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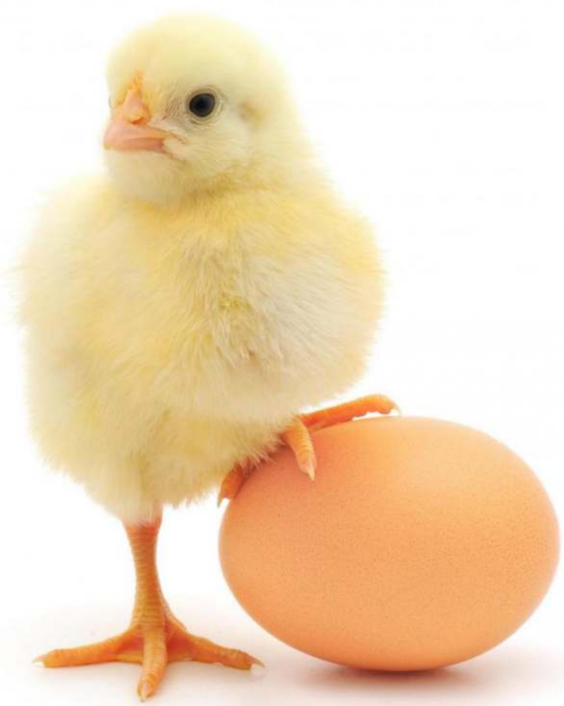

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The Effect of Proportion of Crumbled Copra Meal and Enzyme Supplementation on Broiler Growth and Gastrointestinal Development

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Abstract: The effect of proportion of crumbled copra meal and enzyme inclusion on bird performance and gastro-intestinal response was studied. Three diets with two enzyme treatments were each fed to four replicates of 10 broilers from 1 to 42 days of age. The diets contained 300 g kg^{-1} crumbled copra meal and were fed either as a finely ground or crumbled or a mixture of 50/50 finely ground and crumbled copra meal, each with or without an enzyme supplement (Hemicell plus Allzyme SSF). Feeding the crumbled copra meal diet, which had the largest crumble sizes, increased body weight, live weight gain, feed intake and water consumption of birds. The gizzard size of birds fed crumbled copra meal in their diets was significantly larger and heavier than for birds fed the fine mash copra meal diet. The inclusion of enzyme significantly increased body weight and live weight gain of birds fed until 6 weeks of age. The duodenum, ileum and overall size of intestines of birds fed the supplemented copra meal diet were larger and heavier than those of birds fed the diet without enzyme supplementation. Including crumbled copra meal in the diet had a beneficial effect in increasing the productivity of birds and supplementation of a copra meal based diet with enzymes was additionally beneficial.

Key words: Copra meal, pellet, digestive tract development, enzyme

Introduction

Pelleting and crumbling copra meal (CM) increased body weight and gizzard size of birds (Sundu *et al*., 2005). A possible reason for the positive effect of crumbling is increased feed intake (Callet, 1965; Choi *et al*., 1986) possibly due to increased bulk density of the crumbled CM based diets to 0.67 g/cm^3 compared to 0.53 g/cm^3 for the unpelleted CM based diets (Sundu *et al*., 2005). The greater development of the gizzard could have been due to the increased total feed intake and increased bulk density.

The inclusion of enzymes in a 300 g kg^{-1} CM diet has been found to increase the body weights of birds kept for 45 days so that they were not significantly different from the weight of birds fed a corn/soy control diet (Sundu *et al*., 2005). Gizzard size of the birds fed 300 g kg^{-1} CM with enzymes was decreased by 28 %. This may indicate that enzymes worked well, particularly in the gizzard of birds fed CM base diets. The following experiment was designed to test the ideal ratio between fine and coarse crumbled CM and the interaction of enzymes with the different proportion of crumbled CM on broiler growth and gastrointestinal development.

Table 1: Diet composition (g/kg)

Ingredients	Starter	Grower
Copra meal	300.0	300.0
Maize	288.6	325.9
Soybean	136.8	102.9
Fish meal	120.0	110.0
Vegetable oil	115.0	115.0
Limestone	5.0	5.0
DCP	5.3	13.1
Salt	3.0	3.0
Vitamin Mix	1.0	1.0
Mineral mix	1.0	1.0
DL Methionine	1.8	0.4
L Lysine	2.5	2.6
Celite	20.0	20.0
Calculated:		
ME (MJ/kg)	13.389	13.389
Protein	230.0	210.0
Digestible Met + Cys	9.0	7.2
Digestible Lysine	11.0	10.0
Digestible Tryptophane	2.3	2.1
Calcium	11.8	11.9
Phosphorus	6.3	6.5
Analyzed:		
Gross energy (MJ/kg)	19.87	19.87
Protein	229.0	212.0
Crude fibre	6.6	6.5

Materials and Methods

Animals and diets: A total of 240 day-old male broiler chicks of Ross commercial strain were obtained from a local hatchery. The chicks were randomly allocated to each treatment in brooder cages and fed from day 1 to 17 with the starter diets containing 230 g kg^{-1} crude protein (CP) and 13.389 MJ kg^{-1}. The birds were then transferred into 24 grower cages equipped with feed and water troughs and fed the grower diets containing 210 g kg^{-1} CP and 13.389 MJ kg^{-1} from day 17 to 42 (Table 1).

Table 2: Particle size distribution and bulk density of the diets

	Particle size distribution (%)					Bulk Density
Diets	<0.35mm	0.35-0.71mm	0.71-100mm	1.00-1.70mm	>1.70mm	(g/cm^3)
Fine ground CM diet (FCM)	13.8	60.5	18.8	6.90	0.00	0.53
50% FCM + 50 % CCM diet	15.0	20.7	24.1	19.3	20.9	0.61
Crumbled CM diet (CCM)	0.00	17.5	13.7	21.2	47.6	0.69

Feed and water were given ad-libitum throughout the trial. Feed was topped up twice a day and temperature was monitored.

Three different forms of the diets were used; fine, coarse and mixed pellet size. The crumbled CM diet was made by pelleting and crumbling CM before mixing with the other ingredients. All the other ingredients of the crumbled CM diet were unmodified as received. The four main ingredients (crumbled copra meal, maize meal, soybean meal and fish meal) were mixed and then finely ground before adding the minor ingredients (minerals, vitamins, vegetable oil and enzyme) to form the fine ground diet. The fine diet was mixed with the crumbled CM diet in ratio of 1:1 to form the mixed fine and crumbled CM diet. The diets were formulated using the UFFF (Pesti *et al.*, 1986) software program to meet standard meat chicken nutrient requirements as recommended by NRC (1994). The requirements of amino acids were based on digestible amino acids (Bryden and Li, 2004) (Table 1). To measure the particle size, the diets were passed through four different screen sizes (0.35mm, 0.71 mm, 1.00 mm and 1.70 mm). The distribution of particle sizes in the diets is given in Table 2. Two different enzyme products, Allzyme SSF[1] (0.04g/100g diet) and Hemicell[2] (0.10 g/100 g diets) were added to half of the diets.

Measurements: The body weight of birds and feed intake were recorded weekly. During the first week, feed was placed on the floor of the cage and hence the record of feed intake was commenced on week two. Water consumption was recorded daily from week four to six after the birds were transferred into grower cages in week three. Faeces were collected on day 39-41. Total faeces was weighed and a representative sample was collected and then frozen. The excreta from the 3 day sample was thawed and oven dried for 48 hours at 65°C. Prior to chemical analysis, feed and faeces were ground (0.5 mm screen). Crude fibre and protein were determined in dry samples according to AOAC (1970) methods.

Acid insoluble ash, analyzed by a method based on Choct and Annison (1992), was used as a marker for the measurement of DM and protein digestibility. Four birds at day 1 and at days 15, 29 and 43, two birds from each replication were randomly taken and weighed. The birds then killed by cervical dislocation. Crop, proventriculus, gizzard, duodenum, jejunum, ileum and caeca were weighed both with and without digesta. The length of the duodenum was measured from the gizzard up to the distal part of duodenal loop, the jejunum from the distal part of the duodenal loop to the yolk stalk (Meckel's diverticulum) and the ileum from the yolk stalk to the ileo-caecal junction. Intestine and caeca were emptied by gentle pressure, while the gizzard, proventriculus and crop were cut it into two halves and the digesta removed. The emptied gastro-intestinal organs were individually weighed.

A completely randomized factorial design was used with three different particle sizes distributions, two enzyme treatments and four replications per treatment. Ten birds were placed into each replicate cage. Data was analyzed using SAS 6.2 statistical program (SAS Institute, 1990). Differences among treatments were tested for significance using Duncan's Multiple Range Test (Steel and Torrie, 1980).

Results

The means of feed intake, body weight (BW), feed conversion ratio (FCR), water intake, water intake: feed intake ratio, DM digestibility and digestive organ dimensions are shown Tables 3, 4 and 5. Data of digestive organ development is shown in Table 6. The data indicate that birds fed the coarser pelleted and crumbled copra meal diet had a significantly higher body weight and live weight gain than the birds fed either the fine ground or the fine ground + coarse crumbled diets (Tables 4 and 5). The difference in weight between the birds fed the crumbled and the fine diets was equivalent to approximately five days growth (Ross, 2002). Crumbled copra meal in the diet increased feed intake significantly. The water intake of birds fed crumbled copra meal in the diet was also significantly higher than for those birds fed the fine ground CM diet. The gizzard weight of birds fed the crumbled CM diet was heavier than for those fed the fine diet, but it was a smaller proportion of the body weight (Table 5).

The addition of the enzyme mixture significantly increased protein digestibility and the body weight (Table 4). The growth pattern of the birds indicated that the enzyme effect became evident when the birds reached 5 weeks of age (Fig. 1). Comparison of the weight and dimensions of different parts of the gastro-intestinal tract found that the intestine, particularly the duodenum and the ileum, were different when enzyme was added to the diets. Birds fed the enzyme treated

Table 3: The effect of particle size of feed on broilers fed for 6 weeks

Parameter	FCM	50%FCM +50% CCM	CCM
Body weight (g)	2130.6[c]	2372.3[b]	2597.6[a]
Live weight gain (g)	2097.4[c]	2336.6[b]	2554.4[a]
Feed intake (FI) (g)	3174.3[b]	3562.4[a]	3748.7[a]
FCR	1.59	1.59	1.53
Water intake (WI) (g/d/h)	358.7[a]	376.4[ab]	395.3[a]
WI: FI ratio	3.01	2.94	2.95
Coefficient of DM digestibility	0.71	0.71	0.69
Coefficient of Protein digestibility	0.74	0.73	0.73

FCM: Fine copra meal diet; CCM; Crumbled copra meal diet. Means with different superscripts in each row are significantly different (P<0.05).

Table 4: The effect of enzyme supplementation on broilers, 6 weeks of age

Parameter	No enzyme	With enzymes
Body weight (g)	2334.5[b]	2404[a]
Live weight gain (g)	2291.3[b]	2326.1[a]
Feed intake (g)	3487.7	3502.5
FCR	1.59	1.55
Water Intake (g/d/h)	372.8	380.8
WI:FI ratio	2.95	2.98
DM digestibility (%)	70.1	70.7
Protein digestibility (%)	72.8[b]	74.1[a]

Means with different superscripts in each row are significantly different (P<0.05)

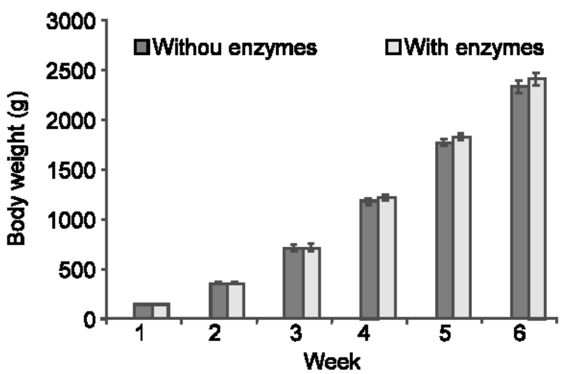

Fig. 1: Body weight of birds fed copra meal diet with or without enzymes

diets had a larger sized duodenum, wider diameter of jejunum and heavier ileum than the birds fed enzyme-unsupplemented diets (Table 4).

Discussion

Previous studies indicated that a diet containing pelleted/crumbled CM increased body weight, live weight gain and feed intake significantly. The improvement in feed intake is probably due to the fact that pelleting and crumbling cause a change in the physical properties of CM, rather than a change in chemical properties. This hypothesis is based on two facts: (1) pelleting/crumbling CM did not increase the dry matter digestibility of the CM based diet (Sundu, *et al.*, 2005) and (2) in this current study, when pelleted / crumbled CM was reground to fine particles and thus bulk density was decreased, all production parameters were impaired. Since pelleting and crumbling the CM increased the bulk density of the diet by about 30 % in this current study, it is assumed that the bird will spent less time for eating

same weight of food (Skinner-Noble *et al.*, 2005) and in the limited space of the digestive organs of young chicks, the bird's digestive tract can hold 30 % more weight of the crumbled CM diet than it can of the ground pelleted CM diets. An increased feed intake weight consequently would increase the amount of nutrients ingested and would lead to increased growth and body weight.

Moreover pelleting also increases the average particle size of the diet and this can affect the development of digestive organs, particularly the gizzard and intestine. In this current study, the birds fed the pelleted / crumbled CM diet had heavier and bigger gizzards (Table 5). Bigger particle size, higher feed intake, coupled with higher volume of digesta in the gizzards, of birds fed the pelleted/ crumbled CM diet may be the reason of the increase in gizzard size. This finding is consistent with the previous finding of Dahlke *et al.* (2003). The ratio of digesta weight in the gizzard to the digesta weight in the duodenum was 1.63, 1.93 and 2.16 for the fine ground, mixed and crumbled CM diets respectively. The quantity of digesta in the duodenum of birds fed the fine ground CM diets was more than that of birds fed the coarser crumbled CM diet or mixed particle size diet in this current study.

The capacity of the duodenum (by calculating the length and diameter of the duodenum) to hold the digesta of birds fed the fine ground CM diet was 2 % and 8 % less than the capacity of the duodenum of birds fed the fine + crumbled CM diet and crumbled CM diet respectively. However, the birds fed the fine ground CM diet had 9 and 18 % more digesta in their duodenum than those birds fed the fine + crumbled and crumbled CM diet respectively. It is possible that more quantity of digesta in the duodenum of birds fed the fine ground CM diet, in this current study, may slow down gastric motility and thus affect feed passage rate. According to Duke (1986), duodenal distention inhibits gastric motility. This mechanism may explain the lower feed intake of birds fed the fine ground CM diet.

The significant improvement of body weight of birds fed CM diets with enzyme supplements is consistent with previous findings of Teves *et al.* (1989), Pluske *et al.* (1997) and Sundu *et al.* (2004). Interestingly, the effect of enzymes on bird performance was only evidenced when the birds reached five weeks of age (Fig. 1). During the first four weeks, the effects of enzymes were not significantly different. Earlier than that, enzyme addition did not increase body weight significantly. According to Thornton *et al.* (1956), passage rate of feed in young chicks is faster than in adults. Hence the feed enzymes

Table 5: Response of the digestive organs of birds fed different particle sizes with or without enzymes (43 days)

Parameters	FCM	50 % FCM +50 % CCM	CCM	No enzyme	With Enzyme
Diameter of Duoden (mm)	15.50	15.60	16.00	15.30[b]	16.20[a]
Length of Duodenum (cm)	36.80	37.40	38.60	36.50	38.80
Duodenum digesta (g)	12.90	11.90	10.90	10.20[b]	13.60[a]
Duodenum (g/ 100 g BW)	0.40[ab]	0.42[a]	0.36[a]	0.38	0.41
Diameter of Jejenum (mm)	16.00[b]	16.30[ab]	17.60[a]	15.80[b]	17.50[a]
Length of Jejenum (cm)	99.80	100.00	98.40	98.80	100.30
Jejenum digesta (g)	37.80	41.90	40.40	38.00	42.10
Jejenum (g / 100 g BW)	0.89[a]	0.87[ab]	0.77[b]	0.82	0.86
Diameter of Ileum (mm)	15.40	14.60	15.40	15.20	15.10
Length of Ileum (cm)	98.00	107.00	101.00	99.20	104.80
Ileum digesta (g)	30.80	35.90	33.20	30.10	36.50
Ileum (g/100 g BW)	0.70[a]	0.65[ab]	0.59[b]	0.61[b]	0.68[a]
Length of Intestine (cm)	235.00	245.00	238.00	234.50	243.00
Intestine (g/100g bw)	1.99[a]	1.94[a]	1.72[b]	1.81[b]	1.95[a]
Intestine (g)	42.80	47.60	44.70	42.70[b]	47.40[a]
Crop (g/ g100 bw)	0.38	0.36	0.31	0.36	0.34
Proventriculus (g/ 100g BW)	0.46	0.48	0.38	0.42	0.45
Gizzard digesta (g)	19.40	21.70	23.70	21.40	21.80
Gizzard (g/ 100g bw)	1.32[a]	1.24[ab]	1.18[b]	1.25	1.24
Gizzard : Duodenum	3.32[a]	2.97[b]	3.24[ab]	3.31[a]	3.05[b]
Giz. digesta : duo. digesta	1.63	1.93	2.16	2.11[a]	1.70[b]
Caeca (g/ 100 g bw)	0.34[a]	0.31[ab]	0.28[b]	0.30	0.32

FCM: Fine copra meal diet; CCM: crumbled copra meal diet. Means with different superscript in each row are significantly different (P<0.05)

Table 6: Digestive organ development of broilers fed CM of different particle sizes with and without enzymes

	Diet				
	Fine CM	Crumbled CM	Mixed	No enzyme	With Enzyme
Length of intestine (cm)					
Day 1	51.5	51.5	51.5	51.5	51.5
Day 15	125[b]	133[a]	129[ab]	128	130
Day 29	186[b]	202[a]	204[a]	194	200
Day 43	235	238	245	235	243
Diameter intestine (mm)					
Day 1	1.13	1.13	1.13	1.13	1.13
Day 15	5.5b	7.8a	7a	6.5	7
Day 29	13.7	14	14.4	14	14
Day 43	15.6[ab]	16.3[a]	15.5[b]	15.6[b]	16.3[a]
Intestine weight (g)					
Day 1	0.71	0.71	0.71	0.71	0.71
Day 15	17.0[b]	21.1[a]	17.9[b]	19.1	18.2
Day 29	26.9[b]	34.8[a]	30.3[b]	29.7	31.7
Day 43	42.8	44.7	47.6	42.7[b]	47.4[a]
Gizzard weight (g)					
Day 1	2.6	2.6	2.6	2.6	2.6
Day 15	10.5[c]	13.6[a]	12.1[b]	13.1[a]	11.0[b]
Day 29	21.3[b]	24.1[a]	21.7[ab]	22.5	22.2
Day 43	28.4[b]	30.6[a]	30.3[ab]	29.6	29.9

CM: copra meal. Means with different superscripts in each row are significantly different (P<0.05).

may not have had enough time to fully attack food in the digestive tract of young chicks or the size of the enzyme digested products of mannan may not have been small enough to aid digestion and absorption in the digestive system of very small chickens and only become of assistance in the larger gut size of birds older than four weeks of age. A small improvement (non-significant) was found in the digestibility of the diet when enzymes were included.

The birds fed the enzyme supplemented diets had heavier and larger duodenums and larger overall size and weight of their small intestines than those of birds fed enzyme unsupplemented diets. This was possibly due to the fact that the enzymes accelerated the process of digestion in the digestive tract, particularly in the gizzard. The quantity of digesta in the duodenum was greater in the birds fed the enzyme supplemented diets than in the birds fed enzyme unsupplemented diets. This become evident in the first two weeks when gizzard weights of birds fed the enzyme supplemented diets were smaller than those of birds fed the enzyme unsupplemented diets (Table 6). The relative gizzard weight of birds fed the enzyme supplemented diets were also significantly lower (2.65 v 3.02) in week two. This indicates that the gizzards of birds may have worked harder and therefore increased their development in the birds fed the diets without enzyme supplementation. In week six, the larger size of the duodenum and of the overall intestine of the birds fed the enzyme supplemented diets have been due to the need to accommodate the higher volume of digesta from the gizzard such as appeared to occur with the fine ground diet (Table 5). Although the quantity of digesta in the duodenum and overall intestine of birds fed enzyme supplements was more than for the birds not fed enzyme supplements, the capacity of the duodenum to hold digesta was also greater.

In conclusion, the results showed that pelleting copra meal and crumbling the pellet to a large particle size increased chick performance, whereas the same ingredients ground to a small particle size decreased the performance of birds. Difference in particle size also changed the relative dimensions of the parts of the digestive tract. The ratio of gizzard digesta weight to duodenum digesta weight that gave the best results was 2.16 and the ratio that gave the worst results was 1.63. Better performance of birds was achieved when enzymes were included in the diet.

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[1] Hemicell is a mannan degrading enzyme, produced of ChemGen company, USA.

[2]Allzyme SSF is a product of Alltech Company. It contains cellulase, pentosanase, protease, phytase, β-glucanase, amylase and pectinase.