximate composition [17,12] and gross energy.

The 3 remaining matured broilers were used to determined endogenous losses. Birds meant for endogenous study were fasted for first 24 hrs but had access to drinking water Excreta voided

during this period were discarded. The birds were further fasted for another 24 hrs making a total of 48 hr of starvation but were dosed each with warm glucose solution (30 g of glucose/50 ml of warm water) as described by Mc Nab and Blair. All the birds survived the experiment as no mortality was recorded throughout the study. Gross energy of samples of excreta was measured while the following equations were used to calculate apparent metabolizable energy (AME), nitrogen corrected apparent metabolizable energy (AMEn), true metabolizable energy (TME), and nitrogen corrected true metabolizable energy (TMEn) of test ingredient [18]:

$$\text{AME /g of feed} = [(Fi \times GEf) - (E \times GEe)]/Fi$$

Where Fi is the feed intake (g on dry matter basis), *E* is quantity of excreta output (g on dry matter basis), GEf is the gross energy (MJ/ kg) of feed, and is GEe the gross energy (MJ/ kg) of excreta.

$$\text{AMEn /g of feed} = \{[(Fi \times GEf) - (E \times GEe)] - (NR \times 36.5)\} / Fi$$

where nitrogen retention (NR) = (Fi × Nf) – (*E* × Ne), Nf is the nitrogen content (g/kg) of feed, Ne is the nitrogen content (g/kg) of excreta.

$$\text{TME /g of feed} = \{[(Fi \times GEf) - (E \times GEe)] + (FEm + UEe)\} / Fi$$

where FEm is metabolic faecal energy (kJ) (calculated from gross energy of excreta from endogenous loss), and UEe is endogenous urinary energy (kJ) (This is assumed zero since urine and faeces are passed together).

$$\text{TMEn /g of feed} = \{[(Fi \times GEf) - (E \times GEe)] - (NR \times K)\} + \{(FEm + UEe) + (NRo \times 36.5)\} / Fi$$

Where NR and NRo are estimates of nitrogen retention for fed (experimental) and starved (control) birds, respectively.

2.4 Statistical Analysis

The data obtained from the chemical analysis were subjected to analysis of variance (ANOVA). Significant differences between means were determined using Duncan's Multiple Range Test [19].

For the analysis of data obtained from estimation of metabolizable energy, individual bird was used as the experimental unit (*n = 4* per treatment). Data obtained were analysed as a 2 factor model (processed cassava meals × inclusion levels). Data generated were subjected to analysis of variance using the general linear models procedure of the SAS [20] to determine the main effects and their respective interactions. Significant differences were considered at *P =.05.*

3. RESULTS

Table 1 shows the proximate composition, gross energy and fibre fraction of raw and processed cassava root meals. Rumen digesta-ensiled cassava meal (RDECRM) had the highest (*P=.05*). Crude protein while RCRM recorded the least (*P=.05*). Raw cassava had the highest crude fibre, ADF, hemicellulose while rumen digesta ensiled cassava recorded the least crude fibre. Ether extract and Ash contents were not affected (*P=.05*).With the exception of raw cassava, all processed cassava root meal had increased dry matter content. The various processing methods employed in this study reduced the ADF and hemicellulose content of cassava root meals.

Table 2 shows the anti-nutritional factors and minerals profile of raw and processed cassava root meals. Various processing methods affected the Ca and K contents of the root meal. Fermented cassava root meal recorded the highest Ca content while raw cassava root had the least K content. Tannin and hydrocyanide content were affected by the processing methods employed in this study. Raw cassava recorded the highest tannin and hydrocyanide content while other processed cassava root meals showed reduced tannin and hydrocyanide content. Saponins values were not affected (*P=.05*) by the processing methods employed.

Table 3 shows the main effect of levels of inclusion and processing of cassava root on the metabolizable energy values of finishing broilers. Varying inclusion levels of cassava root meal affected (*P=.05*) the AMEn. Birds fed control (0%), 20% and 30% cassava root diets showed increased AMEn while birds fed 10% had reduced (*P=.05*)values. Main effect of processing methods showed no effect (*P=.05*) on AME, AMEn, TME and TMEn.

Table 1. Proximate composition, gross energy and fibre fraction of raw and processed cassava root meal (n=samples per determination (3 samples per treatments)

Parameters %	RCRM	SDCRM	FCRM	RDECRM	SEM
Crude protein	1.50[c]	1.92[b]	1.94[b]	2.71[a]	0.60
Crude fibre	9.70[a]	8.35[d]	8.46[c]	9.20[b]	0.35
Ether extract	1.90	0.59	0.59	0.60	0.04
Dry matter	21.50[b]	89.94[a]	89.90[a]	90.00[a]	0.19
M/C	11.00	10.06	10.10	10.00	0.18
Ash	2.70	2.09	2.08	2.12	0.68
Gross energy (Kcal/kg)	4859[c]	4905[b]	4910[b]	4948[a]	20.04
NDF	27.20	26.15	26.10	26.6	2.49
ADF	15.70 [a]	13.16[b]	13.15[b]	13.17[b]	0.65
ADL	5.60[b]	4.56[b]	4.60[b]	4.02[c]	0.57
Cellulose	11.50	12.98	12.93	13.43	2.08
Hemicellulose	10.10[a]	8.61[b]	8.57[b]	9.15[b]	3.93

[a b c] Means on the same row with different superscripts are significantly (P<0.05) different
RCRM= Raw cassava root meal, SDCRM, Sun-dried cassava root meal, FCRM=Fermented cassava root meal, RDECRM=Rumen digesta- ensiled cassava root meal

Table 2. Mineral profile of raw and processed cassava root meal

Parameters	RCRM	SDCRM	FCRM	RDECRM	SEM
Zn (mg/100 g)	0.40	0.43	0.44	0.45	0.09
Ca (mg/100)	24.10[b]	25.16[b]	37.53[a]	25.37[b]	2.38
Mg(mg/100 g)	39.20	37.66	37.67	37.08	1.21
Non-phytate PO_4 (mg/100 g)	1.23	1.24	1.25	0.21	9.02
K (mg/100 g)	13.50[b]	17.67[a]	17.90[a]	17.96[a]	2.28
Fe (mg/100 g)	1.10	1.23	1.24	1.25	0.21
Mn (mg/100 g)	0.09	0.01	0.01	0.01	0.00
Se(mg/100 g)	ND	ND	ND	ND	ND
Cu(mg/100 g)	0.09	0.43	0.44	0.43	0.05
Tannin(mg/100 g)	10.00[a]	5.60[b]	6.10 [b]	5.40 [b]	0.70
Saponin (mg/100 g)	3.40	3.20	3.28	3.27	0.50
HCN(mg/100 g)	72.50 [a]	31.58[b]	31.00 [b]	29.55	6.52

[a b c] Means on the same row with different superscripts are significantly (P<0.05) different
RCRM= Raw cassava root meal, SDCRM, Sun-dried cassava root meal, FCRM=Fermented cassava root meal, RDECRM=Rumen digesta- ensiled cassava root meal

Table 3. Metabolizable energy values of processed cassava root meal based diet fed to broiler finisher

Parameters	Levels of cassava inclusion					Processing methods			
	0%	10%	20%	30%	SEM	SDCRM	FCRM	RDECRM	SEM
AME	13.29	12.94	12.85	12.89	0.39	13.40	13.08	12.49	0.19
AMEn	12.32[a]	11.33[b]	11.12[c]	11.11[c]	0.34	11.73	12.11	11.25	0.18
TME	14.09	14.61	14.50	14.42	0.56	14.68	14.39	14.15	0.28
TMEn	13.81	12.88	12.56	12.93	0.57	13.50	13.05	12.58	0.28

[a b c] Means on the same row with different superscripts are significantly (P<0.05) different
AME = Apparent metabolizable energy, AMEn = Apparent metabolizable energy nitrogen corrected, TME = True metabolizable energy, TMEn = True metabolizable energy nitrogen corrected

Table 4 shows the interaction effect of levels of inclusion and processing of cassava root on the metabolizable energy values of finishing broilers. Similar AME values were obtained for all treatments with the exception of birds fed 20% fermented cassava root meal which recorded the least (*P=.05*). value. Finishing broilers fed 10%, 20% SDCRM, 20% FCRM and control diets showed increased AMEn values. All broilers fed with RDECRM irrespective of the levels showed reduced AMEn values. TME and TMEn were not affected by the interaction effect of levels of inclusion and processing of cassava root.

Table 4. Interaction effect of metabolizable energy of processed cassava root meal fed finishing broiler chickens

Parameters	SDCRM				FCRM				RDECRM				
	0%	10%	20%	30%	0%	10%	20%	30%	0%	10%	20%	30%	SEM
AME+	13.41^{ab}	13.24^{ab}	14.02^{ab}	13.33^{ab}	14.73^{a}	13.24^{ab}	11.19^{b}	12.67^{ab}	13.29^{ab}	11.78^{ab}	12.47^{ab}	12.79^{ab}	1.8
AMEn	11.92^{cd}	11.72^{ad}	12.34^{ab}	10.97^{cd}	12.74^{ab}	10.93^{cd}	12.95^{a}	11.84^{cd}	12.30^{ab}	11.53^{cd}	10.41^{d}	10.76^{cd}	0.18
TME	14.48	14.93	15.04	14.29	15.25	14.43	13.16	14.71	12.54	14.48	15.30	14.26	0.27
TMEn	13.83	14.07	13.62	12.07	13.73	11.42	14.15	13.06	12.30	13.37	10.78	13.53	0.28

^{abcd} Means on the same rows having different superscript were significantly (P<0.05) different

AME = Apparent metabolizable energy, AMEn = Apparent metabolizable energy nitrogen corrected, TME = True metabolizable energy TMEn = True metabolizable energy nitrogen corrected

4. DISCUSSION

The chemical composition of raw and processed cassava root meal revealed that RDECRM cassava meal had the highest crude protein while RCRM recorded the least. The increased crude protein content in RDECRM could be due to the processing methods employed in this study. This corroborated previous studies which recorded increased protein of cassava treated with rumen filtrate [3]. Numerically, there seems to be a slight increase in the crude protein content of processed cassava root meals when compared to RCRM. The slight increase in crude protein of processed cassava root meal observed in this study agreed with [21] who reported slight increase in protein content of cassava tubers subjected to various processing methods. This could be as a result of secretion of some extracellular enzymes (proteins) such as amylases, linamarase and cellulase by the fermenting organisms in an attempt to make use of the cassava starch as a source of carbohydrate [22].

The prominent increase in crude protein noticed with RDECRM cassava root in this study could be due to the presence of rumen micro-organisms in the rumen digesta which contributed significantly to the nutritional enrichment of cassava root during ensiling [3,23]. These micro-organisms could also synthesize (protein) in the cassava root. The microbial biomass synthesized inform of single cell protein may also be another reason for the increase in the protein content of RDECRM cassava root meal [21]. Chemical assay of differently processed cassava root meal showed high crude protein and apparent metabolizable energy with RDECRM cassava meal when compared with other processing methods. Fermented cassava root meal recorded the highest Ca content while raw cassava root had the least K content. The Anti-nutritional content of raw and processed cassava root meal showed that tannins and HCN content were affected by varying processed methods employed. When compared with RCRM meal, tannin and HCN content of the processed cassava root meal reduced (*P=.05*) drastically with different processing methods, saponins were not affected (*P=.05*) by the processing methods [24]. Natural fermentation of cassava root makes the constituent microorganisms in the fermenting liquid to break down cyanogenic glycosides into other forms of a hydrogen cyanide and cyanohydrins which are less toxic [25]. The reduction in tannin and HCN concentration observed for differently processed cassava root in this study when compared with RCRM is suggestive of improved nutritional value of the cassava root meal. Reduction of cyanide content from 10.9 to 3.4 mg/kg following natural fermentation of cassava root was reported by [26]. Different processing methods employed in this study had no effect on the saponin content of the cassava root. The highest calcium content recorded in this study for FCRM root meal could be due to increased Ca mobilization in fermenting liquid which resulted in improved Ca content of the final product [24]. The presence of selenium was not detected in the cassava root. This could be due to age of crop at harvest, climatic condition and variation in minerals uptake from soil by cassava plant during the production of these root tubers [27]. Processing methods employed in this study showed no effect on AME and TME of broilers.

The metabolizable energy of finishing broilers fed 10%, 20% SDCRM, 20% FCRM and control diets showed increased AMEn values. The reduced AMEn values obtained for broilers fed with RDECRM could be attributed to its increased constituent crude fibre levels which dilute the resultant energy values, as reported y [28], apart from this, increased activity of gut microflora on the dietary factors can lead to a wastage of energy [29].

5. CONCLUSION

AME values were similar in all the treatment with the exception of broilers fed with 20% FCRM which had the least AME. In conclusion, various processing methods used in this study improved the nutritional profile of cassava root meal with the best improvement obtained with rumen digesta ensiled cassava root meal. However, various processing methods employed had no improvement on metabolizable energy values in finishing broilers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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