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GROWTH PERFORMANCE, CARCASS YIELD AND COST IMPLICATIONS OF BROILERS FED WITH SPENT GRAIN AND ENZYME SUPPLEMENTED DIETS

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Abstract

Purpose: This study was aimed at investigating growth performance, carcass characteristics and cost of feed consumption of broilers fed with enzyme fortified diet containing high fibre content.

Methodology: One hundred and forty-four broilers of 7 d old were randomly assigned into nine treatments (SN1 to SN9) with each treatment replicated twice at eight birds per replicate. The experimental design used was a 3 x 3 factorial arrangement involving three levels of enzyme supplementation of 0 g, 0.5 g and 0.8 g per kg diet and three levels of spent grain inclusion of 0%, 6% and 12% in starter's diet and 0%, 7% and 12% in finisher's diets.

Findings: Results obtained proved that DFI, FW, WG, FCR and FC were affected ($p < 0.05$) in starter and finisher birds across treatments. Carcass traits (CW, TW, SW, WW, LW and HW) of finisher broilers were also affected ($p < 0.05$) in all treatments. Starter broilers fed SN3 diet had the best growth traits of the highest ($p < 0.05$) FW (1300.50 g) and WG (1149.58 g) value and the lowest ($p < 0.05$) DFI (73.03 g) and FCR (1.98) means. Finisher broilers fed SN3 diet expressed the highest ($p < 0.05$) FW (3221.54g), WG (1920.54 g) and DFI (177.23 g) means and the lowest ($p < 0.05$) FCR (2.71) value, while finisher broilers fed SN9 diet had lowest ($p < 0.05$) DFI value of 148.43 g. However, finisher broilers fed SN6 diet exhibited moderate growth performance and carcass yield at the lowest FC value of ₦362.50, while finisher broilers in treatment SN3 had the highest ($p < 0.5$) value of each carcass traits investigated.

Unique contribution to theory, practice and policy: In conclusion, SN3 starter diet and SN6 finisher diet are therefore recommended to farmers because the diets showed better growth performance of broilers at low cost of feed consumption and SN6 diet showed good carcass traits of finisher broilers.

Key words: *broilers, spent grains, enzyme, diet, growth and carcass.*

1. Introduction

Poultry industry in Nigeria is fast growing (FAO, 1989) and the production of broilers is a fast means of bridging the gap of animal protein intake in the country. However, the poultry industry has been unable to tackle its numerous challenges in which high cost of feed is the most paramount challenge the industry is currently facing (Gbenga, 2021). Madubuike (2012) reported that 70 to 75% of total cost of poultry production accounts for the cost of feed production. The high cost of feed has also been attributed to high cost of poultry products which affected the quality and quantity of animal protein intake of Nigerians. Gbenga (2021) further reported that the high cost/shortages of maize have forced many farmers out from the poultry business. However, the country has struggled, over the years, to encourage local production of maize as a means of solving this challenge, but to no avail.

However, the replacement of expensive ingredients with alternatives that are cheap and available is a practicable technique to minimize the cost of feed production. Ideally, maize is most suitable ingredient to be substituted because it constitutes about 50 to 60% of poultry feed (NRC, 1994). This will go a long way to reduce the quantity of maize used and the amount of money invested in feeding birds. For instance, by-products of cereal milling and brewery industries such as wheat offal, rice offal, wheat bran and spent grains may be supplemented with energy-source ingredients. Spent grains are predominantly available in brewery industries as by-product or waste which may be supplemented with maize and/or other energy-based feedstuffs (Igwebuike *et al*., 2001). However, spent grains are low energy-base ingredient with high fibre level and non-starch polysaccharides (NSPs). This high level of NSPs causes high rate of viscosity in small intestine, sticky droppings, and also induces reduction in nutrient utilization and metabolizable energy (Bedford, 1997; Alam *et al*., 2003). These side-effects of spent grains consequently impede the growth performance and carcass traits of broilers.

The use of NSP-degrading enzymes in animal feed industries is basically to improve the efficiency of feed utilization, increase the rate of growth, enhance the health conditions and functions of the gastrointestinal tract of animals as well as to reduce environmental pollution by decreasing output of droppings (Acamovic, 2001; Carsten, 2013; Oyeagu *et al*., 2015). NSP enzymes is also used to break the anti-nutritional factors like phytate molecules that bind phosphorous and some other mineral elements in spent grain and other plant based feedstuff (Bedford and Patrige, 2010). Nutrizyme is an exogenous NSP enzymes that contain synthesized complex compounds (viz: carbohydrases, phytase, xylanase, glucanase, pectinase and hemicellulase) which collectively hydrolyze a broad spectrum of carbohydrate polymers such as hemicelluloses, pectin and glycan into low molecular weight fractions. Despite, the benefits of spent grain and feed enzyme, the use of these ingredients is not widespread among farmers due to lack of relevant information required in our local environments to improve the poultry sector of Nigeria. Therefore, this study was aimed at investigating the growth performance and carcass yield of broiler birds fed diets containing different levels of spent grains and feed enzyme when reared in deep litter system.

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2. Methodology

2.1 Location and duration of the study

This study was conducted in the Poultry Unit of the Teaching and Research Farm of the University of Nigeria Nsukka, Enugu State. Nsukka lies in the derived savannah region located on longitude 6º 25¹ N and latitude 07º 24¹ E, at an altitude of 430 m above sea level (Ofomata, 1975). The climate is a tropical humid type with a relative humidity and annual rainfall ranging from 34 to 78% (Momoh *et al*., 2010) and 1567.05 mm to 1846.98 mm (Energy Centre UNN, 2008) respectively. The natural day length for Nsukka is between 11hr : 44 min. to 12hr:31min. (Elile *et al*., 2020; Weather Spark, 2019) and average annual maximum and minimum temperatures is 29.7ºC and 21.0ºC (Energy Centre UNN, 2008) respectively. The study lasted for 56 days which included 7days of pre-experimental period when the chicks were brooded.

2.2 Management of birds and treatments

A total of one hundred and forty-four (144) unsexed Acre broiler chicks were randomly allocated into nine treatments of sixteen birds each after one week of brooding. Each treatment was replicated twice with eight birds per replicate. The treatments were randomly assigned in a 3 x 3 factorial arrangement involving three levels of enzyme supplementation of 0 g, 0.5g and 0.8g per kg diet in both starter and finisher diets; and three levels of spent grain inclusion of 0%, 6% and 12% in starter diet and 0%, 7% and 12% in finisher diet as shown in Table 1. These diets were formulated to meet the nutrient requirements of broilers recommended by NRC (1994). Starter and finisher diet was given *ad libitum* between 7 d to 28 d and between 29 d to 56 d age of the birds respectively. Representative feed samples were assayed for their proximate composition using AOAC (2001) method. The birds were reared in deep litter system and clean cool water was given *ad libitum.* The basic medications and vaccinations were administered and other procedures carried out in this study were in compliance with the provisions of the University of Nigeria, Nsukka Research Policy (2013).

2.3 Measurement of growth and carcass traits

Weight gain (WG) (final body weight – initial body weight) in grammes; average daily feed intake (DFI) [(total feed consumed by birds ÷ the number of the birds) ÷ number of days of the diet was given] in grammes; feed conversion ratio (FCR) (quantity of feed consumed ÷ weight gain); and feed cost per weight gain (FC) (cost of total feed consumed ÷ total weight gain) in naira (Nigerian currency) were calculated for starter and finisher broilers. At the end of the experiment (56 d), a total of eighteen finished broilers were randomly selected (i.e. two birds from each replicate). The birds were put off from feed for 10 h, weighed and then slaughtered. After slaughtering and bleeding, the birds were scalded, defeathered, the heads and shanks were removed. The shanks were weighed and recorded as shank weight (SW), while the remaining

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carcasses were individually weighed and recorded as carcass weight (CW). Each carcass was further dissected into various parts viz: thigh, breast, wing, liver, heart and they were weighed and recorded in grammes as TW, BW, WW, LW and HW respectively using electronic weighing scale.

Table 1: Composition of experimental diets containing different levels of spent grain and enzyme

Treatment		**SN1**	**SN2**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**
					Ingredient (%)					
	Maize	33.30	33.30	33.30	28.42	28.42	28.42	23.28	23.28	23.28
	Wheat offal	22.21	21,71	21.41	22.41	22.91	21.61	23.00	22.05	22.00
	Spent grain	**0.00**	**0.00**	**0.00**	**6.00**	**6.00**	**6.00**	**12.00**	**12.00**	**12.00**
	Soybean meal	15.79	15.79	15.79	15.27	15.27	15.27	14.72	14.72	14.72
	GNC	15.79	15.79	15.79	15.27	15.27	15.27	14.72	14.72	14.72
	Fishmeal	7.89	7.89	7.89	7.63	7.63	7.63	7.36	7.36	7.36
	Bone meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	*Vit-min. premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Starter	Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

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Nutrizyme	**0.00**	**0.05**	**0.08**	**0.00**	**0.05**	**0.08**	**0.00**	**0.05**	**0.08**
Total	100	100	100	100	100	100	100	100	100
	Calculated analysis								
Crude protein (%)	24	24	24	24	24	24	24	24	24
Crude fibre (%)	5	5	5	7	7	7	9	9	9
ME (kcal/kg)	3200	3200	3200	3120	3120	3120	2950	2950	2950
	Proximate composition								
Dm (g)	91.00	90.40	89.25	91.10	89.90	88.40	91.92	91.95	91.90
Cp (%)	23.70	24.04	23.50	23.00	23.03	23.30	23.00	23.01	23.00
Cf (%)	5.03	5.02	5.01	7.07	7.09	6.90	8.98	9.02	8.99
Ee (%)	5.45	5.33	5.35	5.20	5.05	5.00	4.96	5.01	4.98
Ash (%)	7.2	7.60	7.70	8.80	8.70	8.75	9.01	9.04	9.01
Nfe	57.31	56.43	56.30	55.95	51.04	50,58	52.68	49.67	52.00
	Ingredient (%)								
Maize	20.27	20.27	20.27	13.84	13.84	13.84	10.50	10.50	10.50
Wheat offal	47.29	47.29	47.05	48.37	47.87	47.57	47.62	47.12	46.82
Spent grain	**0.00**	**0.00**	**0.00**	**7.00**	**7.00**	**7.00**	**12.00**	**12.00**	**12.00**

	Soybean meal	19.21	19.21	17.47	18.05	18.05	18.05	17.47	17.47	17.47
	GNC	5.49	5.49	4.99	5.16	5.16	5.16	4.99	4.99	4.99
	Fishmeal	2.74	2.74	2.49	2.58	2.58	2.58	2.49	2.49	2.49
Finisher	Bone meal	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
	Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	*Vit-min. premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Lysine	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	Nutrizyme	**0.00**	**0.05**	**0.08**	**0.00**	**0.05**	**0.08**	**0.00**	**0.05**	**0.08**
	Total	100	100	100	100	100	100	100	100	100
		Calculated analysis								
	Crude protein (%)	20	20	20	20	20	20	20	20	20
	Crude fibre (%)	7	7	7	9	9	9	11	11	11
	ME (kcal/kg)	2950	2950	2950	2850	2850	2850	2720	2720	2720
		Proximate composition								
	Dm (g)	91.00	90.40	89.25	91.10	89.90	88.40	91.92	91.95	91.90
	Cp (%)	23.70	24.04	23.50	23.00	23.03	23.30	23.00	23.01	23.00
	Cf (%)	5.03	5.02	5.01	7.07	7.09	6.90	8.98	9.02	8.99
	Ee (%)	5.45	5.33	5.35	5.20	5.05	5.00	4.96	5.01	4.98

Ash (%)	7.2	7.60	7.70	8.80	8.70	8.75	9.01	9.04	9.01
Nfe	57.31	56.43	56.30	55.95	51.04	50,58	52.68	49.67	52.00

GNC = Groundnut cake; ME = Metabolizable energy; Dm = Dry matter; Cp = Crude protein; Cf = Crude fibre; Ee = Esther extract; Nfe = Nitrogen free extract; *Vitamin and mineral premix (commercial source B.p max), each diet was supplied with 2.5 kg ton^{-1} and each 2.5kg contains, vit A 10,000,000 MIU, Vit. D 2,000,000 MIU, Vit. E 1,000 mg, Vit. K_3 1,000 m, Vit. B1 1,000 mg, Vit. B2 5,000 mg,Vit. B6 1,500 mg, Biotin 50 g, BHT 1,000 mg, Pantothenic 10,000 mg, Folic acid 1,000 mg, Nicotinic acid 30,000 mg, Mn 60 g, Zinc 50g, Fe 30 g, Cu 4 g, Selenium 0.1g and Co 0.1 g.

2.4 Experimental design

The experimental design used was a completely randomized design (CRD) with the following model:

$X_{ijk} = \mu + S_i + N_j (SN)_{ij} + €_{ijk}$, where:

X_{ijk}= overall observations of the birds fed diets containing (i^{th}) spent grain and (j^{th}) enzyme at different

(k^{th}) levels;

μ = overall mean of the experiment;

S_i = effect of the (i^{th}) spent grain on the individual bird;

N_j = effect of the (j^{th}) enzyme on the individual bird;

$(SN)_{ij}$ = interaction effect of the (i^{th}) spent grain and the (j^{th}) enzyme on the individual bird; and

$€_{ijk}$= experimental error associated with the (i^{th}) spent grain and (j^{th}) enzyme at different (k^{th}) levels.

2.5 Statistical analysis

Data collected were subjected to analysis of variance for factorial experiments in a completely randomized design (CRD) as described by Steel and Torrie (1980) using a statistical computer package (SPSS, 2007) model. Means were separated using Duncan's New Multiple Range Test and accepted at the level of $p < 0.05$.

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3. Results and discussion

The results of the study are presented in Table 2 and 3. Analyses of variance of the data revealed that body weight (BW), weight gain (WG), feed intake (FI), feed conversion ratio (FCR) and feed cost (FC) were significantly ($p < 0.05$) affected in the starter and finisher birds subjected across the dietary treatments. The weight of carcass (CW), thigh (TW), breast (BW), shank (SW), wing (WW), liver (LW) and heart (HW) were also affected ($p < 0.05$) among finisher birds in the treatments.

Table 2: Interaction effects of different levels of spent grain and enzyme on growth performance and cost of feed intake of starter broilers

Trts	**SN1**	**SN2**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	
LS (%)	**0**	**0**	**0**	**6**	**6**	**6**	**12**	**12**	**12**	
LE (g/kg)	**0**	**0.5**	**0.8**	**0**	**0.5**	**0.8**	**0**	**0.5**	**0.8**	**SEM**
					Growth indices and feed cost					
IW (g)	164.29	150.00	151.58	150.00	152.15	150.00	161.56	161.87	161.58	4.38
FW (g)	1123.44^{b}	1194.46^{b}	1300.50^{a}	1038.22^{c}	1125.43^{b}	1138.22^{b}	988.22^{cd}	1075.43^{c}	973.44^{d}	6.32
WG (g)	959.15^{c}	1044.46^{b}	1149.58^{a}	886.43^{d}	975.06^{c}	987.21^{c}	827.4^{d}	913.30^{d}	812.02^{e}	7.2
DFI(g)	74.01^{a}	74.07^{a}	73.03^{a}	77.01^{b}	75.4^{ab}	74.05^{a}	76.10^{b}	84.11^{c}	83.04^{c}	1.63
FCR	2.10^{d}	$2.0.03^{d}$	1.98^{e}	2.54^{c}	2.50^{cd}	2.43^{d}	3.22^{a}	2.65^{b}	$2.62.12^{b}$	0.33
FC (₦)	282.19^{f}	292.50^{e}	282.03^{f}	336.20^{b}	318.54^{d}	338.25^{b}	322.03^{cd}	397.30^{a}	326.84^{c}	1.62

a, b, c, d, e = Means with different superscripts significantly different at $p < 0.05$; Trts = Treatments; SEM=Standard error of mean; LS=Level of spent grain; LE = Level of enzyme; IW = Initial weight; FW = Final weight; WG = weight gain, DFI = Daily feed intake; FCR =

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Feed conversion ratio; FC = Feed cost per kg weight gain.

Table 3: Interaction effects of different levels of spent grain and enzyme on growth performance and carcass characteristics of finisher broilers

Trts	**SN1**	**SN2**	**SN3**	**SN4**	**SN5**	**SN6**	**SN7**	**SN8**	**SN9**	
LS	**0**	**0**	**0**	**7**	**7**	**7**	**12**	**12**	**12**	
LE	**0**	**0.5**	**0.8**	**0**	**0.5**	**0.8**	**0**	**0.5**	**0.8**	**SEM**
					Growth indices and feed cost					
IW (g)	1123.44	1194.46	1300.50	1038.22	1125.43	1138.22	988.22	1075.43	973.44	5.51
FW (g)	3000.07^{a}	3065.66^{a}	3221.54^{a}	2500.10^{c}	2575.43^{b}	2645.89^{b}	2100.01^{d}	2150.09^{c}	2450.87^{c}	7.34
WG (g)	1878.44^{a}	1886.46^{a}	1920.54^{a}	1375.43^{c}	1507.33^{bc}	1537.01^{b}	1105.22^{c}	1125.43^{d}	1478.43^{c}	6.71
DFI (g)	164.49^{b}	173.58^{d}	177.23^{d}	169.64^{c}	163.14^{b}	158.14^{ab}	154.14^{a}	151.14^{a}	148.43^{a}	3.38
FCR	3.07^{c}	2.92^{d}	2.71^{e}	3.56^{b}	3.20^{bc}	3.12^{c}	3.84^{a}	3.69^{a}	3.53^{b}	0.96
FC (₦)	410.43^{c}	390.50^{c}	365.25^{b}	456..02^{d}	399.87^{c}	362.50^{c}	493.32^{e}	429.62^{c}	342..04^{a}	23.06
				Carcass traits						
CW (g)	232.55^{b}	235.89^{b}	256.44^{a}	173.43^{d}	196.73^{c}	197.66^{d}	146.77^{e}	160.89^{de}	193.14^{c}	12.89
TW (g)	560.29^{b}	570.29^{b}	640.07^{a}	425.29^{c}	494.29^{bc}	493.44^{bc}	351.58^{d}	381.58^{d}	483.02^{c}	18.93
BW (g)	607.87^{b}	657.87^{b}	715.29^{a}	420.00^{d}	510.87^{cd}	515.29^{c}	354.58^{e}	417.02^{d}	543.73^{c}	31.19

SW (g)	95.29^{ab}	95.00^{ab}	103.50^{a}	70.00^{cd}	79.19^{c}	80.29^{c}	65.29^{d}	67.58^{d}	77.87^{c}	3.44
WW (g)	230.00^{ab}	235.29^{ab}	250.00^{a}	181.58^{c}	190.00^{c}	196.87^{c}	150.00^{d}	159.29^{d}	190.00^{c}	16.70
LW (g)	60.29^{a}	58.00^{a}	65.29^{a}	45.00^{c}	50.29^{b}	50.00^{b}	40.00^{c}	41.29^{c}	47.87^{bc}	2.42
HW (g)	14.00^{b}	14.06^{b}	15.12^{a}	11.00^{cd}	12.63^{c}	12.05^{c}	9.05^{d}	10.16^{d}	11.12^{cd}	1.95

$^{a, b, c, d, e}$ = Means with different superscripts significantly different at $p < 0.05$; SEM = Standard error of mean; LS = Level of spent grain; LE = Level of enzyme; IW = Initial weight; FW = Final weight; WG = Weight gain, DFI = Daily feed intake; FCR = Feed conversion ratio; FC = Feed cost per kg weight; CW = Carcass weight; TW = Thigh weight; SW = Shank weight; WW = Wing weight; LW = Liver weight; HW = Heart weight.

3.1 Growth performance

At the starter stage of development, the birds fed enzyme supplemented diet of 0.8g/kg (SN3) had the lowest ($p < 0.05$) DFI of 73.03 g; and the highest ($p < 0.05$) WG of 1149.58 g and FW of 1300.50 g when compared to the broilers fed with enzyme-free diets (SN1) and diet containing 0.5g enzyme (SN2) at the same 0% level of spent grain. This implies that starter broilers fed enzyme-fortified diets tends to adapt to the high level of enzyme introduced into the diet by increasing the digestive secretions and the weight and size of the gastrointestinal tract (Brenes *et al*., 1993). This increase in the rate of digestion and absorption of nutrients may in turn improve weight gain at low feed intake in starter broilers (Ani and Omeje, 2007; Oyeagu *et al*., 2015). FW and WG means were significantly ($p < 0.05$) improved among the birds fed enzyme-fortified diets containing 6% and 12% of spent grain (SN5, SN6 and SN8 diets) compared to birds fed enzyme-free diet containing 6% and12% spent grain (SN4 and SN7 diets), with the exception of SN9 diet that had lowest ($p < 0.05$) FW (973.44 g) and WG (812.02 g) at starter phase. These results indicated that enzyme supplementation had beneficial impacts on the utilization of diets by improving the energy digestibility (Pourreza *et al*., 2007; Ramesh and Chandrasekaran, 2011) through the increase of degradation of high fibre (as shown in Table 1) and NSP content (Tufarelli *et al*., 2007; Hosseini and Afshar, 2017). According to Caspary (1992) and Ritz *et al*. (1995), enzyme supplementation promotes nutrient absorption by increasing the length of villi within the jejunal and ileal sections. Wang *et al*. (2005) further observed that starter broilers fed with enzyme supplemented diet increases the length and weight of ileum and cecum within the first 21days of age. However, birds in treatment SN9 were relatively retarded ($p < 0.05$) in their growth indices. This may be as a result of the incapacity of the microflora and enzymes in

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digestive tract of young birds to breakdown the complex chemical composition of spent grain taken in large quantity by the birds (Vranjes and Wenk, 1995; Choct *et al*., 1996). Thus, starter broilers fed diet SN3 (0.8 g enzyme/kg and 0% spent grain) had the best ($p < 0.05$) growth traits of lowest daily feed intake (73.03 g), highest feed conversion ratio (1.98), highest final body weight (1300.50 g) and weight gain (1149.58 g) at lowest feed cost per weight gain (₦282.03).

At the finisher stage of development, it was observed that broilers fed SN1, SN2 and SN3 diet had better ($p < 0.05$) FW means of 3000.07 g, 3065.66 g, 3220.54 g; and WG ($p < 0.05$) values of 1878.44 g, 1886.46 g and 1920.54 g respectively than broilers fed diets containing high levels of spent grain (i.e. diet SN4 to SN9). This may be attributed to the high metabolizable energy and low crude fibre content of diet SN1, SN2 and SN3, as shown in Table 1. This argument is in line with the findings documented by Adebiyi *et al*. (2010) on the nutritional potentials of enzyme-treated and enzyme-free diets with different levels of cowpea seed hulls inclusion. Furthermore, looking at each level of spent grain inclusion (i.e. 0%; 7% and 12%), birds fed with 0.5 g or 0.8 g of enzyme per kg diets had improved growth traits than birds fed with enzyme-free diets. This indicates that enzyme supplementation promotes digestion and absorption of nutrients which concur with the observations reported by Pourreza *et al*., (2007), Tufarelli *et al*. (2007), and Hosseini and Afshar (2017), as earlier discussed. The birds in SN7 treatment had the lowest ($p < 0.05$) WG of 1125.22 g and FW of 2100.01 g. This therefore showed high NSP concentration inhibits the growth performance of birds at finisher stage of development. This adverse-effect of high NSP concentration may be moderately controlled by increasing the level of enzyme supplement in finisher diets. Broilers in treatment SN3 had highest ($p < 0.05$) mean of FW (3220.54 g), WG (1923.54 g) and DFI (177.23 g) as well as the best ($p < 0.05$) FCR (2.71), while birds fed SN9 diet had the lowest ($p < 0.05$) DFI (148.43 g) and the highest ($p < 0.05$) FCR (3.53) mean. These observations showed that enzyme supplementation improves feed utilization (Gunal and Yasar 2004) and spent grain inclusion reduces feed efficiency (Zhou, 2009). Economically, in finisher broilers, enzyme-free diet containing high level of spent gain incurred high cost of feed consumption and exhibited retarded growth traits when compare to poor growth indices and cost of feed intake of birds subjected to enzyme-fortified diet. For instance, broilers in treatment SN7 had the lowest ($p < 0.05$) body weight of 2100.01 g but incurred the highest ($p < 0.05$) feed cost per kg weight gained of ₦493.50, while birds in treatment SN9 obtained an improved ($p < 0.05$) final body weight of 2450.87 g and weight gain of 1478.43g at cheapest cost of feed per kg weight gain of ₦342.04 due to the increased level of 0.08g/kg enzyme supplementation.

3.2 Carcass performance

The dressed carcass of broilers fed diet SN3 had the highest ($p < 0.5$) values in all the carcass traits, while carcass of broilers in SN7 treatment exhibited the lowest ($p < 0.5$) values of carcass traits investigated, expect in the shank weight (SW) of the broilers fed SN8 diet that showed lowest ($p < 0.5$) mean of 65 g. This showed that enzyme supplementation improves carcass characteristics. These results are in agreement with the findings reported by Wang *et al*. (2005) and Alam *et al*. (2003) that enzyme supplementation increases carcass yield and carcass fat deposit. On the other hand, these results contradicted the recent findings of Abdelrahim *et al*. (2018) that carcass traits of birds fed with enzyme treated diets were almost the same with the carcass traits of birds given non-treated diets.

4.0 Conclusion and recommendation

It is evident from the results obtained in this study that inclusion of exogenous enzyme to broilers' diet improves growth and carcass performance and consequently reduces cost of feed consumption of the birds. Inclusion of 0.8g enzyme per kg starter diet that was free from spent grain improves the growth of young broilers at favourable cost of feed consumption. Finisher birds fed enzyme-free diets that contained 7% (SN4) or 12% (SN7) spent grain retarded growth and carcass traits and also incurred high cost of feed. The inclusion of 7% spent grain and 0.8g enzyme supplement in finisher diet (SN6) moderately improves growth and carcass yield at minimal cost of feed consumption. Therefore, SN3 (starter) and SN6 (finisher) diets are recommended to poultry farmers in order to increase profit and production of broilers.

Conflict of interest

The authors declare that they have no conflict of interest.

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