RESPONSE OF TWO BROILER GENOTYPES TO DIETS WITH VARYING LEVELS OF INCLUSION OF PALM KERNEL OIL RESIDUE (PKOR)

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ABSTRACT

An experiment was carried out to evaluate the effects of strain of broilers and different levels of inclusion of palm kernel oil residue (PKOR) diets on the growth and carcass characteristics of two commercial broiler strains. A total of 450 birds were evaluated in a 2 x 3 factorial experiment involving two broiler strains (Cobb and Ross) and three dietary treatments with 0%, 10% and 20% levels of inclusion of PKOR. For each of the broiler strains, a total of 225 birds were randomly assigned to each of the three diets with each dietary treatment having 75 birds with three replications with 25 birds in each replicate group. The experiment was done using 3-week old broiler chicks and fed over a period of 5 weeks in 18 partitioned deep litter pens (2.5m x 2.1m; floor space of 0.21m^2/bird). Both feed and water were supplied ad libitum, under a 24-hour lighting regime. Growth parameters were taken from week three to week eight. At the end of the experimental period, 4 birds from each replicate group were randomly selected and slaughtered for carcass evaluation. Data obtained were subjected to a two-way Analysis of Variance (ANOVA) with strain of broilers and dietary treatments as fixed factors using the general analysis of variance procedure of GenStat. Where differences in means occurred, the means were separated using the least significant difference (LSD) test at 5% level of significance. The results showed no significant effect of genotype on growth performance. There were, however, significant difference in growth performance with the different levels of inclusion of the PKOR, with the birds on the control diets (0% PKOR) being superior in terms of final live weights as compared to the birds fed 10 and 20% levels of inclusion of the PKOR diets. Interestingly, birds fed 0% and 20% levels of inclusion of PKOR were able to significantly convert feed to meat better (better FCR) than their counterparts on the 10% level of inclusion. There were no significant genotype × diet interaction effects on all performance parameters assessed. Furthermore, the results obtained showed no significant ($p>0.05$) effect of genotype on carcass characteristics. On the other hand, birds on 0% PKOR recorded significantly ($p<0.05$) higher warm carcass weight and warm dressing percentage than birds fed 10% and 20% PKOR; chilled carcass traits assessed were, however, similar ($p>0.05$) for all dietary treatments. The effects of genotype x diet interactions on all carcass traits assessed were not significant ($p>0.05$). The outcome of this work showed that the inclusion of PKOR at 10% and 20% led to a reduction in feeding cost/kg weight gain of US$0.34 and US$0.45 respectively; this can increase the profit margin of farmers.

Keywords: *Genotype, diet, interaction, carcass parameters, Cobb and Ross broiler strains*

INTRODUCTION

The growth of the broiler industry in Ghana has been unstable due to challenges like high cost of feed, competition with cheap importation of poultry products (dressed chicken), diseases and inadequate processing plant to process chicken into parts readily available to consumers, etc. (MoFA, 2016). Despite these challenges, the industry is one of the cheapest sources of meeting the unlimited demand for protein-rich food. It is one of the most productive and cheapest ways to provide nutritious food for human beings. The broiler industry, like any other livestock industry, provides several jobs along its value chain and if properly harnessed it can help reduce the unemployment situation in Ghana. Farmers in the broiler industry in Ghana raise different breeds or strains of birds with varying growth and carcass characteristics. These breeds are mostly developed in Europe and United States of America. Their performances are curtailed when they are brought from their countries of origin and raised in Ghana due to genotype × environment interactions (G × E). Genotype × environment interaction describes the conditions where different genotypes (e.g. breeds, lines, strains, progeny groups) respond differently to different environments (e.g. diet/feed/nutrition, housing, location, season, production system, medication, sanitation, weather conditions), due to the fact that some alleles or genes may only be expressed in some specific environments, and consequently, gene regulation may change depending on the particular environment (Hagan *et al*., 2022). Thus, superior (best performing) genotypes under one environment may not be superior under other environments, leading to reranking of genotypes (Hammami *et al*., 2009; Gwaza *et al*., 2017; Chu *et al*., 2019). The aspect of genotype × environment interaction in broiler production that is best known to influence phenotypic and economic performance is that of genotype × nutrition/diet interaction (Alagawany *et al*., 2022; Razuki and Al–Rawi, 2007). Consequently, Hoste (2007) reported that in terms of the future direction of genetics linked to nutrition, costs of feed will remain a factor in the economics of production, and therefore the optimization of feed utilization by improved birds will remain a priority to geneticists in making economic decisions.

According to Catolico and Ampode (2019), the broiler chicken has been highly selected for high growth rate, breast meat yield and feed conversion efficiency under intensive production system. However, due to the high cost of feed and other inputs, according to Gofredo *et al*. (2018), the production cost has increased significantly in recent years. There is therefore the need to consider the use of cheap and readily available and equally nutritive alternative source of feedstuff to partly or completely substitute the conventional commercial diets. Due to the competing demand for conventional feed ingredients like maize, soyabean and wheat bran (especially for making wheat bran bread, otherwise called ‘‘brown bread’’) for human consumption and the possible unsustainable nature of these ingredients, the search for non-conventional feedstuff has become more important than ever.

The growth and carcass yield performance is dependent on the breed or strain of broiler used and the quality of feed provided (England *et al*., 2022). Farmers in the broiler industry have been battling with the influx of some poor quality broiler breeds coupled with high feed cost. It is therefore imperative that research is geared towards identifying highly productive and fast-growing breeds and a locally available and nutritious feed to meet the nutritional requirements of the birds. Farmers have been trying different breeds with varying performance and different feed mixes also with varying results. One of the locally available feed ingredients which has been tried by nutritionists is the palm kernel oil residue (PKOR). This is a by-product from the palm kernel oil processing industry, which is scattered all over the country (Hagan *et al*., 2022).

Catolico and Ampode (2019) indicated that, the residue from the palm kernel oil processing could be utilized into a meal called the palm kernel meal (PKM). This by-product is considered to be agro-industrial waste derived from the oil extraction process. It has been widely used as source of protein and energy in various poultry and livestock animals such as laying hens (Chong *et al*., 2008; Yanktul *et al*., 2013), broiler chickens (Hagan *et al*., 2022; Abdollahi *et al*., 2016; Odoi *et al*., 2007), dairy cows (Carvalho *et al*., 2006), rabbit (Orunmuyi *et al*., 2006) and pigs. Several studies have been reported on different levels of inclusion of the PKM in poultry (layer and broiler) diet and its effects on the performance parameters. The challenge with its use is its fibrous nature, low palatability and low availability of amino acids. The current research was therefore conducted to evaluate the effects of the different levels of palm kernel oil residue diets on growth and carcass characteristics of different broiler strains or genotypes.

MATERIALS AND METHODS

Location and duration of experiment

The experiment in this study was conducted on the Teaching and Research Farm of the School of Agriculture, University of Cape Coast, Ghana. The mean temperature recorded in the experimental room was 25.6^{o}C (range: 23^{o}C-26^{o}C). The trial lasted for a period of five (5) weeks, after chicks were brooded on commercial diet for three (3) weeks.

Experimental design

Four hundred and fifty (450) broilers, 225 each of Cobb and Ross genotypes were randomly selected (using completely randomized design) and evaluated for growth and carcass characteristics in a 2 x 3 factorial experiment with two broiler strains or genotypes (Cobb and Ross) and three dietary treatments (consisting of 0%, 10% and 20% levels of inclusion of the PKOR). The PKOR replaced wheat bran at 0% (control - T1), 10% (T2) and 20% (T3) of the total diet. There were a total of 75 birds on each of the three dietary treatments with three replicates consisting of 25 birds in each replicate group.

Management of the experimental birds

The dietary experiment involved 3-week old broiler chicks of each breed, which were fed over a period of 5 weeks. After brooding, the 3-week old broiler chicks were housed in 18 deep litter pens with the floor covered with wood shavings as bedding material. The floor dimensions of each pen were 2.5m X 2.1m, giving a standard floor space of 0.21m^2 per bird. All birds were fed once daily at 7.00-8.00 am. Both feed and water were supplied *ad libitum* under 24-hour lighting regime. Standard preventive and curative healthcare and medications were instituted along recommended lines with a high level of hygiene maintained throughout the experimental period.

Composition of experimental diets (percentage of 100 kg weight)

Table 1 shows the feed composition of the experimental diets used. With the exception of wheat bran and PKOR, which were varied, all other ingredients and levels were the same for all dietary treatments. The diets were of similar caloric density (isocaloric) and similar protein level (isonitrogenous).

Table 1: Experimental diets (% composition and calculated analysis)

Ingredient	0% PKOR	10% PKOR	20% PKOR
Maize	50.0	50.0	50.0
Wheat Bran	28.5	18.5	8.5
Fish Meal	12.0	12.0	12.0
Broiler Concentrate	8.0	8.0	8.0
PKOR	**0.0**	**10.0**	**20.0**
Oyster Shells	1.0	1.0	1.0
*Vitamin Premix	0.3	0.3	0.3
Salt	0.2	0.2	0.2
TOTAL	100.0	100.0	100.0
Nutrient analysis			
% Crude Protein (CP)	19.01	19.48	19.25
% Fat (EE)	3.42	3.73	4.69
% Crude Fibre (CF)	5.13	6.03	6.53
% Ash	9.33	10.36	11.16
[2]ME (Kcal/Kg)	2,740.13	2,740.86	2740.75

[1]*Calculated. composition of vitamin premix per kg: Vitamin E, 25mg; Vitamin A, 6250 IU; Vitamin D3, 1250 IU; Vitamin K3, 25mg; VitaminB1, 25mg; Vitamin B2, 60mg; Vitamin B6, 40mg; Vitamin B12, 2mg; Elemental calcium, 25mg; Elemental phosphorus, 9mg; Elemental magnesium, 300mg; Iron, 400mg; Selenium 1.0mg, Iodine 20mg, Copper 60mg, Magnesium 100mg, cobalt 10mg, Zink, 150mg; Sodium Chloride, 1.5mg; Choline Chloride, 500mg; Live Lactobaccillus spore, 0.2 million cfu; Niacin, 40mg; Folic Acid, 10mg; d-Biotin,5mcg.*
[2]*PKOR – Palm kernel oil residue; ME – Metabolisable Energy*

Data collection

Data on initial body weight (4-week body weight), final live weight (8-week body weight), weight gain, growth rate, feed intake and water intake as well as feed conversion ratio (FCR) were taken. Feeding cost (US$)/kg/bird/5weeks, feeding cost/kg weight gain in US$, and savings on feed cost (US$)/kg weight gain/bird were then estimated. At the end of the feeding trial (exactly 56 days of age), 4 birds were randomly selected from each replicate. The birds were weighed after 12-hour feed withdrawal, and tagged to differentiate them. They were then stuck with a sharp knife to cut the jugular veins and allowed to bleed for about 60 seconds, after which they were scalded in warm water (60°C). The feathers were plucked manually and head and shanks removed. An incision was then made around the vent to remove the viscera (internal organs). The viscera were separated into heart, liver, kidney, spleen, and gizzard and weighed. The abdominal fat pad was removed and each weighed and then the warm carcass weight was taken. The dressed carcass was chilled for 24 hours and cold weight taken. Primal cuttings (wings, back, breast, drumsticks and thigh muscles) were made from the chilled carcass, weighed and recorded. All the weighing was done using a standing electronic balance. Description of other methods including formulae used to measure/estimate some parameters are given as follow:

Initial weight

Body weight per bird in each genotype at the start of the feeding trial.

Final weight

Body weight per bird in each genotype at the end of the feeding trial.

Feed intake per bird

$$\text{Feed intake (kg)} = \frac{\text{Feed offered - Feed leftover}}{\text{Number of birds}}$$

Live weight gain

Weight gain was calculated as the difference between the final body weight and the initial body weight of a bird.

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Feed intake}}{\text{weight gain}}$$

Dressing percentage

The dressing percentage is the proportion of the live weight of the broiler, which is sold as meat, expressed as a percentage:

$$\text{Dressing Percentage} = \frac{\text{Carcass weight}}{\text{Live weight just before slaughter}} \times 100$$

Carcass weight is the weight of carcass after removal of feathers, head with neck where it joins the spine, shank with toes and all internal organs.

Cost-benefit analysis of feeding PKOR-based diets

The cost of ration was calculated using the prevailing market prices of the individual feed ingredients used in formulating the rations. The cost of PKOR was obtained by summing the cost of the fresh PKOR, cost of sacks, cost of drying materials (example black rubbers), cost of transporting fresh material from collection site to the experimental site, labour cost for drying 50kg of PKOR to moisture content of 8% or less. The ration cost/weight gain (1000g) in USD (US$) was obtained by multiplying the ration cost per bird by the FCR as documented by Okeudo *et al*. (2006) and Bello *et al*. (2011). Savings on feed cost (US$)/kg weight gain/bird were then estimated as the difference between the cost of the control diet and that of the PKOR-based diets.

Statistical analysis

Data collected were subjected to analysis of variance (ANOVA) with strain of broilers and dietary treatments as fixed factors and the growth and carcass characteristics as response variables using the generalized linear model procedure of the Genstat Discovery Edition (VSNI, 2011). Where differences in means were observed, the means were separated using the least significant difference (lsd) test at 5% level of significance.

The statistical model used was as follows:

$$Y_{ijk} = \mu + S_i + D_j + (SD)_{ij} + e_{ijk}$$

Where:

Y_{ijk} = observation of trait Y on the *k*th individual of the i^{th} strain or genotype, fed the *j*th dietary treatment

μ = the general mean,

S_i = the fixed effect of the *i*th broiler strain or genotype (i = Cobb or Ross)

D_j = the fixed effect of the *j*th dietary treatment (j = 0%, 10% OR 20%),

$(SD)_{ij}$ = the fixed effect interaction between the *i*th broiler strain and the *j*th dietary treatment,

e_{ijk} = the random error term associated with an observation ~ $N(0, \sigma^2_e)$ where σ^2_e is residual variance.

RESULTS AND DISCUSSION

Effect of Genotype on Growth Performance

The influence of genotype on the growth performance parameters that were studied is presented in Table 2.

From Table 2, all growth performance parameters (final weight, weight gain, growth rate, feed intake, water intake and FCR) evaluated did not reveal any significant differences (p>0.05) between the two genotypes, and this might be due to the fact that the two breeds have comparable genetic potential or the expression of genes encoding nutrient uptake and distribution is similar in the two strains (England *et al*., 2022); as such any one of Cobb and Ross genotypes can serve as a farmer's preference. The results of growth performance traits assessed in this study contradicted the findings of Sterling *et al*. (2006) who observed significant difference in body weight gain, feed intake and feed conversion ratio of Cobb and Ross 308 birds, with the former breed recording better performance than the latter; parallel to the findings of Amao (2018) whose results showed that Arbor acre strain was significantly (p<0.05) favoured for body weight, daily weight gain, daily feed intake and daily water intake compared with Marshall birds. Similarly, Hristakieva *et al*. (2014) reported that Cobb 500 broiler genotypes attained a higher live weight, and were heavier than Ross 308 genotypes by about 6.29 % at 49 days of age (7 weeks). Results from the current study also disagreed with those of Mmereole and Udeh (2009) who found that local chicken by Barred Plymouth Rock crossbred (Genotype 3, G3) and Barred Plymouth Rock (Genotype 4, G4) were significantly (p<0.01) heavier than the local chicken (Genotype 1, G1) and the Barred Plymouth Rock by local chicken reciprocal crossbred (Genotype 2, G2) groups, at the 1st, 4th and 8th weeks of age, respectively. Mmereole and Udeh (2009) concluded that the G4 and G3 genotypes had superior genetic potential for body weight gain than the G1 and G2 genotypes. The results of the current study again contradicted the findings of Olawumi *et al*. (2012) who reported that both sexes of Marshal broilers recorded the highest live weight at 56 days of age (8 weeks) when

Table 2: Effect of genotype on growth performance of broilers (4-8 weeks of age)

Trait/parameter	Cobb	Ross	SEM	p-value
Initial weight (g)	609.90	622.30	14.21	0.39
Final weight (g)	2674	2757	50.80	0.13
Weight gain (g)	2065	2135	49.40	0.18
Growth rate (g/day)	58.99	61.02	1.40	0.17
Total feed intake (g)	5711	5687	142.40	0.87
FCR/bird	2.77	2.68	0.04	0.07
Total water intake (g)	11186	10657	463.30	0.28

[1]*FCR – Feed conversion ratio; SEM – standard error of mean*

compared with Arbor Acre and Hubbard chickens, and described the former (Marshal) as having superior genetic potential for meat yield than the latter. Furthermore, genotype affected performance parameters, namely body weight gain (BWG), feed intake (FI), energy intake (EI), feed conversion ratio (FCR), energy conversion ratio (ECR), and production efficiency factor (PEF), irrespective of growth phase ($p<0.05$) according to Tudorache *et al.* (2022) who studied the effects of genotype and diet on performance of commercial and local chickens and their crosses contrary to the observations of the present study.

Effect of Dietary Treatments on Growth Performance

The effect of dietary treatments on growth performance of Cobb and Ross broiler chickens in this study is presented in the Table 3.

Birds on 0% PKOR had significantly ($p<0.05$) higher final live weight, weight gain and growth rate than birds on diets with 10% and 20% PKOR (Table 3); indicating that these traits were negatively related to the levels of PKOR. The trend may be attributed to lower nutrient digestibility as PKOR levels increased. This explanation is supported by Sundu and Dingle (2003) who reported that heating agro-industrial by-products at high temperatures during processing may cause feed products such as PKC (and its variants, PKM and PKOR) to undergo Maillard reaction (the reaction of reducing sugar with amino groups leading to the formation of a characteristic brown complex); a high level of heat is applied before and during oil extraction which may adversely affect nutrient digestibility. Confirming this explanation, McDonald *et al.* (2002) reported that Maillard reaction occurring as a result of prolonged heating of feed products leads to formation of complex linkages within and between peptide chains, some of which are resistant to hydrolysis by proteases enzyme, thereby reducing the solubility, digestibility and utilisability of proteins in such feed products. Another feed feature which might have contributed to the lower live weight and correlated traits in birds on the 20% compared with the 0% PKOR diet is the higher fibre content in the former, a factor which is known to reduce digestibility of feeds (McDonald *et al.*, 2002). The results obtained in this study are also in agreement with those of Ojewola and Ozuo (2006) who reported that birds fed diets containing 10%, 15% and 20% of PKC, instead of soybean meal, had depressed body weight compared with the control (0% PKC).

Furthermore, Soltan (2009) as well as Ezieshi and Olomu (2008) indicated that feeding PKM

Table 3: Dietary treatment effects on growth performance parameters of broiler chickens (4-8 weeks of age)

Parameter	0% PKOR	10% PKOR	20% PKOR	SED	p-value
Initial weight (g)/bird	612.60	616.40	618.90	17.40	0.935
Final weight (g)/bird	2849[a]	2654[b]	2644[b]	62.30	0.010
Weight gain (g)/bird	2236[a]	2037[b]	2025[b]	60.50	0.007
Growth rate (g/day)/bird	65.13[a]	59.93[b]	58.00[b]	1.72	0.007
Total feed intake (g)/bird	5984[a]	5698[ab]	5416[b]	174.4	0.022
FCR/bird	2.68[a]	2.80[b]	2.68[a]	0.04	0.022
Total water intake (g)/bird	11715[a]	10862[ab]	10186[b]	567.4	0.040

[1]*Means in a row with same letter superscripts are not significantly different (p>0.05)*
[2]*SED – standard error of difference of means*

(mechanically extracted) depressed broiler chick weights, while PKM types (solvent extracted) highly depressed final body weight of broiler birds. In contrast with these, Okeudo *et al*. (2006) reported that average body weight of broilers was approximately 2kg in each dietary group at the 8th week of age, and was not significantly affected by inclusion of PKC up to levels of 30% in the diets. Egenuka *et al*. (2013) who studied the effect of different dietary levels (0%, 20% and 40%) of PKC on the growth of chickens indicated that there were significant (p<0.05) increases in the final live weight of the growers with increase in the level of palm kernel cake included in the diets. These differences in the findings reported from feeding trials using PKOR and PKC/PKM may be related to the different levels of fibre in the diets fed and the varying degrees of Maillard reaction that had occurred in these products used. It is known for example that all reactions up to the formation of Amadori compounds at the initial stage of Maillard reactions, are reversible, to release amino acids for utilisation (van Rooijen *et al*., 2013; Lund and Ray, 2017). It is advisable for agro-processing industries that produce PKC/PKM/PKOR used as feed to reduce the amount and duration of heat applied during processing in order to minimize the degree of Maillard reaction that occurs in the by-products. Also, farmers and feed manufacturing companies may use PKOR/PKC/PKM in combination with feedstuffs high in essential amino acids, or incorporate industrially manufactured amino acids such as lysine (the main essential amino acid most affected by Maillard reaction), and/or enzymes to improve the overall utilisation of heat treated agro-industrial by-products.

Birds on diets with 20% PKOR consumed significantly (p<0.05) lower amount of feed than birds on 0% PKOR diets; intakes on 20% diets were not different however from those on 10% PKOR diets (Table 3). The lower feed intake by birds on diets with 20% PKOR compared with those on 0% PKOR, may be due to the higher energy content in the 20% PKOR (Table 1); birds will generally consume feed at levels to meet their energy requirements (McDonald *et al*., 2002). Thus, the higher the amount of energy in the feed, the lower the amount of feed needed to meet the energy requirements, and vice versa. The lower feed intake observed with increasing levels of PKOR agree with work by Soltan (2009) and Onuh *et al*. (2010) who worked with palm kernel cake in diets for broiler chickens.

Feed conversion ratio (FCR) of birds on diets with 0% and 20% PKOR (Table 3) were significantly lower (p<0.05) than for birds on 10% PKOR; implying that the diet without PKOR and diet with 20% PKOR had similar and better utilisation levels than on 10% PKOR. Feed conversion ratio (FCR) is a measure of the animal's efficiency in converting feed mass into body mass. Some feed factors that influence utilisation are digestibility and nutrient or energy content. The better utilisation of the diet without the PKOR and the diet with the 20% PKOR may have resulted from combined effects of higher digestibility, higher nutrient absorption and higher energy content; this may be so, even though the diet with 20% PKOR might have had a lower digestibility. In effect, the higher energy content of the diet with 20% PKOR might compensate for any nutrient losses to chickens due to lower digestibility, giving it a favourable feed conversion ratio. The FCR results from this study agree with those from Egenuka *et al*. (2013) who reported no significant differences in FCR of broilers fed 0% PKC and 40% PKC diets. This work however, conflicts with the report of Okeudo *et al*. (2006) who observed that broilers fed 0% PKC diet had significantly lower FCR than those fed 45% PKC diet.

Comparing the results of the diet with 0% PKOR with that of the 10% PKOR in the current study, the higher FCR of the latter may be attributed to poorer digestibility and lower nutrient utilisation relative to the former. However, comparing the FCR of the 10% and 20% diets, the higher value for the former could be due to its lower energy content relative to the latter; though both may have similar lower digestibility. Consequently, in spite of the apparent poorer digestibility of the

20% PKOR diet, its higher energy content might have compensated for nutrient losses, resulting in better feed conversion ability. Farmers may be able to reduce feed intake and therefore feeding cost with 20% PKOR inclusion in diets, and yet still achieve good feed conversion ratios.

Economic benefits of using PKOR in broiler diets

The cost-benefit analysis of using PKOR in broiler diets are provided in Table 4

The important economic motivation for the use of PKOR in poultry rations is its potential to minimize feed cost when it replaces a conventional feed ingredient of relatively higher price. The results from this study revealed that the inclusion of PKOR at 10% and 20% (with PKOR directly replacing wheat bran) led to a reduction in feeding cost/kg weight gain of US$0.34 and US$0.45 respectively; this confirmed work by Odoi *et al*. (2007) who also reported significant reduction in feed cost when up to 15% of PKOR were fed to broiler finisher chickens. These reductions in feed cost per kilogram weight gain translate into potentially huge savings and therefore increased profit margins. The results are also similar to those of Ezieshi and Olomu (2008) and Egenuka *et al*. (2013), who reported significant reductions in feed cost per weight gain with increasing PKC inclusion rates. The results of this work suggest that farmers can make substantial savings on feed costs, which translates into increased profit margins, when they replace wheat bran with PKOR up to 20% rate in broiler finisher rations.

Table 4: Cost-benefit analysis of using palm kernel oil residue (PKOR) in broiler diets

Parameter	0% PKOR	10% PKOR	20% PKOR
FCR/bird	2.68	2.80	2.68
Feeding cost (US$)/ kg/bird/5weeks	0.65	0.50	0.48
Feeding cost/kg weight gain in US$	1.74	1.4	1.29
Savings on feed cost (US$)/kg weight gain/bird/5weeks	0.00	0.34	0.45

[1]*FCR – Feed conversion ratio*

Effect of Genotype x Diet Interaction on Growth Parameters

The effect of genotype x diet interaction on some growth parameters is presented in Table **5**.

There was no significant (p>0.05) genotype × diet (environment) interaction effects on growth

Table 5: Effect of genotype × diet interaction on growth parameters in broiler chickens

Traits	Breeds						SED	p-value
	Cobb			Ross				
	Diets							
	0% PKOR	10% PKOR	20% PKOR	0% PKOR	10% PKOR	20% PKOR		
Initial weight (g)/bird	590.00	628.50	610.40	635.1	604.40	627.40	24.61	0.18
Final weight (g)/bird	2783	2607	2633	2915	2701	2656	88.00	0.68
Total weight gain (g)/bird	2193	1978	2022	2280	2096	2028	85.60	0.64
Growth rate (g/day)/bird	62.68	56.51	57.77	65.13	59.93	58.00	0.02	0.65
Total feed intake (g)/bird	5948	5700	5484	6019	5695	5348	246.60	0.84
Total water intake (g)/bird	11683	11082	10792	11747	10643	9580	802.40	0.54
FCR	2.71	2.88	2.71	2.64	2.71	2.64	0.06	0.49

[1]*FCR – Feed conversion ratio; SED – Standard error of difference of means*

parameters studied in the broilers. This work implied that there were no joint effects of breed and diet on birds' performance; that is, the two factors acted autonomously of each other as explained by Olawumi *et al.* (2012). The results of the current investigation are also in consonance with work by Mmereole and Udeh (2009) who reported no significant genotype by diet interactions on body weight and weight gain of the Nigerian local chicken, and its crosses with the Barred Plymouth Rock. The outcome of the contemporary work however, deviates from that of Erdem and Savas (2021) who reported that three different layer chicken genotypes (Atak-S, New Hampshire Red, and Light Sussex) responded differently to poultry red mite infestation in different feeding environments during the grower stage, similar to the results of Chu *et al.* (2019) who documented significant G × E interactions in body weight traits of commercial broiler chicken genotypes due to environmental differences which led to re-ranking of the genotypes. The absence of genotype × diet interactions in the present study indicates that the nutritional environment of birds on the three diets (0%, 10% and 20% PKOR) similarly favoured gene expression and regulation of traits. Hence, the two genotypes could be said not to have differed in ranking. The implication is that farmers may keep any of the two genotypes, on any of the three rations fed, without any detrimental effect on growth performance or production; this is provided that nutritional composition of diets fed are adequate to meet requirements of broiler birds in that category.

Influence of Genotype on Carcass Parameters

The influence of genotype on the carcass parameters that were studied is presented in Table 6.

The carcass weights, dressing percentages, weights of primal cuts, weights of visceral organs and abdominal fat pad did not vary significantly ($p>0.05$) between Cobb and Ross genotypes (Table 6). This implies that the two geno-

Table 6: Effect of genotype on carcass traits of broilers

Parameter	Cobb	Ross	SED	p-value
Live weight (g)	2674	2757	50.80	0.13
Warm carcass weight (g)	2070	2126	56.20	0.34
Warm dressing percentage (%)	77.41	77.11	1.04	0.70
Chilled carcass weight (g)	2010	2074	57.60	0.34
Chilled dressing percentage (%)	76.98	76.85	1.04	0.67
Weight of cut parts (g)				
Breast (g)	643.00	710.00	34.80	0.14
Thigh (g)	321.90	322.30	14.87	0.66
Drumstick (g)	282.50	278.70	12.95	0.66
Back (g)	519.00	516.00	27.80	0.51
Wing (g)	243.60	249.40	15.25	0.83
Weight of organs (g)				
Heart (g)	11.92	12.41	0.309	0.14
Liver (g)	55.60	56.10	3.73	0.89
Kidney (g)	13.94	15.02	0.62	0.11
Spleen (g)	1.96	2.05	0.21	0.15
Gizzard (g)	56.19	59.55	1.48	0.09
Abdominal fat pad (g)	18.45	18.79	0.24	0.18

[1]SED - standard error of difference of means

types had similar genetic potential for carcass yield. The productive performance of three commercial broiler genotypes (Marshall, Arbor Acres and Hubbard) reared in the savannah zone of Nigeria was assessed by Olawumi and Fagbuaro (2011) and in contrast to the results of this study reported that, as regards the carcass traits, Marshall genotype had superior (p<0.05) and higher mean values in dressing out weight, eviscerated weight, carcass weight, carcass percentage, breast muscle weight, back muscle weight, thigh muscle weight, drumstick weight, neck weight and wing weight when compared with Arbor Acres and Hubbard, supporting Musa *et al*. (2006) and Ojedapo *et al*. (2008) who also reported significant effect of breed in all the carcass traits evaluated including abdominal fat weight. Again, the results of the recent study by Obeidat *et al*. (2022) showed that there was a significant strain effect for most of the carcass traits of Hubbard broilers and Indian River commercial broiler genotypes contrary to the outcome of the present study. Moreover, the results of the current research differed from that of Tudorache *et al*. (2022) who reported that genotype influenced the carcass and organ yields (p<0.05) of commercial and local chickens and their crosses.

However, the three genotypes studied by Olawumi and Fagbuaro (2011) recorded similar values in dressing out percentage and abdominal fat, similar to the findings of the present study. Moreover, there was no significant difference between the Arbor Acres and Hubbard genotypes for the carcass traits evaluated, indicating that these two genotypes probably shared common genetic composition (Olawumi and Fagbuaro, 2011), which is in consonance with the outcome of the current study. The weight of visceral organs were also similar for both Cobb and Ross genotypes in this study which agrees with the report of Olawumi and Fagbuaro (2011) but contrary to the result of Taha *et al*. (2010) who reported significant effect of breed on these traits. The non-significant difference in the weight of visceral organs in the present study indicates that Cobb and Ross broiler genotypes shared comparable genetic composition in respect of these organs and hence had similar organ functions. Consequently, farmers can choose to buy either Cobb or Ross broiler chicken and raise them for the market as whole carcass or cut carcass parts.

Influence of Dietary Treatments on Carcass Traits

The effect of dietary treatments on carcass performance of Cobb and Ross broiler chickens in this study is presented in Table 7.

From Table 7, birds on 0% PKOR recorded significantly (p<0.05) higher warm carcass weight than birds fed diets with 10% and 20% PKOR. The warm dressing percentage of birds on 10% and 20% PKOR diet was significantly lower (p<0.05) than those on 0% PKOR diet. The differences could be attributed to the fact that birds on the 0% PKOR diet had significantly higher weight gain than those on the 10% and 20%; implying that body weight gain and warm carcass traits are correlated. The warm dressing percentage measures the yield of the body muscle of the chicken, made ready to be cooked or frozen. The values obtained were 79.14%, 76.38% and 75.99% for the 0%, 10% and 20% PKOR diets respectively. These values are slightly above reported average of 70-75% (Lessler *et al*., 2007), due possibly to the fact that more of the nutrients derived from the diets fed to the broilers were used to synthesize muscles rather than to develop such unwanted parts as feathers, offal and viscera. The significant reduction in the dressing percentage with increasing level of PKOR observed in this study disagrees with work of Soltan (2009) who revealed that PKC dietary inclusion at different levels had no effect on dressing percentage when compared with the control, similar to what has been reported by Shakila *et al*. (2012). Though the warm carcass weight and warm dressing percentage of the 0% PKOR were significantly higher (p<0.05) than the 10% and 20% PKOR diets in the current study, the values obtained for the PKOR-based diets were slightly above reported values of 70-75%; implying that PKOR inclusion up 20% in broiler finisher ration sup-

Table 7: Effect of diet on carcass parameters of broiler chickens

Trait/parameter	0% PKOR	10% PKOR	20% PKOR	SED	P-Value
Live weight (g)	2894a	2654b	2644b	62.30	0.010
Warm carcass weight (g)	2254[a]	2027[b]	2012[b]	68.8	0.007
Warm dressing percentage (%)	79.14[a]	76.38[b]	75.99[b]	1.27	0.040
Chilled carcass weight (g)	2130	1994	1989	70.50	0.072
Chilled dressing percentage (%)	77.73	75.62	75.48	1.28	0.184
Weights of cut parts (g)					
Breast (g)	716.80	683.20	667.90	42.60	0.121
Thigh (g)	327.60	306.50	318.70	18.22	0.289
Drumstick (g)	285.50	269.3	279.90	15.86	0.290
Back (g)	553.20	497.50	475.30	38.10	0.060
Wing (g)	246.90	227.50	247.20	26.41	0.609
Weight of organs (g)					
Heart (g)	12.02	12.37	12.10	0.38	0.639
Liver (g)	53.80	58.30	55.60	4.56	0.626
Kidney (g)	14.35	14.24	14.84	0.76	0.708
Spleen (g)	1.81	1.96	1.90	0.25	0.851
Gizzard (g)	59.63	57.24	57.71	1.81	0.403
Abdominal fat pad (g)	18.38	18.66	18.82	0.29	0.341

[1]Means in a row with same letter superscripts are not significantly different (p>0.05)

ports good carcass traits. Hence, farmers who wish to slaughter and sell their broilers on warm carcass weight can make considerable financial gains by using up to 20% of PKOR in their broiler finisher diet.

The chilled carcass weight and chilled dressing percentage were similar for all the treatment groups even though the trend in values for the control diet was numerically higher than the diets with the PKOR. Fresh meat is approximately 70 to 75 percent water, making carcasses very susceptible to evaporative cooling loss in the first 24 hours of chilling, with the losses ranging from 3 to 5 percent of the hot carcass weight (Rentfrow, 2010). Carcasses with moderate fat cover will have good water-holding capacity and less liable to cooler shrink. Knowing the effect of chilling on the carcass is necessary to avoid misunderstandings between meat processors and consumers, in terms of the price difference between warm and chilled carcasses or the possible reduction in weight of paid hot carcass which has to be chilled by the processor and later collected by the consumer/buyer. From Table 7, the warm carcass weight of the control diet lost about 5.5% weight after chilling for 24 hours whereas the 10% and 20% lost 1.63% and 1.14% weight respectively within the same chilling period; indicating that the carcass of birds fed PKOR diets was more resistant to evaporative cooling losses due probably to moderate intramuscular fat content of the meat. Consequently, farmers and companies who wish to process live birds and add value to the meat by chilling and selling chilled broiler meat would find PKOR inclusion in the broiler diets profitable.

The weight of visceral organs (heart, liver, spleen, kidney and gizzard) did not vary significantly (p>0.05) across the dietary treatments; neither did the values indicate any particular trend. PKOR is high in oil; and oxidized oil raises the levels of aldehyde and other oxidized metabolites (Sottero *et al*., 2019). According to earlier work by Fellenberg and Speisky (2006), the accumulation of oxidative products may lead to increased weight of visceral organs, an indication of abnormality. However, none of the organs showed signs of abnormality in the present study as weight of organs were similar for all the dietary groups. The results are consistent with that of Chinajariyawong and Muangkeow (2011) who reported no significant difference in the relative weights of visceral organs of broiler chickens when fed palm kernel meal in diets up to 40%. Subsequently, feeding PKOR in broiler diets up to 20% will not cause organ abnormality and malfunction.

Influence of Genotype × Diet Interaction on Carcass Traits of Broilers

The effect of genotype × diet interaction on carcass parameters is presented in Table 8.

There was no significant (p>0.05) genotype × diet interaction effect on carcass parameters in broilers (Table 8). The results of this work implied that there was absence of joint effect of breed and ration on birds' carcass performance; that is, the two factors acted independently of each other as explained by Olawumi *et al*. (2012). The results of the current work supports the findings of Obeidat *et al*. (2022) who found no strain-diet interaction for carcass traits but contradicts the study by Toledo *et al*. (2004) who reported significant genotype × diet interaction effect on some carcass traits such as breast yield. The absence of genotype × diet interaction in the present study indicates that the nutritional environment of the three diets (0%, 10% and 20% PKOR) similarly favoured gene expression and

Table 8: Effect of genotype × diet interaction on carcass traits in broiler chickens

Traits	Breeds						SED	p-value
	Cobb			Ross				
	Diets							
	0% PKOR	10% PKOR	20% PKOR	0% PKOR	10% PKOR	20% PKOR		
LW (g)	2783	2607	2633	2915	2701	2656	88.00	0.68
WCW (g)	2213	1981	2015	2294	2073	2009	97.30	0.74
WDP (%)	79.57	76.02	76.54	78.71	76.75	75.64	1.80	0.74
CW (g)	2121	1960	1983	2200	2045	1979	99.70	0.77
CDP (%)	76.21	75.18	75.31	75.47	75.71	74.51	0.02	0.78
BW (g)	735.30	653.80	688.30	742.20	637.60	661.50	28.15	0.88
Thigh weight (g)	319.70	310.80	307.30	343.50	336.20	311.90	25.76	0.52
DW (g)	279.40	271.80	268.20	301.60	300.90	273.40	22.40	0.52
Back weight (g)	553.00	488.00	486.00	560.20	496.00	490.80	25.20	0.80
Wing weight (g)	233.60	235.60	233.70	252.80	274.30	242.40	26.41	0.54
AbFW (g)	18.13	18.59	18.63	18.63	18.73	19.01	0.42	0.83

[1]*LW – live weight; WCW – warm carcass weight; WDP – Warm dressing percentage; CW – Chilled weight; CDP –Chilled dressing percentage; BW – Breast weight; DW – Drumstick weight; AbFW – Abdominal fat weight*
[2]*SED – Standard error of difference of means*

regulation of carcass traits. Hence, the two genotypes did not differ in ranking. The implication is that farmers can raise any of the two genotypes on any of the three diets without detrimental effect on carcass yield; provided nutritional composition of diets fed are adequate for requirements of birds in that group.

CONCLUSION

It can be concluded based on the results obtained that the Cobb and Ross strains had similar growth characteristics, an indication that any of them can be used for meat production. There is also a remarkable reduction or savings in feed cost per kilogram weight gain; an indication that farmers would reduce feeding costs, if they used PKOR in diets for Cobb and Ross genotype of broilers in place of wheat bran. Again, it can be concluded that Cobb and Ross genotypes have comparable genetic potential for carcass yield hence any one of the two can serve as a farmer's choice. There was no genotype by diet effect on carcass traits, implying that farmers can raise any of the two genotypes on any of the three diets without detrimental effect on carcass performance; provided nutritional composition of diets are adequate for requirements of birds in that set.

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