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Nutrient Metabolisability of Treated False Yam (Icacina Oliviformis) Seed meal for Broiler Chickens

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ABSTRACT

A study was conducted to evaluate apparent metabolizable energy (AME) and nutrient metabolisability (NM) of maize-based diets containing treated false yam seed meal (TFYSM) using a 5x6 factorial [5 treatment samples (Un_T, Urea_T, NaCl_T, NaOH_T and KOH_T) at 6 levels (0, 10, 20, 30, 40 and 50) each] design for 15 days. Matured false yam (Icacina oliviformis) fruits were harvested and seeds extracted. Five different FYSM samples were prepared. One untreated sample (Un_T) was prepared by crushing fresh false yam seed and sun-drying to 12% moisture. Four treated samples (T) were crushed and each soaked in water (1:2; w/v) for 12 days with water replaced every 3 days. Afterwards, each sample was re-soaked in 1 M concentration of urea (Urea_T), sodium chloride (NaCl_T), sodium hydroxide (NaOH_T) or potassium hydroxide (KOH_T), for 24 h, washed, blanched and sun-dried to a moisture content of 12%. Apparent metabolizable energy (AME) of the experimental diets indicated an increasing trend of AME values as the level of FYSM samples were increased in the diets. Generally, all the treatment diets showed a higher AME content. However, among the treatment diets, urea, potassium hydroxide and sodium hydroxide-treated FYSM-based diets out-performed their sodium chloride treated counterpart ($P<0.001$) in their AME values. The nutrient metabolisability coefficients of varying inclusion levels of each treated FYSM sample did not influence ($P>0.05$) the coefficients of metabolisability of dry matter (DM) and crude protein (CP). However, in terms of methods of processing, DM metabolisability was significantly higher ($P<0.001$) in the FYSM samples that were sequentially treated with water-based and chemical treatment methods than in the untreated sample. Among the sequentially treated FYSM samples, sodium hydroxide-treated samples had the highest ($P<0.001$) gross energy metabolisability, while the untreated sample recorded the lowest ($P<0.001$) gross energy metabolisability. The interaction between level of inclusion and treatment methods in this study showed that treatment methods had different effects on crude protein metabolisability ($P < 0.011$) and gross energy metabolisability ($P < 0.017$) values of FYSM samples depending on the level of inclusion.

Key words: *false yam seed, gross energy, metabolisability, processing, chemicals*

INTRODUCTION

The use of non-conventional feed ingredients in poultry diets, as substitute for maize has been recognized as an important means of curtailing the scarcity and high price of maize. A newly identified non-conventional energy feed ingredient known as false yam seed is commonly found in the savannah zone of Ghana. False yam is a perennial shrub that produces both tuber and seed. Although the seed is high in starch (NRI, 1987), its feed value for poultry is low due to the presence of anti-nutritional factors notably gum resins (NRI, 1987). The major effect of the anti-nutritional factors is the reduction in feed intake of birds (Dei, Adjokatse, Abdulai, Amoako, Mohammed, and Teye 2011) with consequent reduction in growth performance. There are variations in the efficiencies of processing techniques used to reduce or eliminate anti-nutritional factors in plant materials that could cause large variations in the gross energies of differently processed false yam seed meals for poultry. Sequential use of water and chemical treatment methods on false yam seeds resulted in significant reduction in anti-nutritional factors, particularly terpenes (Mohammed, Dei, Addah, Roessler and Schlecht 2019). However, it is not known how 4 differently treated false yam seed meal samples (Urea_T, NaCl_T, NaOH_T and KOH_T) with varying residual anti-nutrients would influence dietary nutrient availability for productive functions of broiler chickens. There is therefore a need to determine dietary apparent metabolizable energy (AME), apparent nutrient digestibility coefficient and gross energy metabolisability of the diets containing the 4 differently treated false yam seed meals.

MATERIALS AND METHODS

The study was conducted at the University for Development Studies (UDS), Tamale, Nyankpala, northern Ghana. Nyankpala is located in the Guinea Savanna Zone on latitude 09° 25″ N and longitude 00° 58″ N at altitude 183m above sea level. The temperature fluctuates between 19°C (minimum) and 42°C (maximum) with a mean annual temperature of 28.3°C. Rainfall is mono-modal and occurs from April to October with a mean annual rainfall of 1200mm and a mean annual day - time humidity of 54% (Kasei, 1988). The poultry house used in this study was open sided to allow for natural ventilation. Light was provided 24 h daily, as is common practice in northern Ghana to stimulate feed intake during cooler night temperatures (Dei *et al*., 2011). The intensity of light was 10 lx. Ethical clearance was obtained from the Ethical Committee on Animal Experimentation of the University for Development Studies (UDS) (code number ANS/FOA/03/25052017). The experiment was conducted in compliance with regulations for animal experiments of UDS, and was closely supervised by a veterinarian. Matured fruits of false yam plants (figure 1) growing in the wild were harvested by hand picking. The fruits were partially sun-dried (figure 2) to reduce their moisture content and facilitate cracking to obtain the false yam seeds (FYS) (figure 3). The fresh FYS were crushed to reduce size, increase surface area and facilitate processing (Dei, Adzokatse, Abdulai, Amoako, Mohammed and Rose 2014). Five types of false yam seed meals (FYSM) were prepared as follows: 1. freshly crushed FYS were sun-dried to approximately 12% moisture on a cement floor and ground into flour using a hammer mill (2 mm). The remaining four seed batches were subjected to multiple-stage processing where each seed batch was first soaked in ordinary water (i.e., addition of fresh seeds in ordinary water at a ratio of 1:2, wt/vol) for 12 days with water being changed every 3 days. After the 12 days of soaking, the seed samples were washed with clean ordinary water. In the second stage of processing, each soaked FYS batch was soaked in a solution of 1M concentration of additive (urea, sodium chloride, sodium hydroxide or potassium hydroxide) at a ratio of 1:2 (wt/vol) for 24 hours, after which all the batches were washed thoroughly with tap water. The last stage of processing involved blanching of all additive-treated seeds, firstly by immersing them in hot water (90^0C) for 20 minutes and then transferring them into cold water (4^0C) for 40 minutes. The seed batches were then washed with clean water, sun-dried to approximately 12% moisture on a cement floor and ground into gritty flour using a hammer mill. The treated false yam seed meals (TFYSM) were labeled as: Sun-dried=Un_T; Urea treated=Urea_T; Sodium chloride treated=NaCl_T; Sodium hydroxide treated=NaOH_T and Potassium hydroxide treated=KOH_T. The nutrient and anti-nutrient components of the TFYSM including maize were earlier determined by Mohammed et al. (2019) and summarized in table 1 below.

FIGURE 1 **Ripped false** yam fruits

FIGURE 2 **Partially dried false yam fruits**

FIGURE 3 **Fresh false yam seeds**

Broiler bioassay

Cobb 500 broiler chicks were reared in a deep-litter-floored pen and fed broiler starter diet (CP=**220.0 g/kg, ME=12.2** MJ/kg) for 21 days. The experiment was a factorial design (5 false yam seed meal samples and 6 dietary levels) with one additional control (no treated false yam seed meals). A total of 108 chicks (54 male, 54 female) aged 4 weeks and with similar body weights (825g ±1.23) were selected and randomly divided into 5 groups of 20 birds per group and each group was subdivided into 5 treatment groups of 4 birds housed in individual wire-mesh floor cages (0.4 m x 0.3 m = 0.12 m^2/chick) in a Completely Randomized Block Design. The control group had 8 birds (8 replications) to enhance the reliability of the control data, since metabolisability values would be derived from these data. The five types of FYSM were tested at inclusion levels of 10, 20, 30, 40 and 50%, replacing maize (wt. / wt.) in a maize-fish meal-based diet (Table 2). Each bird received one of the 26 dietary treatments for 15 days. The first 10 days constituted the preliminary stage of the trial, where birds were allowed to adapt to their new environment as well as new diets. The last 5 days were used for data collection.

TABLE 1. **Determined nutrient composition of maize, untreated and treated false yam seed meals (% DM)[1]**

Chemical component	Maize	False yam seed meal batches[2]				
		Un_T	Urea_T	NaCl_T	NaOH_T	KOH_T
Dry matter	92.1	91.3	91.3	92.0	89.0	92.8
Crude protein	9.7	13.2	9.1	4.0	2.7	2.2
Crude fiber	1.7	2.7	3.8	1.7	2.7	2.7
Ether extract	4.3	1.5	2.5	2.0	2.5	1.5
Nitrogen free extract	77.8	71.4	74.9	83.9	78.1	82.6
Ash	1.4	2.5	1.0	0.5	3.0	3.8
ME (kcal/kg)[3]	3464	3132	3190	3284	3073	3149
Essential amino acids						
Phenylalanine	0.5	0.6	0.1	0.2	0.2	0.2
Leucine	1.2	0.9	0.2	0.3	0.2	0.4
Alanine	0.6	0.6	0.1	0.2	0.2	0.3
Valine	0.5	0.5	0.1	0.2	0.1	0.2
Threonine	0.3	0.4	0.1	0.1	0.1	0.2
Methionine	0.2	0.1	<0.03	0.03	0.03	0.04
Lysine	0.3	0.4	0.1	0.1	0.1	0.2
Arginine	0.5	1.4	0.1	0.3	0.2	0.5
Histidine	0.3	0.4	0.1	0.1	0.2	0.2
Tryptophan	0.1	0.2	0.04	0.1	0.1	0.1
Anti-nutrients (mg/g DM)						
Total terpenes	1.33	2.97	0.24	0.35	0.41	0.55
Total saponins	5.7	12.5	4.0	2.9	3.8	4.0

DM: dry matter; [1]Values presented are from one replicate analysis of amino acids and means of triplicate analyses for the other chemical components; [2]Un_T, Urea_T, NaCl_T, NaOH_T and KOH_T refer to the untreated, urea treated, sodium chloride treated, sodium hydroxide treated and potassium hydroxide treated false yam seed meals, respectively; [3]ME was calculated using the formula of Pauzenga (1985) and used in calculating ME content of experimental diets.

TABLE 2. **Ingredients and calculated nutrient composition (g/kg DM) of the basal diet and the diets containing untreated (Un_T) and treated false yam seed meal (TFYSM) diets**

Ingredient	Control diet	10	20	30	40	50
Maize	620	558	496	434	372	310
Un_T/TFYSM	0	62	124	186	248	310
Fish meal	115	107	106	105	105	104
Wheat bran	98	93	94	95	95	96
Soybean meal	137	150	150	150	150	150
Vit./Min. Premix[1]	2.5	2.5	2.5	2.5	2.5	2.5
Di-calcium phosphate	10	10	10	10	10	10
Oyster shell	15	15	15	15	15	15
Common salt	2.5	2.5	2.5	2.5	2.5	2.5
Calculated nutrient[2] analysis						
CP (g/kg DM)	200	200	200	200	200	200
Ca (g/kg DM)	16.2	16.0	16.2	16.3	16.6	16.7
P (g/kg DM)	8.8	8.4	8.3	8.1	8.0	7.8

Lys (g/kg DM)	10.9	10.9	10.9	10.7	10.7	10.6
Met (g/kg DM)	4.3	4.2	4.2	4.1	4.0	3.8
ME (kcal/kg DM)	2905	2891	2877	2863	2850	2836

[1]Composition of vitamin/trace mineral premix per kg diet (Arosol Chemicals Ltd, India): Vitamin A, 6250 IU; Vitamin D3, 1250 IU; Vitamin E, 25 mg; Vitamin K3, 25 mg; Vitamin B1, 25 mg; Vitamin B2, 60 mg; Vitamin B6, 40 mg; Vitamin B12, 2 mg; Folic acid, 10 mg; Niacin, 40 mg; D-Biotin, 5 mg; Elemental calcium, 25 g; Elemental phosphorus, 9 g; Elemental magnesium, 300 g; Choline chloride, 500 mg; Sodium (as sodium chloride), 1.5 mg; Copper (as penta-hydrate sulphate copper), 60 mg; Cobalt (as hepta-hydrate sulphate cobalt), 10 mg; Zinc (as zinc oxide), 150 mg; Manganese (as manganous oxide), 100 mg; Iron (as ferrous carbonate); 90 mg Iodine (as potassium iodine), 20 mg; and Selenium (as sodium selenium), 1.0 mg. Lime lactobacillus spore, 0.2 million cfu.
[2]CP crude protein; Ca calcium; P phosphorus; Lys lysine, Met methionine; ME metabolizable energy, DM dry matter.

Weighed quantities of the diets were supplied and faeces collected in plastic sheets placed under the wire-mesh floor of the cages using total collection method. Faeces were collected every 24 hours, weighed and stored under cool temperature (4°C in refrigerator). At the end of the trial, the daily samples collected from chickens in each replicate cage were pooled into one sample per treatment, oven dried (60°C), weighed, ground and stored in airtight plastic containers. Triplicate samples of treatment diets and dried faeces were analysed for proximate components in accordance with Standard methods described by AOAC international (2000). The gross energy of experimental feed and excreta was calculated using the formula of Anderson and Anderson (2002).

Calculations

The apparent metabolizable energy (AME) values of the diets were calculated from the gross energy (GE) values of the diets and excreta using the following formula:

$$AME_{diet} = [(\text{feed intake} \times GE_{diet}) - (\text{excreta output} \times GE_{excreta})] / \text{Feed intake}$$

Equation 1.

The gross energy of diets and excreta were calculated from their proximate components according to the equation of Ewan (1989):

$$GE = 4{,}143 + (56 \times \%EE) + (15 \times \%CP) - (44 \times \%ash), R^2=0.98$$

Equation 2.

Where

GE= gross energy

EE= ether extract

CP= crude protein

Ash= crude ash

An apparent nutrient digestibility coefficient estimate of each sample was derived according to calculation of digestibility of a single feed of a mixed ration (Lloyed et al., 1978).

$$S = A + \frac{100 (T - A)}{s}$$

Equation 3.

S is the coefficient of apparent digestibility of the test feed ingredient.

A is the coefficient of digestibility of the basal diet (Control diet)

T is the coefficient of digestibility of the combination of the basal feed plus test ingredient

s is the proportion of test feed ingredient in the mixed diet **(T)**

The gross energy metabolizability (GEM) co-efficients of false yam seed samples (FYSS) were calculated using the following formula:

GEM = apparent metabolizable energy of the sample/gross energy of the sample. I.e. GEM=AME/GE
Equation 4.

RESULTS AND DISCUSSION

Apparent metabolizable energy (AME) values of the experimental diets (Table 3) increased as the level of FYSM samples were increased in the diets. Generally, all the treatment diets showed a higher AME content. However, among the treatment diets, urea, potassium hydroxide and sodium hydroxide-treated FYSM-based diets had higher (P<0.001) AME values than the sodium chloride treated FYSM diet. The lower apparent metabolizable energy values in the untreated seed sample could be attributed to high anti-nutrients content). High anti-nutrient contents of a meal could have a pronounced negative effect on its metabolizable energy (Smulikowska, Pastuszewska, Swiech, Ochtabinska, Mieczkowska, Nguyen and Buraczewska 2001). The results of this study suggest that anti-nutrients have an energy effect in poultry diets. These results are consistent with the findings of Farrell, Perez-Maldonado and Mannion (1993), who reported significant increases in the AME of sorghum-soya bean meal-based diets with phytase addition. The fact that these negative effects on AME were overcome by sequential use of water-based and chemical treatment methods as seen in this study suggests that anti-nutrients may be partly responsible for the observed depressions in AME values in the untreated FYSM. This may explain the lower CP metabolisability in the untreated than the treated FYSM samples.

TABLE 3. **Apparent metabolizable energy of experimental diets**

	Level	Treatment						ANOVA		
Component	(%)	Un_T	Urea_T	NaCl_T	NaOH_T	KOH_T		Factor	LSD	P
	0						*14.8^{fz}*	T	0.543	<.001
AME	10	16.1^{av}	16.9^{au}	16.3^{av}	16.4^{av}	16.3^{av}		L	0.543	<.001
(MJ/Kg,	20	17.3^{bx}	18.9^{bu}	18.3^{bw}	19.2^{bu}	18.2^{bw}		T x L	0.976	<.001
DM)	30	19.1^{cy}	20.1^{cw}	20.3^{cw}	21.4^{cu}	20.7^{cv}				
	40	20.4^{dw}	23.1^{du}	22.3^{dv}	23.1^{du}	22.9^{du}				
	50	21.2^{ew}	24.2^{ev}	23.9^{ev}	25.3^{eu}	24.8^{eu}				

[1]Un_T= Untreated, Urea_T= Urea treated, NaCl_T= Sodium chloride treated, NaOH_T= Sodium hydroxide treated, KOH_T= Potassium hydroxide treated, LSD=least significant difference, P= probability. Means with the same superscript within colunms (a,b,c,d,e,f) are not significantly different and mean with the same superscript within rows (u,v,w,x,y,z) are not significantly different.

The nutrient metabolisability coefficients of the treated FYSM samples are presented in table 4. Varying inclusion levels of each treated FYSM sample did not vary (P>0.05) the coefficients of metabolisability of dry matter (DM) and crude protein (CP). However, in terms of methods of processing, DM metabolisability was significantly higher (P<0.001) in the FYSM samples that were sequentially treated with water-based and chemical treatment methods than in the untreated sample (Table 4). The sodium hydroxide-treated FYSM sample had higher (P<0.001) CP metabolisability than its counterparts. Urea and potassium hydroxide-treated samples had similar (P>0.05) CP metabolisability, with the untreated sample recording the lowest (P<0.001) CP metabolisability.

The low nutrient metabolisability values of the untreated false yam seed meal recorded in this experiment could be due to high amount of anti-nutrients. The terpenes and saponin contents of the meal could be implicated as Dei et al. (2011) reported that high concentration of terpenes in soaked false yam tuber meal fed to experimental birds at increasing level may have been responsible for the poorer growth performance of the birds due to poor nutrient utilisation. According to MacDonald et al. (2002), terpenes actually impair the availability of nutrients, particularly protein and reduce performance when fed to animals. Terpenes, reported to be constituents in false yam (Vanhaelen, Planchon, Vanhaelen-Fastre, and On'Okoko 1986), are plant biosynthetic substances, many of which have pronounced effects on animal metabolism (Frohne and Pfander, 2005). The interactions of anti-nutrients (terpenes) and proteins to form protein complexes have been described (Anderson, 1985) and the nutritional significance of these complexes is being increasingly recognized. *In vitro* studies have shown that these protein complexes are insoluble and less subject to attack by proteolytic enzymes than the uncomplexed protein (Cheryan, 1980). Saponins significantly affect growth, feed intake, impair the digestion of protein, and the uptake of vitamins and minerals in animals gut (Francis *et al*., 2002).

Generally, sequentially treated FYSM samples had increasing values of carbohydrate metabolisability as their levels were increased in the diets. The untreated sample had a significant (P<0.001) reduction in carbohydrate metabolisability beyond 30% inclusion level (Table 4). Carbohydrate metabolisability was higher (P<0.001) in potassium hydroxide-treated FYSM sample and lower (P<0.001) in the untreated sample. Improvement (P<0.001) in gross energy metabolisability was observed in sodium chloride, sodium hydroxide and potassium hydroxide-treated samples as their levels were increased in the diets. However, the untreated sample had a declining (P<0.001) gross energy metabolisability as the level was increased in the diets.

Among the sequentially treated FYSM samples, sodium hydroxide-treated samples had the highest (P<0.001) gross energy metabolisability, while the untreated sample recorded the lowest (P<0.001) gross energy metabolisability. The interaction between level of inclusion and treatment methods in this study showed that treatment methods had different effects on crude protein metabolisability

(P < 0.011) and gross energy metabolisability (P < 0.017) values of FYSM samples depending on the level of inclusion. All the false yam seed meal samples had residual terpenes and saponin contents, and in particular, the untreated false yam seed samples had very high terpenes and saponin levels (Mohammed et al., 2019). This indicates that the residual anti-nutrients in the false yam seed meals may have contributed significantly to their ME contents. The false yam seed meal samples treated with sequential use of water-based and chemical treatment methods had high metabolisability (AME/GE; mean of 0.82) compared with the untreated false yam seed meal samples (mean of 0.75). This gives evidence that the anti-nutrients content of false yam seed meals may have a deleterious effect on ME, although the sequential treatment methods employed in this study reduced the terpenes concentration by 55.2 to 91.9% and saponin concentration by 54.4 to 76.8% in the false yam seed meal samples. The processing conditions, the presence of anti-nutritional factors and dietary fiber are some factors that influence digestibility and nutrient metabolisability of feed (Leeson and Summers, 2002).

TABLE 4. **Nutrient digestibility and gross energy metabolisability coefficients in false yam seed meal samples**

Variable	Level (%)	TREATMENT					ANOVA		
		Un_T	Urea_T	NaCl_T	NaOH_T	KOH_T	Factor	LSD	P
DM	10	0.51	0.78	0.69	0.62	0.60	T	0.148	<0.001
	20	0.48	0.81	0.72	0.88	0.72	L	0.148	0.798
	30	0.51	0.74	0.70	0.87	0.80	T x L	0.330	0.997
	40	0.48	0.71	0.73	0.81	0.81			
	50	0.43	0.74	0.71	0.82	0.78			
CP	10	0.56	1.10	0.26	0.48	0.54	T	0.193	<0.001
	20	0.18	0.76	0.37	0.95	0.56	L	0.193	0.869
	30	0.16	0.23	0.56	0.90	0.63	T x L	0.431	0.011
	40	0.32	0.29	0.54	0.79	0.64			
	50	0.20	0.41	0.52	0.83	0.65			
CHO	10	0.51	0.47	0.70	0.65	0.58	T	0.064	<0.001
	20	0.79	0.78	0.87	0.84	0.96	L	0.064	<0.001
	30	0.76	0.81	0.84	0.88	0.95	T x L	0.144	0.202
	40	0.72	0.84	0.88	0.89	0.93			
	50	0.64	0.84	0.85	0.91	0.92			
Gross energy (AME/GE)	10	0.76	0.79	0.77	0.77	0.76	T	0.018	<0.001
	20	0.74	0.81	0.79	0.82	0.79	L	0.018	<0.001
	30	0.75	0.81	0.80	0.84	0.82	T x L	0.040	0.017
	40	0.75	0.87	0.82	0.84	0.84			
	50	0.73	0.83	0.82	0.86	0.84			

Un_T= Untreated, Urea_T= Urea-treated, NaCl_T= Sodium chloride-treated, NaOH_T= Sodium hydroxide-treated, KOH_T= Potassium hydroxide-treated, FYSM= False yam seed meal, LSD= Least significant difference, P= Probability. T=Treatment, L=Level.

CONCLUSION AND RECOMMENDATION

In conclusion, sodium hydroxide and potassium hydroxide-treated false yam seed meals showed higher AME and better nutrient and gross energy metabolisability values. The content and nature of the anti-nutrients in the false yam seed meal samples as well as the method of processing probably accounted for most of the variability observed in available nutrient concentrations. Therefore, the residual anti-nutrient content is important quality variable of false yam seed meal that affect its nutrients and energy metabolisability values for poultry. It is recommended that varying inclusion levels of nutritionally improved false yam seed meals in diets of broiler chickens be fed to ascertain their effects on performance.

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CONFLICT OF INTEREST DECLARATION

The authors declare that there are no conflicts of interest.

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