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Research Article
Evaluation of *Arachis hypogaea* Husk Diet in the Growth and Performance of Poultry Birds

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Abstract

Background and Objective: Poultry production is the fastest mean of remediating the problem of low animal protein intake in Nigeria owing to its short production cycle; however, this progress is undermined by the continuous rise in the cost of feed resulting in low performance of diverse poultry species. This study investigated the growth performance of poultry birds fed using different forms and proportions of *Arachis hypogaea* (Groundnut) husk incorporated with commercial feed. **Materials and Methods:** The roasted, raw and boiled groundnut seeds were first de-husked, air-dried for 3, 7 and 11 days, respectively, pulverized to a powder and thereafter, analyzed to determine the phytochemical, anti-nutrient and physicochemical composition. Subsequently, 81 four-week-old birds weighing between 300 and 750 g were randomly divided into nine groups of nine birds each and fed with commercial feed for one day to accustom to feed before feeding with the experimental diets for 21 days. The weights of the birds were taken on a weekly basis while those carcasses were taken after slaughter. Stool samples were collected aseptically through the intestines after evisceration for bacteriological analysis. **Results:** Findings reveal that boiled groundnut husk possessed the best proximate composition amongst the three forms of groundnut husks. While the roasted groundnut husk had the highest presence of phytochemicals, the boiled groundnut husk recorded the least presence of anti-nutrients. Birds fed with a mixture of the different forms of the groundnut husk those fed with a low concentration of raw groundnut husk with high commercial feed proved to be effective as regards to the weight gain of the birds, however, a mixture of high concentration of boiled groundnut husk with low commercial feed, also proved to be effective. **Conclusion:** Basically, the boiled groundnut husk proved to be the most effective form amongst the groundnut husks for the best growth performance.

Key words: Poultry bird, groundnut husk, growth performance, weight gain, commercial feed

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Animals need proper nutrition for growth, maintenance of weight and to provide energy for work and vital functions. Most poultry species are omnivores (having a simple digestive system with non-functional caeca). However, this rule excludes geese and ostriches. The digestive tract of poultry has more organ but shorter than those of the other domestic animals. To compensate for the relatively short digestive tract and rapid digest a transit time, high-performing birds need easily digested, nutrient-dense diets. Nutrient balance is imperative[1].

Poultry production in Nigeria, over the years, has been tremendously improved and has been described as the fastest means of remediating the problem of low animal protein intake in the country owing to its short production cycle[2,3]. However, this progress is presently being undermined by the continuous rise in the cost of feed and poor funding of the agricultural sector[4] thus, resulting in low performance of diverse poultry species that are stocked. Aside from feed which accounts for about 60-75% of the cost of rearing commercial poultry, the unavailability of some ingredients for feed making militates against further expansion of the poultry industry, mostly in developing countries. The non-conventional feeding-stuffs to poultry have gained prominence in Africa[5]. Some of these by-products possess dissimilar anti-nutritional factors and diverse processing methods[6].

The application of crop residues as non-ruminant feed ingredients would necessitate prior chemical or biological treatment to disrupt the major association between structural polysaccharides and lignin which restricts the enzymatic breakdown of cellulose[7,8].

Nigeria ranks 3rd position amongst the producers of groundnut in the world producing about 1.92 M tons and generating 0.288 M tons of groundnut husks as a byproduct of the processing of groundnut. Unfortunately, this byproduct is under-utilized[2] albeit groundnut pod being reported to contain a remarkable amount of crude protein, crude fiber, calcium, phosphorus and other nutrients and thus, groundnut husk can be explored in poultry feed. Groundnut husk can be used as a replacement ingredient which could lead to a marked reduction in the feeding cost of birds[9]. It serves as a source of energy which has been found to be effective and better digested by broiler finisher birds[10].

Recent studies have shown the wide range of potential applications of groundnut husk biomass. Groundnut husk ash is used as a binder in sandcrete blocks for the replacement of cement[11]. It has potential applications in packaging, tissue engineering and drug delivery[12]. Groundnut shell activated carbon production for the removal of Methylene blue dye from aqueous solution with microbiostatic activity has likewise been reported[13]. The high percentage of organic matter and very low ash content shows that groundnut husk can be used as fuel for heating and as well, its ashes can be used as organic fertilizer thereby saving the cost of chemical fertilizer, along with reducing environmental pollution[14]. Groundnut husk compost is an appropriate alternative to peat as the growth medium of ornamental plants because of the favorable properties and high porosity[15]. The biomass is the only renewable carbon-based fuel, which plays an increasingly important role in climate protection[16]. This study was designed to evaluate the different forms and proportions of *Arachis hypogaea* (Groundnut) husk in the growth performance of poultry birds.

MATERIALS AND METHODS

Study area: The study area is Sangana market located close to Leventis bus stop opposite First Bank headquarters, Leventis, Port Harcourt, Rivers State and also, the Faculty of Agriculture animal farm located at the Choba campus of the University of Port Harcourt situated close to the Department of Biochemistry animal farm. This study was carried out between July-December, 2019.

Preparation of the experimental diets: The raw groundnut seeds were obtained commercially from groundnut deport at Sangana market, Port Harcourt, Rivers state, Nigeria and further processed by boiling and roasting to obtain the boiled and roasted groundnut seeds, correspondingly. The roasted, raw and boiled groundnut seeds were de-husked, air-dried for 3, 7 and 11 days, respectively and thereafter pulverized to powder. On the other hand, the commercial feed was purchased from an animal feed shop.

Management of birds and experimental layout: The poultry birds (broiler chickens) were used for this study. A total of 81-four weeks old broilers weighing between 300 and 750 g were obtained from the University of Port Harcourt Animal Farm where they were previously fed with normal feed and water. The birds were divided into nine groups with each group containing nine birds. The birds were first fed with commercial feed (finisher mash) for one day so as to acclimatize with the feed and thereafter fed with the experimental diets for 21 days. Birds in group 1 were fed with 30% raw groundnut husk and 70% commercial feed while those in group 2 were fed with 60% raw groundnut husk and

40% commercial feed. Birds in group 3, on the other hand, received 30% boiled groundnut husk and 70% commercial feed while group 4 received 60% boiled groundnut husk and 40% commercial feed. Groups 5 and 6 birds were given 30% roasted groundnut husk and 70% commercial feed and 60% roasted groundnut husk and 40% commercial feed, respectively. While group 7 birds had 30% mixed groundnut husks (10% raw, 10% boiled and 10% roasted) and 70% commercial feed, group 8 had 60% mixed groundnut husks (20% raw, 20% boiled and 20% roasted) and 40% commercial feed. The control group however was constantly availed with 100% commercial feed. Each of these groups received 900 g of the diet (100 g per bird), daily.

Sampling: A total of 81 faecal samples were collected from 81 slaughtered poultry birds. Immediately after that, the carcasses were weighed and the intestines were collected aseptically using gloves after evisceration. The stool samples were thereafter collected and placed in sterile stool bottle after which they were transported in a cool box to the laboratory.

Proximate analysis: The moisture, protein and ash contents were analyzed via following the methods as described by Buba *et al.*[17]. Lipid and crude fiber were determined by the method of Association of Official Analytical Chemists International, AOAC[18]. Carbohydrate content was determined by the method as described by Faulks and Timms[19].

Phytochemical analysis: Flavonoids, phenol, tannins, alkaloids and carbohydrates was determined using the alkaline reagent, standard ferric chloride, gelatin, Mayer's and Wagner's and Benedict's tests methods respectively, as described by Pandey and Tripathi[20]. Saponin was determined using the method of Birk *et al.*[21] as modified by Hudson and El-Difrawi[22]. Diterpenes were determined using the copper acetate test method described by Wadood *et al.*[23]. Phlobatannin was determined using Analytical method as described by Ejikeme *et al.*[24]. Terpenoid and quinone were determined by methods described by Tyagi[25].

Anti-nutrients analysis: Oxalate content was determined by the titration method as described by Solomon *et al.*[26]. Phytate content was determined following the method described by Reddy and Love[27]. Hydrocyanic acid content was determined by the method of the Association of Official Analytical Chemists International, AOAC as described by the Food Safety Standards Authority of India[28].

Physiochemical analysis: The organic matter and carbon of the groundnut husks were determined by the method of the Association of Official Analytical Chemists International, AOAC as described by Chukwuma *et al.*[29]. The pH of the groundnut husks was determined by the following method described by Motsara and Roy[30]. The weight of the birds was determined by the method described by Ukwu *et al.*[31].

Bacteriological analysis

Poultry faecal samples processing/preparation of inoculums: One gram of the caeca contents was added to 9 mL of buffered peptone water, mixed and incubated at 37°C for 24 hrs. An aliquot of 0.1 mL was transferred to 10 mL of RV broth and incubated for 24 hrs at 42°C. A loopful (10 µL)[32] was then streaked on nutrient agar, MacConkey agar, Chapman agar, rabbit blood agar and TSA agar containing 5% fetal calf serum and LB agar. The culture was inoculated into liquid LB culture medium and cultured at 37°C for 18-24 hrs with vigorous shaking[33]. Colonial morphology such as shape, size, surface, texture, edge, elevation, color and opacity that developed after 24 hrs of incubation in different media was carefully studied and recorded[34].

Statistical analysis: Results are Mean±standard deviation of triplicate determination. Statistical analysis was carried out using one-way analysis of variance (ANOVA). The data were analyzed by the Turkey HSD test using Statistical Package for the Social Science (SPSS®) Version 20 statistics software at 95% ($p<0.05$) confidence level.

RESULTS

The proximate compositions of the raw, roasted and boiled groundnut husks are presented in Table 1. The moisture content of the raw groundnut husk (11.64±0.16 g/100 g) was significantly ($p<0.05$) lower compared to roasted (16.08±1.07 g/100 g) and boiled (14.50±0.02 g/100 g) groundnut husks. However, roasted groundnut husk recorded a significantly ($p<0.05$) higher moisture content compared to boiled groundnut husk. Nonetheless, no significant difference ($p>0.05$) was observed in the protein content of the samples. Additionally, a significantly ($p<0.05$) lower ash content was recorded in the raw groundnut husk (3.52±0.03 g/100 g) when compared with the roasted (9.51±0.15 g/100 g) and boiled (4.44±0.02 g/100 g) groundnut husks. Nonetheless, a significantly ($p<0.05$) higher ash content was recorded for the roasted groundnut husk when compared with the

Table 1: Proximate composition of the raw, roasted and boiled groundnut husks

Samples	Moisture (g/100 g)	Ash (g/100 g)	Carbohydrate (g/100 g)	Lipid (g/100 g)	Fiber (g/100 g)	Protein (g/100 g)	Energy value (KJ/100 g)
Raw	11.64±0.16[a]	3.52±0.03[a]	48.24±1.08[a]	0.41±0.02[a]	29.27±0.01[a]	6.94±0.91[a]	952.96±3.53[a]
Roasted	16.08±1.07[b]	9.51±0.15[b]	50.56±1.46[b]	2.46±0.15[b]	13.89±0.68[b]	7.52±0.30[a]	1078.21±24.2[b]
Boiled	14.50±0.02[c]	4.44±0.02[c]	57.11±0.09[c]	4.27±0.01[c]	12.56±0.03[c]	7.13±0.02[a]	1249.99±0.91[c]

Values are ±standard deviation of mean of nine determinations, when compared between the groups (across the column), values with same superscript alphabet are not significant (p>0.05) while values with different superscript alphabets are significant (p<0.05)

Table 2: Preliminary qualitative phytochemical screening

Parameters	Raw	Roasted	Boiled
Flavonoids	+	+	-
Saponins	-	-	-
Phenols	-	-	-
Tannins	-	-	-
Diterpenes	-	+	-
Phlobatannins	-	+	-
Alkaloids	-	-	-
Terpenoids	+	+	-
CHOs	+	+	+
Quinones	-	-	-

Table 3: Anti-nutritional composition of the raw, roasted and boiled groundnut husks

Samples	Oxalate (mg g^{-1})	Hydrocyanic acid (mg g^{-1})	Phytate (%)
Raw	0.0016±0.0001[a]	0.0520±0.0010[a]	0.0021±0.0001[a]
Roasted	0.0017±0.0001[a]	0.4800±0.0100[b]	0.0018±0.0001[b]
Boiled	0.0007±0.0001[b]	0.0510±0.0010[a]	0.0020±0.0001[a,b]

Values are ±standard deviation of mean of nine determinations, when compared between the groups (across the column), values with same superscript alphabet are not significant (p>0.05) while values with different superscript alphabets are significant (p<0.05)

Table 4: Physicochemical properties of the raw, roasted and boiled groundnut husks

Samples	Organic matter (%)	Organic carbon (%)	pH
Raw	96.47±0.02[a]	55.95±0.01[a]	6.4350±0.01[a]
Roasted	90.46±0.14[b]	52.45±0.11[b]	5.5600±0.36[b]
Boiled	95.39±0.16[c]	55.32±0.09[c]	6.2950±0.01[a]

Values are ±standard deviation of mean of nine determinations, when compared between the groups (across the column), values with same superscript alphabet are not significant (p>0.05) while values with different superscript alphabets are significant (p<0.05)

boiled groundnut husk. Carbohydrate as well as the lipid contents, on the other hand, were found to be significantly (p<0.05) lower in the raw groundnut husk (48.24±1.08 and 0.41±0.02 g/100 g, respectively) compared to the roasted (50.56±1.46 and 2.46±0.15 g/100 g, respectively) and boiled (57.11±0.09 and 4.27±0.01 g/100 g, respectively) groundnut husks, while a similar lower significant difference (p<0.05) was observed in roasted groundnut husk when compared with boiled groundnut husk. The fibre content of the raw groundnut husk (29.27±0.01 g/100 g) was significantly (p<0.05) higher compared to the roasted (13.89±0.68 g/100 g) and boiled (12.56±0.03 g/100 g) groundnut husks, however, the roasted groundnut husk was significantly (p<0.05) higher when compared with boiled groundnut husk. The resulting energy value of the raw groundnut husk (952.95±3.53 KJ/100 g) was significantly (p<0.05) lower compared to the roasted (1078.21±24.20 KJ/100 g) and boiled (1249.99±0.91 KJ/100 g) groundnut husks. Similarly, roasted groundnut husk recorded a significantly (p<0.05) lower energy value when compared with the boiled groundnut husk.

The preliminary qualitative phytochemical screening of the raw, roasted and boiled groundnut husks as presented in Table 2 revealed that amongst the groundnut husks tested for the presence of flavonoids, saponins, phenols, tannins, diterpenes, phlobatannins, alkaloids, terpenoids, carbohydrates and quinones, the raw groundnut husk tested positive for flavonoids, terpenoids and carbohydrates. The roasted groundnut husk, on the other hand, tested positive for flavonoids, diterpenes, phlobatannins, terpenoids and carbohydrates while the boiled groundnut husk only tested positive for carbohydrates.

The anti-nutritional composition of the raw, roasted and boiled groundnut husks presented in Table 3 revealed that the anti-nutrient oxalate was found to be significantly (p<0.05) higher in raw (0.0016±0.0001 mg g^{-1}) and roasted (0.0017±0.0001 mg g^{-1}) groundnut husks when compared with boiled groundnut husk (0.0007±0.0001 mg g^{-1}), however, no significant difference (p>0.05) was observed on the comparison between the raw and roasted groundnut husks. Similarly, no significant difference (p>0.05) was recorded in the phytate concentration of the roasted groundnut husk when compared with the boiled groundnut husk and roasted groundnut husk when compared with the boiled groundnut husk, a significantly (p<0.05) higher concentration was recorded in the raw groundnut husk (0.0021±0.0001%) when compared with the roasted groundnut husk (0.0018±0.0001%). Nonetheless, hydrocyanic acid (HCN) was found to be significantly (p<0.05) lower in raw (0.0520±0.0010 mg g^{-1}) and boiled (0.0510±0.0010 mg g^{-1}) groundnut husks when compared with the roasted groundnut husk (0.4800±0.0100 mg g^{-1}). Notwithstanding, no significant difference (p>0.05) was observed on the comparison between the raw and boiled groundnut husks.

The physicochemical properties of the raw, roasted and boiled groundnut husks as presented in Table 4, revealed that the organic matter and carbon contents of the raw groundnut husk (96.47±0.02 and 55.95±0.01%) were significantly

Table 5: Weight of birds fed with raw, roasted and boiled groundnut husks

	Weight of birds (g)				
Groups	0 W	1 WA	2 WA	3 WA	Carcass
Control	463.33±135.03[a]	673.33±110.15[a]	833.33±230.07[a,*]	896.67±170.39[a,*]	833.33±115.47[a]
Group 1	566.67±28.87[a]	786.67±23.09[a,*]	918.33±45.37[a,*]	873.33±61.10[a,*]	856.67±50.33[a]
Group 2	666.67±76.38[b]	703.33±50.33[a]	806.67±15.28[a]	816.67±175.59[a]	666.67±152.75[a]
Group 3	473.33±92.92[a]	676.67±136.50[a]	836.67±105.04[a]	1233.33±450.92[a,*]	860.00±111.36[a]
Group 4	416.67±85.05[a]	526.67±75.06[a]	640.00±69.28[a,*]	716.67±76.38[a,*]	710.00±81.85[a]
Group 5	546.67±161.66[a]	766.67±175.59[a]	946.67±277.55[a]	1120.00±524.60[a]	896.67±359.21[a]
Group 6	433.33±125.83[a]	563.33±80.83[a]	633.33±160.73[a]	603.33±177.86[a]	576.67±155.03[a]
Group 7	543.33±60.28[a]	753.33±45.09[a,*]	863.33±85.05[a,*]	1100.00±173.21[a,*]	916.67±57.74[a]
Group 8	456.67±136.50[a]	620.00±26.46[a]	653.33±142.24[a]	740.00±121.66[a,*]	703.33±107.86[a]

Values are ±standard deviation of mean of nine determinations, when compared with the control (across the column), values with same superscript alphabet are not significant ($p<0.05$) while values with different superscript alphabets are significant ($p<0.05$), *$p<0.05$ when compared to the corresponding week 0 (0W). For carcass, **$p<0.05$ when compared to the corresponding week 3. W: Week, WA: Week after

Table 6: Total heterotrophic bacteria (THB) and total coliform count (TCC) of birds fed with different concentrations of feed and groundnut husk

			Number of colonies		Frequency	
Groups	THB ($\times10^3$ CFU)	TCC ($\times10^3$ CFU)	Pathogenic ($\times10^3$ CFU)	Non-pathogenic ($\times10^3$ CFU)	Pathogenic ($\times10^3$ CFU)	Non-pathogenic ($\times10^3$ CFU)
Control	273.00±137.00	230.67±120.55	48.00±12.00	220.00±120.00	20.50±5.50	79.50±5.50
Group 1	316.00±28.00	180.00±36.00	136.00±12.00*	180.00±40.00	59.00±23.00*	56.00±8.00*
Group 2	389.00±73.00	328.00±48.00*	59.00±23.00	330.00±50.00*	14.50±3.500	85.50±3.50
Group 3	379.50±35.50	264.00±20.00	75.00±45.00	264.50±20.50	21.00±14.00	79.00±14.00
Group 4	412.00±4.00*	346.00±10.00*	69.50±3.50	342.50±7.50*	17.00±1.00	83.00±1.00
Group 5	318.00±102.00	194.00±62.00	75.00±15.00	193.00±67.00	28.00±14.00	72.00±14.00
Group 6	372.00±112.00	246.00±34.00	117.00±67.00*	255.00±45.00	59.50±21.50*	40.50±21.50*
Group 7	382.00±46.00	294.00±58.00	94.00±6.00	288.00±52.00	25.50±4.50	74.50±4.50
Group 8	396.00±84.00	306.00±30.00	96.00±54.00	300.00±30.00	22.00±9.00	78.00±9.00

Values are ±standard deviation of nine determinations, *$p<0.05$ when compared to the corresponding control

($p<0.05$) higher when compared with the roasted (90.46±0.14 and 52.45±0.11%) and boiled (95.39±0.16 and 55.32±0.09%) groundnut husks. However, a significantly ($p<0.05$) lower organic matter and carbon contents were recorded in the roasted groundnut husk when compared with the boiled groundnut husk. Similarly, a significantly ($p<0.05$) higher pH value was recorded in the raw (6.4350±0.01) and boiled (6.2950±0.01) groundnut husks when compared with the roasted groundnut husk (5.5600±0.36). Nonetheless, no significant difference ($p>0.05$) was recorded on the comparison between raw and boiled groundnut husks.

The results of the weights of birds fed with raw, roasted and boiled groundnut husks are presented in Table 5. Compared to the corresponding 0 weeks, no significant difference ($p<0.05$) was observed in all the groups, 1 week after, with the exception of groups 1 (786.67±23.09 g) and 7 (753.33±45.09 g) which showed significantly ($p<0.05$) increased weight. A comparison between the groups and their corresponding control group, at week 0, revealed no significant difference ($p>0.05$) with the exception of group 2 (666.67±76.38 g) which showed significantly ($p<0.05$) higher weight. Likewise, 1 week after no significant difference ($p<0.05$) was recorded. Similarly, compared to the corresponding 0 weeks no significant difference ($p<0.05$) was observed, 2 weeks after with the exception of the control group (833.33±230.07 g), groups 1 (918.33±45.37 g), 4 (640.00±69.28 g) and 7 (863.33±85.05 g) which recorded significantly ($p<0.05$) increased values. However, no significant difference ($p<0.05$) was observed on the comparison between the groups and their corresponding control, 2 weeks after. By 3 week after a significantly ($p<0.05$) higher body weight was recorded in the control group (896.67±170.39 g), groups 1 (873.33±61.10 g), 3 (1233.33±450.92 g), 4 (716.67±76.38 g) and 7 (1100.00±173.21 g) when compared with the corresponding 0 week with the exception of groups 2, 5 and 6 which showed no significant difference ($p>0.05$). However, no significant difference ($p>0.05$) was revealed on the comparison between the groups and their corresponding control, 3 weeks after. A comparison between the carcass and the weight of the birds 3 weeks after, prior to sacrifice, revealed no significant difference ($p>0.05$). Likewise, a comparison between the groups and their corresponding control revealed no significant difference ($p>0.05$) in the weight of the carcass.

The bacteriological analysis of the birds' droppings presented in Table 6 disclosed that compared to the corresponding control (273.00±137.00×10^3 CFU), no significant difference ($p>0.05$) was observed in the Total

Heterotrophic Bacteria (THB) count in all the groups with the exception of group 4 (412.00±4.00×10^3 CFU) which recorded significantly ($p<0.05$) higher count. Likewise, no significant difference ($p>0.05$) was observed in the total coliform count of the groups when compared with the control with the exception of groups 2 (328.00±48.00×10^3 CFU) and 4 (346.00±10.00×10^3 CFU) which recorded significantly ($p<0.05$) higher counts. Compared with the control (48.00±12.00×10^3 CFU), no significant difference ($p>0.05$) was observed in the number of colonies (pathogenic) with the exception of groups 1 (136.00±12.00×10^3 CFU) and 6 (117.00±67.00×10^3 CFU) which recorded significantly ($p<0.05$) higher counts. Likewise, for the non-pathogenic, no significant difference ($p>0.05$) was observed in the groups when compared with the control (220.00±120.00×10^3 CFU) with the exception of groups 2 (330.00±50.00×10^3 CFU) and 4 (342.50±7.50×10^3 CFU) which had significantly ($p<0.05$) higher counts. The frequency of occurrence of the pathogenic colonies, when compared with the control (20.50±5.50×10^3 CFU), revealed no significant difference ($p>0.05$) with the exception of groups 1 (59.00±21.50×10^3 CFU) and 6 (59.50±21.50×10^3 CFU) which were significantly ($p<0.05$) higher. For the non-pathogenic, when compared with the control, no significant difference ($p<0.05$) was observed with the exception of groups 1 ($p<0.05$) and 6 ($p<0.05$) which were significantly ($p>0.05$) lower.

DISCUSSION

Groundnut plays a useful role in alleviating nutrient deficiencies as it is a rich source of edible oil and protein. Groundnut has an outer thick woody shell. Inside, normally, there are 2 or 3 embedded seeds (kernel). The seed consists of 2 cotyledons and the germ covered by an outer thin skin called the testa. The color of the testa may be red, brown, purple or white depending upon the type and variety. Testa constitutes about 4-5% of the weight of the kernel. The cotyledons constitute the bulk of the seed in the range of around 92-94% of the weight. The germ constitutes around 3-4% of the seed weight. The testa protects the seed against pests and diseases. Cotyledons are the storage organs, which supply food to the germ during germination. As a result of these functional differences, the chemical make-up of the parts of the kernel also different[35].

From the result of the proximate analysis carried out on the raw, roasted and boiled groundnut husks disclosed in Table 1, the majority were significantly different ($p<0.05$) amongst all of the groups despite differences in the processed forms of the groundnut husks. This may be attributed to the processed forms of the groundnut husks. In a study[36], the moisture content of groundnut husk was higher than that of the melon husk. Perea-Moreno *et al.*[16] reported that the average ash content in a peanut shell, when compared to other biomass, such as olive stones, avocado stones oak pellets and almond shells had a remarkable higher value. Similarly, Sim *et al.*[37] reported that peanut shells contain ash in the range that shows a rich source of minerals. On the other hand, Omogbai *et al.*[38] conveyed that carbohydrate sources are natural microbial substrates that can provide a carbon source for growth and metabolism. The order of lipid content of the groundnut husks (boiled>roasted>raw) could be as a result of the processed form of the husks. It is well known that during boiling, because of the richness in oil of the groundnut seed, oil is usually released and can be absorbed by the shell. Additionally, enzymes according to Sogbesan and Ekundayo[39] can affect the fiber content of the groundnut husks when process. In their study, they reported a decline in fiber content and associated such to the action of enzymes secreted by a fungus and also recognized that during the solid-state fermentation process and activities, enzymes from the fungus broke down polysaccharides into less complex structures. Albeit no significant difference ($p>0.05$) was observed amongst the groups, Boli *et al.*[40] had reported that the protein content of peanut butter could be considered as a valuable source of protein in improving the nutrition status. Hence, from the result obtained for the proximate, it can be deduced that boiled groundnut husk has the best energy value trailed by the roasted and then raw groundnut husks.

The result of the qualitative phytochemical screening, as shown in Table 2, obtained for the groundnut husks may be indicative of the antioxidant properties of the different forms of the groundnut husks. In a study carried out by Prabasheela *et al.*[41], the phytochemical analysis established the presence of important bioactive compounds such as; flavonoids and terpenoids and was considered to be effective plant-derived antioxidants, but confirmed a significant variation of the antioxidant activity of the processed groundnut. The study further showed that 1, 1-diphenyl-2-picrylhydrazyl (DPPH) scavenging activities increased with increasing phenolic components such as flavonoids, phenolic acids and phenolic diterpenes. DPPH scavenging activity of runner and Spanish variety was found to be high for fried groundnut when compared to boiled and raw as the antioxidant activity increased with an increase in concentration. Boiling also had a significant effect on the antioxidant activity as the antioxidant activities were also found to be high when compared to raw in both varieties. The study concluded that the effectiveness of processing step to liberate antioxidant compounds from plants may vary depending on species.

Although most of the anti-nutrients revealed in Table 3 were extremely low, however, the higher content of hydrocyanate compared to oxalate and phytate may be due to the presence of substances which might have interfered with the nutrients of the pod. In a study carried out by Agbaire[42], it was revealed that low anti-nutritional factors may not pose any serious nutritional problem. However, the high content of these anti-nutrients could exert negative effects on the bioavailability of some mineral nutrients.

From the results obtained for the physicochemical properties of the groundnut husks as shown in Table 4, it can be deduced that the roasted groundnut husk had the least organic carbon matter and pH compared to raw and boiled groundnut husk. This is possible because of the processing method of the roasted groundnut husk which involved drying of the husk, thereby leading to the reduction in water content of the husk. This could have led to a decrease in pH of the roasted groundnut husk.

The significant increase ($p<0.05$) in the weight gain of the birds (Table 5) across the experimental period in the majority of the groups may be attributed to the feed concentrations and assortment. It was observed that birds fed with a mixture of 30% raw groundnut husk and 70% commercial feed, 30% mixed (10% raw+10% boiled+10% roasted) and 70% commercial feed performed best in terms of periodic gain in weight per week. This is trailed by the group of birds fed with 60% boiled and 40% commercial feed, as they showed remarkable weight gain from week 2. While the groups fed with 30% boiled and 70% commercial feed and 60% mixed (20% raw+20% boiled+20% roasted) and 40% commercial feed only showed remarkable weight gain at end of the third week, groups fed with 60% raw and 40% feed, 30% roasted and 70% feed and 60% roasted and 40% feed showed no remarkable weight gain throughout the feeding period. Likewise, when these groups were compared periodically against the control group, no remarkable difference in weight was observed. This, therefore, indicates that at such concentrations and assortments, poultry birds have a higher tendency to gain weight and as such, supplementing commercial feed with the types, concentrations and assortments of the groundnut husks can be encouraged. This is in line with the previous study[43] which reported that birds fed with Alkali-treated groundnut shell gained more weight than those treated with salt and potash at the finisher stage. Likewise, no significant difference ($p<0.05$) was observed in the carcass yield amongst all of the groups. In support of the findings from this study, Muftau *et al.*[2] had previously reported that fermented groundnut husk if properly treated could serve as a suitable feed ingredient for non-ruminants and does not have any adverse effect on the carcass yield and the hematological indices of broiler chicken.

From the result obtained for the bacteriological analysis, no remarkable difference was recorded in the majority of the groups when compared with the control, an indication that supplementing commercial poultry feed with groundnut husks may not necessarily be a bacteriological concern. However, the significantly ($p<0.05$) higher THB and TCC recorded in the group fed with 60% boiled groundnut husk and 40% commercial feed may be due to contamination during boiling. It could however, be that the presence of salt used for the boiling acted as a medium for microbial growth while selectively inhibiting certain microorganisms. If this is true, it could indicate that the boiling of the groundnut husk paved way for adsorption of microorganisms on the husk since moisture can also act as a growth medium for the proliferation of microorganisms. This is likewise possible if the water used for the boiling was contaminated, thereby making available on the husk microorganisms which could not be killed by the heat. According to Medved'ova *et al.*[44], the presence of salt can stimulate the growth of fresco culture and could also be used to inhibit pathogenic bacteria sensitivity. Nerín *et al.*[45] opined that the use of high cooking temperature in combination with external factors can lead to the formation of toxic compounds which can have a deleterious effect on food quality and safety. The remarkable high TCC recorded in the group fed with 60% raw groundnut husk and 40% commercial feed compared to the control group could be as a result of contamination of the raw groundnut husk. It was also observed the majority of the groups recorded no remarkable pathogenicity when compared with the control group, however, the difference observed in the groups fed with 30% raw groundnut husk and 70% commercial feed and 60% roasted groundnut husk and 40% feed may be attributed to the assortment of the groundnut husks. Pathogenic organisms present amongst the groups were *Bacillus* spp., *Klebsiella* spp., *Shigella* spp., *Salmonella* sp., *Staphylococcus* spp., while the non-pathogenic organisms were *Escherichia coli* and *Coliform bacilli*. In a previous study[46], the presence of *Salmonella* spp., *Listeria* spp., *E. coli*, total aerobic mesophilic bacteria, coliform, yeast and mould in groundnut husk after harvesting was similarly revealed.

CONCLUSION

Credibly, the boiled groundnut husk showed to possess the best proximate composition amongst the three forms of groundnut husks. This is evident through the derived energy value. Birds fed with a mixture of the different forms of the groundnut husk as well as those fed with a lower concentration of raw groundnut husk with high commercial feed proved to be effective as regards to the weight gain of the birds, however, a mixture of higher concentration of boiled groundnut husk with lower commercial feed also proved to be effective. Overall, the boiled groundnut husk proved to be the most effective form amongst the groundnut husks and therefore recommended as the most appropriate supplement or replacement for poultry feed.

SIGNIFICANCE STATEMENT

This study discovered that groundnut husk can be beneficial for supplementing poultry feed. This study will help the researchers to uncover the critical areas of poultry feed research that many researchers were not able to explore. Thus a new theory on the use of degradable waste materials as feed supplements may be arrived at.

REFERENCES

1. Ravindran, V., 2013. Poultry feed availability and nutrition in developing countries. Poult. Dev. Rev., 1: 60-63.
2. Alaba, M.M., E.C. Vitalis, S.A. Oyiza, A.Y.D. Rade and R.M. Ibrahim, 2015. Effect of dietary fermented groundnut husk for wheat offal on carcass and hematological characteristics of broiler chickens in semi-arid area of Kebbi State, Nigeria. IOSR J. Agric. Vet. Sci., 8: 39-42.
3. Oluyemi, J.A. and F.A. Roberts, 2000. Poultry Production in Warm Wet Climates. 2nd Edn., Spectrum Books, Ibadan, Nigeria, ISBN: 9789780290979, Pages: 190.
4. Nworgu, F.C., 2007. Economic importance and growth rate of broiler chickens served fluted pumpkin (*Telfaria occidentalis*) leaves extract. Afr. J. Biotechnol., 6: 167-174.
5. Odunsi, A.A., O. Sobamiwa and O.G. Longe, 1999. Comparative utilization of alkali-treated and untreated cocoa bean cake in diets of egg-type chickens. Trop. J. Anim. Sci., 2: 63-68.
6. Beguin, P., 1990. Molecular biology of cellulose degradation. Ann. Rev. Microbiol., 44: 219-248.
7. Silverstein, R.A., Y. Chen, R.R. Sharma-Shivappa, M.D. Boyette and J. Osborne, 2007. A comparison of chemical pretreatment methods for improving saccharification of cotton stalks. Bioresour. Technol., 98: 3000-3011.
8. Vancov, T. and S. McIntosh, 2011. Alkali pretreatment of cereal crop residues for second-generation biofuels. Energy Fuels, 25: 2754-2763.
9. Eshag, N.A., Bakhiet, M.H., Bukhari, S.A.S., A.M.A. Mohamed and J.J. Barram, 2015. Effects of feeding groundnut shells enriched with protein and energy on feed intake, nutrients digestibility and weight changes of sudanese desert lambs J. Agric. Nat. Resour. Sci., 2: 537-542.
10. Alu, S.E., Adua, M.M., Damulak, H.I., Umar, R.S., A.D. Abubakar and U.D. Matthew, 2012. Growth rate and nutrient digestibility by broiler birds fed alkali-treated groundnut (Arachis hypogea) shell meal-based diets. Scholarly J. Agric. Sci., 2: 231-237.
11. Sada, B.H., Y.D. Amartey and S. Bako, 2013. An investigation into the use of groundnut shell as fine aggregate replacement. Niger. J. Technol., 32: 54-60.
12. Adeosun, S., O. Taiwo, E. Akpan, O. Gbenebor, S. Gbagba and S. Olaleye, 2016. Mechanical characteristics of groundnut shell particle reinforced polylactide nano fibre. Matéria (Rio J.), 21: 482-491.
13. Kamaraj, M. and P. Umamaheswari, 2017. Preparation and characterization of Groundnut shell activated carbon as an efficient adsorbent for the removal of Methylene blue dye from aqueous solution with microbiostatic activity. J. Mater. Environ. Sci., 8: 2019-2025.
14. Grandawa, M.M., 2014. Characterisation of physico-chemical properties of *Arachis hypogaea* L. shells (groundnut) as environmental remidation. International Conference on Chemical, Biological and Environmental Sciences (ICCBES'14), May 12-13, 2014, International Academy of Arts, Science & Technology, Kuala Lumpur, Malaysia, pp: 1-10.
15. Torkashvand, M.A., A. Alidoust and M.A. Khomami, 2015. The reuse of peanut organic wastes as a growth medium for ornamental plants. Int. J. Recycl. Org. Waste Agric., 4: 85-94.
16. Perea-Moreno, M.A., F. Manzano-Agugliaro, Q. Hernandez-Escobedo and A.J. Perea-Moreno, 2018. Peanut shell for energy: properties and its potential to respect the environment. Sustainability, Vol. 10. 10.3390/su10093254.
17. Buba, F., A. Gidado and A. Shugaba, 2013. Analysis of biochemical composition of honey samples from North-East Nigeria. Biochem. Anal. Biochem., 2: 139-145. 10.4172/2161-1009.1000139.
18. AOAC., 2019. Official Methods of Analysis. 21st Edn., Association of Official Analytical Chemists, Washington D.C. USA.
19. Faulks, R.M. and S.B. Timms, 1985. A rapid method for determining the carbohydrate component of dietary fibre. Food Chem., 17: 273-287.
20. Pandey, A. and S. Tripathi, 2014. Concept of standardization, extraction and pre phytochemical screening strategies for herbal drug. J. Pharmacogn. Phytochem., 2: 115-119.

21. Birk, Y., A. Bondi, B. Gestetner and I.A. Ishaya, 1963. Thermostable hemolytic factor in soybeans. Nature, 197: 1089-1090.
22. Hudson, B.J.F. and E.A. El-Difrawi, 1979. The sapogenins of the seeds of four lupin species. J. Plant Foods, 3: 181-186.
23. Wadood, A., M. Ghufran, S.B. Jamal, M. Naeem, A. Khan and R. Ghaffar, 2013. Phytochemical analysis of medicinal plants occurring in local area of Mardan. Biochem. Anal. Biochem., Vol. 2. 10.4172/2161-1009.1000144.
24. Ejikeme, C.M., C.S. Ezeonu and A.N. Eboatu, 2014. Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta area of Nigeria. Eur. Sci. J., 10: 247-270.
25. Tyagi, T., 2017. Phytochemicals screening of active metabolites present in *Eichhornia crassipes* (Mart.) Solms and Pistastratiotes (L.): Role in ethnomedicine. Asian J. Pharm. Educ. Res., 6: 40-56.
26. Ugochukwu, S.C., I.A. Uche and O. Ifeanyi, 2013. Preliminary phytochemical screening of different solvent extracts of stem bark and roots of *Dennetia tripetala* G. Baker. Asian J. Plant Sci. Res., 3: 10-13.
27. Reddy, M.B. and M. Love, 1999. The impacts of food processing on the nutritional quality of vitamins and minerals. Adv. Exp. Med. Biol., 459: 99-106.
28. Food Safety Standards Authority of India, 2016. Manual on cereal and cereal products. https://fssai.gov.in/upload/uploadfiles/files/Manual_Cereal_25_05_2016(1).pdf.
29. Chukwuma, C.C., M.O. Monanu, J.C. Ikewuchi and C. Ekeke, 2018. Variance in protease, dehydrogenase, phosphatase and respiratory activities during phytoremediation of crude oil polluted agricultural soil using *Schwenkia americana* L. and *Spermacoce ocymoides* Burm. f. Annu. Res. Rev. Biol., 28: 1-9.
30. Motsara, M.R. and R.N. Roy, 2008. Guide to Laboratory Establishment for Plant Nutrient Analysis. Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN: 9789251059814, Pages: 204.
31. Ukwu, H.O., V.M.O. Okoro and R.J. Nosike, 2014. Statistical modelling of body weight and linear body measurements in Nigerian indigenous chickens. J. Agric. Vet. Sci., 7: 27-30.
32. Kagambega, A., T. Lienemann, L. Aulu, A.S. Traore, N. Barro, A. Siitonen and K. Haukka, 2013. Prevalence and characterization of *Salmonella enterica* from the feces of cattle, poultry, swine and hedgehogs in Burkina Faso and their comparison to human *Salmonella* isolates. BMC Microbiol., Vol. 13. 10.1186/1471-2180-13-253.
33. Zhenxiang, L.U., G.U.O. Weina and L.I.U. Chang, 2018. Isolation, identification and characterization of novel *Bacillus subtilis*. J. Vet.Med. Sci., 80: 427-433.
34. Islam, M.M., M.N. Islam, F.M. Sharifuzzaman, M.A. Rahman and J.U. Sharifuzzaman, 2014. Isolation and identification of *Escherichia coli* and *Salmonella* from poultry litter and feed. Int. J. Nat. Social Sci., 1: 1-7.
35. Nautiyal, P.C., 2002. Groundnut: Post-Harvest Operations. In: Food and Agricultual Operation of the United Nations, Meija, D. and B. Lewi (Eds.), National Research Centre for Groundnut (ICAR), India, Pages: 126.
36. Abdulrazak, S., D. Otie and Y.A. Oniwapele, 2014. Proximate analysis and anti-nutritional factors of groundnut and melon husk. Online J. Anim. Feed Res., 4: 25-28.
37. Sim, E.W., S.Y. Lai and Y.P. Chang, 2012. Antioxidant capacity, nutritional and phytochemical content of peanut (*Arachis hypogaea* L.) shells and roots. Afr. J. Biotechnol., 11: 11547-11551.
38. Omogbai, B.A., E.I. Obazenu, A.S. Iduoriyekemwen, L.N. Ubaka and A.A. Imoni, 2019. Proximate composition of agro-shell wastes and their utilisation for bioprotein production with Candida tropicalis MYA- 3404. J. Basic Appl. Sci., 4: 101-114.
39. Sogbesan, O.A. and T.M. Ekundayo, 2014. Cost benefits of fermented groundnut shell meal as supplemented feed in the diets of *Clarias gariepinus* fingerlings. Niger. J. Fish. Aquacult., 2: 30-41.
40. Boli, Z.A., L.T. Zoue, W.A.M. Alloue-Boraud, C.A. Kakou and R. Koffi-Nevry, 2013. Proximate composition and mycological characterization of peanut butter sold in retail markets of Abidjan (Cote d'Ivoire). J. Applied Biosci., 72: 5822-5829.
41. Prabasheela, B., R. Venkateshwari, S. Nivetha, P.M. Priya, T. Jayashree, R. Vimalaand and K. Karthik, 2015. Phytochemical analysis and antioxidant activity of *Arachis hypogea*. J. Chem. Pharm. Res., 7: 116-121.
42. Agbaire, P.O., 2011. Nutritional and anti-nutritional levels of some local vegetables (*Vernomia anydalira*, *Manihot esculenta*, *Teiferia occidentalis*, *Talinum triangulare*, *Amaranthus spinosus*) from Delta State, Nigeria. J. Applied Sci. Environ. Manage., 15: 625-628.
43. Alu, S.E., Adua, M.M., Damulak, H.I., Umar, R.S., A.D. Abubakar and U.D. Matthew, 2012. Growth rate and nutrient digestibility by broiler birds fed alkali-treated groundnut (Arachis hypogea) shell meal-based diets. Scholarly J. Agric. Sci., 2: 231-237.
44. Medveďová, A., P. Šipošová, T. Mančušková and Ľ. Valík, 2018. The effect of salt and temperature on the growth of fresco culture. Fermentation, Vol. 5. 10.3390/fermentation5010002.
45. Nerín, C., M. Aznar and D. Carrizo, 2016. Food contamination during food process. Trends Food Sci. Technol., 48: 63-68.
46. Uçkun, O. and I. Var, 2018. Microbiological quality of peanuts: from field to consumption. Sustainable Food Prod., 4: 31-39.