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Gastro-Intestinal Response and Passage Time of Pelleted Diets in Digestive Tract of Broilers

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Abstract: An experiment was conducted to examine the effect of pellet size and fibrous diet on intestinal passage time of feed in the digestive tract of broilers. A total of 64 day old chicks were used in a completely randomized factorial design with two different diets (copra meal and corn-soy based diets) and two pellet size (fine and coarse). On day 1-5 of week seven, the birds were fed the experimental diets. On day 6, after a 12 h feed restriction, all birds were orally administered with 85 mg chromium oxide in a gelatine capsule. Four birds per treatment were killed by cervical dislocation. Gizzard and small intestine were weighed and opened. The colour of the digesta observed to visually determine the location of the chromium oxide. The faeces were observed for first appearance of entire coloured faeces and then on an hourly basis up to the disappearance of coloured faeces. The experimental design was a two way factorial with two basal diets and pellet sizes. Data indicated that a copra meal diet moved in the digestive tract was slower than a corn-soy diet. The first appearance of the marker in the faeces of birds fed the copra meal diet was 52 min later than for those fed the corn-soy diet. The movement in the digestive tract of the fine ground diets was slower than that of the coarse diets. The effect of pellet size on feed passage time was only evident in the copra meal based diet.

Key words: Passage time, pellet size, copra meal and broilers

INTRODUCTION

Pelleting and crumbling diet increased feed intake. An increased feed intake led to bigger gizzard size and heavier intestinal weight (Sundu *et al*., 2005). The quantity of digesta in the gizzard and intestine was associated with the flow of digesta in the digestive tract of broilers and thus affect feed digestibility (Sundu *et al*., 2008). Since ingested food is the main source of the building blocks for body growth and maintenance, production of the chicken is thus largely determined by feed intake. Passage time of feed is inversely proportional to feed intake of broilers (Almirall and Esteve-Garcia, 1994). Digestibility is also influenced by passage time. Any stimulus that suppresses feed consumption may affect passage time, digestion efficiency and nutrient throughput (Duke, 1986). Therefore, feed digestibility and passage time are important indicators in judging feed quality.

Measurement of feed passage rate has been undertaken by either analyzing markers (Gohl and Gohl, 1977; Almirall and Esteve-Garcia, 1994) or visual detection (Washburn, 1991; Hughes, 2003). Fluorescent dye (Day-Glo) and ferric oxide have been used by Hillerman *et al*. (1953) and Washburn (1991) and Hughes (2003) respectively. The use of chromic oxide as a marker for determining feed passage rate has been widely used (see Gohl and Gohl, 1977; Almirall and Esteve-Garcia, 1994).

Several feed ingredients characteristics may affect passage time including viscosity, dietary fibre, particle size, pelleting, digestibility of starch, lipid and protein content (Sibbald, 1979). Copra meal which is widely produced in many parts of the globe, is high in crude fibre and thus move more slowly in the digestive tract of birds (Sundu, 2008) than any conventional feedstuffs. Accordingly, addition of copra meal in the diets resulted in decreased feed intake.

It has long been believed that feed passage time in the digestive tract of birds varies from one segment to another. Contraction of gizzard affected flow digesta in the duodenum as duodenum, gizzard and proventriculus contractions are totally coordinated (Duke, 1986). Larger particle size and higher dietary fibre in the diet increased gizzard contraction and therefore increased gizzard size. This experiment aimed at examining passage time of feed in the digestive tract and gastro-intestinal response of broilers fed pelleted diets.

MATERIALS AND METHODS

Birds and diets: A total of 64 day old male Ross chicks were used as experimental animals and were placed in the brooder cages from days 1-17. The birds were then transferred into metabolism cages up to day 49. The birds were fed either control corn-soy diet or 30% copra meal diet (Table 1). Both basal diets were pelleted and then half of each diet was finely ground through a 1 mm screen. The diets used were coarse pellet greater than a 4 mm screen while the fine diets were the pellet less than 1 mm size. The birds were randomly placed in cages, equipped with trough feeders and drinkers.

Table 1: Nutrient composition of experimental diets (g/kg)

	0 % copra meal diet		30 % copra meal diet	
Ingredients	Starter	Grower	Starter	Grower
Copra meal	0.0	0.0	300.0	300.0
Maize	608.8	663.3	340.0	390.0
Soybean	220.6	171.5	128.0	90.0
Fish meal	120.0	120.0	120.0	110.0
Vegetable oil	32.9	27.0	101.0	97.0
Limestone	5.0	5.0	2.0	4.0
Dicalcium phosphate	4.3	5.0	0.7	0.7
Salt	3.6	4.7	2.0	2.7
Vitamin Mix	1.0	1.0	1.0	1.0
Mineral mix	1.0	1.0	1.0	1.0
DL Methionin	1.8	0.5	1.7	0.8
L Lysine	1.0	1.0	2.6	2.8
Calculated:				
Metabolizable energi (MJ/kg)	13.39	13.39	13.39	13.39
Neutral detergent fibre (%)	11.3	11.1	25.1	24.8
Protein	231.0	211.0	230.0	210.0
Methionin + Cystein	9.0	7.6	9.0	7.6
Lysine	11.0	10.0	11.0	10.0
Arginine	14.4	13.0	20.2	18.7
Calcium	10.7	10.7	10.6	10.6
Phosphor	6.0	6.0	6.7	6.4

MJ: Megajoule

Measurement of organs and passage time: The measurement of organs was done by weighing the gizzard and intestine with and without digesta. Intestine digesta was taken from duodenum to ileum. Faeces were observed and faeces trays were cleaned every 15 minutes until it was clear that the marker appeared in the faeces. The time of observation was recorded.

On day 1-5 of week seven, the birds were fed the experimental diets. On day six all 64 birds were orally administered with 85 mg chromium oxide (placed in a gelatine capsule), following a 12 h feed withdrawal. Washburn (1991) stated that the accuracy of feed passage time by visual detection is enhanced when the digestive tract is emptied before dosing. The time of administration was recorded. One, two, three and 24 h after administration of the gelatine capsules, four birds per treatment diet per killing time (total 16 birds per killing time; see Table 2) were killed by cervical dislocation for visual detection of chromium oxide. The gut was immediately exposed and gizzard and small intestine were dissected out. The gizzard and small intestine were opened and the colour of the digesta observed to visually determine the location of the chromium oxide. Using the remaining live birds at each stage, the faeces were observed every ten minutes from 2 h after gelatine capsule administration and the time of the first appearance of entire green coloured faeces was recorded. Observations were continued on an hourly basis for 12 h and the time of disappearance of this colour in the faeces was recorded.

Prior to this experiment, a small trial was done to investigate the more visually detectable colour between ferric oxide and chromium oxide. Chromic oxide was more easily detected, particularly in CM based diets. Digesta and faeces containing chromic oxide are green. Detection of the colour started from the proventriculus to determine how far the food had moved. Distance was measured from the gizzard/duodenum junction to the farthest chromic oxide detected, expressed in cms.

The experimental design was a two way factorial with two basal diets (corn-soy and copra meal diets), two pellet size diets (fine and coarse), four killing times and four replicate cages per treatment in which birds were randomly allocated one per cage. Digestive tract measurements were pooled from the measurements made at different killing times. Data was analyzed by analysis of variance using the SAS 6.2 statistical program (SAS Institute, 1990). The significance of difference between treatment means was tested by Duncan's Multiple Range Test (Steel and Torrie, 1980).

RESULTS

Data on gizzard weight, intestine weight and their digesta were shown in Table 3 while data on the distance the digesta moved down the digestive tract, length of time in the digestive tract are shown in Tables 4 and 5. There was a significant decrease in gizzard digesta when a coarse pelletd diet was finely ground. However, there was no significant difference of digesta weight in the small intestine. No interaction between diet and particle size was found in the weight of digesta (Table 5).

Passage time of the diet was significantly ($p<0.05$) affected by diet and pellet size. The copra meal based

Table 2: Treatment diets

Diet	Pellet size	Number of birds
Corn-soy	<1.0 mm (fine)	(4 killing times X 4 replicates) = 16
Corn-soy	>4 mm (coarse)	(4 killing times X 4 replicates) = 16
30% copra meal	<1.0 mm (fine)	(4 killing times X 4 replicates) = 16
30% copra meal	>4 mm (coarse)	(4 killing times X 4 replicates) = 16

Table 3: Digesta weight in the gizzard and small intestine of birds fed copra meal and corn-soy based diets with different pellet sizes

	Gizzard		Small intestine		
Treatments	Weight (g)	Digesta (g)	Length (cm)	Weight (g)	Digesta (g)
CM diet	35.9±1.1	15.2±3.7	230.1±2.4	66.6±2.1	87.9±4.4
CS diet	36.8±0.7	13.3±3.8	229.4±2.4	66.2±1.6	81.1±1.5
Fine diet	36.0±0.8	4.6±1.5^{b}	227.3±2.2	64.2±1.6	85.4±3.1
Coarse diet	36.7±1.1	23.8±0.7^{a}	232.2±2.3	68.6±1.7	84.9±3.8
Fine CM diet	35.9±1.5	6.1±2.9	227.8±2.0	63.1±3.3	86.9±6.3
Fine CS diet	36.0±1.9	3.2±0.7	232.5±4.4	70.2±0.9	88.9±7.1
Coarse CM diet	36.1±0.9	24.3±1.5	226.8±4.2	65.3±0.3	83.9±1.9
Coarse CS diet	37.5±1.1	23.4±0.2	232.0±2.2	67.0±3.4	79.7±1.9

Means with different superscript in each row are significantly different (p<0.05)

Table 4: Passage time of feed in the digestive tract of broiler (during 3 h after gelatine capsule administration)

	Flow rate (cm/hour)	
Treatments	Average	G.M.
Copra meal diet	57.3^{b}	59.5^{b}
Corn-soy diet	63.3^{a}	78.5^{a}
Pellet size (>4 mm)	58.3^{b}	63.5^{b}
Pellet size (<1 mm)	62.2^{a}	74.5^{a}
Copra meal diet (<1 mm)	53.6^{b}	50.8^{c}
Corn-soy diet (<1 mm)	63.0^{a}	76.1^{a}
Copra meal diet (>4 mm)	57.3^{a}	68.2^{b}
Corn-soy diet (>4 mm)	63.5^{a}	80.6^{a}

Means with a different superscript in each cell are significantly different (p<0.05). G.M. = Geometric Mean

diets moved slower in the digestive tract than the corn-soy based diets (Table 3 and 4). The faecal marker appeared more slowly but disappeared more quickly for the copra meal fed birds than the corn-soy fed birds. The coarse pellet size of pelleted diets significantly (p<0.05) reduced the passage time of digesta. The faecal marker appeared more quickly and disappeared more quickly for birds fed the coarse pellet diets. Interaction between diet and pellet size was found in the first and third hour of digesta flow in the digestive tract of the bird. The first appearance of the marker in the faeces of the fine copra meal was significantly slower than for the other three diets. The coarse pellet of copra meal and corn-soy diets gave similar passage time of digesta.

DISCUSSION

The weight of digesta in the gizzard of birds fed fine pelleted diets found in this study was less. This was possibly due to faster digesta flow out of the gizzard. It is not difficult to postulate that fine particles of feed are likely to move through the gizzard more quickly and not be held back by the gizzard sphincter (Sundu, 2008). Although corn-soy diet move faster in the digestive tract, the digesta weight in the gizzard was not affected. It is possible that faster flow of corn-soy dieted to more frequency of eating.

The inclusion of copra meal would slow the flow of digesta in the digestive tract of birds. This hypothesis was due to the fact that inclusion of copra meal in the diet depressed feed intake and feed digestibility. These two parameters are partly associated with the passage rate of digesta (Graham and Aman, 1991). However, the mechanism by which copra meal plays a part in decreasing feed intake is still unclear. The mechanism by which copra meal slowed the flow of digesta is possibly due to poor digestibility of the copra meal. It is not difficult to explain this phenomenon because food in the digestive tract of bird would flow out of the intestine both to the caeca and to the blood stream. A highly digestible diet would be absorbed quickly and thus empty the gut faster. In this current study, the corn-soy based diet had a higher bulk density and higher digestibility than the copra meal based diet and had a faster flow in the digestive tract of birds than the copra meal based diet.

The time to the appearance of the marker in the faeces was faster in the corn-soy based diet but marker disappearance was slower. It is hard to explain this finding. It may indicate that some components of the corn-soy based diet moved more slowly in the digestive tract of birds. The galactomannan in soybean has been reported to be highly viscous (Jackson *et al.*, 1999) and may move more slowly than other components, especially in the colon where water resorption could be more difficult than from the mannan and galactomannan of copra meal. This speculation needs to be examined in more detail.

Feed particle size plays an important role in affecting the passage rate of digesta. Early findings indicated that the larger the feed particle size of grain the greater the flow rate of digesta in the digestive tract (Svihus *et al.*, 2002).

Table 5: Appearance and disappearance of marker in the faeces of birds

	Appearance of chromium oxide in the faeces (Number per treatment)								predicted hrs. and min.	
Treatments	3-4 h	4-5 h	5-6 h	6-7 h	7-8 h	8-9 h	9-10 h	10-11 h	Start	End
CM diet	0/8	4/8	6/8	8/8	8/8	5/8	1/8	0/8	4.45	8.45
CS diet	0/8	5/8	8/8	8/8	8/8	7/8	4/8	0/8	4.23	9.23
Fine diet	0/8	3/8	6/8	8/8	8/8	8/8	3/8	0/8	5.08	9.23
Coarse diet	0/8	6/8	8/8	8/8	8/8	4/8	2/8	0/8	5.15	8.53
Fine CM diet	0/4	1/4	2/4	4/4	4/4	4/4	1/4	0/4	5.15	9.15
Fine CS diet	0/4	2/4	4/4	4/4	4/4	4/4	2/4	0/4	4.30	8.30
Coarse CM diet	0/4	3/4	4/4	4/4	4/4	1/4	0/4	0/4	4.15	9.15
Coarse CS diet	0/4	3/4	4/4	4/4	4/4	3/4	2/4	0/4	4.15	9.15

However, no information about the passage time of the increased feed size due to pelleting has been reported. Our data indicated that pelleting the diet increased flow rate and decreased retention time of the food in the digestive tract. The mechanism of decreased retention time of a pelleted diet may be similar to the whole or unground ingredients. Hetland and Svihus (2001) found that addition of coarsely ground oat hull increased feed retention time due to the fact that particles will remain in the gizzard until the particles were broken down to a certain size (Svihus *et al.*, 2002). The presence of bulk in the gizzard, either due to a longer stay of bigger particles or to a large amount of food flowing into the gizzard, will stimulate the gizzard to keep contracting to break down the particles.

Duke (1986) stated that peristaltic movement in the intestine is influenced by gizzard contraction. This theory suggests that faster contraction of the gizzard will increase the contraction of the intestine and thus decrease the passage time of digesta in the intestine. The current data show that birds fed the coarse diet had more digesta in the gizzard. This may lead to an increased frequency of contraction, compared with the gizzard of birds fed fine pellet sizes. This current finding supports Duke's theory because the first appearance of the marker in the faeces of birds fed coarse pellet was faster than for those fed fine pellet sizes.

Interestingly, the large pellet size of the copra meal diet had a big impact on increasing the passage time of digesta, while the passage time of the corn-soy based diet was not affected by particle size. Thus, passage time is probably a combination of pellet size and digestibility of the feed. In conclusion, fine pelleted diet led to a faster digesta flow out of the gizzard but moved more slowly in the small intestine of broiler chickens. Increasing the pellet size and digestibility of the feed decreases the passage time of the feed in the small intestine. Increasing the viscosity of the diet.

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