



Growth Performance and Carcass Characteristics of Broiler Chickens fed Supplemental Palm Kernel Shell Ash

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Abstract

The objective of the study, was to determine the growth performance and carcass/organ weight responses of broilers to palm kernel shell ash (PKSA) mineral. Collected palm kernel shells were pyrolyzed and the ash yield evaluated for its mineral contents. Two hundred and Forty (240) Abor Acre chicks were randomly assigned to four groups (T1-T4) of 60 birds each and triplicates of 20 birds per replicate in a completely randomized design (CRD) experiment that lasted for 28 and 56 days, respectively. Four experimental broiler diets containing graded levels of PKSA at 0, 0.50, 1.00 and 1.50% to replace equal weights of bone ash were respectively formulated with T1 representing the control. Performance characteristics were determined at 28 and 56 days. At the 56th day, carcass, and organ weights were evaluated. The order of mineral elements in PKSA was Ca>K> P> Na>Mg> Fe> Mn> Zn> Cu>Co. The PKSA supplemented birds recorded similar final weight, feed intake and feed conversion ratio values ($p>0.05$) with the control. At 56 days, however, the control birds had superior ($p<0.05$) growth performance over PKSA treated birds. The T3 group nevertheless had comparable results with the control ($p>0.05$), while no significant differences ($p>0.05$) in FCR across the treatments. The T3 diet provoked good carcass values, with significantly higher ($p<0.05$) dressed weight, breast, thigh and drumstick percentage values than T4, but similar to the control values. Therefore, PKSA inclusion in broiler diets is recommended at 1.00% (T3) level due to better growth performance, and carcass/organ characteristics.

Keywords: Palm kernel shell, Plant ash, Mineral, Broiler performance

Introduction

Minerals are dietary essential to all classes of livestock and therefore perform structural, physiological, catalytical and reproductive functions in animals (Suttle, 2010). They are inorganic substances, present in all body tissues and fluids and therefore play vital roles in various metabolic, enzymatic and biochemical reactions ultimately leading to better growth and skeletal development, egg production and feed efficiency (Esonu, 2015; Raje *et al.*, 2018). Poultry derives its mineral requirements from its diets, often supplemented with inorganic mineral mixes (Nollet *et al.*, 2008). It has been a common practice to routinely over-formulate poultry diets with these mineral salts to ensure that adequate levels are fed and requirements are met. This practice has raised concerns regarding high feed cost and mineral excretions in manure with the attendant

environmental pollution (Elwinger *et al.*, 2016; Gautier *et al.*, 2017; Hejna *et al.*, 2018).

The most reasonable solution to excessive mineral excretion is to make them more biologically available so that lower doses can be applied in the feed (Ao and Pierce, 2013; Wang *et al.*, 2019). This has been achieved by using commercially developed organic trace mineral/chelated products which are readily available in the market. These are however expensive and may not be easily accessed by small holder farmers in low-income countries like Nigeria. Bone ash, and commercially available calcium phosphate minerals have been traditionally used as conventional sources of Calcium (Ca) and phosphorus (P) in poultry nutrition. Again, they are becoming scarce and expensive due to importation cost, or further

diversion of these materials towards the industrial production of glasses/porcelain wares (Heimann, 2014; Gouvêa *et al.*, 2015), bio-ceramics (Mansour *et al.*, 2016; Eliaz and Metoki, 2017; Malla *et al.*, 2020), gelatine (Aycan and Alemdar, 2018; Al-Hassan *et al.*, 2021), or fertilizers (Möller, 2015; Hidayat, 2020) etc.

Plant ash has been shown to be a rich source of macro (Ca, K, P, Na) and trace mineral elements (Fe, Cu, Zn), for improved mineral nutrition in livestock (Ndlovu, 2007; Saccomani *et al.*, 2016). Reports have highlighted its potentials to improve the nutritional value of animal feeds and increases fibre digestibility by ruminants (Ramirez *et al.*, 1992; Kyarisima *et al.*, 2004).

Ash derived from plantain biomass has been shown to enhance dietary mineral elements absorption and edible carcass development in pullets (Nwogu, 2013; Okoli *et al.*, 2014). However, at high supplementation levels, it lowers feed intake, laying performance and shell quality (Nwogu, 2013). Oso *et al.* (2011) also reported occurrence of lameness and poor gaits in broilers fed diets containing plant ash as calcium source and therefore discouraged its inclusion in broiler diets due to low Ca availability. The actual method of pyrolysis and ash source known to influence ash quality (Nwogu *et al.*, 2012; Ebere, 2013; Iwu, 2013) was however not reported by these authors. More recent reports have shown improved edible carcass and reproductive organ development in pullets and rabbits fed plant ash (Iwu *et al.*, 2013; Okoli *et al.*, 2014), indicating that plant ash may have some promise in broiler production. There is the need to evaluate the benefits of different ash sources in broiler production.

Reports have shown that palm kernel shell is useful not only in terms of its combustive or biofuel value but also its content of minerals. Akpakpan *et al.* (2012), investigated the level of metals contained in kernels and shells and reported that it contains different

levels of magnesium, calcium, copper, zinc, potassium, iron, and lead among other trace minerals. Levels of calcium, potassium and magnesium were high compared to other mineral elements, while the lead concentration in kernel shell is insignificant in relation to the other elements and may not pose any toxic problem to plants and animals. Since the roles of these minerals in animal physiology, metabolism and regulation of body functions are well documented (Suttle, 2010), palm kernel shell ash may serve as a good mineral source for broiler production.

The objective of this study is to determine the growth performance and carcass/organ weight responses of broilers to supplemental palm kernel shell ash.

Materials and Methods

Collection and preparation of palm kernel shells: Palm kernel shells (PKS) were collected from a local oil mill located at Umuokile, Enyigugu in Aboh Mbaise Local Government Area, Imo State. Thereafter, the PKS was processed and pyrolyzed at 500°C as described by (Nwogu, 2013).

PKSA mineral analysis: The PKSA was analyzed for its mineral concentrations after acid digestion, using the Atomic Absorption Spectrophotometer (Bulk Scientific, 205), according to the methods of AOAC (2010). Minerals such as Calcium (Ca), Magnesium (Mg), potassium (K), Phosphorus (P), sodium (Na), Manganese (Mn), Zinc (Zn), Copper (Cu), and Iron (Fe) were measured using the Atomic Absorption Spectrophotometer (AAS).

Experimental diets: The feed ingredients used in diet formulation were purchased from a reliable source in Owerri, Imo State. For the broiler starter and finisher phases, four experimental diets each were formulated such that the control diets had no PKSA supplementation, whereas the other three diets at each phase had graded levels of PKSA included in the diets at 0.5, 1.0 and 1.5% in replacement of bone ash as shown in

Tables 1 and 2 representing diets T1 to T4, respectively. All other ingredients were of equal proportions across the test diets. The diets were analyzed for their proximate and mineral concentrations according to the methods of AOAC (1995).

Experimental design and management:

Two hundred and forty (240) Abor Acre day-old chicks were purchased from a reputable local hatchery. The birds were divided into four groups of 60 birds per group and in triplicate of 20 birds per replicate assigned in a completely randomized design (CRD). The birds were brooded under proper feeding, medication and vaccination management as practiced at the Teaching and Research Farm of the Federal University of Technology Owerri. During the various stages of the experiment, each group of birds was assigned to the treatment diets (T1 to T4). The birds were given feed and water *ad libitum* throughout the entire experimental period of eight weeks

comprising four weeks each of starter and finisher diets feeding.

Growth performance determination: The initial live weights of the birds were recorded at the beginning of the experiment and subsequent weighing was also done weekly on individual basis in the morning hours (7.00 – 9.00 am) till the end of the experiment. Weekly weight gain was obtained by subtracting the initial live weight from the current weekly live weight. Feed intake was determined on daily basis by subtracting the weight of the leftover feed from the weight of the feed initially offered. These were subsequently equated to weekly values. Feed conversion ratio (FCR) was determined by dividing the total feed intake by final weight gain (Esonu, 2015). The growth efficiency ratio (GER) was derived as a ratio of the percentage increase in initial weight of the birds within a specific period of time to the total feed intake of the birds over the same period of time.

$$\text{GER} = \frac{\text{Percentage increase in body weight of birds over a period}}{\text{Total feed intake over the same period}}$$

These values were determined for the starter and finisher phases of development at the 28th, and 56th day of experiment.

Carcass and organ weights characteristics determination

At the end of the finisher phase of the experiment (56 days), a bird from each replicate of the groups was randomly selected, weighed and slaughtered after fasting them over-night and used for the determination of carcass and organ weight characteristics. The slaughtered birds were allowed to bleed cleanly before processing. The cuts that were determined included breast muscle, thigh, drumstick, wing, back formation, and shank. The weights of each of these were expressed as percentages of live weight of the bird. Organs such as the proventriculus, gizzard, liver, and intestines were weighed and expressed as percentages of the live weight of the birds. The intestinal lengths were also determined in centimeters.

Statistical analysis

Data collected were subjected to Analysis of Variance and differences between the treatment means were compared using the Duncan’s Multiple Range Test using Statistical Package for Social Sciences (SPSS, 2017).

Results and Discussion

Mineral composition of palm kernel shell ash:

The mineral concentrations of PKSA is summarized in Table 3. The major minerals were calcium (26,269.11 mg/kg), potassium (2490.68 mg/kg), phosphorus (657.62 mg/kg), sodium (360.00 mg/kg) and Magnesium (181.00 mg/kg), with cobalt recording the lowest concentration of 1.23 mg/kg. Thus, the order of mineral elements in PKSA is Ca > K > P > Na > Mg > Fe > Mn >

Zn > Cu > Co. The result is in agreement with the reports of Ndlovu (2007) and van Ryssen and Ndlovu (2018) that Ca, K, Mg, Si, and P are the major mineral components in plant ash. A near similar trend was also reported by Blake and Hess (2014) in poultry litter ash (PLA) except that PLA had more P than K.

PKSA had more Ca and K concentrations than P and other minerals. Similar reports on wood ash also recorded more Ca and K than any other metal assayed (Ramirez *et al.*, 1992; Imbeah, 1998; Ndlovu, 2007). Akpakpan *et al.* (2012) also recorded higher values of K in PKSA and CSA (118.70 and 348.40 mg/kg, respectively) even more than Ca and P. The high concentration levels of K indicate the possibility of these plants to be natural accumulators of potassium in their shells. The Ca concentration in PKSA can provide the Ca mineral requirements for broilers but had much lower P concentrations than PLA or wood ash.

Bone meal also contains high levels of Ca and P. On dry matter basis, bone meal and oyster shell contain more calcium than wood ash while bone meal and wood ash contain more phosphorus than oyster shell (Imbeah, 1998; NRC, 2001). Wood ash however contains much higher levels of zinc and copper than bone meal. The magnesium and potassium contents of wood ash were also much higher than those of bone meal, which were less than 6.4 and 1.9 g/kg respectively. Thus, bone meal has superior Ca, P, Na and Zn concentrations to PKSA, while the latter has superior magnesium and potassium concentrations.

A calcium/phosphorus ratio of 39.95 and sodium/potassium ratio of 0.14 was calculated for PKSA. This agrees with the reports of Van Ryssen (2018) who reported that high Ca to P ratio is common with wood ash containing products and could result in phosphorus deficiency in livestock. However, the Na/K ratio obtained in this study is much lower than the range of 2.09 –

3.85 reported for coconut shell ash by Iwu *et al.* (2013).

Growth performance characteristics

The performance data of chicks subjected to 28 days feeding with the experimental diets are presented in Table 4a. The initial live weights of the experimental chicks were similar ($p > 0.05$) among the groups. However, at the end of the 28-days starter period, T2 (0.5% PKSA) and T3 (1.00% PKSA) birds had averaged similar final body weight, weight gain, average daily weight gain and average daily feed intake similar to the control. The reduction in growth parameter values beyond T3 may have been due to the reduced feed intake observed in birds on the T4 (1.50% PKSA) diet. The results are in agreement with the findings of Nwogu, (2013), Ebere, (2013) and Iwu, (2013), who also reported reduced feed intakes, final weights and weight gains at higher supplementation levels of coconut shell ash, plantain stalk ash and plantain root base ash in the diets of rabbits and pullets, respectively. A non-significant reduction in feed intake was also recorded by Blake and Hess (2014) when PLA replaced di calcium phosphate at higher inclusion levels, but did not negatively affect growth performance in broilers.

Even though T4 (1.50% PKSA) birds recorded significantly inferior growth performance values as earlier reported, its GER value was similar to that of the control birds. This means that the T4 birds have used 1 gram of feed to achieve 1.39% increase in their initial bodyweight per day over the 28 days feeding period, against the 1.34% achieved by the control birds.

At the end of 56 days of finisher feeding (Table 4b), all the PKSA treated birds recorded statistically similar final weight values, which were significantly lower than T1 (control) value. Weight gains generally followed the same trend, although T3 (1.00% PKSA) value was similar to the control value. Again, birds fed the control diet consumed significantly ($p < 0.05$) more

feed than the PKSA-treated birds indicating that the feed intake pattern actually drives the final weight results obtained in this study. This may be as a result of some imbalance in the mineral ratios and dietary electrolyte content of the PKSA-treated diets particularly at the highest inclusion in the T4 diet (Unamba-Opara *et al.*, 2017). According to Mongin (1981) there is a critical effect of changes in the acid – base balance and imbalances in Na^+ K^+ - Cl^- of a diet on appetite, with reduction in weight gain, affecting FCR and mortality rate if not corrected. This phenomenon called the dietary electrolyte balance (dEB) is determined by the monovalent chemical elements (Na, K^+ , and Cl^-), which are considered strong ions because of their effect on the acid-base balance of body fluids (Hooge, 2003). The dEB has a crucial role in broiler performance, and it is important for proper bone development and litter quality (Olivieri *et al.*, 2010). Though, we did not calculate dEB of the experimental diets, it is probable that the increasing addition of PKSA to the diets altered the dEB and mineral ratios (Ca/P and Na/K ratios) of the diets leading to poor appetite, especially in the T4 birds (Borges *et al.*, 2003). The chemical form of minerals in plant ash are found in their carbonate, bicarbonate, oxide and hydroxide states which influences the alkalinity of plant ash (Naylor and Schmidt, 1986; Etiegni and Campbell, 1991). It is again possible that the reduced feed intake associated with plant ash inclusion in the diets of livestock is due to the unpalatability of the bicarbonate, hydroxide and sulphate forms of the ash minerals.

There was no PKSA treatment effect on the FCR of the birds, indicating that the PKSA inclusion in the diets of broilers at the various levels studied caused the treated birds to convert similar amounts of flesh as the control birds, while consuming significantly less quantity of feeds. Again, GER at this period was 0.58, 0.69, 0.71 and 0.66 for T1 through T4 respectively.

Carcass characteristics of broilers fed diets containing PKSA

Carcass characteristics of the birds fed PKSA are shown in Table 5. Live and carcass weights of birds decreased with increasing inclusion of PKSA, with the control birds recording significantly higher live and carcass weights than T3 and T4 birds ($p < 0.05$) but similar value with T2.

The birds on the test diets however manifested remarkable dressed weights, with only T4 having significantly lower value than the control ($p < 0.05$). This indicates that all diets supported proportional flesh accretion. The dressed weight of chicken is usually not directly proportional to the weight gain or performance traits since a high weight gain value may not imply an increase in dressed weight value. It may also mean that the test diets did not support undue feathering of the experimental birds (Fasuyi and Aletor, 2005). Majewska *et al.* (2011) reported a dressed carcass percentage range of 76.09 – 76.36 in broilers fed diets supplemented with 0.30% charcoal for 42 days. Blake and Hess (2014) reported dressed carcass percentage range of 71.92 – 76.00% when graded levels of PLA replaced equal weights of di calcium phosphate in broilers. The present range of 72.38 – 75.75% dressed show that PKSA inclusion had positive effect on dressed weight of broilers.

Other carcass traits such as the thigh, drumstick, breast muscle, wings etc were similarly supported by the test diets as they recorded good weight percentages of the carcass part relative to the control. Generally, the inclusion of PKSA at 1.00% level (T3) recorded the most superior edible cuts, while 1.50% PKSA inclusion in the diet (T4) recorded the least percentage edible cuts. This finding shows again that growth performance results need to be related to carcass yield in order to appropriately determine the overall effects of a feed supplement or ingredient on poultry productivity (Nwogu *et al.* (2014). The results of this study also compare favourably

with that of Abor Acre specification manual for carcass evaluation (Aviagen, 2019). Again, no skeletal deformity or lameness was physically observed in all the experimental groups suggesting that PKSA did not negatively affect the carcass trait of birds.

Organ weight characteristics of broilers fed diets containing PKSA

The organ weight characteristics of broilers fed diets containing PKSA are shown in Table 6. Generally, feeding of PKSA resulted in increased percentage weights of proventriculus, gizzard, intestine and heart. Specifically, it resulted in significant ($p < 0.05$) increase in the proventriculus, gizzard and intestinal weights beyond that of the control. Liver weight and abdominal fat contents of the treated birds were also significantly ($p < 0.05$) lower than those of the control birds, while the intestines of the PKSA treated birds were equally longer than the control.

High proportion of gizzard weight in the body of birds have been associated with better muscle development, capable of improving nutrient absorption in broilers (Kokoszynski *et al.*, 2017). Nwogu *et al.* (2014) also reported increased spleen and gizzard weights in layers fed plantain ash and attributed these to increased grittiness of the experimental diets as a result of the ash supplementation. These workers also reported decreases in liver weights of ash supplemented birds which suggests that the dietary feeding of PKSA to broilers did not cause any hepatic toxicity or excess liver weight syndrome. It would seem from the results of this study that ash causes increases in the weights of secretory organs such as the proventriculus, gizzard and intestines. Longer intestines are often associated with efficient feed digestion, and provision of larger surface area for nutrient absorption (Mabelebele *et al.*, 2014). The report by Iwu *et al.* (2013) also showed that the feeding of coconut shell ash to growing rabbits resulted in agonist effects on reproductive organs development and sex hormones released in

both male and female rabbits. The abdominal fat results obtained in this study are of economic value, since lower abdominal fat is desirable in modern broiler production.

Conclusion

This study showed that palm kernel shell ash contained Ca, K, P, and Na as its major macro mineral elements while Fe, Mn and Zn were the major micro minerals. All the growth performance characteristics evaluated were similar up to T3 (1.00% PKSA) beyond which a decline was recorded. Although the partial replacement of bone ash with PKSA in the experimental diets resulted in reduced feed intake in the finisher broilers, it did not adversely affect their feed conversion ratio, with birds fed diets containing 1.00% PKSA yielding similar dressed, breast, thigh and drumstick percentage weight values as the control birds. PKSA inclusion also had a positive effect on secretory organs such as the proventriculus, gizzard, intestines, liver weight and abdominal fat contents which were better in treated birds than in the control. Therefore, PKSA can successfully replace a portion of bone ash (1.00%) in broiler starter and finisher diets without any adverse effect on performance and carcass characteristics.

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Table 1: Nutrient composition of the PKSA based diet for broiler chicks

Ingredients g/100g	T1	T2	T3	T4
	Control	0.50% PKSA	1.00% PKSA	1.50% PKSA
Maize	52.00	52.00	52.00	52.00
Soya bean meal	12.00	12.00	12.00	12.00
Groundnut cake	20.00	20.00	20.00	20.00
Palm kernel cake	2.95	2.95	2.95	2.95
Fishmeal	4.00	4.00	4.00	4.00
Wheat offal	4.00	4.00	4.00	4.00
Bone meal	4.00	3.50	3.00	2.50
Salt	0.30	0.30	0.30	0.30
Vitamin/ trace mineral premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
PKSA	0.00	0.50	1.00	1.50
Total	100.00	100.00	100.00	100.00
Calculated ingredients composition of diets				
Crude protein	23.25	23.25	23.25	23.25
Crude fibre	4.05	4.05	4.05	4.05
Calcium	1.65	1.47	1.29	1.11
Phosphorus	1.07	0.98	0.90	0.82
Metabolizable energy (ME kcal/kg)	2925.29	2925.29	2925.29	2925.29

2.5 kg premix Vitamin premix contains: Vit A = 10,000 000 I.U, Vit D3 = 2,000,000 IU, Vit E = 23,000 mg, Vit K₃ = 2000 mg, Thiamine (B₁) = 3000 mg, Vit. B₂ 6000 mg, Niacin = 50,000 mg, Calcium Pantothenate = 10,000 mg, Vit. B₆ 4000 mg, Vit B₁₂ = 25 mg, folic acid = 1000 mg, Biotin = 50 mg, Choline Chloride = 400,000 mg, Manganese = 120,000 mg, Iron = 100,000 mg, Zinc 80,000 mg, Copper = 8500 mg, Iodine = 1500 mg, Cobalt = 300 mg, Selenium = 120 mg, Antioxidant 120 mg.

Table 2: Nutrient composition of the PKSA based diet for finisher broilers

Ingredients	T1	T2	T3	T4
	Control	0.50% PKSA	1.00% PKSA	1.50% PKSA
Maize	56.00	56.00	56.00	56.00
Soya bean meal	10.00	10.00	10.00	10.00
Groundnut cake	15.00	15.00	15.00	15.00
Palm kernel cake	6.95	6.95	6.95	6.95
Fishmeal	3.00	3.00	3.00	3.00
Bone meal	4.00	3.50	3.00	2.50
Wheat offal	4.00	4.00	4.00	4.00
Salt	0.30	0.30	0.30	0.30
Vitamin/ trace mineral premix	0.25	0.25	0.25	0.25
Lysine	0.25	0.25	0.25	0.25
Methionine	0.25	0.25	0.25	0.25
PKSA	0.00	0.50	1.00	1.50
Total	100.00	100.00	100.00	100.00
Calculated ingredients composition of diets				
Crude protein	20.61	20.61	20.61	20.61
Crude fibre	4.20	4.20	4.20	4.20
Calcium	1.62	1.44	1.26	1.08
Phosphorus	1.07	0.99	0.90	0.82
Metabolizable energy (kcal/kg)	2952.12	2952.12	2952.12	2952.12

2.5 kg premix Vitamin premix contains: Vit A = 10,000 000 IU, Vit D3 = 2,000,000 IU, Vit E = 23,000 mg, Vit K₃ = 2000 mg, Thiamine (B₁) = 3000 mg, Vit. B₂ 6000 mg, Niacin = 50,000 mg, Calcium Pantothenate = 10,000 mg, Vit. B₆ 4000 mg, Vit B₁₂ = 25 mg, folic acid = 1000 mg, Biotin = 50 mg, Choline Chloride = 400,000 mg, Manganese = 120,000 mg, Iron = 100,000 mg, Zinc 80,000 mg, Copper = 8500 mg, Iodine = 1500 mg, Cobalt = 300 mg, Selenium = 120 mg, Antioxidant 120 mg.

Table 3: Mineral compositions of the PKSA

Sample Parameters	Results
Calcium (mg/kg)	26,269.11
Phosphorus (mg/kg)	657.62
Sodium (mg/kg)	360.00
Magnesium (mg/kg)	181.00
Potassium (mg/kg)	2490.68
Manganese (mg/kg)	18.23
Iron (mg/kg)	106.66
Zinc (mg/kg)	5.55
Copper (mg/kg)	1.83
Cobalt (mg/kg)	1.23
Ca/P ratio	39.95
Na/K ratio	0.14

Ca/P = calcium/phosphorus ratio

Na/K = sodium/potassium ratio

Table 4: Growth performance of broiler chicks fed starter diets supplemented with PKSA

(a) Starter phase					
Parameters	T1	T2	T3	T4	SEM
	Control	0.50% PKSA	1.00% PKSA	1.50% PKSA	
Initial weight(g)	40.50	38.63	38.53	39.90	0.59
Final weight (g)	848.79 ^a	834.31 ^a	793.03 ^a	693.12 ^b	20.60
Weight gain(g)	808.29 ^a	795.68 ^a	754.50 ^a	654.22 ^b	20.45
Avg. daily weight gain(g)	28.87 ^a	28.42 ^a	26.94 ^a	23.36 ^b	0.73
Feed intake (g/bird/day)	49.66 ^a	51.53 ^a	48.19 ^{ab}	44.66 ^b	0.93
Feed conversion ratio (FCR)	1.72	1.81	1.79	1.91	0.03
Growth efficiency ratio	1.34	1.50	1.53	1.39	
(b) Finisher phase					
Parameters	T1	T2	T3	T4	SEM
	Control	0.50% PKSA	1.00% PKSA	1.50% PKSA	
Initial weight (g)	848.79 ^a	834.31 ^a	793.03 ^a	693.12 ^b	20.60
Final weight(g)	2346.25 ^a	2146.74 ^b	2161.96 ^b	2025.93 ^b	40.35
Weight gain(g)	1497.46 ^a	1312.43 ^b	1368.93 ^{ab}	1332.81 ^b	29.41
Avg. daily weight gain (g)	53.48 ^a	46.88 ^b	48.89 ^{ab}	47.60 ^b	1.05
Feed intake (g/bird/day)	158.81 ^a	144.01 ^b	140.50 ^b	136.77 ^b	3.93
Feed conversion ratio	2.97	3.08	2.87	2.88	0.07
Growth efficiency ratio	0.58	0.69	0.71	0.66	

Means with different superscript on the same horizontal row are significantly different @ (p<0.05)

Table 5: Carcass characteristics of broilers fed PKSA supplement

Parameters	T1	T2	T3	T4	SEM
	Control	0.50% PKSA	1.00% PKSA	1.50% PKSA	
Live weight (g)	2466.67 ^a	2300.00 ^{ab}	2166.67 ^{bc}	1983.33 ^c	59.49
Carcass wt. (g)	2297.33 ^a	2165.67 ^{ab}	2059.67 ^{bc}	1823.00 ^c	57.35
Dressed (%)	74.73 ^a	74.34 ^a	75.75 ^a	72.38 ^b	1.83
Breast (%)	18.01 ^{ab}	16.78 ^b	18.96 ^a	17.18 ^b	1.47
Thigh (%)	12.06 ^{ab}	12.60 ^a	13.23 ^a	10.93 ^b	1.20
Drumstick (%)	9.95 ^{ab}	10.37 ^a	10.54 ^a	9.54 ^b	0.66
Back formation (%)	19.69	20.81	20.11	20.94	1.77
Wing (%)	7.08 ^b	8.42 ^a	8.53 ^a	8.13 ^a	0.18
Shank (%)	3.41	3.95	3.71	3.73	0.54

Means with different superscript on the same horizontal row are significantly different @ (p<0.05).

Table 6: Organ weight measurement of broilers fed PKSA supplement

Parameters	T1 Control	T2 0.50% PKSA	T3 1.00% PKSA	T4 1.50% PKSA	SEM
Proventriculus (%)	0.36 ^b	0.46 ^a	0.43 ^a	0.45 ^a	0.06
Gizzard (%)	1.77 ^c	1.73 ^{bc}	2.02 ^a	2.01 ^{ac}	0.24
Intestinal wt. (%)	2.00 ^c	2.13 ^{bc}	2.44 ^{ab}	2.69 ^a	0.33
Intestinal length (cm)	186.00 ^b	210.00 ^a	192.67 ^{ab}	199.33 ^{ab}	25.01
Liver (%)	2.54 ^a	2.00 ^b	2.13 ^b	1.85 ^b	0.39
Abdominal fat (%)	2.22 ^a	1.27 ^b	1.39 ^b	1.55 ^b	0.48

Means with different superscript on the same horizontal row are significantly different @ (p<0.05)