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Nutritional Evaluation of Different Processing Methods of Bambaranut (*Vigna subterranean* (L.) Verdc.) on Performance of Broiler Chickens

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Abstract: The effect of feeding differently processed bambaranut was investigated using two hundred and fifty broilers chicks. Five different processed bambaranut was used to formulate diets with raw, sprouted, salt treated, cooked and roasted bambaranut. The birds were randomly allotted to five dietary treatments replicated five times in a completely randomized block design (CRBD). Results showed at the starter phase, daily feed intake, daily weight gain and feed conversion ratio were statistically similar (P>0.05). At the finisher and overall phases, daily feed intake, daily weight gain and feed conversion ratio were significantly affected (P<0.05) by the different processing methods. Most of the carcass characteristics measured were affected (P<0.05) by the different processing methods. The hematological parameters were not affected by the different processing methods. (P>0.05). The total feed cost (N 339.62 gain) was lower in roasted bambaranut and highest in sprouted bambaranut (N416.00). The feed cost gain was highest in cooked bambaranut (N 248.20) and lowest in sprouted bambaranut (N 199.04). The different processing methods enhanced the performance of broiler chickens, however sprouted bambaranut was more efficient in enhancing the performance of broiler chickens. As such it should be recommended for poultry farmers wishing to use bambaranut as a source of protein.

Keywords: Bambaranut, Processing Methods, Performance, Economics of Production

1. Introduction

Bambaranut (Vigna subterranean (L.) Verdc.) Is a self pollinatory annual legume crop which is contain high protein (18%CP), drought resistance, can be grown under dry climatic conditions on poor marginal soils with high temperature and the crop is less susceptible to diseases and pest [1]. It is widely distributed in the country and research has shown that it can be used as a source of proteins in poultry and rabbits [2]. Bambaranut contains antinutritional factors such as cyanogens, flatulence factors, tannins, trypsin inhibitor and Heamogluttinins in the raw state [3]. The methods of processing the legume seeds have been a major challenge to most poultry farmers [4]. Several processing methods has been reported to eliminating/reducing antinutritional factors of raw bambaranut to a tolerable limit by application of heat, sprouting and fermentation, extrusion, salt treatment, micronising, enzyme treatment etc [5]. This study was therefore designed to reduce the antinutritional factors in raw bambaranut and assess the performance of broiler birds fed differently processed Bambara groundnut meal.

2. Materials and Methods

2.1. Experimental Site

Katagum local government is situated on the northern part of Bauchi state, Nigeria. It is located between latitudes 110 42’ and 110 400 and longitude 100 31’ and 100 11’ East [6].

2.2. Methods of Processing of Ingredients

2.2.1. Dry Heat Treatment (Roasting)

Bambaranut were sand roasted. This involves making a bed of alluvial sand in half drum and heating the sand to about 100oC. Sufficient quantities of the ingredients to cover two third of the area of sand was placed on the sand. Stirring of the ingredients was done constantly until they were roasted for the duration of thirty minutes (30). Grinding of the roasted beans produced full-fat bambaranut meal.

2.2.2. Cooking

Bambaranut were cooked by bringing water in a half drum to boiling point and pouring the ingredients in the boiling water for thirty minutes (30) to produce the cooked full-fat bambaranut meal, and the seeds were then sun dried for 3-4 days and ground to produce the corresponding meals.

2.2.3. Salt Treatment

Salt solution is prepared by adding 3% salt of total weight of sample, dissolved in water and soaked the protein sources for twenty-four hours (24 hours) they are then sun dried for 3-4 days and stored in bags. Salt treated bambaranut meals were produced by grinding the salt treated bambaranut.

2.2.4. Sprouting

Sprouts of bambaranut were done by soaking the seeds in water for 24 hours. The seeds were removed and germinated on jute bags. Sprouted seeds bambaranut were sun-dried and ground to produce the meals.

2.3. Determination of Anti-nutritional Factors

The anti-nutritional factors determinations were carried out at the Biochemistry Department, National Veterinary Research Institute (NVRI), Vom, Jos Plateau State. These include:

2.3.1. Phytate

The method used for phytate analysis was described by AOAC [7].

2.3.2. Oxalate

The oxalate content of different bambaranut were determined using the method described by AOAC [7].

2.3.3. Tannins

The method of estimation of tannin content of different protein sources were according to the standard method described by Santram et al. and Negi [8, 9].

2.3.4. Trypsin Inhibitor

Determination of trypsin inhibitor activity of different protein sources were based on the methods described by Kakade et al. [10].

2.4. Blood Analysis

Blood analysis was done based on the procedures of Bush and Baker et al. [11, 12].

2.5. Proximate Analysis

Proximate analysis was carried out according to the method of AOAC [7].

2.6. Design of the Experiment

Two hundred and fifty Anak 2000 broiler chicks aged seven days were randomly allotted to five treatments. There were fifty chicks per treatment which was replicated five times in (ten chicks per replicate) in a Randomized Completely Block Design (RCBD).

2.7. Experimental Diets

The differently processed bambaranut used in this experiment was milled and mixed with other ingredients to formulate five experimental diets containing raw, sprouted, salt treated, cooked and roasted bambaranut designated as 1, 2, 3, 4, and 5 respectively. The ingredients and nutritional composition of the diets are presented in Tables 1 and 2, respectively.

Table 1. *Ingredients and nutrient composition (%) of differently processed bambaranut diets fed to broiler chickens at the starter phase (1-5 weeks).*

Diets					
	1	**2**	**3**	**4**	**5**
Raw	**Sprouted**	**Salt**	**Roasted**	**Cooked**	**Ingredients**
					Treated
Maize	46.32	46.32	46.32	46.32	46.32
Bambaranut	27.82	27.82	27.82	27.82	27.82
Soybean (Full-fat)	6.96	6.96	6.96	6.96	6.96
Wheat offal	10.00	10.00	10.00	10.00	10.00
Fishmeal	5.00	5.00	5.00	5.00	5.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Sodium chloride	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00

Calculated analysis					
Crude protein	23.00	23.00	23.00	23.00	23.00
Metabolisable energy (kcal/kg)	2800.00	2800.00	2800.00	2800.00	2800.00
Crude fibre	4.07	4.07	4.07	4.07	4.07
Ether extract	5.98	5.98	5.98	5.98	5.98
Calcium	1.42	1.42	1.42	1.42	1.42
Available phosphorus	0.92	0.92	0.92	0.92	0.92

Each kilogram contains; vit. A, 10,000,000 IU, vit. D_3 2,000,000 IU, Vit. E 23,000mg, Vit. K_3 2.000mg, Vit, B_1 1,800mg, Panthothenic Acid 7,500mg, Vit. B_6 3,000mg, Vit. B_{12} 15mg, Folic acid 750mg, Biotin 11260mg, Choline Chloride 300,000mg, Cobalt 200mg, Copper 3,000mg, Iodine 1,000mg, iron 20,000mg, Manganese 40,000mg, Selenium 200mg, Zinc 30,000mg, Antioxidant 1,250mg

***Table 2.** Ingredients and nutrient composition (%) of broiler finisher (21% CP) diets containing differently processed bambaranut.*

Diets					
	1	**2**	**3**	**4**	**5**
Raw	**Sprouted**	**Salt**	**Roasted**	**Cooked**	**Ingredients**
					Treated
Maize	44.00	44.00	44.00	44.00	44.00
Bambaranut	25.82	25.82	25.82	25.82	25.82
Soybean (Full-fat)	6.28	6.28	6.28	6.28	6.28
Wheat offal	15.00	15.00	15.00	15.00	15.00
Fishmeal	5.00	5.00	5.00	5.00	5.00
Limestone	1.00	1.00	1.00	1.00	1.00
Bone meal	2.00	2.00	2.00	2.00	2.00
Sodium chloride	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20
Methionine	0.20	0.20	0.20	0.20	0.20
Vitamin/mineral premix*	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00

Calculated analysis					
Crude protein	21.00	21.00	21.00	21.00	21.00
Metabolisable energy (kcal/kg)	300.00	300.00	300.00	300.00	300.00
Crude fibre	4.37	4.37	4.37	4.37	4.37
Ether extract	5.63	5.63	5.63	5.63	5.63
Calcium	1.42	1.42	1.42	1.42	1.42
Available phosphorus	0.90	0.90	0.90	0.90	0.90

*Each kilogram contains Vit A 3600, 000iu. Vit. D_3 600.000 IU. Vit E 4.000.000mg. Vit B_1-B_6 640, 1600, 600, 4.00mg. Panthothenic acid 2000mg, Biotin 300mg. Manganese 16000mg. Manganese 16000mg. Selenium 80mg. Vit. K_3 600mg. Cobalt 80mg. Copper 1200mg. Zinc 12,000mg. Folic acid 200mg. Choline chloride 700000mg. Antioxidant 500mg.

2.8. Carcass Evaluation

At the end of the experiment ten (10) birds from each treatment that is 2 birds per replicate were randomly selected for carcass analysis. Carcass weights and organs weight were measured and expressed as a percentage of live weight.

2.9. Data Analysis

Data generated from performance and laboratory were analyzed using Analysis of variance techniques [13] using the Minitab software and means were separated using Duncan's multiple range test (DMRT).

3. Results

3.1. Proximate Composition of the Differently Processed Bambaranut Meal

The proximate compositions of the differently processed bambaranut are presented in Table 3. Results showed that there was a decrease in crude protein content in all the differently processed bambaranut (Table 3), with sprouted bambaranut (19.27%) and cooked bambaranut (19.20%) having the highest crude protein. while salt-treated bambaranut (17.74%) and roasted bambaranut (17.61%) have the least crude protein. The crude fibre of the differently processed bambaranut reduced drastically with salt treated bambaranut (10.60%) and cooked bambaranut (10.00%) having the highest values and roasted bambaranut (8.60%) and sprouted bambaranut having the least values (Table 3). There was an increase in the crude fat of the differently processed bambaranut compared to the control (3.60%) with roasted bambaranut (7.35%) and cooked bambaranut (7.15%) having the highest values and salt-treated bambaranut (6.35%) having the least values. The ash content of the differently processed bambaranut decreased slightly with sprouted bambaranut remaining fairly constant (2.65%) and salt treated bambaranut having a slight increase (3.25%). The nitrogen-free extract of the differently processed bambaranut increase slightly with roasted bambaranut (57.79%) and sprouted bambaranut (57.38%) having the high values and cooked bambaranut (56.50%) and salt-treated bambaranut (55.81) with the least values (Table 3). There was slight decrease in the calcium content of differently processed bambaranut with sprouted bambaranut having the higher values (0.18%) than the other processed bambaranut (Table 3). There was a slight increase in the phosphorus content of differently processed bambaranut in the following sequence: salt-treated bambaranut<roasted bambaranut<sprouted bambaranut<cooked bambaranut.

Table 3. *Chemical composition (%) of the differently processed bambaranut meal.*

Diets					
	1	**2**	**3**	**4**	**5**
Parameters	**Raw**	**Sprouted**	**Salt**	**Cooked**	**Roasted**
					Treated
Dry matter	94.10	93.69	93.75	95.35	93.90
Crude protein	19.58	19.27	17.74	19.20	17.61
Crude fibre	14.20	8.79	10.60	10.00	8.60
Crude fat	3.60	5.60	6.35	7.15	7.35
Ash	2.65	2.65	3.25	2.50	2.55
Nitrogen-free extract	54.07	57.38	55.81	56.50	57.79
Calcium	0.33	0.18	0.08	0.08	0.08
Phosphorus	0.10	0.14	0.66	0.11	0.19

3.2. Antinutritional Factors of Differently Processed Bambaranut Meal

Sprouting (98.37%), cooking (97.63%) and roasting (97.33%) are the most efficient methods of reducing trypsin inhibitor of bambaranut (Table 4). Sprouting is less effective in reduction of tannin content of bambaranut (41.71%) while roasting is the most effective method of tannin reduction (56.78%) (Table 4). With respect to phytic acid salt-treatment was the least method of reduction (1.65%) compared to sprouting (79.68%) and cooking (68.41%). Oxalate reduction tends to favor sprouting (66.47%) compared to other processing methods. Roasting has no reduction effect on the oxalate content of bambaranut (00.00%).

Table 4. *Antinutritional factors of the differently processed bambaranut meal.*

Diets					
	1	**2**	**3**	**4**	**5**
Parameters	**Raw**	**Sprouted**	**Salt**	**Cooked**	**Roasted**
					Treated
Trypsin inhibitor (mg/100g)	6.75	0.11	4.51	0.16	0.18
Destruction of trypsin inhibitor (%)	00.00	98.37	33.19	97.63	97.33
Tannin (mg/100g)	0.398	0.232	0.198	0.216	0.172
Destruction of tannin (%)	00.00	41.71	50.25	45.73	56.78
Phytic acid (mg/100g)	13.98	2.84	13.75	12.60	13.25
Phytic acid destruction (%)	00.00	79.69	1.65	9.87	5.22
Oxalate (mg/100g)	85.00	28.50	80.00	30.00	85.00
Oxalate destruction (%)	00.00	66.47	5.88	64.71	00.00

3.3. Growth Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut Meal (1-5 Weeks of Age)

The growth performance of broiler chickens fed diets containing differently processed bambaranut during the starter phase (1-5 weeks) are presented in Table 5. The initial weight varied between 98.21g in cooked bambaranut to 99. 98g in sprouted bambaranut and the values were similar. The final weight varied between 756g in raw bambaranut to 1112.16g in salt treated bambaranut and the values were affected ($P<0.05$) by the different processing methods. The daily feed intake ranged between 58.27g in raw bambaranut to 61.55g in sprouted bambaranut and the values were similar ($P>0.05$) (Table 5). The daily weight gain ranged between 22.91g in roasted bambaranut to 26.07 g in raw bambaranut and the difference between the values were statistically similar (P<0.05). The feed conversion ratio (2.24-2.58) of the raw and processed bambaranut were not significantly different (P>0.05). The feed efficiency followed the same trend and varied between 0.38 in roasted and cooked bambaranut and 0.44 in raw bambaranut. The survivability of the birds was lower in raw bambaranut than in the differently processed bambaranut (98.00%).

Table 5. *Performance of broiler chickens fed diets containing differently Processed bambaranut meal at starter phase (1-5 weeks of age).*

Diets						
	1		2	3	4	5
Parameters	**Raw**		**Sprouted**	**Salt**	**Cooked**	**Roasted**
						Treated
Initial weight (g/bird)	98.75	99.98	98.25	98.21	99.13	0.26^{NS}
Final weight (g/bird)	756.00^{c}	1102.08^{a}	1112.16^{a}	920.08^{b}	1106.84^{a}	119.28*
Daily feed intake (g)	58.27	61.55	60.58	61.03	59.29	0.23^{NS}
Daily weight gain (g)	22.07	24.57	25.49	23.63	22.91	0.08^{NS}
Feed conversion ratio	2.94	2.33	2.38	2.47	2.58	0.02^{NS}
Feed efficiency	0.44	0.40	0.42	0.38	0.38	0.02^{NS}
Survivability (%)	98.00	100	100	100	100	-

SEM= Standard error of means. NS= Not significant

3.4. Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut Meal at Finisher Phase (5-8 Weeks of Age)

The growth performance of broiler chickens fed diets containing differently processed bambaranut at the finisher phase (5-8 weeks of age) are presented in Table 6. The initial weigh ranged between 756.00g in raw bambaranut to 1112.16g in salt treated bambaranut and the values were affected by the different processing methods. The final weight varied between 1620 g in raw bambaranut to 1972g in sprouted bambaranut and the values were affected by the different processing methods. The daily feed intake ranged between 101.69g in raw bambaranut and 126.95 g in sprouted bambaranut and the difference between the values were significant (P<0.05)). The daily weight gain ranged between 27.00g in raw bambaranut and 39.72 g in salt treated bambaranut and the difference between the values were significant (P<0.05). The feed conversion ratio varied from 2.95 in salt treated bambaranut to 3.76 in raw bambaranut and the difference between the values were significant (P<0.05). The feed efficiency ratio of 0.26 and 0.34 in raw treated bambaranut and in salt-treated bambaranut respectively are significant (P<0.05). The survivability of birds ranged between 98% in raw bambaranut to 99.80% in sprouted and salt treated bambaranut.

Table 6. *Performance of broiler chickens fed diets containing differently processed bambaranut meal at finisher phase (5-8 weeks of age).*

Diets						
	1	2	3	4	5	
Parameters	**Raw**	**Sprout**	**Raw**	**Roasted**	**SEM**	**Treated**
Initial weight (g/b)	756.00^{c}	1102.08^{a}	1112.16^{a}	920.08^{b}	1106.84^{a}	119.28*
Final weight (g/b)	1620^{b}	1972^{a}	1632^{b}	1800^{a}	1940^{a}	310*
Daily feed intake (g)	101.69^{d}	126.95^{a}	118.07^{b}	111.62^{c}	118.44^{b}	9.84*
Daily weight gain (g)	27.00^{c}	39.36^{a}	39.72^{a}	32.86^{b}	39.53^{a}	4.26*
Feed conversion ratio	3.76^{b}	3.22^{a}	2.95^{a}	3.42^{b}	2.99^{a}	0.36*
Feed efficiency	0.26^{c}	0.31^{a}	0.34^{b}	0.29^{a}	0.34^{b}	0.06*
Survivability	98.00	99. 80	99.80	99.60	99.60	-

SEM= Standard error of means, abc= Means bearing different superscripts within the same row are statistically different (P<0.05).

3.5. Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut Meal (1-8 Weeks)

The overall performance of broiler chickens fed diets containing differently processed bambaranut is presented in Table 7. The initial weight varied between 98.21g in cooked bambaranut to 99. 98g in sprouted bambaranut and the values were similar. The final weight ranged between 1620g in raw bambaranut to 1972g in sprouted bambaranut and the values were affected (P<0.05) by the different processing methods. The daily feed intake ranged between 79.98g in raw bambaranut and 94.25g in sprouted bambaranut and the difference between the values were significant (P<0.05). The daily weight gain ranged between 25.26g in raw bambaranut to 37.25g in sprouted bambaranut and the difference between the values were statistically significant (P<0.05). The feed conversion ratio varied from 2.53 in sprouted bambaranut to 3.17 in cooked bambaranut and the difference between the values were significant (P<0.05) (Table 7). The feed efficiency ratio ranged between 0.32 in raw bambaranut to 0.42 in roasted bambaranut and the difference between the values were significant (P<0.05). The survivability of birds ranged between 97.60% in raw bambaranut and 99.80% in sprouted bambaranut.

Table 7. *Pooled performance characteristics of broiler chicks fed differently processed bambaranut meal (1-8weeks of age).*

Diets						
	1	**2**	**3**	**4**	**5**	
Parameters	**Raw**	**Sprout**	**Raw**	**Roasted**	**SEM**	**Treated**
Initial weight (g)	98.75	99.78	98.25	98.21	99.13	0.20^{NS}
Final weight (g)	1620^{b}	1972^{a}	1632^{b}	1800^{a}	1940^{a}	310*
Daily feed intake (g)	79.98^{c}	94.25^{a}	89.52^{a}	86.46^{b}	88.87^{a}	5.07*
Daily weight gain (g)	25.26^{b}	37.25^{a}	34.98^{a}	26.66^{b}	36.75^{a}	3.54*
Feed conversion ratio	3.17^{a}	2.53^{b}	2.55^{b}	3.24^{a}	2.42^{b}	0.34*
Feed efficiency	0.32	0.40^{a}	0.39^{ab}	0.32^{b}	0.42^{a}	0.05*
Survivability	97.60	99.80	99.20	98.80	9.80	-

SEM= Standard error of means, abc= Means bearing superscripts within the same raw are statistically different (P<0.05).

3.6. Carcass Characteristics and Cut up Parts of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut Meal

The carcass yield, internal organ weight and gut characteristics of broilers fed diets containing differently processed Bambaranut are presented in Table 8 and cuts up parts are presented in Table 9. All the parameters measured were expressed as percentage of live weight in order to remove the difference in body weight of slaughtered birds. The carcass parameters studied include live weight (1620-2180 g), slaughtered weight (1465-1972 g), plucked weight (1404-1972 g) and the difference between the values were significant (P<0.05). The dressed weight (82.46-90.45%) are statistically similar (P>0.05). The internal organs measured were abdominal fat (0.25-4.34%), proventriculus (0.43-1.02%), liver (0.30-2.51%), lungs (0.14-0.41%), pancrease (0.14-0.32%), large intestine (3.16-4.21%), small intestine (42.60-54.60 cm) and large intestine (150.40-246.20 cm) (P<0.05) (Table 8). The small intestine (0.25-4.34%), heart (0.26-0.35%) and caeca (1.15-1.35%) were all similar (P>0.05). Results of cut up parts showed that neck (2.79-3.62%), wings (15.60-21.65%), chest (4.52-7.63%), back (5.87-8.09%), and thigh (18.80-20.09%) were affected by the different processing methods (P<0.05). The breast muscle (17.59-21.76%) was affected by different processing methods (P<0.05).

Table 8. *Carcass yield, internal organ weights, and gut characteristics (% live weight) of broilers fed differently processed bambaranut meal.*

Diets						
	1	**2**	**3**	**4**	**5**	
Parameters	**Raw**	**Sprout**	**Raw**	**Roasted**	**SEM**	**Treated**
Slaughter weight (g)	$\mathbf{1465^{b}}$	$\mathbf{1972^{a}}$	$\mathbf{1632^{b}}$	$\mathbf{1800^{a}}$	$\mathbf{1940^{a}}$	**310***
Plucked weight (g)	1404^{c}	1972^{a}	1632^{b}	1667^{a}	1836^{a}	281*
Dressing percentage (%)	82.46	87.70	87.29	85.53	89.02	11.75^{NS}
Abdominal fat (%)	4.34	0.31	0.25	0.68	0.49	0.24*
Gizzard (%)	1.56	1.36	1.18	1.46	1.30	0.009^{NS}
Proventriculus (%)	0.56	0.43	0.71	0.80	1.02	0.93*
Lungs (%)	0.24^{b}	0.38^{a}	0.41^{a}	0.17^{b}	0.14	0.13*
Liver (%)	2.51^{a}	1.17^{b}	0.56^{c}	0.30^{c}	0.43^{c}	0.34*
Pancreas (%)	0.25^{a}	0.14^{c}	0.14^{c}	0.32^{b}	0.22^{b}	0.03*
Heart (%)	0.32	0.26	0.50	0.25	0.38	0.08^{NS}
Caeca (%)	1.23	1.15	1.28	1.35	1.24	0.08^{NS}
Small intestine (%)	0.52	0.48	0.37	0.32	0.45	0.01^{NS}
Large intestine (%)	3.64^{b}	3.31^{b}	3.16^{b}	4.21^{a}	3.51^{b}	0.54*
Small intestine (cm)	42.60^{d}	51.20^{b}	46.60^{c}	45.00^{c}	54.60^{a}	2.40*

SEM= Standard error of means, abc= Means bearing different superscripts within the same row are statistically different (P<0.05), NS= Not significant

Table 9. *Cut up parts (% carcass weight) of broilers fed diets containing differently processed bambaranut meal.*

Diets						
	1	**2**	**3**	**4**	**5**	
Parameters	**Raw**	**Sprout**	**Raw**	**Roasted**	**SEM**	**Treated**
Wings	15.60^{b}	20.52^{a}	20.44^{a}	17.73^{b}	21.65^{a}	2.29*
Neck	4.52^{c}	6.84^{b}	7.12^{a}	6.29^{b}	7.63^{a}	0.77*
Back	5.87^{d}	7.79^{ab}	7.05^{bc}	6.92^{c}	8.09^{a}	0.82*
Thigh	18.80^{b}	20.09^{a}	18.67^{b}	18.40^{b}	18.40^{b}	0.63*

SEM= Standard error of means, abc= Means bearing different superscripts within the same row are statistically different (P<0.05).

3.7. Hematological Parameters of Broilers Fed Diets Containing Differently Processed Bambaranut Meal

The haematological parameters of broiler chickens fed diets containing differently processed bambaranut are presented in Table 10. Results showed the PCV (33.37-35.42%), haemoglobin (10.87-11.96 g/dl), red blood cells (5.56-5.90 X10µl), white blood cell (30.94-32.5010^{3}mm^3), serum protein (5.37-6.38 g/dl), serum albumin (1.32-1.81 g/dl), serum glucose and (1.92-2.42 g/dl), all the values were similar (Table 10).

Table 10. *Haematological parameters of broilers fed diets containing differently processed bambaranut meal.*

Diets						
	1	2	3	4	5	
Parameters	Raw	Sprout	Raw	Roasted	SEM	Treated
Packed cell volume %	33.37	35.35	34.96	35.42	35.07	0.09^{NS}
Haemoglobin conc. (g/dl)	11.02	11.96	11.70	10.87	11.53	0.03^{NS}
Red blood cell (X10µl)	5.56	5.89	5.82	5.90	5.85	0.03^{NS}
White blood cell ($10^{3/}$mm^3)	31.75	32.13	30.97	30.94	32.50	0.05^{NS}
Serum protein (g/dl)	5.87	6.38	5.95	5.37	6.09	0.03^{NS}
Serum Albumin (g/dl)	1.45	1.81	1.32	1.49	1.69	0.02^{NS}

SEM= Standard error of means, NS= Not significant

3.8. Economics of Production of Broiler Chicken Fed Diets Containing Differently Processed Bambaranut Meal

The economics of production of broiler chickens fed diets containing differently processed bambaranut are presented in Table 11. Results showed that the total feed intake (kg) ranged between 4.48 kg in raw bambaranut to 5.28 kg in sprouted bambaranut. The feed cost per kg feed (₦/kg) ranged between ₦ 75.81 in raw bambaranut to ₦ 86.98 in roasted bambaranut. The total feed cost (₦) was highest in the roasted bambaranut (₦ 433.16) and lowest in raw bambaranut (₦ 339.62). The total weight gain (kg) varied from between 1.41 in raw bambaranut to 2.09 in sprouted bambaranut. The feed cost per kg gain (₦/kg gain) was lowest in roasted bambaranut (₦ 199.04) and highest in cooked bambaranut (₦ 248.20) (Table 11).

Table 11. *Economics of production of broiler chickens fed diets containing differently Processed bambaranut meal.*

Diets					
	1	2	3	4	5
Parameters	Raw	Sprout	Raw	Roasted	Treated
Initial weight (g)	98.75	99.78	98.25	98.21	99.13
Final weight (g)	1620.00	1972.00	1632.00	800.00	1940.00
Cost per kg feed (₦ /kg)*	75.81	78.84	78.75	76.41	86.98
Total feed cost (₦)	339.62	416.00	394.54	369.82	433.16
Total weight gain (kg)	1.41	2.09	1.96	1.49	2.06

*Calculated based on the prevailing price of ingredients at the time of study.

4. Discussion

4.1. Chemical Composition (%) of the Differently Processed Bambaranut

The decrease in crude protein content of differently processed bambaranut is attributed to leaching, volatization and hydrolysis of proteins due to different processing methods. [14; 15] observed reduction of nutrients as a result of different processing methods. The highest crude protein was reported in sprouted bambaranut (19.27%) followed by cooked bambaranut (19.20%) while the lowest was recorded in roasted bambaranut (17.61%), this result is in harmony with the earlier reports of [16, 17]. Fibre content decrease drastically in the differently processed bambaranut in the following order sprouted bambaranut<roasted bambaranut<cooked bambaranut<salt treated bambaranut. The reduction in crude fibre reported in this work is in tandem with earlier reports of [17, 18]. The crude fat increase drastically in the different processed bambaranut in the following order roasted bambaranut<cooked bambaranut<sprouted bambaranut. [18] reported an increase in crude fibre in soaked and sprouted bambaranut while [17] reported an increase in crude fat of dehulled bambaranut. The fat content reported in this work are however lower than 6-14% for bambaranut [19]. This may be attributed to different cultivars of bambaranut, geographical location and methods of analysis used to determine the fat content. [20] reported decrease in crude fat of cowpea. Slight decrease in ash content in cooked (2.50%) and roasted bambaranut (2.55%) were attributed to leaching and volatization while the slight increase in salt-

treated bambaranut is attributed to increase in Na+ and Cl- ions while the ash content of sprouted bambaranut remain fairly constant. Several authors have reported an increase in the ash content of bambaranut [21, 22].

The nitrogen-free extract of differently processed bambaranut increase slightly as a result of different processing methods. [21] have reported increase in nitrogen-free extract of bambaranut as a result of soaking in water. The values of NFE reported in this work are slightly lower than values (60.89) reported by [22] on roasted bambaranut; the variation can be attributed to cultivars of bambaranut. The different processing methods reduced the calcium content of differently processed bambaranut as reported by [17]. The phosphorus content appreciates slightly as a result of different processing methods and this confirm the earlier reports of [16] who observed increase in the phosphorus content of differently processed bambaranut.

4.2. Antinutritional Factors of Differently Processed Bambaranut

There is a drastic reduction of trypsin inhibitor in the differently processed bambaranut in the following order: sprouted bambaranut<cooked bambaranut<roasted bambaranut<salt treated bambaranut. (The variation is attributed to effectiveness of different processing methods. Abeke et al. [15] and Akanji et al. [27] asserted that for any processing method there must be a loss of nutrients). Several authors reported a decrease in trypsin inhibitor of bambaranut as a result of different processing methods [17]. The destruction of trypsin inhibitor reported in this study is within the range (0.00-77.05%) reported by Fadahunsi [37] and Yisa et al. [19] for differently processed bambaranut. The decrease in tannin of different processed bambaranut is given in the following sequence: roasted bambaranut<salt treated bambaranut<cooked bambaranut<sprouted bambaranut. Roasting is a proven method of reduction of tannin. Roasting is an effective method of reducing tannin of legumes [43]. Sprouting is the least method of tannin reduction [36]. The reduction of tannin content reported in this work is within the range reported in literature [50].

The reduction of phytate of different processed bambaranut is given in the following sequence: sprouted bambaranut<cooked bambaranut<roasted bambaranut<salt-treated bambaranut. Sprouting involves the breakdown of phytate by enzyme phytase and the subsequent transport of minerals from the endosperm to cotyledon to the other parts [36]. Salt soaking is less effective method of phytic acid reduction in bambaranut as there is no appreciable reduction of phytic acid (1.65%). The reduction in oxalate content of the differently processed bambaranut is given in the following sequence: sprouted bambaranut<cooked bambaranut<salt treated bambaranut<roasted bambaranut. Ijarotimi et al. [17] reported a decrease of oxalate content of the differently processed bambaranut with highest reduction in fermented bambaranut.

4.3. Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut in Starter Phase (1-5 Weeks of Age)

The depressed final weight (756.00 g) and feed intake (P<0.05) in raw bambaranut (58.27 g) could be attributed to presence of antinutritional factors in raw bambaranut. Several authors reported decrease in feed intake as a result of feeding raw bambaranut [50, 47, 3]. The high feed intake in sprouted bambaranut (61.55g) (Table 3) can be attributed to high protein intake and high reduction of tannin and trypsin inhibitor which have been known to depress feed intake [43]. The high daily weight gain in raw bambaranut at starter phase (22.07 g) can be attributed to ability of the broiler chicks to utilize raw bambaranut even though the values are not statistically significant (P<0.05). The feed conversion ratio followed the same trend being better in raw bambaranut (2.64) but the values are statistically similar (P<0.05). Abubakar et al. [26] reported significant difference in feed intake, weight gain and feed conversion ratio of broilers fed water-soaked bambaranut (P<0.05). The feed efficiency ratio was higher in raw bambaranut (0.44) and the values are statistically similar (P<0.05). The mortality of chicks in the starter phases can be attributed to antinutritional factors and the values are statistically significant (P<0.05). Ukpabi et al. [50] has reported higher mortality of chicks (P<0.05) on broiler chicks fed raw bambaranut offal.

4.4. Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut at the Finisher Phase (5-8 Weeks of Age)

The enhanced feed intake of broiler birds fed differently processed bambaranut in the finisher phase and final weight can be attributed to reduction of antinutritional factors of bambaranut (P<0.05). The depressed feed intake in the raw bambaranut (101.69g) at the finisher phase could be attributed to toxic factors in the raw seeds. The values of feed intake reported in this study are lower than the values (150.67-161.00 g) reported by Obih et al. [45] and Abdullahi et al. [25] on soaked bambaranut and higher than those reported by Asaniyan et al. [31] on bambaranut offal. The daily weight gain followed the same trend being lower in raw bambaranut (27.00g) and higher in differently processed bambaranut (P<0.005). The values of weight gain obtained in this study are within the range of 28.93-44.29 g reported by Ani et al. [29]. The high daily weight gain in sprouted bambaranut (39.36 g) and roasted (39.53 g) can be attributed to significantly (P<0.05) high feed intake. The feed conversion ratio followed the same trend. The high feed conversion ratio (3.76) in raw bambaranut was an indication of poor utilization of raw bambaranut compared to lower values in differently processed bambaranut (P<0.05). The values of feed conversion ratio are better than those reported by Esonu et al. [36] in broiler finisher chickens. The feed efficiency ratio was relatively better in cooked and roasted bambaranut (0.34). The survivability of birds was better in differently processed bambaranut compared to the control (raw bambaranut). Higher mortality was earlier reported by Ukpabi et al. [50] in broilers fed raw bambaranut.

4.5. Pooled Performance of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut (1-8 Weeks of Age)

The depressed feed intake (79.78 g) in the overall performance in broiler chickens fed raw bambaranut is attributed to toxic factors in the raw bambaranut (P<0.05). The high feed intake in sprouted bambaranut (94.25 g) and roasted bambaranut (88.87g) can be attributed to adequate processing of bambaranut to eliminate ANFS. The overall performance of feed intake is within the range reported in literature [50]. The daily weight gain followed the same trend, was lower in birds fed raw bambaranut (25.26 g) (P<0.05). Nwaigwe et al. [44] reported significant difference in broiler birds fed raw and differently processed bambaranut. The feed conversion ratio is better in roasted bambaranut (2.24) and sprouted bambaranut (2.53) and these values are reflections of high feed intake and better weight gain. The values of weight gain are within the range of 18.00-20.90 g reported by Obih et al. [45]. The feed efficiency ratio followed the same trend as feed conversion ratio with better efficiency in sprouted and roasted bambaranut (0.40 and 0.42 respectively) (Table 7). The survivability (Table 7) was higher in the differently processed bambaranut compared to the control diet (97.60).

4.6. Carcass Yield, Internal Organs Weight, Gut Characteristics and Cut up of Parts of Broilers Fed Diets Containing Differently Processed Bambaranut

The carcass yield, organs weight and gut characteristics are presented in Table 8 and cut up parts are presented in Table 9. All parameters were express as percentage of live weight in order to remove the effect of difference in body weight of slaughtered birds. The higher live weight in sprouted bambaranut can be attributed to effective processing to reduce the toxic antinutritional factors in raw bambaranut while lower live weight in raw bambaranut (1620g) is attributed to poor growth performance in the finisher stage coupled with combine effect of antinutritional factors. The values of live weight reported in this study are within the range of 1650-1850g reported by Ekenyem et al. [23] on bambaranut. The slaughter weight followed the same trend being higher in differently processed bambaranut than the control diet (P<0.05) (Table 8). Better utilization of bambaranut could be attributed to minimum level of anti-nutritional factors as a result of processing of the seeds used in the experimental diets. Anti-nutritional factors in legumes prevent protein digestibility and decrease absorption of divalent metallic ions in the intestine [51]. The depressed slaughter weight and plucked weight in raw bambaranut is attributed to poor performance of birds in the finisher stage coupled with the low value of live weight. Similar enhanced slaughter weight in sprouted bambaranut (1972 g) and plucked weight (1962 g) is a function of live weight of the broilers chickens which is a related to the plucked weight. This is an indication of better utilization of the diets. The dressing percentage was not affected by the different processing methods and the values reported in this work are higher than 68.60-74.80% reported by Ugwu et al. [51].

The abdominal fat was affected by different processing methods (P<0.05) and is an indication of poor carcass quality [43]. The gizzard was not affected by different processing methods even though the values are higher in raw bambaranut compared to differently processed bambaranut, this is in agreement with the report of Abdullahi et al. [25] who observed no significant difference of gizzard of broilers fed soaked bambaranut. Higher liver (2.51%) (P<0.05) and pancreas (0.25%) (P<0.05) in raw bambaranut is an indication of hyperactivity of these two organs and this finding is in harmony with the earlier reports of Oleyede et al., Ekenyem et al. and Ani et al. [47, 23, 29]. The small intestine, caeca and heart were not affected by different processing methods (P>0.05) and findings is in agreement with the findings of Abdullahi et al. [25]. The percentage of cut up parts of broilers fed differently processed bambaranut affected all the parameters with superior weight of wings, thigh and breast muscle in the sprouted bambaranut (P<0.05). Abdullahi et al. [25] reported similar findings using broiler chickens fed parboiled bambara groundnut seed meal. Higher breast weight (P<0.05) was reported in the sprouted bambaranut and breast is one of the main determinants of carcass yield [43].

4.7. Haematological Parameters of Broilers Chickens Fed Diets Containing Differently Processed Bambaranut

The haematological parameters of broilers fed diets containing differently processed bambaranut is presented in Table 10 The PCV, haemoglobin and white blood cells are statistically similar (P<0.05) this reaffirmed the earlier report of Ilu et al. [38] who reported no significant difference in blood parameters of broilers fed different levels of bambaranut waste. The values of PCV are within the range (25-45%) of normal chickens reported by Awoniyi et al. and Kwari et al. [32, 39]. The serum protein, serum albumin and serum glucose are not affected by the processing methods (P<0.05) (Table 11).

4.8. Economics of Production of Broiler Chickens Fed Diets Containing Differently Processed Bambaranut

The economics of production of broiler chickens fed diets containing differently processed bambaranut is presented in Table 35. The reduced cost per kg feed in raw bambaranut (N 75.81) is attributed to lack of additional cost of processing in raw bambaranut and the high cost per kg feed in sprouted bambaranut (N 78.84) is attributed to high cost of labour during processing. The reduced total feed cost (N339.62) in raw bambaranut is attributed to low total feed intake (4.48 kg) and high total feed cost in sprouted bambaranut (N 416.00) is attributed to high feed consumption (5.28 kg). The feed cost per kg gain (N/kg gain) is highest in salt treated bambaranut

((N 199.04) and lowest in sprouted bambaranut ((N 63.27). The sprouted bambaranut is the least cost diet as such it has the lowest cost per kg gain.

5. Conclusion

The following conclusions were made:

The different processing methods affected the proximate and antinutritional factors of bambaranut.

The differently processing methods of bambaranut affected the growth performance, carcass characteristics, blood parameters and economics of production of broiler chickens.

Sprouting is an effective method of bambaranut processing.

Prolong feeding of raw bambaranut has negative effect on mortality.

6. Recommendations

Sprouted bambaranut are recommended as good protein sources in broiler diets. Further research is needed to expand the scope of this study by considering other processing methods and examining the antinutritional factors not covered in this study.

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