EFFECTS OF VARYING PROCESSING TECHNIQUES ON NUTRITIVE VALUE OF FALSE YAM SEED MEAL IN BROILER CHICKEN DIETS

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ABSTRACT
False yam (Icacina oliviformis syn. I. senegalensis) is a shrub found in Savannah regions of Sub-Saharan Africa that produces seeds high in starch content, but contains anti-nutritive factors (resins). The objective of this study was to evaluate the feeding value of the seeds for broilers when fed raw (RSM), soaked (SSM) or boiled (BSM). Three samples [RSM (seeds sun-dried and milled), BSM (seeds crushed, boiled in water, i.e. 1 kg to 2 L water for 30 min, rinsed with fresh water, sun-dried and milled), SSM (seeds soaked in water, i.e. 1 kg to 2 L water for 9 d and water changed every 3 d, sun-dried and milled)] were substituted for maize (w/w basis) at 50, 75 and 100 g/kg in a basal (control) broiler grower diet. Diets were fed to chicks (Cobb 500) from 21 to 56 d of age using a 3x3 factorial design with an additional control (3 replicates and 10 chicks per replicate). Data were analyzed using Genstat. Nutrient concentrations of the seed meals (RSM, BSM, SSM) on g/kg 'as fed' basis were dry matter: 884.6, 872.8, 869.0; crude protein: 126.9, 123.8, 97.5, crude fat: 10.1, 6.7, 4.1 neutral detergent fiber: 124.8, 298.5, 63.7, starch: 456.1, 385.3, 384.7, ash: 24.0, 18.7, 4.8, lysine (4.1, 4.6, 3.8), methionine (1.7, 1.4, 0.9), and gross energy: 3830, 3900, 3850 kcal/kg. Increasing dietary level of RSM or BSM linearly decreased feed intake (P<0.001), weight gain (P=0.004), gain/feed ratio (P=0.041) and dressed carcass yield (P=0.011); but no such linear (P>0.05) effects of these variables were observed for SSM. There were significant (P<0.05) seed meal x level interactions. Mortality was 1.33% or less (P>0.05). Inclusion of each meal in the diets did not affect the health of birds; and no pathological changes in blood haemoglobin and haematocrit were observed.

Keywords: *broiler chicken, false yam (Icacina oliviformis) seed, nutritive value, processing*

INTRODUCTION

False yam [*Icacina oliviformis* (Poiret) J. Raynal or *Icacina senegalensis* A. Juss.] of the *Icacinaceae* family is a drought-resistant and fire-adapted shrub that grows in the Savanna regions of West and Central Africa. It produces both seeds and large tubers. Reports by Fay (1993) showed that false yam's tuberous root yield can be as high as 20 mt/ha [compared with ~30 mt/ha for normal yam] and a relatively lower seed yield [0.214 mt/ha compared with ~1.3 mt/ha of maize] (International Institute of Tropical Agriculture (IITA), 2009). It is envisaged that with proper agronomic practices both seed and tuber yields can be substantially increased if cultivated.

Comparatively, the seed protein content is higher (140 g CP/kg DM) than that of the tuber (44 g CP/kg DM) (Fay, 1991). However, both have high starch content which is close to that of maize; therefore it can serve as a partial substitute for maize (major energy source) in poultry diets (Dei *et al*., 2011). This can reduce competition between humans and animals for this commodity in sub-Saharan Africa, where maize is a staple food for an estimated 50% of the population (IITA, 2009). Incidentally, the competition for maize has led to high poultry feed costs in the industry.

The major disincentive for using false yam as food for humans and animals is the presence of resins, a toxic anti-nutritional factor, in both the seeds and tubers (Fay, 1991). However, processing of the tuber using methods such as soaking in water (Dei *et al*., 2013) or boiling in water (Dei *et al*., 2011) have been shown to improve its utilization by broiler chickens. The objective of this study was to evaluate the nutritive value of processed false yam seed meal samples (raw, boiled and soaked) when incorporated at 50, 75 and 100 g/kg as substitute for maize in broiler grower diets.

MATERIALS AND METHODS

Preparation of false yam seed meal samples

The ripe fruits of false yam plants growing in the wild were harvested for sample preparations. The raw seed meal (RSM) was prepared as follows: dried fruits were cracked using stone to remove seeds, sun-dried and milled. The boiled seed meal (BSM) was prepared as follows: dried fruits were cracked using stone to remove seeds, crushed with stone, boiled in water, i.e. 1 kg to 2 L water for 30 min, rinsed with fresh water, sun-dried and milled. The soaked seed meal was prepared as follows: dried fruits were cracked using stone to remove seeds, soaked in water, i.e. 1 part to 2 parts of water for 9 d with water changed every 3 d, sun-dried and milled.

Chemical analyses

The seed samples were analysed using standard methods (AOAC International, 2000) for dry matter (Method 934.01), nitrogen (Method 968.06) and crude protein obtained as N x 6.25, ash (Method 942.05) and gross energy (adiabatic bomb calorimeter Model 1261; Parr Instrument Co., Moline, IL). Ether extract content was determined after an hydrochloric acid (4M) digestion (Method 920.39). The neutral detergent fibre content was determined by the method of Van Soest (1963) using neutral detergent solution. Starch contents of the samples were determined using Method 979.10 (AOAC International, 2005). The concentrations of amino acids in the dried samples were determined by Eurofins Laboratories Ltd, Wolverhampton, UK using standard methods of the European Union (2009) as follows: The sample was analyzed for all amino acids except methionine, cystine, and tryptophan following acid hydrolysis using hydrochloric acid (Method D1004). Methionine and cystine were analyzed after oxidation hydrolysis with performic acid/phenol mixture (Method DJ011). The amino acids were separated by ion exchange chromatography using a Biochrom 30 analyzer (Biochrom Ltd, Cambridge, UK) and determined by reaction with ninhydrin using photometric detection at 570 nm (440 nm for proline). Total tryptophan in the sample was extracted under mild acidic conditions in the presence of an internal standard following alkaline hydrolysis using saturated barium hydroxide solution and determined by HPLC with fluorescence detection at 280 nm (Method DJ009). The chemical compositions of the samples are shown in Table 1.

Experimental site

The study was conducted between October and December at Nyankpala in the Northern Region of Ghana, which is located in the Guinea Savanna zone. The zone is characterized by a wide diurnal temperature variation (28-45°C) with low day-time humidity (17-42%) during the dry season from November to April (Kasei, 1988).

Experimental feeding

Day-old Cobb 500 broiler chicks obtained from Israel and brooded for 21 d and fed a broiler starter mash (230 g CP/kg, 3,014 kcal ME/kg) were used. At 21 d of age, 120 chicks of similar body weight were divided into 12 groups with equal sexes, reared in raised-floor pens $0.16m^2$/ bird in an open-sided house and fed one of 10 meal-form maize-fishmeal based experimental diets. The maize in the basal diet (210 g CP/kg, 3,170 kcal ME/kg) was replaced with each seed meal sample on weight-for-weight basis at 50, 75 and 100 g/kg (Table 2). Each treatment was replicated three times in a 3x3 factorial arrangement with an additional control (basal diet). Feed and water were provided for *ad libitum* consumption from 21 to 56 d of age and light was provided 24 h. Light is usually provided throughout the night in the northern Guinea Savanna zone in order to stimulate feed intake, which is depressed by the prevalent high day time temperatures. The prevailing ambient temperatures in the pens during the experimental period ranged between 28 to 37°C.

Growth and carcass parameters measured

Bird weights and feed intakes were measured.

Table 1: Composition of false yam seed meals (g/kg, as fed basis)[1]

Chemical component	False yam seed products[2]		
	RSM	SSM	BSM
Dry matter	884.6	869.0	872.8
Gross energy (kcal/kg)	3,830	3,900	3,850
Crude protein	126.9	97.5	123.8
Ether extract	10.1	4.1	6.7
Neutral detergent fibre	124.8	63.7	298.5
Starch	456.1	384.7	385.3
Ash	24.0	4.8	18.7
Calcium	1.0	1.0	1.3
Phosphorus	1.5	0.4	1.6
Essential Amino Acids			
Arginine	11.3	8.8	11.2
Histidine	3.1	2.8	3.3
Isoleucine	7.7	6.9	7.7
Leucine	8.8	7.7	9.3
Lysine	4.1	3.8	4.6
Methionine	1.7	0.9	1.4
Phenylalanine	5.7	4.9	6.0
Threonine	4.8	4.1	5.2
Tryptophan	1.5	1.4	2.1
Valine	5.9	5.2	6.2
Non-essential amino acids			
Alanine	6.2	5.2	6.5
Aspartic acid	13.1	10.6	13.0
Cystine	0.7	0.7	0.7
Glutamic acid	21.6	15.2	18.6
Glycine	5.0	4.3	5.4
Proline	4.9	4.4	5.3
Serine	5.6	5.2	6.4
Tyrosine	4.4	3.4	4.5

[1]*Values presented are from 1 replicate analysis of amino acids and means of duplicate analyses for the other chemical components*

[2]*RSM, SSM and BSM refer to the raw, soaked and boiled seeds meals, respectively.*

Table 2: Composition of the diets fed to broilers from d 21-56

Ingredient	Dietary levels of false yam seed meals (g/kg)			
	0	50	75	100
Maize (*Zea mays*)	548	498	473	448
False yam seed meal	0	50	75	100
Fishmeal (66% CP)	64	64	64	64
Soybean meal	267	267	267	267
Wheat bran	41	41	41	41
Soybean oil	47	47	47	47
Oyster shell	18	18	18	18
Dicalcium phosphate	6	6	6	6
Lysine	2	2	2	2
Methionine	2	2	2	2
Vitamin/mineral premix[1]	2.5	2.5	2.5	2.5
Sodium chloride	2.5	2.5	2.5	2.5
Calculated nutrient composition (g/kg)[2]				
Crude protein	210.1	212.8	214.3	215.6
Lysine	13.5	13.6	13.7	13.7
Methionine	5.7	5.7	6.2	5.7
Methionine+Cystine	9.2	9.2	9.2	8.9
Metabolisable energy (kcal/kg)[3]	3,170	3,117	3,090	3,062

[1]*Composition of vitamin/mineral premix per kg diet (Arosol Chemicals Ltd, India): Vitamin A, 6250 IU; Vitamin D_3, 1250 IU; Vitamin E, 25 mg; Vitamin K_3, 25 mg; Vitamin B_1, 25 mg; Vitamin B_2, 60 mg; Vitamin B_6, 40 mg; Vitamin B_{12}, 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); Iodine (as potassium iodine), 20 mg; and Selenium (as sodium selenium), 1.0 mg. Lime lactobacillus spore, 0.2 million cfu.*
[2]*Calculated nutrient composition was based on that of RSM.*
[3]*ME of the raw false yam seed is 2300 kcal/kg DM (Dei et al., 2011, unpublished data).*

Feed conversion efficiency was defined as live weight gain per unit feed consumed. Records of mortality were kept and all dead birds were sent to the Veterinary Laboratory of the Department of Animal Science, University for Development Studies, Tamale, Ghana for post-mortem examination. At 56 d of age, four birds (2 males, 2 females) were randomly selected from each replicate. They were starved for 8 h, slaughtered using a recommended procedure (FAO, 1992) at the Meat Processing Unit of the Department of Animal Science, University for Development Studies, Tamale-Ghana, defeathered, eviscerated and carcass dress weight and carcass yield were measured.

Blood collection and assays

At 56 d of age, blood samples from 2 birds (male and female) per replicate were collected for the determination of haemoglobin (Hb) and haematocrit (packed cell volume, PCV). The blood samples were obtained by using sterile disposable syringes (2 ml) and needles (23G x 1″) to draw blood from the left wing vein of each bird. Blood samples for the haematological tests were mixed with the dipotassium salt of EDTA as an anticoagulant. Hb was determined using the cyanmethaemoglobin method described by Cheesbrough (2001) and the PCV was determined using the microcapillary method (Mukherjee, 2005). Each determination was made in duplicate and the mean calculated.

Statistical analysis

Samples of false yam seed meals and their inclusion levels were considered as treatment factors by ANOVA using GENSTAT 8th version (Lawes Agricultural Trust, 2005). Linear and non-linear regression techniques with grouping factors (sample) were used to examine the effect of level of dietary sample on growth variables. Treatment means were compared by using the least significant difference (LSD) tests (Snedecor and Cochran, 1980).

RESULTS

Both raw and boiled samples appeared to have similar nutrient composition, except that the latter contained about thrice the level of NDF (Table 1). The boiled sample was quite hard. It had slightly higher crude protein content as well as higher neutral detergent fibre content than the soaked sample, largely in part as a result of some loss of starch content during the boiling process. The soaked sample contained lower nutrient levels than the raw or boiled sample, and contained relatively less starch (Table 1). Generally, all samples had very low concentrations of crude fat and total ash as well as low contents of crude protein, but high in carbohydrates, particularly starch. Also, the amino acid profiles of the samples showed low concentrations of most essential amino acids except arginine, and were virtually devoid of methionine (Table 1). All samples had similar contents of gross energy (Table 1).

Increasing dietary level of RSM or BSM linearly ($P<0.001$) decreased feed intake ($P<0.001$), weight gain ($P=0.004$), gain/feed ratio ($P=0.041$) and dressed carcass yield ($P=0.011$); but no such linear ($P>0.05$) effects of these variables were observed for SSM (Tables 3 & 4). There were significant ($P<0.05$) seed meal x level interactions. Mortality was 1.33% or less ($P>0.05$). Inclusion of each meal in the diets did not affect the health of birds; and no pathological changes in blood haemoglobin and haematocrit (Table 4) were observed.

DISCUSSION

The crude protein and starch contents recorded in this study compared favorably with those of cereal grains such as maize (Larbier and Leclercq, 1994), a common source of dietary energy for poultry. However, the major nutritional concern is their relatively very low concentrations of most limiting amino acids, particularly lysine and methionine. Although this shortcoming can be corrected in the diet through supplementation with high protein concentrates or synthetic amino acids, additional feeding cost may be incurred due to the poorer amino acid profile. Nevertheless, the material at the moment is not sold and the only cost item is the processing cost. Therefore it can be useful as a feedstuff.

In this study, due to logistical reasons, the anti-nutritional factors (gum resins) reported in false yam tuber (NRI, 1987; Dei *et al*., 2011) were not determined for the seed meals. Nonetheless, their negative impact on broiler productivity was observed, particularly in the untreated seed meal (Table 3). The most likely explanation for the relatively poor growth performance of birds fed the boiled seed meal compared to the soaked seed meal could be due to their nutrient metabolism. Terpenes, reported as constituents of *Icacina* resin (Vanhaelen *et al*., 1986), can have negative impact on animals through toxic effects. Toxicity may result from several mechanisms, including inhibition of ATP formation, interference with hormone production, and binding proteins or sterols in the gut (Langenheim, 1994). Even though cooking is reported as an effective way of debittering *Icacina* resin in the tuber (Dei *et al*., 2011), it appears the cooking duration used for the seeds (30 min versus 2 h) may have been too short. Probably, simple boiling of the seeds may only partially inactivate or liberate the anti-nutritional factor which may be extracted in the cooking water as opposed to prolonged soaking (e.g. 9 days). It has also been observed that heat processing, as in the case of the boiled seed sample could increase the solubility of NSP (Table 1), especially in the case of β-glucans (Vukic Vranjes *et al*., 1994), which might compromise chick productivity. Therefore, soaking has shown the clearest potential for improving the nutritional value of the seed, and must be further studied.

Generally, there was an overall low performance of the birds during the study period that could be attributed to the high ambient temperatures in this ecological zone in the dry season. Day-time ambient temperatures recorded in the pens during the experimental period ranged between 30 and 38°C. High ambient temperatures are known to affect broiler chicken performance (Donkoh, 1989).

In this study, the birds showed no pathological changes in the blood parameters measured. This suggests that *Icacina* resin might have no health consequences for poultry. Previous work involving false yam tuber meals in broiler diets did not show any deleterious effects on their health status (Dei *et al*., 2011). It has been reported that some animals are capable of detoxifying terpenes (resins) when ingested; and the mechanism seems to be to poly-oxygenate the molecules forming highly polar, acidic metabolites that can be readily excreted (McLean *et al*., 1993).

The results of this study have indicated that, soaking seeds in water for prolonged period (e.g. 9 days) should be a preferred method of ameliorating adverse nutritional effects of *Icacina* resin in poultry diets. However, studies on the best methods of further processing (e.g. use of weak base) and their effects on macro-nutrient availability are required to allow this potentially valuable plant material to be efficiently utilized.

Table 3: Growth performance of broilers (21-56 d) fed three types of false yam seed meal at three levels[1]

Variable	Level (g/kg)	Test samples Raw	Boiled	Soaked	mean	ANOVA Factor	SED (rdf=20)	P
Feed intake (g/b/d)	0				106	Sample (S)	3.9	0.001
	50	102	106	105	103	Level (L)	3.9	<0.001
	75	89	98	97	98	S x L	4.8	0.007
	100	76	88	95	87			<0.001(L)
	mean	89	97	99	96			
Weight gain (g/b/d)	0				49.4	Sample (S)	1.96	<0.001
	50	42.1	42.7	47.5	44.9	Level (L)	1.96	0.005
	75	34.5	40.4	44.3	40.6	S x L	2.41	0.041
	100	30.4	39.4	45.5	39.3			0.002(L)
	mean	35.7	40.8	45.8	41.6			
Gain/feed ratio	0				0.47	Sample (S)	0.019	<0.001
	50	0.41	0.44	0.45	0.44	Level (L)	0.019	ns
	75	0.39	0.39	0.46	0.42	S x L	0.024	ns
	100	0.40	0.45	0.48	0.45			ns(L)
	mean	0.40	0.42	0.46	0.43			
Mortality (%)	0				0.00	Sample (S)	0.408	ns
	50	0.33	0.33	0.00		Level (L)	0.408	ns
	75	0.33	0.67	0.00		S x L	1.307	ns
	100	1.33	0.67	0.33				
	mean	2.21	1.83	0.37				

SED-standard error difference of means, P-probability, rdf-residual degrees of freedom, ns- not significant (p>0.05), Polynomial contrasts for sample x level interaction: L-linear effects
[1]Values are means of 10 birds from 3 pens (n=30)

Table 4: Dressed carcass[1] and blood constituents[2] of broilers (21-56 d) fed three types of false yam seed meal at three levels[1]

Variable	Level (g/kg)	Test samples Raw	Boiled	Soaked	mean	ANOVA Factor	SED	P
Dressed carcass (% of live weight)	0				81.5	Sample (S)	1.98	<0.05
	50	81.5	81.3	82.7		Level (L)	1.98	<0.05
	75	79.7	79.5	81.6		S x L	1.368	ns
	100	77.5	75.8	81.9				
	mean	79.6	78.9	82.1				
Hb (g/dl)	0				11.9	Sample (S)	0.45	ns
	50	11.4	11.0	10.7		Level (L)	0.45	ns
	75	11.7	10.7	12.4		S x L	0.509	ns
	100	11.5	11.9	11.8				
	mean	11.5	11.2	11.6				
Haematocrit (%)	0				35.5	Sample (S)	1.40	ns
	50	34.0	32.8	32.2		Level (L)	1.40	ns
	75	35.0	32.0	36.8		S x L	1.565	ns
	100	34.3	35.7	35.2				
	mean	34.4	35.5	34.7				

Hb-haemoglobin, SED-standard error difference of means, P-probability, Polynomial contrasts for sample x level interaction: L-linear effects, ns-not significant (P>0.05)
[1]Values are means of 2 males and 2 females from 3 pens per diet (n=12; 6 per sex), [2]Values are means of 1 male and 1 female from 3 pens per diet (n=6; 3 per sex)

CONCLUSION

Soaking of false yam seed improved its nutritive value and dietary level up to 100 g/kg had no adverse effects on performance of broiler chickens.

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