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RESEARCH ARTICLE

Growth Response and Nutrient Digestibility of Broiler Chickens Fed Wheat-Based Diets Supplemented With an Exogenous Enzyme

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ABSTRACT

The objective of this study was to determine the effect of Roxazyme G2G supplementation on the growth performance and nutrient digestibility in broiler chickens fed wheat-based diets at varying levels of inclusion (0, 10, 20 and 30%) without or with enzyme supplementation in an experiment that lasted for 56 days. Four hundred and twenty (420) 1-day-old broiler chicks (Arbor Acre strain) were randomly assigned to 7 dietary treatments consisting 6 replicates with 10 birds each in a 2×4 factorial arrangement of a completely randomised design. Weekly feed intake and weight gain of birds in the starter and finisher phases were significantly ($P<0.05$) improved though enzyme supplementation did not affect the feed conversion ratio (FCR) and protein efficiency ratio of the birds. There was no positive interactive effect of wheat and enzyme on the performance parameters of birds measured in both the starter and finisher phases except the feed intake. Although, wheat-based diets affected the feed intake of birds in starter phase with a corresponding effect when enzyme was supplemented, similar trend was observed for the finisher phase. Apparent nutrient digestibility in birds was significantly ($P<0.05$) improved with enzyme supplementation when compared with other diets. The cost of feed per kilogram weight gain was highest (₦262.87) for the birds on 20% wheat with enzyme supplementation and lowest (₦175.57) for those on the control diet in the finisher phase. The results showed that Roxazyme G2G evaluated improved some performance indices and positively enhanced nutrient digestibility in broilers chickens fed wheat-based diets.

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INTRODUCTION

The identification and alleviation of factors that inhibit nutrient utilisation are necessary for successful poultry production. Among potential factors reducing nutrient bioavailability are the non-starch polysaccharides (NSPs) in ingredients such as wheat, soyabean meal, barley, oat, rye, sesame meal etc. (Mehri *et al*., 2010). NSPs are considered the major anti-nutritive factors in cereals and other varieties of feed ingredients (Bedford and Classen, 1992). Wheat contains both water-soluble and insoluble NSPs which constitute between 7.5 and 16.6% of the dry matter. The physical entrapment of wheat starch and protein by cell wall polysaccharides has been suggested as an important factor by which NSP exert their anti-nutritive properties (Theander *et al*., 1989; Bedford and Autio, 1996; Wiseman *et al*., 2000). The anti-nutritive effect of soluble NSP is manifested through inhibition of digestion of starch, lipid and protein in the foregut (Choct and Annison, 1992). Salih *et al*. (1991) reported that, NSP reduced feed intake and decreased broiler chicken performance. However, arabinoxylans, which are the predominant NSP in wheat cannot be digested and adequately utilised by birds. Nevertheless, the use of NSP-degrading enzymes has been shown to improve the nutritive value of wheat for birds by reducing the anti-nutritional effects of non-starch polysaccharides (Preston *et al.,* 2001; Choct and Annison, 2004). The benefits of exogenous enzyme supplementation to non-starch polysaccharide diets are well documented (Bedford and Classen, 1992; Almirall *et al*., 1995; Yu *et al*., 1997). Roxazyme G2G is one of the numerous exogenous enzymes used in poultry diets. It is a commercial multi-enzyme complex which contains β-glucanase and β-

xylanase activities. Its addition to poultry diets has been reported to improve growth performance, enhance flock uniformity as well as reduction of nutrient waste that is released to the environment (Cowieson and Adeola, 2005). The aim of this study therefore was to investigate the effect of Roxazyme G2G on performance and nutrient digestibility in broilers fed wheat-based diets.

MATERIALS AND METHODS

Management of experimental birds

The experiment was carried out in the Poultry unit of the Teaching and Research Farm, University of Ibadan, Ibadan, Nigeria. Four hundred and twenty (420) broiler chicks were used for this study. The birds were reared in a well ventilated and illuminated standard poultry house. After 7 days of brooding, the birds were randomly allotted to 7 dietary treatments by body weight consisting of 6 replicates of 10 birds each. The experimental diets and water were supply *ad libitum* during the study period that lasted for 56 days. During the experimental period daily feed intake was determined by deducting the left over from the total quantity of feed supplied to the birds. Weights of birds were monitored weekly, protein efficiency ratio, feed conversion ratio and cost of feed/kg weight were also calculated as follows:

Protein efficiency ratio = Weight gain/ Protein intake
Feed conversion ratio = Feed intake/ Weight gain
Cost of feed/kg weight gain = Feed intake/ Weight gain × Feed cost

Experimental diets

Seven dietary treatments were formulated to evaluate the effect of Roxazyme G2G supplementation on birds fed wheat-based diets. The starter and finisher diets were offered to the birds from day 8 to 28 and day 29 to 56 respectively. Treatment 1 was the control which had a diet, without wheat and Roxazyme G2G; treatments 2, 3 and 4 contained wheat at 10%, 20% and 30% inclusion levels without enzyme inclusion while treatments 5, 6 and 7 contained wheat at 10%, 20% and 30% inclusion levels with 0.025% of Roxazyme G2G (contains endo-1,4-beta Glucanase and endo-1,3 (4)-beta Glucanase and endo-1,4-beta Xylanase) for both the starter and finisher phases (Tables 1 and 2).

Experimental design

The experimental design was a completely randomised design with a 2x4 factorial arrangement.

Nutrient digestibility

At week 8, six birds were taken from each treatment and placed in metabolic cages for collection of faeces; for digestibility studies. Fresh excreta were collected in the morning, weighed, and oven dried for a period of 3 days. The oven-dried excreta were used for analysis and subsequently used for digestibility calculation.

Nutrient digestibility was calculated as follows:

Apparent Nutrient Digestibility (%) = Nutrient intake – Nutrient output/ Nutrient intake × 100

Chemical analysis

Proximate analyses of the diets and excreta samples were carried out according to the methods of AOAC (2000).

Statistical analysis

Data obtained were analysed using descriptive statistics and ANOVA ($P<0.05$) (SAS, 2006). Mean differences were separated using Duncan Multiple Range Test.

RESULTS

Performance of broilers on experimental diets (starter phase)

The result of proximate composition of experimental broiler finisher diets is as shown in Table 3. The crude protein and crude fibre of birds fed wheat based-diets ranged from 16.37 - 21.51% and 4.14- 4.55 respectively.

Table 1: Gross composition of experimental broiler diets (g/100gDM) (starter diets)

	Without Enzyme				With Enzyme		
Ingredients	0	10	20	30	10	20	30
Maize	58.50	48.50	38.50	28.50	48.50	38.50	28.50
Wheat	0.00	10.00	20.00	30.00	10.00	20.00	30.00
Soyabean meal	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Groundnut cake	9.80	9.80	9.80	9.80	9.80	9.80	9.80
Fish meal (72% CP)	3.10	3.10	3.10	3.10	3.10	3.10	3.10
Limestone	1.10	1.10	1.10	1.10	1.10	1.10	1.10
*DCP (23%Ca; 18% P)	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
**Broiler premix	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
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Roxazyme G2G	-	-	-	-	0.025	0.025	0.025
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients (%)							
Crude protein	23.00	23.10	23.20	23.30	23.10	23.20	23.30
Energy (Kcal/gME)	3.03	3.00	2.97	2.93	3.00	2.97	2.93
Lysine	1.38	1.38	1.38	1.38	1.38	1.38	1.38
Methionine	0.61	0.61	0.61	0.61	0.61	0.61	0.61

*DCP- Dicalcium Phosphate **Composition of Premix per Kg of diet: vitamin A, 12,500 I.U; vitamin D_3, 2,500 I.U; vitamin E, 40mg; vitamin K_3, 2mg; vitamin B_1, 3mg; vitamin B_2, 5.5mg; niacin, 55mg; calcium pantothenate, 11.5mg; vitamin B_6, 5mg; vitamin B_{12}, 0.025mg; choline chloride, 500mg; folic acid, 1mg; biotin, 0.08mg; manganese, 120mg; iron, 100mg; zinc, 80mg; copper, 8.5mg; iodine, 1.5mg; cobalt, 0.3mg; selenium, 0.12mg; Anti-oxidant, 120mg.

Table 2: Gross composition of experimental broiler diets (g/100gDM) (finisher diets)

	Without Enzyme				With Enzyme		
Ingredients	0	10	20	30	10	20	30
Maize	66.50	56.50	46.50	36.50	56.50	46.50	36.50
Wheat	0.00	10.00	20.00	30.00	10.00	20.00	30.00
Soyabean meal	19.50	19.50	19.50	19.50	19.50	19.50	19.50
Groundnut cake	8.30	8.30	8.30	8.30	8.30	8.30	8.30
Fish meal (72% CP)	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Limestone	1.20	1.20	1.20	1.20	1.20	1.20	1.20
*DCP (23%Ca; 18% P)	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Salt	0.25	0.25	0.25	0.25	0.25	0.25	0.25
**Broiler premix	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
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Roxazyme G2G	-	-	-	-	0.025	0.025	0.025
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated nutrients (%)							
Crude protein	20.00	20.10	20.20	20.30	20.10	20.20	20.30
Energy (Kcal/gME)	3.09	3.01	2.94	2.87	3.01	2.94	2.87
Lysine	1.02	1.17	1.17	1.17	1.17	1.17	1.17
Methionine	0.56	0.56	0.56	0.56	0.56	0.56	0.56

*DCP- Dicalcium Phosphate **Composition of Premix per Kg of diet: vitamin A, 12,500 I.U; vitamin D_3, 2,500 I.U; vitamin E, 40mg; vitamin K_3, 2mg; vitamin B_1, 3mg; vitamin B_2, 5.5mg; niacin, 55mg; calcium pantothenate, 11.5mg; vitamin B_6, 5mg; vitamin B_{12}, 0.025mg; choline chloride, 500mg; folic acid, 1mg; biotin, 0.08mg; manganese, 120mg; iron, 100mg; zinc, 80mg; copper, 8.5mg; iodine, 1.5mg; cobalt, 0.3mg; selenium, 0.12mg; Anti-oxidant, 120mg.

Table 3: Proximate composition of experimental finisher diets (g/100gDM)

		Without Enzymes			With Enzymes		
					Wheat Inclusion Levels		
Variable	0	10	20	30	10	20	30
Dry Matter	91.01	91.42	91.62	91.15	91.75	91.73	89.51
Crude Protein	21.51	17.51	18.25	20.11	16.37	18.67	21.03
Crude Fibre	4.46	4.33	4.55	4.53	4.14	4.42	4.48
Ether Extarct	7.21	6.36	6.22	5.56	4.74	8.07	4.56
Ash	5.73	6.31	7.51	6.65	6.61	8.53	5.91
NFE	61.09	65.49	63.47	63.15	68.14	60.31	64.02

*NFE = Nitrogen Free Extract

Table 4: Performance of broilers on experimental diets (starter phase)

		Without Enzyme			With Enzyme			
Variables	Control	10	20	30	10	20	30	SEM
Initial weight (g/b)	128.33	126.67	126.83	125.83	127.50	129.17	130.83	3.24
Final weight (g/b)	943.87^{c}	1031.83^{b}	1014.53^{b}	1018.47^{b}	1027.03^{b}	1086.00^{a}	1019.01^{b}	26.70
Weekly weight gain (g/b)	815.53^{c}	905.17^{b}	887.70^{b}	892.63^{b}	899.53^{b}	956.83^{a}	888.27^{b}	26.67
Weekly feed intake (g/b)	1205.35^{e}	1365.90^{c}	1390.68^{c}	1346.27^{d}	1520.73^{a}	1526.72^{a}	1487.03^{b}	20.33
FCR	1.48	1.52	1.56	1.51	1.69	1.60	1.68	0.23
PER	2.77^{b}	2.42^{c}	2.86^{a}	2.76^{b}	2.74^{b}	2.88^{a}	2.39^{c}	0.05

Means with different superscripts on the same row are significantly (P<0.05) different; SEM- Standard Error of Mean, g/b- gram per bird, FCR- Feed Conversion Ratio, PER- Protein Efficiency Ratio

The results of the feed intake, weight gain, feed conversion ratio and protein efficiency ratio of broilers fed the experimental diets are shown in Table 4. The highest final weight, weight gain and feed intake were recorded in birds on 20% wheat inclusion with enzyme supplementation. The weight gain in birds on wheat based-diets without or with enzyme supplementation were significantly higher (P<0.05) than those on the control diet. The birds on the control diet had significantly (P<0.05) lower (1205.35g) feed intake than birds on other dietary treatments. There were no significant differences in the feed conversion ratio (FCR) of birds across the treatments. Although, improved FCR value (1.48) was recorded in birds on the control diet. The protein efficiency ratio was highest (2.88) in birds on 20% wheat based-diet with enzyme supplementation while birds on 30% wheat diet with enzyme had the least value (2.39).

Table 5: Effect of wheat, enzyme and their interactions (P-ANOVA) on growth performance indices of birds on experimental diets (Starter Phase)

Parameters	Wheat	Enzyme	Wheat*Enzyme
Initial weight	0.5527^{ns}	0.0851^{ns}	0.5218^{ns}
Final weight	0.0677^{ns}	0.3106^{ns}	0.2936^{ns}
Weight gain	0.0470^{ns}	0.4215^{ns}	0.3479^{ns}
Feed intake	0.0004*	0.0003*	0.2946^{ns}
Feed Conversion Ratio	0.6322^{ns}	0.3917^{ns}	0.4983^{ns}
Protein Efficiency Ratio	0.6475^{ns}	0.3148^{ns}	0.4983^{ns}

ns - not significant, * - significant at 0.05%

The effect of wheat, enzyme and their interactions on growth performance indices of birds on experimental diets are shown in Table 5. No interactive effects were observed in wheat inclusion and enzyme supplementation on the initial weight, final weight, weight gain, feed conversion ratio and protein efficiency ratio of broilers

Table 6: Performance indices of birds on experimental diets (finisher phase)

Variable	Control	Without Enzyme			With Enzyme			SEM
		10	20	30	10	20	30	
Initial weight (g/b)	943.87^{c}	1031.83^{b}	1014.53^{b}	1018.47^{b}	1027.03^{b}	1086.00^{a}	1019.10^{b}	31.30
Final weight (g/b)	2177.50^{b}	1059.30^{c}	2224.10^{a}	2139.80^{b}	2290.60^{a}	2144.60^{b}	2104.30^{b}	87.16
Weekly Weight gain (g/b)	1233.70^{a}	1027.50^{b}	1209.80^{a}	1121.00^{b}	1263.60^{a}	1058.60^{b}	1086.90^{b}	100.95
Weekly Feed intake(g/b)	2499.60^{b}	2569.10^{b}	3038.40^{a}	2751.20^{b}	3023.80^{a}	3007.70^{a}	2982.00^{a}	47.17
Feed Conversion Ratio	2.03^{e}	2.50^{c}	2.40^{d}	2.45^{c}	2.39^{d}	2.84^{a}	2.74^{b}	0.05
Protein Efficiency Ratio	2.48^{d}	2.93^{a}	2.30^{e}	2.58^{c}	2.83^{b}	2.41^{d}	2.07^{f}	0.07
Mortality (%)	0.00^{d}	5.00^{a}	5.00^{a}	3.30^{b}	0.00^{d}	1.70^{c}	1.70^{c}	0.26

Means with different superscripts on the same row are significantly (P<0.05) different; g/b- gram per bird, SEM- Standard Error of Mean

Table 7: Effect of wheat, enzyme and their interactions (P-ANOVA) on growth performance indices of birds on experimental diets (Finisher Phase)

Parameters	Wheat	Enzyme	Wheat*Enzyme
Initial weight	0.0677^{ns}	0.3106^{ns}	0.2936^{ns}
Final weight	0.7859^{ns}	0.5137^{ns}	0.0802^{ns}
Weight gain	0.6296^{ns}	0.8005^{ns}	0.0644^{ns}
Feed intake	0.0121*	0.0084*	0.0518*
Feed Conversion Ratio	0.0808^{ns}	0.9171^{ns}	0.3646^{ns}
Protein Efficiency Ratio	0.0223*	0.5105^{ns}	0.1654^{ns}

ns - not significant, * - significant at 0.05%

fed the experimental diets for starter phase. However, the feed intakes of birds were observed to be affected by wheat and enzyme supplementation.

Performance of broilers on experimental diets (finisher phase)

There were significant (P<0.05) differences observed in the initial weight, final weight, weight gain and feed intake of birds on the experimental diets (Table 6). Birds fed 10% wheat with enzyme supplementation had the highest (2290.60g/b) final weight gain which was not different from those on 20% wheat diet without enzyme. Weight gain of birds fed 10% wheat based-diet with enzyme was significantly (P<0.05) improved and compared favourably with the birds on the control diet. There was no significant difference in the feed intake among the birds fed wheat-based diets with enzyme supplementation. Birds fed with 20% wheat diet without enzyme had the highest (3038.40g/b) feed intake, though similar to those birds on enzyme supplementation while least value (2499.60g/b) was recorded in birds fed the control diet.

The least feed conversion ratio (2.03) was recorded in birds fed the control diet which was significantly (P<0.05) lower than other diets. The highest (2.84) feed conversion ratio (FCR) was recorded for birds on 20% wheat based-diet with enzyme which was significantly (P<0.05) different from those on other dietary treatments. Highest value (2.93) of protein efficiency ratio (PER) was observed in birds fed 10% WW without enzyme and was significantly (P<0.05) different from birds on the other diets. Birds on 30% wheat with enzyme had the least PER (2.07) value. There was no mortality observed in birds on the control diet and those on 10% wheat with enzyme. However, 1.70% mortality was observed in birds fed with 20 and 30% wheat-based diets with enzyme which significantly (P<0.05) differ from the birds on 10 and 20% wheat diets without enzyme supplementation with 5% mortality recorded.

The results on the effect of wheat, enzyme and their interactions in birds on the experimental diets are presented in Table 7. There was no significant effect of wheat on the initial weight, final weight, weight gain and FCR of birds on the dietary treatments but the effect of wheat was pronounced on the feed intake and PER of the birds on the experimental diets. Similarly, enzyme supplementation had effect on the feed intake of birds on wheat diets. No significant effect of wheat and enzyme on other performance parameters measured.

Nutrient Digestibility of Experimental Broilers

The results on nutrient digestibility of birds fed wheat-based diets are shown in Table 8. Significant differences (P<0.05) were observed in the digestibility of dry matter, crude protein, crude fibre, ash, ether extract and nitrogen free extract in birds on the experimental diets. Percentage digestibility of crude protein and crude fibre was significantly (P<0.05) higher in birds on 30% wheat based-diet with enzyme supplementation. Birds on 10% wheat diet with enzyme had highest ash digestibility (78.37%) and least value (68.12%) was recorded in birds on 20% wheat diet without enzyme. Ether extract digestibility was improved in birds on 30% wheat based-diet with enzyme which was significantly (P<0.05) higher (80.72%) than those on the other diets. However, least ether extract percentage digestibility (67.91%) was recorded in birds on 30% wheat diet without enzyme. Digestibility of nitrogen free extract in birds on 10% wheat diet with enzyme did not differ significantly from those on 20 and 30% wheat diets without enzyme and the control diet.

Cost benefit ratio of enzyme supplemented wheat-based diets fed to broilers (Starter and Finisher Phases)

Table 9 shows the cost benefit ratio of birds on the experimental diets. The control diet had the least (₦ 115.14) feed cost/kg/bird and feed cost/kg weight gain (₦140.84) while birds on 30% wheat based-diet with enzyme had the highest feed cost/kg/bird (₦ 154.93) and feed cost/kg weight gain (₦ 174.27) for the starter phase. Similar trend was observed in the finisher phase, the control diet and diet with 30% wheat with enzyme maintained the lowest and highest feed cost/kg respectively. However, the feed cost/kg weight gain for broiler finisher phase was highest (₦262.87) in birds on 20% wheat with enzyme supplementation and lowest (₦175.57) in birds fed control diet.

DISCUSSION

Performance of broilers on experimental diets

Xylanase and β-glucanase are enzymes that degrade non-starch polysaccharides (NSPs) and have been shown to improve the nutritive value of wheat-based diet for

Table 8: Nutrient digestibility of birds fed wheat-based diets (%)

		Without Enzyme			With Enzyme			
Variables	0	10	20	30	10	20	30	SEM
Dry Matter	78.48^{d}	70.84^{g}	76.36^{e}	85.06^{a}	82.26^{b}	75.00^{f}	80.47^{c}	0.70
Crude Protein	61.72^{b}	53.47^{c}	36.92^{e}	43.95^{d}	63.18^{b}	55.08^{c}	71.14^{a}	2.12
Crude Fibre	63.10^{d}	61.72^{d}	69.04^{bc}	65.38^{cd}	69.27^{bc}	72.89^{ab}	76.71^{a}	1.02
Ash	70.15^{b}	71.21^{b}	68.12^{b}	71.94^{b}	78.37^{a}	69.78^{b}	73.89^{ab}	0.85
Ether Extract	71.53^{bc}	78.89^{ab}	72.30^{bc}	67.91^{c}	69.43^{c}	78.14^{ab}	80.72^{a}	1.16
NFE	67.61^{ab}	67.18^{b}	68.83^{ab}	70.57^{ab}	72.07^{a}	67.33^{b}	66.46^{b}	0.59

Means with different superscripts on the same row are significantly ($P<0.05$) different; Nitrogen NFE- Free Extract; SEM- Standard Error of Mean

Table 9: Cost Benefit Ratio of Enzyme Supplemented Wheat-Based Diets fed to Broilers

		Without Enzyme			With Enzyme		
	Control	10%	20%	30%	10%	20%	30%
Starter Phase							
Weight gain (kg/b)	0.82	0.91	0.89	0.89	0.90	0.96	0.89
Feed Intake (kg)	1.21	1.37	1.39	1.35	1.52	1.53	1.49
Feed Conversion Ratio	1.48	1.52	1.56	1.51	1.69	1.60	1.68
Feed cost/kg (₦)	95.16	97.67	100.17	102.66	98.74	101.24	103.73
Feed Cost (₦ /kg/bird)	115.14	133.81	139.24	138.59	150.09	154.90	154.93
Feed cost/kg weight gain(₦/kg)	140.84	148.46	156.27	155.01	166.87	161.98	174.27
Finisher Phase							
Weight gain (kg/b)	1.23	1.03	1.21	1.12	1.26	1.06	1.09
Feed Intake (kg)	2.50	2.57	3.04	2.75	3.02	3.01	2.98
Feed Conversion Ratio	2.03	2.50	2.51	2.45	2.39	2.84	2.74
Feed Cost/kg (₦)	86.49	88.98	91.48	94.06	90.06	92.56	94.82
Feed Cost (₦/kg/b)	216.23	228.68	278.10	258.67	271.98	278.61	282.56
Feed Cost/kg weight gain(₦/kg)	175.57	222.45	229.61	230.45	215.24	262.87	259.81

Kg- kilogram, kg/b- kilogram per bird, ₦ –naira, ₦ /kg- naira per kilogram, ₦ /kg/b- naira per kilogram per bird, ₦160 = 1US dolla

birds by reducing the anti-nutritional effects of NSPs (Preston *et al.,* 2001; Choct and Annison, 2004). The addition of exogenous enzyme to relevant poultry diets usually result in numerous beneficial effects, such as increased utilisation of nutrients (e.g. fat and protein), improved apparent metabolisable energy (AME) values, increased growth rate, improved feed to gain ratio, decreased viscosity of intestinal digesta and reduced incidence of sticky excreta with improved litter condition (Broz and Ward, 2007).

The weight gain and feed intake of birds on enzyme supplemented diets were significantly improved for both starter and finisher phases. The results of this study are in agreements with the findings of previous studies (Gao *et al*., 2007; Yu *et al*., 1997; Gutierrez *et al.,* 2008). Lazaro *et al*. (2003) reported that enzyme supplementation of wheat-based diets improve broiler performance via increased feed intake and improved nutrient digestibility. Thus, improved performance observed in this study can be attributed to increased feed intake and improved nutrient digestibility. This was contrary to the findings of Agboola *et al.* (2013) who reported that enzyme supplementation did not positively improve the growth performance of birds on 20% wheat based-diet when compared with those on wheat diet without dietary supplemental enzyme inclusion. However, lower weight gain observed in birds fed diets without enzyme supplementation can be as a result of increased digesta viscosity associated with high NSPs diets. According to Edwards *et al*. (1988) and Ikegami *et al.* (1990), high gut viscosity decreases the rate of diffusion of substrates and digestive enzymes and hinders their effective interaction at the mucosal surface therefore reducing growth and feed conversion ratio.

Feed conversion ratio was improved by enzyme supplementation at 10% inclusion level of wheat in the finisher phase. This is an indication that the birds were able to utilise the diet efficiently as a result of the addition of Roxazyme G2G. However, the results on feed conversion ratio, weight gain and protein efficiency ratio contradicts the report of Acamovic (2001) who observed that enzyme supplementation in poultry does not necessary result in improved performance.

Nutrient digestibility of experimental broilers

Enzymes have been shown to improve nutrient digestibility when added to poultry diets containing cereals such as barley (Hesselman *et al*., 1982), maize (Saleh *et al*., 2003), oats (Friesen *et al*., 1992), rye (Fengler and Marquardt, 1988) and wheat (Fengler *et al*., 1988). Roxazyme G2G reduces gut viscosity and nutrient entrapment (mostly starch and protein) and lead to better digestion in broilers (Bedford, 2000).

In the present study, nutrient digestibilities were significantly influenced by enzyme supplementation. Birds on 30% wheat with enzyme recorded the highest values for crude protein, ether extract and crude fibre digestibility. This is in agreement with the report of Choct *et al.* (1995; 1999), who stated that starch and/or protein digestibility of birds on xylanase treatment is always better compared to those without xylanase treatment. According to Bedford and Schulze (1998), the non-soluble cell wall components in wheat trap protein and starch within the wheat kernel, thus, the improved digestibility of nutrients observed in this present study could be due to disruption of plant cell wall fraction by xylanase and β-glucanase in Roxazyme G2G. This disruption liberates locked protein and starch for easier

digestion, thus improving feed digestibility and poultry performance. This is supported by the reports of Khan *et al. (*2006) and Awoyemi (2012). Also the poor nutrient digestibility recorded in birds fed wheat-based diet without enzyme supplementation can be attributed the gel forming capacity (viscosity) of non-starch polysaccharides which is the cause of low nutrient digestibility and/or availability (Bedford and Classen, 1992).

Enzyme supplementation improved ether extract digestibility as evidenced by the highest and lowest values recorded in birds fed 30% with and without enzyme respectively. It was noted that the presence of NSPs in the diet reduces bile acids secretions thus affecting lipids emulsification. This leads to decreased absorption of lipids and fat-soluble vitamins (Knarreborg *et al*., 2002). This is probably related to a slower digesta passage rate. Soluble NSP increases the residence time of digesta in the intestine (Van der Klis *et al*., 1993), which consequently decrease oxygen tension and favor the development of anaerobic microflora. This results in the proliferation of some anaerobic organisms that can produce toxins and deconjugate bile salts which are essential for the digestion of fat (Carré *et al*., 1995). This explains the lower digestibility values observed in birds fed diets without enzyme supplementation. However, the use of exogenous enzyme mitigates this problem. This is substantiated by the results of this present study and that of Zanella *et al.* (1999), who demonstrated that the supplementation of low energy broiler diet with enzyme mixture containing amylase, protease and xylanase improved digestibility of nutrients and birds' performance.

Cost benefit ratio of enzyme supplemented wheat-based diets fed to broilers

The cost of feed per kilogram weight gain was least in the control diet (₦140.84) and (₦175.57) for starter and finisher phases respectively. This is probably as a result of slight differences in the price of maize (₦70.00/kg) and wheat (₦80.00/kg) at the period of the experiment. Birds on 20% and 30% wheat with enzyme had relative high feed cost/kg weight gain (₦/kg) when compared with birds on other diets. This could be as a result of higher value of FCR recorded.

Conclusion

The results of this study showed that enzyme supplementation positively influenced the growth response and nutrient digestibility of birds fed graded levels of wheat as compared to those without enzyme supplementation.

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