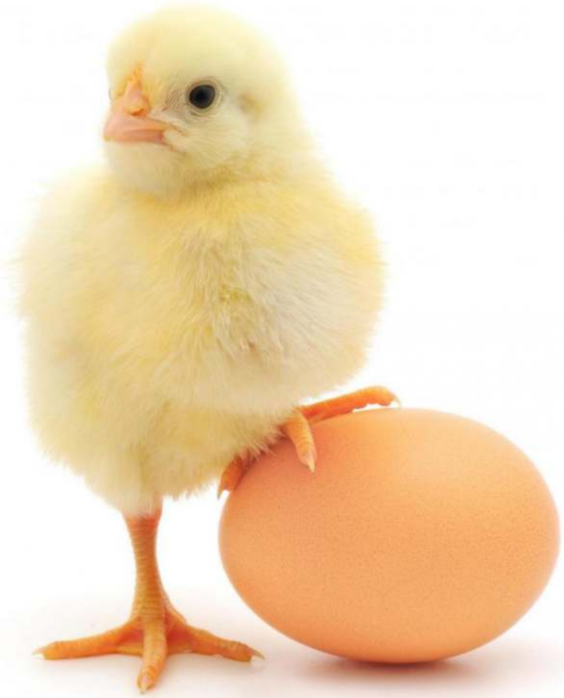
ISSN 1682-8356
ansinet.org/ijps



INTERNATIONAL JOURNAL OF
POULTRY SCIENCE

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

International Journal of Poultry Science 10 (12): 952-958, 2011
ISSN 1682-8356

Effects of Dietary Inclusion Level of Distillers' Dried Grains with Solubles (DDGS) from Wheat and Corn on Amino Acid Digestibilities in Broilers

Sherief M. Abdel-Raheem[1], R. Leitgeb[2] and C. Iben[3]
[1]Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt
[2]Department of Agrobiotechnology,
University of Natural Resources and Applied Life Science, Vienna, Austria
[3]Institute of Animal Nutrition, Department of Farm Animals and Veterinary Public Health,
University of Veterinary Medicine, Veterinärplatz 1, A-1210, Vienna, Austria

Abstract: The objective of this study was to determine the effect of different levels of Distillers' Dried Grains with Solubles (DDGS) from wheat and corn on prececal Amino Acids (AA) digestibilities, growth performance and some slaughter characteristics of broilers. A total number of 240 one day-chicks (Ross 308) were randomly allotted to 3 treatments (80 birds/group), with four replicate pens per treatment and 20 birds per pen. Chicks were fed the experimental diets with DDGS at levels of 0, 6 and 12%. All chicks had free access to feed and water *ad libitum* during the 5-wk experiment. Average daily gain, feed intake and feed conversion efficiency were determined weekly for 35 days. The results indicated that, body weight decreased in broilers fed 12 % DDGS than the control group at the end of the experiment. No significant differences with respect to feed intake and feed conversion at the first (1-22 d) and second (22-35 d) growing periods. A significant reduction in the warm and cold carcass weight and the warm and cold dressing % at 12 % inclusion level of DDGS. Tryptophan digestibility was lower ($p \leq 0.05$) with the addition of 12% levels of DDGS at d 21. At day 35 there is a significant decrease in the digestibility of total amino acids, some individual AA like threonine (9.1%) and arginine (6.38%) at 12% inclusion of DDGS in comparison with the control group. The results suggest that 12 % level of DDGS from wheat and corn reduce growth performance, carcass traits, some AA and DM digestibilities in broilers under present experimental conditions.

Key words: DDGS, digestibility of amino acids, broilers, performance, carcass traits

INTRODUCTION

DDGS is a by-product obtained during ethanol and beverage production which is the residual component of the grain kernel after the starch has been fermented by yeast to produce ethanol. Heat processing is needed to reduce the moisture concentration of wet distillers' grains, but it may reduce the utilization of heat-sensitive AA such as Lys (Cromwell *et al*., 1993). It is preferentially used in ruminant feeding due to its high content of fiber fractions. Due to its high CP content, it could be a potential feedstuff for poultry as well. Based on the reported results, corn DDGS is an acceptable ingredient in poultry diets and can be safely fed at 60 g/kg in starter broiler diets and at 120-150 g/kg in grower-finisher broiler diets (Lumpkins *et al*., 2004; Swiatkiewicz and Koreleski, 2007).

DDGS can partially replace corn and soybean meal in broiler diets, but the amino acids in DDGS are not balanced. Soybean meal is a good protein source with high amino acid content, so the combined use of DDGS and SBM may improve the amino acid balance. Distillers' dried grains with solubles have been used in commercial poultry diets at a level of 5% or less for many years. Other researchers have concluded that up to 25% DDGS can be incorporated in broiler diets if dietary energy is held constant (Waldroup *et al*., 1981). However, it is presumed that most of the DDGS used in these studies came from the beverage industry and DDGS from modern ethanol plants may differ in nutrient composition.

The digestibility of amino acids until the end of the ileum [Prececal (PC) digestibility] developed as an important tool in poultry nutrition in recent years for the description of the value that a protein source has (Ravindran and Bryden, 1999). Using PC digestibility is suggested because it helps avoiding the influence of postileal microbial activity in protein evaluation. Measurements with both broilers and hens should be based upon digesta collected from the last two-thirds of the small intestine between Meckel's diverticulum and 2 cm anterior to the ileo-ceca-colonic junction (Kluth *et al*., 2005; Rezvani *et al*., 2008).

Recent poultry studies have looked into the value of DDGS from corn (Fastinger *et al*., 2006; Kim *et al*., 2008). However, DDGS can originate from a variety of grain sources, including wheat, for which there is not a

Corresponding Author: Sherief M. Abdel-Raheem, Department of Nutrition and Clinical Nutrition, Faculty of Veterinary Medicine, Assiut University, Assiut, Egypt

lot of data about the digestibilities of amino acids (AA) of DDGS from wheat. Incorporation of DDGS at higher levels may provide an additional outlet for the increasing amounts available (Noll *et al*., 2001). Therefore, the present study was conducted to investigate the effects of different levels of DDGS from wheat and corn on prececal AA digestibility, broiler performance, carcass traits and organ weights.

MATERIALS AND METHODS

Birds and housing: A total number of 240 one day-chicks (Ross 308) were randomly divided into 3 groups (80 birds/group) and housed in pens of identical size (1 x 2 m) in a deep litter system with a wood shaving floor. Each group had 4 replicates (20 birds/pen). The birds had free access to water and feed. The climatic conditions and lighting program followed the commercial recommendations. Environmental temperature in the first week of life was 28°C and decreased to 20°C until the end of the experiment. During the first week, 22 h of light was provided with a reduction to 20 h afterward.

Dietary treatments: The dietary treatments were: 1) basal diet (control), with 0% DDGS, 2) basal diet plus 6% DDGS and 3) basal diet plus 12% DDGS. DDGS was always included with the ingredients in the diets. The chicks were fed with the starter diets from d 1 to 21 and grower feed from d 22 to 35 (Table 1, 2, 3) in mash from. The DDGS used in the experiment was completely derived from wheat and corn came from an ethanol plant in Pischelsdorf (AGRANA Bioethanol GmbH, Austria). Soybean meal and corn were changed against the DDGS to receive feed with similar energy and protein content. Titanium dioxide $TiO2$ (0.3%) was added as indicator. After 3 weeks (day 21) 8 bird from each box (32/group) were slaughtered and the ingesta were taken from the distal two-thirds of the intestine section between Meckel's diverticulum and 2 cm anterior to the ileo-cecal junction. The digesta from each replicate were pooled and freeze-dried to calculate the coefficient of ileal apparent digestibility of AA components. At d 35 all remaining birds were slaughtered and the ingesta from 6 bird/pen (24/group)

Table 1: Nutritional composition of DDGS from wheat and corn (as-fed) used in the experiment (Ages Company, Vienna, Austria)

Nutrient	%
DM (%)	91.80
ME (MJ/kg)	8.13
CP (%)	33.30
EE (%)	6.00
Ash (%)	5.50
CF (%)	6.70
Starch (%)	1.74
Sugars (sucrose) (%)	4.74
Lysin (%)	0.58
Methionine (%)	0.47
Threonin (%)	0.87
Tryptophan (%)	0.34
Ca (%)	0.09
P (%)	1.40

Table 2: Composition of experimental diets (% as fed)

	Starter phase (0-21 d)			Grower phase (22-36 d)		
	DDGS inclusion (%)					
Item	0%	6%	12%	0%	6%	12%
Corn	49.00	46.50	44.02	53.00	50.47	48.00
Wheat	10.00	10.00	10.00	10.00	10.00	10.00
Soy bean (HP)	32.90	28.77	24.64	27.37	23.30	19.16
DDGS	0.00	6.00	12.00	0.00	6.00	12.00
Grass meal	2.00	2.00	2.00	3.00	3.00	3.00
Fat	2.60	3.25	3.91	3.23	3.89	4.55
Limestone	1.30	1.48	1.66	1.14	1.31	1.49
Di-calcium Phosphate	1.04	0.77	0.50	1.15	0.88	0.60
NaCl	0.30	0.27	0.21	0.34	0.28	0.22
Vit. Prem.[1]	0.03	0.03	0.03	0.03	0.03	0.03
Min. Mix.[2]	0.06	0.06	0.06	0.06	0.06	0.06
L-Lysine	0.07	0.17	0.27	0.10	0.20	0.30
DL-Methionin	0.21	0.19	0.16	0.16	0.13	0.11
L-Threonin	0.04	0.06	0.09	0.06	0.09	0.12
Cholin-Cl	0.08	0.08	0.08	0.04	0.04	0.04
Antioxidant	0.01	0.01	0.01	0.01	0.01	0.01
Phytase	0.01	0.01	0.01	0.01	0.01	0.01
Titanium dioxide	0.30	0.30	0.30	0.30	0.30	0.30
Coccidiostat	0.05	0.05	0.05	-	-	-
Total	100.00	100.00	100.00	100.00	100.00	100.00

1) Each 1 kg Vitamin premix contains: 40000000 I U. Vitamin A, 16500000 IU Vitamin D, 165000 mg Vitamin E, 13500 mg Vitamin K, 10000 mg Vitamin B1, 25000 mg Vitamin B2, 15000 mg Vitamin B6, 75 mg Vitamin B12, 230000 mg Nicotinic acid, 65000 mg Pantothenic acid, 6500 mg Folic acid and 400 mg Biotin.

2) Each 1 kg Trace element contains: 120 g Fe, 120 g/kg Zn, 180 g Mn, 30 g Cu, 2 g I, 2 g Co, 0.8 g Se

Table 3: Calculated nutrients of experimental diets

	Starter phase (0-21 d)			Grower (22-36 d)		
	DDGS inclusion (%)					
Item	0	6	12	0	6	12
ME (MJ/kg)	12.58	12.57	12.50	12.71	12.65	12.71
ME (kcal/kg)	3006.7	3004.3	2987.6	3037.8	3023.4	3037.8
CP (%)	19.2	19.5	19.7	18.0	18.2	18.3
EE (%)	6.0	6.7	7.2	6.3	7.2	7.7
Starch (%)	41.2	39.5	37.9	42.5	40.4	39.5
Sugars (%)	5.1	5.0	5.0	5.1	4.7	4.9
Ca (%)	0.96	0.93	0.85	0.84	0.81	0.84
Ava. P (%)	0.54	0.51	0.48	0.55	0.54	0.51
Na (%)	0.17	0.17	0.17	0.15	0.14	0.14
L-Lysine (%)	1.20	1.22	1.20	1.1	1.1	1.1
DL-Methionine (%)	0.52	0.5	0.49	0.39	0.38	0.37

was collected as well. Every six samples are pooled, freeze-dried, homogenized and analyzed for AA by HPLC as previously described by Altman (1992). Apparent ileal amino acid digestibilities were determined using titanium dioxide as internal marker. Amino acid digestibilities were calculated by the equation of Maynard and Loosli (1956).

$$\text{Apparent digestibility (\%)} = 100 - \left(\frac{\text{\% of indicator in feed}}{\text{\% of indicator in feces}} \times \frac{\text{\% of nutrient in feces}}{\text{\% of nutrient in feed}}\right) \times 100$$

Growth performance traits: All birds were weighed individually after their arrival from the hatchery to the experimental farm (initial weight) and every week till the end of the experiment the Body Weight (BW) was recorded. Daily weight gain for each dietary treatment was calculated. Feed consumption was recorded in the course of the whole experiment for each treatment and the feed conversion rates were calculated subsequently.

Organ weights and carcass yield percentages: At the end of experiment, after weighing, 34 birds per treatment were randomly selected and killed by cervical dislocation. Afterward, the birds were scalded, de-feathered and carcasses were eviscerated. The gizzard, heart, liver, were excised and weighed. The head, neck and feet were removed and the carcass subsequently was ready to cook. The weight of warm carcass refers to the weight of carcass without blood, feather and giblet (liver, heart and gizzard); while cold carcass represents the weight of warm carcass after 16 h keeping in the refrigerator (3°C). Grill carcass refer to the weight of cold carcass without head, neck and legs.

Statistics: Statistical analyses were conducted with the Statistical Package for Social Science (SPSS for Windows Version 15; SPSS GmbH, Munich, Germany) to determine if variables differed between groups. The Kolmogorov-Smirnov test was used to test the normal distribution of the data before statistical analysis was performed. The digestibility of AA, BW gain, feed intake, feed conversion and organ weights, were compared between groups by 1-way ANOVA and subsequent Duncan's multiple range tests. Probability values of less than 0.05 ($p<0.05$) were considered significant. Values in tables are means±pooled SE.

RESULTS

Growth performance: The mean BW of chicks did not differ significantly ($p>0.05$) between the dietary treatments at d 21 (Table 4). At the end of the experiment (d 35), broilers fed the control diet had a higher ($p<0.05$) BW (2133 g) than broilers that were fed 12% (1945 g) DDGS, however birds fed 6% DDGS had an intermediate value in relation to BW. No differences existed ($p>0.05$) among daily weight gain in broilers during either in the first 21 d or in the last 2 weeks of the experiment. No differences existed ($p>0.05$) with respect to the daily feed intake from broilers that were fed different percentages of DDGS in both the starter phase (d1 to d 21) or during the grower phase (d 22 to d 36).

Feed conversion rate: No differences existed ($p>0.05$) among DDGS treatments with respect to feed conversion ratio (Table 4). There is a slight numerical increase in the feed conversion ratio in broilers fed 12% DDGS at 21 d feeding period.

Carcass yield percentage and absolute weights of organs: The inclusion of 12% DDGS in the diet depressed ($p<0.05$) the warm (1514 g) and cold (1493 g) carcass weight in comparison with control group (1681 and 1653), respectively (Table 5). In addition, the warm and cold carcass yield were higher in the control group (78.8 and 77.7) compared with 12% DDGS group (77.7 and 76.7), respectively. A significant reduction in grill carcass weight and grill carcass % was observed in broiler chicks fed 12% of DDGS in comparison with the control group. No differences existed ($p>0.05$) among dietary treatments with respect to abdominal fat weight and the absolute gizzard, head and neck and legs weight in comparison with the control diet. Group fed diet

Table 4: Effects of feeding DDGS to broilers on weight gain and feed efficiency

	Feeding group DDGS inclusion (%)				
Item	0	6	12%	SEM	p-value
Initial BW (g)	44.8	44.8	44.9	0.02	0.333
At 21 day (g)	761	769	752	15	0.722
Final BW (g)	2133[a]	2055[ab]	1945[b]	41	0.008
Daily weight gain (g)					
1-21 day	34	34	33	0.7	0.619
22-36 day	90	88	85	1.8	0.245
Daily feed consumption (g)					
1-21 day	51	52	52	1.4	0.928
22-36 day	137	141	144	4.1	0.586
Feed conversion					
1-21 day	1.51	1.51	1.55	0.01	0.095
22-36 day	1.53	1.62	1.69	0.05	0.178

[a,b]Within the same row, means with different superscripts are significantly different (p<0.05).

Table 5: Effect of feeding DDGS to broilers on carcass weights and yields

	Feeding group DDGS inclusion (%)				
Item	0	6	12%	SEM	p-value
n	34	34	34	-	-
Live weight (g)	2133[a]	2055[ab]	1945[b]	41	0.008
HCW (g)	1681[a]	1607[ab]	1514[b]	33	0.003
HCY (%*)	78.8[a]	78.2[ab]	77.70[b]	0.23	0.007
CCW (g)	1653.0[a]	1584.0[ab]	1493.00[b]	33.00	0.004
CCY (%)	77.7	77.1	76.70	0.20	0.054
GCW (g)	1485.0[a]	1423.0[ab]	1330.00[b]	30.00	0.003
GCY (%)	69.6[a]	69.2[a]	68.30[b]	0.20	0.002
Abdominal fat (g)	28.0	29.0	25.00	1.70	0.200
Heart (g)	11.4[a]	10.3[ab]	10.00[b]	0.40	0.035
Liver (g)	42.0[ab]	44.0[a]	39.00[b]	1.30	0.045
Gizzard (g)	32.0	31.0	32.00	0.90	0.379
Head and neck (g)	88.0	85.0	85.00	1.80	0.426
Legs (g)	80.0	76.0	77.00	1.60	0.177

HCW = Hot Carcass Weight, HCY = Hot Carcass Yield (relative to live weight), CCW = Cold Carcass Weight, CCY = Cold Carcass Yield, GCW = Grill Carcass Weight, GCY = Grill Carcass Yield, n = number of birds.
[a,b]Within the same row, means with different superscripts are significantly different (p<0.05)

containing 6% DDGS had a greater (p<0.05) absolute liver weight in g (44) in comparison with 12% (39) group. However, Heart weight (10) was lower (p<0.05) in broilers fed 12% DDGS than control (11.4) group.

Prececal digestibilities of amino acids and DM: At d 21 no significant differences were noticed among total and individual AA digestibilities except tryptophan and lysine in broiler chicks fed any of the dietary treatments as shown in Table 6. Tryptophan digestibility was lower ($p \leq 0.05$) at 12% level of DDGS, however, lysine digestibility tended (p<0.1) to be higher with both 6 and 12% DDGS levels.

At day 35 there is a significant decrease in the digestibility of total amino acids at 12% inclusion of DDGS. Also, a significant reduction in the digestibility of threonine (9.1%) and arginine (6.38 %) at 12% inclusion level than the control group. Also there is a tendency of methione, isoleucine, leucine and valine to be lower (p<0.1) at 12% level of DDGS. However, at 6% level of DDGS nearly no effect on amino acid digestibilities. The prececal AA digestibility values of the first 3 weeks were absolutely 5% higher than in the next 2 growth weeks.

The DM digestibility was reduced at 12% inclusion level of DDGS at day 35, however at day 21 it tended to be lower.

Blood metabolites: Data in Table 7 demonstrated that no effect was recorded in serum total protein, albumen and urea at day 21, whereas urea was significantly higher at 6% DDGS level at day 35 than control and 12% DDGS levels.

Table 6: Effect of feeding DDGS to broilers on prececal digestibilities of Dry Matter (DM) and AA

	At d 21					At d 35				
	DGGS level					DGGS level				
	0	6	12%	SEM	p-value	0	6	12%	SEM	p-value
n	32.0	32.0	32.0	-	-	24.0	24.0	24.0	-	-
DM	64.06	65.97	61.81	0.79	0.080	62.76[a]	65.68[a]	59.25[b]	0.94	0.004
Lysine	79.9	83.1	83.1	0.92	0.077	75.5	76.5	70.3	2.05	0.150
Methionin	89.2	89.3	87.5	0.73	0.215	84.0	83.3	78.9	1.46	0.091
Threonine	71.6	74.0	71.7	0.99	0.225	68.2[a]	68.6[a]	62.0[b]	1.57	0.042
Tryptophan	77.3[a]	75.3[ab]	70.2[b]	1.64	0.052	70.3	70.6	62.3	3.14	0.190
Arginine	83.8	85.1	83.1	0.73	0.227	81.5[a]	81.7[a]	76.3[b]	1.12	0.023
Cystine	66.6	63.8	58.9	2.29	0.134	66.7	64.8	61.1	1.70	0.139
Isoleucine	79.6	81.5	79.4	0.95	0.297	75.4	74.7	69.5	1.64	0.082
Leucine	81.4	83.2	81.7	0.85	0.359	77.5	77.8	73.1	1.43	0.095
Valine	77.9	79.7	77.2	1.01	0.255	73.2	72.7	66.9	1.64	0.063
Total amino acid	80.1	81.9	79.9	0.74	0.203	76.8[a]	76.8[a]	71.8[b]	1.34	0.059

[a,b]Within the same row, means with different superscripts are significantly different ($p<0.05$)

Table 7: Effect of feeding DDGS to broilers on some blood metabolites

	Feeding groups				
	DGGS level				
	0	6	12%	SEM	P-Wert
At day 21					
n	8	8	8	-	-
Urea (mg/dl)	0.85	1.24	1.16	0.35	0.718
Total protein (g/dl)	1.86	1.95	2.06	0.18	0.727
Albumin (g/dl)	1.00	0.95	1.08	0.09	0.645
At day 35					
n	8	8	8	-	-
Urea (mg/dl)	1.96[ab]	2.64[a]	1.10[b]	0.31	0.014
Total protein (g/dl)	1.85	2.05	1.96	0.23	0.842
Albumin (g/dl)	0.84	0.88	0.86	0.11	0.971

[a,b]Within the same row, means with different superscripts are significantly different ($p<0.05$)
n = number of birds

DISCUSSION

Dietary treatments had no significant effect on performance from 1 to 21 d of age. The lack of performance effects is in contrast to results reported by Wang *et al.* (2007). Inclusion of up to 20% of traditional DDGS into broiler diets did not affect BW or feed:gain ratio, whereas feeding up to 25% DDGS increased feed intake by 4% (Wang *et al.*, 2007). Similarly, Lumpkins *et al.* (2004) noted no difference in BW or carcass yield when up to 12% DDGS was included in broiler diets to 42 d of age, but 18% DDGS decreased BW gain by 3%. The significant reduction in body weight in broilers fed 12% DDGS at day 35 was consistent with results of Liua *et al.* (2011), who reported that with the increased DDGS from corn, Feed Intake (FI) and BWG significantly decreased at 22-42 days. The same author explained the reason for those the presense of anti-nutritional factors such as non starch polysaccharide from the high corn DDGS diet most likely limited the growth performance of broilers. In contrast, Wang *et al.* (2007) found that a corn-based diet containing 50-250 g/kg of DDGS did not influence BWG for14, 35 and 49-day-old broilers, however, FI was increased and FCR was poor in the diet containing 250 g/kg cDDGS for 35 and 49-day-old broilers. On the contrary, Loar *et al.* (2010) reported that increasing DDGS inclusion levels during the grower phase resulted in a linear decrease ($p<0.001$) in BW gain.

Lumpkins *et al.* (2004) explained that the depressed performance observed at the higher inclusion levels was likely due to the decreases in the level of soybean protein, the main lysine source in the diet, resulting in a marginal lysine deficiency. At lower inclusion levels of DDGS, there appeared to be sufficient lysine from the soybean protein and thus no It appears that increased inclusion levels of DDGS resulted in a marginal lysine deficiency, which was most limiting when the birds were young and had the highest amino acid requirements. Another explanation for the reduced weight gain by the high level of DDGS is the interaction between lysine and reducing sugars in DDGS, which can lead to the initiation of the Maillard reaction (Maillard, 1912). When Lys is complexed with reducing sugars, it becomes unreactive Lys (Hurrell and Carpenter, 1981; Friedman, 1982). Because unreactive Lys is biologically unavailable but may be partially absorbed in the intestine (Finot and Magnenat, 1981), it is hypothesized that the conventional digestibility measurement may overestimate the amount of bioavailable Lys in DDGS.

The feed conversion was not significantly affected by the inclusion level of DDGS. This results was in harmony with results of Loar *et al.* (2010) who reported that feed conversion, mortality, were unaffected by DDGS level in the grower diet. Another study noted that no significant difference was recorded in FCR in broilers randomly assigned to diets with 0, 5, 10, 15, 20 and 25% DDGS levels (Min *et al.*, 2009).

Daily weight gain and daily feed intake not affected by any of the DDGS level in the present study. These results were consistent with data of Youssef *et al*. (2008) who reported that there were no significant effects of increased DDGS levels on feed intake, weight gain, excreta quality or digestibility of CP and organic matter. However, feed conversion showed a tendency to decline at the highest DDGS level (15%). Another study done by Loar *et al*. (2010) found that feed intake was higher in broiler chicks at inclusion levels of 22.5% or higher after 14 d of age. However, the data suggest that the young broiler can be negatively affected with inclusion levels of 15% DDGS or higher up to 28 d of age.

Carcass traits were reduced by high inclusion of DDGS and this results coincided with the finding of Loar *et al*. (2010).

The amino acid digestibilities: Tryptophan digestibility was lower at 12% inclusion of DDGS; however lysine digestibility tended to be higher with both 6 and 12% addition of DDGS. These results could be attributed to the differences in the raw materials and in the ethanol production process can have consequences for the chemical composition of DDGS and may also affect AA digestibilities.

The reduction in the digestibility of total and some individual amino acids (methionine, arginine, therionine, isoleucine, leucine and valine) at d 35 agreed with the observations of Martinez Amezcua and Parsons (2007); Pahm *et al*. (2008). They mentioned that, the nutritional value of DDGS can be influenced by many factors. For example, the type of drying conditions can affect amino acid digestibility, particularly Lys digestibility (Martinez Amezcua and Parsons, 2007; Pahm *et al*., 2008).

The higher digestibility of AA at day 21 in comparison with digestibility values of AA at day 35 confirm the results of Ten Doeschate *et al*. (1993); Huang *et al*. (2005) who reported that digestibility was affected by the age of the birds.

In conclusion, the growth performance was decreased with 12% inclusion of DDGS from wheat and corn in the diets, prececal total AA-digestibility was not influenced by 6 or 12% DDGS till the end of the third week. The addition of 12% DDGS decreased total AA digestibility significantly at the 5th week of growing. From the obtained results it could be concluded that DDGS from wheat and corn can be used as a protein source up to 6% without any harmful effect on prececal AA digestibilities and growth performance. High addition of DGGS from wheat and corn (12%) decreases ($p<0.05$) the prececal digestibilities of threonine, arginine, valine and total amino acids and DM as well under present experimental conditions.

REFERENCES

Altman, F., 1992. Determinations of amino sugars and amino acids in glycoconjugates using precolumn derivatization with o-phthalaldehyde. Anal. Biochem., 204: 215-219.

Cromwell, G.L., K.L. Herkelman and T.S. Stahly, 1993. Physical, chemical and nutritional characteristics of distillers dried grains with solubles for chicks and pigs. J. Anim. Sci., 71: 679-686.

Fastinger, N.D., J.D. Latshaw and D.C. Mahan, 2006. Amino acid digestibility and metabolizable energy content of corn distillers dried grains with solubles in adult cecectomized roosters. Poult. Sci., 85: 1212-1216.

Finot, P.A. and E. Magnenat, 1981. Metabolic transit of early and advanced Maillard products. Prog. Food Nutr. Sci., 5: 193-207.

Friedman, M., 1982. Chemically reactive and unreactive lysine as an index of browning. Diabetes, 31: 5-14.

Huang, K.H., V. Ravindran, X. Li and W.L. Bryden, 2005. Influence of age on the apparent ileal amino acid digestibility of feed ingredients for broiler chickens. Br. Poult. Sci., 46: 236-245.

Hurrell, R.F. and K.J. Carpenter, 1981. The estimation of available lysine in foodstuffs after Maillard reactions. Prog. Food Nutr. Sci., 5: 159-176.

Kim, E.J., C. Martinez Amezcua, P.L. Utterback and C.M. Parsons, 2008. Phosphorus bioavailability, true metabolizable energy and amino acid digestibilities of high protein distillers dried grains and dehydrated corn germ. Poult. Sci., 87: 700-705.

Kluth, H., K. Mehlhorn and M. Rodehutscord, 2005. Studies on the intestine section to be sampled in broiler studies on prececal amino acid digestibility. Arch. Anim. Nutr., 59: 271-279.

Liua, N.B., Y.J. Ruc, D.F. Tangb, T.S. Xua and G.G. Partridged, 2011. Effects of corn distillers dried grains with solubles and xylanase on growth performance and digestibility of diet components in broilers. Anim. Feed Sci. Technol., 163: 260-266.

Loar, R.E., J.S. Moritz, J.R. Donaldson and A. Corzo, 2010. Effects of feeding distillers dried grains with solubles to broilers from 0 to 28 days posthatch on broiler performance, feed manufacturing efficiency and selected intestinal characteristics. Poult Sci., 89: 1355-1359.

Lumpkins, B.S., A.B. Batal and N.M. Dale, 2004. Evaluation of distillers dried grains with solubles as a feed ingredient for broilers. Poult. Sci., 83: 1891-1896.

Maillard, L.C., 1912. Action des acides amines sur les sucres: Formation des melanoidines per voie methodologique. C.R. Acad. Sci., 154: 66-68.

Martinez Amezcua, C. and C.M. Parsons, 2007. Effect of increased heat processing and particle size on phosphorus bioavailability in corn distillers dried grains with solubles (DDGS). Poult. Sci., 86: 331-337.

Maynard, L.A. and J.K. Loosli, 1956. Animal nutrition. 4th Edn., McGraw Hill Book Company, New York, pp: 269.

Min, Y.N., A. Hancock, F. Yan, C. Lu, C. Coto, A. Karimi, J.H. Park, F.Z. Liu and P.W. Waldroup, 2009. Use of combinations of canola meal and distillers dried grains with solubles in broiler starter diets. J. Appl. Poult. Res., 18: 725-733.

Noll, S., V. Stangeland, G. Speers and J. Brannon, 2001. Distillers grains in poultry diets. In 62nd Minnesota Nutrition Conference and Corn Growers Assoc. Tech. Symposium. Bloomington, MN., pp: 53-61.

Pahm, A.A., C. Pedersen, D. Hoehler and H.H. Stein, 2008. Factors affecting the variability in ileal amino acid digestibility in corn distillers dried grains with solubles fed to growing pigs. J. Anim. Sci., 86: 2180-2189.

Ravindran, V. and W.L. Bryden, 1999. Amino acid availability in poultry - *In vitro* and *in vivo* measurements. Aust. J. Agric. Res., 50: 889-908.

Rezvani, M., H. Kluth, C. Elwert and M. Rodehutscord, 2008. Effect of ileum segment and protein source on net disappearance of amino acids from the ileum of laying hens. Br. Poult. Sci., 49: 28-36.

Swiatkiewicz, S. and J. Koreleski, 2007. Effect of dietary level of maize- and rye distiller dried grains with solubles on nutrient utilization and digesta viscosity in laying hens. J. Anim. Feed Sci., 16: 668-677.

Ten Doeschate, R.A.H.M., C.W. Scheele, V.V.A.M. Schreurs and J.D. Van der Klis, 1993. Digestibility studies in broiler chickens: Influence of genotype, age, sex and method of determination. Br. Poult. Sci., 34: 131-146.

Waldroup, P.W., J.A. Owen, B.E. Ramsey and D.L. Whelchel, 1981. The use of high levels of distillers dried grains with solubles in broiler diets. Poult. Sci., 60: 1479-1484.

Wang, Z., S. Cerrate, C. Coto, Y. Fan and P.W. Waldroup, 2007. Use of constant or increasing levels of distillers dried grains with solubles (DDGS) in broilers diets. Int. J. Poult. Sci., 6: 501-507.

Youssef, I.M.I., C. Westfahl, A. Sunder, F. Liebert and J. Kamphues, 2008. Evaluation of dried distillers' grains with solubles (DDGS) as a protein source for broilers. Arch. Anim. Nutr., 62: 404-414.