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EFFECT OF GRADED LEVELS OF DIETARY NON-STARCH POLYSACCHARIDE ON THE PERFORMANCE OF BROILERS

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Abstract: A feeding trail of five weeks duration was conducted to find out the effect of ration containing different level of non-starch polysaccharides (NSP) on the performance of broilers. Chicks (Cobb) of both sexes (n=100) were distributed randomly into five experimental groups with two replicates of ten birds in each replicate. Broiler starter ration with 7% total NSP and 2850 kcal/kg of ME served as control ration (T1). Ration T2 and T3 were formulated to contain 10% total NSP each but with either low (2623 kcal/kg, T2) or similar caloric density (T3) to that of T1. Similarly, ration T4 and T5 were formulated to have 14% total NSP but with either low (2376 kcal/kg, T4) or similar energy density (T5) as that of control. At the end of five weeks, body weight of birds fed with rations T2 and T3 (1310±23.1 and 1338±32.4g, respectively) were comparable to T1 (1361 ±32.7) whereas birds received T4 and T5 had significantly ($P<0.05$) lower body weight (1243±23.5 and 1271±23.9g) to that of T1. Feed to gain ratio in birds receiving T2 and T4 rations (1.87 and 2.03) were improved in birds fed T3 and T5 rations (1.72 and 1.86) by increasing the dietary energy levels. The relative viscosity in the intestine and ileal volatile fatty acid content of the five experimental groups did not show significant difference ($P<0.05$) between them. Weight of gizzard, liver, pancreas and different parts of intestinal segments did not have any significant variations between the experimental groups. These results indicate that high level of insoluble NSP does not cause any increase in the intestinal viscosity and does not alter the hindgut fermentation. This study revealed that, increasing total NSP to 10% and 14 % in the diet predominantly having insoluble fraction decreased energy level to around 2600 and 2400 kcal/kg in the diet resulted in significant ($P<0.05$) increase in feed intake in birds without altering intestinal viscosity and gut morphology. Further, raising the energy level of high NSP diets has completely overcome the deleterious effect of 10 % NSP diet but fails to improve the performance of birds fed with diet containing 14% NSP. It is concluded that increasing dietary NSP consisting predominantly of insoluble fraction exert nutrient dilution in the diet.

Keywords: Broiler, Energy, Non starch polysaccharide, Viscosity.

Introduction

Feed accounts to major cost of poultry production and often accounts for more than 60 % of total costs of commercial poultry production. Increasing cost of conventional ingredient such

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as soybean meal has become bottle neck for the profit margins. One strategy to reduce feed cost is by the use of alternative, locally available feed ingredients such as sunflower meal. However, inclusion of sunflower meal in poultry feeds is of limited value due to high NSP content (Dusterhoft *et al*., 1992; Juskiewicz *et al*., 2010). The physiological or anti-nutritional effect of NSP in poultry depends on the quality and quantity of NSP present. Soluble NSP of cereals such as wheat, barley and rye increases intestinal viscosity thereby interfere with the digestive processes and exert strong negative effects on net utilisation of energy (Smits and Annison, 1996; Jorgensen *et al*., 1996; Langhout *et al*., 2000). While major detrimental effects of soluble NSP are reported to be associated with viscous property, insoluble NSP makes up the bulk in the diets but have little or no effect on nutrient utilisation in monogastric animals (Carre, 1990). In contrast, Kirwan *et al.* (1974) reported that elevated levels of insoluble fibre in the diet shorten residence time of digesta which may lead to lower nutrient digestibilities, reduce AME and performance of birds. Diet dilution with high fibre feedstuffs reduces the AME content of broiler feeds and increases feed intake (Meremikwu, *et al*., 2013). If the physiological and antinutritive effect of insoluble NSP is due to nutrient dilution alone, increasing the concentration of nutrients in such diet will reflect in improvement in bird's performance. Hence, present study was conducted to find out the effect of graded levels of dietary insoluble NSP on the performance of broilers.

Materials and Methods

One hundred day-old straight run broiler chicks (Cobb) of both sexes were wing banded and weighed. Birds were distributed randomly into five experimental groups with two replicates per group. Ten birds were allotted to each replicate. Broiler starter ration with 7 % total NSP and 2850 kcal/kg of ME served as control ration (T1). Ration T2 and T3 were formulated to contain 10% total NSP each but with either low (2623 kcal/kg, T2) or similar caloric density (T3) to that of T1. Similarly, ration T4 and T5 were formulated to have 14% total NSP but with either low (2376 kcal/kg, T4) or similar energetic density (T5) as that of control. Crude protein and crude fibre content of the experimental diets were analysed as per AOAC (1980). NSP contents of the diets were calculated from NSP content of each ingredient with its inclusion levels (Senthilkumar and Balakrishnan, 2013). The ingredients and chemical compositions of the experimental rations are presented in Table 1.

The feeding experiments were conducted for a period of five weeks. Birds were maintained under uniform management conditions in battery type cages with *ad libitum* supply of feed and potable water. Weekly body weight and feed intake were recorded throughout the experimental period. At the end of the feeding trial, six male birds from each group were selected randomly and slaughtered. Entire digestive tract was dissected and the empty weight of gizzard, liver, pancreas, small intestine, caecum and colo-rectum and length of small intestine, caecum and colo-rectum were recorded. The content of ileum (from Meckel's diverticulum to ileo-caecal junction) were collected, centrifuged at 5000 rpm and the supernatant was separated and stored for the determination of relative viscosities using Oswald U-tube viscometer, comparing with distilled water as suggested by Choct and Annison (1992). Volatile fatty acid contents of the ileal supernatant samples were determined by external standard method using gas liquid chromatography (Netel, Omega QC+) fitted with flame ionization detector, as described by Playne (1985).

The data collected from the feeding trial were subjected to analysis of variance (ANOVA) by completely randomized design as per Snedecor and Cochran (1980). Data on body weight of birds were subjected to sex-correction before applying statistics.

Results and Discussion

At the end of five weeks feeding trial, there was no difference in body weight of birds (Table 2) fed with T1 (control) and 10% NSP rations with either levels of energy (T2 and T3), whereas significant reduction ($P<0.05$) in body weight was observed in birds fed ration T4 when compared to that of T1. Increasing the energy levels of 14% NSP ration (T5) had improved the body weight gain, but performance remains significantly ($P<0.05$) lower than T1. Higher inclusion of ingredients with high soluble NSP content in the ration are reported to reduce body weight of birds (Moran, 2006; Lin et al., 2010) where as insoluble NSP are reported to have no harmful effect on birds (Hetland and Svihus, 2001). When graded levels of cellulose (insoluble NSP) were added to the diet of broiler chicks, birds were unable to increase the feed intake sufficiently to maintain body weight gain (Newcombe and Summers, 1985). Similarly, Babu and Devegowda (1997) reported significant decrease in weight gain of broilers fed with diets containing varying fibre levels from 5 to 12.5% with correspondingly decreased levels of energy. Increasing the NSP level of the ration iso-energetic to that of control did not have any significant improvement over the body weight gain (Jorgensen et al. 1996). Findings of the present study revealed that weight gains up to 10% NSP in the diet are in accordance with above reports. Considering the harmful effect of soluble NSP, ingredients used in the present experimental rations are high in insoluble NSP and hence possible harmful effect over the body weight of birds was correspondingly less or absent. Diet with 10 % NSP hardly produced any observable reduction in weight gain. However, with 14 % NSP diet, the birds were not able to sustain the diluent effect of insoluble NSP and hence reduction in body weight was observed. These observations tend to suggest that higher levels of insoluble NSP in T4 and T5 (14 % total NSP) diet but not at T2 and T3 (10% NSP) could be the possible reason for poor performance.

At the end of 5 weeks of experiment, there was no appreciable difference in feed intake, feed to gain ratio and protein efficiency ratio in birds receiving T1 or T2. Increase in feed intake might be due to energy dilution by the presence of higher level of insoluble NSP in the ration. As the energy level increased, feed and protein efficiency were improved. This finding confirms that the presence of high levels of insoluble NSP *per se* may not have any anti-nutritive effect over body weight gain but increased feed intake and poor feed and protein efficiency ratios were perhaps due to nutrient dilution and bulking property.

The levels of volatile fatty acids in the ileal contents were measured in order to assess the microbial proliferation at the proximal intestine due to the presence of NSP as substrate for fermentation. Irrespective of the dietary treatments, acetate was more abundant than butyrate and propionate. No significant difference existed among the experimental groups fed different levels of dietary NSP on the ileal volatile fatty acids irrespective of energy levels. As observed in the present study, high concentration of acetate to other volatile fatty acids were also reported by Choct et al. (1996) in broilers fed with wheat based diets. Total volatile fatty acids content were not elevated due to feeding of NSP enriched diet in broilers and suggested that the hindgut microbes were incapable of fermenting the large insoluble NSP molecules. In another study Jorgensen et al. (1996) observed no significant difference in the faecal volatile fatty acids concentration when increasing the dietary NSP from 9.1 to 12.7 % by the inclusion of oat bran. Ricke et al. (1982) suggested that greater quantities of feed intake resulted in increased passage to the extent that gut microbes do not have time to effectively ferment cell wall carbohydrate arriving at the caecum and large intestine. This may also hold good for the present study wherein, no significant difference was observed with regard to the ileal volatile fatty acids content.

The relative viscosity of the ileal digesta supernatant of the five experimental groups ranged from 1.22±0.05 to 1.29±0.06. No significant difference in ileal viscosity was observed between the groups. Bedford and Classen (1992) reported that intestinal viscosity correlates positively with luminal concentration of high molecular weight soluble carbohydrates. Choct and Annison (1992) reported that the relative viscosity of ileal content of control diet was less than 1.5, but increased to as high as 3.0 when the diet contained isolated wheat pentosans.

The viscosity values obtained in the present study are very low and did not affect bird's performance perhaps due to presence of high levels of insoluble NSP and the rations were not having any viscous ingredients.

Diets containing different levels of NSP, irrespective of dietary energy levels, did not have any significant influence on the weight of gizzard, liver, pancreas, empty weight of small intestine (Table 3) and length of various segments of intestinal tract. Increased level of soluble NSP in the diet resulting in increased length and weight of digestive organs has been reported by Jorgensen et al. (1996). Intestinal adaptation was more pronounced with feeding of pectin, compared to cellulose or finely ground rice straw (Siri et al., 1992). Hetland and Svihus (2001) also suggested that addition of oat hulls containing 84.7% insoluble fibre and less than 5% soluble fibre were associated with increased gut volume. The non-significant increase in the length and weight of gastrointestinal organs of birds fed high NSP diets in the present study reflected the adaptive changes of the digestive system to increased levels of NSP.

In conclusion, broilers birds were able to tolerate up to 10% total NSP which predominantly contains insoluble NSP (more than 70%), whereas 14% of total NSP reduced the performance considerably. Hence it is recommended that the total NSP content of broiler starter ration should not exceed 10 % while insoluble NSP is the predominant fraction of total NSP.

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Table 1. Per cent ingredient and nutrient composition of the experimental rations.

Rations	**T1**	**T2**	**T3**	**T4**	**T5**
Ingredients (%)					
Maize	50.5	26.5	20.5	13.5	0.0
Pearl millet	7.0	20.0	20.0	20.0	21.5
Soyabean meal	33.0	21.0	22.0	8.0	10.0
Sunflower meal	-	23.0	23.0	49.0	49.0
Fish meal	7.0	7.0	7.0	7.0	7.0
Sunflower oil	-	-	5.0	-	10.0
Dicalcium phosphate	0.5	0.5	0.5	0.5	0.5
Mineral mixture*	2.0	2.0	2.0	2.0	2.0
Nutrient compositions					
Crude protein (%)	23.3	23.4	23.3	23.4	23.2
Crude fibre (%)	3.53	7.92	7.85	12.97	12.83
Total NSP (%)	7	10.85	10.72	14.11	13.92
Insoluble NSP (%)	5.98	7.76	7.72	9.48	9.42
Soluble NSP (%)	1.57	3.08	3.01	4.64	4.50
ME (kcal/kg)	2850	2623	2849	2376	2827

** Supplied per kg of diet: calcium 6.4 g, phosphorus 1.2g, manganese 55 mg, iodine 2 mg, zinc 52 mg, copper 2 mg and iron 20 mg .*

Vitamin mixture was added 10g/100 kg of feed. Each gram contained A 82000 IU, D3 12000 IU, K 10 mg and B250 mg.

B complex vitamins mixture was added at the rate of 25g/100kg feed supplied thiamine 1mg, pyridoxine 2 mg, cyanocobalamine 15 mcg, niacin 15 mg, calcium pantothenate 10 mg and folic acid 1 mg.

Coccidiostat (Diclazuril) was added at the rate of 10g/100kg of feed.

Toxin binder (Sodium alumino silicate) was added at the rate of 10g/100kg of feed.

Table 2. Effect of experimental rations containing different levels of NSP on body weight, weight gain, feed to gain ratio, protein efficiency ratio, ileal volatile fatty acid and ileal viscosity in broilers at 5th week of age.

Ration	T1	T2	T3	T4	T5
Body wt at 5 wks (g) *	1361^{c} ± 32.7	1310^{abc} ± 23.1	1338^{bc} ± 32.4	1243^{a} ± 23.5	1271^{ab} ± 23.9
Weight gain (g)*	1314^{c}± 39.9	1263^{abc} ± 26.8	1291^{bc} ± 40.4	1197^{a} ± 31.8	1224^{ab} ± 24.4
Feed/gain ratio at 5 wks	1.81	1.87	1.72	2.03	1.86
Protein efficiency ratio	2.41	2.30	2.49	2.11	2.32
Ileal volatile fatty acids (mmol/lit)					
a. Acetate ^{NS}	28.11± 3.54	29.72 ± 4.44	31.39 ± 2.76	30.28 ± 2.26	32.22 ± 2.59
b. Butyrate ^{NS}	2.99 ± 0.85	3.18 ± 0.66	2.01 ± 0.77	1.78 ± 0.67	2.16 ± 0.29
c. Propionate ^{NS}	0.60 ± 0.16	0.93 ± 0.37	0.72 ± 0.46	0.67 ± 0.28	0.94 ± 0.48
Ileal viscosity ^{NS}	1.26 ± 0.08	1.22 ± 0.05	1.25 ± 0.07	1.24 ± 0.07	1.29 ± 0.06

* Means in the same row bearing different superscripts differ significantly (P<0.05)
NS – not significant

Table 3. Relative weight of digestive organs and length of different segments of intestine of broilers fed with rations containing different levels of NSP

Ration	T1	T2	T3	T4	T5
Weight (g/kg body weight) ^{NS}					
Gizzard	23.75±0.61	23.73±2.95	25.11±2.45	25.77±2.21	27.18±0.78
Liver	33.45±3.65	20.18±0.74	23.55±2.50	20.50±0.63	24.27±3.54
Pancreas	2.81±0.29	2.75±0.23	2.51±0.18	2.87±0.20	2.88±0.38
Small intestine	23.02±0.50	23.55±1.60	20.29±1.04	25.91±2.01	20.86±1.91
Caecum	3.92±0.23	4.84±0.51	4.15±0.29	4.55±0.42	4.53±0.50
Colo-rectum	1.54±0.32	1.87±0.44	1.35±0.17	2.12±0.18	1.85±0.35
Length (cm/kg body weight) ^{NS}					
Small intestine	127.53±9.26	131.90±4.82	133.55±8.38	161.62±7.49	148.86±10.8
Caecum	15.42±0.96	15.66±0.5	15.03±0.16	16.80±1.44	15.85±0.92
Colo-rectum	7.71±1.1	7.63±0.33	7.86±1.02	8.54±1.47	8.14±0.94
Total	151.66±9.91	154.53±5.42	156.44±9.33	186.96±10.25	172.85±12.58

Means of six observations
^{NS} – Not significant