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GROWTH RESPONSE, FLOCK UNIFORMITY, ORGAN WEIGHT, ABDOMINAL FAT, CARCASS YIELD AND HEPATIC HISTOLOGY OF FINISHER BROILER CHICKEN FED TOASTED PIGEON PEA SEED MEAL

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Abstract: Three hundred (300) 21d old (Arbor-acre) broiler chicks apportioned to five (5) dietary groups of sixty (60) birds each, further replicated six (6) times were fed graded levels of toasted pigeon pea seed meal (TPSM) to assess the performance, flock uniformity, organ weights, carcass yield and hepatic histology at the finisher phase. A maize-full-fat soybean meal diet served as the control diet (I). The TPSM was incorporated to replace full-fat soybean meal at 12.5%, 25.0%, 37.5% and 50.0% in diets II, III, IV and V, respectively. Toasting improved the protein content, ether extract, fibre content, metabolizable energy and reduced the anti-nutrients except for oxalate. The final weight, total weight change, average weight gain, feed conversion ratio, eviscerated weight, breast yield and thigh yield were significantly influenced ($P<0.05$), especially depressed at 50% replacement, unlike the average feed intake, mortality and flock uniformity ($P>0.05$). The kidney and abdominal fat were also influenced ($P<0.05$). There were varying levels of hepatic degeneration, which increased in intensity as the level of inclusion increased. They ranged from mild sinusoidal congestion and cellular infiltration to necrosis of the cells in the liver. Up to 37.5% TPSM toasted pigeon pea seed meal replacement for soybean meal supported optimum growth, breast and thigh yield, and mild to moderate hepatic disruptions.

Key words: broiler, *Cajanus cajan*, growth response, organ weight, carcass yield.

Introduction

Pigeon pea is a drought-resistant, fast-growing (Bekele-Tessema, 2007), multi-purpose perennial legume shrub (Sarkar et al., 2018), adapted to tropical and sub-tropical climates of Africa, Asia and the Caribbean (Mallikarjuna et al., 2011). It is majorly planted for its seeds, especially in drought prone areas, for food

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security. Dried stems are a source of fuel in rural settings, and the leaves are a source of forage to ruminants. It is also used to reclaim unfertile lands because of its nitrogen-fixing potentials as green manure, a shade plant or a cover crop (Cook et al., 2005).

The *Cajanus cajan* seed has a low monetary value and is obtainable at Nigerian markets (Esonu, 2006). This is because of its despised food preference ascribed to lengthy cooking time, unlike alternative beans (Amaefule and Obioha, 2001) resulting in a decline in popularity, thus, on the brink of extinction in some areas. So, the alternative economic use has to be explored. The seed, according to Amaefule and Nwagbara (2004) and Esonu (2006), has crude protein ranging from 18% to 30%, while Ahmed et al. (2006) observed 7%–10% crude fiber, 61% nitrogen-free extract and an average of 1.85% ether extract. Amaefule et al. (2011) and Esonu (2006) showed that the seed is somewhat lower in methionine compared to lysine.

Material and Methods

The site and interval of the experiment

The feeding trial was carried out at the Broiler Unit, Ladoke Akintola University of Technology Farm, Ogbomosho, Nigeria, situated in the derived savannah zone between latitudes 8°15'N and longitude 4°16'E. The location has a mean annual temperature of about 26.20°C and a mean annual rainfall of about 1200mm, with the relative humidity ranging from 75% to 95%. The experiment lasted for four weeks (Ojedapo et al., 2009).

The collection of test ingredients

Pigeon pea (*Cajanus cajan*) seeds were purchased from a local market. They were properly cleaned and toasted in a pan at 105^0C for 7 minutes, and they were later hammer-milled to pass through a chick mesh at a reputable feedmill.

Experimental birds and management

A total of three hundred (300) day-old unsexed Abor-acre broiler strain chicks were procured from a reputable hatchery. Standard management practices and routine vaccination were strictly observed. At the three-week starter phase, the chicks were placed on a commercial starter ration, after which the birds were apportioned into 5 dietary groups of 60 birds each and were further replicated six times, comprising 10 birds per replicate in a completely randomized design. Open system housing was used, and the replicate pen was $1m^2$ each.

Study diets

Five treatment diets were compounded. A maize-full-fat soybean meal diet served as the control diet (I). The milled toasted pigeon pea seed meal was incorporated to replace full-fat soybean meal at 12.5%, 25.0%, 37.5% and 50% in diets II, III, IV and V, respectively, as shown in Table 1. The feeds were isocaloric.

Table 1. The composition of experimental diets (%), 3–7 weeks.

Parameter (%)	I (0.00%)	II (12.5%)	III (25%)	IV (37.5%)	V (50%)
Maize	50.00	50.00	50.00	50.00	50.00
Full-fat soybean meal	27.00	23.62	20.25	16.87	13.50
Pigeon pea	0.00	3.38	6.75	10.13	13.50
Fish meal (72%)	4.00	4.00	4.00	4.00	4.00
Palm kernel cake	8.00	8.00	8.00	8.00	8.00
Wheat offal	8.00	8.00	8.00	8.00	8.00
Bone meal	1.00	1.00	1.00	1.00	1.00
Limestone	1.00	1.00	1.00	1.00	1.00
Lysine	0.25	0.25	0.25	0.25	0.25
Salt	0.25	0.25	0.25	0.25	0.25
Premix	0.25	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25	0.25
Total	100.00	100.00	100.00	100.00	100.00
Calculated nutrient composition					
Metabolizable E (Kcal/kg)	3110.4	3111.85	3113.85	3114.96	3116.21
Crude protein	20.20	19.69	19.19	18.53	18.18
Ether extract	7.94	8.30	8.75	9.18	9.34
Crude fibre	4.17	4.45	4.74	5.02	5.31
Lysine	1.33	1.22	1.14	1.04	0.93
Methionine	0.63	0.61	0.59	0.57	0.35

Data sets and analysis

Chemical and anti-nutrient composition:

Proximate composition and anti-nutrients were evaluated using the AOAC (2005) procedure while the metabolizable energy component was estimated by the formula ME ($Kcalkg^{-1}$) = 37 x %crude protein+81.1x %ether extract+35.0x%nitrogen free extract (Pauzenga, 1985). Trypsin inhibitors and tannin were evaluated by the procedure of Kakade et al. (1969) and Swain (1979), respectively. Total saponin and phytate were determined by the spectrophotometric method described by Hiai et al. (1989) and the procedure recommended by Maga (1983), respectively.

Growth performance:

Growth indices (feed consumed, weight change and feed conversion ratio) were monitored, and flock uniformity was calculated as described by Ojediran et al. (2017), including the average daily feed intake (ADFI), average daily gain (ADG) and feed conversion ratio (FCR).

Organ weight and carcass cuts

At the termination of the experiment, 2 birds per replicate were picked, tagged, fasted overnight for 12 h and were humanely decapitated for organ and carcass examination. The internal organs were collected after evisceration prior to scalding, de-feathering and dissection for carcass cuts. Eviscerated organs and carcass cuts were measured by the use of an electronic weighing scale and were expressed in percentages relative to the live weight of the chicken.

Histological study

Samples of the liver fixed in pre-tagged bottles filled with 10% formalin for histopathological examination were transported to the laboratory. Microscopic slides were prepared by fixing portions of the liver in eosin-haematoxylin dye as described by Carson and Christa (2009). The histopathological observations were completed under light microscopes. Photomicrographs of the liver samples were snapped using Authtek Camera (L GmBh, Germany).

Experiment design and analysis

The birds were allocated to respective treatments in a completely randomized design. The various data taken were analyzed in a one-way analysis of variance using the SAS (2005) package while significant means were separated using Duncan's multiple range test.

Results and Discussion

The chemical composition and anti-nutrients of raw and toasted *C. cajan* seed meal are shown in Table 2. The unprocessed seed had 92.77% dry matter, 21.70% crude protein, 32.74% ether extract, 5.07% crude fibre, 4.00% ash, 29.26% NFE and 4482.21 kcal/kg ME, while the toasted seed meal had 93.11% dry matter, 25.26% crude protein, 35.01% ether extract, 4.40% crude fiber, 3.10% ash, 25.28% NFE and 4663.60 kcal/kg ME. The concentration of anti-nutrients revealed that phytic acid, trypsin inhibitor, oxalate and tannin amounted to 20.02 mg/kg, 65.70 TIU/mg, 105.62 mg/kg and 28.50mg/kg in the raw pigeon pea seed meal, respectively, unlike 19.00 mg/kg, 38.25 TIU/mg, 194.10 mg/kg and 18.40 mg/kg, respectively, in the toasted seed meal.

Table 2. The chemical composition and anti-nutrient composition of raw and toasted pigeon pea seed meals.

Parameter (%)	Raw	Toasted
Chemical composition		
Dry matter	92.77	93.11
Crude protein	21.70	25.26
Ether extract	32.74	35.07
Crude fibre	5.07	4.40
Ash	4.00	3.10
Nitrogen free extract	29.26	25.28
Metabolizable energy (kcal/kg)	4482.21	4663.60
Anti-nutrients		
Phytic acid (mg/kg)	20.02	19.00
Trypsin inhibitor (TIU/mg)	65.70	38.25
Oxalate (mg/kg)	105.62	194.10
Tannin (mg/kg)	28.50	18.40

The growth response of finisher broilers offered graded levels of toasted pigeon pea seed meal is presented in Table 3. The final weight, total weight gain, average weight gain and FCR were significantly influenced ($P<0.05$), while average feed intake, mortality and flock uniformity ($P>0.05$) were not influenced by pigeon pea meal supplementation. A linear decrease in final weight and weight gains was observed as the toasted seed meal increased from diets I to V. Although birds fed diets I to IV were not different ($P>0.05$) from one another, they were different ($P<0.05$) from those feed diet V. However, a quadratic response ($P<0.05$) was observed for feed conversion ratio with chickens offered diet 2 having the least value (3.08) comparable to those fed diet I (3.28) and IV (3.39) while birds on diet IV had the highest value (4.17).

Table 3. The growth response and flock uniformity of finisher broiler chickens offered toasted pigeon pea seed meal.

Parameter	I	II	III	IV	V	SEM	P-value
IW g/b	426.77	435.00	435.00	436.77	425.00	2.37	0.430
FW g/b	1255.00^{a}	1283.33^{a}	1231.67^{a}	1205.00^{a}	1056.67^{b}	24.19	0.003
TWG g/b	828.33^{a}	843.33^{a}	796.67^{a}	768.33^{a}	631.67^{b}	23.27	0.003
ADWG g/b/d	29.58^{a}	30.30^{a}	28.45^{a}	27.44^{a}	22.56^{b}	0.83	0.003
ADFI g/b/d	97.02	93.38	99.82	92.85	94.10	1.48	0.600
FCR	3.28^{bc}	3.08^{c}	3.53^{b}	3.39^{bc}	4.17^{a}	0.11	0.001
Mortality %	3.33	10.00	3.33	10.00	0.00	1.92	0.398
FU %	82.62	89.32	88.80	87.06	85.72	1.06	0.320

abc = means with different superscripts in rows are significantly ($P<0.05$) different. IW = Initial weight; FW = Final weight; TWG = Total weight gain; AWG = Average weight gain; AFI = Average feed intake; FCR = Feed conversion ratio; FU = Flock uniformity.

Table 4 shows the carcass characteristics, organ weight, and abdominal fat weights of finisher broiler chickens fed toasted *C. cajanus* seed meal. The eviscerated weight, breast yield, thigh yield, kidney and abdominal fat were influenced (P<0.05) by the feeds, unlike the live weight, back, drumstick, liver, pancreas, proventriculus, heart, lungs, and empty gizzard (P>0.05). The eviscerated weight ranged from 75.98% to 80.75% in birds fed diets V to II, respectively. This trend is also noticeable in breast weight. The breast weight of birds fed diets I–IV were comparable (P>0.05), while those fed diet V had the least breast weight. The kidney of animals offered pigeon pea diets had higher weight compared to those fed diet I (P<0.05). Observation on the abdominal fat is quadratic (P<0.05): birds given diet II (2.06%) had a higher value, those offered diet III (1.58%) had the least while those fed other diets were comparable (P>0.05).

Table 4. Carcass characteristics, organ weight and abdominal fat of finisher broiler chickens fed toasted pigeon pea seed meal.

Parameter (%)	I	II	III	IV	V	SEM	P-value
Live weight (kg)	1.73	1.85	1.77	1.80	1.60	0.39	0.30
Eviscerated weight	79.62^{a}	80.57^{a}	79.53^{a}	77.28^{ab}	75.98^{b}	0.59	0.04
Back yield	12.73	12.35	12.84	13.13	13.52	0.24	0.67
Breast yield	19.98^{a}	20.05^{a}	18.87^{ab}	17.91^{ab}	16.53^{b}	0.47	0.05
Thigh yield	11.45^{b}	13.02^{a}	13.14^{a}	12.82^{ab}	11.81^{ab}	0.24	0.04
Drumstick yield	9.77	10.46	10.41	10.06	10.21	0.31	0.47
Liver	2.15	2.20	2.22	2.63	2.74	0.11	0.34
Kidney	0.14^{b}	0.44^{a}	0.43^{a}	0.37^{a}	0.34^{a}	0.04	0.01
Pancreas	0.31	0.23	0.20	0.20	0.15	0.02	0.16
Proventriculus	0.49	0.38	0.36	0.49	0.40	0.03	0.41
Heart	0.42	0.47	0.42	0.41	0.42	0.01	0.81
Lungs	0.43	0.45	0.48	0.43	0.44	0.03	0.98
Empty gizzard	1.82	1.63	1.72	1.96	1.95	0.98	0.42
Abdominal fat	1.98^{ab}	2.06^{a}	1.58^{b}	1.78^{ab}	1.72^{ab}	0.07	0.03

a,b,c means with different superscripts in rows and columns are significantly (P>0.05) different.

The histological observation of the liver

Histological studies revealed some structural changes in the liver sections examined from the chickens fed pigeon pea seed meal. There were no hepato-histological alterations observed in the liver of the birds fed diet I. The arrangement of hepatocytes was normal (normal sinusoids NS, portal vein NPV and hepatocytes NH) and neat (Plate 1). The liver of birds fed diet II showed mild sinusoidal congestion (mSC) with mild diffuse necrosis (mN) of the hepatocytes (Plate 2). Moderate portal sinusoidal congestion (MSC), mild hepatic erosion (mHE) and mild necrosis (mN) of the hepatocytes were noticed in birds offered diet III (Plate 3).

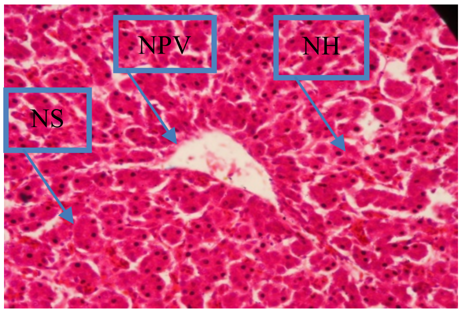

Plate 1. The micrograph of the liver of birds fed diet I (x40).

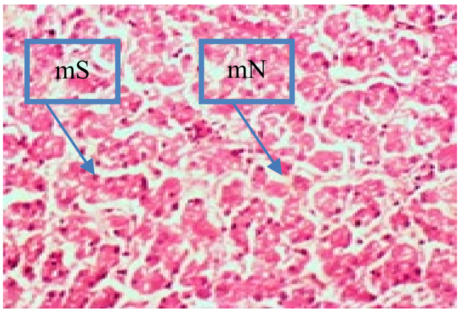

Plate 2. The micrograph showing the liver structure of birds fed diet II.

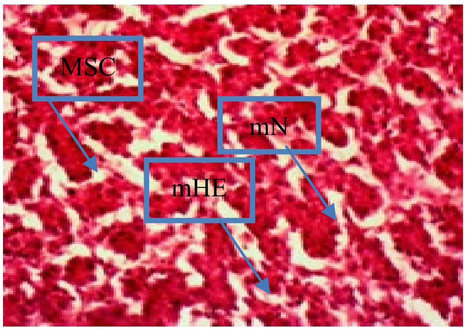

Plate 3. The micrograph showing the liver structure of birds fed diet III.

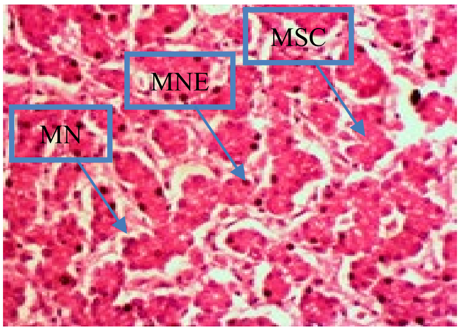

Plate 4. The micrograph showing the liver structure of birds fed diet IV.

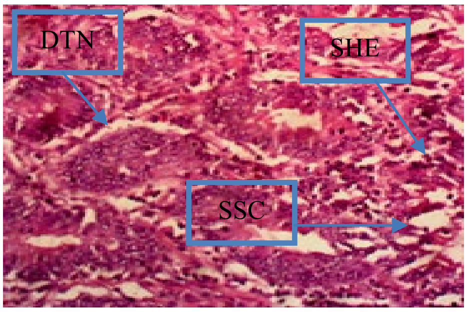

Plate 5. The micrograph showing the liver structure of birds fed diet V.

The histological changes in birds offered diet IV included moderate sinusoidal congestion (MSC), hepatic erosion (MHE) and necrosis (MN) (Plate 4). The group fed diet V (Plate 5) showed diffuse tubular necrosis (DTN) or tissue autolysis or severe degeneration and destruction of hepatocyte architecture with severe sinusoidal congestion (SSC) and hepatic erosion (SHE).

The crude protein observed in this study fell within the range reported by Amaefule and Nwagbara (2004), and Esonu (2006), while the other proximate contents and metabolizable energy fell short. Ahmed et al. (2006) and Abioye et al. (2018) have reported that *Cajanus cajan* seed meal contains 21–28% CP, 4.57%–10% CF, 61.2–66.70% NFE, 1.7%–3.89% EE, 2.57–4.2% ash. Abioye et al. (2018) observed an improved CP, ash and NFE while the CF and EE reduced post-fermentation. However, Solomon et al. (2017) observed that toasted pigeon pea seed meal had higher crude protein and fibre content than the raw meal, which agrees with the report of this study. However, the author reported a non-significant EE as a result of toasting.

Processing of pigeon pea seed meal was reported to improve the growth performance of broiler chickens, unlike the unprocessed one. However, the processing method employed determined the level of residual anti-nutrients in the seed meal and subsequently the performance of the birds with higher effects in starter broilers than in finishers (Ani and Okeke, 2011; Igene et al., 2012). Oso et al. (2012) had earlier observed depressed performance in broilers fed pigeon pea seed meal, which corroborates the findings of this study at 50% replacement for soybean meal. The feed intake in this study was not influenced, similarly to the report of Tangtaweewipat and Elliot (1989), suggesting that palatability problems were not induced. However, the feed conversion ratio was degraded beyond 37.50% replacement for full-fat soybean in this study translating to 10.13% inclusion. Nevertheless, toasted pigeon pea was reported to support performance up to 27% in finisher broilers (Ani and Okeke, 2011). Amaefule et al. (2011) and Babiker et al. (2006) have observed that methionine addition to pigeon pea diet improves performance, indicating that amino acid balance could play an important role in a pigeon pea diet apart from the anti-nutrients.

Carcass output is a crucial factor in the poultry subsector. Carcass quality could affect consumer perception because of health advantages in low cholesterol-lean meat (Attia et al., 2001) which Iyayi et al. (2014) reported to be affected by feed crude protein content. Although, Furlan et al. (2004) had earlier concluded that nutritional composition, especially the class of amino acids, the monomeric unit of protein in the feed, was interconnected with the building of structural tissues. Arif et al. (2017) observed that feeding a 20% potash-boiled pigeon pea seed meal diet favoured carcass and breast weight, which is not similar to this study in which breast yield peaked at 12.50% compared to those fed 37.50%. Ojediran et al. (2016a) demonstrated that thigh weight was influenced by the lysine portion of the feed. According to Barbosa Filho et al. (2017), there is a mathematical connection in carcass yield: low breast yield translates to a higher yield of other parts like shank, back and wings. This is similar to the report of Rance et al. (2002).

The kidney weight observed in this study was higher in birds fed toasted pigeon pea seed meal than those fed the control diet, which may be attributed to the test ingredients used. Holanda et al. (2009) had earlier confirmed that the rate of fat deposition rose by the terminal point of the rearing phase when broiler chickens were butchered at 42 days old. As a crucial organ in the body, the liver has an important role in detoxification. Birds fed the pigeon pea seed meal had varying levels of hepatic degeneration, which increased in intensity as the level of inclusion increased. It ranged from mild sinusoidal congestion and cellular infiltration to necrosis of the cell in the liver. Ojediran et al. (2016b) observed that broiler chicken fed *Jatropha curcas* kernel meal damaged liver due to residual anti-nutrients. The report of Emiola et al. (2007) on broilers fed raw and dehulled kidney bean meals indicated extensive coagulative necrosis, congestion of sinusoids and extensive degeneration of hepatocyte, whereas it was less marked in the liver of birds placed on a toasted-kidney bean-based diet. The findings of Safameher (2008) also showed changes in the liver and kidney of cockerel chicks fed raw full-fat neem seed. However, within this study, the hypertrophy of the liver was not observed, thus the liver was managing the situation which may result in a total breakdown in the long run. This does not agree with the findings of Akande et al. (2012) when broiler chickens were fed *Ricinus communis* because the liver was not enlarged in that study. Despite some level of detoxification attained with toasting, slight changes in hepatic structure are indicative of toxicity of residual anti-nutritional factors.

Conclusion

This study showed that toasted *C. cajan* seed meal had a satisfactory protein content with reduced anti-nutrients. Up to 37.50% toasted pigeon pea seed meal replacement for soybean meal supported optimum growth, breast and thigh yield, and mild to moderate hepatic disruptions.

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ODGOVOR PRIRASTA, UJEDNAČENOST JATA, MASA ORGANA, ABDOMINALNA MAST, KVALITET TRUPA I HISTOLOGIJA JETRE BROJLERSKIH PILIĆA HRANJENIH TOSTIRANIM KAJANOM (GOLUBIJI GRAŠAK) U ZAVRŠNOJ FAZI TOVA

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R e z i m e

Tri stotine (300) brojlerskih pilića (Arbor-acre) starih dvadeset i jedan dan raspoređenih u pet (5) hranidbenih grupa sa po šezdeset (60) jedinki, u šest (6) ponavljanja hranjene su različitim nivoima termički tretirane sačme kajana (TSK) kako bi se ocenio učinak, ujednačenost jata, masa organa, kvalitet trupa i histologija jetre u završnoj fazi tova. Smeša na bazi kukuruza i punomasnog sojinog griza poslužila je kao kontrolna smeša (I). TSK je supstituisala punomasni sojin griz u koncentracijama od 12,5%, 25,0%, 37,5% i 50,0% za smeše u II, III, IV odnosno V grupi. Tostiranje je imalo pozitivan efekat na proteine, BEM, sadržaj vlakana, metaboličku energiju i smanjenje antinutritivnih, materija osim oksalata. Završna masa, promena ukupne težine, prosečni prirast, masa, konverzija hrane, masa trupa, masa grudi i masa bataka imale su značajne razlike ($P<0,05$), posebno značajno manje pri 50% supstitucije u eksperimentalnim smešama, za razliku od prosečne konzumacije hrane, mortaliteta i ujednačenosti jata ($P>0,05$). Bilo je značajnog uticaja ($P<0,05$) i na bubrežnu i abdominalnu mast. Postojali su različiti nivoi degeneracije jetre, čiji se intenzitet povećavao kako se nivo uključivanja TSK povećavao. Kretali su se od blage sinusoidne kongestije i ćelijske infiltracije do nerkoze ćelija u jetri. Dodavanje TSK do 37,5% umesto punomasnog sojinog griza, omogućava optimalan porast, masu grudi i bataka, kao i blage do umerene poremećaje u radu jetre.

Ključne reči: brojler, *Cajanus cajan*, odgovor prirast, masa organa, masa trupa.

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