

EFFECTS OF ENZYME SUPPLEMENTATION ON A RICE OFFAL -BASED DIET ON PERFORMANCE, CARCASS CHARACTERISTICS, BLOOD PROFILE AND INTESTINAL MORPHOLOGY OF BROILER CHICKENS

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ABSTRACT

A 56 days feeding trial was conducted to determine the effect of supplementing rice offal based diets with 0, 50 and 100g per kg of Quadraxyme® enzyme on the growth performance, carcass characteristics, blood profile and intestinal morphology of broilers chickens. One hundred and thirty-five (135) day old Marshal Strain broiler chicks sourced from Obasanjo Farm, Ota, Ogun state, Nigeriawere randomly allocated to three diets in a completely randomized design. Data collected during the experiment were subjected to Analysis of Variance. The result of growth performance were significantly ($P<0.05$) influenced by the level of enzyme supplementation. Final body weight increased from 2036.00g in (T1) to 2402.00g in (T3). Total body weight (TBW) and Total feed intake (TFI) significantly increased ($P<0.05$) as the level of enzyme supplementation increased in the diets. Birds fed (T3) diet recorded superior feed conversion ratio. Enzyme supplementation significantly ($p<0.05$) increased carcass weight, dressing percentages, breast weight and thigh percentage. The result however showed significant ($P<0.05$) decreased the relative size of internal organs. The values of lymphocytes and percentages of RBC and WBC were not influenced by the levels of enzyme supplementation ($P>0.05$) significant between the experimental groups. However, the values of cholesterol, LDL, urea, AST, creatinines and ALT decreased among birds fed enzyme supplemented diet, while the HDL was significantly ($p < 0.05$) increased compared to the control. It was concluded that supplementing broiler chicken with the enzyme up-to 100g/kg improved performance, increased carcass weight, dressing percentages, breast weight and thigh percentage of broiler chickens and has no adverse effects on haematological, biochemical indices and intestinal morphology. Broiler chicken rice offal-based diet can be supplemented with 100g/kg of Quadraxyme enzyme.

Keywords: Broiler, Enzyme, Rice offal, Supplementation

INTRODUCTION

Exogenous enzymes are widely recognized for their ability to enhance the nutritional value of feedstuffs high in soluble non-starch polysaccharides, which can lead to increased viscosity (Lazaro *et al.*, 2003). Notably, research has shown that enzyme cocktails containing carbohydrase and protease can improve both productivity and digestibility of corn and soybean meal, reducing viscosity for

broilers (Olukosi *et al.*, 2007; Cowieson and Ravindran, 2008). The inclusion of exogenous enzymes in broiler chicken feeds has garnered attention due to environmental and economic considerations. These enzymes aim to enhance diet utilization, reducing the amount of feed required to produce a given amount of meat and minimizing nutrient excretion into the litter (Kalmendal and Tauson, 2012). Commercial enzyme

products range from single enzymes to blends and fermentation products from microorganisms with diverse enzyme activities (Freitas *et al.*, 2011). While the efficacy of many commercial enzyme products is well-established, there remains some uncertainty about their precise mechanisms of action (Bedford, 2002). Numerous studies have indicated that dietary enzymes improve nutrient digestibility in broilers (Cowieson and Ravindran, 2008; Kalmendal and Tauson, 2012). Furthermore, Gao *et al.* (2007) proposed that enzyme supplementation could enhance immune organ development, suggesting a potential link between improved nutrient digestibility, immunity, and alterations in blood metabolite profiles, especially when enzymes are derived from anaerobic bacteria during ensiling (Safaa *et al.*, 2010).

Rice offal, an agricultural by-product, holds potential as a valuable component in poultry nutrition. Abundant year-round in many Nigerian rice-growing regions with numerous small-scale rice mills, this by-product comprises approximately 40% of parboiled rice and includes husk, bran polishing, and broken grains (Dafwang&Damang, 1995). Previous research (Dafwang and Damang, 1995; Carew *et al.*, 2005) has explored its substitution for cereals in poultry diets. However, high levels of non-conventional feedstuff with high fiber content have led to negative responses due to reduced nutrient utilization and metabolic issues in non-ruminants (Aletor, 1999; Onyimonyi, 2005). The use of Quadraxyme® enzyme could enhance the breakdown and utilization of non-starchy polysaccharides in rice offal, potentially expanding its role in poultry diets. This study aimed to assess Quadraxyme® enzyme impact on the utilization of rice offal-based diets in broiler chickens' diet.

MATERIALS AND METHODS

Study Site

The study was carried out at the Poultry Unit of the Department of Animal

Production and Health, Federal University Wukari located in Taraba State, Nigeria. Wukari is located at coordinates 9°47'0" E longitude and 7°51' 0" N latitude. The region predominantly features the characteristics of a savannah zone in terms of its vegetation. The climate exhibits distinct wet or rainy seasons, running from March or April through October, as well as a dry season extending from November to March or April, as outlined in the (Taraba State Dairy, 2008)

Experimental Diets

Basal diet was formulated for the starter and finisher phases to meet the requirements for broiler chickens according to NRC, (1994). The basal diet was supplemented with 0, 50 and 100g per kg of Quadraxyme enzyme. The gross compositions for the diets are as presented in Table 1

Experimental Design and Animal Management

One hundred and thirty-five (135) day old Marshal Strain broiler chicks sourced from Obasanjo Farm, Ota, Ogun state, Nigeria. The chicks were divided into three groups of 45 birds per group replicated three times in a completely randomized design. The birds were housed in pen on a deep litter system. Each pen was provided with feeders and drinkers. The birds were fed *ad libitum* and the experiment lasted for 56 days.

Carcass Characteristics and Internal Weight Evaluation

At the end of the study, two birds per replicate were randomly selected and starved for about 12 hours to empty the crops to avoid contamination of carcass. They were then slaughtered, scalded, plucked and eviscerated. The carcass and internal organs were removed, weighed and weight as described by Yakubu *et al.* (2017).

Blood Profile Examination

On the 56th day of the experiment, 6 birds were slaughtered from each group, and samples of blood were obtained immediately in two different kinds of tubes: those with EDTA for hematological parameters: red blood cells (RBC) and packed cell volume (PCV) were carried out utilizing the method described by Campbell, (1995), as well as

blood hemoglobin (Hb), which was performed with Drabkin's method using Biosystems kit described by Abdulmajeed *et al.* (2022). After that, the mean corpuscular hemoglobin (MCH), mean corpuscular volume (MCV), and mean corpuscular hemoglobin concentration (MCHC) were estimated using the methods of Abdulmajeed *et al.* (2022). Other tubes were plain tubes (without anticoagulant) for serum isolation, which was done according to Hameed *et al.* (2022), then kept at -20°C for estimating the glucose, cholesterol, triglycerides, high-density-lipoprotein

cholesterol (HDL-C), protein, albumin, globulin, ALT and AST activities by using Biosystems (Spain).

Data Analysis

All data obtained during the experiment were subjected to Analysis of Variance (ANOVA) described by Steel and Torrie (1980) using the General Linear Model procedure of Statistical Analysis System (SAS, 2009). Means were separated using Least significant difference (LSD) option the software.

Table 1. Ingredient Percentage Composition of Experimental Diets

Ingredients	Starter	Finisher
Maize	48.00	50.00
Soybean cake	15.00	13.00
Kapok seed cake	5.00	5.00
Groundnut cake	4.00	4.00
Fish meal	3.00	3.00
Rice offal	20.00	20.00
Limestone	1.00	1.00
Bone meal	3.00	3.00
Methionine	0.25	0.25
Lysine	0.25	0.25
Salt	0.25	0.25
*Premix	0.25	0.25
Total	100	100
Calculated analysis		
ME kcal	2891.50	3023.89
Crude protein	22.36	19.00
Crude fibre	5.00	5.01

premix composition (per kg of diet): vitamin A, 12500 IU; vitamin D₃, 2500 IU; vitamin E, 50.00 mg; vitamin K₃, 2.50 mg; vitamin B₁, 3.00 mg; vitamin B₂, 6.00 mg; vitamin B₆, 6.00 mg; niacin, 40 mg; calcium pantothenic, 10 mg; biotin, 0.08 mg; vitamin B¹², 0.25 mg; folic acid, 1.00 mg; chlorine chloride, 300 mg; manganese, 100 mg; iron, 50 mg; zinc, 45 mg; copper, 2.00 mg; iodine, 1.55 mg; cobalt, 0.25 mg; selenium, 0.10 mg; and antioxidant, 200 mg.

Enzyme composition per kg diet: amylase 110,000units, cellulose 500,000.00units, xylanase 1,000,000units, lipase 10,000units, pectinase 30,000.0units and 4,000 unit

RESULTS AND DISCUSSION

Effects of Enzyme Supplementation on Growth Performance of Broiler Chickens

The result of enzyme supplementation on growth performance of broiler chickens is shown in Table 2. All the parameters evaluated were significantly ($P < 0.05$) influenced by the level of enzyme supplementation. Final body weight increased from 2036.00g in (T1) to 2402.00g in (T3). Total body weight (TBW) and Total feed intake (TFI)

significantly increased ($P < 0.05$) as the level of enzyme supplementation increased in the diets. Birds fed (T3) diet recorded superior feed conversion ratio. These results are in agreement with several reports regarding enzyme supplementation in broiler chicken diets. Kocher *et al.* (2003) reported that using an enzyme in broiler chickens resulted in an improved performance. Also, Cowieson *et al.* (2006) indicated that enzyme can be used successfully in a strategically formulated low nutrient density diet to maintain

performance to that of birds fed on a nutritionally adequate diet. In addition, Cowieson and Ravindran (2008) stated that supplementing corn-SBM-based broiler diets with an enzyme improved BWG and feed efficiency compared with the un-supplemented diets. Improved performance observed in this study could

be attributed to the mode of action of enzymes in the diet which could linked to the modification of the intestinal microbial communities, improved protein solubility and digestibility and a reduction in the inimical effects that might be caused by the diets

Table 2 Effects of Enzyme supplementation on Growth Performance of Broiler Chicken

Parameter	Levels of enzyme supplementation			SEM	P-value
	T1 (0g control)	T2 (50g)	T3(100g)		
Initial body weight (g)	45.84	46.34	46.45	1.52	>0.939
Final body weight (g)	2036.00 ^c	2104.00 ^b	2402.00 ^a	3.54	<0.001
Total body weight (g)	1991.20 ^c	2158.00 ^b	2457.00 ^a	8.69	<0.001
Total Feed intake (g)	4029.00 ^b	4340.00 ^{ab}	4539.70 ^a	16.22	0.050
Feed conversion ratio	2.02 ^a	2.00 ^a	1.80 ^b	0.03	<0.02

Means on the same row bearing different superscript differ significantly

Carcass characteristics and internal organ weights of broiler chicken fed enzyme supplemented diets.

Effects of enzyme supplementation on carcass characteristic and internal organ weights is presented in Table 3. Enzyme supplementations significantly ($p < 0.05$) increased carcass weight, dressing percentages, breast weight and thigh percentage. The result however showed significant ($P < 0.05$) decreased the relative size of internal organs. This result is in agreements with findings of Alam *et al.* (2003), Pisarski and Wang *et al.* (2005), they reported increased carcass yield by addition of enzymes in diet attributable to higher fat deposition in carcass and also for increased breast meat yield. On the other hand, this result contradicts with the report of Biswas *et al.* (1999) who found that carcass yield was similar in enzyme

treated and non-treated diets. This finding demonstrated that enzyme supplementation has more positive effect on carcass yield of broiler chickens. Hajati *et al.* (2009) showed that enzyme supplementation improved digestion and nutrient utilization and absorption suggesting this factor may be responsible for the improved performance of broiler chickens thereby translating to the deposition of adipose tissue which is clearly seen in the carcass yield. However, non-inflammatory observation made on the internal organs such as liver and kidney showed that the diet was not toxic to the birds. Bone, (1979) that if a feed contain toxic metabolite, abnormalities in weights of organs such liver and kidney would be observed. This abnormality will arise a result of increase in metabolic rate of this organs.

Table 3 Carcass characteristics and Internal Organ Weights of Broiler Chicken Fed Enzyme Supplemented Diets

Parameter	Levels of enzyme supplementation			SEM	P-value
	T1 (0g control)	T2 (50g)	T3(100g)		
Live weight (g)	2016.00 ^c	2184.00 ^b	2302.20 ^a	3.10	<0.001
Dressed weight	1574.23 ^b	1734.56 ^a	1845.78 ^a	23.67	<0.05
Dressing percentage (%)	78.08 ^b	79.21 ^a	80.17 ^a	3.30	<0.01
Cut –parts					
Breast	32.50 ^b	33.13 ^a	34.34 ^a	0.70	<0.03
Thighs + Drumsticks	24.45 ^b	25.66 ^b	27.45 ^a	0.20	<0.02
Wings	7.24	7.56	7.53	0.15	>0.09

Shanks	3.36	3.47	3.90	036	>0.07
Internal organs (% live weight)					
Heart	0.69	0.65	0.68	0.60	>0.78
Liver	2.45	2.46	2.43	0.01	>0.53
Proventriculus	0.36	0.34	0.37	0.05	>0.35
Gizzard	1.31	1.30	1.30	0.10	>0.08
Spleen	0.094	0.093	0.094	0.40	>0.34
Abdominal fat	2.98	3.02	3.01	0.10	> 0.87
Kidney	0.12	0.13	0.12	0.03	>0.067

Means on same row bearing different superscript differed significantly

SEM = Standard error means

Effect of Enzyme Supplementation on the Biochemical Indices of Broiler Chickens

Table 4, showed the biochemical indices of broiler chickens fed enzyme supplemented diets. The result showed significant ($P < 0.05$) decrease in the cholesterol, LDL, urea, AST, creatinines and ALT, among birds fed enzyme supplement diet, while the HDL was significantly ($p < 0.05$) increased compared to the control.

There was a gradually significant decrease in cholesterol and LDL as enzyme levels increased in the diet. Birds fed T3 diet showed the lowest cholesterol and LDL among all experimental groups. Concerning HDL, birds fed T3 diet had significantly higher values. The most important mechanism upon which prebiotics reduce blood cholesterol levels is certainly through decreased intestinal lipid absorption by binding bile acids, leading to enhanced cholesterol excretion and hepatic synthesis of new bile acids (Ooi and Liong, 2010). Synthesis of bile acids from cholesterol in the liver is the most important way of cholesterol excretion (Wilson *et al.*, 1998). In this connection, Biswas *et al.* (2019) reported that cholesterol level was decreased ($p < 0.05$) in the 0.2% MOS group compared with other treated groups. Similarly, Kannan *et al.* (2005) and Juskiewicz *et al.* (2003) stated that serum total cholesterol concentration was significantly lower in broilers fed enzyme supplemented diets

when compared to a control diet. Additionally, among all treatment group, birds fed T3 diet had the lowest ALT and AST levels. When compared to the control group. The current result was in agreement with Helal *et al.* (2015) who found a significant reduction in the AST and ALT in the chicks that received prebiotic in their diet as compared with chicks fed control diet. The result ascertained the explanations of Jameel *et al.* (2014) who indicated a significant decrease in ALT and AST and declared that the differences might be due to the inclusion level of enzymes, probiotics, experimental plan executed, and management differences during rearing and environmental conditions. The creatinine levels were significantly low for the enzyme supplemented diets in comparison to those fed basal diet control diet. This was in line with the results of Helal *et al.* (2015) who found a significant reduction in creatinine levels in the chicks that received prebiotics compared to the control group. However, Muhammad *et al.* (2020) reported no significant difference in creatinine levels among treatment groups. The blood parameters showed that the group fed enzyme supplemented diet had the significantly lowest blood urea compared to the control diet. The result agrees with Biswas *et al.* (2019) and disagrees with (Muhammad *et al.*, 2020) who reported a non-significant difference among the urea levels between treatment groups.

Table 4 Effect of Enzyme Supplementation on The Biochemical Indices of Broiler Chickens

Parameters	levels of Enzyme Supplementation			SEM	P value
	T1(0g control)	T2 (50g)	T3 (100g)		
Aspartate transaminase (U/L)	116.34 ^a	99.76 ^b	88.68 ^c	0.45	<0.03
Alanine aminotransferase (U/L)	18.07 ^a	15.90 ^b	13.56 ^b	0.12	<0.001
Cholesterol (mg/dl)	128.22 ^a	122.10 ^b	113.30 ^c	11.89	<0.05
Low density lipoprotein (mg/dl)	58.09 ^a	43.64 ^b	40.32 ^c	1.23	<0.03
High density lipoprotein (mg/dl)	39.70 ^b	65.96 ^a	66.78 ^a	2.11	<0.001
Urea (mg/dl)	4.12	4.05	4.09	0.89	>0.09
Creatinine (mg/dl)	0.30 ^a	0.22 ^b	0.23 ^b	0.06	>0.001

Means with different letters within a row differs significantly

SEM: Standard error means

Effect of Enzyme Supplementation on the Haematology of Broiler Chickens

The result in Table 5 showed higher ($P < 0.05$) value (3.91) of Hb in birds fed T3 diet compared to the other treatment groups. In contrast, the lower value of 32.05 Heterophile was recorded in birds fed T3 diet. In addition, the H/L ratio was significantly decreased ($P < 0.05$) in enzyme supplemented diets. The values of lymphocytes and percentages of RBC and WBC were not influenced by the levels of enzyme supplementation ($P > 0.05$) significant between the experimental groups. The non-significant difference was

recorded in RBCs, WBCs, and lymphocytes observed. The results in this study agreed with the report of Ewuola and Egbunike, (2008). Moreover, Hb levels were significantly higher in all experimental treated groups as compared to the control group. However, Abdel-Fattah and Fararh (2009) reported that there was a significant increase in Hb when they used 1 kg of prebiotic (Bio-MOS®)/ton of feed compared with the basal diet fed, but a significant increase in RBCs count was detected in broilers fed prebiotic.

Table 5 Effect of Enzyme Supplementation on The Haematology of Broiler Chickens

Parameter	levels of Enzyme Supplementation			SEM	P -value
	T1 (control)	T2 (50g)	T3 (100g)		
Red blood cells (Cells/ μ L)	2.16	2.71	2.86	0.15	>0.08
White blood cells ($\times 10^3/\text{mm}^3$)	24.23	23.32	23.78	1.58	>0.06
Hemoglobin (%)	9.04 ^b	10.02 ^a	10.35 ^a	0.11	<0.001
Lymphocytes (%)	65.89	65.53	64.36	1.34	>0.09
Heterophile (%)	35.35 ^a	34.70 ^b	32.05 ^c	0.03	<0.05
Heterophile, : Lymphocytes ratio	0.58 ^a	0.54 ^b	0.51 ^b	0.56	<0.001

Means different letters within each row are significantly different

SEM: Standard error mean

Effects of Enzyme supplementation on the intestinal morphology of broiler chickens

The effect of enzymes supplementation on intestinal morphology of the broilers has been shown in Table 6. The intestine length was not significantly ($P > 0.05$) affected due to enzymes

supplementation. The result revealed a numerical increase between the enzymes supplemented diets. This implies that enzymes supplementation did not affect the intestine length of broilers. The finding from this negate earlier report of Momtazan *et al.* (2011) noted that inclusion of anvenzyme reduced the

relative weight of duodenum and length of the jejunum. The result also revealed that birds fed enzyme based diets recorded significant higher ($P<0.05$) duodenal villous height. The finding agreed with report of Luo *et al.* (2009) who found that supplementation of xylanase improved the villus height in the duodenum of the broiler chickens. Gao *et al.* (2008) also reported similar finding that supplementation of broilers with yeast increased the height of duodenal villi significantly. Increase in the villous height observed in enzyme supplemented groups may be due to trophic effect of enzyme on intestinal wall thereby increasing the villi height in broiler chicken.

Supplementation of enzymes showed a significant ($P<0.05$) variation on duodenal crypt depth. Maximum crypt depth was recorded in birds fed T1 diets and minimum crypt depth was noted in birds fed T3 diets. The findings of the present study confirmed the report of Awad *et al.* (2009) who found that supplementation of probiotics decrease the crypt depth in the small intestine of broilers.

The result also showed Maximum villous height and crypt depth ratio was recorded in birds fed (T3) diet while the minimum villous height and crypt depth ratio was observed in birds fed T1 (control). There were no significant differences in the villous height-crypt depth ratio among the dietary treatment. The result confirmed the report of Awad *et al.* (2009) who reported in their study that enzyme supplementation increased the villus height: crypt depth ratio both duodenum and ileum. Similarly, Luo *et al.* (2009) found that supplementation of xylanase improved the villus height: crypt depth ratio in the small intestine of broilers. The increase in the villus height and villus height: crypt depth ratio was associated with improvement in feed efficiency and growth performance by the enzyme thereby improving the gut health of broiler chickens.

Table 6 Effects of Enzyme Supplementation on The Intestinal Morphology of Broiler Chicken

parameter	Level of enzyme supplementation				P-value
	T1 (0g control)	T2 (50g)	T3 (100g)	SEM	
Duodenum length (cm)	33.12	32.45	31.78	0.45	>0.98
Jejunum length (cm)	81.45	84.56	83.56	2.45	>0.06
Ileum length length (cm)	75.45	76.45	73.56	1.34	>0.08
Small intestinal length (cm)	198.56	198.23	199.45	2.11	>0.87
Duodenum villous height (DVH) (µm)	1224.34 ^c	1562.45 ^b	1645.34 ^a	2.22	<0.02
Duodenum crypt depth (DCD) (µm)	156.45	158.34	164.56	2.12	>0.65
DVH/DCD	9.67	10.54	11.78	1.04	>0.34

Means different letters within each row are significantly different

SEM: Standard error mean

CONCLUSION

Supplementing broiler chicken with the enzyme up-to 100g/kg improved performance, increased carcass weight, dressing percentages, breast weight and thigh percentage of broiler chickens and has no adverse effects on haematological,

biochemical indices and intestinal morphology. Broiler chicken rice offal based diet can be supplemented with 100g/kg of Quadroxyme enzyme. Further study on the use of Quadroxyme enzyme beyond 100g/kg could be carried out.

REFERENCES

- Abdel-Fattah, F.A, and Fararh K.M (2009). Effect of dietary supplementation of probiotic, prebiotic and synbiotic on performance, carcass characteristics, blood picture and some biochemical parameters in broiler chickens. *Benha Veterinary Medical Journal*, 20: 9-23.
- Abdul-Majeed , A.F., Rahawi, G.A and Abdul-Rahman, S.Y.(2022). Supplementation of broiler drinking water with zinc sulfate and its impact on physiological performance Iraqi Journal of Veterinary Sciences, Vol. 36, Supplement I, 2022 (131-136)
- Alam, M.J.,Howlader, M.A.R., Pramanik, M.A.H &Haque, M.A. (2003). Effect of exogenous enzyme in diet on broiler performance. *International Journal of Poultry Science*. 2: 168-173.
- Aletor V.A, (1999). Some agro-industrial by-products and wastes in livestock feeding. A review of problems and prospects. *World Review of Animal Production* 32: 26-29
- Awad, W.A., Ghareeb, K., Abdel Raheem, S. and Bohm J. (2009). Effects of dietary inclusion of probiotic and symbiotic on growth performance, organ weights, and intestinal histomorphology of broiler chickens. *Poultry. Sci.*, 88: 49-55.
- Bedford, M.R. (2002). The role of carbohydrases in feedstuff digestion. Pages 319-336 in *Poultry Feedstuffs: Supply, Composition and Nutritive Value*. J. MacNab and N. Boorman, ed. CAB International, Wallingford, UK.
- Biswas, T., L. Mandal and S.K. Sarker, (1999). Studies of enzymes supplementation and herbal preparation at different levels of energy on the performance of broilers. *Journal of Interacademic*, 3: 53-58
- Biswas A, Namit M, Messam R, Nasir A.M, and Asitbaran M. (2019). Production performance, immune response and blood biochemical parameters in broiler chickens fed diet incorporated with prebiotics. *Journal of Animal Physiology and Animal Nutrition*, 103(2): 493-500. DOI: <http://www.dx.doi.org/10.1111/jpn.13042>

- Cowieson, A.J., Singh, D.N and O. Adeola (2006). Prediction of ingredient quality and the effect of a combination of xylanase, amylase, protease and phytase in the diets of broiler chicks. 1. Growth performance and digestible nutrient intake. *British Poultry Science*, 47: 477-489.
- Cowieson, A.J. and Ravindran, V (2008). Effect of exogenous enzymes in maize-based diets varying in nutrient density for young broilers: growth performance and digestibility of energy, minerals and amino acids. *British Poultry Science* 49: 37-44.
- Carew, S.N., Tuleun, C.D, Yaakugh, I.DI.(2005). The feed value of rice milling by products in broiler finisher diets. *Journal of Sustainable Tropical Agricultural Research*. 13: 69-73.
- Dafwang I.I. and Damang P, 1995. Rice offal in finishing diets for broilers. *Journal of Animal Production Research* 15 (1): 131-139.
- Ewuola, E.O, and Egbunike, G.N (2008). Haematological and serum biochemical response of growing rabbits bucks fed different levels of dietary fumonisin. *African Journal of Biotechnology*, 7: 4304-4309.
- Freitas, D.M., S.L. Vieira, C.R. Angel, A. Favero and A. Maiorka (2011). Performance and nutrient utilization of broilers fed diets supplemented with a novel mono-component protease. *J. Appl. Poult. Res.*, 20: 322-334
- Gado, H.M.,Metwally, H.M.,Soliman, HBasiony, A.Z.L. and. El-Galil,E.R (2007). Enzymatic treatments of bagasse by different sources of cellulase enzymes. In: The 11th Conf. Animal Nutrition, Egypt on November, 13-18, 10: 607
- Gao, J., Zhang, H.J., Yu, S.H., Wu, S.G., Yoon, I., Quigley, J. and Gao, Y.P. (2008). Effects of yeast metabolites in broiler diets on performance and immunomodulatory functions. *Poult. Sci.*, 87: 1377-1384.
- Hajati,HRezaei, M and Sayyahzadeh, H(2009). The Effects of Enzyme Supplementation on Performance, Carcass Characteristics and Some Blood Parameters of Broilers Fed on Corn-Soybean Meal-Wheat Diets. *International Journal of Poultry Science* 8 (12): 1199-120
- Hameed, H.M., Maty, H.N., Hassan, A.A.(2022) Effect of dietary BHA supplementation on certain physiological values in broiler chicken. *Iraqi J Vet Sci.*;36(3):815-819. DOI: 10.33899/ijvs.2022.132202.2068
- Helal M, Youssef F, Moursi M, Khalil W, and Abdel-Daim M (2015). The effectiveness of prebiotic as an alternative to the antimicrobial growth promoter on growth performance, blood constituents, intestinal healthiness and immunity of broilers. *Alexandria Journal of Veterinary Sciences*, 45: 13-25. DOI: <https://www.doi.org/10.5455/ajvs.179869>
- Jameel YJ, Abed A, and Al-Shimmary F (2014). Influence of adding garlic and thyme and their combination on immune response and some blood parameters in broiler. *International Journal of Advanced Biological Research*, 2: 102-106.
- Juskiewicz J, Zdunczyk Z, and Jankowski J (2003). Effect of adding mannan-oligosaccharide to the diet on the performance, weight of digestive tract segments, and caecal digesta parameters in young turkeys. *Journal of Animal and Feed Sciences*, 12: 133-142. DOI: <https://www.doi.org/10.22358/jafs/67690/2003>
- Kalmendal, R. and R. Tauson (2012). Effects of axylanase and protease, individually or in combination and an ionophore on coccidiostat performance, nutrient utilization and intestinal morphology in broiler chickens fed a wheat-soybean meal-based diet. *Poult. Sci.*, 91: 1387-1393
- Kannan M, Karunakaran R, Balakrishnan V, and Prabhakar T.G (2005). Influence of prebiotics supplementation on lipid profile of broilers. *International Journal of Poultry Science*, 4: 994-997. DOI: <https://www.doi.org/10.3923/ijps.2005.994.997>
- Kocher, A., M. Choct, G. Ross, J. Broz and T.K. Chung (2003). Effects of enzyme combinations on AME of corn-SBM based diet in broilers. *J. Appl. Poult. Res.*, 12: 275-283.

- Lázaro, R., M. García, M.J. Aranibar and G.G. Mateos (2003). Effect of enzyme addition to wheat-, barley-and rye-based diets on nutrient digestibility and performance of laying hens. *Br. Poult. Sci.*, 44:256-265.
- Luo, Dingyuan, Yanga, Fengxia, Yang, Xiaojun, Yao, Junhu, Shi, Baojun and Zhou, Zhenfeng (2009). Effects of xylanase on performance, blood parameters, intestinal morphology, microflora and digestive enzyme activities of broilers fed wheat-based diets. *Asian-Aust. J. Anim. Sci.* 22(9): 1288- 1295
- Mohamed FF, Hady MM, Kamel NF, and Ragaa NM (2020). The impact of exogenous dietary nucleotides in ameliorating *Clostridium perfringens* infection and improving intestinal barriers gene expression in broiler chicken. *Veterinary and Animal Science*, 10: 1- 9. DOI: <https://www.doi.org/10.1016/j.vas.2020.100130>
- National Research Council (1994). *Nutrient Requirements of Poultry*. 9th rev. ed. Natl. Acad. Press, Washington, DC, USA.
- Ooi L.G, and Liong M .T (2010). Cholesterol-lowering effects of probiotics and prebiotics: a review of in vivo and in vitro findings. *International Journal of Molecular Sciences*, 11: 2499-2522. DOI: <https://www.doi.org/10.3390/ijms11062499>
- Olukosi, O.A., A.J. Cowieson and O. Adeola (2007). Age-related influence of a cocktail of xylanase, amylase and protease or phytase individually or in combination in broilers. *Poult. Sci.*, 86: 77-86.
- Pisarski, R.K. and S. Wojcik, (1995). The effectiveness of pentosanase in relation of the composition of concentration for broiler chickens, *Annales Universitatis Mariae curie-lodowska. Sectio EE Zootechnica*, 13: 171-177. In *International Journal of Poultry: Science Abst.*, 1997, 23: 267
- Safaa, H.M., S.A. Riad, F.R. Mohamed, S.S. Siam and H.A. El-Minshawy (2010). Probiotic, prebiotic and yeast supplementation in broiler diets from 1 to 42 days of age: 2. Immune response and slaughter traits. *Poult. Sci.*, 89 (Suppl. 1): 546-547. (Abstr.)
- SAS Institute Inc. *SAS/STAT® 9.2 User's Guide*. 2nd ed. Cary: NC: SAS Institute Inc; (2009.) 115-125
- Taraba State Diary. (2008). *State Annual Official Diary Reports*;
- Yakubu, B; Mbahi, T.F, Haniel, G and Wafar, R.J. (2017). Effects of Feeding *Cassia obtusifolia* Leaf Meal on Growth Performance, Carcass Characteristics and Blood profile of Broiler Chickens. *Greener Journal of Agricultural Sciences*. Vol. 7(1) Pp001- 008
- Wilson PW, Agostino RBD, Levy D, Belanger AM, Silbershatz H, and Kannel WB (1998). Prediction of coronary heart disease using risk factor categories. *Circulation*, 97: 1837-1847. DOI: <https://www.doi.org/10.1161/01.cir.97.18.1837>