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Evaluation of Raw and Boiled Velvet Bean (*Mucuna utilis*) as Feed Ingredient for Broiler Chickens

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Abstract: Chemical analysis and a performance trial were carried out to determine the effect of boiling *Mucuna utilis* seeds on their proximate composition, minerals assay and amino acid profile, level of antinutritional factors and blood seral and haematological parameters of finisher broiler chickens. Four types of mucuna seed meal were prepared. Type 1 was prepared from raw seeds, types 2, 3 and 4 were from seeds soaked in water for 24 h and then boiled in water for 20, 40 and 60 min respectively. The four dietary treatments had 20% inclusion of the four types of mucuna seed meal respectively. A four week feeding trial was conducted using one hundred and twenty, five week old, broiler birds averaging 590 gm live weight. Results of the study show that raw mucuna seeds are a good source of nutrients. Increase in boiling time significantly ($p<0.05$) reduced the crude protein content, phosphorus, iron, selenium, methionine, cystine, lysi, isoleucine, alanine, tyrosine and threonine content. Concentration of antinutritional factors in the seeds were significantly ($p<0.05$) reduced. Significant ($p<0.05$) improvements in feed: gain and protein efficiency ratios with a corresponding increase in mean daily weight gain were observed as the boiling time increased. At the end of the experiment, the haematological parameters revealed no significant differences among treatments in the levels of Packed Cell Volume (PCV), Haemoglobin (Hb), Red Blood Cell (RBC) counts, mean corpuscular volume (MHV) and Mean corpuscuscular Haemoglobin concentration (McHc). Similarly, albumin, globulin, serum glutamic pyruvic transaminase estimated were found to be insignificantly varied with the exception of total protein.

Key words: Mucuna seeds, boiling, nutritive values and performance of broiler chickens

INTRODUCTION

The prevalence of hunger and malnutrition in the tropical and subtropical areas of the world is well documented (F.A.O., 1994). Several reports indicated protein deficiency as the commonest form of malnutrition in the developing countries, particularly in regions where diets are based mainly on roots, stems and tubers crops. The problem become more obvious when per caput protein intake is considered (Tewe, 1997).

The development of the poultry industry has been described as the fastest way of ameliorating the animal protein deficiency in third world countries, due to the high turn-over rate associated with poultry production and consequent economic efficiency (Dipeolu *et al*., 2004). However, the ever-increasing cost of poultry feeds with attendant increase in cost of poultry products (meat and eggs) makes it necessary to explore the use of alternative feed ingredients that are cheaper, locally available and of low human preference. In realization of this, there is need to evaluate the nutritional adequacy of such feedstuffs. One of such alternative feed ingredients is velvet bean *(Mucuna utilis)*.

M. utilis is a widely available leguminous crop that thrives well in tropical, subtropical and temperate regions. Ukachukwu and Obioha (1997) reported that mucuna is adaptable to a wide variety of soils and relatively free of pests and disease. Average yield of seeds of about 1.8-2.29 tons/ha has been reported (Wanjekechi *et al*., 2003). The raw beans, though high in crude protein (24-35.4%) (Ukachukwu, 2006), energy (2570 Kcal/Kg) (Del Carmen *et al*., 1999) and having a good amino acid profile (Siddhuraju *et al*., 1996), contains anti-nutritional factors (Udedibe and Carlini, 1998) that affect its acceptability and utilization as poultry feed ingredient. Hence the need for proper processing of the raw beans. A limited number of studies have indicated that dry heat treatment alone (Emenalom and Udedibie, 1998; Del Carmen *et al*., 1999; Tuleun *et al*., 2008) cracking the seeds prior to soaking and cooking (Emenalom, 2004; Tuleun and Patrick, 2007) only gave partial detoxification. Presoaking in 4% $Ca(OH)^2$ solution for 48 h before cooking improved the nutritive value of velvet bean. (Emenalom and Ukachukwu, 2006), hence a boiling time-regimen to normal softness should be explored.

This study is specifically aimed at determining:

i The proximate composition, mineral assay, amino-acid profile and energy content of the processed mucuna products
ii The impact of boiling time on the anti-nutritional factors' contents of mucuna products

iii The impact of the mucuna products on the performance and seral and haematological parameters of broiler finisher chickens.

MATERIALS AND METHODS

Seed collection and preparation: The mucuna seeds were obtained from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The seeds were divided into four batches, one batch was left raw while the other three batches were soaked in plain water for 24 hours at room temperature. At the end of soaking, the water was discarded and the seeds were washed, added to boiling water in a cooking pot and boiled for 20, 40 and 6o min respectively. Timing commenced immediately after adding seeds in boiling water. Boiled seeds were drained of water and sun-dried for four days. The raw and boiled seeds were milled in a hammer mill and stored in screw-capped container until required for feed formulation.

Chemical analysis: Standard analytical methods (AOAC, 1990) were used to determine Crude Protein (CP) Ether Extract (EE) and Crude Fibre (CF)and Nitrogen Free Extract (NFE). The gross energy of the samples were determined by bomb calorimetry.

Calcium, magnesium and iron were determined with atomic absorption spectrophotometer after ashing of samples in a muffle furnace at 550^{0}C. Sodium and potassium were estimated using a flame photometer and phosphorus by spectrophotometer (spectronic 20) while sulphur was analyzed by standard colorimetric procedure.

Amino acid analysis was carried out in triplicate using Technicon Sequential Multi-sample (TSM) amino acid analyzer (DNA 0209) on previously defatted and hydrolyzed samples of raw and boiled mucuna seeds.

Anti-nutritional factors analysis: *Tannin* was determined by the Folin-Denis method (AOAC, 1990).

Phytic acid was determined by the calorimetric method of Stewart (1974). A 2.5 g amount of sample was extracted for 3 h with 100 ml of 0.2 MHcl. The phytic acid was isolated from the acidified extract recovered, digested and estimated as phytate phosphorus.

Trypsin inhibitory activity was determined following method of Kakade *et al.* (1974) using benzoyl-DL-arginine-P-nitro anilide (BAPNA) as the substrate and expressing the results as Trypsin Units Inhibited (TUI) per milligram of dry sample.

Hydrocyanide was determined by modified alkaline titration method (AOAC, 1990). Titration of distillate was carried out with 0.02 M sodium thiosulfate using 1 ml iodine a drop of starch as the indicator.

Total oxalate content was determined b the procedure of Abaga *et al.* (1968).

Experimental procedure: The mucuna beans were used to formulate diets for broiler finisher chickens at 20% inclusion level (Table 1). One hundred and twenty, five-week old broiler chickens were randomly assigned to four dietary treatments.

Each group was further sub-divided into three replicates of 10 birds per replicate in a Completely Randomized Design (CRD). Feed and water were provided *ad libitum*. The birds were weighed initially and thereafter on a weekly basis while feed intake was recorded daily.

Table 1: Percentage composition of finisher broiler diets (%)

	Treatments			
	1	2	3	4
Maize	49.93	48.92	48.13	48.55
Soyabean	26.17	27.18	26.97	27.55
Mucuna seed meal	20.00	20.00	20.00	20.00
Bone meal	3.00	3.00	3.00	3.00
Salt	0.50	0.50	0.5	0.50
DL methionine	0.15	0.15	0.15	0.15
Premix*	0.25	0.25	0.25	0.25
Calculated analysis				
Crude protein (%)	20.00	20.00	20.00	20.00
Crude fibre (%)	3.93	4.18	4.15	4.23
Available P (%)	0.79	0.83	0.80	0.83
Calcium (%)	1.23	1.24	1.23	1.24
Methionine	0.45	0.45	0.45	0.45
ME (Kcal/Kg)	3015.00	3034.00	3012.00	3036.00

*Propritery premix added to provide recommended vitamins and microminerals

Blood collection and analysis: At the end of the feeding trial, two chickens per treatment replicates were randomly selected and bled by severing the jugular vein. A set of blood samples were collected into sterile universal bottles containing a pinch of dried Ethyl Diamine Tetra Acetic Acid (EDTA) powder for haemotological evaluation while another set of blood samples were collected without EDTA (anticoagulant), for biochemical evaluation. Packed Cell Volume (PCV), Haemoglobin (Hb) concentration, Red Blood Cell (RBC) were determined as described by Device and Lewis (1991). The serum metabolites were assessed using standard principles according to Baker and Silverton (1985).

Statistical analysis: Data collected were subjected to analyses of variance. Where significant differences were observed between treatments, the means were compared using Duncan's New Multiple Range test as outlined by Obi (2002).

RESULTS AND DISCUSSION

The proximate composition of the raw and various types of boiled velvet bean is presented in Table 2. Duration of boiling had no significant effect on dry matter, crude fibre and gross energy.

Table 2: Proximate composition of raw and boiled mucuna seeds (%) DM)

	Duration of boiling (min)				
Percent	0	20	40	60	SEM
Dry matter	89.70	89.55	90.19	89.31	0.90
Crude protein	29.37[a]	27.95[b]	28.27[ab]	27.93[b]	0.87
Crude fibre	5.53	6.63	6.61	6.87	0.45
Ether extract	5.90[a]	4.53[b]	4.08[bc]	3.17[c]	0.43
Ash	4.43[c]	6.68[b]	8.78[a]	7.76[ab]	0.47
NF E	44.47[a]	43.76[a]	42.45[b]	43.75[a]	0.85
GE (Kcal/g)	3.49	3.65	3.47	3.67	0.30

[abc]Means on the same row with different superscripts are significantly ($p<0.05$) different. S.E.M: Standard error of means

Table 3: Mineral content of raw and boiled mucuna seeds

	Duration of boiling (min)				
	0	20	40	60	SEM
Calcium (%)	0.47	0.35	0.53	0.51	0.36
Phosphorus (%)	0.41[a]	0.34[b]	0.32[bc]	0.26[c]	0.01
Magnesium (%)	0.04	0.04	0.03	0.04	0.03
Potassium (%)	0.27	0.30	0.20	0.25	0.04
Selenium (ppm)	0.24[a]	0.10[c]	0.09[c]	0.12[b]	0.01
Iron (ppm)	103[a]	94.33[b]	70.00[c]	96.00[b]	0.85
Sulphur (ppm)	1250	1180	1076	1167	8.95

[abc]Means on the same row followed by different superscripts are significantly ($p<0.05$) different. S.E.M: Standard error of means

However, the crude protein, ether extract and NFE content decreased significantly ($p<0.05$) as the duration of boiling increased. This tended to confirm earlier observations (Mbajunwa, 1995; Nestare *et al.*, 1996). The decrease might be due to loss of soluble forms of these fractions into the boiling water. Ukachukwu and Obioha (1997) also observed a reduction in fat content by soaking and boiling mucuna seeds in water. They attributed the decrease to leaching of some fats into the cooking water or volatilization of fats during boiling.

Table 3 summarizes the mineral element profile of raw and boiled mucuna seeds. There was a significant decrease in the levels of phosphorus, iron and selenium as the boiling time increased. On the other hand, boiling regimen caused no significant ($p>0.05$) reduction in the levels of calcium, magnesium and potassium. This result is in consonance with the report of Iyaji and Egharevba (1998) who reported that soaking over-night and cooking for one hour generally reduced the levels of all the major minerals except calcium. Similarly, Ologhobo (1992) showed a decrease in the level of calcium, phosphorus, magnesium and sodium in Ife brown, Aduki and Farv-13 varieties of cowpeas with cooking, soaking, autoclaving and sprouting treatments. Aletor and Ojo (1989) observed a decrease in potassium, magnesium, sodium and phosphorus levels of samples cooked soya and lima beans.

The amino acid profile of raw and boiled mucuna seeds are presented in Table 4. Both raw and boiled mucuna seeds were rich sources of essential amino acids particularly lysine and methionine which makes it a useful supplement for cereal grains which are generally low in these amino acids (Iyayi and Taiwo, 2003). Duration of boiling had no effect on leucine, histidine, phenylalanine, arginine and glycine composition. However, methionine, cystine, valine, isoleucine, tyrosine, lysine, alanine, proline, serine, glutamic acid, aspartic acid and threonine were significantly ($p<0.05$) reduced as the boiling time increased. The lower level of lysine in the boiled seeds may be due to its reaction with oxidized lipids (Findley and Ludin, 1980). Likewise, Van Der Peol, *et al.* (1990) reported that overheating of soyabeans in terms of excessive temperative and/or exposure time to heat may depress digestibility of amino acid, particularly lysine. Nonetheless, the lysine content of boiled seeds (6.09-6.41 g/16 gN) is well above those of many conventional legume seeds products such as soya bean meal (3.27%), full fat soyabean cooked for 30 min (2.59%) (Balogun *et al.*, 2001) and groundnut cake (1.73%) (Aduku, 1993).

Table 5 shows the results of anti-nutritional factors present both in raw and processed seeds. Raw mucuna seeds contained very high levels of anti-nutritional factors. There were significant reductions in the levels of anti-nutrients as the duration of boiling increased. The most affected was trypsin inhibitor, followed by tannin, oxalates and hydrocyanic acid. Boiling for 60 min was able to reduce 47, 29.7, 29.2 and 10.9% of trypsin inhibitor, tannin, oxalates and HCN respectively, in comparison to the raw seeds. The result clearly demonstrated that trypsin inhibitor had higher susceptibility to heat than the other Antinutritional Factors (ANFs), measured. This confirm earlier observations (Wanjekechi *et al.*, 2003; Abdullahi and Abdullahi, 2005). More so, the values of total oxalates and phytic acid were too low to be of nutritional concern when compared with the values of 5.0-9.9g Kg/DM reported in cereal grains (Ravindran *et al.*, 1994).

Performance of the birds during the trial are summarized in Table 6. The birds fed diets containing mucuna seeds cooked for 40 and 60 min had comparable average daily weight gain which were significantly ($p<0.05$) higher than those fed raw mucuna seed diet. The same trend was observed with feed intake and average daily protein intake. Feed conversion was significantly better for broilers on the boiled than on the raw beans (typically values were 2.52, 2.52, 2.38 vs. 3.23). Likewise broilers on the boiled mucuna beans had higher Protein Efficiency Ratio (PER) than those on the raw bean diet. The results suggest that raw mucuna seeds, as is frequently the case among legumes, contain anti-nutritional factors that were partially inactivated by the mode of boiling employed in this study, since feed intake and weight gain were significantly improved and feed conversion ratios were positively affected in the like manner. Earlier studies have shown that heat treatment

Table 4: Amino acid profile of raw and boiled Mucuna seeds (g/16gN)

	Duration of boiling (min)				
	0	20	40	60	SEM
Amino acids					
Methionine	1.547^{a}	1.200^{b}	1.30^{b}	0.890^{c}	0.170
Cystine	1.460^{a}	1.080^{b}	1.260^{ab}	0.990^{b}	0.209
Valine	5.347^{a}	4.180^{b}	4.300^{b}	4.680^{b}	6.600
Isoleucine	4.517^{a}	3.390^{c}	4.020^{b}	3.010^{c}	0.493
Leucine	7.373	7.300	7.410	7.600	0.531
Tyrosine	4.740^{a}	3.220^{b}	3.060^{b}	3.380^{b}	0.501
Histidine	2.467	2.820	2.880	2.630	0.308
Lysine	6.660^{a}	6.410^{ab}	6.390^{ab}	6.090^{b}	0.365
Phenylalanine	4.437	5.070	5.240	4.730	0.681
Arginine	6.287	5.960	6.210	5.960	0.414
Alanine	4.710^{a}	3.780^{a}	3.980^{b}	3.023^{c}	0.487
Proline	4.580^{a}	3.500^{b}	3.080^{b}	2.870^{b}	0.639
Glycine	3.967	3.380	3.550	3.400	0.584
Serine	5.210^{a}	5.410^{a}	5.187^{a}	4.160^{b}	0.257
Aspartic acid	12.370^{a}	11.280^{b}	8.610^{d}	10.040^{c}	0.560
Glutamic acid	14.910^{a}	12.290^{b}	12.370^{b}	12.140^{b}	1.210
Threonine	3.970^{a}	3.380^{b}	3.390^{b}	2.800^{c}	0.340

^{abc}Means on the same row with different superscripts are significantly different ($p<0.05$). SEM: Standard error of means

Table 5: Anti nutritional factor content of raw and boiled Mucuna seeds

	Duration of boiling (min)				
	0	20	40	60	SEM
HCN (mg/kg DM)	33.46^{a}	32.04^{ab}	29.02^{c}	29.81^{b}	1.00
Phytic acid (g/kg DM)	1.56	1.49	1.53	1.52	0.42
Tannin (g/kg DM)	1.41^{a}	1.01^{b}	1.16^{b}	0.99^{b}	0.08
Trypsin inhibitor activity(TU1/mg)	33.59^{a}	23.03^{b}	20.40^{bc}	17.77^{c}	1.16
Oxalates (g/kg DM)	1.95^{a}	1.90^{a}	1.59^{ab}	1.38^{b}	0.12

^{abc}Means on the same row followed by different superscripts are significantly ($p<0.05$) different. HCN: Hydrocyanic acid; SEM: Standard Error of Means, TUI: Trypsin Units Inhibited

Table 6: The performance of finisher broilers fed raw and boiled mucuna seeds

	Duration of boiling (min)				
	0	20	40	60	SEM
Weight gain (g/day)	26.32^{c}	34.68^{b}	37.13^{ab}	39.79^{a}	0.61
Feed Intake (g/day)	84.93^{b}	87.53^{b}	93.47^{a}	94.62^{a}	2.09
Feed conversion	3.23^{a}	2.52^{b}	2.52^{b}	2.38^{b}	0.10
Protein intake (g/day)	16.79^{b}	17.50^{b}	18.69^{a}	18.93^{a}	0.29
PER	1.55^{b}	1.99^{a}	1.99^{a}	2.10^{a}	0.60

^{abc}Means on the same row with different superscripts are significantly different ($p<0.05$). SEM: Standard Error of Means. PER: Protein Efficiency Ratio

resulted in improvement in performance of birds on mucuna diet which brings them to par with that of corn-soybean, control diet (Emenalom and Udedibie, 1998; Tuluen *et al.*, 2007). Similarly, Kaankuka (1998) have reported that the nutritive values of legume seeds were improved when subjected to cooking. According to Essig (1985), leguminous anti-nutritional factors occur in five broad categories (alkaloids, toxic amino acids, cyanogenic glycosides, poly-phenolic compounds and phytoestrogens), but that the most frequently found are

Table 7: Haematological and Biochemical indices of broilers fed raw and boiled mucuna

		Duration of boiling (min)				
	Raw	20	40	60	NV	SEM
PCV (%)	17.00	22.33	26.67	30.00	25-45	7.80
Hb(g/dl)	6.00	7.94	7.67	10.00	7-13	2.35
RBC (x10^{6}/mm^{3})	4.33	3.62	3.17	3.55	2-4	1.01
Mcv (fl)	42.03	56.77	68.59	84.05	90-140	12.37
McH (Pg)	14.58	20.38	26.35	28.09	26-35	5.32
McHc (g/dl)	35.55	36.66	28.89	33.33	33-47	4.23
Total protein (g/l)	57.00^{c}	69.00^{b}	88.00^{a}	63.00^{bc}	-	4.60
Albumin (g/l)	22.27	29.30	43.40	23.10	-	8.12
Globulin (g/l)	39.70	38.40	39.90	48.93	-	5.59
SGOT(iu/l)	92.57	83.00	134.5	118.10	-	17.55
SGPT(iu/l)	12.50	9.17	11.00	16.47	-	5.36

NV = Normal values (Adapted from Mistruka and Rawnsley, 1977) ^{abc}Means on the same row followed by different superscripts are significantly ($p<0.05$) different; RBC = Red Blood Cell; Mcv = Mean corpuscular volume; McH = Mean corpuscular Haemoglobin; McHc = Mean corpuscular haemoglobin concentration; SGOT = Serum Glutamic Oxaloacetic Transaminase; SGPT = Serum Glutamic Pyruvic Transaminase; PCV = Packed Cell Volume

the poly-phenols (tannins). These compounds are strongly proteophillic, binding and precipitating large amounts of proteins as a result of which the proteins (including digestive enzymes such as trypsins) are denatured and inactivated. It is also the opinion of Essig (1985) that tannins bind to the proteins of the mucous membranes of the mouth, attenuating taste sensation and lowering palatability and thereby intake of feeds containing raw legume seeds.

The haematological and biochemical indices of broiler finishers fed raw and boiled mucuna seeds are presented in Table 7. There were no significant differences ($p>0.05$) among the treatment means for all measured parameters. This suggests that the mucuna seeds used for this study had no adverse effect on the red blood cell indices in broiler chickens. The PVC values (17-30%) and Hb value (6-10.0 g/dl) obtained in the present study are comparable with the PCV value (25-45%) and Hb(7-13 g/dl) reported by Mistruka and Rawnsley (1977) for chickens in tropical environments. These values also fall within the normal PCV range (30-33%) and Hb range (6.5-9.00 g/dl) reported by Swenson and Reece (1993) for chickens. The results obtained in this trial suggest that mucuna seeds soaked in plain water and boiled for 40 and 60 min can be incorporated at 20% on broiler finishers diet without adverse effect o n the birds. All the values of McHc obtained compared favourably with normal value (Table 7).

There were no significant differences ($p>0.05$) among the treatment means for most measured biochemical parameters. However, the serum total protein content of broiler chickens fed the boiled mucuna seed diets were significantly ($p<0.05$) higher than the group fed raw mucuna seed diet. The significantly higher serum total protein concentration on the boiled mucuna diet is further evidence of the superiority of the boiled mucuna seeds over the raw seeds. Similarly, the serum albumin and globulin concentration of broilers fed boiled mucuna seeds were higher. These reveal the better quality of the boiled material at the level of inclusion investigated. None of the treatments applied in this trial increased Serum Glutamic Oxaloacetic Transaminase (SGOT) and Serum Glutamic Pyruvic Transanimase (SGPT) activities significantly.

Conclusion: The proximate composition, mineral assay and amino acid profile of velvet bean (*mucuna utilis*) lends it high potential as a plant protein feedstuff and the results of this trial have showed that the anti-nutritional factors, that could impair utilization of its nutrients by monogastric livestock, are sufficiently inactivated by soaking in water for 24 h and cooking for 60 min.

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