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Effect of phytase and zinc supplementation on growth performance, haemato-biochemical and carcass attributes in broiler chicken

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ABSTRACT

The present study evaluated phytase supplementation with or without dietary zinc (Zn) on growth performance, feed utilization, blood bio-chemicals and carcass attributes of broiler chickens in a 5×3 randomized design. One hundred and eighty (180) day-old Cobb chicks were randomly divided in to fifteen groups of twelve in each and were allocated to five dietary treatments with three replications. The control group of chicks received a basal diet without phytase and Zn, wherein the treatment groups in addition to basal diet received phytase alone or phytase with Zn. The treatment group P600 received (phytase 600 U/kg feed), PZ640 (phytase 600 U/kg + Zn 40 mg/kg), P800 (phytase 800 U/kg), and PZ840 (phytase 800 U/kg + Zn 40 mg/kg) and were reared for five weeks under uniform management conditions. Results indicated that phytase supplementation ($p < 0.01$) improved body weight gain and feed conversion ratio (FCR) compared to the control treatment, with maximum improvement observed in the PZ840 group. Birds fed phytase with Zn exhibited superior growth and feed efficiency compared to phytase alone. Blood biochemical analysis revealed increased total protein, reduced uric acid, and elevated alkaline phosphatase (ALP) activity in phytase- and Zn-supplemented groups, indicating enhanced protein metabolism and mineral utilization. The present study concluded that the supplementation of phytase 800 U along with Zn 40mg per kg feed improved feed conversion ratio and growth performance in broilers chicks.

Keywords: Broiler chicken, Growth performance, Feed conversion ratio, Phytase, Zinc

The poultry sector in India contributes substantially to the agricultural economy (NRC, 1994) and is the fastest growing sector. The major challenges faced by this sector is the escalating cost of feed, creating financial burden on producers, thus reducing profitability and sustainability of poultry enterprises. Another critical issue is the indiscriminate and excessive use of antibiotics in poultry diets to promote faster growth and reduce production costs. Such practices not only compromise the health and welfare of birds but also pose serious risks to human health and environment. To address prevailing challenges, researchers are exploring phytase and zinc (Zn) as low-cost, locally available, and safe alternatives for enhanced growth and improve nutrient utilization without compromising bird health or food safety.

Phytase is an exogenous enzyme that hydrolyses phytate, the principal storage form of phosphorus in cereals and oilseeds, thereby improving the availability of phosphorus, calcium, zinc, and other nutrients in plant-based diets (Denbow *et al.* 1995). Zinc (Zn), an essential trace mineral required for numerous enzymatic and metabolic functions, plays a critical role in growth, immune response, and skeletal development (Zakaria *et al.* 2017; Dibaiee-Nia *et al.* 2017). In plant-based feeds, a large proportion of Zn remains bound to phytate and is therefore unavailable to birds (O'Dell and Savage, 1960). NRC (1994) has recommended a dietary Zn level of 40 mg/kg in poultry diets. Phytase supplementation has been shown to improve phosphorus and protein digestibility (Selle and Ravindran 2007, Sapkota *et al.* 2021) and may also enhance Zn bioavailability (Yi *et al.* 1996, Chang *et al.* 2001). However, limited studies are available on the combined use of phytase and Zn in broilers. Therefore, the present study evaluated the effect of phytase with or without dietary Zn supplementation on growth performance, feed utilization, blood biochemical profile, and carcass traits of broiler chickens.

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MATERIALS AND METHODS

Ethical approval: The experimental protocol was approved by the Institutional Animal Ethics Committee (IAEC) of SVPUAT, Meerut.

Experimental birds and design: The experiment was carried out in a 5×3 randomized design, where one hundred and eighty (180) day-old Cobb chicks were randomly divided into fifteen groups of twelve in each and were allocated to five dietary treatments and each treatment had three replications. The control group chicks were fed a basal diet, while the treatments groups received either Phytase, Zn or combinations of both Zn as P_{600} (Phytase 600 Units/kg feed), P_{800} (Phytase 800 Units/kg feed), PZ_{640} (Phytase 600 Units and Zinc 40mg/kg feed) and PZ_{840} (Phytase 800 Units and Zinc 40 mg/kg feed) in addition to basal diet. The starter (0-2 weeks of age) and the finisher (3-5 weeks of age) diets were formulated as per BIS (2007) and their ingredients and nutrient content are presented in Table 1. During the entire experimental period, the chicks were raised in deep litter system under uniform managemental conditions with fresh, clean drinking water in the morning and evening.

Table 1. Ingredient and nutrient content of the experimental diet (g/kg as DM) having phytase[1] supplementation with or without Zn[2]

Attributes	Experimental basal diet	
	Starter	Finisher
Ingredients(g/kg) as feed		
Maize	515.5	575.5
Rice polish	70.0	100.0
Soyabean meal	300.0	250.0
Fish meal	80.0	40.0
Di-calcium phosphate	10.0	11.0
Limestone	12.0	12.0
Feed premix*	05.0	05.0
Salt	06.0	06.0
DL-Methionine	01.5	0.5
Nutrient content (g/kg DM)		
Dry matter	886.5	860.5
Total ash	142.8	149.6
Crude protein	229.6	207.8
Ether extract	44.2	48.2
Crude fibre	38.9	45.0
Nitrogen free extract	544.3	550.3
Neutral detergent fibre	315.0	347.3
Acid detergent fibre	118.7	113.2
Calcium	13.0	11.6
Phosphorus	8.8	8.3

* Include trace minerals, vitamins, toxin binder, coccidiostat. 1Phytase was commercially available product from Enzyme Bioscience Pvt Ltd, Surat, Gujarat; [2]Zn supplementation was from laboratory-grade $ZnSO_4 \cdot 7H_2O$ (Sigma Aldrich, St. Louis, MO, USA).

Measurement of growth performance and feed intake: Body weight of the individual birds was recorded at the beginning of the experiment and thereafter at weekly intervals using a digital weighing balance. The body weight gain (BWG) was calculated as difference between final and initial body weight each replication on weekly basis. Growth performance parameters were expressed on a replicate basis. Feed offered and residual feed were recorded weekly for each replicate to determine feed intake to calculate cumulative feed intake.

Feed conversion ratio (FCR) was calculated as the ratio of feed intake (g) to body weight gain (g) for each replicate.

Blood biochemical traits: At the end of the 5th week, two birds from each replication (six birds per treatment) were randomly selected for blood sampling. Approximately 3-4 mL blood was collected aseptically from wing vein, allowed to clot at room temperature and then centrifuge at 3000 rpm for 15 minutes to separate serum. Harvested serum was stored at -20 °C until analysis. Serum biochemical parameters such as total protein, uric acid , calcium, phosphorus, and alkaline phosphatase (ALP) activity were estimated using standard commercial diagnostic kits following the manufacturer's instructions. All biochemical estimations were performed using a semi-automatic biochemical analyser.

Carcass traits: At the end of experiment, six representative birds from each treatment group (two birds/replicate) were randomly selected. The birds were fasted overnight with free access to water before their slaughtering in humane manner. The pre-slaughter shrinkage in live weight was recorded. After defeathering and evisceration, carcass weight was recorded to calculate dressing percentage. The eviscerated weight was calculated by dividing the eviscerated carcass weight by the live weight of bird. The weight of giblet (heart, liver, gizzard) and individual cut-up parts (thighs, drumsticks, breast, back, neck, wings) were taken to study the organ attributes. Similarly, the parts of gastrointestinal tract (proventriculus, gizzard, small intestine, large intestine, caeca and spleen) were excised and weighed individually.

Statistical analyses: The observations on growth performance, feed efficiency and blood-biochemical parameters were analyzed using ANOVA using statistical package (SPSS version 20.0; SPSS Inc., Chicago, IL, USA). The model used was:

$$Y_{ij} = \mu + T_i + e_j$$

Where Y_{ij} is dependent variable, μ is the overall mean of the population, T_i is the effect of treatments, e_j is the random error. Duncan multiple range test was applied to separate treatment means for significance among the treatments.

RESULTS AND DISCUSSION

The addition of phytase and Zn to the basal diets of broiler chicken improved the performance in terms of weekly body weight and body weight gain (Table 2). The effect of phytase in broiler diet was enhanced ($p < 0.01$) on addition of zinc as overall body weight gain increased in PZ_{640} and PZ_{840} groups. The improved FCR in PZ_{640} and PZ_{840} groups was due to better efficiency of nutrient utilization. The results suggested that phytase and zinc can act synergistically for better growth in growing birds which cannot be expressed by mere presence of natural or exogenous Zn source in the diets. In present study, addition of 40 mg/kg Zn in feed to phytase supplemented basal diets improved the performance, which further improved at 800 Units phytase supplementation in PZ_{840} group. The present findings were in agreement with the reports of Akter *et al.* (2017), who studied the effect of Zn supplementation at three levels i.e. low, mid, and high levels (30, 40, and 50 mg/kg, respectively) with 500 Units/kg exogenous microbial phytase and reported significant enhancements in energy utilization in mid and high-level zinc diets with phytase supplementation. The supplementation of phytase could possibly increase the digestibility of proteins and various amino acids in birds, which contributed to the observed improvements in growth performance (Gehring *et al.* 2013). Similar to present findings, previous studies have also reported a positive impact of dietary zinc supplementation on the growth rate and feed efficiency of broiler chicks **(**Zhao *et al.* 2014**)** and ducks **(**Cufadar and Bahtiyarca, 2004, Attia *et al.* 2019).

The body weight gain in broiler chicken improved significantly by phytase supplementation and which was further enhanced at 40 mg/kg dietary Zn supplementation in feed. The results of present study corroborated favorably with the findings of Yi *et al.* (1996) and Chang *et.al.* (2001), who observed positive effect on body weight gain and feed intake with adding of phytase to a low-zinc diet. Burrell *et al.* (2004) had also reported increased body weight gain in broilers reared under thermoneutral conditions with the addition of Zn to the basal diet at 0, 20, 40, and 80 mg/kg of Zn.

The increased FCR indicated the beneficial role of phytase and zinc in regulating feed intake and efficiency to optimize growth and production in broiler chickens. The chicks of control group had the highest feed intake, while chicks of P_{800} and PZ_{840} groups consumed less feed, indicating that higher phytase levels reduce early feed intake. During the entire period of study, the birds of control group had the highest total feed consumption as compared to birds of P_{600} and PZ_{640} groups. P_{800} and PZ_{840} groups consumed significantly lesser feed (Table 3). The lower feed consumption and the higher body weight gains revealed in the higher feed conversion efficiency in P_{800} and PZ_{840} groups. Thus, the present study indicated that the P_{800} and PZ_{840} treatments have optimized feed utilization and improved growth resulting feed cost savings with improved growth performance. The chicks of PZ_{840} treatment exhibited higher overall FCR, followed by P_{800} and PZ_{640} treatments. The improved FCR is likely to be due to enhanced nutrient utilization or metabolic adjustments induced by the treatments. Previous studies support the findings of the present study that adding phytase to the diet can enhance the growth performance of broiler chickens through better digestion and absorption of phosphorus from plant-based sources in the birds' gut. Phytase also improves the digestion and absorption of protein from the feed (Selle and Ravindran, 2007, Sapkota *et al.* 2021).

The blood biochemical attributes of broiler chicken among different treatments (Table 4) were within the range of normal variation. The total protein, cholesterol, ALP, SGPT and SGOT level increased ($p<0.01$), whereas uric acid levels decreased ($p<0.01$) in chicks of treatment groups. The higher ($p<0.01$) total protein and reduced uric

Table 2. Effect of dietary treatments on the growth performance of broiler chicken

Age of bird	Weekly body weight (g)						
	C	P_{600}	PZ_{640}	P_{800}	PZ_{840}	SEM	P-value
Initial (day 1)	44.56	45.67	46.11	46.33	45.33	0.56	0.20
Week 1	180.89 (136.33)	181.89 (136.22)	180.89 (134.78)	183.44 (137.11)	181.56 (136.22)	0.89 (1.00)	0.26 (0.59)
Week 2	392.00^{a} (211.11^{a})	414.11^{b} (232.22^{ab})	411.78^{ab} (230.89^{ab})	427.56^{b} (244.11^{b})	407.89^{ab} (226.33^{ab})	7.08 (7.16)	0.02 (0.04)
Week 3	784.67^{a} (392.67^{a})	819.56^{b} (405.44^{a})	804.00^{ab} (392.22^{a})	845.56^{c} (418.00^{a})	811.56^{b} (403.67^{a})	8.40 (8.32)	<0.01 (0.18)
Week 4	1405.89^{a} (621.22^{ab})	1416.67^{ab} (597.11^{a})	1443.56^{c} (639.56^{b})	1431.78^{bc} (586.22^{a})	1449.00^{c} (637.44^{b})	8.18 (11.78)	<0.01 (0.01)
Week 5	2016.67^{a} (610.78^{a})	2041.22^{a} (624.56^{a})	2151.67^{c} (708.11^{b})	2087.11^{b} (655.33^{a})	2183.00^{c} (734.00^{b})	13.88 (17.04)	<0.01 (<0.01)
Overall BW gain (gm)	1972.11^{a}	1995.56^{a}	2105.56^{c}	2040.78^{b}	2137.67^{c}	13.68	<0.01

C- Control; P_{600}- Phytase 600 unit/kg feed; PZ_{640}- Phytase 600 unit/kg feed+ Zinc 40 mg/kg feed; P_{800}- Phytase 800 unit/kg feed; PZ_{840}- Phytase 800 unit/kg feed + Zinc 40 mg/kg feed. [abc]Means bearing different superscripts in a row differ significantly ($P<0.05$). Figure in parenthesis represent body weight gain (gm/bird/week) acid levels in treatment groups indicated a better utilisation of dietary protein due to phytase and Zn supplementation. The Zn supplementation with phytase further improved protein utilisation as indicated by the higher levels of total protein and reduced levels of uric acid in PZ640 and PZ840 groups. The elevated levels of ALP, cholesterol and liver enzymes in treatment groups indicated a supportive role in maintaining overall metabolic balance with higher synthetic activities of the liver. Similar to our results, Mohamed *et al.* (2024) reported higher values of liver enzymes alanine aminotransferase (ALT) and aspartate aminotransferase (AST) in serum of broilers fed diet containing phytase enzyme indicating potential impact of phytase on liver function in birds. The phytase produces inositol and release of phosphorus from the phytate compound leads to starch digestibility and increased access to protein (Singh, 2008). The Zn supplementation also increased ALP activity in broiler breeder stock (Al-Daraji and Amen 2011, Sridhar *et al.* 2015).

Carcass characteristics: The results of carcass evaluation (Table 5) revealed that dietary supplementation of phytase, either alone or in combination with zinc, had a significant effect (P<0.05) on most carcass traits of broiler chickens. Shrinkage percentage was significantly lower in the PZ_{840} group compared to control and other treatments, indicating better water-holding capacity and reduced moisture losses. This improvement may be attributed to enhanced nutrient utilization and muscle accretion due to phytase-induced release of bound phosphorus and improved metabolic activity supported by zinc. Dressing percentage improved significantly (P<0.01) in all phytase- and phytase + zinc-fed groups compared to control, with the highest value observed in PZ_{840} (75.00%). This suggests that higher phytase levels combined with zinc enhanced carcass yield, possibly through improved protein synthesis, skeletal development, and nutrient digestibility. Similarly, eviscerated yield and ready-to-cook yield increased significantly in P_{600}, PZ_{640}, and PZ_{840} groups. These improvements indicated finer carcass finishing and better edible meat production, supported by enhanced enzymatic breakdown of phytate and improved mineral availability.

Regarding cut-up parts, birds in the P_{800} and PZ_{840} groups exhibited significantly higher breast and thigh percentages compared to the control. Breast muscle yield

Table 3. Effects of dietary treatments on the feed consumption (g/bird/week) and feed conversion ratio (FCR) of broiler chicken

Age of bird	Weekly Feed Consumption (g) and FCR						
	C	P_{600}	PZ_{640}	P_{800}	PZ_{840}	SEM	P-value
Week 1	166.56^b (1.22^a)	165.67^b (1.22^{ab})	166.78^b (1.24^b)	163.00^a (1.19^a)	161.78^a (1.19^a)	0.79 (0.01)	<0.01 (0.01)
Week 2	279.78^b (1.33^b)	279.44^b (1.22^{ab})	283.44^c (1.24^{ab})	277.67^b (1.14^a)	270.78^a (1.21^{ab})	0.82 (0.04)	<0.01 (0.04)
Week 3	560.44^d (1.44^b)	522.67^a (1.29^a)	532.00^b (1.36^{ab})	546.33^c (1.31^a)	523.78^a (1.30^a)	1.11 (0.03)	<0.01 (<0.01)
Week 4	920.44^e (1.49^c)	890.44^d (1.49^c)	871.67^c (1.36^{ab})	831.44^a (1.43^{ac})	836.67^b (1.32^a)	1.41 (0.03)	<0.01 (<0.01)
Week 5	1157.00^d (1.90^b)	1120.78^b (1.80^b)	1167.00^d (1.65^a)	1076.67^a (1.66^a)	1140.33^c (1.57^a)	4.37 (0.04)	<0.01 (<0.01)
Overall	3084.22^e (1.56^d)	2979.00^c (1.49^c)	3020.89^d (1.43^b)	2895.11^a (1.42^b)	2933.33^b (1.37^a)	5.40 (0.01)	<0.01 (<0.01)

C- Control; P_{600}- Phytase 600 unit/kg feed; PZ_{640}- Phytase 600 unit/kg feed+ Zinc 40 mg/kg feed; P_{800}- Phytase 800 unit/kg feed; PZ_{840}- Phytase 800 unit/kg feed + Zinc 40 mg/kg feed. [abc]Means bearing different superscripts in a row differ significantly (P<0.05). Figure in parenthesis represent feed conversion ratio.

Table 4. Effect of dietary treatments on blood biochemical parameter of Broiler chicken

Parameters	Treatments					SEM	P-value
	C	P_{600}	PZ_{640}	P_{800}	PZ_{840}		
Total protein (g/dl)	3.74^a	4.21^b	4.99^c	5.19^d	5.86^e	0.02	<0.01
Uric Acid (mg/dl)	4.01^c	3.86^c	3.49^b	3.63^b	3.20^a	0.07	<0.01
Cholesterol (mg/dl)	110.26^a	116.92^b	120.10^b	154.97^d	126.66^c	1.22	<0.01
ALP (IU/L)	97.65^c	63.54^a	63.89^a	99.15^c	77.07^b	0.70	<0.01
SGPT (IU/L)	22.60^a	27.41^b	26.52^b	53.47^c	52.45^c	0.38	<0.01
SGOT (IU/L)	125.34^a	169.85^d	138.31^b	160.71^c	124.17^a	0.41	<0.01

C- Control; P_{600}- Phytase 600 unit/kg feed; PZ_{640}- Phytase 600 unit/kg feed+ Zinc 40 mg/kg feed; P_{800}- Phytase 800 unit/kg feed; PZ_{840}- Phytase 800 unit/kg feed + Zinc 40 mg/kg feed. [abc]Means bearing different superscripts in a row differ significantly (P<0.05).

Table 5. Effects of dietary treatments on carcass characteristics

Parts of carcass	Treatment					SEM	P-value
	Control	P_{600}	PZ_{640}	P_{800}	PZ_{840}		
Shrinkage %	5.52[a]	5.29[a]	5.50[a]	5.27[a]	4.91[b]	0.10	0.01
Dressing %	70.39[a]	71.84[ab]	72.72[b]	71.99[ab]	75.00[c]	0.50	<0.01
Eviscerated weight %	52.44[a]	57.67[b]	57.49[b]	54.12[a]	57.48[b]	0.84	<0.01
Ready to cook yield %	53.88[a]	58.85[b]	58.69[b]	55.23[a]	58.71[b]	0.85	<0.01
Thigh %	19.86[ab]	18.35[ac]	16.85[c]	20.78[b]	20.90[b]	0.54	<0.01
Drumstick %	19.90[a]	16.68[b]	18.06[bc]	18.22[c]	17.79[bc]	0.46	0.01
Breast %	31.06[a]	27.06[b]	28.42[b]	31.43[a]	31.05[a]	0.80	0.01
Back %	24.21[a]	21.83[b]	21.37[b]	20.51[b]	19.98[b]	0.74	0.02
Neck %	5.85[a]	4.57[b]	4.52[b]	4.40[bc]	3.86[c]	0.18	<0.01
Wing %	11.13[a]	10.32[bc]	10.45[bc]	10.83[ab]	9.91[c]	0.19	0.01
Heart %	0.55[a]	0.48[b]	0.47[b]	0.44[b]	0.49[b]	0.02	0.02
Liver %	2.11[a]	2.39[b]	2.45[b]	2.29[b]	2.03[a]	0.06	<0.01
Gizzard %	1.51[a]	1.25[b]	1.75[c]	1.43[a]	1.69[c]	0.05	<0.01

C- Control; P_{600}- Phytase 600 unit/kg feed; PZ_{640}- Phytase 600 unit/kg feed+ Zinc 40 mg/kg feed; P_{800}- Phytase 800 unit/kg feed; PZ_{840}- Phytase 800 unit/kg feed + Zinc 40 mg/kg feed. [abc]Means bearing different superscripts in a row differ significantly (P<0.05).

Table 6. Effect of dietary treatments on development of digestive organ

Digestive organs	Treatment					SEM	P-value
	Control	P_{600}	PZ_{640}	P_{800}	PZ_{840}		
Periventricular wt. (%)	0.50[a]	0.45[b]	0.40[c]	0.41[bc]	0.41[bc]	0.01	<0.01
Small intestine wt. (%)	3.73[a]	3.39[b]	3.25[bc]	3.42[b]	3.01[c]	0.09	<0.01
Small intestine length (cm/100gm)	6.18[a]	5.49[b]	5.39[b]	5.64[b]	5.45[b]	0.12	.01
Large intestine wt. (%)	0.18[a]	0.14[b]	0.16[b]	0.11[c]	0.11[c]	0.01	<0.01
Large intestine Length (cm/100gm)	0.35[a]	0.24[b]	0.32[c]	0.23[b]	0.28[d]	0.01	<0.01
Cecal wt. (%)	0.57[a]	0.41[b]	0.47[c]	0.50[c]	0.54[cd]	0.01	<0.01
Caecal length (cm/100gm)	0.57[a]	0.42[b]	0.47[c]	0.50[c]	0.54[a]	0.01	<0.01
Spleen wt. (%)	0.69[a]	0.63[b]	0.57[c]	0.51[d]	0.58[c]	0.01	<0.01

C- Control; P_{600}- Phytase 600 unit/kg feed; PZ_{640}- Phytase 600 unit/kg feed+ Zinc 40 mg/kg feed; P_{800}- Phytase 800 unit/kg feed; PZ_{840}- Phytase 800 unit/kg feed + Zinc 40 mg/kg feed. [abc]Means bearing different superscripts in a row differ significantly (P<0.05).

is a key economic indicator in broiler production, and the observed increase reflects improved lean tissue deposition. The reductions in back, neck, and wing percentages among supplemented groups suggested a favorable shift toward more commercially valuable muscle portions. Variations in giblet yields such as higher liver percentage in phytase-fed birds may be associated with increased metabolic activity, whereas lower heart percentage indicated reduced physiological load. Overall, PZ_{840} consistently showed superior carcass responses, indicating a synergistic effect of high-level phytase and zinc on carcass quality and muscle development.

Supplementation with phytase and zinc significantly improved(P<0.05) the development of digestive organs (Table 6). A general reduction was observed in the weight and length of the small and large intestines in supplemented groups compared to control. Reduced gastrointestinal size is frequently associated with improved nutrient utilization, minimal digestive stress, and enhanced feed efficiency. A significant reduction in periventricular fat weight in P_{600}, PZ_{640}, P_{800}, and PZ_{840} birds suggested improved fat metabolism and better nutrient partitioning toward muscle deposition. Cecal weight and length also showed significant differences across treatments, with reduced values in P_{600}, PZ_{640}, and P_{800} groups. Since the ceca are associated with microbial fermentation of undigested material, these reductions implied a lower flow of undigested feed to the hindgut, indicating improved enzymatic digestion in the small intestine. The spleen weight showed a marked decline in all phytase- and zinc-supplemented groups. A reduced spleen size may reflect lower oxidative stress and improved immune regulation, possibly due to zinc's role in antioxidant defence and phytase's role in minimizing anti-nutritive effects of phytate.

The present study demonstrated that dietary supplementation of phytase, either alone or in combination with zinc, significantly improved growth performance, feed utilization, and nutrient metabolism in broiler chickens. Among the treatment groups, the combination of higher phytase levels (800 U/kg) and zinc (40 mg/kg) yielded the best results in terms of body weight gain, feed conversion ratio, and overall nutrient efficiency. Blood biochemical parameters indicated enhanced protein metabolism, improved mineral utilization with no adverse effects on liver function, as enzyme levels remained within the normal physiological range. Significant improvement in carcass yield and overall carcass quality in addition to significant reduction in digestive organ size, suggested enhanced nutrient absorption and efficient feed utilization. These findings highlighted the synergistic effect of phytase and zinc in enhancing nutrient availability from plant-based diets, thereby reducing the need for excessive mineral supplementation. Thus, phytase with optimal zinc supplementation can be recommended as a sustainable nutritional approach to support broiler production.

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