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Effect of different processing methods of pigeon pea (*Cajanus cajan*) on growth performance, carcass traits, and blood biochemical and hematological parameters of broiler chickens

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Abstract: A trial was conducted to evaluate the effect of different processing methods of pigeon pea (Pp; *Cajanus cajan*) on fattening performance and carcass traits as well as blood biochemical and hematological parameters of broiler chickens. For this purpose, 300 day-old chicks were assigned to 5 treatments. Each treatment had 5 replicates and contained 12 birds each under a completely randomized design. Five isonitrogenous and isocaloric diets were formulated with the inclusion of pigeon pea crushed (control, PPC), boiled with potash (PPP), boiled (PPB), soaked (PPS), or roasted (PPR) at the rate of 20% of the basal diet. The highest values of weight gain were observed in chicks fed the PPP diet through the starter and overall periods. Throughout the starter phase, the feed conversion ratio was significantly affected by dietary treatments. Highest values for carcass and breast weight were observed in birds fed the PPP diet as compared to the control diet. Blood biochemical parameters were not statistically influenced by Pp treatments. Hematology was also similar in all the diets. In conclusion, PPP can be used as a protein source in broiler diets and it can improve the growth performance of broilers.

Key words: Broilers, carcass parameters, fattening, hematological parameters, pigeon pea

1. Introduction

In developing countries the availability of conventional feed ingredients in the formulation of balanced diets is limited (1,2). Therefore, inaccessibility and cost of feed are the major constrictions faced by poultry producers. Increasing demand for protein ingredients has drawn the attention of poultry nutritionists towards the use of unconventional, inexpensive, and locally available feed ingredients. However, the drawback of these ingredients is the presence of antinutritional factors. Use of pigeon pea (Pp; *Cajanus cajan*) seed may be considered in this respect (1,2). Incorporation of some unconventional feed ingredients in the formulation of a balanced diet may overcome the problems and may also minimize feed costs (3–5). Most formulations of the modern poultry feed industry in Pakistan use maize, soybean meal, or groundnut cake as the base ingredients, but these ingredients are being used as food in human nutrition. This has encouraged improved effort at finding cheaper alternatives to prolong the production of poultry and maximize the potentials of the improved poultry strains available, at a reasonable cost.

Pp is an important grain legume commonly grown and consumed in both tropical and subtropical regions of the world. It is also known as "lobiaadassy" (6). According to Saxena (7) the area cultivated has jumped to over 4.92×10^6 ha. It is considered a multipurpose nitrogen-fixing plant that provides food, fuel wood, and fodder as well as shelter material to farmers throughout the world. The shells, leaves, seeds, and young stems of Pp could be a good protein source for poultry feed. This plant can tolerate drought conditions and has greater adaptability to poor soil conditions as compared to most other tropical legumes (8). It is widely cultivated throughout the tropics as a cover crop or green manure crop and it has high dry matter yield potential. *Cajanus cajan* contains crude protein (CP) of

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22%–27%, crude fiber (CF) of 7.3%–10%, nitrogen-free extract (NFE) of 61.2%, ether extract (EE) of 1.7%–2.1%, ash of 3.1%–4.2%, and lysine of about 7.59% (9–11). It is also a good source of soluble vitamins, especially thiamin, riboflavin, niacin, and choline.

There are some limitations such as trypsin and chymotrypsin inhibitors regarding the use of Pp as a feed ingredient; some antinutritional factors reduce feed intake and affect feed efficiency along with its good nutritive value. These harmful effects could be reduced by different processing methods such as boiling, crushing, soaking, and roasting. It has a good nutritional profile and could replace maize and soybean (12). It could be a better and cheaper protein alternative as compared to other legume grains. In Pakistan its supply is scarce and therefore it has a higher price. This limits its use as feed ingredient. If some attention is paid to this conventional feed ingredient then Pp could be used for dual purposes, i.e. in both food and feed (10,13).

There are some studies that used raw Pp at up to 15%–30% inclusion (14) and Yagoub and Zubair (14) reported that a 30% incorporation rate significantly increased feed conversion ratio and decreased body weight in broiler chicks. This effect may be attributed to the high amounts of trypsin and chymotrypsin inhibitors in raw Pp and they indicated that decortication reduced the impacts of antinutritional agents. On the other hand, Hassan et al. (15) pointed out that broilers can perform well at up to a 12% inclusion rate of Pp as a substitute for sesame meal. Awdallah (16) used 7.5% and 15% levels of corticated and decorticated Pp seeds in the diets of Lohmann broiler chicks and reported statistically better feed intake and body weight gain for the chicks fed 7.5% decorticated Pp seeds. Amaefule et al. (17) reported that the chemical composition of Pp depends on cultivar, geographical location, and growth conditions. Roasted Pp can successfully be included up to 30% in the diets of rabbits without adverse effect on performance (18).

Therefore, the aim of the present experiment was to study the effect of different processing methods of Pp (*Cajanus cajan*) on growth performance and carcass traits as well as blood biochemical and hematological parameters of broiler chickens throughout the fattening period. It was hypothesized that Pp could be used as an alternative protein source.

2. Materials and methods

The experiment was conducted to evaluate the effect of inclusion of different processed forms (crushed, boiled with potash, boiled in water, soaked, and roasted) of Pp seeds in broiler diet.

2.1. Birds, diets, and experimental design

A total of 300 day-old unsexed broiler chicks (Hubbard) with average live body weight of 45.79 ± 0.25 g, purchased from a local hatchery, were weighed and randomly assigned to 5 treatments. Each treatment had 5 replicates and contained 12 birds each under a completely randomized design. Five isonitrogenous and isocaloric diets were formulated with the inclusion of 20% treated Pp: 1) crushed (control, PPC), 2) boiled with potash (PPP; Pp was boiled in water with potash at 2 g/kg Pp for 60 min and the boiled sample was drained and sun-dried), 3) boiled (PPB; Pp was boiled in water for 60 min and the boiled sample was drained and sun-dried), 4) soaked (PPS; Pp was soaked in water for 24 h before use), and 5) roasted (PPR; Pp was roasted in a frying pan in fire supplied by firewood) (11,12). Each experimental unit was kept in a separate pen. Every pen had the same brooding temperature (35 °C). All the pens had the same space for birds and dimensions of pens were $4 \times 3 \times 2.5$ cm^3.

A week before the arrival of the chicks, the house was fully abandoned for its renovation, sanitation, and disinfection. After washing with clean water, the pens were disinfected using a formalin solution (1:10) and left to dry fully. During this time all feeders, drinkers, and other necessary equipment were cleaned, washed, and disinfected with $KMnO_4$ solution for 1 h and dried before placement in the house. Sun-dried rice husk was spread on the floor of each pen with an approximate depth of 3 cm. The turning of bedding material was done on a regular basis to avoid the caking of litter material. The drinkers and feeders were placed in the house and fumigation was done by using $KMnO_4$ (17.5 g) and formalin (35 mL) at a standard concentration (1X). The house was made airtight for 24 h and after that the house was opened for cross-ventilation. The birds were reared under similar conditions such as temperature, ventilation, humidity, space, and light. The temperature of the house was recorded three times a day throughout the experimental period. The temperature was maintained at 35 °C during the first week and then incrementally lowered each week until it reached 24 °C.

Glucose was supplied to the chicks through drinking water at the time of arrival with the objective of minimizing the transportation and handling stresses. Feed and fresh drinking water were provided ad libitum to all birds throughout the experimental period. The total duration of the experiment was 35 days. The trial was divided into two phases: a starter phase (days 1–21) and a finisher phase (days 22–35). The diets were formulated according to the requirements given by Leeson and Summer (19). Five isonitrogenous (21% CP) and isocaloric (2931 kcal/kg) starter diets were formulated and fed from day 1 to day 21 as given in the treatment program (Table 1). Similarly, five isonitrogenous (18. 68% CP) and isocaloric (2964 kcal/

Table 1. Ingredients and experimental diets of the starter phase of broiler chickens.

Items	Diets	
	Starter (days 1–21)	Finisher (days 22–35)
Ingredient, %		
Corn 8.5% CP	41.6	45.0
Pigeon pea 20% CP	20.0	20.0
Rice polishing 11% CP	8.80	12.30
Soybean meal 44% CP	8.19	5.00
Canola meal 39% CP	5.50	4.50
Sunflower meal 28%	5.00	4.00
Poultry meal 82.2% CP	4.30	3.10
Fish meal 50%	4.00	3.00
Salt	1.30	1.30
Premix[1]	0.30	0.50
Limestone	0.30	0.50
Di-calcium phosphate	0.31	0.30
Lysine	0.20	0.30
DL-methionine	0.20	0.20
Nutrient composition, %		
Crude protein	21.0	18.70
ME (kcal/kg)[2]	2931	2964
Lysine	1.30	1.25
Methionine	0.52	0.48
Calcium	1.50	1.10
Available phosphorus	0.40	0.40
Chemical composition, %[3]		
Dry matter	90.01	90.22
Crude protein	21.11	18.81
Crude fat	5.30	5.30
Crude fiber	5.02	5.11
Ash	7.35	7.40
NFE[4]	51.23	53.60

[1]Supplied per kilogram of diet: vitamin A 7500 IU; vitamin D3 2500 IU; vitamin E 8 mg; vitamin K3 2 mg; vitamin B1, 3 mg; vitamin B2 12 mg; vitamin B6 4 mg; vitamin B12 0.03 mg; nicotinamide 37 mg; calcium-D-pantothenate 13 mg; folic acid 0.50 mg; D-biotin 0.10 mg; choline chloride 500 mg; Mn 66 mg; Fe 27.5 mg; Zn 55 mg; Cu 6 mg; I 1.2 mg; Co 0.1 mg; Se 0.15 mg.
[2]Calculated according to Amaefule et al. (21).
[3]Determined according to the AOAC (20).
[4]NFE: Nitrogen-free extract.

kg) finisher diets were formulated and fed to birds from day 22 to day 35 (Table 1). The proximate composition of the experimental diets was determined using the standard methods of the AOAC (20). Samples were analyzed for crude protein, crude fat, and crude fiber and metabolizable energy was calculated according to Amaefule et al. (21).

2.2. Data collection

Weekly feed intake was recorded. Chicks were weighed on the day of their arrival and at the end of each week regularly to estimate weekly body weight gain. Total live weight gain was recorded at the end of the trial. Data recorded for weight gain and feed intake were used to calculate the weekly feed conversion rate (FCR).

At the end of the trial, two birds from each replicate were randomly selected, weighed individually, and slaughtered to obtain data on carcass characteristics. In order to record data on carcass characteristics, live body weights of birds were noted. After slaughtering, feathers were removed, followed by evisceration to determine dressed weight, breast meat weight, thigh meat weight, and giblet organ weights like heart weight, liver, and gizzard. The dressing percentage was calculated by dividing carcass weight (including organs like the heart, liver, and gizzard) of the birds slaughtered by live weight in grams.

Five milliliters of blood was collected by wing vein puncture from selected birds by using a 24-gauge needle in separate screw-type tubes for obtaining plasma and serum. Each blood collection tube had 0.2 mL of heparin as an anticoagulant to collect the blood plasma. Blood samples containing anticoagulant were used for the study of various hematological parameters. However, samples of blood for getting the serum were collected in centrifuge tubes without anticoagulant. These blood samples were centrifuged in a centrifuge machine for 5 minutes at 2000 rpm. Plasma and serum thus obtained were taken out of the centrifuge tubes and stored in a refrigerator at –4 °C until analysis. Blood biochemical parameters of total protein (g/dL), glucose (mg/dL), urea (g/dL), triglyceride (mg/dL), total cholesterol (mg/dL), creatinine (mg/dL), calcium, and phosphatase levels were estimated in serum using commercial biodiagnostic kits (22).

2.3. Statistical methods

The data collected during the research trial on all parameters like feed intake, weight gain, feed conversion ratio, and carcass characteristics like dressing percentage, carcass percentage, breast meat yield, thigh meat yield, and weight of giblet organs (liver, heart, and gizzard), as well as blood biochemical and hematological parameters, were subjected to statistical analysis using the analysis of variance technique under a completely randomized design and means were separated by Tukey test (23).

3. Results

3.1. Performance

As shown in Table 2, feed intake and FCR were not significantly ($P > 0.05$) affected in broiler chicks fed PPC, PPP, PPB, PPS, or PPR diets throughout the experimental period, except for FCR through the starter period. The best value (1.50) of FCR was achieved in chicks fed the PPP diet compared with the PPC diet. During the starter and

Table 2. Effect of treatments on body weight gain, feed intake, and feed conversion of broiler chickens (n = 5).

Performance	Treatments[1]					
	PPC	PPP	PPB	PPS	PPR	Sig.[2]
Body weight gain (g)						
Starter phase	724 ± 10.40^{c}	812 ± 11.20^{a}	759 ± 9.21^{bc}	776 ± 8.21^{ab}	757 ± 10.49^{bc}	*
Finisher phase	1015 ± 40.22	1148 ± 39.16	1099 ± 42.01	1087 ± 37.36	1125 ± 39.28	NS
Overall period	1709 ± 34.56^{b}	1921 ± 35.21^{a}	1819 ± 33.25^{ab}	1824 ± 32.66^{ab}	1842 ± 35.66^{ab}	*
Daily feed intake (g)						
Starter phase	1250 ± 26.84	1221 ± 27.84	1232 ± 24.84	1258 ± 26.84	1196 ± 25.84	NS
Finisher phase	1994 ± 63.24	1973 ± 63.24	2032 ± 65.24	1982 ± 64.24	1937 ± 66.24	NS
Overall period	3244 ± 78.65	3194 ± 76.65	3265 ± 77.65	3241 ± 75.65	3134 ± 77.65	NS
Feed conversion ratio (g feed/g gain)						
Starter phase	1.72 ± 0.04^{a}	1.50 ± 0.05^{b}	1.62 ± 0.06^{ab}	1.62 ± 0.04^{ab}	1.58 ± 0.04^{ab}	*
Finisher phase	1.96 ± 0.09	1.71 ± 0.09	1.84 ± 0.09	1.82 ± 0.09	1.72 ± 0.09	NS
Overall period	1.89 ± 0.05	1.66 ± 0.03	1.80 ± 0.05	1.78 ± 0.04	1.71 ± 0.06	NS

[1]Treatments: PPC: pigeon pea crushed, PPP: pigeon pea boiled with potash, PPB: pigeon pea boiled, PPS: pigeon pea soaked, and PPR: pigeon pea roasted

[2]Different superscripts within rows are significantly different ($P < 0.05$). NS: Not significant.

overall periods, body weight gain was affected (P < 0.05) by the different treatments. The highest values of body weight gain (812 and 1921 g) were observed in chicks fed the PPP diet, while the lowest (724 and 1709 g) were observed in chicks fed the PPC diet during the starter and overall periods, respectively (Table 2).

3.2. Carcass characteristics

Table 3 presents the effects of different treatments of Pp on carcass parameters in broiler chickens. All parameters of carcasses were not significantly (P > 0.05) influenced by dietary treatments, except carcass and breast weights (P < 0.05). The highest values of carcass (1219 g) and breast (481 g) weights were observed in birds fed the PPP diet as compared to the control diet.

3.3. Blood biochemical and hematological parameters

Table 4 summarizes the effect of different treatments of Pp on blood biochemical and hematological parameters in broiler chickens. No difference (P > 0.05) was observed in broiler blood glucose, urea, calcium, phosphorus, cholesterol, triglycerides, creatinine, and total protein when birds were fed either the control or other processed diets. Hematological parameters were similar (P > 0.05) across all the diets.

4. Discussion

Pigeon pea treatments had an effect on body weight gain through the overall period. The results of the present study are in line with the findings of Amaefule and Onwudike (24). Amaefule and Obioha (12) observed that when boiled with potash Pp in the broiler diet resulted in higher body weight as compared to raw, soaked, and toasted Pp. This was possibly due to the greater reduction of antitryptic and hemagglutinating activities of Pp seeds, achieved through boiling with potash. The present results are in agreement with the findings of Amaefule et al. (25), who reported that the body weight of broilers was higher with a diet having Pp boiled with potash as compared to diets containing raw, soaked, and toasted Pp. Results of the present study are contradictory to the findings of Amaefule et al. (26), who observed that there were nonsignificant differences among the treatments with respect to all the parameters measured, such as growth performance and carcass characteristics of rabbits fed boiled Pp at the rate of 0%, 10%, 20%, or 30% of the basal diet. This might be attributed to poor utilization of boiled Pp by rabbits as compared to broilers.

Results of the present study are in line with the findings of Ciftci et al. (27), who recorded nonsignificant differences regarding feed intake and different levels of processed Pp seed meal in broiler diets. The findings of the present study are supported by Ani and Okeke (28), who reported that feed intake was not affected by dietary inclusion of processed Pp seeds. The results of the present study were not in line with the findings of Onu and Okongwu (29), who found significant differences in feed intake among the groups fed diets containing processed Pp (raw, boiled, and toasted) seeds. Similar results were also found by Adeparusi (30), who reported that the Pp seed coat affected the palatability of Pp meal. It was further stated that processing of the seeds may help to alleviate the reduced feed intake related to addition of higher levels of Pp seed meal, and it was also found that decortication improved the nutritional value of

Table 3. Effect of treatments on carcass traits of broiler chickens at the end of the experimental period (n = 10).

Items	Treatments[1]					
	PPC	PPP	PPB	PPS	PPR	Sig.[2]
Carcass weight, g	1029 ± 35.50^{b}	1219 ± 34.50^{a}	1112 ± 34.52^{ab}	1126 ± 36.51^{ab}	1187 ± 34.50^{a}	*
Dressing, %	64.30 ± 2.48	65.62 ± 0.33	64.64 ± 1.66	62.58 ± 1.55	63.40 ± 1.45	NS
Breast weight, g	400 ± 18.63^{b}	481 ± 17.63^{a}	415 ± 15.63^{ab}	410 ± 17.63^{ab}	443 ± 15.63^{ab}	*
Neck weight, g	66.6 ± 2.44	69.0 ± 2.64	66.4 ± 2.53	64.0 ± 2.54	72.8 ± 1.53	NS
Gut length, cm	9.0 ± 0.11	9.1 ± 0.10	9.0 ± 0.12	9.0 ± 0.10	8.9 ± 0.13	NS
Abdominal fat, g	29.2 ± 3.26	34.4 ± 2.26	28.8 ± 3.26	31.0 ± 1.26	30.8 ± 2.28	NS
Thigh weight, g	154 ± 7.03	173 ± 8.03	157 ± 9.03	154 ± 10.03	162 ± 8.41	NS
Heart weight, g	12.6 ± 1.01	12.6 ± 0.98	12.2 ± 0.99	13.0 ± 1.00	14.4 ± 1.00	NS
Gizzard weight, g	55.2 ± 4.05	57.0 ± 2.05	54.8 ± 3.05	53.6 ± 4.05	57.8 ± 3.05	NS
Liver weight, g	44.0 ± 1.83	47.6 ± 1.73	41.4 ± 1.88	41.6 ± 3.83	41.0 ± 2.83	NS
Giblets, g	111 ± 5.88	117 ± 5.99	108 ± 4.88	108 ± 2.88	113 ± 3.88	NS

[1]Treatments: PPC: pigeon pea crushed, PPP: pigeon pea boiled with potash, PPB: pigeon pea boiled, PPS: pigeon pea soaked, and PPR: pigeon pea roasted.
[2]Different superscripts within rows are significantly different (P < 0.05). NS: Not significant.

Table 4. Effect of treatments on blood biochemical and hematological parameters of broiler chickens at the end of the experimental period (n = 10).

Items	Treatments[1]					
	PPC	PPP	PPB	PPS	PPR	Sig.[2]
Blood biochemical parameters						
Glucose, mg/dL	171 ± 16.71	189 ± 16.51	178 ± 15.61	220 ± 17.61	179 ± 14.61	NS
Total protein, g/dL	3.54 ± 0.36	4.24 ± 0.38	3.98 ± 0.36	4.60 ± 0.37	3.80 ± 0.36	NS
Urea, mg/dL	10.60 ± 1.31	10.40 ± 1.21	9.60 ± 1.52	10.00 ± 1.21	8.80 ± 1.22	NS
Creatinine, mg/dL	0.14 ± 0.02	0.16 ± 0.01	0.14 ± 0.01	0.14 ± 0.02	0.12 ± 0.03	NS
Triglycerides, mg/dL	99.6 ± 7.98	103.4 ± 8.70	100.6 ± 8.98	104.0 ± 8.58	90.6 ± 8.88	NS
Cholesterol, mg/dL	122 ± 4.06	132 ± 3.06	128 ± 4.66	135 ± 4.36	134 ± 4.26	NS
Calcium, mg/dL	11.40 ± 1.19	11.30 ± 1.17	9.70 ± 1.18	10.60 ± 1.17	10.80 ± 1.22	NS
Phosphatase, U/L	5.50 ± 0.28	5.10 ± 0.34	5.80 ± 0.29	5.80 ± 0.35	5.80 ± 0.34	NS
Hematological parameters						
RBCs (10^6/μL)	2.58 ± 0.10	2.34 ± 0.13	2.54 ± 0.09	2.78 ± 0.13	2.58 ± 0.15	NS
WBCs (10^3/μL)	23.68 ± 0.20	23.63 ± 0.21	23.68 ± 0.22	23.73 ± 0.19	23.65 ± 0.20	NS
HB (g/dL)	10.96 ± 0.45	9.72 ± 0.55	10.68 ± 0.49	11.16 ± 0.53	10.64 ± 0.52	NS

[1]Treatments: PPC: pigeon pea crushed, PPP: pigeon pea boiled with potash, PPB: pigeon pea boiled, PPS: pigeon pea soaked, and PPR: pigeon pea roasted.
[2]NS: Not significant.

PP and broilers performed well at higher inclusion levels without any problem. Moreover, toasting or dry heating of Pp seeds resulted in less reduction of trypsin inhibitor in the seeds as compared to boiling the Pp seeds (31).

Pp seed contains antinutritional factors such as amylase inhibitor and trypsin inhibitors. These harmful substances interfere with digestion, due to which Pp is used in limited amounts as a feed ingredient for monogastric animals. Processing of the seeds deactivates the antinutritional factors, resulting in the enhancement of the nutritive value. By boiling 97.84% of trypsin inhibitor can be reduced in Pp seeds. Similarly, by toasting or dry heating, 89.82% of trypsin inhibitor can be reduced in the seeds (18,32–34).

Consistent with our findings, Amaefule and Onwudike (24) and Amaefule et al. (35) indicated that there were significant differences in FCR among birds fed processed Pp such as raw, boiled, toasted, and soaked as compared to the controls. This might be attributed to improved digestibility, which resulted in more availability of nutrients for growth. Some others also stated that boiling with potash can improve the utilization of Pp in broiler diets and result in an improved weight gain and FCR (24,30).

Feeding a 20% PPP diet increased carcass and breast weight while other carcass parameters were not affected by treatments (Table 3). Similar results were observed by Abdelati et al. (36), who reported in their comparative study that a diet with inclusion of 10% soaked Pp seeds after decortication with enzymes (multienzyme mix with a high content of pentosanase) fed to broilers in comparison to decorticated roasted Pp seeds had no influence on dressing percentage. In this regards, Iheukwumere et al. (37) pointed out the nonsignificant effect of Pp (0% and 20% raw Pp and 20% boiled Pp) seed meal on dressing percentage in rabbits. In this context, Asaduzzaman (38) observed that there were nonsignificant differences among the percentages of feather, drumstick bone, drumstick meat, abdominal fat, gizzard, liver, neck, and heart in the birds fed diets containing Pp seeds. It was concluded that the enhancement of the meat yield with inclusion of Pp seeds was due to higher body weight gain and better feed utilization in birds because of the improved palatability with inclusion of boiled Pp seeds in diets. Similarly, Bamgbose et al. (39) and Yisa et al. (40) found that there was no difference between treatments with regard to weights of heart, liver, and head. The present results are contradictory to the findings of Amaefule et al. (26), who observed a nonsignificant difference among the carcass characteristics of birds fed diets containing varying levels of Pp seeds given at the rates of 0%, 10%, 20%, and 30%.

The blood biochemical and hematological parameters were not affected by dietary treatments (Table 4). Our results are in agreement with the observations of Saeed et al. (41), Ahamefule et al. (42), and Dousa et al. (43), who

reported that blood chemistry values for weaner rabbits fed raw or processed Pp-based diets (boiled, soaked, or toasted) were nonsignificant among the treatment groups. Ahamefule et al. (42) also reported that hematological values for weaner rabbits fed raw or processed Pp-based diets (boiled, soaked, or toasted) remained unaltered. Similar results were obtained by Mitruka and Rawnsley (44), who found that hematological values were generally low and did not fall within the normal range for rabbits after provision of raw Pp. The present results are in agreement with the observations of Akinmutimi (45), who found that harmful substances were reduced by processing methods but complete elimination of all traces of antinutritional factors in feedstuffs was not achieved.

In conclusion, from the results of present study, it can be concluded that the processing of Pp, especially when boiled with potash (PPP), improved nutritive quality and thus enhanced broiler growth performance. Therefore, it can be successfully used as an alternative protein source in broiler diets.

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