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Synergetic effect of enzymes and probiotic in improving sorghum (*Sorghum bicolor*) based diets for broiler chickens

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Target Audience: *Animal Scientist, Nutritionist, Feed millers, Extension staff*

Abstract

The study was carried out to assess the synergetic effect of the combination of enzymes and probiotic in sorghum based diet for broiler chickens. Three hundred and ninety-six (396) Ross broiler chicks were allotted to six (6) dietary treatments with three (3) replicates, each having twenty-two (22) birds in a completely randomized design. Treatment 1, maize based diet; T2, sorghum based diet; T3, Sorghum based diet with Ronozyme® ProAct and Enviva® Pro 202 GT; T4, Sorghum based diet with Roxazyme® G2G and Enviva® Pro 202 GT; T5, Sorghum based diet with Axtra XAP® 101 TPT and Enviva® Pro 202 GT, and T6, Sorghum based diet with Enviva® Pro 202 GT. Diets were formulated to meet standard requirements. Results showed significant (P < 0.05) difference in the growth performance of birds in starter and finisher phase. Results for digestibility and carcass values in some parameters showed significant (P < 0.05) difference across the different treatment diet, with birds fed sorghum based diet alone having the least values. The net profit (₦/bird) for birds fed sorghum based diet without feed additive was low compared with birds fed sorghum based diet with enzyme and probiotics in combination. It was concluded that the synergetic effect of exogenous enzymes and probiotics in sorghum based diets showed complementary effect on performance and increased net profit of broiler production.

Key words: *Poultry; sorghum; enzymes; probiotics*

Description of Problem

Feed additives are ingredients that are used to enhance the effectiveness of nutrients and exert their effects in the gut or on the gut wall cells to the animal (1). The use of feed additive has been encouraged because of its effect in promoting animal growth through their impact in increasing feed quality and palatability (2). Supplementation with feed additives in animal feed contributes to increase production of animal protein for human consumption and decrease the cost of animal products (3). Quite a number of feed additives are now used in animal feeds to improve end products and make them more homogenous and of better quality. They include antibiotics, probiotics, oligosaccharides, enzymes, essential oil and organic acids. From the different additives, antibiotics have been widely used in livestock diets during the past several decades due to their therapeutic effects (4).

Consequently, the change in the consumer's demand for a safe food production coupled with the regulatory issues about the ban of antibiotic growth promoters have ensured a search for natural strategies to modulate gut development and health (5). Hence, many activities have been initiated to establish alternative strategies aimed to

improve nutrient utilization in farm animals, to maintain their health and performance.

The use of varying exogenous enzymes such as xylanase, amylase, protease, lipase, β-glucanase, phytase have been used in poultry diets for years (6) and their use is of utmost importance in the poultry industry due to the fact that the major feedstuffs commonly used (maize, sorghum, soybean meal, wheat) contain varying levels of different anti-nutritive factors such as non-starch polysaccharides (NSP), phytic acid and protease inhibitors which can impede normal digestion and absorption of nutrients in the gastro intestinal tract. (7).

Probiotic is a culture of live microorganisms that can manipulate and maintain a beneficial microflora in the gut. These supplements were proposed with success as alternatives to antibiotic growth-promoting feed additives (8). Nonetheless, the exact mechanisms by which probiotics bring about their beneficial actions have not been well documented. However, there are several hypothesized mechanisms that explain many of their favourable effects (9). The performance of poultry birds on sorghum-based diets may not often be comparable to diets based on maize and other cereals. This may perhaps be due to the probability that most varieties of sorghum contains anti-nutritional factor such as tannin and phytate present in the grains. The anti-nutritive factors are manifested by depressed nutrient utilization accompanied by poor growth, poor feed conversation ratio and livability in chickens. These adverse effects can thus, be overcome by supplementing sorghum based diet with feed additives. The problems may be resolved by application of exogenous enzymes to make available nutrients bound by antinutrients such as tannins in Sorghum (10). Furthermore, the use of probiotics may help to improve the digestion and absorption of nutrients bound by antinutrients in the gut (11).

In view of the above, this research is aimed at evaluating the effect of feeding exogenous enzymes and probiotics in combination in sorghum based diets fed to broiler birds.

Materials and Methods

Experimental site

The experiment was conducted at the poultry research unit, National Veterinary Research Institute, Vom, Plateau State, Nigeria. The study area is located on Latitude 09° 44' N and Longitude 08°45' E with a physical feature of rocky granites of old volcanoes at altitude of 4200 ft (1285 m) above sea level with a mean annual rainfall ranging between 1300 to 1500mm and average daily temperature ranges between 17 ºC to 28.6 ºC. The wet season extends from late April to middle October and relative humidity which ranges from 22 % in January to 78 % in July/August. Mean monthly sunshine hours ranges from 177 - 288.3 (12).

Test Materials, Sources and Constituents

The test materials used in the current study were Ronozyme ProAct® and Roxazyme G2G®, which contains serine-protease and endo-1,4 β-glucanase, respectively (DSM Nutritional Products, Stanley, USA). The multienzyme used was AxtraXAP 101 GT® containing a blend of xylanase, amylase and Protease (Danisco Animal Nutrition, DuPont, Malborough, UK). EnvivaPro 202 TPT® served as the probiotic which contains *Bacillus amyloliquifaciens*® (Danisco Animal Nutrition, DuPont, Malborough, UK).

Experimental Design and Management of birds

Three hundred and ninety-six (396) 1-day old Ross broiler chicks were allotted to six dietary treatments with three replicates and each having twenty-two birds in a completely

randomized design (CRD). The birds were housed in deep litter pens and managed with all necessary routine management practices with feed and water provided *ad libitum*.

Six experimental diets; Maize, Sorghum, Sorghum+ProAct+ENV, Sorghum+G2G+ENV, Sorghum+XAP+ENV and Sorghum+ENV were formulated for both starter and finisher phases, respectively (Table 1 & 2). The diets were formulated to meet the nutrient requirement of broiler birds as recommended by (13)

Table 1: Composition of experimental diets for starter broiler chicks fed enzymes and probiotics in combination

Feed ingredients (Kg)	T1 Maize	T2 Sorg	T3 Sorg + ProAct + ENV	T4 Sorg+ G2G + ENV	T5 Sorg+ XAP+ ENV	T6 Sorg+ ENV
Maize	55.85	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	57.85	57.85	57.85	57.85	57.85
Soya bean meal	25.00	25.00	25.00	25.00	25.00	25.00
Groundnut cake	15.00	13.00	13.00	13.00	13.00	13.00
Bone meal	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.40	0.40	0.40	0.40	0.40	0.40
Common salt	0.25	0.25	0.25	0.25	0.25	0.25
Vit/Mineral Premix*	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Roxazyme®G2G (g)+	0.00	0.00	0.00	0.02	0.00	0.00
Ronozyme® ProAct (g)+	0.00	0.00	0.02	0.00	0.00	0.00
Axtra® XAP 101 TPT (g) +	0.00	0.00	0.00	0.00	0.01	0.00
Enviva® PRO 202 GT (g) +	0.00	0.00	0.006	0.006	0.006	0.006
TOTAL	100	100	100	100	100	100
ME (Kcal/Kg DM)	2906	2849	2849	2849	2849	2849
Crude protein (%)	23.31	23.31	23.31	23.31	23.31	23.31
Crude fibre (%)	4.00	3.74	3.74	3.74	3.74	3.74
Ether extract (%)	3.37	2.36	2.36	2.36	2.36	2.36
Calcium (%)	1.28	1.29	1.29	1.29	1.29	1.29
Phosphorus (%)	0.84	0.86	0.86	0.86	0.86	0.86
Lysine (%)	1.31	1.43	1.43	1.43	1.43	1.43
Methionine (%)	0.50	0.51	0.51	0.51	0.51	0.51
Cost/kg diet (₦/kg)	112.16	111.95	118.90	118.06	118.07	116.40

*Nutripoult broiler premix each 2.5kg cotains: Vit A, 10,000,000 IU; Vit D3, 2,000,000 IU; Vit E, 40,000mg;Vit K3, 2000mg; Vit B1, 1500 mg; Vit B2, 5000mg; Vitamin B6 4000 mg; Vit B12, 20mg; Niacin,40,000mg; Calpan, 10,000 mg; Folic acid, 10,000mg; Biotin, 100mg; Chlorine chloride, 30,000mg; Iodine, 800mg; iron, 40,000mg; Manganese, 80,000mg; Cobalt, 300; Copper, 80,000; Selenium, 200mg; Zinc, 60,000mg; Antioxidant, 100,000mg Sorg: sorghum, ProAct: Ronozyme® Proact enzyme, G2G: Roxazyme® G2G enzyme, XAP: Axtra® XAP 101 TPT enzyme, ENV: Enviva® PRO 202 GT, +Feed additives exclusive of 100kg diet

Table 2: Composition of Experimental Diets for Finisher Broiler Chickens exogenous enzymes and Probiotics in Combination

Feed Ingredients (Kg)	T1 Maize	T2 Sorg	T3 Sorg + ProAct + ENV	T4 Sorg + G2 G + ENV	T5 Sorg + XAP+ ENV	T6 Sorg+ ENV
Maize	59.00	0.00	0.00	0.00	0.00	0.00
Sorghum	0.00	59.00	59.00	59.00	59.00	59.00
Soya bean meal	17.00	17.00	17.00	17.00	17.00	17.00
Groundnut cake	13.00	11.00	11.00	11.00	11.00	11.00
Maize offal	7.00	9.00	9.00	9.00	9.00	9.00
Bone meal	2.50	2.50	2.50	2.50	2.50	2.50
Limestone	0.70	0.70	0.70	0.70	0.70	0.70
Common salt	0.30	0.30	0.30	0.30	0.30	0.30
Vit/Min Premix*	0.25	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.05	0.05	0.05	0.05	0.05	0.05
Roxazyme®G2G+	0.00	0.00	0.00	0.02	0.00	0.00
Ronozyme® ProAct+	0.00	0.00	0.02	0.00	0.00	0.00
Axtra® XAP 101 TPT+	0.00	0.00	0.00	0.00	0.01	0.00
Enviva® PRO 202 GT+	0.00	0.00	0.006	0.006	0.006	0.006
TOTAL	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis						
ME (Kcal/Kg DM)	2950	2900	2900	2900	2900	2900
Crude protein (%)	20	20.17	20.17	20.17	20.17	20.17
Crude fibre (%)	4.27	4.19	4.19	4.19	4.19	4.19
Ether extract (%)	3.36	2.15	2.15	2.15	2.15	2.15
Calcium (%)	1.21	1.23	1.23	1.23	1.23	1.23
Phosphorus (%)	0.77	0.81	0.81	0.81	0.81	0.81
Lysine (%)	1.12	1.16	1.16	1.16	1.16	1.16
Methionine (%)	0.48	0.49	0.49	0.49	0.49	0.49
Cost/kg diet (₦/kg)	107.17	106.47	113.41	112.58	112.58	110.91

*Nutripoult broiler premix each 2.5kg cotains: Vit A, 10,000,000 IU; Vit D3, 2,000,000 IU; Vit E, 40,000mg; Vit K3, 2000mg; Vit B1, 1500 mg; Vit B2, 5000mg; Vitamin B6 4000 mg; Vit B12, 20mg; Niacin, 40,000mg; Calpan, 10,000 mg; Folic acid, 10,000mg; Biotin, 100mg; Chlorine chloride, 30,000mg; Iodine, 800mg; iron, 40,000mg; Manganese, 80,000mg; Cobalt, 300; Copper, 80,000; Selenium, 200mg; Zinc, 60,000mg; Antioxidant, 100,000mg**;** Sorg: sorghum**,** ProAct: Ronozyme® Proact enzyme, G2G: Roxazyme® G2G enzyme, XAP: Axtra® XAP 101 TPT enzyme, ENV: Enviva® PRO 202 GT, +Feed additives exclusive of 100kg diet

Growth Performance

Initial and final weights of the birds were taken at the beginning and at the end of the starter and finisher phases. Feed intake and body weight changes were monitored on weekly basis at both the starter and finisher phases. Feed/gain ratio and cost per Kg gain were also computed from the feed intake and weight gain data for both phases while protein efficiency ratio was computed from the weight gain and protein intake of the birds. Mortality was recorded as they occurred.

Digestibility Study

Digestibility trial was carried out on day 48 of the study. Three birds were selected from each treatment. The birds were kept in individual cages for 5 days adjustment period

and were fasted over-night at the end of the adjustment period. Each bird was offered a known amount of experimental diet. Faecal sample was collected using the total faecal collection method (14), weighed and oven-dried at 65 °C for 24 hours. The dried faecal samples were assayed for their nutrient contents using the methods described by (14). Apparent nutrient digestibility was determined for crude protein, ether extract, crude fibre, ash and nitrogen-free extract using the formula:

% Digestibility of Nutrient

$$= \frac{Amount\ of\ Nutrient\ intake - Amount\ of\ nutrient\ output}{Amount\ \ 0f\ Nutrient\ intake} \times 100$$

Carcass Evaluation

Six birds were selected from each treatment at the end of the 8 weeks feeding trial. They were kept off-feed overnight, weighed and slaughtered for carcass evaluation. Carcass weight, prime cuts (breast, drumstick, thigh and back) and organ weights (liver, lungs, kidney, spleen, empty gizzard and intestinal weights) were recorded. The prime cuts and organ weights were expressed as a percentage of dressed weight and live weight, respectively (15).

Statistical Analysis

Data obtained in the experiment were statistically analysed using the General Linear Model Procedure of Statistical Analysis software package. Significant differences between treatments mean were separated by Tukey test (16).

Results and Discussion

Performance of broiler starter birds fed sorghum based diet with enzymes and probiotics in combination

The performance of broiler birds fed sorghum based diet with enzymes and probiotics in combination is shown in Table 3. The result showed that there was significant ($P< 0.05$) difference on treatment effects in the final weight and weight gain of birds across all treatment. Experimental birds fed sorghum based diet without feed additives had the least final weight and weight gain compared to birds fed maize based diet, Sorg+ProAct+ENV, Sorg+G2G+ENV, Sorg+XAP+ENV and Sorg+ENV. Experimental birds fed sorghum based diet without feed additives did not compare favorably well with feed additives inclusion diets. The improvement in final weight and weight gain of broiler chickens fed diets with enzymes and probiotics as observed in this study may be attributed to the fact that the crude protein and energy bond by tannin present in sorghum (10) might have been released thus, increasing availability of nutrients to the birds for utilization and overall improvement and apparently due to their effects on the gut health status of experimental birds. This was in line with (17) who reported a positive interaction of broiler chickens fed enzymes and direct-fed microbials on increased body weight gain.

The result for feed conversion ratio was significantly different ($P < 0.05$) between the maize based diet and sorghum based diet combined with exogenous enzyme and probiotics, and sorghum based diet without exogenous enzyme and probiotics inclusion. The significant improvement in FCR of broiler chicks in the above groups could be attributed to efficient utilization of protein and energy, present in the form of non-starch polysaccharides (NSP) which could have been made available to the birds via enzymatic degradation. The improved FCR could also be attributed to the effects of probiotic on the chicks' gut health status (18). Feed cost/Kg gain (₦/Kg) was significantly ($P < 0.05$) highest for sorghum based diet only and lowest for the maize control diet and sorghum based diets with exogenous enzyme and probiotic inclusion. It was evident that feed cost/kg gain (₦/Kg) broiler was reduced based on addition of enzyme and probiotics, thereby increasing profitability of broiler meat.

Table 3: Performance of starter broiler chicks fed sorghum based diet with enzymes and probiotics in combination

Parameters	Maize	Sorghum	Sorghum+ ProAct+ ENV	Sorghum+ G2G+ ENV	Sorghum+ XAP+ ENV	Sorghum+E NV	SEM
Initial weight (g/bird)	40.53	41.21	41.21	40.53	40.75	41.21	0.62
Final weight (g/bird)	783.84[a]	691.01[b]	749.53[a]	758.37[a]	747.42[a]	733.33[a]	27.24
Weight gain (g/bird)	743.30[a]	649.79[b]	708.32[a]	717.84[a]	706.66[a]	692.12[a]	27.16
Feed intake (g/bird)	1234.31[b]	1344.45[a]	1206.50[b]	1182.26[b]	1246.00[b]	1227.99[b]	35.03
Feed/gain ratio	1.66[a]	2.07[b]	1.70[a]	1.65[a]	1.76[a]	1.77[a]	0.05
Feed cost/Kg gain (₦/Kg)	186.26[b]	232.28[a]	202.91[b]	195.13[b]	208.14[b]	206.74[b]	6.31
PER	2.58[a]	2.06[d]	2.50[b]	2.59[a]	2.42[c]	2.41[c]	0.06
Mortality (%)	11.66	10.47	4.41	10.34	7.37	5.93	2.86

a,b,c,d: Means with different superscripts on the same row are significantly different (P<0.05), SEM: Standard error of means, ProAct: Ronozyme® ProAct enzyme, G2G: Roxazyme® G2G enzyme, XAP: Axtra® XAP 101 TPT enzyme, ENV: Enviva® PRO 202 GT probiotics, PER: Protein efficiency ratio.

The result for protein efficiency ratio showed that birds fed sorghum based diet with inclusion of enzymes and probiotics efficiently utilized dietary protein compared with birds fed sorghum based diet alone and this can be seen in the weight gain of broiler chicks. This shows that the utilization of protein in the feed helped to build more tissue for the birds at the starter phase. The percentage mortality, however, showed no significant (P > 0.05) difference between the treatment groups.

Performance of finisher broiler birds fed sorghum based diet with enzymes and probiotics in combination

The performance of broiler chickens fed sorghum based diet with enzymes and probiotics in combination is shown in Table 4. Final weight and weight gain showed that birds fed sorghum based diet without feed additives had a poor performance compared with birds fed sorghum based diet with feed additives. Also, birds in dietary feed inclusion groups, compared favourably well with the control maize. The low weight gain of birds in sorghum based diet only showed that without enzyme and probiotic inclusion, birds will have poor growth performance. This could be due to increased viscosity of the intestinal content of birds. The non-starch polysaccharide contained in cereal grains was shown to be responsible for high viscosity and consequent impairment in productivity (19). The result for feed/gain ratio was significantly higher and poor for birds in sorghum based diet only, while the other treatments were having a better feed/gain ratio. This explains that sorghum diets compared favourably with maize diets in converting feed nutrients to muscle, and agrees with the findings of (10) who showed that enzymes improved feed conversion ratio of birds fed sorghum diet supplemented with exogenous enzymes. The result for Feed cost/Kg gain (₦/Kg) showed that the inclusion of feed additives in sorghum based diet. This clearly indicated that enzymes supplementation is more feasible and economical to obtain maximum profitability from broiler production.

The protein efficiency ratio of birds fed sorghum based diet with enzymes and probiotics inclusion showed that birds fed sorghum based diet alone was significantly (P < 0.05) lower, compared to birds fed sorghum based diet with enzyme and probiotic inclusion. This shows that the feed additives present in the sorghum based diet helped the birds efficiently utilize protein.

Table 4: Performance of finisher broiler chickens fed sorghum based diet with enzymes and probiotics in combination

Parameters	Maize	Sorghum	Sorghum+ ProAct+ ENV	Sorghum+ G2G+ ENV	Sorghum+ XAP+ ENV	Sorghum+ ENV	SEM
Initial weight (g/bird)	812.28	782.45	828.07	814.03	798.24	796.66	36.67
Final weight (g/bird)	2162.96 ^{a}	1940.74 ^{b}	2155.55 ^{a}	2105.55 ^{ab}	2107.79 ^{ab}	2021.05 ^{ab}	42.12
Weight gain (g/bird)	1350.68 ^{a}	1158.28 ^{b}	1327.48 ^{ab}	1291.52 ^{ab}	1309.55 ^{ab}	1224.38 ^{ab}	37.21
Feed intake (g/bird)	2585.77	2581.57	2569.29	2452.53	2505.95	2448.14	41.62
Feed/gain ratio	1.91 ^{a}	2.22 ^{b}	1.94 ^{a}	1.90 ^{a}	1.91 ^{a}	1.99 ^{a}	0.05
Feed cost/Kg gain (₦/Kg)	205.26^{a}	237.52^{b}	220.35^{a}	213.97^{a}	215.74^{a}	221.77^{a}	5.84
PER	2.61^{a}	2.22^{c}	2.56^{a}	2.61^{a}	2.59^{a}	2.48^{a}	0.06

a,b,c: Means with different superscripts on the same row are significantly different (P<0.05), SEM: Standard error of means, ProAct:Ronozyme® ProAct enzyme, G2G: Roxazyme® G2G enzyme, XAP: Axtra® XAP 101 TPT enzyme, ENV: Enviva® PRO 202 GT probiotics, PER: Protein efficiency ratio

Table 5: Carcass characteristics and organ weights of finisher broiler birds fed sorghum based diet with enzymes and probiotics in combination

Parameters	Maize	Sorghum	Sorghum+ ProAct+ ENV	Sorghum + G2G+ ENV	Sorghum + XAP+ ENV	Sorghum + ENV	SEM
Live wt (g/bird)	2150.00 ^{a}	1726.66^{b}	1826.66^{b}	2116.66 ^{a}	1873.33^{b}	1873.33^{b}	53.43
Dressed wt (g/bird)	1510.00^{a}	1116.66^{c}	1233.33^{b}	1466.66 ^{a}	1273.33^{b}	1273.33^{b}	54.61
Dressing percent (%)	69.76^{b}	64.75^{c}	72.35^{a}	69.74^{b}	66.22^{b}	67.83^{b}	1.08
Cut parts expressed as percentage of dressed weight (%)							
Breast	32.28	26.99	24.30	28.14	26.12	26.20	2.02
Drumstick	15.10	14.23	12.61	15.77	14.49	14.56	0.39
Thigh	17.06^{a}	15.12^{b}	14.05^{b}	17.33^{a}	15.03^{b}	14.05^{b}	0.59
Organ weights expressed as percentage of live weight (%)							
Liver	2.96	2.69	2.49	3.05	2.61	2.62	0.21
Lungs	0.88	0.82	0.71	0.71	0.90	0.91	0.10
Kidney	0.66	0.73	0.66	0.64	0.73	0.73	0.05
Gizzard empty	2.92	3.68	3.00	3.32	3.64	3.66	0.29
Intestinal weight	4.77	5.20	4.53	5.19	5.37	5.40	0.35
Intestinal length (cm)	17.59	17.93	16.94	17.65	19.67	19.78	1.18

a,b: Means with different superscripts on the same row are significantly different (P<0.05), SEM: Standard error of means, ProAct:
Ronozyme® ProAct enzyme, G2G: Roxazyme® G2G enzyme, XAP: Axtra® XAP 101 TPT enzyme, ENV: Enviva® PRO 202 GT, wt: weight.

Nutrient digestibility of finisher broiler birds fed sorghum based diet with enzyme and probiotics in combination

The results of protein, ether extract, crude fibre, ash and Nitrogen free extract (NFE) digestibility by broiler chickens fed sorghum based diet with enzyme and probiotics in combination is shown in Table 6. The result for protein, crude fibre and ash retention result were significantly (P < 0.05) different with maize based diet and sorghum based diet without additives having the least value. The values for protein, crude fibre and ether extract showed that chickens fed maize based and sorghum based diets with feed additives had high nutrient digestibility values. This could be as a result of the presence of the enzymes protease and G2G releasing much of the available nutrients bound by the presence of tannin in treatments. Numerically, results for

NFE showed that experimental chickens fed sorghum based diet alone had the least value of NFE.

Similar findings were recorded by (20) and (21) in enzyme supplemented poultry ration. Improvement in nitrogen retention in Sorg+G2G+ENV group could be due to partial hydrolysis of NSPs, thereby reducing the viscosity of gut contents and resulting in improvement of nutrient absorption. The digestibility values for crude fibre and ash were significantly ($P < 0.05$) different with maize diet and sorghum based diet with enzyme and probitics having the best digestibility, while sorghum based diet alone having the least digestibility. This shows that both enzymes and probiotics either singly or in combination improved the use of sorghum by making available nutrients that are bound by tannins. Santoso *et al.* (22) reported increased nutrient digestion and utilization in broiler chicks due to supplementation with a *Bacillus* direct-fed microbial (DFM), which was speculated to be due to the secretion of protease, amylase and lipase by the DFM. Similarly, supplementation of broiler diets with exogenous enzymes resulted in increased dietary energy and protein utilization through increased substrate availability (23).

Table 6: Nutrient digestibility of finisher broiler birds fed sorghum based diet with enzyme and probiotics in combination

Parameters	Maize	Sorghum	Sorghum+ ProAct+ BSG	Sorghu+ G2G+ BSG	Sorghum+ XAP+ BSG	Sorghum+ ENV+ BSG	SEM
Protein (%)	71.41^{b}	69.74^{b}	77.05^{a}	76.67^{a}	75.18^{a}	72.58^{b}	1.62
Ether extract (%)	86.55^{b}	86.41^{b}	87.95^{a}	89.65^{a}	87.54^{a}	89.14^{a}	0.92
Crude fibre (%)	48.75^{a}	38.47^{b}	52.43^{a}	53.93^{a}	53.28^{a}	32.95^{b}	4.16
Ash (%)	50.41^{a}	28.43^{b}	24.44^{b}	36.28^{b}	29.67^{b}	45.39^{a}	4.42
N.F.E (%)	78.06	74.35	78.82	79.75	78.96	77.05	1.43

a,b: Means with different superscripts on the same row are significantly different ($P<0.05$), SEM: Standard error of means,
ProAct: Ronozyme® Proact enzyme, G2G: Roxazyme ® G2G enzyme, XAP: Axtra® XAP 101 enzyme, ENV: Enviva® PRO 202 GT, NFE: Nitrogen free extract

Carcass characteristics and organ weights of finisher broiler birds fed sorghum based diet with enzymes and probiotics in combination

The carcass characteristics and organ weights of broiler birds fed sorghum based diet with enzymes and probiotics in combination is shown in Table 5. The dressed weight and dressing percentage were significantly ($P < 0.05$) different across the different treatment diets. Experimental birds fed the maize based diet and Sorg+G2G+ENV were comparable, their dressed weight was significantly ($P < 0.05$) better than others fed sorghum based diet alone and Sorg + ProAct + ENV, Sorg + XAP + ENV and Sorg + ENV. This trend can also be seen in the performance study, thus showing that feed additives are of beneficial effect in sorghum based diet. The result for dressing percentage was significantly ($P < 0.05$) higher for birds fed sorghum based diet with ProAct enzyme and Enviva Pro in combination, compared to birds in the other treatments, while birds fed sorghum based diet alone had the least dressing percentage. Adejinmi *et al.* (24) indicated that carcass quality is closely related to the level of nutrients intake especially protein and energy. Therefore, differences obtained across treatments could be as a result of the presence of feed additives in the sorghum based diet treatments.

Effect of enzymes and probiotics combination in sorghum based diet on economics of production for broiler chickens

The result for economics of production of broiler chickens fed sorghum based diet with enzymes and probiotics inclusion is shown in Table 7. The result for feed cost/kg showed that sorghum based diet with enzymes and probiotics inclusion had the highest values. This was as a result of the cost of enzymes and probiotics in their diets. Feed intake was highest for birds fed maize based diet and sorghum based diet alone and lowest for birds fed sorghum based diet with enzyme and probiotics inclusion. The average yield cost and net profit recorded were least for birds fed sorghum based diet alone. The net profit of birds fed Sorghum + ProAct + ENV, Sorghum + G2G + ENV, Sorghum + XAP + ENV and Sorghum + ENV was higher, compared to birds fed Sorghum alone. The use of sorghum based diet with feed additive showed increased profit of 11.90 - 24.56 % above the use of sorghum without feed additives. This shows that profit can be improved through the use of enzymes and probiotics combination in sorghum based diet regardless of feed cost/kg. This is in line with Wealleans *et al*. (25) who reported that direct-fed microbials and enzymes in broiler chickens diet improved performance and profitability.

Table 7: Effect of enzymes and probiotics combination in sorghum based diet on economics of production for broiler chickens

Parameters	Maize	Sorghum	Sorghum+ ProAct+ ENV	Sorghum+ G2G+ ENV	Sorghum+ XAP+ ENV	Sorghum+ ENV
Feed cost/Kg (₦)	109.66	109.21	116.15	115.32	115.32	113.65
Average feed intake (Kg/bird)	3.82	3.93	3.77	3.63	3.75	3.67
Average feeding cost (₦ /bird)	418.90	429.19	437.88	418.61	432.45	417.09
Other expenses (₦ /bird)	420.00	420.00	420.00	420.00	420.00	420.00
Total expenses (₦ /bird)	838.90	849.19	857.88	838.61	852.45	837.09
Average final weight (Kg/bird)	2.16	1.94	2.15	2.11	2.11	2.02
Cost of chicken/Kg (₦)	750.00	750.00	750.00	750.00	750.00	750.00
Average yield cost (₦ /bird)	1620.00	1455.00	1612.50	1582.50	1582.5	1515.00
Net profit (₦ /bird)	781.1	605.81	754.62	743.89	730.05	677.91

Conclusion and Applications

From the results obtained in the study, it may be concluded that:

1. The inclusion of Enviva Pro 202 GT probiotics at 60 g/ton sorghum based diet and the synergetic effect of enzymes and probiotics; ProAct (200 g/ton), ENV (60 g/ton), G2G (200 g/ton), ENV (60 g/ton) and XAP (100 g/ton) in sorghum based diet, improved body weight gain and feed efficiency, and were comparable to maize based diet.
2. Nutrient digestibility and carcass characteristics showed that exogenous enzymes and probiotics made more nutrients available for broiler chicken utilization and increased the dressing percentage of broiler chickens.
3. The inclusion of probiotics and in combination with enzymes in sorghum based diet increased the net profit of birds.

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