



Effect of fibre degrading multi-enzyme on the performance of commercial broiler

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ABSTRACT

The objective of the present experiment is to study the effect of multi-enzyme on maize-soyabean-deoiled rice bran (DORB) diets on broiler. Day-old broiler chicks (192) were randomly distributed into 8 groups. In 4 control groups i.e. C₁, C₂, C₃, C₄ the ME content of starter feed was decreased @ 0, 5, 7.5, 10%, respectively, from C₁ (2800 Kcal/kg and CP 23%). In the treatment groups i.e. T₁, T₂, T₃ and T₄ multi enzyme was added @ 500 g/ tonne of feed. At the end of the experiment, the birds of T₁ group recorded highest body weight of 1760 g which was not significantly different with T₂ and C₁. During fourth, fifth and sixth week of age, chicks under the enzyme treated groups in T₁ and T₂ had higher body weights. At the end of the sixth week the FCR by the birds varied between 2.01 to 2.34. The average retention nitrogen in all the control groups varied from 36.34 to 49.24% and in treated groups from 38.36 to 50.59%. The digestibility of CF decreased and the % retention of energy in T₁, T₂ and T₄ groups was significantly higher than their corresponding control groups. Calcium and phosphorus retention in the birds varied from 37.58 to 41.13% and 28.98 to 32.15% in control where as it varied from 38.70 to 45.60% and 34.94 to 38.87 in treated groups, respectively. There was nonsignificant difference in dressing percentage and yield percentage in all the treated groups. By addition of enzyme to the control ration, the expenditure on feed was reduced.

Key words: Broiler, Digestibility, Economics, Enzyme

Addition of suitable multi-enzyme preparations improves nutrient utilization in animals. Phytase, was used to increase the availability of plant phytin phosphorus. Using β -glucanases, the growth rate and feed efficiency were improved remarkably in birds. The use of xylanases improves the nutritional values of rye to acceptable levels. Pectins like xylans and glucans also increase the viscosity of the digesta. The nutritional benefit of the cellulases is mainly attributed to the increase in the amount of released nutrients. Current issues of concern for all enzymes include variability in response. The chemical effects of enzymes are well understood, but the manner in which these enzymes cause benefits to the birds is still under debate. Keeping this in view, the present experiment was designed to study effect of fibre degrading multi-enzyme on maize-soybean-deoiled rice bran (DORB) based diets on the performance of commercial broiler.

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MATERIALS AND METHODS

Day-old broiler chicks (192) were wing-banded and randomly distributed into 8 groups with 24 chicks in each group and each group were again sub-divided into 2 replicates having 12 chicks in each replicate. Randomized block design was followed. There were 4 control and 4 treatment groups. In the control group i.e. C₁, C₂, C₃, C₄ the ME content of starter feed was decreased @ 0%, 5%, 7.5%, 10%, respectively, from C₁ (ME 2800 Kcal/kg and CP 23%) as per BIS (1992) requirement. In the treatment group i.e. T₁, T₂, T₃ and T₄ fibre degrading multi-enzyme (K-zyme: composed of cellulase, xylanase, pectinase and phytase enzymes of Karnataka antibiotics) was added @ 500 g/ tonne of feed and rest other ingredients were kept same as their corresponding control group such as C₁, C₂, C₃ and C₄. Feeding of starter feed continued for 4 weeks. All the feeds were prepared iso-nitrogenous. Similar feeding procedure was also followed during the finisher period i.e. from fifth to sixth week. The 8 dietary treatments are presented in Table 1. Samples of experimental feeds were analyzed for proximate composition as per AOAC (1975). The ingredients composition and chemical compositions of the experimental feed are given in Tables 2 and 3, respectively. The experiment was continued for 6 weeks. The weekly body weight and

Table 1. Dietary treatments of the experimental groups of birds

Treatments	Starter feed	Finisher feed	Remarks
C ₁	ME-2800 Kcal / kg, CP-23 %	ME-2900 Kcal / kg, CP-20 %	As per BIS Standard
C ₂	ME-2660 Kcal / kg, CP-23 %	ME-2755 Kcal / kg, CP-20 %	ME 5 % less than C ₁
C ₃	ME-2590 Kcal / kg, CP-23 %	ME-2682.5 Kcal / kg, CP-20 %	ME 7.5 % less than C ₁
C ₄	ME-2520 Kcal / kg, CP-23 %	ME-2610 Kcal / kg, CP-20 %	ME 10 % less than C ₁
T ₁	C ₁ + K-zyme @ 0.5 g/kg	C ₁ + K-zyme @ 0.5 g/kg	As per BIS Standard
T ₂	C ₂ + K-zyme @ 0.5 g/kg	C ₂ + K-zyme @ 0.5 g/kg	ME 5% less than C ₁
T ₃	C ₃ + K-zyme @ 0.5 g/kg	C ₃ + K-zyme @ 0.5 g/kg	ME 7.5 % less than C ₁
T ₄	C ₄ + K-zyme @ 0.5 g/kg	C ₄ + K-zyme @ 0.5 g/kg	ME 10 % less than C ₁

Table 2. Ingredient composition of experimental feed

	Maize (kg)	Soyabean (kg)	Sunflower cake (kg)	DORB (kg)	Fish meal (kg)	Veg. oil (kg)	Min. mix. (kg)	Enzyme (g)	Total (kg)
<i>Starter feed</i>									
C ₁	41	17.5	12.6	13.9	10	2	3	-	100
C ₂	31.5	15	16.5	22	10	2	3	-	100
C ₃	27	16	13	29	10	2	3	-	100
C ₄	22.2	14.6	15	33.2	10	2	3	-	100
T ₁	41	17.5	12.6	13.9	10	2	3	50	100
T ₂	31.5	15	16.5	22	10	2	3	50	100
T ₃	27	16	13	29	10	2	3	50	100
T ₄	22.2	14.6	15	33.2	10	2	3	50	100
<i>Finisher feed</i>									
C ₁	46.8	10.7	11	15.5	10	3	3	-	100
C ₂	37	10	10.1	26.9	10	3	3	-	100
C ₃	32	9	11.5	31.5	10	3	3	-	100
C ₄	27.4	8.8	10.3	37.5	10	3	3	-	100
T ₁	46.8	10.7	11	15.5	10	3	3	50	100
T ₂	37	10	10.1	26.9	10	3	3	50	100
T ₃	32	9	11.5	31.5	10	3	3	50	100
T ₄	27.4	8.8	10.3	37.5	10	3	3	50	100

Table 3. Proximate composition of experimental ration (in percentage)

Treatments	Starter							ME*(Kcal/kg)
	CP	EE	CF	TA	NFE*	Ca	P	
C ₁	23.00	4.55	8.01	10.63	53.81	1.672	0.926	2801
C ₂	23.03	4.29	10.31	10.85	51.52	1.674	0.996	2661
C ₃	23.07	4.05	11.33	11.03	50.52	1.665	1.040	2592
C ₄	23.04	3.92	12.51	11.57	48.96	1.666	1.077	2520
T ₁	23.00	4.55	8.01	10.63	53.81	1.672	0.926	2801
T ₂	23.03	4.29	10.31	10.85	51.52	1.674	0.996	2661
T ₃	23.07	4.05	11.33	11.03	50.52	1.665	1.040	2592
T ₄	23.04	3.92	12.51	11.57	48.96	1.666	1.077	2520
<i>Finisher</i>								
C ₁	20.01	5.74	7.65	10.32	55.28	1.66	0.91	2904
C ₂	20.02	5.36	9.98	10.58	54.06	1.65	1.00	2756
C ₃	20.06	5.21	11.17	10.73	52.83	1.65	1.04	2682
C ₄	19.99	5.01	12.28	11.05	51.67	1.65	1.08	2611
T ₁	20.01	5.74	7.65	10.32	55.28	1.66	0.91	2904
T ₂	20.02	5.36	9.98	10.58	54.06	1.65	1.00	2756
T ₃	20.06	5.21	11.17	10.73	52.83	1.65	1.04	2682
T ₄	19.99	5.01	12.28	11.05	51.67	1.65	1.08	2611

*Calculated value.

feed consumption were recorded. At the end of the fourth week, 4 birds from each of the 8 treatments (2 from each replicate) were picked up having similar body weights for balance study. The birds were transferred to metabolic cages and kept 1 bird in each cage. Feed consumption and droppings voided individually during 24 h, were collected for 3 consecutive days separately. The input and output difference between feed consumed and excreta voided was calculated on dry matter basis to assess the apparent dry matter digestibility. A 12-day feeding period was followed by a four-day recording of individual feed intake as well as faeces voided. The feed and excreta samples were assayed for total combustible energy with the help of the Isothennal bomb calorimeter. The AME values of the test diets and test material were determined. The nitrogen corrected metabolizable energy (AMEn) values were estimated from the nitrogen balance. Data recorded from the experiment was subjected to statistical analyses.

RESULT AND DISCUSSION

Effect of multi-enzyme on body weight: The average weekly body weight of the experimental birds is presented in Table 4. At the end of the fourth week of age, the body weight of all the treatment groups was similar to their corresponding control group. This trend in growth indicated that supplementation of fibre degrading multi-enzyme did not exert any significant effect on growth at fourth week of

age at different level of energy intake. At the end of the experiment, (i.e. the sixth week) the birds of T₁ group recorded highest body weight of 1760 g which was not significantly ($P>0.05$) different with T₂ and C₁. The body weight of C₁ (fed as per BIS standard) was comparable with the T₂ group which was fed 5% less energy than the BIS recommendation and supplemented with enzyme. During fourth, fifth and sixth week of age chicks under the enzyme treated groups in T₁ and T₂ had higher body weights although was not significantly higher from the corresponding control groups i.e. C₁ and C₂, respectively. The better body weight in the enzyme supplemented T₁ and T₂ groups might be due to action of the multi-enzyme by increasing the availability of trapped nutrients present in different feed ingredients. The body weight of birds in C₃ and C₄ were significantly ($P<0.05$) lower than C₁ and C₂. Similarly the body weight of T₃ and T₄ were decreased significantly ($P<0.05$) than T₁ and T₂. From the above observation it is suggested that decrease of energy by 7.5% and 10% from BIS standard, is not recommended either with or without enzyme supplementation. Many other workers have also reported higher body weight gain by supplementing enzyme in the feed. While lower body weight gain were observed in some other findings when low energy diet were fed and enzyme supplementation did not improve the body weight gain significantly.

Effect on cumulative feed consumption: The average

Table 4. Average weekly body weight (in g) of broiler chicks up to sixth week of age

Treatments	Day old	First week	Second week	Third week	Fourth week	Fifth week	Sixth week
C ₁	35.79±0.50	126.67 ^{ab} ±3.59	320.46 ^a ±6.37	583.08 ^a ±12.80	864.92 ^{ab} ±23.58	1283.13 ^{ab} ±24.88	1661.88 ^{ab} ±34.06
C ₂	35.79±0.50	125.21 ^{ab} ±3.01	296.92 ^{ab} ±5.48	509.21 ^b ±11.28	865.63 ^{ab} ±15.28	1210.63 ^b ±21.77	1600.00 ^b ±29.47
C ₃	36.29±0.77	112.39 ^{bc} ±2.94	256.55 ^c ±8.22	485.00 ^{bc} ±12.71	788.75 ^{bc} ±19.00	1119.94 ^c ±23.19	1445.00 ^c ±44.77
C ₄	36.00±0.63	104.00 ^c ±3.19	214.46 ^d ±4.83	360.75 ^c ±7.43	597.75 ^c ±16.33	972.50 ^c ±19.18	1366.63 ^c ±27.03
T ₁	36.20±0.65	133.63 ^a ±2.81	321.13 ^a ±5.16	574.63 ^a ±7.99	942.92 ^a ±17.11	1345.00 ^a ±21.47	1760.00 ^a ±24.27
T ₂	35.27±0.68	122.00 ^{ab} ±3.02	281.35 ^{bc} ±5.33	518.26 ^b ±9.64	863.00 ^{ab} ±21.82	1233.13 ^b ±24.98	1651.25 ^{ab} ±31.10
T ₃	35.67±0.65	117.92 ^{bc} ±3.26	272.25 ^{bc} ±6.47	459.79 ^{cd} ±9.86	713.54 ^{cd} ±18.83	1093.75 ^{cd} ±20.65	1395.00 ^c ±38.15
T ₄	35.54±0.59	107.00 ^c ±2.29	252.96 ^c ±5.93	412.17 ^d ±8.60	678.54 ^{de} ±17.18	1036.88 ^{de} ±13.69	1361.25 ^c ±31.66

* Means with same superscripts are not different from each other ($P < 0.05$).

Table 5. Average cumulative feed consumption of broiler chicks up to sixth week of age

Treatments	Average cumulative feed consumption (g)					
	First week	Second week	Third week	Fourth week	Fifth week	Sixth week
C ₁	124.50±5.51	421.33±14.85	881.66 ^a ±44.21	1455.29±43.97	2396.04±106.69	3447.11±90.86
C ₂	130.13±4.49	410.25±24.63	800.85 ^{abc} ±51.73	1519.37±78.37	2348.14±38.41	3455.85±30.51
C ₃	122.43±12.62	388.15±0.57	840.43 ^{ab} ±34.73	1508.52±72.74	2291.73±88.07	3267.67±44.66
C ₄	113.90±12.41	319.03±21.18	619.71 ^d ±30.72	1151.59±64.48	2080.24±133.16	3233.24±105.09
T ₁	123.74±9.81	391.44±17.62	803.58 ^{abc} ±33.61	1480.11±86.70	2357.41±89.51	3466.59±80.69
T ₂	119.34±5.10	367.30±10.72	776.37 ^{abc} ±42.83	1450.03±119.62	2302.44±166.54	3442.99±139.05
T ₃	122.43±12.85	380.13±38.20	733.46 ^{bcd} ±52.93	1270.07±68.32	2189.43±36.62	3097.44±95.94
T ₄	111.27±0.51	367.18±8.21	682.64 ^{cd} ±1.40	1270.48±34.18	2130.03±51.03	3099.18±77.38

Means with same superscripts are not different from each other ($P < 0.05$).

cumulative feed consumption by the experimental broiler chicks up to sixth week of age are presented in Table 5. The average total feed consumption by each bird in 6 week varied from 3097.44 g for T₃ group to 3447.11 g for C₁ group. Even though numerically wide variation was seen in those groups but statistically found nonsignificant. Only significant variation was found in the cumulative feed intake on the completion of third week of age. Generally, poultry birds consume feed to satisfy their energy need as the energy content of the feed in different groups C₁ to C₄ and T₁ to T₄ was prepared by decreasing the ME content of the feed @ 0, 5.0, 7.5 and 10.00%, respectively, and it was presumed that the birds will consume feed in ascending order, respectively. Contrary to the presumption, the feed consumption was in descending order. The reason of such decreasing feed intake might be due to inclusion of progressively high amount of DORB in control and treatment groups. Supplementation of multi-enzyme could not produce any significant effect on total feed consumption by the birds. This result is in agreement with the findings of the earlier workers where progressively high amount of crude fibre was used in the experimental diet.

Effect on feed conversion ratio (FCR): The FCR of the experimental birds in every week up to the completion of sixth week of age are presented in Table 6. At the end of the sixth week the FCR by the birds varied between 2.01 to 2.34. There was nonsignificant difference ($P>0.05$) in the FCR values between treatment groups with their corresponding control groups, but numerical differences between the control and treatment groups were observed, which could be attributed to multi-enzyme supplementation effect. At sixth week of age the FCR values of T₁ and T₂ groups were comparable with the C₁ and C₂ group whereas the feed was prepared as per the BIS recommendation in C₁ and T₁ groups. There was nonsignificant difference between C₃ and C₄ groups with T₃ and T₄ groups, which indicated that multi-enzyme supplementation did not exert any effect on these four groups. The T₁ group showed the best FCR of 2.01 (kg of feed consumed/kg live weight gain). The performance of broiler birds in T₂ group receiving 5% less energy than BIS recommendation and supplemented with

enzymes are found to be promising. Many earlier workers observed improvement in FCR value due to various enzyme supplementation and some other workers found non-significant effect of enzyme supplementation in the diet. As the feed, fed to group C₃, C₄, T₄ and T₄ were energy-deficient-dietary protein could not be utilize properly towards growth. The observations in present finding is in agreement with the result of earlier findings (Cotta *et al.* 2002, Srivastava *et al.* 2005, Tabook *et al.* 2006 and Tiwari *et al.* 2006). Positive effect of enzyme supplementation were also observed (Bhatt *et al.* 2005, Sundu *et al.* 2006).

Effect of multi-enzyme supplementation on nutrient digestibility: The percentage of N, GE, Ca and P retained and digestibility percent of CF and EE of experimental birds at the end of fourth week of the experiment is presented in Table 7. With increase of fibre in the diet from C₁ to C₄ and T₁ to T₄, there was decrease of the retention of nitrogen in the birds. The average retention nitrogen % in all the control groups varied from 36.34 to 49.24% where as the retention of the treated groups ranged from 38.36 to 50.59%. With the addition of enzymes in the diet in the treated groups, there was significant ($P<0.05$) increase in the retention of nitrogen % in the corresponding groups, as well as within the treatment and control groups. The percentage of nitrogen retained was highest in T₁ group and lowest in C₄ group. The results indicated that inclusion of enzyme increased the % of nitrogen retention. Similar observations were also reported earlier by Wang *et al.* (2005) and Tiwari *et al.* (2006). However, in some other experiments enzyme supplementation did not have any significant effect on the nitrogen retention (Roble *et al.* 1999, Elangovan *et al.* 2004 and Kirkpinar and Acikgoz 2004). The increase in percentage of nitrogen retention may be due to better utilization of plant proteins (Schutte *et al.* 1988) which can be attributed to increased availability of energy to intestinal microbes from fibre degradation. With the decrease in energy content of the feed by addition of DORB, there was increase of the fibre content of the feed which was reflected on higher CF intake in control groups (C₁ to C₄). But, there was no significant change in the feed intake by the birds. In treatment groups (T₁ to T₄) the feed intake was also not affected but the intake

Table 6. Feed conversion ratio of broiler chicks up to sixth week of age

Treatments	First week	Second week	Third week	Fourth week	Fifth week	Sixth week
C ₁	1.37 ^{cd} ±0.06	1.48 ^{cd} ±0.05	1.61 ^{cd} ±0.05	1.75 ^{cd} ±0.04	1.92 ^b ±0.05	2.12 ^{de} ±0.06
C ₂	1.46 ^{bc} ±0.01	1.57 ^{bc} ±0.07	1.69 ^{bc} ±0.07	1.83 ^c ±0.07	2.00 ^{ab} ±0.07	2.21 ^{cd} ±0.03
C ₃	1.57 ^{ab} ±0.04	1.68 ^{ab} ±0.04	1.80 ^{ab} ±0.04	1.95 ^{ab} ±0.05	2.11 ^a ±0.04	2.32 ^{abc} ±0.03
C ₄	1.68 ^a ±0.08	1.79 ^a ±0.08	1.91 ^a ±0.08	2.05 ^a ±0.04	2.22 ^a ±0.08	2.43 ^a ±0.05
T ₁	1.26 ^d ±0.03	1.37 ^d ±0.03	1.49 ^d ±0.03	1.63 ^d ±0.03	1.80 ^b ±0.03	2.01 ^e ±0.03
T ₂	1.38 ^{cd} ±0.04	1.49 ^{cd} ±0.06	1.61 ^{cd} ±0.06	1.75 ^{cd} ±0.06	1.92 ^b ±0.06	2.13 ^{de} ±0.04
T ₃	1.53 ^b ±0.06	1.64 ^b ±0.03	1.76 ^b ±0.06	1.90 ^{bc} ±0.02	2.07 ^a ±0.04	2.28 ^{bc} ±0.02
T ₄	1.59 ^{ab} ±0.03	1.70 ^{ab} ±0.02	1.82 ^{ab} ±0.03	1.98 ^{ab} ±0.03	2.13 ^a ±0.03	2.34 ^{abc} ±0.02

Means with same superscripts are not different from each other ($P<0.05$).

Table 7. Percentage of retained N, GE, Ca, P and digestibility percent of CF and EE of experimental birds at the end of fourth week of the experiment

Treatments	% of intake N retained	% of intake GE retained	Crude fiber % digestibility	Ether extract % digestibility	% of intake Ca retained	% of intake P retained
C ₁	49.24 ^b ±0.25	66.81 ^b ±0.15	17.37 ^b ±0.55	80.38 ^{ab} ±0.30	41.13 ^b ±0.23	32.15 ^d ±0.33
C ₂	47.68 ^d ±0.23	62.84 ^c ±0.60	15.55 ^c ±0.36	80.23 ^{ab} ±0.60	40.12 ^c ±0.26	31.32 ^d ±0.20
C ₃	44.56 ^e ±0.43	63.71 ^{bc} ±0.50	13.00 ^d ±0.17	78.98 ^b ±0.66	38.24 ^d ±0.46	30.35 ^d ±0.18
C ₄	36.34 ^g ±0.31	56.05 ^d ±1.23	11.86 ^d ±0.31	78.03 ^b ±0.58	37.58 ^d ±0.17	28.98 ^e ±0.31
T ₁	50.59 ^a ±0.28	70.24 ^a ±0.85	20.63 ^a ±0.60	80.85 ^a ±0.59	45.60 ^a ±0.17	38.87 ^a ±0.38
T ₂	48.22 ^c ±0.38	67.02 ^b ±0.91	17.00 ^b ±0.42	80.36 ^{ab} ±0.81	42.63 ^b ±0.35	37.64 ^b ±0.42
T ₃	46.26 ^d ±0.37	65.84 ^b ±1.34	14.43 ^c ±0.27	79.26 ^{ab} ±0.61	39.43 ^c ±0.19	36.68 ^b ±0.19
T ₄	38.36 ^f ±0.37	64.23 ^c ±0.33	12.22 ^d ±0.26	78.69 ^b ±0.68	38.70 ^c ±0.09	34.94 ^c ±0.61

* Means with same superscripts are not different from each other (P < 0.05).

of CF was increased progressively ranging from 7.871 to 12.142 g/day in T₁ to T₄ groups. The digestibility of CF decreased and ranged from 17.37 to 11.86% in the control groups where as it was 20.63 to 12.22% in treated groups. With the addition of enzymes, there was increase in the digestibility of fibre in T₁, T₂ and T₃ with respect to C₁, C₂ and C₃, respectively, whereas no significant difference was observed between C₄ and T₄, where the CF % of feed was above 12%. The CF digestibility of T₂ group was statistically comparable with the 1 group. Similarly the CF digestibility of T₃ group was comparable with the C₂ group. The above observation clearly indicated that supplementation of fibre degrading exogenous enzymes broke the cell wall components of the feed to short chain sugars which could improve the CF digestibility. According to Bedford (2001), much of the performance response is thought to relate to the changes in the intestinal micro flora rather than to a direct effect of the enzyme per se in diet digestibility. The increase in % of CF digestibility in T₁, T₂ and T₃ groups with corresponding to their control groups C₁, C₂ and C₃, respectively, was also reflected in better body weight gain, better feed efficiency and better balance of nitrogen. The result obtained in this experiment is in agreement with the earlier findings by Tiwari *et al.* (2006). In all the controlled groups, with the increase in fibre % in the diet there was nonsignificant difference in the ether extract digestibility. Whereas addition of enzyme in the treatment groups, showed significant difference in the digestibility between T₁ and T₄, but there was no significant difference in the ether extract digestibility between T₁, T₂ and T₃ groups. The treatment groups when compared with their corresponding control groups the result did not vary significantly. From the above findings, it can be concluded that supplementation of multi-enzyme did not have any effect on ether extract digestibility. Even if reducing the energy level in different groups as compared to control could not produce any significant effect on ether extract digestibility percentage. Similar findings were also recorded earlier by and Kirkpinar and Acikgoz

(2004). On the contrary, some other workers reported significant improvement in ether extract digestibility due to multi-enzyme supplementation (Ponnuvel *et al.* 2002 in layer birds, Sundu *et al.* 2006 and Tiwari *et al.* 2006 in broiler birds). The intake of gross energy in control groups ranged from 289.06 to 331.19 kcal per day whereas intake range varied from 304.58 to 347.47 kcal/ day in the enzyme-supplemented groups. The birds usually consume feed to satisfy their energy requirement, so when the dietary energy was reduced the intake increased, which was seen in T₁ and T₂ groups. But simultaneously when the fibre % of the diet was increased which limited the birds to consume more feed to satisfy their energy need. The % retention of energy in T₁, T₂ and T₄ groups was significantly higher than their corresponding control groups. Similar observations were also observed by earlier researchers (Steenfeldt *et al.* 1998). Contrary to the above findings and Wang *et al.* 2005 did not observe significant effect of enzyme-supplementation on the energy retention by the broiler birds. In the present study no difference was seen in T₃ with C₃ groups, the reason of such effect might be due to some error in management. The percentage of calcium retention in the birds varied from 37.58 to 41.13% in control groups, whereas it varied from 38.70 to 45.60% in treated groups. With the addition of enzymes in all the treated groups there was significant increase in retention of calcium in comparison to their corresponding control groups. Similarly, within the treated groups the % retention of calcium in T₁ group significantly (P<0.05) higher than T₂, T₃ and T₄ groups. Both T₃ and T₄ groups showed significantly (P<0.05) less retention than both T₁ and T₂ groups. There was nonsignificant difference in the percentage of calcium retention between T₃ and T₄ groups. Though the calcium % of the feed remains same in all the feed, higher retention of calcium in the treated groups was recorded, possibly due to the enzymatic action of phytase, which cleaved the organic calcium from its bound form. The percentage of retention of phosphorus in birds varied from 28.98 to 32.15% in the control groups whereas it varied from

34.94 to 38.87 in enzyme supplemented groups. In control groups, nonsignificant difference was observed among C₁, C₂ and C₃ groups where as C₄ group showed significantly less retention than all other 3 control groups. In addition of enzymes there was significant increase in phosphorus retention. This higher retention of phosphorus in the birds in all the treatment groups might be due to the action of enzyme phytase, that breaks the phytin phosphorus to its available form. The multi-enzyme contained phytase as one of its component. It is well established fact that, due to the effect of enzyme phytase there was increased availability of phosphorus from the plant phosphorus sources. Earlier many other scientists have reported positive effect of phytase supplementation either alone or in combination with other fibre degrading enzymes (Medhi *et al.* 2003), however, Tiwari *et al.* (2006) reported non significant difference in phosphorus retention and attributed that the exogenous phytase enzyme

could not produce desired performance which might be due to the less potency of the enzyme. In the present study, the phosphorus intake in different groups was similar but the % in phosphorus retention by the birds varied, which might be due to positive effect of the enzymes.

Effect of multi enzyme on the carcass characteristics: The effect of multi-enzyme supplementation in the carcass attributes in broiler chicken at the end of sixth week of age and the intestinal measurements in broiler chicken at the end of sixth week of age presented is presented in Tables 8 and 9, respectively. Different measurements like defeathered weight, eviscerated weights, dressed weight, dressing percentage, edible offals such as heart liver and gizzard, dressing yield and yield % were measured in different groups separately. There was nonsignificant difference ($P>0.05$) in dressing % and yield percentage in all the treated groups as compared to their control groups. This finding is in agreement

Table 8. Carcass attributes in broiler chicken at the end of sixth week of age

Treatments	Live Wt.(g)	Defeathered Wt.(g)	Eviscerated Wt.(g)	Dressed Wt.(g)	Dressing % Wt.(g)	Heart Wt.(g)	Liver Wt.(g)	Gizzard Wt.(g)	Edible offal yield Wt.(g)	Dressing %	Yield
C1	1735.50 ±7.88	1562.25 ±7.03	1109.50 ±12.26	1211.25 ±12.98	69.79 ^{ab} ±0.61	9.08 ±0.37	55.47 ±0.88	37.00 ±0.71	101.75 ±1.18	1313.00 ±13.77	75.66 ^{ab} ±0.67
C2	1648.75 ±8.98	1484.25 ±8.04	1004.00 ±5.43	1107.00 ±5.20	67.15 ^{bcd} ±0.55	8.29 ±0.63	56.67 ±1.04	38.25 ±0.75	103.00 0.71	1210.00 ±5.05	73.40 ^{bcd} ±0.57
C3	1470.00 ±4.08	1323.00 ±3.72	849.50 ±24.44	947.00 ±23.99	64.44 ^d ±1.76	8.37 ±0.60	54.33 ±1.48	34.88 ±0.83	97.50 ±1.26	1044.50 ±23.60	71.06 ^d ±1.73
C4	1413.25 ±5.68	1272.00 ±5.21	814.25 ±13.66	916.50 ±12.36	64.86 ^d ±0.91	7.91 ±0.31	57.23 ±1.25	37.25 ±0.85	102.25 ±1.70	1018.75 ±11.16	72.09 ^c 0.86
T1	1774.25 ±8.84	1596.63 ±7.99	1159.33 ±5.4	126000 ±6.65	71.02 ^a ±0.39	9.23 ±0.52	55.10 ±1.11	36.25 ±1.11	100.75 ±1.70	1360.75 ±8.06	76.70 ^a ±0.49
T2	1672.00 ±4.55	1504.75 ±4.07	1041.75 ±15.55	113600 ±14.74	67.95 ^{bc} ±1.04	7.80 ±0.55	51.25 ±0.31	35.25 ±0.85	94.25 ±0.95	1230.25 ±13.94	73.59 ^{bcd} ±1.01
T3	1445.25 ±5.91	1300.75 ±5.44	886.75 ±10.69	983.25 ±10.35	68.04 ^{bc} ±0.77	7.60 ±0.11	54.78 ±0.26	33.96 ±0.76	96.50 ±0.65	1079.75 ±10.04	74.72 ^{abc} ±0.76
T4	1386.00 ±4.04	1247.75 ±3.57	833.25 ±11.81	926.50 ±10.99	66.85 ^{cd} ±0.92	7.85 ±0.52	49.18 ±0.42	36.27 ±0.35	93.25 ±0.85	1019.75 ±10.18	73.58 ^{bcd} ±0.89

* Means with same superscripts are not different from each other ($P \leq 0.05$).

Table 9. Intestinal measurements in broiler chicken at the end of sixth week of age

Treatments	Proventriculus (g/kg)	Duodenum (cm/kg)	Jejunum (cm/kg)	Ileum (cm/kg)	Small intestine (cm/kg)
C1	7.70±0.04	26.82±0.34	56.73±1.12	60.78±0.41	144.96±1.51
C2	7.63±0.09	26.52±0.64	56.73±1.12	60.82±0.38	144.83±1.57
C3	7.58±0.03	27.00±0.30	56.09±1.20	60.58±0.32	144.43±0.89
C4	7.62±0.04	26.32±0.31	56.80±1.12	60.64±0.28	144.48±0.73
T1	7.52±0.09	25.87±0.36	55.40±0.62	60.63±0.30	142.71±0.94
T2	7.55±0.05	25.74±0.34	56.89±0.60	60.26±0.32	143.62±1.11
T3	7.51±0.06	25.74±0.37	56.47±0.78	60.38±0.42	143.35±0.95
T4	7.46±0.04	25.41±0.42	56.35±0.72	59.54±0.67	142.03±0.65

* Means with same superscripts are not different from each other ($P \leq 0.05$).

Table 10. Expenditure on the feed for experimental birds per kg of live weight gain

Treatments	Cost of starter feed/Q (₹)	Cost of finisher feed / Q(₹)	Average quantity of feed consumed (g)	Total cost of feed incurred/ bird (₹)	Feed cost for production of 1 kg live bird (₹)
C1	1044.70	1048.84	3447.11	36.10	21.72
C2	999.00	994.95	3455.85	34.43	21.50
C3	971.20	970.55	3267.67	31.72	21.95
C4	947.12	942.81	3233.24	30.53	22.34
T1	1055.70	1059.84	3466.59	36.66	20.82
T2	1010.00	1005.95	3442.99	34.67	20.99
T3	982.20	981.55	3097.44	30.40	21.79
T4	958.12	953.81	3099.18	29.61	21.75

with the observation of earlier researchers (Swain *et al.* 2000, Hanumantrao *et al.* 2000, Medhi *et al.* 2003, Tyagi *et al.* 2003, Elangovan *et al.* 2004, Tabedin *et al.* 2006, Tabook *et al.* 2006). Contrary to the above findings positive effects of multi-enzyme supplementation on carcass attributes were observed by (Ramaroa *et al.* 2005, Kangaraju *et al.* 2000, Selle *et al.* 2003). There was nonsignificant effect of enzyme supplementation in any of the portion of the intestine in all the groups. This finding is in agreement with Shayamsundar and Kumar 2006. However Wang *et al.* 2005 observed enzyme supplementation decreased the size of digestive organs and GI tract to some extent.

Economics on the cost of broiler feeding: The expenditure on the feeding of broiler bird per kg of live weight gain under different treatment groups is presented in Table 10. It was the highest (₹ 22.34/ kg live weight) in C₄ and was lowest (₹ 20.82/ kg live weight) in T₁. Considering the other expenditure being same for all the treatment groups the cost of 1 kg live weight production was calculated on the basis of on the feed cost and the quantity of feed consumed. By addition of enzyme to the control ration, the expenditure on feed was reduced which could be due to the better feed efficiency and better live weight gain. Selle *et al.* (2003), Srivastava *et al.* (2005) and Barik *et al.* (2006) have also observed less feed cost per kg body weight gain by supplementing enzyme to the broiler ration. The lower cost of production per kg of live weight gain was possible due to the less cost of the feed and better feed efficiency.

REFERENCES

- AOAC. 1975. *Official Methods of Analysis*. 12th edn. Association of Official Analytical Chemists. P.O. Box 540, Washington, D C.
- Barik B, Dehuri P K, Mishra S C, Mishra P K, Das S K and Mishra S K. 2006. Effect of multi enzyme supplementation in maize soya diet of broiler chicken. *Journal of Research OUAT* 24(1&2): 82–86.
- Bhatt G A, Khan A A and Wani S S. 2005. Effect of incorporating multienzyme preparation on the performance of white leghorn pullets. *Indian Journal of Animal Nutrition* 23(3): 186–87.
- BIS. 1992. *Bureau of Indian Standards, Specification for Poultry Feeds* IS: 0963 Manak Bhavan, New Delhi.
- Cotta T, Torres D M and Oliveira A I G de. 2002. Effect of addition of enzyme complex on performance of broiler chicken. *Cienciacia-e- Agro Technologia* (Brazil Aug, 2002) 26(4): 852–57.
- Elangovan A V, Mondal A B, Tyagi Pramod, K Tyagi Praveen K, Toppo S and Johri T S. 2004. Utilization of sorghum and finger millet with or without feed enzyme in broiler chickens. *Journal of Applied Animal Research* 26: 33–38.
- Kirkpinar F and Acikgoz Z. 2004. Effect of antibiotic, prebiotic and enzyme mixture supplementation on performance and nutrient utilization of broilers. *Journal of Applied Animal Research* 25: 13–16.
- Medhi D, Ahmed H F, Konwar B K and Chakravarty P. 2003. Effect of dietary ajar seed meal with or without multi-enzyme supplementation on vountary feed intake and nutrient digestibilities. *Indian Veterinary Journal* 80(7): 667–71.
- Ponnuvel P, Jalaludeen A and Ramakrishnan A. 2002. Influence of cellulase enzyme supplementation in high fibre diet on the production performance of layer chicken. *Indian Journal of Poultry Science* 36(1): 54–57.
- Schutte J B and Pereira A S. 1998. Effect of enzyme preparation (Vegpro) on broiler chick performance. *Zootechnica International* 21(5): 44–47.
- Selle P H, Haung K H and Muier W I. 2003. Effects of nutrient specifications and xylanase plus phytase supplementation of wheat based diets on growth performance and carcass traits of broiler chicks. *Asian-Australasian Journal of Animal Science* 16(10): 1501–09.
- Srivastava S P, Singh S and Saraswat B L. 2005. Effect of enzyme supplementation in high fibre diet on the performance of broilers. *Indian Journal of Animal Nutrition* 22(1): 13–15.
- Steenfeldt S, Hammers S J M, Mullertz A and Jensen J F. 1998. Enzyme supplementation of wheat based diets for broilers. 2. Effect on AME content and nutrient digestibility. *Animal Feed Science and Technology* 75(1): 45–64.
- Sundu B, Kumar A and Dingle J. 2006. Response of broiler chicks fed increasing levels of coprameal and enzyme. *International Journal of Poultry Science* 5(1): 13–18.
- Swain B K, Sundaram R N S, Barbudhe S B and Nirmale A V. 2000. Effect of feeding brewery dried grain with enzyme supplementation on the growth performance carcass traits and organ weights of broilers. *IPSACON* 2000: 108.
- Tabook N M, Khadim I T, Mahgoub O and Al-Marzooqi W. 2006. The effect of dead fibre supplemented with an exogenous

- enzyme on the performance and meat quality of broiler chicken. *British Journal of Poultry Science* **47**(1): 78–82.
- Tiwari R K, Singh S K, Baghel R P S and Nayak S. 2006. Influence of dietary enzyme supplementation on the performance of starter chicken fed poor cereals and oil seed meal based diet. *Indian Journal of Poultry Science* **41**(1): 91–94.
- Wang Z R, Quao S Y, Lu W Q and Li D F. 2005. Effects of enzyme supplementation on performance, nutrient digestibilities, G I morphology and V F H profiles in the hindgut broiler feed wheat based diets. *Poultry Science* **84**: 875–81.