PROCESSED AFRICAN YAM BEAN *(SPHENOSTYLIS STENOCARPA)* IN BROILER FEEDING: PERFORMANCE CHARACTERISTICS AND NUTRIENT UTILIZATION

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ABSTRACT

The objective of this study was to investigate the effect of feeding raw and processed African yam bean (AYB) Sphenostylis stenocarpa on the performance and nutrient utilization of broiler chickens. The experiment utilized one hundred and twenty one day old Abor-Acre broiler chicks in 56-days intensive feeding trial. Four dietary treatments comprising a basal maize-soybean meal diet and three differently processed AYB meals were used to replace soybean at 50% protein for protein in the basal diet (raw, aqueous heating and dehulled AYB). There were four 4 treatments groups of 3 replicates with 10 birds per replicate. Birds were randomly divided into four groups in a completely randomized block design. It was revealed that a 50% protein for protein replacement of SBM with cooked AYB was equally as good as feeding SBM as protein source in diet of broiler chicks. Hence, Aqueous heating was a better processing method for African yam bean compared to dehulling or better still dehulling prior to aqueous heating to enable adequate removal of the anti-nutritional factors to the barest minimum.

Keywords: African yam bean, broiler feeding, nutrient, performance

INTRODUCTION

Most legumes are consumed by man while also serving as plant protein source for monogastric animals. Although, reasons for under-utilization of indigenous pulses as feedstuffs for monogastric animals and as food for humans are varied, the presence of potent anti-nutritional substances in these seeds is a significant factor. The anti-nutritional factors include: protease inhibitors, haemagglutinins (lectins), tannins, glycosides and alkaloids. These effects limit the use of raw African yam bean in livestock feed although various processing techniques tend to reduce the anti-nutritional factor content of the seed. An important aim of research in animal production is to enhance cost effective livestock production while providing adequate animal protein and livestock by-products for human consumption.

Several studies indicate that heat processing for example, aqueous and dry heating (toasting)] increases the digestible nutrients available to young nonruminant animals, especially young chicks, resulting in improved growth. The hulls of legumes consist of poorly digestible glumes that completely enclose the seed. Removal of this hull should therefore increase the concentration of digestible nutrient level for broilers comparable with that of soybean. However, many authors reported suboptimal performance when broilers are fed processed mucuna bean meals (Emenalom and Udedibie, 1998; Emiola et al., 2003; Emiola et al., 2007). This was attributed to varying concentrations of residual trypsin inhibitor and haemagglutinins in the meals. Emphasis has been placed on the various ways of inactivating the anti-nutritional factors in the legume seed and the improvement of the nutritive value. However, little attention has been given to the evaluation of the effects of intake of residual anti-nutritional factors in processed legume seeds on performance and nutrient utilization broiler chickens fed African yam bean meal. This study investigated the replacement of soybean meal with processed African yam bean (AYB) in broiler diets and its effects on growth performance and nutrient digestibility.

MATERIALS AND METHODS

Raw African yam beans were obtained from Iseyin local government arear of Oyo State, Nigeria. The African yam bean was subjected to one of the following processing methods:

Aqueous Heating: Dry legume seeds were poured into boiling water (100°C) in a cooking pot and heated for 1 hour. Cooked beans were air dried for 4 days after which they were oven dried at 85°C for 48 hours.

Dehulling: The dry seeds were soaked in cold water for between 18 to 24 hours, and the outer seed coats were removed by hand. The seeds were sun dried for 4 days after which they were oven dried at 85°C for 48 hours. The processed African yam beans were milled and used to replace soybean meal at 50% protein for protein. The raw and processed seeds were ground using a 2mm screen and stored separately in a sealed Kilner jar until required for chemical analysis and incorporation into diets.

Experimental Diets: Isocaloric and isonitrogenous diets were formulated by incorporating raw and differently processed African yam bean meals into broiler starter and finisher diets. A corn-soybean meal diet served as control; raw, aqueous heated and dehulled African yam bean meals was used to replace 50% of the protein supplied by soybean in the experimental diets. All diets were supplemented with methionine and lysine to meet NRC (1994) requirements. The experimental diets and their proximate composition are presented on tables.

Experimental Birds: One hundred and twenty unsexed 1 day old broiler chicks of the Abor-Acre strain weighing 40.00 ± 0.05 g were used for this study. The chicks were randomly divided into 4 groups of 30 birds, and each group was assigned to 1 of the 4 dietary treatments (control, raw, aqueous heating, and dehulled African yam bean meals) in a completely randomized block design. A corn-soybean diet served as control. Each group was further subdivided into 3 replicates of 10 birds and each replicate kept on litter in pens measuring 2.4m × 2.6m. Starter diet was fed from 1 to 4 weeks, whereas the finisher diet was fed from 5 to 8 weeks. Feed and water were provided ad libitum.

Measurements: Feed intake was recorded daily, and body weight (BW) was recorded weekly. Feed consumption, weight gain, and efficiency of feed utilization were used as measures of chick performance. The study lasted for 56 days. On day 56, 2 birds per replicate (6 birds/treatment) were randomly selected and transferred into metabolic cages for excreta collection. Birds were allowed 4 days adjustment period followed by 3 days of feacal collection.

Chemical Analysis: Diets, raw and processed African yam bean meals and feacal samples were milled to pass through 1-mm screen prior to chemical analyses. Samples were analyzed for dry matter (DM), ether extract (EE), crude fiber (CF), ash, nitrogen free extract (NFE) and Crude protein (CP). Raw and processed African yam beans were subjected to proximate analysis using the methods of AOAC, (1990). Concentration of haemagglutinins was determined using the haemagglutination assay as described by Valdebouze et al. (1980). For measurement of trypsin inhibitor activity, African yam bean seeds were ground with a mortar and pestle, and 100mg of the powder produced was further homogenized in 10ml of 0.001 M HCl with an all-glass Potter Elvelijam tissue grinder.

Tannins content were determined by the methods described by Hoff and Singleton (1977). Phytate content in the raw and processed African yam bean samples was determined using the methods of Haug and Lantzsch (1983). Briefly, 10ml of 0.2 N HCl was added to 100mg of raw and processed African yam bean seed, and the mixture was shaken for 3 hours at room temperature and then filtered. Distilled water (0.5ml) and 2ml of ferric solution were then added to 0.5ml of filtrate. The mixture was boiled for 30 minutes, centrifuged at 2,400 × g, after which 1.5ml of bipyridine solution was added to 1ml of the supernatant. The absorbance of the mixture was read against distilled water at 519mm with a Pharmacia Ultrospec 2000 spectrophotometer (Perkin-Elmer, Amersham Pharmacia Biotech, Piscataway, NJ). Oxalate was assayed by a gravimetric method described by Apata and Ologhobo (1989). All analyses were done in duplicate (table 1).

Data Analysis: Data collected were analyzed as a completely randomized design using the GLM procedures of SAS (SAS Inst. Inc., Cary, NC). When a significant F-value for treatment means ($P < 0.05$) was observed in the ANOVA, treatment means were compared using Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Aqueous heating reduced the crude protein content of African yam bean, whereas dehulling enhanced it (Table 1). Raw African yam bean contained 48.60 trypsin inhibitor units/mg of protein and 34.32 haemagglutinin units/mg of protein (Table 1). Dehulling marginally reduced the contents of trypsin inhibitors and haemagglutinin in African yam bean and caused substantial reduction in tannin content. Aqueous heating inactivates trypsin inhibitors and haemagglutinin, whereas heat treatment was less effective in the detoxification of tannin and phytate.

The performance of the chicks was significantly affected by the dietary treatments. Average daily gain (ADG; see Table 4) was reduced in birds fed diets containing raw or dehulled African yam bean compared with those fed aqueous heated African yam bean meal diet. The ADG in birds fed the control diet and aqueous heat-treated African yam bean meal were similar. Average daily feed intake (ADFI) was not influenced by the processing methods (Table 4). Feed conversion ratio was higher in birds fed raw and dehulled African yam bean meals than those that received the control or aqueous heated AYB meal diets. Apparent total tract digestibilities (ATTD) of CP, CF, ether extract and ash were significantly influenced by the dietary treatments. Crude protein, CF and EE digestibilities in birds fed the control diet and those fed aqueous heat treated AYB were similar and were significantly higher than those that received raw and dehulled AYB meal diets. ATTD of ash was higher in birds fed the control diet compared with those that received aqueous heated AYB meal. ATTD of ash was improved by aqueous heating compared to birds that received either raw or dehulled AYB meal based diets.

The result of the proximate composition revealed that African yam bean is a good source of protein. Aqueous heating reduced the CP content in the processed beans with a corresponding denaturation and solubilisation of heat-labile anti-nutritional factors. The reduced CP contents in aqueous heated AYB could be as a result of loss of protein, carbohydrate and other nutrients into the cooking water. The crude fiber content of the bean is low, which makes it ideal for poultry. Dehulling marginally reduced the contents of trypsin inhibitor and haemagglutinins in African yam bean and caused reduction in tannin contents. This is in agreement with the findings of Marquardt et al. (1978).

Aqueous heating inactivates trypsin inhibitor and haemagglutinins, whereas it was less effective in the detoxification of tannin and phytate. This result reaffirms the earlier observations of Babar et al. (1998) and Emiola et al. (2007). Average daily feed intake (ADFI) was not affected by the dietary treatments (see Table 4). This result contradict the findings of other authors like Udedibie and Carlini (2000); Ologhobo et al. (2003). These authors reported a significant reduction in feed intake when broilers were fed diets containing raw or improperly processed legume seed meals. However, our report showing no significant differences in ADFI agrees with the report of Liener (1989). The present study was conducted over a period of 56 days compared with a 21 day feeding trial reported by Ologhobo et al. (2003). Similarly, the contents of the anti-nutritional factors in African yam bean used in this experiment could be responsible for the observed differences. In the present study, the replacement of soybean meal in the control diet with raw and dehulled African yam bean meals caused a significantly poorer growth of chicks as a result of reduced absorption of nutrients within the gastrointestinal tract.

The most significant effect of the intake of residual anti-nutritional factors in legumes was the enlargement of the pancreas caused by the hypertrophy and hyperplasia of the cells. There is evidence that the ingestion of trypsin inhibitors from legumes result in the hypertrophy and hyperplasia of the pancreas (Liener, 1989; Ologhobo et al., 2003), an indication of dysfunction of the pancreas. Liener and Kakade (1980) have reported that the presence of protease inhibitors in legumes are in part responsible for the depression in the nutritive values of proteins, inhibition of growth, and stimulation of pancreatic hypertrophy and hyperplasia. Trypsin inhibitors have been implicated in growth depression in broiler chicks (Liener and Hasdai, 1986). The depressed ADG in birds fed raw and dehulled African yam bean diets could be attributed to higher intake of trypsin inhibitors in these diets. According to Lyman and Lepkovsky (1957), the growth depression caused by trypsin inhibitors might be the consequence of an endogenous loss of essential amino acids being secreted by a hyperactive pancreas. This could be as a result of a combination of endogenous losses of essential amino acids, especially threonine, which are important components of trypsin and decreased proteolysis of dietary proteins. The pancreatic hypertrophy and hyperplasia according to Lyman and Lepkovsky (1957) divert the amino acids from the synthesis of body protein to the synthesis of these enzymes. This loss in sulphur-containing amino acids exacerbates an already critical situation with respect to legume seeds, which are inherently deficient in these amino acids.

Similarly, haemagglutinins are known to exert deleterious effects via structural and functional disruptions of the intestinal microvilli resulting in reduced nutrient absorption. The improvement in growth recorded in the groups fed aqueous-heated African bean meal could be attributed to the inactivation or reduction in trypsin inhibitors and haemagglutinins in the meals. Efficiency of feed utilization was significantly influenced by the dietary treatments. This is consistent with the observation of Zarkadas and Wiseman (2005) who report a reduction in the efficiency of feed utilization when diets containing trypsin inhibitor was fed to monogastric animals. There is improvement in efficiency of feed utilization by broilers fed with aqueous heated African yam bean meal diets.

The high average daily weight gain in the control and aqueous heated AYB diets suggest a better feed utilization. Aqueous heating has been reported to be effective in reducing haemagglutinin and trypsin inhibitor content of AYB (Emiola, 2004), while reducing the tannin content marginally. Tannins form insoluble or inactive complexes with dietary proteins thereby reducing their biological value, while forming complexes with digestive enzymes. Other negative effects are reduced palatability, reduced weight gain and feed efficiency (Emiola et al., 2007) which was observed in the values obtained for weight gain and feed conversion efficiency (FCE) in birds fed raw and dehulled African yam beans diets. The presence of tannins in diets results in reduced weight gain and poor feed efficiency (Ahmed 1991, Mariscal-Landin 1992). Reduced weight gain and FCE obtained in this study suggested a probable retention of over 70% of the original activity of trypsin inhibitor in the dehulled than aqueous heated AYB with the presence of a level of residual condensed tannin in the cotyledon of dehulled AYB.

Crude protein digestibility was significantly decreased across the dietary treatments with the lowest value in the raw and dehulled diets. Earlier reports indicate that tannin complexes formed initially in the grain or in the digestive tract of the animal reduces the digestibility of dietary components mainly protein (Apata 1990, Hu et al.,1997). Inhibition of enzymatic digestion of dietary proteins in the digestive tract could also result in poor total tract and ileal digestibility, digestive disturbances and reduced animal performance (Butler et al., 1984). Ether extract digestibility was significantly low in the raw and decorticated diets compared with the control and the aqueous heated AYB based diet. This suggested the probable effects of tannins on activities of lipase, α -amylase and digestion of lipids (Longstaff and McNab 1991). Crude fibre digestibility was also significantly reduced in the raw and dehulled AYB yam beans but significantly increased in aqueous heat AYB diet. The structure and amount of residual tannins likely present in the processed African yam beans probably determined their nutritional effects (Makkar 1995). These effects include; reduction of voluntary intake, reduced apparent digestibility of dry matter, crude protein and crude fibre (Waghorn et al., 1990; Muhammed et al., 1994).

Table 1: Chemical composition and anti-nutritional factors in raw and processed African Yam Beans (% dry matter)

		African yam beans	
Parameters	Raw	Aqueous heated	Dehulled
Crude protein	24.72	22.03	25.68
Crude fibre	4.92	4.52	3.22
Ether extract	3.14	2.95	2.07
Ash	4.00	3.65	3.36
Nitrogen free extract	62.32	66.85	63.95
Trypsin inhibitors (Tiu/mg protein)[1]	48.60	ND3	44.60
Haemagglutinin activity (Hu/mg of protein)[2]	34.32	ND3	31.55
Tannins (g/100g)	0.52	0.48	0.08
Phytate (g/100g)	0.69	0.66	0.63

[1]Tiu/mg of protein = trypsin inhibitor units/mg of protein
[2]Hu/mg of protein = haemagglutinin units/mg of protein
[3]ND = not detected

Table 2: Gross and chemical composition of starter diet diets (g/kgDM)

Ingredients	Control	Raw	Aqueous heated	Dehulled
Maize	545	455	450	455
AYB	-	257.5	262.6	257.5
SBM	300	150	150	150
Fishmeal	65	40	40	40
Wheat offal	45	54.5	54.4	54.5
Fixed*	45	43	43	43
Analyzed Nutrient Composition of Experimental Diets				
Dry matter	946.8	894	890	894
Crude Protein	232.2	224.8	226.3	227.2
Ether extract	82.4	38.2	38.5	39.5
Crude fibre	58.3	34..2	36.2	41.0
Ash	95.4	82.1	84.0	84.2
NFE	531.6	619.6	573.2	617.2
Calculated ME (MJ/kg)	3000.2	2960.8	2920	2985.7

1 Fixed ingredients include bone meal, 2.50; oyster shell, 0.50; vitamin premix, 0.50; methionine, 0.30; lysine,0.20; salt, 0.50 premix supplied, per kilogram of diet: vitamin A, 12,000 IU; vitamin D3, 2,000 IU; vitamin E, 50IU; vitamin B1, 1 mg; vitamin B2, 3 mg; vitamin B6, 1 mg; vitamin B12, 10 _g; vitamin K, 2 mg; copper (cupricsulphate), 75 mg; nicotinic acid, 12 mg; pantothenic acid, 10 mg; iron, 200 mg; cobalt, 0.5 mg; manganese, 40mg; zinc, 90 mg, iodine, 1 mg; selenium, 0.2 mg; calcium, 31.25 g; sodium, 10 g.

Table 3: Gross and chemical composition of finisher diets (g/kgDM)

Ingredients	Control	Raw	Aqueous heated	Dehulled
Maize	470	475	475	470
AYB	-	257.5	262.6	257.5
SBM	300	150	150	150
Fishmeal (72%)	20	20	20	20
PKC	167	54.5	54.5	54.5
Fixed*	43	43	43	43
Analyzed Nutrient Composition of Experimental Diets				
Dry matter	894	894	894	890
Crude Protein	205.5	204.8	207.2	198.3
Ether extract	44.6	38.2	39.5	38.5
Crude fibre	39.0	34..2	41.0	36.2
Ash	90.4	82.1	84.2	84.0
NFE	608.7	619.6	617.2	573.2
Calculated ME(MJ/kg)	2830	2860	2860	2820

1Fixed ingredients include bone meal, 2.50; oyster shell, 0.50; vitamin premix, 0.50; methionine, 0.30; lysine, 0.20; salt, 0.50 premix supplied, per kilogram of diet: vitamin A, 12,000 IU; vitamin D3, 2,000 IU; vitamin E, 50; IU; vitamin B1, 1 mg; vitamin B2, 3 mg; vitamin B6, 1 mg; vitamin B12, 10 _g; vitamin K, 2 mg; copper (cupric sulphate), 75 mg; nicotinic acid, 12 mg; pantothenic acid, 10 mg; iron, 200 mg; cobalt, 0.5 mg; manganese, 40; mg; zinc, 90 mg, iodine, 1 mg; selenium, 0.2 mg; calcium, 31.25 g; salt, 25 g; sodium, 10 g.

Table 4: Performance characteristics and nutrient digestibility of broilers fed processed African Yam Bean based diet.

Parameters	African Yam Beans				
	Control	Raw	Aqueous heating	Dehulled	P value
ADFI (g/b/day)	73.14	71.43	72.86	72.00	0.43
ADG (g/wk)	36.43^{a}	23.57^{c}	33.43^{b}	25.00^{c}	0.03
F:G ratio	2.01^{c}	3.03^{a}	2.18^{c}	2.88^{b}	0.05

$^{a, b, c}$ Means along the same row with different superscripts are significantly different (P < 0.05).

Table 5: Nutrient digestibility in broiler chicks fed differently processed African Yam bean

Parameters	African Yam Beans				
	Control	Raw	Aqueous heating	Dehulled	P value
Dry matter	65.5	57.5	63.5	60.4	0.07
Crude protein	72.1a	56.6c	67.7b	57.4c	0.04
Crude fibre	65.0a	54.2b	61.4a	56.8b	0.03
Ether extract	94.2a	76.0c	87.5b	78.2c	0.05
Ash	23.5a	12.0c	18.7b	12.5c	0.02
NFE	71.0	61.6	73.0	63.0	0.15

$^{a, b, c}$ Means along the same row with different superscripts are significantly different (P < 0.05).

CONCLUSION

This study investigated the replacement of soybean meal with processed African yam bean (AYB) in broiler diets and its effects on growth performance and nutrient digestibility. It was observed that the processing methods reduced the contents of crude fibre (CF), ether extract (EE) and ash content. Aqueous heating reduced the crude protein content of African yam beans, whereas dehulling enhanced it. Dehulling marginally reduced the contents of trypsin inhibitors and haemagglutinin in African yam bean and caused substantial reduction in tannin content. Aqueous heating inactivates trypsin inhibitors and haemagglutinin and was less effective in the detoxification of tannin and phytate. Average daily gain (ADG) and efficiency of feed utilization were influenced by dietary treatments. Average daily gain in birds fed the control diet and the aqueous heat treated AYB meal were similar and significantly higher than those fed dehulled AYB meal diet.

Efficiency of feed utilization was significantly higher in birds fed raw and dehulled AYB meal compared with those fed either the control diet or aqueous heat treated AYB meal diets. Apparent total tract digestibilities (ATTD) of CP, CF, EE and ash were influenced by the dietary treatments. Crude protein, CF and EE in birds fed the control diet and aqueous heated AYB were similar and were significantly higher than those that received raw and dehulled AYB meal diets. ATTD of ash was higher ($P < 0.05$) in birds fed the control diet compared with those that received aqueous heated AYB meal diet. Aqueous heating improved ATTD of ash compared to birds that received either raw or dehulled AYB meal based diets.

Although several studies with African yam beans show that the anti-nutritional factors present in the beans exert their deleterious effect via reduced nutrient absorption. However, results from this study indicated that a 50% protein for protein replacement of SBM with aqueous heated African yam bean gave performance that was equally as good as feeding SBM as protein source. Aqueous heating was a better processing method for African yam bean compared to dehulling or better still dehulling prior to aqueous heating to enable adequate removal of the anti-nutritional factors to the barest minimum.

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