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Effects of Dietary Distillers Dried Grains with Solubles (DDGS) Concentrations on Intestinal Morphology of Broiler Chicken

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Abstract: This experiment was conducted to evaluate the effects of dietary DDGS levels on small intestinal morphology of broilers. A total of 720 Cobb 48 male broilers were used in this experiment. Birds were fed diets formulated to contain 0, 5, 10, 15, 20 and 25% DDGS, respectively for a period of 6 week. On day 21 and 42, significant differences were observed in Villus Height (VH), Crypt Depth (CD) and the ratio of villus height to crypt depth (VCR) in duodenum, jejunum and ileum except for ileum on day 42. About 10-15% DDGS inclusion level showed better VH, CD and VCR for broiler intestinal morphology. Therefore, dietary added with DDGS can improve intestinal morphology, up till to 15% DDGS concentrations were considered to be suitable for broiler starter and grower age.

Key words: DDGS, broiler, intestinal morphology, CD, VCR, VH

INTRODUCTION

The shortage of traditional feedstuff resources accelerate the exploiting of substitute resources development, such as corn Distillers Dried Grains with Solubles (DDGS). Moreover, there has been significant research on the utility of DDGS in poultry feeds (Runnels, 1966; Berg, 1972; Waldroup *et al*., 1981; Parsons *et al*.,1983; Lumpkins *et al*., 2004; Wang *et al*., 2007).

DDGS is a nutritionally suitable ingredient for poultry diets with a large content of dietary fiber (Martinez-Amezcua *et al*., 2007; Pahm *et al*., 2009). Dietary fiber appears to be important for maintaining intestinal health in nonruminant animals (Montagne *et al*., 2003) because of its beneficial effects on digestive physiology (Jin *et al*., 1994; Hedemann *et al*., 2006; Wilfart *et al*., 2007). The gastrointestinal tract is responsible for the breakdown and absorption of nutrients from food. The intestinal damage reduces the ability of the bird to absorb nutrients and results in reduced BW and poor feed conversion (Brake *et al*., 1997). Yeast products promote the growth of beneficial bacteria in the intestine which ultimately can enhance gut health and the immune response (Sauerwein *et al*., 2007), the producing process of DDGS is based on fermentation so researchers considered that the diets addition with DDGS can promote animal intestine healthy. Knott *et al*. (2005) considered that feeding the diet containing residual solubles and the positive control diet containing spray-dried porcine plasma resulted in greater villus height and a greater villus height: Crypt depth ratio compared with pigs fed diets containing carbadox. Stein and Shurson (2009) demonstrated that compounds in a fraction of condensed distillers solubles may improve the villus height and crypt depth ratio in the proximal portion of the small intestine. Moreover, a larger VCR is considered a sign of intestinal health (Pluske *et al*., 1997).

Nevertheless, data on the effect of DDGS on digestive function in poultry is rare. Therefore, this experiment was designed to evaluate the effect of dietary DDGS on intestinal morphology.

MATERIALS AND METHODS

Six dietary treatments that differed in the percentage of DDGS were used in this study, diets were based primarily on corn, soybean meal and fish meal and contained 0, 5, 10, 15, 20 and 25% DDGS. Diets were formulated to meet or exceed (National Research Council, 1994) nutrient recommendations. Diets were offered in two feeding phases, starter and grower from 0-21 and 22-42 days of age. Table 1 displays only the ingredient and nutrient composition of the lowest (0% DDGS) and highest containing DDGS (25%). The remaining experimental diets were made by blending at various proportions to generate the 5, 10, 15 and 20% DDGS diets.

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A total of 720 Cobb 48 male broiler chicks were obtained from a commercial hatchery and distributed equally across 24 pens so that each treatment was replicated 4 times with 30 broilers each. Chicks were vaccinated for Marek's disease, Newcastle disease and Infectious Bronchitis. Birds consumed feed and water on an *ad libitum* basis and experimental diets were provided in crumble form.

At 21 and 42 days of age, two broilers from each of six treatments within four replications (Total of 48 Cobb birds per treatment) were randomly selected for slaughtering, duodenum, jejunum and ileum were separated and washed with 0.9% NaCl solution then 2 cm samples were preserved in 10% formaldehyde fixing solution. Tissue samples for the morphometric study were dehydrated and embedded in paraffin, sectioned at 4 μm and stained with hematoxylin and eosin. Morphometric measurements were performed with a light digital microscope. VH, CD and calculate VCR were measured. Measurements were taken in 10 well-oriented villi and crypts for each intestinal section of each bird.

The villus height and crypt depth were measured using a linear ocular micrometer (Olympus, Microplanet). Villus: Crypt ratio was calculated by dividing villus height by crypt depth. All morphometric analysis was done by the same person who was blinded to the treatments.

Differences among groups were determined by ANOVA using the GLM procedure of SAS (SAS Institute, 2002) and significant differences were determined using Duncan's multiple range test at a level of $p<0.05$ (Duncan, 1955).

Table 1: Composition of experimental diets (DDGS% as is)[1]

	Starter phase (0-21 days)		Grower phase (22-42 days)	
Ingredients (%)	0%	25%	0%	25%
Corn	60.44	47.15	63.58	50.25
Soybean meal	31.00	18.40	28.20	15.60
DDGS[1]	0.00	25.00	0.00	25.00
Fish meal	2.20	2.20	1.50	1.50
Limestone	1.37	1.50	1.00	1.12
Dicalcium phosphate	1.20	1.22	1.10	1.12
Salt	0.22	0.10	0.25	0.13
Soybean oil	1.70	2.30	2.60	3.25
Premix[2]	1.50	1.50	1.50	1.50
L-Lysine	0.16	0.40	0.14	0.38
Methionine	0.17	0.16	0.10	0.09
L-Threonine	0.04	0.07	0.03	0.06
Total	100.00	100.00	100.00	100.00
Nutrient analysis (% or as indicated)				
ME (kcal kg^{-1})	3,100.00	3,100.00	3,150.00	3,150.00
CP (calculated)	22.70	22.60	21.20	21.30
Calcium (calculated)	1.07	1.07	0.90	0.90
Nonphytate phosphorus	0.44	0.44	0.40	0.40
Methionine	0.52	0.51	0.42	0.42
Cystine	0.33	0.30	0.31	0.28
Lysine	1.17	1.17	1.05	1.05

[1]DDGS: Distillers Dried Grains with Solubles; [2]Provided per kilogram of diet: Retinyl acetate, 2,970 μg; Cholecalciferol, 75 μg; DL-α-Tocopherol Acetate, 40 mg; Menadione, 2 mg; Vitamin B_{12}, 0.04 mg; Folic acid, 1.96 mg; D-pantothenic acid, 15.64 mg; Riboflavin, 8 mg; Niacin, 39.2 mg; Thiamin, 2.76 mg; D-biotin, 0.3 mg; Pyridoxine, 4.9 mg; Cu, 10 mg; Fe, 72 mg; Zn, 89.7 mg; Mn, 101.76 mg; Se, 0.41 mg; I, 0.31 mg

RESULTS

Morphometric measurements of 21 days age broilers are summarized in Table 2. Significant differences were observed in duodenum VH, CD and VCR ($p<0.05$), 15% DDGS concentration showed close VH to control treatment, 10% DDGS concentration showed lowest CD and highest VCR similar to control group. Significant difference were observed in jejunum VH, CD and VCR ($p<0.05$), 10% DDGS concentration showed close VCR to control treatment, 10% DDGS concentration showed lowest CD and highest VCR. Significant differences were observed in ileum VH, CD and VCR ($p<0.05$), 10 and 15% DDGS concentration showed lowest CD and highest VCR similar to control group.

Morphometric measurements of 42 days age broilers are presented in Table 3. Significant differences were observed in duodenum VH and VCR ($p<0.05$), 10% DDGS concentration showed highest VH and 15% DDGS concentration showed highest VCR similar to control group, however there was no difference in duodenum CD ($p = 0.0539$). Significant differences were observed in jejunum VH, CD and VCR ($p<0.05$), 10% DDGS concentration showed higher VH and VCR than other treatments. In contrast, there were no significant effects of DDGS concentration on chick ileum morphology ($p>0.05$).

Table 2: Effects of DDGS on small intestinal morphology of broiler (21 days)

	Duodenum			Jejunum			Ileum		
Items	VH (μm)	CD (μm)	VCR	VH (μm)	CD (μm)	VCR	VH (μm)	CD (μm)	VCR
Control	1168.08^{d}	92.08b^{c}	18.65^{a}	1012.94^{b}	90.73^{c}	11.87^{b}	930.59^{a}	101.90^{b}	9.29^{a}
5%	1192.99^{c}	102.06^{ab}	12.02^{c}	1303.96^{a}	128.86^{a}	10.31^{bc}	698.79^{c}	95.84^{b}	7.60^{bc}
10%	1364.10^{b}	83.09^{c}	16.52^{ab}	1073.96^{b}	71.34^{d}	15.41^{a}	710.73^{c}	77.23^{c}	9.36^{a}
15%	1458.56^{a}	99.90^{ab}	14.83^{b}	883.73^{c}	95.18^{bc}	9.39^{c}	787.51^{b}	90.53^{bc}	8.91^{ab}
20%	950.49^{e}	93.29^{bc}	10.58^{c}	1048.06^{b}	89.83^{c}	11.97^{b}	878.86^{a}	119.30^{a}	7.48^{bc}
25%	1364.79^{b}	111.92^{a}	12.50^{c}	1314.69^{a}	109.81^{b}	12.22^{b}	719.21^{c}	99.59^{b}	7.33^{c}
SEM	42.13	10.45	1.83	63.65	9.70	1.05	22.68	10.53	0.98
p-value	<0.0001	0.0048	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0049

[a-e]Means in the same column not sharing a common superscript are significantly different ($p<0.05$)

Table 3: Effects of DDGS on small intestinal morphology of broiler (42 days)

	Duodenum			Jejunum			Ileum		
Items	VH (μm)	CD (μm)	VCR	VH (μm)	CD (μm)	VCR	VH (μm)	CD (μm)	VCR
Control	1911.23^{a}	152.78	13.18^{ab}	1209.20^{c}	154.86^{a}	8.26^{b}	953.51	88.14	11.88
5%	1152.12^{d}	152.73	7.89^{c}	1425.56^{b}	161.67^{a}	9.24^{b}	1002.79	75.82	10.28
10%	1792.70^{a}	166.47	11.38^{b}	1563.78^{a}	115.98^{b}	14.24^{a}	965.04	84.00	11.22
15%	1643.50^{b}	113.42	15.91^{a}	1381.76^{b}	132.52^{ab}	11.06^{b}	940.09	88.33	11.56
20%	1477.47^{c}	147.90	10.32^{bc}	937.61^{d}	123.40^{b}	8.02^{b}	949.04	94.01	10.49
25%	1568.12^{bc}	149.37	10.80^{bc}	1066.39^{d}	107.74^{b}	10.43^{b}	934.98	98.65	11.08
SEM	55.81	24.55	2.05	81.38	21.90	2.10	79.18	11.19	1.03
p-value	<0.0001	0.0539	<0.0001	<0.0001	0.0029	0.0003	0.8205	0.2135	0.7483

$^{a-d}$Means in the same column not sharing a common superscript are significantly different ($p<0.05$)

DISCUSSION

The villi are primarily responsible for absorption of nutrients. Villus height is an indicator of intestinal health, because damaged villi are shorter and the enterocytes at the villi tip are more immature. Crypt depth is another indicator of intestinal health as crypts will deepen to produce more cells if cell turnover rates are high. The VH to CD ratio is a third indicator of intestinal health. If the ratio is high then the villi are mature and cell turnover rates are lower. A high ratio indicates a greater surface area to absorb nutrients and more functionally mature enterocytes at the tip (Wyhe, 2009). Knott *et al.* (2005) observed that feeding the diet containing residual solubles and the positive control diet containing spray-dried porcine plasma resulted in greater villus height and a greater villus height: Crypt depth ratio compared with pigs fed diets containing carbadox. Stein and Shurson (2009) considered that compounds in a fraction of condensed distillers solubles may improve the villus height and crypt depth ratio in the proximal portion of the small intestine; similarly, Perez (2010) considered that the villus height in jejunum of EcCR pigs increased proportionally to the concentration of dietary DDGS. The current study agrees with those results.

However, Agyekum (2011) found that although morphological data showed no differences ($p>0.1$) in the duodenum, jejunum and colon segments among diets, the dietary DDGS (30%) tended to decrease ($p<0.10$) villous height and villous height to crypt depth in the ileum in pig. This result is partly in accordance with the current study which considered that in excess of 15% DDGS showed poor intestinal morphology.

It has been estimated that approximately 3.9% of the dry weight of DDGS is contributed from yeast cell biomass (Ingledew, 1999). Beta-glucans, mannan-oligo-saccharides, chitin and proteins are biologically important fractions of yeast cell walls with many of these compounds capable of stimulating phagocytosis (Stone, 1998). Based on this point, it appears that inclusion of DDGS in diets to broilers may improve intestinal health, meanwhile, insoluble fiber in DDGS maybe yield some beneficial responses in stimulating villus growth and crypt development of gut. Hedemann *et al.* (2006) observed that feeding pigs a diet with large concentration of insoluble fiber improved their intestinal morphology by increasing villus height, DDGS enriches fibre, it may improve intestinal morphology based on this point whereas further studies are needed to elucidate the mechanism responsible for these effects.

CONCLUSION

DDGS from modern ethanol plants have proven to be a highly acceptable feed ingredient in commercial broiler diets. DDGS was shown on altering intestinal morphology in broilers. Furthermore, up till to 15% DDGS were proved to be suitable for boiler diets based on intestinal morphology and digestion and absorption characteristics.

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