Effects of Graded Levels of Full Fat Palm Kernel Meal on Growth Performance and Carcass Characteristics in Broiler chicks.

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Abstract
This study was conducted to evaluate the effects of Full Fat Palm Kernel Meal (FFPKM) on growth performance and carcass characteristics of broiler chicks. A total of 120 one-day-old broiler chicks of the ANAC-2000 strain were assigned to 4 experimental groups in a completely randomised experimental design and fed graded levels (0%, 5%, 7% and 9%) of FFPKM as partial replacement for maize for seven weeks (42 days). The experimental groups, which were designated as Treatments A, B, C and D respectively were further replicated three times with 10 birds per replicate so that each group had a total of 30 birds. Treatment A, which contained 0% FFPKM or 100 % maize served as the control. Growth parameters (average final live weight and average daily weight gain), average daily feed intake and feed conversion ratio were determined. On day 56 of the experiment, three birds per treatment were randomly selected from each of the replicates, starved overnight and slaughtered to evaluate carcass characteristics. Internal organs such as the gizzard, spleen, thigh, shank, breast, wings, neck, jejunum, lung, drum stick, pancreas, heart, liver, duodenum and kidney were removed and grossly examined for any pathological changes. The results showed that there was a significant difference (P<0.05) in the average final live weight, average daily weight gain and average daily feed intake in the broiler chicks. In birds fed with diets containing FFPKM up to 9%, average daily live weight gain was significantly increased. By contrast, average daily feed intake was significantly decreased with increasing levels of FFPKM in the ration. Consequently, feed conversion ratio was markedly altered in birds receiving 9% FFPKM in the diets. Birds in the control group (0% FFPKM) and 5% FFPKM were less efficient in feed to gain, and significantly (P<0.05) different from treatments C (7% FFPKM) and D (9% FFPKM). There was significant difference (P<0.05) in organ weights (gizzard, spleen, thigh, shank, breast, wings, neck, jejunum, lung, drum stick, pancreas, heart, liver, duodenum and kidney) and some cut parts between the experimental and control groups. There was considerably high abdominal fat deposition in the dressed carcass of broilers fed FFPKM, which was prominent in the gizzards compared to the control group. These results suggest that Full Fat Palm Kernel Meal can replace maize up to 10% in broiler diets without any adverse effects on growth and carcass qualities, and could marginally reduce feed cost in broiler production.
Key words: Full Fat Palm Kernel Meal, Body weight gain, Feed intake, Carcass characteristics, Broilers, Organ weight, Gizzard.

Introduction

Despite her teeming human and abundant natural resources, the intake of protein of animal origin of an average Nigerian still remains below the normal intake of 35g/head/day as recommended by FAO/WHO (Okuneye, 2002). The protein intake of an average Nigerian has been within the region of 53.8g of which, only 6.0 – 8.4g/head/day is of animal origin (Egbunike, 1997). Broiler meat provides an essential means of animal protein production that can close the gap in the nutritional needs of Nigeria and several other developing countries. However, the increasing cost of conventional feedstuffs contributes considerably to the low level of animal protein intake in Nigeria (Tegbe *et al.*, 1995) as feed cost is presently very high, accounting for up to 60 – 70 % (Larry, 1993) or 75 – 85 % (Oruwari *et al.*, 1995) of the total cost of poultry production under Nigerian economic conditions compared to 50 – 70 % in developed countries (Thackie and Flenscher, 1995). It is therefore exigent to exploit practicable means of reducing feed cost with a view to produce cheaper products without adversely affecting profits.

Since energy sources alone constitutes 45 – 60 % of finished feeds for monogastric animals (Tewe and Egbunike, 1992) and birds eat to satisfy their energy requirements (Sibbald, 1982), they represent the most expensive component in Nigerian poultry feeds given the current high cost of grains. Conventional feed grains such as maize, groundnut and soyabeans, are basic staple for millions of humans throughout the developing world, particularly in the countries of sub-Saharan Africa. There is high competition for maize from the human food and the livestock feed sectors being a good source of energy, which raises its price and makes it difficult for the poorest and most vulnerable people to consume. This developmental problem is of particular concern in relation to intensive poultry production systems, in which the ration may comprise maize at up to 70 per cent. The competition between human and animals for maize over the year has placed additional cost constrain and scarcity on its continued used in poultry diets (George and Sese, 2012). Thus, the need to reduce feed cost has necessitated investigations of several novel nutritional materials that are cheaper, non-competitive and readily available for possible incorporation into animal (particularly poultry) feeds as replacements for the more expensive conventional sources (Siddhuraju et al., 2001; Olorede *et al.*, 2002) and promote their widespread adoption in developing countries.

The Oil palm (*Elaeis guineensis* Jacq.) is one of Nigeria's most important food crops, widely distributed in the tropical rain forest of Southern Nigeria. It is a versatile tree crop with almost all its parts being useful and of economic value. The nut of the oil palm is usually cracked to release the endosperm (kernel), which is a rich source of energy due to the oil it contains. Palm kernel cake, which is a by-product of palm kernel oil extraction, has the potential of supplying major quantity of energy in poultry diets (Palanival and Purushothaman, 2009) because of their low pricing and availability in Nigeria. Palm kernel cake generally contains 17 - 21% protein, 10 - 17% crude fibre; 4 - 5% ash and ether extract values of 0.7 - 0.9% depending on the efficiency of oil extraction from the kernel (Nwokolo et al., 1977; Onwudike, 1986). Although, the use of palm kernel cake in the feed industry is mainly limited to the ruminant sector because of its high fibre and low energy contents, its successful utilization in the diets of broilers, layers and local chicks have been documented severally in literature (Onwudike, 1986; Onifade and Babatunde, 1998; Abonyi and Uchendu, 2005; Ugwuene *et al*., 2005; Sundu *et al*., 2005; Akpodiete, 2007). However, the focus of the present study is on whole unextracted or Full Fat Palm Kernel meals (FFPKM).

Full Fat Palm Kernel meals, which contain about 46 - 54% DM of oil (fat) and therefore has a high gross energy content (28.9 MJ/kg DM), have been found to be a valuable alternative ingredient for increasing the metabolisable energy levels of broiler diets based on soybean meal or maize grain (Oruwari et al., 1996; Jackson and Zumbado 1996; Vargas and Zumbado 2003). The use of FFPKM in the diet of broilers may also offer some advantages on account of its fat content being a concentrated source of energy, and a means of increasing the energy content of diets (Pesti *et al*. 2002; Salma *et al*. 2007). Other benefits include decreased dustiness of feeds and lubricant for equipment in feed mills (Firman *et al*. 2008). The economic incentive arising from the favourable cost of Palm kernel in Nigeria relative to cereals and most other oilseed products, together with its ever increasing global production (Shahidi, 1990) as well as its considerable potential as a source of both protein and dietary energy source also tend to promote its increased use in animal feeding. There is no published information on the use of FFPKM in place of maize for broilers. The objective of this study was therefore, to determine the effect of feeding graded levels of Full Fat Palm Kernel meals as an alternative energy source on the growth performance and carcass characteristics of broiler chicks.

Materials and Methods

Location of experiment

This study was conducted at the Teaching and Research farm, of the Niger Delta University, Wilberforce Island, which is situated within the hot and humid tropical rain forest zone in Southern Nigeria.

Experimental diets

The palm kernel product obtained from the Bayelsa Palm Limited, Yenagoa, Nigeria, comprised Full-Fat Palm Kernel (FFPK), which were crushed with the hammer mill of the feed mill to pass through a 2.5 mm screen. Loss of oil during the process was small, and the Full-Fat Palm Kernel Meal was incorporated into a basal diet at the expense of maize at the rate of 5%, 7% and 9% in dietary treatments designated as B, C and D respectively. Treatment A, which served as the control diet contained 0% FFPKM or 100 % maize. The ingredients and nutrient composition of the experimental diets are presented in Table 1.

Experimental Birds and Management

The experimental diets were evaluated using one hundred and twenty (120) day old broiler chicks of the ANAK-2000 heavy strain, purchased from Zartech hatchery, a division of Zartech Farms, Ibadan, Nigeria. The birds were stabilized in the brooding room and fed *ad libitum* with 24 % crude protein commercial broiler starter ration for a one-week acclimatization period after arrival from the hatchery prior to the commencement of the experiment, and thereafter transferred to the rearing pens. The birds were randomly allocated to the four (4) dietary treatment groups so that each group had a total of 30 birds. Each group was further replicated three times with 10 birds per replicate in a Completely Randomized Design (CRD).

The chicks were brooded and reared in a open-sided well ventilated deep litter house constructed with solid dwarf walls and wire gauze erected from the top of walls up to the roof of the building to protect the birds from predators and allow free flow of air. The house was partitioned into 12 pens measuring 1 x 3 m each. All the pens were thoroughly washed and disinfected prior to the arrival of the birds. The floor of all the pens, which was concrete, was covered with wood shavings up to a thickness of about 4-5 cm. Chick feeders and chick drinkers were placed at central positions on the floor in each pen. Kerosene stoves and incandescent electric bulbs of 200 watts were also placed in each of the pen to provide supplemental heat for the young chicks. After 3 weeks, the stoves were removed while the electric bulbs were retained to supply light during the night hours. The birds were subjected to standard broiler chick management procedure, which included routine vaccinations against Newcastle and Gumboro disease administered to all the birds within the first three weeks.

Experimental procedure and data collection

The experiment diets and water were provided *ad libitum* throughout the seven weeks (49 days) duration of the feeding trial. The feed intake was determined by the difference between the feed supplied and the left over in the feeding trough after 24hrs. Initial body weights of the birds were taken on replicate basis at the start of study and thereafter at the end of each period of seven days; the birds were weighed individually to determine body weight gain. Feed conversion (feed to gain ratio) was subsequently derived. At the eighth week of the experiment, three birds were randomly selected from each of the replicates and starved overnight in order to empty their crops. The birds were slaughtered by severing the jugular vein, ex-sanguinated, scalded in warm water for about a minute, defeathered manually, eviscerated and dressed to determine carcass characteristics. The gizzard, spleen, thigh, shank, breast, wings, neck, jejunum, lung, drum stick, pancreas, heart, liver, duodenum and kidney were removed and grossly examined for any pathological changes. Each cut-up parts and organs were separately weighed using a sensitive electronic scale and expressed as a percentage of dressed weight.

Proximate and statistical analyses

The proximate analysis to chemically evaluate the nutritional potential of the FFPKM and experimental diets was determined by the methods of AOAC (2002). All other data were subjected to one way analysis of variance (ANOVA) in a Completely Randomized Design (CRD), by the method of Steel and Torrie (1980) and where significant differences were indicated, the means were separated using Duncan’s Multiple Range Test (Duncan, 1955).

Results and Discussion

The results of calculated and proximate composition of the experimental diets and Full Fat Palm Kernel Meal are presented in Tables 1 and 2 respectively. The values are quite comparable to each other. The inclusion of graded levels of FFPKM in replacement of maize in the experimental diets resulted in increasing metabolisable energy levels and ether extract levels, which was probably due to unextracted oil in the FFPKM. A marginal decrease in feed cost per ton was also evident with decreasing level of maize in the diets as maize was more expensive than palm kernel. Data also showed increase in crude fibre content with increasing levels of FFPKM in the diets.

There was reduction in average daily feed intake with increasing levels of FFPKM, especially at 9% level of inclusion, which was significantly ($P<0.05$) lower than the control diet (Table 3). The decreasing average daily feed intake observed in the birds in this study may be due to the increasing fat and dietary energy levels in treatments B to D (Table 1) resulting from the proportionate increase in FFPKM. In most research conducted on poultry feeding, chickens are not only especially sensitive to dietary energy concentration as they adjust their feed intake to achieve their energy requirements (Scott *et al*., 1982; NRC, 1994; Leeson et al., 1996); they are also easily affected by the fibre content of the feed (Yaakugh *et al*., 1988; Rougière and Carre, 2010). These workers had reported that diets high in energy and fibre reduce feed consumption and digestibility of the diet. This may be the case with results of the present study where graded levels of FFPKM increased the metabolisable and crude fibre content of the diets. The results therefore showed that the broilers have the ability to reduce feed consumption with the increasing FFPKM level. The increase in average daily feed intake by the birds in the control group was probably an attempt by the birds to consume sufficient energy for optimum performance (Tooci et al., 2009). However these observations seem at variance with Sundu et al., (2006) who stated that the feed intake of birds fed on a palm kernel meal-based diet was usually higher than that of a maize-based diet. A study by Onifade and Babatunde (1998) also indicated that the passage rate of digesta of a diet containing 20% palm kernel meal was faster than that of a diet containing maize offal or brewers’ dried grains, resulting in higher feed intake.

The results also showed that birds that consumed 0% (control), 5% and 7% FFPKM diets had comparable average final live body weight values and these were lower ($P<0.05$) than the average final live body weight value of birds that consumed the 9% FFPKM diet. The inclusion of FFPKM thus did not negatively affect the growth of broiler chickens. The results agrees with the reports of Okeudo *et al*. (2005; 2006) and Sundu *et al*. (2005) who reported that body weight gain of birds fed 30% palm kernel meal diet increased by 2% over the body weight of birds fed maize-soy diets. It could also be deduced from this result that high dietary energy level concomitant with increasing levels of FFPKM significantly increased average live body weight gain. The same conclusion was reached by Greenwood *et al.* (2004) as they found that birds fed 3200 Kcal ME /Kg diet had greater live body weight gain than those fed 3050 Kcal ME/kg diet. Nahashon *et al.* (2005) also stated that French guinea broilers fed 3100 and 3150 Kcal ME/kg diet exhibited significantly greater live body weight gain than those fed 3050 Kcal ME/kg diet.

The Feed conversion ratio (FCR) indicated significant difference (P<0.05) between the treatment means. Treatments A and B were less efficient in feed to gain, and significantly (P<0.05) different from treatments C and D, which suggests that live weight gain increased if dietary energy intake increased proportionately with other nutrients. Leeson, *et al.* (1996) and Nahashon *et al.* (2005) also reported that feed conversion significantly improved with increasing energy level (3200 Kcal ME/kg diet) during the finishing period of broiler chicks. Dietary energy content must thus be specified to maintain the proper ratio of protein to energy so that birds can consume an adequate amount of protein to obtain optimum performance. A major objective to reduce feed consumption per unit of meat produced by raising the metabolisable energy with increasing level of FFPKM (fat) in the diets was thus achieved in this study. With increasing dietary FFPKM (fat) levels the feed consumption was decreased and broiler grained more weight as compared to lower dietary FFPKM (fat) levels.

The dress weights and cut parts of the carcass as percentage of the dress weight are shown in table 4. The broiler eviscerated weight was significantly higher (P<0.05) in treatment D compared to the other treatments and this was due to the higher final live weight However, the carcass yield was not significantly different among the treatments. Relative weights of all organs found in this study were consistent with the findings of Hernandez *et al*. (2004), Huang *et al*. (2009) and Havenstein *et al*. (2003). There was significant difference (P<0.05) in organ weights (gizzard, spleen, thigh, shank, breast, wings, neck, jejunum, lung, drum stick, pancreas, heart, liver, duodenum and kidney) and some cut parts between experimental and control groups. Therefore, it is likely that the high dietary energy levels in the present study resulting from increasing levels of FFPKM may have caused a significant difference in carcass characteristics. This finding is similar to reports by previous researchers (Okeudo et al, 2005; Olorede and Alayande, 1999). Gizzard weight as a percentage of dressed weight of birds linearly increased with increasing levels of FPKM in the diets, consistent with the effect of increasing crude dietary fibre intake. Onwudike (1986) showed that as palm kernel meal dietary fibre content increased, gizzard weight of broiler chicks also increased. There was considerably high abdominal fat deposition in the dressed carcass of broilers fed FFPKM compared to the control group. The fat deposition was prominent around the gizzard (Plate 1) and it was also observed that the tissues of the slaughtered birds fed varying levels of FFPKM were soft and oily. Similarly, Ayorinde (1994); Leeson *et al.* (1996) and Raju *et al.* (2004) found that the percentage of abdominal fat was significantly increased as the dietary energy level increased. Shrivastav and Panda (1991) confirmed that fat content of whole carcass was significantly increased with increasing energy content of diet. However previous studies (Zanini et al., 2006) had reported a decrease in fat deposit in the body of broiler chicks fed vegetables and fruits.

Feed cost per bird and feed cost per kg (₦) in the present study were significantly higher in the control diet than in the FFPKM containing diets (Table 3). Feed cost per bird thus decreased with increasing levels of FFPKM in the diets in spite of the higher average daily weight gain observed. This is not surprising following the marked difference in prices between maize and palm kernel, with maize being at least 4 times more expensive than palm kernel. Although it is much cheaper compared to maize, very little FFPKM is used by the poultry producers in Nigeria. According to Waller (2007), the use of cheaper feed can reduce broiler performance and did not produce maximum margin. As nutrient level increased, feed cost per bird also increased. Improvement in bird performance from better feed also increased revenues from the birds. Thus, the most economic option is not always to reduce feed cost by using cheaper feed ingredients.

In conclusion, the present study suggest that broilers can be reared on ration containing up to 10% FFPKM in partial replacement of maize without any adverse effects on growth performance and carcass characteristics of the birds, and also improved feed cost per bird that agreed with Mierlina *et al.* (2007); McGill and Parker, (2010). Full fat Palm kernel meal has no anti-nutritional factors and thus can be beneficially included in the diet of broilers. However, the use of FFPKM in the diet can be maximized provided that the diet is balanced, particularly in amino acids and metabolisable energy. Since its inclusion up to 9% did not have a negative effect on body weight of broilers, this may encourage farmers, and the poultry industry, in palm kernel meal producing countries to use more of this ingredient in commercial rations due to its cost effectiveness and possibility to reduce environmental problems.

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Table 1: Experimental diets comprising graded levels of Full fat Palm kernel meal in replacement of Maize fed to the Broiler chicks.

Ingredients (%)	Starter test diets				Finisher test diets			
	A	B	C	D	A	B	C	D
Maize	56.70	51.70	49.70	47.70	61.20	56.20	54.20	52.20
Full Fat Palm Kernel Meal	0.00	5.00	7.00	9.00	0.00	5.00	7.00	9.00
Soya Bean Meal	15.00	15.00	15.00	15.00	10.00	10.00	10.00	10.00
Groundnut Cake	13.00	13.00	13.00	13.00	8.00	8.00	8.00	8.00
Fish Meal	3.00	3.00	3.00	3.00	2.00	2.00	2.00	2.00
Wheat Offal	9.00	9.00	9.00	9.00	15.00	15.00	15.00	15..00
Bone Meal	2.50	2.50	2.50	2.50	3.00	3.00	3.00	3.00
Dl-Methionine	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Salt (NaCl)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40
*Vitamin/Mineral Premix	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Total (100%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Nutrient Composition								
Crude Protein (%, Calculated)	22.80	22.00	22.10	22.22	18.44	18.14	18.14	18.24
Crude Protein (%, Analyzed)	23.10	22.8	23.00	22.8	19.00	18.60	18.86	18.80
Crude Fibre (%, Calculated)	3.78	4.06	4.17	4.28	3.89	4.17	4.28	4.39
Crude Fibre (%, Analyzed)	5.92	6.14	6.97	7.22	6.56	6.40	6.92	7.46
Ether Extract (Fat; %, Calculated)	4.36	6.96	8.00	9.04	4.15	6.75	7.79	8.83
Ether Extract (Fat; %, Analyzed)	5.00	7.24	8.70	8.98	5.85	7.66	8.83	9.42
Calcium (%, Calculated)	1.07	1.08	1.08	1.08	1.20	1.21	1.22	1.22
Phosphorus (%, Calculated)	0.85	0.85	0.84	0.84	0.87	0.86	0.86	0.85
Lysine (%, Calculated)	0.98	0.99	0.99	1.00	0.78	0.78	0.79	0.79
Methionine (%, Calculated)	0.45	0.45	0.45	0.45	0.40	0.40	0.40	0.40
ME (Kcal/kg)	2949.38	3097.68	3157.00	3216.32	2920.51	3068.81	3128.13	3187.45
Feed Cost/ ton (₦)	94,356	93,956	93,796	93,636	88,706	88,306	88,146	87,986

*Vitamin A 8000000 I.U, vitamin D_3 1600000 I.U, vitamin E 5000 I.U, vitamin K 2000 mgr, Thiamine 1500 mgr, Riboflavin B_2 4000 mgr, Pyridoxine B_6 1500 mgr, Niacin 15000 mgr vitamin B_{12} 10 mgr, Pantothenic Acid 5000 mgr, Folic Acid 500 mgr, Biotin 20 mgr, Choline chloride 200 gr, Antioxidant 125 gr, Manganese 80 gr, Zinc 50 gr, Iron 20 gr, Copper 5 gr, Iodine 1.2 gr, Selenium, 200 mgr Cobalt 200 mgr.

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Table 2: Proximate Composition of Full Fat Palm Kernel Meal

Constituents	Composition
Moisture content (%)	9.34 ± 0.57
Crude Protein (%)	11.26 ± 0.62
Fat (%)	54.74 ± 0.52
Crude Fibre (%)	13.38 ± 0.66
Ash (%)	3.41 ± 0.57
***Metabolisable energy (Kcal/kg)**	6400

*** Source: Oruwari et al., 1996**

Table 3: Performance of broiler chicken fed graded levels of Full Fat Palm Kernel Meal in replacement of Maize.

Parameters	Dietary treatment groups			
	A	B	C	D
Average Initial Live weight (g)	65.20 ± 20.42	68.60 ± 21.06	59.40 ± 13.07	65.40 ± 19.58
Average Final Live weight (g)	1505.80^{b} ± 1.17	1514.55^{b} ± 0.76	1524.50^{b} ± 0.41	1604.13^{a} ± 0.89
Average Daily Weight gain (g)	29.46^{b} ± 1.63	29.50^{b} ± 2.10	29.95^{b} ± 2.73	31.42^{a} ± 1.49
Average Daily Feed intake (g)	83.82^{b} ± 1.60	81.05^{ab} ± 2.43	80.85^{ab} ± 2.33	79.30^{a} ± 1.07
Feed Conversion ratio	2.85^{b} ± 0.35	2.77^{b} ± 0.48	2.71^{ab} ± 1.02	2.58^{a} ± 0.96
Feed Cost/ Bird (₦)	119.87 ± 3.22	118.25 ± 4.43	115.76 ± 1.97	117.44 ± 3.22
Feed Cost /Kg (₦)	79.38	78.31	76.16	73.51

^{a,b,c} Means within rows with different superscripts are significantly different ($P < 0.05$)

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Table 4: Carcass characteristics of broiler chicks fed graded levels of Full Fat Palm Kernel Meal in replacement of Maize

Parameters	Dietary treatment groups			
	A	B	C	D
Liveweight (g)	1611.59 ± 49.97	1528.81 ± 87.44	1631.27 ± 39.77	1728.47 ± 76.42
Dressed Weight (g)	1346.00 ± 46.29	1370.00 ± 74.48	1386.00 ± 26.53	1410.33 ± 51.51
Carcass yield (% LW)	83.52^{b} ± 2.54	89^{b}.62 ± 4.54	84.55^{b} ± 1.51	81.50^{b} ± 4.56
Cut Parts (% DW)				
Gizzard	4.98^{b} ± 0.12	5.19^{a} ± 0.02	5.20^{a} ± 0.10	5.22^{a} ± 0.12
Spleen	1.85^{a} ± 0.09	1.71^{ab} ± 0.05	1.68^{b} ± 0.08	1.66^{b} ± 0.1
Thigh	15.16^{a} ± 0.47	14.63^{b} ± 0.06	14.44^{bc} ± 0.25	14.21^{c} ± 0.48
Shank	6.82^{a} ± 0.27	6.41^{b} ± 0.14	6.27^{c} ± 0.28	6.31^{c} ± 0.24
Breast	18.03^{a} ± 0.32	17.71^{ab} ± 0.01	17.58^{b} ± 0.13	17.34^{c} ± 0.33
Wing	14.02^{a} ± 0.12	13.98^{ab} ± 0.08	13.89^{ab} ± 0.01	13.78^{b} ± 0.12
Neck	6.17 ± 0.05	6.06 ± 0.06	6.13 ± 0.01	6.10 ± 0.02
Jejunum	3.47 ± 0.18	3.49 ± 0.16	3.62 ± 0.03	3.82 ± 0.17
Lung	2.02 ± 0.05	1.90 ± 0.07	1.99 ± 0.02	1.91 ± 0.06
Drum stick	12.98^{a} ± 0.35	12.62^{ab} ± 0.01	12.43^{b} ± 0.2	12.27^{c} ± 0.36
Pancreas	1.65^{a} ± 0.07	1.51^{b} ± 0.07	1.50^{b} ± 0.02	1.52^{b} ± 0.04
Heart	2.05 ± 0.04	1.98 ± 0.03	1.97 ± 0.04	1.99 ± 0.02
Liver	3.37^{c} ± 0.28	3.57^{b} ± 0.08	3.68^{ab} ± 0.03	3.92^{a} ± 0.27
Duodenum	2.77^{c} ± 0.19	2.90^{ab} ± 0.06	3.14^{a} ± 0.18	2.84^{b} ± 0.12
Kidney	2.03 ± 0.02	1.98 ± 0.03	1.97 ± 0.04	1.99 ± 0.02

^{a,b,c} Means within rows with different superscripts are significantly different ($P< 0.05$)

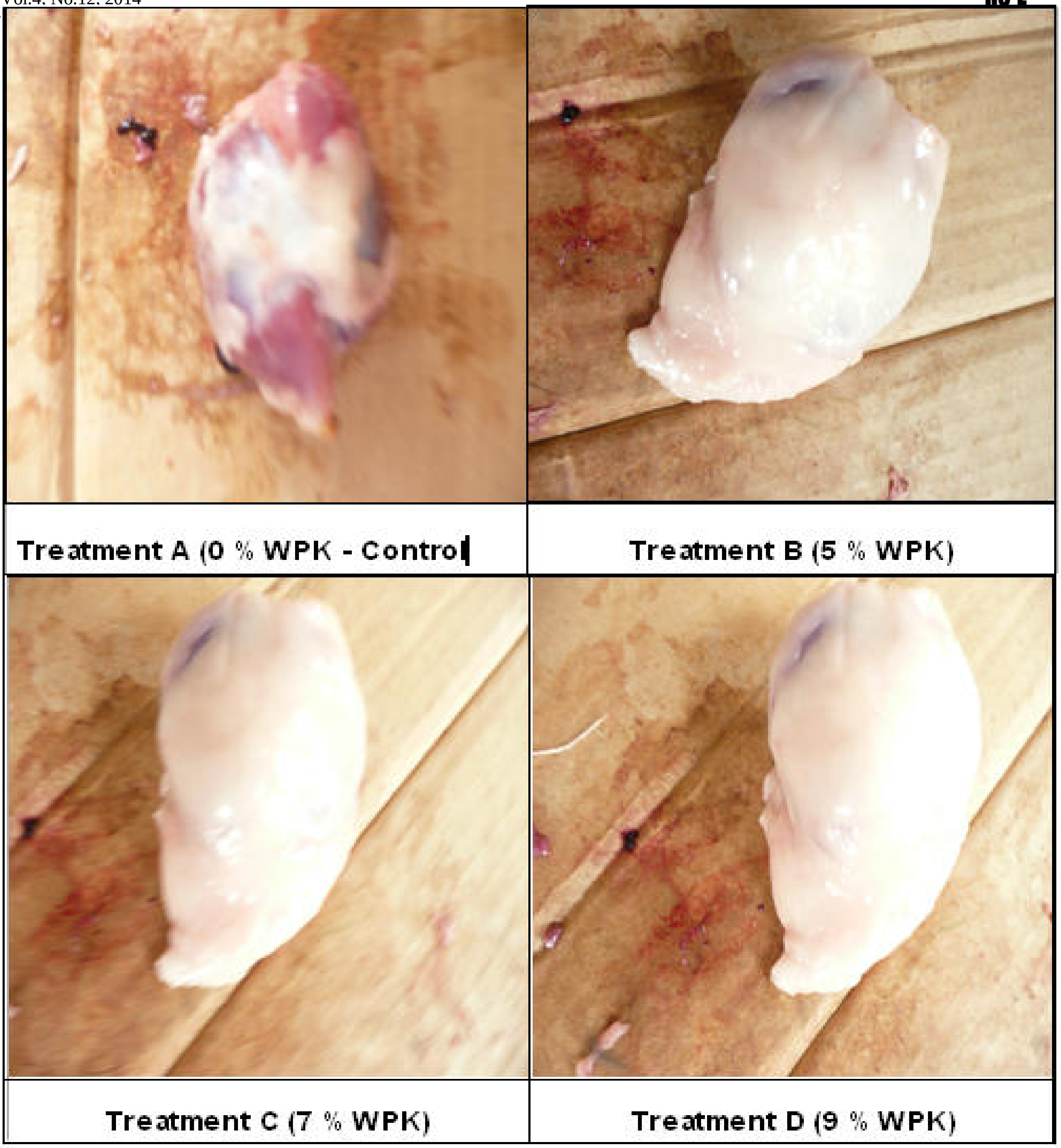

Plate 1. Photograph showing fat deposition around the gizzard in the WPK diets relative to the control