Growth Traits and Carcass Characteristics of Broiler Birds Fed Brewer's Spent Grain

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Abstract**—** The effect of different levels of brewer's spent grain (BSG) with enzyme on growth performance and carcass traits was investigated in a five week trial. A total of 300 day old "Anak strain" chicks were randomly assigned to four dietary treatments with five replicates of 15 birds each. The treatments include, BSG0, BSG3, BSG6 and BSG9 for 0 %, 3 %, 6 % and 9 % with enzyme. Birds fed BSG3 recorded an improved ($P<0.05$) growth traits at the end of the feeding trial. Carcass yield, thigh, breast and drumstick weights were higher ($P<0.05$) for birds fed BSG3, whereas, birds fed BSG9 recorded the lowest ($P<0.05$) carcass, thigh, breast and drumstick weights. With regards to improved growth traits and cut yields, 3 % BSG with enzyme can be used safely.

Keywords: broiler chicks, carcass trait, enzyme, weight gain.

I. Introduction

A major problem of poultry in the under developed countries today, despite disease incidence, is the high cost of poultry feeds due to high cost of feed ingredients [1] and it is as a result of the expensiveness of some major conventional feed ingredients which are competed for by both man and animals [2]. The situation does not encourage the proliferation of poultry industry, which may contribute to increase in unemployment, food insecurity and poverty. One of the efforts made to step down the high cost of poultry diets which will help reduce the cost of poultry products was the utilization of cheap and readily available alternative feedstuffs such as brewer's spent grain. It is an extracted residue of cereal grain resulting from the manufacture of beer [3] and it has no human or industrial use for now. Para and Escobar [4] described that 35kg to 45kg of brewer's waste can be generated as residue from the production of 1000 liters of beer. The increased number of brewery industries indicates that large volume of brewer's dried grain is generated yearly. It has concentrated source of digestible fiber, amino acid, B vitamin (water soluble vitamin) and phosphorus quantities [5], [6]. Poultry cannot fully digest high fibre diets because they are devoid of the digestive mechanisms to handle highly fibrous diets which can be solved with exogenous enzyme addition (supplementation) in monogastric diets [7], [8], [9]. Enzymes improves the digestion of fibrous diets and also prevents excreta output of some pollutants such as phosphate and nitrogen, including ammonia [10], [11]. The present trial was therefore designed to investigate the feeding value of enzyme fortified brewer's spent grain with enzyme as a replacement for maize in broiler ration.

II. Materials and Methods

A. Ethical consideration

Ethical principles were taken into consideration during the study to adhere to the national and international standards governing research of this nature with regards to the use of research animals. The permission to use animals was obtained from the Ethical Clearance Committee of the Federal Collage of Agriculture, Ishiagu, Ebonyi State, Nigeria.

B. Study site

The experiment was conducted at the poultry unit of Federal College of Agriculture, Ishiagu, Ivo Local Government Area of Ebonyi State, Nigeria. Ishiagu lies within latitude $06^o\ 22^1$ North and longitude $07^o\ 24^1$ East. It has an annual rainfall range of 1567.05mm to 1846.98m. Natural day lengths are 12-13 hours and mean minimum and maximum daily temperatures are 20.99^oC and 30.33^oC, respectively. Relative humidity ranges from 46.68% to 76.20%. Ishiagu belongs to the humid tropical rainforest zone of South-eastern Nigeria. The entire study lasted for five weeks.

C. Experimental diet.

The brewer's spent grain (BSG) was bought undried in bulk from Nigeria Brewery PLC, Enugu State, Nigeria and was sun dried to 85 percent dry matter (15 percent moisture content). After which, the dried crumbs was broken into homogeneous

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texture and was included in the diet at different levels. The BSG was substituted for maize in four different levels for both starter and finisher diets (Tables 1 and 2). The exogenous enzyme was included at a constant level of 2 g/kg feed in all the experimental diets except for the control diets for both broiler starter and broiler finisher diets, respectively. The four experimental diets was represented as BSG0, BSG3, BSG6 and BSG9 containing 0 %, 3 %, 6 % and 9 % dietary inclusion of BSG with enzyme for both starter and finisher phases. Dietary BSG0 was the control with 0 % BSG without enzyme. The ingredient (%) and chemical composition (g/kg DM) of the four experimental diets (starter and finisher diets) are presented in Tables 1 and 2. The feed ingredients used were supplied by Chidera feeds (PTY) LTD, Enugu State, Nigeria.

D. *Enzyme characteristics*

The exogenous enzyme under consideration in this study is Roxazyme G, it is an enzyme complex derived from *Trichodermaviride* with beta-glucanases, cellulases and xylanase activity produced by DSM Nutritional Products Johannesburg South Africa. The enzyme was selected as feed enzyme candidate because of its bioactive intrinsic characteristics. According to the manufacturer, at peptic and acidic conditions (pH), the enzyme retains more than 90% residual activity after 2hrs at 40°C (DSM).

E. *Experimental birds and management*

A total of 300 day old "Anak strain" chicks were used for the study. Seventy five birds were assigned randomly to one of the four experimental diets (BSG0, BSG3, BSG6 and BSG9) both for starter and finisher phases. Each experimental diet was replicated into five experimental pens (replicates) with fifteen birds per pen measuring 3 m length x 3 m width x 3 m height. The birds were housed in cages with wood shavings as litter. The birds were provided with feed and clean water *ad libitum* in a five-week feeding trial. General flock prophylactic management and routine vaccinations were administered. A stress pack was administered to the birds via drinking water at 100g/50litres (according to manufacturer's prescription) to boost appetite and energy supply.

TABLE I. INGREDIENT (%) AND CHEMICAL COMPOSITION (G/KG DM UNLESS OTHERWISE STATED) OF EXPERIMENTAL DIETS FOR BROILER CHICKS AT THE STARTER PHASE.

Treatments	**BSG0**	**BSG3**	**BSG6**	**BSG9**
Maize	53.00	50.00	47.00	44.00
BSG	0.00	3.00	6.00	9.00
Soy bean meal	11.00	11.00	11.00	11.00
Groundnut cake	21.00	20.90	20.90	20.90
Fish meal	2.00	2.00	2.00	2.00
Wheat offal	8.00	8.00	8.00	8.00
Oyster shell	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Salt	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
Premix	0.25	0.25	0.25	0.25
Enzyme	**0.00**	**0.02**	**0.02**	**0.02**
Total	**100**	**100**	**100**	**100**
Calculated analysis				
Crude protein (%)	22.80	23.02	23.41	23.93
Crude fibre (%)	4.02	5.98	6.97	7.96
ME (kcal/kg)	3100.00	2990.00	2884.00	2801.00
Chemical Composition				
Crude protein (%)	22.09	22.45	22.88	23.09
Crude fibre (%)	4.80	5.93	6.78	7.09
Ether extract (%)	4.60	6.20	8.40	9.50
Ash (%)	10.78	10.86	11.22	11.64
Dry matter (%)	91.95	91.90	91.91	91.93
Moisture	8.05	8.10	8.09	8.07
Nitrogen free extract (%)	53.68	52.41	50.76	47.89
Ether extract (%)	4.60	6.20	8.40	9.50

ME = metabolizable energy. BSG = brewer's spent grain. BSG0 = Basal Diet: BD (without enzyme addition). BSG3 = BD + 3 % BSG with enzyme. BSG6 = BD + 6 % BSG with enzyme. BSG9 = BD + 9 % BSG with enzyme.

F. *Measured growth*

At the beginning of the experiment, birds in each replicate were weighed individually and subsequently on weekly basis. Feed intake was determined daily by the weigh-back technique. Feed conversion ratio was determined as quantity (g) of feed consumed per unit (g) weight gained over the same period.

TABLE II. INGREDIENT (%) AND CHEMICAL COMPOSITION (G/KG DM UNLESS OTHERWISE STATED) OF EXPERIMENTAL DIETS FOR BROILERS AT THE FINISHER PHASE.

Treatments	BSG0	BSG3	BSG6	BSG9
Maize	64.00	61.00	58.00	55.00
BSG	0.00	3.00	6.00	9.00
Soy bean meal	8.00	8.00	8.00	8.00
Groundnut cake	11.00	10.90	10.90	10.90
Fish meal	2.00	2.00	2.00	2.00
Wheat offal	10.00	10.00	10.00	10.00
Oyster shell	2.00	2.00	2.00	2.00
Bone meal	2.00	2.00	2.00	2.00
Salt	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
Premix	0.25	0.25	0.25	0.25
Enzyme	**0.00**	**0.02**	**0.02**	**0.02**
Total	**100**	**100**	**100**	**100**
Calculated analysis				
Crude protein (%)	20.40	20.39	20.41	20.43
Crude fibre (%)	4.28	6.72	8.66	10.45
ME (kcal/kg)	3088.96	2931.86	2812.06	2701.66
Chemical Composition				
Crude protein (%)	19.59	20.00	20.09	20.16
Crude fibre (%)	4.85	6.77	8.66	10.09
Ether extract (%)	4.61	6.30	8.44	10.05
Ash (%)	10.89	10.99	11.45	11.92
Dry matter (%)	91.95	91.90	91.92	91.91
Moisture	8.05	8.10	8.08	8.09
Nitrogen free extract (%)	51.16	50.92	49.01	48.51
Ether extract (%)	4.61	6.30	8.44	10.05

ME = metabolizable energy. BSG = brewer's spent grain. BSG0 = Basal Diet: BD (without enzyme addition). BSG3 = BD + 3 % BSG with enzyme. BSG6 = BD + 6 % BSG with enzyme. BSG9 = BD + 9 % BSG with enzyme.

G. Slaughter procedure

At 35 days of age, all chickens were slaughtered. The chickens were gas stunned by exposing them to relatively low concentrations of carbon dioxide (< 40% by volume in air), and then, once they were unconscious, exposed to a higher concentration (approximately 80% to 90% by volume in air). At the abattoir, all the chickens were hung onto a movable metal rack that holds them upside down by their feet. Chickens were then slaughtered by cutting the jugular vein with a sharp knife and they were left hanging until bleeding stopped.

H. Carcass characteristics

Immediately after slaughter, the feathers were plucked and the gastro intestinal tract (GIT) was removed. The carcasses were then weighed to obtain the carcass weight of the birds. Five birds per replicate were randomly selected for determination of carcass characteristics. For the measurement of carcass cuts, head and shanks were removed close to the scull and at hock joint, respectively. Wings were removed by cutting at the humeoscapular joint, the cuts were made through the rib head to the shoulder girdle, and the vertebrae was then removed intact by pulling outwardly [12]. The breast muscle, neck, wings, shank, thighs, drumsticks and vertebrae (back) were each weighed separately.

I. Proximate analysis

Five Samples of the four experimental diets (starter and finisher diets respectively) were determined for their proximate components using the methods of AOAC [13] and were presented in tables 1 and 2. Again, brewer's spent grain and maize meal were also analysed for their chemical compositions according to AOAC [13] methods (Table 3).

TABLE III: PROXIMATE EVALUATION OF MAIZE MEAL AND BREWER'S SPENT GRAIN

	Maize meal	Brewer's spent grain
Nutrients		
Crude protein (%)	9.89	20.34
Crude fibre (%)	2.90	11.70
Ether extract (%)	3.11	6.19
Ash (%)	1.96	5.98
Dry matter (%)	90.25	84.46
Moisture	9.75	15.54
Nitrogen free extract (%)	63.43	61.57

J. Statistical design and analysis

Data collected during the study were subjected to analysis of variance (ANOVA) for Completely Randomized Design (CRD) as described by Steel and Torrie [14] using Statistical Package for the Social Sciences [15], windows version 17.0. Significantly different means were separated using Duncan's New Multiple Range Test [16] as outlined by Obi [17].

III. RESULTS

A. Growth traits

The growth performance of broiler finisher fed different levels of enzyme fortified brewer's spent grain (BSG) is presented in Table 4. Birds fed BSG3 recorded the highest ($P<0.05$) final body weight, total weight gain and daily weight gain compared with the control (BSG0) fed birds. Birds fed BSG9 had the lowest ($P<0.05$) daily weight gain, total weight gained and final body weight. Increase in total and daily feed consumed was observed for birds fed BSG0 and BSG6 although they are statistically similar to BSG3 fed birds while the lowest total and daily feed consumed was recorded for birds fed BSG9. Birds fed BSG3 showed a better ($P<0.05$) feed conversion (1.79) compared with those provided BSG0, BSG6 and BSG9 with FCR values of 1.92, 2.27 and 2.66 respectively.

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TABLE IV. THE GROWTH PERFORMANCE OF BROILER BIRDS AFFECTED BY BREWER'S SPENT GRAIN WITH ENZYME.

Treatment	BSG0	BSG3	BSG6	BSG9	SEM	P-value
FBW (g)	3020[b]	3120[a]	2590[c]	2010[d]	3.32	0.04
TWG (g)	2978.96[b]	3077.98[a]	2547.99[c]	1968.45[d]	3.40	0.02
DWG (g)	70.93[b]	73.29[a]	60.67[c]	46.87[d]	0.16	0.01
TFI (g)	5676.84[a]	5560.00[ab]	5710.86[a]	5144.00[b]	6.07	0.04
DFI (g)	135.16[a]	132.38[ab]	135.97[a]	122.48[b]	1.22	0.03
FCR	1.91[c]	1.81[d]	2.24[b]	2.61[a]	0.05	0.01

a,b,c,d; Row means with different superscripts differ significantly. SEM= Standard error of the mean. FCR= Feed conversion ratio. BSG = brewer's spent grain. BSG0 = Basal Diet: BD (without enzyme addition). BSG3 = BD + 3 % BSG with enzyme. BSG6 = BD + 6 % BSG with enzyme. BSG9 = BD + 9 % BSG with enzyme. FBW = final body weight. TWG = total weight gain. DWG = daily weight gain. TFI = total feed intake. DFI = daily feed intake. FCR = feed conversion ratio.

B. *Carcass characteristics*

Table 5 showed the carcass characteristics of broiler birds fed brewer's spent grain (BSG) with enzyme. The carcass weight, drumstick, thigh and breast meat weights were all affected ($P<0.05$) by brewer's spent grain with enzyme. However, neck, wing, vertebrate and shank weights were not influenced ($P>0.05$). Carcass weight was higher ($P<0.05$) for birds fed BSG3 compared to those fed other treatments. Thigh weight recorded the highest ($P<0.05$) value for birds fed BSG3 but they are statistically similar with those provided BSG0, while birds fed BSG9 recorded the lowest ($P<0.05$) carcass, thigh and drumstick weights. Breast meat weight was lowest ($P<0.05$) for birds fed BSG6 and BSG9. Birds fed BSG3 had the highest ($P<0.05$) breast meat weight. The highest ($P<0.05$) drumstick weight was recorded for birds fed BSG3, though statistically similar to birds fed BSG0 and BSG6.

TABLE V THE EFFECT OF DIFFERENT LEVELS OF BREWER'S SPENT GRAIN WITH ENZYME ON CARCASS CHARACTERISTICS OF BROILER BIRDS

Treatment	BSG0	BSG3	BSG6	BSG9	SEM	P-Value
CW (g)	2220.90[b]	2316.80[a]	1814.05[c]	1650.09[d]	18.97	0.02
NW (g)	86.47	89.20	84.40	88.07	2.32	0.11
WW (g)	85.47	77.07	83.20	76.33	2.06	0.09
DW (g)	92.00[ab]	99.67[a]	92.27[ab]	81.60[b]	2.57	0.01
TW (g)	109.33[ab]	115.93[a]	90.33[b]	86.67[bc]	2.98	0.04
BW (g)	517.66[b]	591.33[a]	430.20[c]	428.00[c]	5.76	0.02
VW (g)	197.93	187.67	184.93	183.27	3.45	0.21
SW (g)	36.20	38.13	37.00	36.27	0.98	0.17

a,b,c,; Row means with different superscripts differ significantly. SEM= Standard error of the mean. BSG = brewer's spent grain. BSG0 = Basal Diet: BD (without enzyme addition). BSG3 = BD + 3 % BSG with enzyme. BSG6 = BD + 6 % BSG with enzyme. BSG9 = BD + 9 % BSG with enzyme. CW = carcass weight. NW = neck weight. WW = wing weight. DW = drumstick weight. TW = thigh weight. BW = breast weight. VW = vertebrate weight. SW = shank weight.

IV. DISCUSSION

A. *Performance of broiler finisher birds*

The significant ($P<0.05$) higher final body weight, total weight gain and daily weight gain recorded for birds fed BSG3 may be an indication that the inclusion level of 3% brewer's spent grain with enzyme was capable of supplying adequate nutrients for a growth rate better than the control diet (BSG0) that did not contain any brewer's spent grain and enzyme. This may have resulted from the efficient bio-activities of cellulases and glycanases contained in the enzyme which might have resulted in a cleavage of the non-starch polysaccharides (NSPs) in brewer's spent grain (BSG) into smaller polymers, thereby preventing the formation of viscous digesta and improves nutrient digestibility [18], [19], [8]. Earlier research from Agbede *et al*. [20] and Shakouri and Kermanshashi [21] showed a similar improvement for a broiler birds. Poor performances was recorded for final body weight, daily weight gain, total body weight gain and feed conversion ratio of birds as the levels of brewer's spent grain (BSG) increases. The poor performance recorded for birds fed BSG6 and BSG9 may be linked to the increased concentration of anti-nutritive factors (ANFs) present in brewer's spent grain (BSG) [22], [23], [9]. Enzyme inclusion or fortification has the potential to improve the performance of broiler birds by at least two mechanism; improving feed consumption and digestibility of nutrients. Both mechanism can be induced, at least partially, by a reduction of the viscosity to reduce retention time of digesta in the gut and therefore releasing nutrients to the birds for improved growth and efficient conversion of feed to meat [24], [25], [26], [27], [28]. The conversion efficiency of feed to meat was better for birds fed BSG3 compared with the control (BSG0) fed birds that do not contain any enzyme addition to brewer's spent grain (BSG). This finding is supported by Alam *et al*. [29] and Ani and Oyeagu [30], they opined that, the conversion of feed to meat was increased due to better feed utilization. Exogenous enzyme complements the endogenous enzyme of poultry birds by causing the NSPs found in cereals and vegetable proteins to undergo hydrolysis, thereby decreasing gut viscosity, and this improves nutrient availability and absorption [31], [32], [33], [8]. Feed enzymes also have the potentials to change the bacteria population by breaking down the long chain carbohydrate molecules utilized by some bacteria to colonize the tract, and this increases the quality of digested protein amino acid in the pre-caecal section of the tract thereby encouraging more nutrient availability to the host [34], [20]. Generally, among all the treatments used in this study, it was noticed that, birds fed BSG3 performed better compared with those fed other treatments (BSG0, BSG6 and BSG9). This may indicate that enzyme inclusion (2g/kg, constant in all the treatments except control) had its peak bio-activities (reduced viscosity and digestion of nutrients) on brewer's spent grain for birds fed BSG3.

B. *Carcass characteristics*

This study verified a significant effect of enzyme fortified brewer's dried grain on the weights of carcass, drumstick, thigh and breast meat of broiler birds. Birds fed BSG3 performed better compared to those that received the control (BSG0) diets that do not contain enzyme fortified brewer's dried grain. The improvements for birds fed BSG3 in the present study conformed to earlier assertion of Adeola and Olukosi [35] that enzyme fortification improves cut yields of birds. The breakdown of fibrous material in the brewers dried grain by the enzymes (used in fortification) enables the birds to acquire more nutrients from the feed, thus depositing them (nutrients) as tissues in the body. These observations were consistent with the previous report of Iyayi and Okhankuele [36], who observed a significant variation in percent weight of drumstick and breast, when they supplemented exogenous enzymes in the diets of broiler finisher chickens. The ingredients of plant origin offered to the birds have some variations in their chemical structure and presence of anti-nutrients (Phytin, hydrocyanic acid and tannis) which often results to poor performance of birds. This may be the reason for poor carcass and cut yields of birds fed BSG9. It is important to note that the unconvincing carcass and cut yields recorded for birds fed BSG6 and BSG9 may be due to the overwhelming presence of non-starch polysaccharides and anti-nutrients that could not be degraded by the fortified enzyme level used in this study. Adequate supplementation level of diets with exogenous enzymes can reduce the adverse effects of some of these compounds [36], [37], [38]. Similar results were found by Dalolio *et al*. [39] who verified an effect of enzyme complex supplementation in diets based on wheat meal. The increased yield of carcass, drumstick, thigh and breast meat of broilers fed BSG3 in relation to other treatments used in this study may have occurred due to increases in the amount of nutrients available for the development of the retail cut yields. These results are very important to poultry industry because there is a tendency to sell cuts more than the whole carcass due to increase in value aggregate. After the study of Silveira *et al*. [40] on the use of enzyme complex in wheat pelleted diets, they were able to verify an effect on the yield of the leg quarter with a percentage increase of 25 % in relation to birds fed the control diet. Although, they found no significant difference on the yield of breast meat. Cardoso *et al*. [41] also did not found any differences on carcass yield for broilers fed multi-enzyme supplementation with 42 days of age. The results of the current study are consistent with the findings of Alam *et al*. [29], Wang *et al*. [42] and Hajati [43]. They reported an increased carcass yield for birds-fed adequate level of enzyme supplemented diets and attributed it to higher fat deposition in carcass and also increased breast meat yield. The results showed that birds fed BSG3 had a better carcass and cut yields than those on the control (BSG0), BSG6 and BSG9 diets.

V. Conclusion

It was concluded that, up to 3% brewer's spent grain with enzyme can be substituted in broiler diets for an improved performance, and a better cut yields. However, further research is required to investigate the level of exogenous enzyme that can tolerate higher levels of brewer's spent grain (BSG) for increased performance.

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