Short Paper

Performance, carcass characteristics and economics of broiler chickens fed dietary enzymes and probiotic

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Abstract

Background: Researchers are challenged with identification of possible feed additives with the ability to increase the efficiency of feed utilization. **Aims:** The present work aimed at studying growth pattern and carcass traits in broiler fed on dietary enzymes (Enzymex) and probiotic (Yeamark) over a period of six weeks. **Methods:** A completely randomized design, including 8 treatments, 3 replications and 15 birds in each experimental unit was applied. **Results:** The results showed that feed intake decreased significantly ($P<0.05$) which might be due to the birds fulfilling their nutrient requirements by taking less amount of feed with improved digestibility of energy sources and amino acids. The results of present study also demonstrate the beneficial effects on performance and dressed yield in the treated groups in broiler. **Conclusion:** Enzymes and probiotic are, therefore, suggested to be used as feed additives in broiler rations for higher profitability.

Key words: Broiler, Carcass traits, Enzymes, Performance, Probiotic

Introduction

Poultry production in India has taken a quantum leap in the last five decades, emerging from an entirely unorganized and unscientific farming practice to a commercial production system with state-of-the-art technological interventions (Singh *et al*., 2017). Nutrition and diseases have been identified as the major limiting factors in poultry rearing. Feed is an important and critical input for the poultry industry as it accounts for 60 to 70% of the production costs (Singh *et al*., 2015). Supplementation of commercial enzymes can enhance the nutritional value of crops containing high contents of soluble non-starch polysaccharides (Alagawany *et al*., 2018).

Consequent on the ban of the sub-therapeutic use of antibiotics as growth promoters in poultry feeds due to their undesirable effects such as the residues in meat products (Singh *et al*., 2014) and development of antibiotic resistant bacteria populations, research efforts in probiotics and enzyme supplementation have gained much attention so as to improve meat and egg production (Chuka, 2014).

Therefore, the present study was conducted to investigate the effects of an enzyme and a probiotic on performance, carcass yield, organ weights, and its economic impact on broiler chickens.

Materials and Methods

Experimental birds and dietary treatments

Three hundred and sixty straight run broilers Ven Cobb[400] (unsexed) were weighed and randomly assigned to eight treatment groups with three replicates of 15 chicks each. The study was conducted for a period of six weeks under standard management conditions. The first treatment was considered as the control group (T1) in which no feed additive was added to the basal feed, in treatments T2, T3, and T4 cocktail of enzymes was provided as 0.25, 0.50, and 0.75 g per kg of feed, respectively, in treatment T5 probiotic was added as 0.25 g per kg, and in treatment T6, T7, and T8 the cocktail of enzymes (Enzymex by Exotic Biosolutions Private Limited, Mumbai, India) as in T2, T3, and T4 with probiotic Yeamark by Exotic Biosolutions Private Limited, Mumbai, India (*Saccharomyces cerevisiae*) as 0.25 g per kg through feed. The experimental treatment groups and feed ingredient composition of the basal diet are given in Tables 1 and 2.

Composition of cocktail of Enzymex and their activity

Enzymex (Cocktail enzymes for poultry) reduces intestinal viscosity for better utilization and absorption of nutrients. Each gram of Enzymex provides Amylase (3600 IU), Protease (400 IU), Cellulase (1000 IU), Beta-glucanase (400 IU), Xylanase (2000 IU), Pectinase (400 IU), and Phytase 400 IU. Yeamark (*S. cerevisiae*; 5 billion CFU/g) stimulates brush border disaccharides, affords anti-adhesive effect against pathogens and provides immunity. Its cell wall is highly effective broad spectrum toxin binder and removes free radicals from the body which ameliorates heat stress (maintains production).

Statistical analysis

All data pertaining to various parameters were analysed statistically by running ANOVAs using SPSS 19 software. Significant mean differences between the treatments were determined at a 5% significance level ($P<0.05$) using Duncan's Multiple Range Test (DMRT) as modified by Kramer (1957).

Results

Data on performance indices are summarized in Tables 3 to 6. Mean body weight (BW) gains at different intervals in different experimental groups are given in Table 3. In the first week, no significant difference was noted in BW gains among different treatment groups. In the second and third weeks, the broilers of the T3, T4, T6, T7 and T8 groups showed significantly ($P<0.05$) higher BW gain as compared to the T1. In these periods, BW gain was maximum in T8 and minimum in T1 of broilers. In the 4th week, the BW gains were significantly ($P<0.05$) higher in T3, T4, T6, T7, and T8 groups compared to T1.

Table 1: Different dietary treatments for experimental broiler chicks

Group	Treatment	Feeding program
1	T1	Basal feed (control)
2	T2	Basal feed + Cocktail of enzymes (0.25 g per kg feed)
3	T3	Basal feed + Cocktail of enzymes (0.50 g per kg feed)
4	T4	Basal feed + Cocktail of enzymes (0.75 g per kg feed)
5	T5	Basal feed + Probiotic (0.25 g per kg feed)
6	T6	Basal feed + Cocktail of enzymes (0.25 g per kg feed) + probiotic (0.25 g per kg feed)
7	T7	Basal feed + Cocktail of enzymes (0.50 g per kg feed) + probiotic (0.25 g per kg feed)
8	T8	Basal feed + Cocktail of enzymes (0.75 g per kg feed) + probiotic (0.25 g per kg feed)

T1: Control group, and T2-T8: Treatment groups

Table 2: Feed ingredient composition (on dry matter basis) of the basal diets (on calculated basis)

Feed ingredients (%)	Broiler starter ration (0-3 weeks)	Broiler finisher ration (4-6 weeks)
Maize	50	55
Soybean meal	36	32
Rice polish	5.5	4.5
Wheat bran	3.5	3
Soybean oil	1	1.5
Marble stone	1	1
Dicalcium phosphate	2	2
DL-Methionine	0.58	0.54
Total Lysine	1.25	1.14
Coccidiostat (Maduramycin)	0.05	0.05
Copper sulphate	0.01	0.01
Common salt	0.3	0.3
Merivite-100 (vitamin B12)	0.02	0.02
Phosphoric acid	0.1	0.1
Lipocare (choline chloride)	0.05	0.05
Hepatocare	0.1	0.1
Vitamin mixture	0.13	0.13
Trace minerals	0.14	0.14
Moisture	9.30	9.70
Crude protein	22.14	20.90
Crude fibre	4.50	4.30
Ether extract	4.50	4.25
Total ash	6.80	6.50
Acid insoluble ash	1.35	130
Calcium (g)	1.25	1.22
Total phosphorus (g)	0.78	0.76
Nitrogen-free extract	62.06	64.05
Metabolizable energy (kcal/kg)	2901.00	3014.00

Body weight gain was maximum (482.51 ± 1.39 g) in T8 group which was statistically (P<0.05) similar to T7 group and minimum (440.87 ± 1.49 g) in T1 which was statistically (P<0.05) similar to T2 group.

Means of feed consumption measured at different intervals in different experimental groups are given in Table 4. During the first week of the experiment, broiler chicks of T1 consumed maximum (121.47 ± 1.40 g) feed which was statistically similar to the feed intake of T2, T3, and T5 groups and minimum (112.81 ± 1.26 g) feed was consumed by T8 group which was statistically similar to the feed intake of T3, T4, T6, and T7 groups. All the supplemented groups showed significant (P<0.05) reduction in the feed intake compared to the T1.

Means of feed conversation ratio (FCR) measured at different intervals in different experimental groups are given in Table 5. In the first week, broiler chicks of T1 showed maximum (1.37 ± 0.015) FCR which was statistically similar to T2 and T5 groups and minimum FCR was showed by T8 group (1.21 ± 0.011) which was statistically similar to the T6 and T7 groups. In 4th week, FCR was the lowest (1.71 ± 0.003) in T8 and (1.71 ±

Table 3: Effect of diet supplemented with Enzymex and Yeamark on broilers' BW gain (mean±SE)

Period	Age (wk)	Dietary treatments							
		T1	T2	T3	T4	T5	T6	T7	T8
Starter (1-3 weeks)	1	88.79 ±1.97	89.83 ±1.07	90.53 ±1.52	90.86 ±1.54	89.69 ±1.96	92.23 ±1.65	92.94 ±1.68	93.37 ±1.67
	2	200.83 ±0.81^{d}	203.81 ±1.52^{d}	209.42 ±1.43^{c}	210.91 ±2.18^{c}	202.58 ±1.36^{d}	219.87 ±1.18^{b}	227.92 ±2.07^{a}	229.55 ±1.29^{a}
	3	331.46 ±1.89^{d}	334.14 ±1.58^{d}	344.67 ±1.37^{c}	345.18 ±1.25^{c}	335.82 ±1.73^{d}	353.24 ±1.11^{b}	362.92 ±1.47^{a}	364.05 ±1.32^{a}
Finisher (4-6 weeks)	CWBG^{A}	621.08 ±2.78^{e}	627.78 ±2.41^{d}	644.62 ±1.20^{c}	646.95 ±1.07^{c}	628.09 ±2.46^{d}	665.34 ±1.56^{b}	683.78 ±1.34^{a}	686.97 ±1.98^{a}
	4	440.87 ±1.49^{d}	443.12 ±1.24^{d}	453.88 ±1.08^{c}	455.14 ±2.21^{c}	442.56 ±1.41^{d}	467.72 ±1.16^{b}	480.96 ±1.09^{a}	482.51 ±1.39^{a}
	5	461.48 ±1.32^{e}	468.83 ±2.38^{d}	481.78 ±1.40^{c}	483.44 ±1.10^{c}	466.36 ±1.25^{d}	496.67 ±2.14^{b}	512.38 ±1.15^{a}	510.92 ±1.09^{a}
Overall	6	479.14 ±1.23^{e}	486.88 ±1.55^{d}	501.12 ±1.25^{c}	502.48 ±1.15^{c}	483.66 ±2.23^{d}	514.96 ±1.41^{b}	529.36 ±1.14^{a}	532.10 ±1.07^{a}
	CWBG^{A}	1381.50 ±1.38^{e}	1398.80 ±1.46^{d}	1436.80 ±3.26^{c}	1441.10 ±2.15^{c}	1392.60 ±2.35^{d}	1479.30 ±2.52^{b}	1522.70 ±2.46^{a}	1525.50 ±1.59^{a}
	CWBG^{B}	2002.60 ±3.99^{e}	2026.60 ±3.76^{d}	2081.40 ±2.43^{c}	2088.00 ±1.63^{c}	2020.70 ±4.80^{d}	2144.70 ±1.85^{b}	2206.50 ±2.25^{a}	2212.50 ±3.34^{a}

$^{a-e}$ Means within rows with different superscript differ significantly (P<0.05). ^{A} Cumulative BW gain for the previous 3-week study period, and ^{B} Cumulative BW gain for the 6-week study period. BW: Body weight, CWBG: Cumulative body weight gain, wk: Week, T1: Control group, and T2-T8: Treatment groups

Table 4: Effect of diet supplemented with Enzymex and Yeamark on broilers' feed intake (mean±SE)

Period	Age (wk)	Dietary treatments							
		T1	T2	T3	T4	T5	T6	T7	T8
Starter (1-3 weeks)	1	121.47 ±1.40^{a}	119.94 ±1.02^{ab}	117.28 ±1.74^{abcd}	116.73 ±1.17^{bcd}	119.27 ±1.09^{abc}	115.02 ±2.06^{cd}	113.18 ±1.21^{d}	112.81 ±1.26^{d}
	2	342.65 ±1.17^{a}	342.18 ±1.00^{a}	336.31 ±1.27^{b}	335.28 ±1.39^{b}	341.96 ±1.19^{a}	327.53 ±1.06^{c}	320.16 ±1.05^{d}	319.69 ±1.03^{d}
	3	603.18 ±1.12^{a}	601.75 ±1.13^{a}	594.91 ±1.62^{b}	595.43 ±0.71^{b}	600.12 ±1.25^{a}	588.15 ±1.16^{c}	581.85 ±1.09^{d}	582.34 ±1.11^{d}
	TFC^{A}	1067.30 ±3.28^{a}	1063.90 ±1.30^{ab}	1048.50 ±1.07^{c}	1047.40 ±1.37^{c}	1061.40 ±1.61^{b}	1030.70 ±2.13^{d}	1015.20 ±0.93^{e}	1014.80 ±1.10^{e}
Finisher (4-6 weeks)	4	865.16 ±1.29^{a}	861.92 ±2.03^{ab}	843.24 ±1.01^{c}	844.86 ±1.12^{c}	859.62 ±1.18^{b}	833.27 ±1.03^{d}	820.54 ±1.13^{e}	822.75 ±1.02^{e}
	5	1031.50 ±2.05^{a}	1021.90 ±1.11^{b}	997.12 ±1.12^{c}	995.87 ±1.55^{c}	1018.10 ±1.06^{b}	979.48 ±2.05^{d}	961.14 ±1.02^{e}	959.65 ±1.01^{e}
	6	1231.70 ±2.00^{a}	1227.30 ±1.24^{b}	1194.80 ±1.21^{c}	1196.10 ±1.28^{c}	1224.70 ±2.06^{b}	1161.40 ±1.18^{d}	1125.20 ±1.08^{e}	1128.60 ±1.21^{e}
	TFC^{A}	3128.40 ±3.95^{a}	3111.10 ±2.36^{b}	3035.20 ±1.32^{d}	3036.80 ±3.60^{d}	3102.50 ±0.49^{c}	2974.10 ±2.58^{e}	2906.90 ±2.63^{f}	2911.00 ±2.59^{f}
Overall	TFC^{B}	4195.70 ±7.23^{a}	4175.00 ±1.92^{b}	4083.70 ±2.33^{d}	4084.30 ±4.32^{d}	4163.80 ±1.27^{c}	4004.80 ±2.81^{e}	3922.10 ±1.93^{f}	3925.80 ±3.55^{f}

$^{a-f}$ Means within rows with no common superscript differ significantly (P<0.05). ^{A} Total feed consumption for the previous 3-week study period, and ^{B} Total feed consumption for the 6-week study period. TFC: Total feed consumption, wk: Week, T1: Control group, and T2-T8: Treatment groups

Table 5: Effect of diet supplemented with Enzymex and Yeamark on broilers' feed conversion ratio (FCR) (mean±SE)

Period	Age (wk)	Dietary treatments							
		T1	T2	T3	T4	T5	T6	T7	T8
Starter (1-3 weeks)	1	1.37 ±0.015^{a}	1.34 ±0.005^{ab}	1.30 ±0.004^{bc}	1.29 ±0.011^{cd}	1.33 ±0.017^{ab}	1.25 ±0.022^{de}	1.22 ±0.011^{e}	1.21 ±0.011^{e}
	2	1.71 ±0.012^{a}	1.68 ±0.009^{b}	1.61 ±0.007^{c}	1.59 ±0.010^{c}	1.69 ±0.006^{ab}	1.49 ±0.004^{d}	1.40 ±0.008^{e}	1.39 ±0.004^{e}
	3	1.82 ±0.007^{a}	1.80 ±0.006^{b}	1.73 ±0.003^{c}	1.73 ±0.006^{c}	1.79 ±0.006^{b}	1.67 ±0.002^{d}	1.60 ±0.004^{e}	1.60 ±0.003^{e}
	AFCR^{A}	1.72 ±0.003^{a}	1.69 ±0.004^{b}	1.63 ±0.001^{c}	1.62 ±0.003^{c}	1.69 ±0.004^{b}	1.55 ±0.004^{d}	1.48 ±0.002^{e}	1.48 ±0.003^{e}
Finisher (4-6 weeks)	4	1.96 ±0.007^{a}	1.95 ±0.010^{a}	1.86 ±0.006^{b}	1.86 ±0.011^{b}	1.94 ±0.009^{a}	1.78 ±0.007^{c}	1.71 ±0.002^{d}	1.71 ±0.003^{d}
	5	2.24 ±0.002^{a}	2.18 ±0.009^{b}	2.07 ±0.007^{c}	2.06 ±0.007^{c}	2.18 ±0.004^{b}	1.97 ±0.005^{d}	1.88 ±0.004^{e}	1.88 ±0.002^{e}
	6	2.57 ±0.002^{a}	2.52 ±0.006^{b}	2.38 ±0.004^{c}	2.38 ±0.004^{c}	2.53 ±0.007^{b}	2.26 ±0.008^{d}	2.13 ±0.003^{e}	2.12 ±0.004^{e}
	AFCR^{A}	2.26 ±0.002^{a}	2.22 ±0.003^{b}	2.11 ±0.006^{c}	2.11 ±0.005^{c}	2.23 ±0.004^{b}	2.01 ±0.003^{d}	1.91 ±0.001^{e}	1.91 ±0.001^{e}
Overall	AFCR^{B}	2.10 ±0.002^{a}	2.06 ±0.004^{b}	1.96 ±0.003^{c}	1.96 ±0.003^{c}	2.06 ±0.004^{b}	1.87 ±0.003^{d}	1.78 ±0.001^{e}	1.77 ±0.001^{e}

$^{a-e}$ Means within rows with no common superscript differ significantly (P<0.05). ^{A} Average feed conversion ratio for the previous 3-week study period, and ^{B} Average feed conversion ratio for the 6-week study period. AFCR: Average feed conversion ratio, wk: Week, T1: Control group, and T2-T8: Treatment groups

Table 6: Effect of diet supplemented with enzymes and probiotic on carcass yield (% of live weight) (mean±SE) in broilers

Treatments	Carcass yield	
	Dressed yield with giblet (%)	Dressed yield without giblet (%)
T1	71.12 ± 0.15^{e}	66.31 ± 0.15^{e}
T2	71.80 ± 0.23^{d}	66.94 ± 0.21^{d}
T3	72.37 ± 0.09^{c}	67.39 ± 0.08^{c}
T4	72.92 ± 0.12^{b}	67.94 ± 0.13^{b}
T5	71.59 ± 0.16^{d}	66.75 ± 0.18^{d}
T6	73.11 ± 0.07^{b}	68.11 ± 0.08^{b}
T7	74.22 ± 0.11^{a}	69.06 ± 0.10^{a}
T8	74.58 ± 0.09^{a}	69.40 ± 0.10^{a}

$^{a-e}$ Values with different superscripts column-wise differ significantly (P<0.05). T1: Control group, and T2-T8: Treatment groups

0.002) T7 groups and the highest (1.96 ± 0.007) in T1. In the fifth week, FCR was the lowest (1.88 ± 0.002) in T8 and (1.88 ± 0.004) T7 groups and the highest (2.24 ± 0.002) in T1. In the sixth week, the lowest (2.12 ± 0.04) FCR was found in T8 and highest (2.57 ± 0.002) in T1. The overall mean values for FCR of broilers were minimum (1.77 ± 0.001) in T8 group and maximum (2.10 ± 0.002) in T1 group which was significantly (P<0.05) higher than other groups. The supplementation of enzymes and probiotic at all levels significantly (P<0.05) reduced FCR.

As Table 6 shows, broilers of the enzymes and probiotic supplemented groups indicated significant positive impact on dressed yield with maximum (74.58 ± 0.09%) dressed yield observed in T8 group and minimum (71.12 ± 0.15%) in T1.

Results regarding the effect of enzymes and probiotic supplementation on cut-up parts are presented in Table 7. Broilers of enzymes and probiotic supplemented in groups T2, T3, T4, T6, T7 and T8 had significant positive impact on back weight with maximum (14.61 ± 0.08%) weight observed in T8 group whereas minimum (13.76 ± 0.03%) back weight was observed in T1 of broilers. Broilers of enzymes and probiotic supplemented groups showed significant positive effect on breast weight with maximum value (20.83 ± 0.05%) in T8 group and minimum (18.57 ± 0.03%) in T1. However, there were no significant differences in the breast weight in T2 with T3 and T4 groups of broilers. Broilers in treatments T6, T7, and T8 which were fed diets supplemented with enzyme and probiotic showed significantly (P<0.05) higher thigh weight in comparison to other groups. Broilers in treatments T6, T7, and T8 which fed diet supplemented with enzyme and probiotic showed significant positive effect on drumstick weight. The maximum and minimum values were related to treatments T7 (10.63 ± 0.04%) and T1 (10.29 ± 0.05%), respectively. However, no significant differences were observed in the drumstick weight among T1, T2, T3, T4, and T5 groups, T6, T7, and T8 groups of broilers.

The effects of enzymes and probiotic supplementation on economics of broilers have been presented in Table 8. The additional profit per bird was as United States Dollar (USD) 0.047, 0.18, 0.19, 0.042, 0.32, 0.46, and 0.47 which was maximum in T8 (USD 0.47) and minimum in T2 groups (USD 0.047).

Table 7: Effect of diet supplemented with enzymes and probiotic on cut up parts (% of live weight) (mean±SE) in broilers

Treatments	Cut up parts					
	Back	Breast	Thigh	Drumstick	Wing	Neck
T1	13.76 ± 0.03^{e}	18.57 ± 0.03^{g}	9.54 ± 0.01^{d}	10.29 ± 0.05^{c}	7.92 ± 0.03^{d}	4.93 ± 0.01^{d}
T2	13.94 ± 0.08^{cd}	18.99 ± 0.02^{de}	9.58 ± 0.03^{cd}	10.32 ± 0.03^{c}	7.95 ± 0.02^{cd}	4.96 ± 0.02^{cd}
T3	14.01 ± 0.01^{bc}	18.92 ± 0.04^{e}	9.65 ± 0.03^{cd}	10.43 ± 0.07^{bc}	8.02 ± 0.03^{c}	5.01 ± 0.01^{bc}
T4	14.06 ± 0.02^{bc}	19.03 ± 0.03^{d}	9.65 ± 0.07^{cd}	10.40 ± 0.03^{bc}	8.02 ± 0.02^{c}	5.07 ± 0.04^{ab}
T5	13.82 ± 0.08^{de}	18.74 ± 0.03^{f}	9.61 ± 0.04^{cd}	10.35 ± 0.01^{c}	7.97 ± 0.02^{cd}	4.98 ± 0.01^{cd}
T6	14.17 ± 0.03^{b}	19.18 ± 0.04^{c}	9.72 ± 0.08^{bc}	10.51 ± 0.01^{ab}	8.11 ± 0.04^{b}	5.07 ± 0.04^{ab}
T7	14.52 ± 0.06^{a}	20.52 ± 0.03^{b}	9.85 ± 0.04^{ab}	10.63 ± 0.04^{a}	8.20 ± 0.03^{a}	5.11 ± 0.01^{a}
T8	14.61 ± 0.08^{a}	20.83 ± 0.05^{a}	9.87 ± 0.04^{a}	10.62 ± 0.07^{a}	8.18 ± 0.02^{ab}	5.13 ± 0.03^{a}

$^{a\text{-}g}$ Values with different superscripts column wise differ significantly (P<0.05). T1: Control group, and T2-T8: Treatment groups

Table 8: Effect of diet supplemented with enzymes and probiotic on economics in broilers

Parameters	Dietary treatments							
	T1	T2	T3	T4	T5	T6	T7	T8
Feed intake (g/bird)	4195.70	4175.00	4083.70	4084.30	4163.80	4004.80	3922.10	3925.80
Cost of feed eaten (USD/bird)	1.92	1.91	1.87	1.87	1.90	1.83	1.79	1.79
Enzyme cost (2.09 USD/kg)	0.00	0.0022	0.0043	0.0064	0.00	0.0021	0.0040	0.0061
Probiotic cost (2.79 USD/kg)	0.00	0.00	0.00	0.00	0.0029	0.0028	0.0028	0.0028
Total feeding cost (USD)	1.92	1.91	1.87	1.87	1.91	1.84	1.80	1.80
Average live weight at 6 weeks (g)	2002.60	2026.60	2081.40	2088.00	2020.70	2144.70	2206.50	2212.50
Income from sale of broilers (1.67 USD/kg live weight)	3.35	3.39	3.48	3.49	3.38	3.59	3.69	3.70
Profit over feed cost/broiler (USD)	1.43	1.48	1.61	1.62	1.48	1.75	1.89	1.90
Additional profit per bird over control group (USD)	-	0.047	0.18	0.19	0.042	0.32	0.46	0.47
Profit per kg of live weight (USD)	0.72	0.73	0.77	0.78	0.73	0.82	0.86	0.86
Additional profit per kg of live weight over control group (USD)	-	0.015	0.59	0.060	0.014	0.10	0.14	0.14

USD: United States Dollar, 1 USD = 71.80 Indian Rupee, Cost of starter diet = Rs. 35/kg, and finisher diet = Rs. 32/kg

Discussion

Findings of the weight gain revealed that maximum weight gain for overall period was noted in broilers fed diet supplemented with 0.75 g enzymes and 0.25 g probiotic per kg of feed and weight gain was improved by addition at all the levels of dietary enzymes and probiotic supplementation. These findings were corroborated by those of Rahman *et al*. (2013), Chuka (2014), and Behnamifar *et al*. (2019) as they found significant increase in BW gain of broilers fed diet supplemented with enzymes and probiotics. The probable reasons for this fact may be that in order to grow faster, broilers need a lot of nutrients which were made readily available in case of supplemented groups to facilitate faster cell division/replication to build protein and fat tissues as is also evident from better nutrient retention of supplemented groups.

Results on feed intake of broilers are in accordance with the findings of Momtazan *et al*. (2011) who reported significant reduction in feed intake in enzymes and probiotic supplemented groups of broilers. Reduction in feed intake in broilers fed diets supplemented with enzymes and probiotic might be attributed to birds fulfilling their nutrient requirements by taking less amount of feed due to improvement in digestibility of energy and amino acid (Zakaria *et al*., 2010).

Improvements (increase) in feed efficiency of broilers in the present study might be due to enzymatic actions on substrates. In addition to this, supplementation of *S. cerevisiae* which is a rich source of vitamins and minerals might have played a crucial role by helping birds maintain good health throughout the study period. Similar trend for FCR was recorded by Midilli and Tuncer (2001), Momtazan *et al*. (2011), and Narasimha *et al*. (2013) who found significantly lower feed to gain ratio of broilers supplemented with enzymes and probiotics. Results of the present study on carcass yield were in agreement with the findings of Midilli and Tuncer (2001) who found that dressed yields were higher in enzymes and probiotic supplemented groups of broilers. Higher dressed yield in enzymes and probiotic supplemented groups may be due to better fleshing and favorable meat to bone ratio in the treated groups.

Results in present investigation revealed that there was significant positive impact on cut up parts of broilers. Results of the present investigation were in accordance with the finding of Midilli and Tuncer (2001) who found better carcass and cut up yields in enzymes and probiotics supplemented groups of broilers. The higher cut up yields observed in supplemented groups may be due to more edible muscle mass in broilers in enzymes and probiotic groups.

Supplementation of enzymes and probiotic decreased the feed cost and increased income over feed cost in all the supplemented groups. Results of present investigation regarding effect of enzymes and probiotic supplementation on economics of broilers over feed cost of broilers were in accordance with the findings of Narasimha *et al*. (2013) who reported that supplementation of enzymes and probiotics singly or in combination significantly reduced the feeding cost and the cost per kg live weight gain. The economic analysis of data showed that supplementation of enzymes at 0.75 g and probiotic at 0.25 g per kg of feed was highly beneficial due to increased digestibility of all the nutrients of the diet which in turn improved performance of broiler and therefore overall economic production. Supplementation of enzymes and probiotics singly or in combination significantly cut down the feeding cost and the cost per kg live weight gain.

The results of the present study indicated that supplementation of enzymes (0.50 g) and probiotic (0.25 g) in combination significantly improves BW gain, FCR, and dressed yield in treated groups, demonstrating the beneficial effect of enzymes and probiotic through improved feed efficiency and more edible yield. It is therefore suggested, that enzymes and probiotic be used as a feed additive in broilers to obtain higher profitability.

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References

Alagawany, M; Elnesr, ShS and Farag, MR (2018). The role of exogenous enzymes in promoting growth and improving nutrient digestibility in poultry. Iran. J. Vet. Res., 18: 157-164.

Behnamifar, AR; Rahimi, Sh; Kiaei, MM and Fayazi, H (2019). Comparison of the effect of probiotic, prebiotic, salinomycin and vaccine in control of coccidiosis in broiler chickens. Iran. J. Vet. Res., 20: 51-54.

Chuka, E (2014). Comparative study of the effects of probiotic and commercial enzyme on growth rate, haematology and serum biochemistry of broiler chicken. Food Proc. And Technol., 5: 367.

Kramer, CY (1957). Extension of multiple range tests to group correlated adjusted means. Biometrics. 13: 13-17.

Midilli, M and Tuncer, SD (2001). The effect of enzyme and probiotic supplementation to diets on broiler performance. Turk. J. Vet. Anim. Sci., 25: 895-903.

Momtazan, R; Moravej, H; Zaghari, M and Taheri, HR (2011). A note on the effects of a combination of an enzyme complex and probiotic in the diet on performance of broiler chickens. Irish J. Agril. Food Res., 50: 249-254.

Narasimha, J; Nagalakshmi, D; Viroji Rao, ST; Venkateswerlu, M and Ramana Reddy, Y (2013). Associative effect of non-starch polysaccharide enzymes and probiotics on performance, nutrient utilization and gut health of broilers fed sub-optimal energy diets. Int. J. Engineering Sci., 2: 28-31.

Rahman, MS; Mustari, A; Salauddin, M and Rahman, MM (2013). Effects of probiotics and enzymes on growth performance and haematobiochemical parameters in broilers. J. Bangladesh Agril. Univ., 11: 111-118.

Singh, MK; Sharma, RK and Singh, SK (2017). Neem supplementation for profitable poultry production: a review. Ind. J. Poult. Sci., 52: 239-245.

Singh, MK; Singh, SK; Sharma, RK; Singh, B; Kumar, Sh; Joshi, SK; Kumar; S and Sathapathy, S (2015). Performance and carcass characteristics of guinea fowl fed on dietary Neem (*Azadirachta indica*) leaf powder as growth promoter. Iran. J. Vet. Res., 16: 78-82.

Singh, MK; Singh, SK; Sharma, RK; Singh, B; Kumar, S; Patoo, RA; Joshi, SK; Sathapathy, S and Chaudhari, BK (2014). Carcass characteristics of guinea fowl supplemented with Neem (*Azadirachta indica*) leaf powder. Int. J. Bas. Appl. Agric. Res., 12: 412-415.

Zakaria, HAH; Jalal, MAR and Ishmais, MAA (2010). The influence of supplemental multi-enzyme feed additive on the performance, carcass characteristics and meat quality traits of broiler chickens. Int. J. Poult. Sci., 9: 126-133.