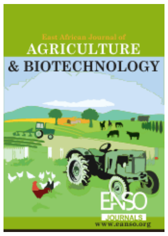

East African Journal of Agriculture and Biotechnology
eajab.eanso.org
Volume 8, Issue 1, 2025
p-ISSN: 2707-4293 | e-ISSN: 2707-4307
Title DOI: https://doi.org/10.37284/2707-4307

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency

General B. Mundida[1], Claudius T. Ndavambi[2] & James Madzimure[3]*

[1] Chinhoyi University of Technology, Private Bag 7724, Chinhoyi, Mashonaland West, Zimbabwe.
[2] Windmill Private Limited, P. O. Box 560, WGT, Harare, Zimbabwe
[3] Africa University, P. O. Box 1320, Nyanga Road, Mutare, Manicaland, Zimbabwe
* Author for Correspondence Email: generalbevenmundida@gmail.com

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Date Published:

07 February 2025

Keywords:

Broiler, Exogenous Enzyme, Feed Intake, Growth Performance, Carcass Characteristics, Economic Evaluation.

ABSTRACT

Non-starch polysaccharides (NSPs) affect poultry performance by lowering the nutritive value of feedstuffs in poultry diets. Poultry naturally produce a wide range of enzymes to aid in digestion, but the range is not comprehensive and most of the NSPs are not digested. High levels of NSPs can result in increased viscosity in the small intestine of chickens, and depress nutrient utilization and performance. The development of exogenous enzymes to target specific substrates and ameliorate anti-nutritive effects has received increased attention. Therefore, a study was conducted to evaluate the effect of exogenous enzymes (No enzyme - control treatment; Avizyme; Probizyme; Natuzyme) on feed intake, growth performance, carcass characteristics, and economic evaluation of enzyme supplementation in broilers fed maize and soya bean-based diets. The enzyme levels added to the diets were 350g/tonne for all enzyme treatments except for the control treatment. A total of 240 one-day-old broiler chicks (Cobb 500) were randomly allocated to one of the four dietary treatments, each replicated three times (20 chicks per pen) in a completely randomised design (CRD). Data obtained were analysed using the GLM procedure of Minitab version 17 for a CRD design, with differences considered significant at P<0.05. Preliminary results showed significant improvement (P<0.05) on broilers that were fed diets supplemented with exogenous enzymes on feed intake, weekly live weights (WLW), average daily gains (ADG), feed conversion ratios (FCRs), performance efficiency factors (PEFs), carcass characteristics and viscera organ weights of broilers. Economic evaluation showed monetary benefits from including the enzymes in poultry diets as birds that were fed diets supplemented with exogenous enzymes yielded more profits due to high organ and viscera weights. It was concluded and recommended that feeding broilers with diets supplemented with exogenous enzymes improved feed intake, growth performance, carcass characteristics as well as economic returns.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

APA CITATION

Mundida, G. B., Ndavambi, C. T. & Madzimure, J. (2025). Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency. *East African Journal of Agriculture and Biotechnology*, *8*(1), 47-59. https://doi.org/10.37284/eajab.8.1.2679

CHICAGO CITATION

Mundida, General B., Claudius T. Ndavambi and James Madzimure. 2025. "Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency". *East African Journal of Agriculture and Biotechnology* 8 (1), 47-59. https://doi.org/10.37284/eajab.8.1.2679

HARVARD CITATION

Mundida, G. B., Ndavambi, C. T. & Madzimure, J. (2025) "Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency", *East African Journal of Agriculture and Biotechnology*, 8(1), pp. 47-59. doi: 10.37284/eajab.8.1.2679.

IEEE CITATION

G. B. Mundida, C. T. Ndavambi & J. Madzimure "Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency", *EAJAB*, vol. 8, no. 1, pp. 47-59, Feb. 2025.

MLA CITATION

Mundida, General B., Claudius T. Ndavambi & James Madzimure. "Impact of Exogenous Enzyme Supplementation on Broiler Growth, Carcass Quality, and Economic Efficiency". *East African Journal of Agriculture and Biotechnology*, Vol. 8, no. 1, Feb. 2025, pp. 47-59, doi:10.37284/eajab.8.1.2679

INTRODUCTION

Enzyme supplementation as a feed additive in poultry diets has become common in the last four decades, mainly to improve the energy utilisation of cereals with high soluble non-starch polysaccharides (NSPs) levels (Zakaria et al., 2008). The main cereal grains that are utilised in poultry diets are maize, sorghum, wheat, barley, oats and rye. However, these feedstuffs contain a number of complex carbohydrates termed non-starch polysaccharides (NSPs). These non-starch polysaccharides (NSPs) possess anti-nutritive activities even at low levels in poultry diets (De-Patch, 2012). Non-starch polysaccharides (NSPs) are refractive to poultry digestive enzymes because of lack of and/or insufficiency of endogenous enzyme secretions (Botha, 2011).

These non-starch polysaccharides (NSPs) found in cereal grains lower the utilization of other dietary nutrients, leading to reduced bird performance. Examples of such anti-nutritive components include β-glucans in maize, xylans in barley, pentosans in wheat, and certain oligosaccharides in soya bean meal (Zakaria et al., 2008). Therefore, the development of commercially available feed enzymes to target specific substrates and ameliorate anti-nutritive effects has received increased attention in the last few decades

The improvements are related to greater digestion and absorption of nutrients and cereal grains caused by the degradation of cell wall non-starch polysaccharides (NSPs) (Gitoee et al., 2015). The degradation of NSPs has been proposed as the underlying mechanism to improve bird performance by releasing nutrients trapped within the cell and lowering digesta viscosity to enhance nutrient digestion and subsequent absorption (Bedford & Schulze, 2008; Ghobadi & Karimi, 2012). Thus, the objective of this study was to evaluate the effect of supplementing exogenous enzymes on feed intake, growth performance, carcass characteristics and economic efficiency of broiler chickens fed maize and soya bean-based diets.

MATERIALS AND METHODS

Study Site

The study was carried out at the Chinhoyi University of Technology Farm, Chinhoyi in Zimbabwe. The farm is located in Mashonaland West Province, 120km from Harare at the coordinates 17.3533° S, 30.2058° E. It falls under the Agroecological Region 2b (Mwale et al., 2023) and is characterised by intensive crop and livestock

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

production. It receives an annual rainfall of 800-1000mm annually which is capable of sustaining crop, poultry and livestock production.

Laboratory Analysis of Feed Ingredients

Samples of feed ingredients that were used in the study were analysed for dry matter (DM), crude protein (CP), ether extract (EE), crude fibre (CF) and ash according to procedures of the Association of Official Analytical Chemists (AOAC, 1998) for proximate analysis. The proximate composition of the feed ingredients used in the study is shown in Table 1 below;

Table 1: Proximate Composition of the Main Ingredients Used in Feed Formulation (%)

	INGREDIENT	
COMPOSITION	**Maize**	**Soya bean**
Crude protein %	7.0	37.69
Crude fat/ oil %	1.5	28.2
Ash %	1.0	4.29
Moisture %	8.0	8.07
Crude fibre %	6.5	5.44
Carbohydrates %	76.0	16.31

Feed Formulation and Manufacturing

Feed formulation and manufacturing were done at Windmill (Pvt) Limited's Stapleford stock-feed factory. The IDT Trial and Error feed formulation software was used to formulate four iso-nitrogenous and iso-energetic diets. This software was used because it is user-friendly and an efficient, cutting-edge solution designed to facilitate the lowest-cost formulation using unlimited feed ingredients. One of the diets was formulated without exogenous enzymes and the other three diets were formulated with different enzymes namely avizyme which contains a cocktail of seven enzymes namely, phytase, protease, pentosanase, β-glucanase, cellulase, amylase and pectinase. The other two diets were formulated using probizyme and natuzyme enzymes which contained xylanase, amylase and protease.) All the diets were formulated at the same inclusion rate of 350g per tonne of feed as per the supplier's recommendation. The diets were formulated according to the recommended nutrient composition of the diets commonly used in the feeding of broiler chickens. In this respect, the starter diets targeted crude protein levels of 21% and metabolisable energy (ME) of 12MJ/KG dry matter. The grower diets targeted a crude protein level of 19% and metabolisable energy of 12MJ/KG dry matter. The finisher diets targeted a crude protein level of 18% and metabolisable energy of 12MJ/KG. Diets were formulated and manufactured for starter, grower, and finisher feeds (Table 2). To create the experimental diets, corn/ maize was ground through a 22.4-kW Jacobson hammer mill equipped with 3-mm screens to achieve an average particle size of 500um. After the grinding process, ingredients were batched and mixed in a horizontal double ribbon mixer for 120 s of dry mixing, followed by 180 s of wet mixing. Enzymes were added at an inclusion rate of 350g per tonne of feed as per the supplier's recommendation. The complete mash diets were conditioned and pelleted with a CPM pellet mill. The pellet mill was equipped with a 31-mm thick die and with 3-mm-diameter holes. In addition, treatments were conditioned at 85°C. Representative samples were collected to assess pellet integrity using standard procedures. After mixing, all diets were bagged and transported to Chinhoyi University of Technology Farm Poultry Section.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Table 2: Ingredient and Calculated Nutrient Composition of the Experimental Diets Used

	TREATMENT											
	Starter				**Grower**				**Finisher**			
Ingredient	**No enzyme**	**Avizyme**	**Probizyme**	**Natuzyme**	**No enzyme**	**Avizyme**	**Probizyme**	**Natuzyme**	**No enzyme**	**Avizyme**	**Probizyme**	**Natuzyme**
Maize meal white	61.13	61.05	61.1	61.11	58.96	58.87	58.93	58.94	68.96	68.97	68.66	68.67
Soya bean meal	34.06	34.02	34	34.55	36.59	36.54	36.58	36.58	26.88	26.89	26.87	26.87
Limestone flour	1.6	1.6	1.6	1.6	1.81	1.81	1.81	1.81	1.69	1.69	1.69	1.69
DL methionine	0.22	0.22	0.22	0.22	0.3	0.3	0.3	0.3	0.13	0.14	0.14	0.13
Lysine	0.26	0.26	0.26	0.26	0.2	0.2	0.2	0.2	0.06	0.07	0.06	0.15
Vit/Min premix	0.3	0.28	0.3	0.3	0.25	0.25	0.25	0.25	0.3	0.3	0.3	0.3
MCP	1.3	1.3	1.3	1.3	0.94	0.94	0.94	0.94	1.2	1.2	1.2	1.2
Salt	0.55	0.55	0.55	0.55	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6
L-threonine	0.13	0.13	0.13	0.13	0	0	0	0	0	0	0	0
t-phosphate	0.1	0.1	0.1	0.1	0	0	0	0	0	0	0	0
Toxin binder	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Pellet binder	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Enzyme	0	0.05	0.05	0.05	0	0.05	0.05	0.05	0	0.05	0.05	0.05
TOTAL (%)	100	100	100	100	100	100	100	100	100	100	100	100
Analysed and calculated nutrient composition												
ME (MJ/KG DM)	12.49	12.54	12.52	12.51	12.74	12.79	12.82	12.81	12.94	12.89	12.92	12.91
Dry matter (%)	90.53	90.67	90.61	90.58	89.48	89.57	89.43	89.63	90.01	89.54	90.04	89
Crude protein (%)	21.19	21.28	21.17	21.21	19.53	19.5	19.47	19.52	18.11	18.09	18	18.06
Calcium (%)	0.89	0.9	0.9	0.87	0.55	0.63	0.89	0.88	0.87	0.9	0.88	0.91
Phosphorus (%)	0.52	0.6	0.6	0.57	0.55	0.63	0.61	0.58	0.55	0.6	0.53	0.59

[1]Enzyme supplementation was done in four dietary treatments: No enzyme (Control); Avizyme; Probizyme; Natuzyme. [2]Vitamin/Mineral premix supplied the following per kilogram of diet: Vitamins:- retinol, 1,500 IU; cholecalciferol, 2,000 IU; dl-α-tocopheryl acetate, 50 IU; menadione, 4 mg; thiamine, 6 mg; riboflavin, 12 mg; pyridoxine 6 mg; cobalamin, 0.05 mg; biotin, 0.2 mg; folic acid, 2 mg; niacin, 50 mg; d-calcium pantothenate, 25 mg. Minerals:- Fe, 80 mg; Mn, 55 mg; Cu, 5 mg; Se, 0.1 mg; I, 0.18 mg. [3]Enzymes were formulated into the experimental diets at 350 g/1 000 kg of diet. [4]In duplicate samples.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Experimental Design

A completely randomized design (CRD) was used on unsexed Cobb-500-day-old broiler chicks, (n=240). Broiler chicks with an initial weight of approximately 34g – 45g were purchased from a local company (Irvine's Zimbabwe) from a parent flock age of 34 to 36 weeks. The experimental units (broiler chicks) were randomly assigned to 4 treatments (No enzyme -control treatment; Avizyme; Probizyme; Natuzyme). Each treatment comprised of three replicates each consisting of 20 birds in a pen measuring 2 square meters which made it easier for sampling. Each pen was equipped with a cylindrical hand feeder and drinker so the birds could take sufficient feed and water.

Brooder Preparation

The chicken pens were cleaned and disinfected two weeks prior to chick arrival using San G detergent. Dry wheat straw was used as bedding at a height of 7 – 10cm on the floor. Pre-heating was done a day before the chicks' arrival using gas brooders.

Management of Experimental Birds

Chicks were monitored three times daily. Gas brooders were used to provide warmth during the brooding period and adjusted in height every two days depending on chick behaviour. Brooder ventilation was checked regularly to avoid colds and accumulation of ammonia gas in the chicken house. The bedding was frequently turned using a fork, depending on the level of compaction. Wet bedding in areas around water troughs was removed and replaced with new bedding. Clean fresh water was given ad libitum.

During the first two to five days, the chicks received multi-vitamin (Stress mix WS) an Interchemie product in drinking water. The experimental birds were first fed experimental crumbled starter diets from day old up to day 18, followed by experimental grower pellets from day 19 to day 28. Lastly, experimental finisher diets from day 29 to day 35 were the trial was terminated.

The birds were vaccinated against Newcastle disease on day 10 and day 18 (in drinking water). Sick and dead birds were taken to the nearest Veterinary training centre for diagnosis and post-mortem respectively. Other management practices were based on the International Standards of Animal Welfare, Animal Handling and Care Standards of 2018 (Bayne and Turner, 2019).

Data Collection

Data on broiler performance parameters was collected over 35 days of the feeding trial. The variables that were measured were feed intake and weekly live weight. From this data, weekly feed average daily gain (ADG), feed conversion ratios (FCR) and performance efficiency factors (PEF) were computed using the formulas below. All the feed and animal weight measurements were taken using digital and platform scales respectively and recorded in tables. All the data was collected between 1000hrs and 1200hrs.

$$\text{Feed intake} = \text{Intial feed given (g)} - \text{Feed left (g)}$$

Equation 1

$$\text{Feed conversion ration} \frac{\text{Total feed (kg) consumed by the birds}}{\text{Total live weights (kg)at slaughter}} \text{ x } 100$$

Equation 2

$$\text{Performance efficiency factor} = \frac{\text{Liveweight (kg) x Liveability (\%)}}{\text{Age at depletion (days) x Feed conversion efficiency)}} \text{ x } 100$$

Equation 3

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Carcass Analysis

At the end of the 35-day trial, 5 birds per treatment were starved for 12 hours and slaughtered for carcass characteristics. Live weights, dressed weights and organ weights were taken using an electronic weighing balance and expressed as a percentage of the live weight of the birds.

Statistical Analysis

Data on the effect of feed enzymes on feed intake, growth performance and carcass characteristics on broilers fed maize and soya bean-based diets, was first tested for normality (normal distribution) using Minitab version 17. The Generalized Linear Model (GLM) of Minitab version 17 was used and initial body weight was used as a covariate. A comparison of means was done using Fisher's procedure of Minitab version 17.

Economic Evaluation

The economic evaluation was conducted to assess the feasibility of using the three enzymes in broiler feeds. The cost of diet was calculated taking into consideration the price of individual feed ingredients (Price prevailing at the time of conducting the experiment). The amount of feed consumed over the entire feeding period, cost of feed per kilogram and return per bird were calculated.

RESULTS

Feed Intake

Results for the effect of exogenous enzymes on feed intake of broilers are shown in Table 3 below. Feed intake results showed no significant difference (P>0.05) across all the treatments in the first 7 days of the experiment. The results of this study also showed that there was no significant difference (P>0.05) in feed intake (FI) from day 7 to day 28 for broilers fed diets supplemented with avizyme and probizyme enzymes. The control treatment (no enzyme) had the lowest feed intakes from day 7 up to day 35. There was a general increase in feed intake with time in all the treatments but at the end of the trial (day 35) results showed a significant difference (P<0.05). At the end of the trial (day 35), birds that were fed with feed supplemented with avizyme enzyme yielded the highest feed intake, followed by birds supplemented with probizyme, natuzyme and no enzyme (control treatment) respectively.

Table 3: Effect of Exogenous Enzymes on Feed Intake of Broilers

	FEED INTAKE (g)				
TREATMENT	**Day 7**	**Day 14**	**Day 21**	**Day 28**	**Day 35**
No enzyme	129.74 ± 6.85^a	468.27 ± 4.50^b	1036.9 ± 7.41^b	1875.1 ± 17.9^c	2801 ± 21.20^d
Avizyme	163.17 ± 0.68^a	532.57 ± 5.64^a	1190.9 ± 21.0^a	2116.3 ± 34.4^a	3310.5 ± 6.10^a
Probizyme	155.14 ± 1.86^a	524.4 ± 15.0^a	1161.3 ± 8.60^a	2083 ± 24.30^a	3228.8 ± 39.3^b
Natuzyme	149.93 ± 5.39^a	526.5 ± 26.60^a	1085.2 ± 24.2^b	1993.9 ± 1.83^b	3075.6 ± 20.5^c

SEM: standard error of the mean; ^{a,b,c} Mean values within a column indicated with different superscripts are significantly different (P<0.05)

Growth Performance

Weekly Live Weight (WLW)

The weekly live weights result of broilers in Table 4 showed that there was no significant difference (P>0.05) in the first 14 days across all the treatments. However, at the end of the trial (day 35), weekly live weights were highest in birds supplemented with avizyme and probizyme enzymes but these two were not significantly different (P>0.05). The control treatment (no enzyme) had the least weekly live weight.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Table 4: Effect of Exogenous Enzymes on Weekly Live Weight (WLW) of Broilers

	LIVE WEIGHT (g)				
TREATMENT	**Day 7**	**Day 14**	**Day 21**	**Day 28**	**Day 35**
No enzyme	174.50±1.89[a]	450.67±2.52[a]	891.17±4.38[b]	1439.50±3.74[c]	1875.50±21.20[c]
Avizyme	183.17±1.09[a]	483.92±3.47[a]	930.42±4.38[a]	1511.33±24.01[a]	2138.68±2.76[a]
Probizyme	179.12±2.97[a]	476.67±4.54[a]	919.83±5.75[ab]	1494.50±2.65[ab]	2101.05±5.98[a]
Natuzyme	178.13±1.42[a]	473.75±1.04[a]	900.92±14.20[ab]	1466.00±32.70[bc]	2011.58±31.70[b]

SEM: standard error of the mean; [a,b,c] Mean values within a column indicated with different superscripts are significantly different (P<0.05)

Average Daily Gain (ADG)

The average daily gain results of broilers in Table 5 showed that there was no significant difference (P>0.05) in the first 14 days across all the treatments. However, at day 35 birds fed diets supplemented with avizyme and probizyme enzymes had the highest average daily gains (ADG) but they were not significantly different (P>0.05). The control treatment (no enzyme) had the least average daily gain.

Table 5: Effect of Exogenous Enzymes on Average Daily Gain (ADG) of Broilers

	AVERAGE DAILY GAIN (g)				
TREATMENT	**Day 7**	**Day 14**	**Day 21**	**Day 28**	**Day 35**
No enzyme	24.93±0.27[a]	64.38±0.36[a]	127.31±0.63[b]	205.64±0.54[c]	267.93±3.03[c]
Avizyme	26.17±0.16[a]	69.13±0.50[a]	132.92±0.63[a]	215.91±3.43[a]	305.52±0.40[a]
Probizyme	25.59±0.42[a]	68.10±0.65[a]	131.41±0.82[ab]	213.50±0.38[ab]	300.15±0.85[a]
Natuzyme	25.45±0.20[a]	67.68±0.15[a]	128.70±2.03[ab]	209.43±4.67[bc]	287.37±4.52[b]

SEM: standard error of the mean; [a,b,c] Mean values within a column indicated with different superscripts are significantly different (P<0.05)

Feed Conversion Ratio (FCR) and Performance Efficiency Factors (PEF)

Results for the effect of exogenous enzymes on feed conversion ratio and performance efficiency factors of broilers are shown in Table 6 below. Feed conversion ratios (FCRs), showed a significant difference (P<0.05) across treatments. Birds fed with diets supplemented with avizyme enzyme had the best feed conversion ratio. Poor feed conversion ratios (FCRs) were observed in birds fed with diets supplemented with natuzyme enzymes and no enzyme (control treatment).

Performance efficiency factor (PEF) results for the study showed no significant difference (P>0.05) in birds fed diets supplemented with avizyme, probizyme and natuzyme. Birds fed with diets supplemented with natuzyme enzyme and no-enzyme supplemented diets were also not significantly different.

Table 6: Effect of Exogenous Enzymes on Feed Conversion Ratios (FCR) and Performance Efficiency Factors (PEF) of Broilers

	FCR AND PEF			
TREATMENT	**No enzyme**	**Avizyme**	**Probizyme**	**Natuzyme**
FCR	1.24±0.06[bc]	1.15±0.07[a]	1.21±0.06[b]	1.23±0.06[bc]
PEF	358.92±8.32[b]	394.75±0.45[a]	390.79±6.85[a]	375.98±9.57[ab]

SEM: standard error of the mean; [a,b,c] Mean values within a raw indicated with different superscripts are significantly different (P<0.05)

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Carcass Characteristics

Results for the effect of exogenous enzymes on organ weights of broilers are shown in Table 7 below. Results showed that birds in control treatment (no enzyme) had the least live weight, dressed weight, dressing percentage, weight of the breast, weight of thigh + drumstick and weight of wings. Birds fed diets supplemented with avizyme and probizyme enzymes were not significantly different (P>0.05) in all carcass quality attributes (live weight, dressed weight, dressing percentage, weight of the breast, weight of thigh + drumstick and weight of wings).

Table 7: Effect of Exogenous Enzymes on Organ Weights as % Body Weight

	TREATMENT			
MEASUREMENT	No enzyme	Avizyme	Probizyme	Natuzyme
Live weight (g)	1875.50±21.20^{c}	2138.70±2.76^{a}	2101.00±5.98^{a}	2011.60±31.70^{b}
Dressed weight (g)	1234.00±36.70^{b}	1547.10±26.80^{a}	1467±5.42^{a}	1475.3±35.70^{a}
Dressing %	65.85±2.66^{b}	72.34±1.34^{ab}	69.82±0.32^{ab}	73.42±2.74^{a}
Wt of Breast (% of LW)	28.56±2.48^{b}	35.40±1.11^{a}	31.78±1.57^{ab}	31.41±1.13^{ab}
Wt of Thigh + Drumstick (% of LW)	9.82±0.70^{b}	13.22±1.18^{a}	11.92±0.95^{ab}	11.92±0.13^{b}
Wt of Wings (% of LW)	7.46±0.31^{b}	10.12±0.17^{a}	8.89±0.39^{ab}	8.10±0.40^{b}

SEM: standard error of the mean; ^{a,b,c} Mean values within a raw indicated with different superscripts are significantly different (P<0.05); LW – Live weight

Viscera Weights

The viscera weight results in Table 8 showed that birds in the control treatment (no enzyme) had the least gizzard weight, liver weight, lung weight and heart weight. However, all other treatments (avizyme, probizyme and natuzyme) were not significantly different (P>0.05) in all parameters measured (gizzard weight, liver weight, lung weight and heart weight). Birds fed diets supplemented with avizyme enzyme perform slightly higher than those fed diets supplemented with probizyme and natuzyme enzymes.

Table 8: Effect of Exogenous Enzymes on Viscera Organ Weights as % Body Weight

	TREATMENT			
MEASUREMENT	No enzyme	Avizyme	Probizyme	Natuzyme
Gizzard weight (% of LW)	1.42±0.80^{b}	1.83±0.11^{a}	1.64±0.14^{ab}	1.57±0.06^{ab}
Liver weight (% of LW)	2.40±0.20^{b}	3.20±0.28^{a}	2.94±0.08^{ab}	2.76±0.20^{ab}
Lungs weight (% of LW)	0.48±0.001^{b}	0.66±0.08^{a}	0.55±0.08^{ab}	0.53±0.01^{ab}
Heart weight (% of LW)	0.50±0.03^{b}	0.83±0.09^{a}	0.71±0.002^{ab}	0.60±0.60^{ab}

SEM: standard error of the mean; ^{a,b,c} Mean values within a raw indicated with different superscripts are significantly different (P<0.05); LW- Live weight

Economic Evaluation of Inclusion of Exogenous Enzymes in Broiler Diets

Results for the economic evaluation of adding enzymes in broiler feeds showed that treatments with exogenous enzymes yielded more profits than the treatments without enzymes Table 9. Birds fed diets supplemented with probizyme enzyme yielded the highest profit followed by birds fed with avizyme, and natuzyme enzymes respectively. Birds fed diets without enzymes (control treatment) had the least profit as shown in Table 9 below.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Table 9: Economic Evaluation of Inclusion of Exogenous Enzymes in Broiler Diets

	DIET CONTAINING			
DIETS	**No enzyme**	**Avizyme**	**Probizyme**	**Natuzyme**
Feed intake (kg/bird)	2.8	3.3	3.2	3.1
Price of feed $/kg	2.04	2.07	2.07	2.07
Price of bird $/kg	3.50	3.64	3.64	3.64
Cost of feed $/bird	5.71	6.83	6.62	6.42
Slaughter weight (kg)	1.88	2.14	2.10	2.01
Price of live bird ($/bird)	6.58	7.79	7.64	7.34
Return $/diet	0.87	0.96	1.02	0.92

Amount of feed consumed over the entire feeding period

Live weight (kg) at the end of the feeding period that the birds were sold on a live weight basis

Return per bird price per kg live weight

Cost of feed consumed only

Return/ Earning per bird when the cost of feed removed

DISCUSSION

As cereal grains dominate in the production of poultry feeds, there is considerable interest in identifying situations in which enzyme addition to feeds based on these ingredients might be profitable. To date, little indication of success exists regarding the development of enzyme preparations specific to maize and soya-bean-based diets (Gitoee et al., 2015). (The primary objective of this study was to evaluate the effect of supplementing exogenous enzymes on feed intake, growth performance and carcass characteristics on broiler chickens fed maize and soya bean-based diets and evaluate the economics of enzyme supplementation.

The similar feed intake cross-treatments at day seven could be due to the fact that birds were still acclimatizing to the diets. These results coincide with the findings of Abbas et al. (2002) and Naqvi et al. (2004). In contrast to this study, other researchers reported that enzyme supplementation resulted in increased feed consumption in the first seven days (National Research Council, 1994; (Aok; 2012). At day 35 birds that were fed on diets with exogenous enzymes had the highest feed intakes probably due to a reduction in bulkiness and intestinal viscosity which is accompanied by the presence of reduced soluble NSPs. The increase in feed intake by birds fed diets supplemented diets could also be due to enzymes that facilitate the breakdown of larger molecular structures of the feed ingredients into smaller ones by their specific action and making these nutrients readily available to the digestive system for better absorption (Aok; 2012; Davey et al., 2014).

The finding that there were no differences in the live weight of birds in the first fourteen days across all the treatments is in agreement with Sekoni et al. (2008). Birds in all treatment diets might have been affected by incomplete hydrolysis of the soluble NSPs which increases viscosity of the intestinal digesta and subsequently results in poor absorption of nutrients. On the contrary Yu et al. (2007) reported higher live weights in treatment groups supplemented with exogenous enzymes. At day 35, the birds in enzyme-supplemented diets had higher live weights due to increased feed intake and improved feed utilisation. This finding is in support of the findings of Schang et al. (2007) and Svihus (2011).

The observation that there were no differences in average daily gain (ADG) in birds during the first two weeks across all the treatments could be due to incomplete hydrolysis of soluble NSPs which lowers the nutritive value of feeds resulting in increased viscosity in the small intestine of

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

chickens, and depress nutrients utilization. This finding is in line with that of Ghazi et al. (2012). However, this finding contradicts the finding of Yu et al. (2007) who reported high average daily gains in birds fed diets supplemented with exogenous enzymes due to improved digestibility and feed utilisation. At day 35, birds fed diets supplemented with exogenous enzymes had high average daily gains due to improved digestibility and feed utilisation as a result of complete hydrolysis of soluble NSPs in feedstuffs. This finding is in agreement with that of Svihus (2011).

Better feed conversion ratios (FCRs) that were observed in birds supplemented diets with exogenous enzymes could be due to the complete hydrolysis of soluble NSPs by exogenous enzymes which reduced the viscosity of the intestinal digesta and increased absorption. This finding is in agreement with the work of several researchers (Yu et al., 2007; Gutierrez del Alamo et al., 2008; Ravindran et al., 2009). On the contrary, Cowan (2000) reported a 2-3% decrease in the efficiency of feed utilisation by birds fed diets containing exogenous enzymes.

High-performance efficiency factors (PEFs) that were observed in birds fed diets supplemented with exogenous enzymes could have been attributed to high live weights and better feed conversion ratios as a result of enzyme supplementation that facilitated the breakdown of larger molecular structures of the feed ingredients into smaller ones by their specific action and making these nutrients readily available to the digestive system for better absorption. These results are in agreement with the findings of Ravindran et al. (2009).

The finding that low live weight at slaughter, dressed weight, dressing percentage, breast weight, thigh + drumstick weight and wing weight observed in the control treatment (no-enzyme) could be due to poor feed conversion efficiency as a result of an increase in bulkiness and intestinal viscosity which was accompanied with the presence of increased soluble NSPs hence birds not fulfilling their nutritional requirements for growing. In agreement with these results, a previous study reported a significantly poor yield in terms of carcass organs of birds that were fed corn-based diets not supplemented with enzymes, (Down et al., 2006). High live weights at slaughter, dressed weights, dressing percentages, breast weights, thigh + drumstick weights and wing weights observed in birds fed diets supplemented with exogenous enzymes could be due to complete hydrolysis of NSPs which reduced bulkiness and intestinal viscosity hence birds fulfilling their nutrients requirements. This finding is consistent with the findings of Alam et al. (2003) and Wang et al. (2005). On the other hand, this finding contradicts that of Omojola and Adesehinwa (2007).

The finding that low weights for viscera organs (gizzard, liver, lungs and heart) were obtained in the control treatment (no-enzyme) could be due to poor feed conversion efficiency. Wang et al. (2005) reported that an increase in bulkiness and intestinal viscosity was accompanied by the presence of increased soluble NSPs hence birds not fulfilling their nutritional requirements for growing. High weights for viscera organs observed in birds fed with diets supplemented with exogenous enzymes could be due to better feed conversion efficiencies as a result of complete hydrolysis of NSPs resulting in broiler chickens fulfilling their nutrient requirements. This finding is in agreement with Pretson et al. (2006). However, on the other hand, this finding contradicts the research that was done by Zhang et al. (2000).

High returns (profits) that were obtained from birds fed with diets containing exogenous enzymes could be due to better feed conversion ratios which resulted in higher body weight gain and higher live weights at slaughter. This finding agrees with that of (Aok; 2012) who reported an increased profit by 20.7% in groups fed diets containing exogenous enzymes.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

CONCLUSIONS

It was concluded that supplementing broiler diets with exogenous enzymes had a beneficial effect on the performance indices of the birds in terms of feed intake, growth performance (average daily gains, average weekly weights and carcass characteristics (organ weights and viscera weights). The use of exogenous enzymes (avizyme, probizyme and natuzyme) improved the returns per bird by ($0.96; $1.02; $0.92) respectively. Diets supplemented with probizyme enzyme yielded the best economic returns with $1.02 per bird.

Acknowledgements

The authors would like to acknowledge the Department of Stock Feeds and Animal Health, Windmill Private Limited for funding the research. The School of Agricultural Sciences and Technology is also greatly appreciated for providing the facilities, in particular the fowl run used during the study. Special thanks to Windmill Private Limited and Nomagugu Nyoni for technical support during feed preparation, sampling, and sample analysis. The Mercantiles: Mr. Only Kudzanai Samanyanga and Miss. Tariro Chikoto are also appreciated for their assistance in daily feeding and sampling of the birds. The Department of Animal Production, Chinhoyi University of Technology is acknowledged for its technical assistance in proximate analysis.

Authors' Contributions

General Beven Mundida, Claudius Tinashe Ndavambi and Prof. James Madzimure planned and designed the experiment. Prof James Madzimure helped with data analysis. General Beven Mundida wrote the paper. All authors read and approved the final manuscript.

Funding Disclosure

This study was funded by the Department of Stock Feeds and Animal Health, Windmill Private Limited.

Data Availability Statement

The authors declare that the data supporting the findings of this study are available from the corresponding author. Should any raw data files be needed, they will be made available upon reasonable request.

Statement of Animal Rights

The experiment was conducted following the approved procedures and guidelines from the Ethics Committee of the Chinhoyi University of Technology.

Competing Interests

The authors declare that they have no conflicts of interest.

REFERENCES

Abbas, W., Khan, S. H., & Sarwar, M. (2002). Sunflower oil meal as substitute for soya bean meal in broiler rations with or without multienzyme (Kemzyme). *Pakistan Veterinary Journal*, *18*(3), 922-928.

Alam., T. G., Adams, C. A. A., & Pough, R. (2003). Non-starch polysaccharides digestion in poultry. Feed Compounder, Vol. 13, pp: 19-21.

Aok, Y. D. P. Y. (2012). Effect of feed enzymes and energy level on broiler chicken (Gallus domesticus) performance in Kenya (Doctoral dissertation, University of Nairobi, Kenya).

Bayne, K., and Turner, P.V. (2019). Animal welfare standards and international collaborations. *ILAR journal, 60(1), 86-94.*

Bedford, M. R., & Schulze, H. (2008). Mechanism of action and potential environmental benefits from the use of feed enzyme. *Animal Feed Science Technology*, 53: 145-155.

Botha, C. (2011). The use of fibrolytic enzymes in maize-soya based broiler diets. March.

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

Cowan, W. D. (2000). The relevance of the intestinal viscosity on performance of practical broiler diets. Proceedings of the Australian Poultry Science Symposium 7: 116-12.

Davey, Y. D., A. Razdan and P. Aman, (1998). Effect of particle size and enzyme supplementation of diets based on dehulled peas on the nutrition value for broiler chickens. Animal Feed Science Tech. Vol. 74; pp: 229-239

De-Patch, A. Y. M. (2012). Effect Of Feed Enzymes And Energy Level On Broiler Chicken (Gallus Domesticus) Performance In Kenya. July.

Down, G. B., Helander, E. A., & Inborr, J. (2006). The Effect of Supplementing Enzymes on Some Nutritionally Important Characteristics of Wheat, Proceedings, 7th European Symposium on Poultry Nutrition, 19-21 June, pp 246.

Ghazi, S., Rooke, J. A. & Galbraith, H. (2003). Improvement of nutritive value of soybean meal by supplementing protease and alpha-galactosidase to broiler cockerels and broiler chicks diets. British Poultry Science. 44: 410-418.

Ghobadi, Z., & Karimi, A. (2012). Effect of feed processing and enzyme supplementation of wheat-based diets on performance of broiler chicks. 2119. https://doi.org/10.1080/09712119.2012.672307

Gitoee, A., Janmohammadi, H., Taghizadeh, A., & Rafat, S. A. (2015). Effects of a multi-enzyme on performance and carcass characteristics of broiler chickens fed corn-soybean meal basal diets with different metabolizable energy levels. *Journal of Applied Animal Research*, 43(3), 295-302.

Gutierrez del Alamo, A., Gruppen, H., Kormelink, F. J. M., & Voragen, A. G. J. (2008). Differences in Efficiency of Xylanases in breakdown of Wheat Flour Arabinoxylans due to their Mode of Action. Enzymes in Animal Nutrition. Kartause Ittingen, Thurgau, Switzerland, pp. 276-280. .Hastings, W. H., 1946. Enzyme Supplementation for Poultry Feeds. Poultry Science, 25: 584-586.

Mwale, V., Terera, T., Chakanya, C., Ndavambi, C., & Madzimure, J. (2023). Growth performance, carcass quality and sensory evaluation of meat produced from broilers fed Lucerne (Medicago sativa) based diets.

National Research Council. (1994). Nutrient requirements of poultry. Washington, DC National Academy Press.

Naqvi, L. U. and A. Nadeem. (2004). Bioavailability of metabolizable energy through kenzyme supplementation in broiler rations. Pakistan Vet. J., 24 (2): 98-100.

Omojola, A. C., & Adesehinwa, E. (2007). Potential of phytase enzymes as biocatalysts for improved nutritional value of rice bran for broiler feed. J Appl Environ Bio Sci. 2014; 4(3):377-380.

Pretson, V., Sundu, B., & Kumar, A. (2006). Response of broiler chicks fed increasing levels of copra meal and enzymes. Journal of Poultry Science 5: 13-18.

Ravindran, V., Selle, P. H. a., & Bryden, W. L. (2009). Effects of phytase supplementation, individually and combination with glycanase, on nutritive value of wheat and barley. Poultry Science, 78: 1588-1595.

Schang, M. J., Azcoma, J. O. a., & Arias, J. E. (2007). Effect of soybean meal enzyme supplement on performance of broiler fed com/soy or corn/soy full-fat soy diets. Poultry Science. 76 (suppl. 1): 132 (Abstr.).

Sekoni., G. B., Saunders., R. M., & Ronald, B. (2008). Effect of soybean meal enzyme supplement on performance of broiler fed

Article DOI : https://doi.org/10.37284/eajab.8.1.2679

com/soy or corn/soy full-fat soy diets. Poultry Science. 76 (suppl. 1): 132 (Abstr.).

Svihus, B. (2011). Effect of digestive tract conditions, feed processing and ingredients on response to NSP enzymes. *Enzymes in farm animal nutrition*, 129-159.

Wang, Z. R., Qiao, S. Y., Lu, W. Q. & Li, D. F., (2005). Effects of enzyme supplementation on performance, nutrient digestibility, gastrointestinal morphology, and volatile fatty acid profiles in the hindgut of broilers fed wheat-based diets. Poult. Sci. 84(6): 875.

Yu, Z., Kornergy, V., Ravindran, V., & Denbow, D. M. (2007). Improving phosphorus availability in corn and soybean meal for broiler using microbial phytase and calculation of phosphorus equivalency values for phytase. Poultry Science, vol. 750; pp: 240-249.

Zakaria, H. A. H., Jalal, M. A. R., & Jabarin, A. S. (2008). Effect of exogenous enzymes on the growing performance of broiler chickens fed regular corn/soybean-based diets and the economics of enzyme supplementation. *Pakistan Journal of Nutrition*, 7(4), 534–539.

Zhang., G. B., Saunders., R. M., & Ronald, B. (2000). Effect of soybean meal enzyme supplement on performance of broiler fed com/soy or corn/soy full-fat soy diets. Poultry Science. 76 (suppl. 1): 132.