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Broiler Chicks Growth Performance and Carcass Traits as Influenced by Feed Form and Enzyme Supplementation

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KhA designed the experiments, analyzed the data and revised the paper. SGK revised the paper. WAM analyzed the data and wrote the paper. WK performed the experiments and conducted the chemical analysis. All authors have read and agreed to the final version of the manuscript.

Key words
Blood, Broilers, Enzyme, Feed form, Growth

ABSTRACT

This study aimed to evaluate the effects of three feed forms (pellet, crumble and mash) with or without CIBENZA enzyme supplementing (0.005%) on growth performance, blood parameters, and carcass traits of broiler. A total number of 576 unsexed one-day-old Cobb broiler chicks were grown over a 35-d period. Chicks were similar concerning body weight and sex. The experimental design was factorial 3x2; three forms of feed (pellet, crumble, and mash) with or without supplementing CIBENZA enzyme (0.005%) in diets. All diets were nearly iso-nitrogenous and iso-caloric based on digestible energy and contained similar levels of microelements. The results showed that chicks fed pellets diet recorded the highest final body weight, while those fed mash diet had the lowest value ($P<0.001$). Enzyme supplementing in diets led to a significant increase in final body weight by 1.04%, as compared with un-supplemented diets. Chicks fed pellets diet had the highest carcass weight percentage; while those fed mash diet had the lowest value ($P<0.05$). Serum total protein was significantly decreased with chicks fed mash diet, as compared with those fed pellets and crumble diets. Conclusively, it could be concluded that pellets feed form in broiler nutrition improved growth performance, feed efficiency, and blood metabolite profile when compared to crumble and mash feed form. Supplementation of protease enzyme in diets enhanced growth performance of broiler chickens.

INTRODUCTION

Modern broilers are genetically selected for higher growth performance. Today's normal growing broiler chickens can reach 2 kg body weight within 35 days, consuming only 3 kg feed (Choct, 2009). This growth enhancement is due to high feed intake rather than improved nutrient digestibility (Klasing, 2007). Therefore, increased feed intake is considered the most important factor determining feed efficiency for broilers (Bao and Choct, 2010). Optimal feed intake is dependent on many factors like temperature of the environment, nutrient density, and physical feed quality, which are considered the most important factors effect on the growth of broiler (Abdel-Moneim *et al*., 2021). Feed represents the major cost of poultry production, constituting up to 70% of the total cost. However, the cost of feed processing represents a significant percentage of feed costs and provides the greatest chance of affecting broiler performance beyond nutritional sufficiency (Behnke and Beyer, 2002). The feed form has a significant impact on growth performance, digestion, nutrient digestion, intestinal health, and productive performance of poultry (Abadi *et al*., 2019). Mash, crumble, and pellet are three commonly used forms of chicken feeds in the commercial broiler. Mash is a finely ground and mixed feed that provides better integration of growth and is more economical (Ahmed and Abbas, 2013). Ground feed is not so palatable and does not retain its nutritive value as well as ungrounded feed (Jahan *et al*., 2006). The pelleting process includes agglomerating the ingredients into bigger structures known as pellets by mechanical action in conjunction with moisture, pressure, and temperature (Massuquetto *et al*., 2020). Crumble also is a type of feed prepared at the mill by pelleting the mixed ingredients and then crushing the pellet to a consistency coarser than mash. Corzo *et al*. (2011) observed that

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mash diets enhanced the feed conversion ratio, starch digestibility, and intestinal glucose uptake of broilers compared with those fed pellet diets. Recently, Wan *et al.* (2021) found that pellet diets increased laying rate, feed intake, egg albumen quality, and apparent digestibility of laying hens, which in turn improved production performance and nutrient metabolism. The pelleting process has a higher cost compared to the mash, but this cost can be compensated by increased growth performance in broilers (Abdollahi *et al*., 2018).

Feed enzymes aim for enhancing nutrient digestibility, which improves live performance (Nusairat *et al*., 2022). The addition of exogenous enzymes to broiler chicken feeds has gotten more and more attention due to economic and environmental factors (El-Sanhoury and Ahmed, 2017). Dietary exogenous enzymes led to reducing feed needed to produce the same amount of meat, which means better utilization of diet nutrients (Kalmenda and Tauson, 2012). Also, Seidavi *et al*. (2017) observed that broilers fed a diet supplemented with Probio enzyme showed a satisfactory immune response compared to those fed a control diet. Furthermore, Saleh *et al*. (2019, 2020) documented that the addition of enzymes improved the growth performance, lipid peroxidation, immune response, and gut morphology in broilers. Therefore, this study aimed to evaluate the effects of three feed forms (pellet, crumble and mash) with or without CIBENZA enzyme supplementation on growth performance, blood parameters, and carcass traits of broiler chicks.

MATERIALS AND METHODS

This experiment was conducted at the Poultry Farm of the Agricultural Experimental Station, Faculty of Agriculture, Kafrelsheikh University, Egypt. All experiment procedures concerning using animals were approved by the Kafrelsheikh University's Faculty of Agriculture's Ethics Committee.

A total number of 576 unsexed one-day-old Cobb broiler chicks were grown over a 35-d period. The experimental design was factorial 3x2; three forms of feed (pellet, crumble, and mash) with or without supplementing CIBENZA enzyme (0.005%) in diets. Chicks were wing-banded, weighed individually, and randomly divided into six equal groups and each group contained six replicates (16 birds each). Chicks were similar concerning body weight and sex. All diets were nearly iso-nitrogenous and iso-caloric based on digestible energy and contained similar levels of microelements (Table I). The enzyme was added to the premix mixture, which is one of the basic ingredients in all diets. The enzyme used was CIBENZA DP100 containing 600000 I.U. enzyme (protease) activity/g (natural thermophilic *Bacillus licheniformis*, PWD-1) from United Bio-med Company. All chicks were raised in identical administrative conditions. Water and food were available *ad libitum* during the trial (0 to 5 weeks of age).

Table I. Composition and chemical analysis of experimental diets.

	Experimental diets			
	Pre starter	**Start-er**	**Grow-er**	**Fin-isher**
Nutrients				
Yellow corn	56.0	58.0	62.0	67.0
Soybean meal (48%)	23.0	25.0	24.5	18.5
Gluten (60%)	7.35	6.00	3.50	2.50
Full fat soybean	9.00	6.00	5.00	6.50
Soybean oil	0.00	0.60	1.20	1.70
Di-calcium phosphate	1.92	1.78	0.90	1.46
Limestone	1.43	1.33	1.60	1.10
Threonine	0.06	0.06	0.05	0.04
L-lysine	0.41	0.41	0.40	0.45
DL-Methionine	0.26	0.25	0.20	0.18
Salt	0.32	0.32	0.40	0.32
Premix(1)	0.20	0.20	0.20	0.20
Colin chloride	0.05	0.05	0.05	0.05
Total	100	100	100	100
Chemical analysis (% as DM)				
Dry matter (DM)	90.5	89.9	90.3	89.8
Ash	4.50	4.42	4.53	4.60
Crude protein (CP)	23.9	23.1	21.1	18.5
Crude fiber (CF)	3.10	3.20	3.20	3.40
Metabolizable energy (kcal/kg)(2)	3050	3071	3095	3190
Ether extract (EE)	4.80	4.20	4.00	4.20
Nitrogen-free extract (NFE)	54.2	54.98	57.47	59.1
Calcium(2)	1.10	0.90	0.85	0.80
Phosphorus(2)	0.67	0.60	0.55	0.50
Methionine(2)	0.65	0.57	0.52	0.56
Lysine(2)	0.90	1.12	1.33	1.17

(1) PESTMIX is produced by Pester company, China. Each 3 Kg vitamin and mineral mixture contains Vitamin A 12000000 IU, Vit.D3 2200000 IU, Vit. E 10000 mg, Vit.K,2000 mg, Vit.$B_1$1000mg, Vit.$B_2$4000mg, Vit. $B_6$1500mg, Vit.B_{12}10mg, Pantothenic Acid 10000mg, Niacin 20000mg, Biotin 50 mg, Folic acid 1000mg, Choline chloride 500gm, Selenium 100mg, Manganese 55000mg, Zinc 50000mg, Iodine 1000 mg and carrier $CaCO_3$, to 3000 gm. (2) Calculated.

Live body weight, feed intake, and the number of dead chicks were recorded weekly. Calculations were made for daily weight gain, feed conversion rate, and

mortality rate. Economic efficiency was estimated using this data. At the end of the experimental period (5 weeks of age), six birds were taken randomly from each treatment, fasted for 12 h, weighed, and then slaughtered to determine the carcass traits (carcass, gastrointestinal tract, liver, gizzard, heart, abdominal fat weights). At the end of the experimental period, blood samples taken from 6 birds of each treatment were analyzed for serum total protein, glucose, triglycerides, cholesterol, AST (aspartate aminotransferase), ALT (alanine aminotransferase), creatinine, and urea by using commercial kits (Bio-Diagnosis Co., Cairo, Egypt).

Data on the growth performance, blood, and carcass traits were subjected to a two-way analysis of variance to determine the impacts of feed form (T), enzyme supplementation in diet (E), and their interactions (T*E) utilizing the SAS (2000) general linear model (GLM) method. Duncan's multiple range tests were used (Duncan, 1955) to find substantial variations between averages at different levels.

RESULTS

Growth performance

Table II shows the impact of feed form and enzyme supplementation on the performance of growth in broiler chicks from 0 to 5 weeks of age. The chicks fed pellets diet recorded the highest final body weight, while those fed with mash diet had the lowest value (P<0.001). The daily weight gain also showed the same trend. Moreover, final body weight and daily weight gain were significantly increased with supplementing enzymes in diets. Daily feed intake reduced significantly by 3.07 and 3.47% for chicks fed crumble and mash diets, respectively, as compared to those fed pellets diet. While no significant differences were observed in daily feed intake due to enzyme supplementation. The feed conversion ratio was significantly improved with chicks fed pellets diet, as compared with those fed crumble and mash diets (P<0.001). However, enzyme supplementation had no impact on the FCR of birds.

Carcass traits

As shown in Table II, carcass percentage significantly differed with different feed forms. Chicks fed pellets diet had the highest carcass percentage; while those fed mash diet had the lowest value (P<0.05). Chicks fed pellets diet had significantly the lowest gastrointestinal tract percentage, while those fed mash diet had the highest value. No significant differences could be observed among chicks fed different feed forms in heart percentage, while the gizzard percentage was significantly higher in chicks fed a mash diet than those fed a pellet diet. Chicks fed pellets diet had significantly the highest values of the liver, giblets, and abdominal fat percentages, while those fed mash diet had the lowest values. Carcass trait values did not influence by enzyme supplementation in the diets.

Table II. Effect of feed form and enzyme supplementation on growth performance of Cobb broiler from 0 to 5 weeks of age.

Parameters	Feed form			SEM	Enzyme (%)		SEM	Sig.		
	Pellets	Crumble	Mash		0	0.005		T	E	T*E
Initial body weight (g)	41.6	41.1	41.4	0.183	41.7	41.7	0.171	NS	NS	NS
Final body weight (g)	2281.1^{a}	2045.1^{b}	1842.7^{c}	4.203	2045.6^{b}	2066.9^{a}	4.354	***	***	*
Daily weight gain (g/ d)	64.0^{a}	57.2^{b}	51.5^{c}	0.120	57.3^{b}	57.9^{a}	0.124	***	***	*
Daily feed intake (g/ d)	100.9^{a}	97.8^{b}	97.4^{b}	0.483	98.8	98.6	0.550	***	NS	NS
FCR (g/ g)(1)	1.577^{c}	1.709^{b}	1.893^{a}	0.009	1.737	1.716	0.033	***	NS	NS
Carcass % BW	78.8^{a}	77.8^{ab}	76.1^{b}	0.568	77.2	77.9	0.558	*	NS	NS
GIT % BW(2)	12.6^{c}	13.3^{b}	14.8^{a}	0.308	13.4	13.8	0.253	***	NS	***
Liver % BW	3.12^{a}	2.77^{b}	2.16^{c}	0.080	2.72	2.65	0.101	***	NS	**
Gizzard % BW	1.09^{c}	1.21^{b}	1.31^{a}	0.514	1.21	1.20	0.031	***	NS	NS
Heart % BW	0.53	0.50	0.51	0.045	0.49	0.54	0.030	NS	NS	NS
Giblets % BW	4.75^{a}	4.48^{b}	3.99^{c}	0.066	4.41	4.40	0.090	***	NS	*
Abdominal fat % BW	0.62^{a}	0.59^{a}	0.47^{b}	0.018	0.57	0.55	0.026	***	NS	NS

$^{a,b,c.}$ Means bearing different superscripts in a raw differ significantly; SEM, Standard error of means; Sig., Significance; ***, Significant at 0.1% level of probability; **, Significant at 1% level of probability; NS, Non-significant; *, Significant at 5% level of probability. T, Treatment; E, Enzyme; T*E, Interaction between treatment and enzyme. (1) FCR, Feed conversion ratio. (2) GIT, Gastrointestinal tract.

Table III. Effect of feed form and enzyme supplementation on blood parameters of Cobb broiler at 5 weeks of age.

Parameters	Feed form			SEM	Enzyme (%)		SEM	Sig.		
	Pellets	Crumble	Mash		0	0.005		T	E	TxE
Total protein (g/dl)	2.89[a]	2.75[a]	2.53[b]	0.056	2.73	2.72	0.053	**	NS	NS
Glucose (mg/dl)	229.7[a]	228.0[ab]	218.3[b]	4.724	221.7	229.0	4.021	*	NS	**
Triglyceride (mg/dl)	91.3[b]	93.2[b]	99.2[a]	1.537	94.1	95.0	0.943	***	NS	*
Total cholesterol (mg/dl)	143.7[c]	149.8[b]	162.5[a]	2.045	152.6	150.8	2.517	***	NS	**
HDL-cholesterol (mg/dl)	56.0[a]	53.2[a]	45.3[b]	1.400	51.4	51.6	1.864	***	NS	NS
AST (U/L)	12.7	12.2	12.3	0.558	12.8	12.0	0.408	NS	NS	NS
ALT (U/L)	9.50	9.83	9.67	0.764	9.56	9.78	0.521	NS	NS	*
Urea (mg/dl)	18.2	17.8	17.3	0.946	18.1	17.4	0.655	NS	NS	NS
Creatinine (mg/dl)	0.90	0.84	0.82	0.056	0.89	0.82	0.046	NS	NS	NS

[a, b, c.] Means bearing different superscripts in a raw differ significantly; SEM, Standard error of means; Sig., Significance; ***, Significant at 0.1% level of probability; **, Significant at 1% level of probability; NS, Non-significant; *, Significant at 5% level of probability. T, Treatment; E, Enzyme; TxE, Interaction between treatment and enzyme. ALT, alanine aminotransferase; AST, aspartate aminotransferase; HDL, high-density lipoprotein.

Blood parameters

As shown in Table III, serum total protein was significantly decreased with chicks fed a mash diet, as compared with those fed pellets and crumble diets. The same trend was observed for serum glucose, which decreased (P<0.05) when chicks were fed a mash diet. Chicks fed pellets diet had the lowest values (P<0.001) of serum total cholesterol and triglycerides, while those fed mash diet had the highest values. Moreover, the chicks fed a pellets diet had the highest value (P<0.001) of serum high-density lipoprotein (HDL), while those fed a mash diet had the lowest value. There were no effects on liver function enzymes (AST and ALT) and kidney function indicators (urea and creatinine). No significant differences could be observed due to enzyme supplementation in diets on blood parameters studied.

DISCUSSION

Chicks fed pellets diet recorded the best growth performance. The improvement in growth performance could be attributed to enhanced nutritional density, improved starch digestibility as a result of chemical changes during pelleting, increased nutrient intake, modifications to the feed's physical shape, decreased feed wastage, and reduced energy expenditure during eating (Amerah *et al*., 2007). Furthermore, Wan *et al*. (2021) found that chickens fed pellets diet had higher villus height (VH) and crypt depth (CD) in the small intestine, as well as a higher ratio of villus height to crypt depth (VCR) in the duodenum, as compared to those fed mash diet. The longer VH could be linked with improved surface area and consequently greater absorption (Soltan, 2009). Higher VCR indicated higher intestinal secretory ability and might result in greater nutrient digestibility and growth performance in chickens (Zang *et al*., 2009). Higher VH and CD in the small intestine of birds fed pellets may result in higher feed consumption and higher flow of nutrients in the proximal small intestine (Amerah *et al*., 2007). Moreover, in the present study, the increased feed intake for chicks fed pellets diet could be attributed to the pelleting process, which involves applying steam and mechanical pressure to the mash to agglomerate the feed particles and enhance the feed texture (Lundblad *et al*., 2011). Therefore, pelleting diets increase bulk density and feed consumption. This was also found by Cutlip *et al*. (2008), who observed an enhancement in feed consumption, weight gain, final body weight, and feed conversion with birds fed pellets compared to mash and 50:50 reground mash and pellets. Moreover, Rezaeipour and Gazani (2014) observed that birds fed pellet diets enhanced weight gain and feed consumption, and feed conversion ratio compared to those fed mash diets. Also, Mirghelenj and Golian (2009) observed that feeding crumble-pelleted diets result in a significant increase in feed consumption. The benefit of crumble-pellet diets may cause by an increase in appetite and diet density, a reduction in feed waste, and changes in ingredients (Sogunle *et al*., 2013). Shabani *et al*. (2015) found that broiler chickens fed the pelleted diet had significantly higher feed intake, weight gain, and better feed conversion ratio as compared to those fed the mash diet. These findings were inconclusive with Ahmed and Abbas (2013) who observed that feed intake was not significantly affected by feed physical form.

The improvement in final body weight and daily weight with supplementing enzymes in diet may be due to an effect on the decomposition of non-nutrients, increasing availability of important nutrients like starch, protein, and

minerals in cell walls rich in crude fiber, and improved diet palatability (Hosseintabar-Ghasemabad *et al*., 2020). Moreover, the enzyme supplementation in bird's diet led to a reduction of anti-nutrient effects, such as reduction of non-starch polysaccharides like xylans that exist in annual plants like amaranth, the role of a drop in viscosity, an increase of endogenous activity of lipase and chymotrypsin enzymes, improvement of digestibility of dry matter and protein and improvement of apparent metabolizability of energy (Bedford and Apajalahti, 2001).

The lower gastrointestinal tract percentage could be explained by the increase in the carcass percentage. No significant differences were observed among chicks fed different feed forms in heart percentage, while the gizzard percentage was significantly higher with chicks fed a mash diet than those fed a pellet diet. The same results have been revealed by Rezaeipour and Gazani (2014), who found that the relative gizzard weight was higher in birds fed mash feeds than in those fed pelleted feeds. Unlike our results, Sogunle *et al*. (2013) reported that the dressing percentage was unaffected by feed forms or feed particle size, and the effects were strongly associated with their interaction. Remarkable gizzard relative weight reduction was observed when broiler mash diets were replaced by whole wheat diets or pelleted diets. These findings could mean that pelleting reduced the gizzard's need for grinding, reducing its function to that of transit, and decreasing transit time due to particle size (Mateos *et al*., 2012) which resulted in reduced organ weight (Svihus, 2011). Also, Shabani *et al*. (2015) found that broiler chickens fed the pelleted diet had significantly higher breast ($P<0.01$) relative to the carcass weight, and lower weight of pancreas ($P<0.01$), duodenum ($P=0.02$), and cecum ($P<0.01$) relative to the carcass weight as compared to those fed the mash diet. Chicks fed pellets diet had significantly the highest values of the liver, giblets, and abdominal fat percentages, while those fed mash diet had the lowest values. Similarly, Attia *et al*. (2014) observed that the percentage of abdominal fat was significantly higher in birds fed pellet diets as compared to those fed mash diet.

In the current study, internal organs were not affected by the enzyme addition. These findings agree with Saleh *et al*. (2005), who observed that supplementing with dietary enzymes did not affect the liver relative weight. Also, Gao *et al*. (2007) stated that the addition of xylanase to broiler diets based on wheat, corn, and SBM did not affect the relative weight of the gizzard. Moreover, Sarica *et al*. (2005) indicated that adding xylanase to broiler diets based on wheat-corn-SBM did not affect the relative weights of the heart, liver, or gizzard. On the other hand, Saleh *et al*. (2019) proved that adding the enzyme combination xylanase and arabin ofuranosidase improved broiler development and carcass qualities.

Chicks fed a pellets diet had the highest value ($P<0.001$) of serum total protein and high-density lipoprotein (HDL) concentration, while those fed a mash diet had the lowest value. Similarly, Shabani *et al*. (2015) found that broiler chickens fed the pelleted diet had significantly higher plasma total protein and globulin concentrations as compared to those fed the mash diet. This is in disagreement with Rezaeipour and Gazani (2014), who found that birds that provided pellet diets, had higher triglyceride and VLDL contents than birds fed mash diets. Also, Attia *et al*. (2014) showed that feed form affected the biochemical and hematological parameters of the broiler's blood. The increase in plasma glucose and cholesterol concentrations in the group fed pellet diet was concurred with increasing meat lipids. On the contrary, Corzo *et al*. (2012) observed that feed form did not affect blood glucose concentration, while broilers fed a pelleted diet significantly increased blood total protein as compared to those fed a mash diet. On the other hand, enzyme supplementation in diets did not have any significant effect on blood parameters. These results are generally consistent with the outcomes mentioned by Attia *et al*. (2003) and El-Ghamry *et al*. (2005). They concluded that adding enzymes to broiler and duck diets had no appreciable impact on plasma components.

CONCLUSION

Conclusively, it could be concluded that pellets feed form in broiler nutrition improved growth performance, feed efficiency, and blood metabolite profile when compared to crumble and mash feed form. Supplementation of protease enzyme in diets enhanced growth performance of broiler chickens.

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IRB approval

This study was approved by the Local Experimental Animals Care Committee's Ethics Committee and done according to the rules of Kafrelsheikh University, Egypt. (No. 4/2016EC)

Ethical statement

All experiment procedures concerning using birds were approved by the Kafrelsheikh University's Faculty of Agriculture's Ethics Committee.

Statement of conflict of interest

The authors have declared no conflict of interest.

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