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Possibilities of Inclusion of corn Distillers Dried Grains with Solubles (DDGS) alone or in combination with Probiotic as Broiler Feed Ingredient

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Abstract: In the production of the ethanol from cereal grains, besides the main product which is ethanol, there are olso very valuable by-product that can be used as animal feed. The dried distilled grains with solubles (DDGS) is quite rich in protein and other nutrients. With the ever-increasing cost of soybeans and corn, many scientists are studying the possibilities of using DDGS in poultry nutrition. The aim of the present study was to determine the effect of including corn DDGS and corn DDGS and probiotic in compound feeds on productive, slaughter performance and some meat physicochemical parameters of broiler chickens under floor-rearing conditions. The experiment included 3 treatments (T), namely T1: the control group received a balanced compound feed, according to the requirements of the hybrid, without the participation of corn DDGS, T2: the diett contained 15% corn DDGS and T3: the dietts contained 15% corn DDGS and supplemented 500g probiotic/ton of feed. Each experiment had 20 one-day-old sexed male Ross-308 broiler chickens, replicated 3 times, and ended when the chickens were 35 days old. The results shown that diets T2 and T3 did not positively affect the weight development of chicks compared to T1 (the control group). At 35 days old, chicken weight from the control group outperformed the two experimental groups: by 8.45% in the T3 (corn DDGS and probiotic) and by 11.76% in the T2 (corn DDGS) at P<0.05. Differences in feed consumption per 1 kg of growth over the 35-day fattening period between the control and experimental groups were small and statistically unproven. Feeding diets with 15% DDGS from corn significantly reduced carcass weight, grill, thight and wing weight in broiler chickens. There were no significant differences in slaughter yield between the study groups. Diets T2 and T3 improved the water holding capacity (WHC %) of breast meat in broilers (at P< 0.001). The lowest loss in thermal processing (cooking) was observed in breast and thigh meat of chickens fed the diets with 15% corn DDGS and probiotic (P<0.05).

Keywords: broiler chickens; corn DDGS; probiotic; productive performance.

INTRODUCTION

The growing demand for protein-rich foods worldwide and strong climate changes, as an important part of ensuring the food and feed balance is the highest priority of the entire population. This makes the EU, and Bulgaria in particular, interested in discovering new non-traditional alternative sources of protein and energy for human and animal nutrition.

Global corn production and fuel ethanol production have steadily increased over the past few decades (Ray and Ramachandran, 2018). The boom in corn bioethanol production has increased the availability of a major byproduct known as distillate dried grains with solubles (DDGS).

Corn DDGS is considered an excellent source of energy and protein and is an important nutritional ingredient in poultry (layers, broilers, ducks, and turkeys), as DDGS containing approximately 85% of the energy value of corn (US Grain Council, 2015 a,b). With the increase in the price of soybeans and corn, the use of DDGS in poultry diets is the best strategy to reduce feed costs (El-Hack et al., 2019; Sharyari et al., 2020). The effect of DDGS inclusion in broiler chicken diets has been studied by numerous scientists (Lumpkins et al., 2004; Choi et al., 2008; Ibrahim et al., 2008; Wang et al., 2008; Applegate et al., 2009). Lumpkins et al. (2004) reported no negative effect on growth and feed consumption in broiler chickens from day 1 to 18 days of age when incorporating 15% DDGS in compound feed. Damasceno et al. (2020) confirmed that inclusion of up to 16% DDGS from corn (160 g DDGS/kg) in compound feed did not affect growth, feed consumption, slaughter performance and meat quality in broiler chickens.

The aim of the present experiment was to study the effect of including 15% of DDGS from corn without probiotic and together with the use of probiotic-B-Act in compound feed for broiler chickens on the performance, the quality of their products under floor conditions.

MATERIAL AND METHODS

To achieve the goal, 3 groups of 60 one-day-old sexed male Ross-308 broiler chickens (one control and two test) were formed, and each group had three subgroups with 20 chickens each. Chickens in the control group received a balanced compound feed, according to the requirements of the hybrid, without the participation of DDGS from corn. One experimental group received a ration containing 15% DDGS from corn from one day of age until the end of the experiment (35 days of age). The other experimental group was fed a ration with the participation of DDGS from corn in an amount of 15% and a probiotic (B-Act® Strain B. licheniformis (DSM 28710- Huvepharma, Sofia, Bulgaria) in a dose of 500 g probiotic/ton of feed from one day of age until the end of the experiment (35 days old).

DDGS from corn is produced by the factory „Zharni zavodi“ JSCo – Ethanol plant, Gorna Oryahovitsa. The physicochemical composition of the trial batch of DDGS from corn is shown in Table 1.

Table 2 shows the data on the composition and nutritional value of the combined feeds used for the respective age periods (up to 35 days of age). They are balanced according to the recommendations for the hybrid. The birds were given drinking water and feed ad libitum.

The main zootechnical parameters were controlled: live weight at one day of age, at 10 days, 28 days and 35 days, feed consumption (daily) and recording of dead birds (daily). Based on them, the following basic zootechnical indicators were calculated: growth rate, gain, feed consumption per kg of live weight and mortality. A slaughter analysis was also performed on 6 chickens from each test group based on average live weight at the end of the experiment. The relative values of the parts of the carcass (breast, thighs, wings) were calculated, as well as the slaughter yield of the carcass, internal abdominal fat, edible offal. Samples were taken from the white and red meat (breast and thighs) to perform analyzes of the sampled meat, of the physical properties - color (L*, a*, b*), water-holding capacity, WHC (%) and cooking loss (%).

Table 1. Physicochemical composition of the used batch of DDGS from corn

Item	Unit	Value
Moisture	%	10.2
Crude protein	%	26±2
Crude fiber	%	6.9±1
Crude fat	%	11.5±1.5
Ash	%	5.4±1
Sulfur	%	0.3±0.15
Phosphorus	%	0.8±0.1
Aflatoxins B1	mg/kg	<0.020

Table 2. Ingredients and nutrition composition of feed

Ingredients (%)	Feed / Groups					
	Starter			Grower		
	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act
Sunflower meal	5.00	-	-	5.00	5.00	5.00
Soybean meal	35.20	32.43	32.43	29.20	22.40	22.40
Methionine	0.18	0.14	0.14	0.15	0.09	0.09
Dicalcium phosphate	1.90	1.60	1.60	1.66	1.30	1.30
Limestone	0.60	1.00	1.00	0.60	0.97	0.97
Salt	0.20	0.20	0.20	0.20	0.20	0.20
Vitamin premix	0.20	0.20	0.20	0.20	0.20	0.20
Wheat	52.34	45.00	44.95	57.65	49.44	49.39
Vegetable oil	4.00	4.00	4.00	5.00	5.00	5.00
B-Act	-	-	0.05	-	-	0.05
Lysine-98%	0.28	0.33	0.33	0.24	0.30	0.30
Maize DDGS	-	15.00	15.00	-	15.00	15.00
Mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
Nutrition composition						
Metabolizable energy (kcal/kg)	2913.54	2871.50	2869.95	3017.35	2930.20	2928.65
Crude protein, %	22.39	22.43	22.42	20.34	20.33	20.33
Crude fiber, %	5.13	4.97	4.97	4.83	5.15	5.15
Lysine, %	1.44	1.42	1.42	1.25	1.21	1.21
Methionine, %	0.51	0.51	0.51	0.45	0.45	0.45
Calcium, %	0.99	1.03	1.04	0.90	0.91	0.92
Abs. phosphorus, %	0.49	0.50	0.50	0.45	0.45	0.45

RESULTS AND DISCUSSION

The effects of including 15% corn DDGS and 15% corn DDGS and probiotic on live weight, average daily gain, and survival in broiler chickens are shown in Table 3.

The live weight of day-old chickens required for the experiment was equal for all three groups of chickens - control 44.07 g, the group with the inclusion of 15% corn DDGS - 43.47 g and the group 15% corn DDGS and probiotic - 43.37 g at P = 0.296. At 10 days of age, chickens in the group with 15% corn DDGs and probiotic had the highest mean live weight of 203.73 g compared to the control group - 190.7 g and the group with the inclusion of 15% corn DDGS - 191.99 g at P=0.028. While in a study by Campasino et al. (2015) observed a negative effect on productive indicators, feed conversion and growth with the inclusion of 15% DDGS in 14-day-old broilers. On the 28th day from the beginning of the experiment, no proven difference was found between the live weight of the control and the two experimental groups (P>0.05 At the end of the experiment on the 35th day, birds from the control group outperformed the two experimental groups in terms of live weight: by 8.45% in

Table 3. Live weight, average daily gain and survivability at broiler chickens

Item	Group			SEM	P- value
	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act		
Live weight, g					
1 day	44.07	43.47	43.37	0.31	0.296
10 day	190.70 **b**	191.99 **b**	203.73 **a**	2.73	0.028
28 day	1106.07	1043.58	1055.09	21.66	0.175
35 day	1783.27 **a**	1573.56 **b**	1632.55 **b**	39.40	0.023
Weight gain, g					
1-10 day	14.66 **b**	14.85 **b**	16.04 **a**	0.28	0.027
11-28 day	51.30	47.31	47.30	1.05	0.056
29-35 day	96.74 **a**	75.71 **b**	84.14 **b**	3.50	0.015
1-35 day	49.69 **a**	43.72 **b**	45.41 **b**	1.12	0.023
Survivability, %	100	98,89	100	-	-

$^{a-b}$- different letters in the row mark statistically significant differences at P<0.05

the group with 15% corn DDGs and probiotic and by 11.76% in the 15% corn DDGs group at P=0.023. This is in contrast to Todorova et al. (2014), who found that the inclusion of DDGS from corn at levels of 15% or 30% in compound feeds of broiler chickens had no negative effect on growth and feed consumption. In an experiment with the inclusion of 15%, 30% and 45% DDGS from corn in the feed for broilers, it was found that the highest live weight was reached by chickens at 15 and 30% participation of DDGS in the feed (Abdulmajid Rashid et al. 2015) . Similar to our results Abdel-Raheem et al. (2011) reported a decrease in live weight in broilers fed 12% DDGS in compound feed compared to the control group. Other authors concluded that 6% and 12% DDGS can be given without adverse effect in starter and grower and finisher. The results in this study suggest that adding enzymes to DDGS diets can improve growth performance in broilers (Abudabos et al. 2017). By day 10 of development in this study, chickens receiving 15% corn DDGS and probiotic in the feed had significantly the highest growth at P = 0.027. This trend did not persist during the subsequent stages of the experiment. As the increase for the entire studied period from 1 day to 35 days has proven to be the highest values in the control group (P=0.023). During the experimental period, no mortality was reported in the chickens of the control and 15% corn DDGS and probiotic groups. In the 15% corn DDGS group, mortality over the study period was 1.11%.

Table 4 shows the results obtained for feed consumption and feed conversion during the experimental period. According to these indicators, no proven differences were found between the studied groups of chickens during the entire experimental period. While Loar et al. (2012) reported reduced feed consumption, observing higher feed conversion with the incorporation of over 8% DDGS through the starter and grower. Similarly, in an experiment with broiler chickens that were raised up to 42 days of age, Lukasiewicz and Kowalczyk (2014) found that the inclusion of 10% and 15% DDGS resulted in reduced feed consumption and less efficient feed conversion compared to the control group.

The results of a slaughter analysis of chickens to track the effect of including 15% DDGS from corn and 15% DDGS from corn with the probiotic B-Act in compound feeds for broiler chickens from 1 day to 35 days of age raised on the floor are indicated in Table 5.

Table 4. Average daily feed consumption and feed conversion at broiler chickens

Item	Group			SEM	P- value
	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act		
Consumption, g					
1-10 day	25.17	24.17	27.17	1.00	0.178
11-28 day	73.40	77.41	75.37	5.86	0.891
29-35day	141.90	130.15	138.57	12.04	0.784
1-35 day	73.28	72.78	74.24	5.34	0.981
FCR, g/g					
1-10 day	1.72	1.63	1.70	0.06	0.628
11-28 day	1.43	1.64	1.59	0.10	0.364
29-35 day	1.47	1.72	1.66	0.16	0.536
1-35 day	1.47	1.67	1.63	0.11	0.435

Table 5. Slaughter performance of broiler chickens

Item	Group			SEM	P- value
	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act		
Slaughter weight, g	1910 **a**	1647 **c**	1723 **b**	24.15	0.000
Grill, g	1329.17**a**	1118.83 **c**	1185.00 **b**	19.07	0.000
Slaughter yield,%	69.61	67.93	68.79	0.80	0.357
Thighs, g	421.17 **a**	359.17 **c**	390.00 **b**	7.90	0.000
Thighs, %	31.69	32.10	32.93	0.50	0.227
Wings, g	161.00 **a**	134.33 **c**	144.17 **b**	2.97	0.000
Wings, %	12.11	12.02	12.17	0.22	0.893
Breast with bone, g	458.17 **a**	369.33 **b**	384.00 **b**	7.41	0.000
Breast with bone, %	34.47 **a**	33.04 **ab**	32.42 **b**	0.52	0.038
Backs, g	272.17	238.83	256.83	10.05	0.095
Backs, %	20.49	21.33	21.65	0.71	0.501
Gizzard, g	29.06	26.88	28.24	2.10	0.761
Gizzard, %	1.52	1.63	1.63	0.11	0.748
Liver, g	36.83	34.46	34.52	1.67	0.536
Liver, %	1.93	2.09	2.00	0.08	0.416
Heart, g	7.87	7.35	7.49	0.34	0.551
Heart, %	0.41	0.45	0.44	0.02	0.224
Spleen, g	2.39	1.59	1.86	0.31	0.207
Spleen, %	0.13	0.10	0.11	0.02	0.449
Abdominal fat, g	10.45	13.31	17.08	2.19	0.139
Abdominal fat, %	0.54	0.81	0.99	0.12	0.059
Viscera, g	131.18	130.88	120.38	9.35	0.656
Viscera, %	6.85	7.96	6.97	0.54	0.305

[a-c]- *Different letters in the row mark statistically significant differences at* $P<0.05$

The chickens from the control group had the highest slaughter weight, grill, thighs and wings, followed by the group with the inclusion of 15% corn DDGS and probiotic in the feed, and with the lowest values for this indicator were the chickens from the group with 15% corn DDGS at P<0.001. While for the relative values of these indicators, the differences between the individual groups have not been proven. No significant differences in slaughter yield were found between the study groups in this experiment.

Lukasiewicz and Kowalczyk (2014) reported that the inclusion of 15% DDGS in compound feed did not affect slaughter performance. In a similar experiment, Lumpkins et al. (2004) also reported no significant differences in slaughter yield with the inclusion of 6, 12 or 18% DDGS in the compound feed of chickens fattened up to 42 days. Relative and absolute breast values were highest in the control group compared to the 15% corn DDGS group and the 15% corn DDGS and probiotic group at P<0.05. For the other indicators, there were no significant differences between the studied groups (P>0.05). This is consistent with what was found by Wang et al. (2007) who reported that diets with 15% DDGS during the 42-day fattening period had no negative effect on slaughter performance of broiler chickens. Abdominal fat had the lowest values in the control group compared to the experimental groups, and the difference was not proven (P=0.059). Rada et al. (2010) also reported no significant difference in slaughter yield and abdominal fat weight comparing the effect of feeding different levels of DDGS in broiler chicken diets – 6%, 12% and 18%. Ivanova (2015) investigated the effect of including increasing levels of DDGS from corn in compound feeds for broiler chickens on slaughter performance and meat chemistry. The participation of 10% DDGS, respectively, in the grower and the finisher of broiler chickens fattened up to 49 days of age did not have a significant effect on their slaughter parameters, compared to those found in the birds of the control group. And Dozier et al. (2016) found that added 14% DDGS at the end of the fattening period did not affect the carcass characteristics of broilers.

Table 6 shows some physicochemical parameters of the meat of the broilers in this study. Choi et al. (2008) and Corzo et al. (2009) reported that inclusion of up to 15% DDGS in broiler compound feed had no effect on performance, color and quality of breast and thigh muscles. Other

Table 6. Physico-chemical parameters of the meat

Item	Group			SEM	P- value
	Control group	Group with 15% corn DDGS	Group with 15% corn DDGS + B-Act		
Thighs					
L *	55.99	54.60	53.50	1.49	0.488
a *	3.91 **b**	6.54 **a**	5.96 **a**	0.61	0.029
b *	3.52	6.20	6.01	0.88	0.095
WHC, %	85.17	85.27	85.14	1.48	0.285
Cooking loss, %	16.78 **b**	20.57 **a**	13.75 **b**	1.09	0.013
Breast					
L *	48.86	49.66	49.69	2.40	0.960
a *	3.10	3.38	3.27	0.72	0.956
b *	4.42	5.49	5.41	1.06	0.726
WHC, %	80.23 **b**	85.24 **a**	88.14 **a**	1.30	0.001
Cooking loss, %	15.30 **a**	15.19 **a**	12.37 **b**	0.59	0.003

$^{a-b}$- Different letters in the row mark statistically significant differences at P<0.05

authors found that the addition of probiotics had a positive effect on the quality of poultry meat. They improve pH, color, chemical composition, water holding capacity (WHC %) and oxidation stability in meat (pova, 2017).

An important feature in determining the freshness and organoleptic qualities of meat is its color. In our study, the L* values of the thighs of the studied groups of broiler chickens were affected very little. Thigh mean values were 53.50 for the 15% corn DDGS and probiotic group versus 54.60 for the 15% corn DDGS in feed group and 55.99 for the control group, with no significant difference between them. And the L* values of the breast meat varied within narrow limits between 48.86-49.66 in the studied groups of chickens, with no statistically significant difference (P>0.05). Meat pigment saturation in the red-green spectrum (a*) was increased in thighs meat, with the highest value in the group receiving 15% corn DDGS and 15% corn DDGS and probiotic compared to the control, with differences proved at P=0.029. In the case of breast meat, the values of this indicator did not vary between the studied groups.

The pigment saturation of the meat in the yellow-blue spectrum (b*) showed variations from 6.20 to 3.52 in the breast meat in the studied groups, and there was no statistically proven difference in this indicator between the individual groups (P>0.05). According to Min et al. (2012) feeding more than 20% DDGS in the forage resulted in higher b* values in breast meat, which could be related to the higher pigment content in DDGS. While Jiang et al. (2014) found that inclusion DDGS had no effect on meat color. In a study with broiler chickens raised to 42 days of age and the inclusion of 0, 6, 12, 18 and 24% DDGS in the feed, Schilling et al. (2010) indicated that there was no significant difference between the breast meat obtained from the different groups in terms of L*,a* and b* values. Meat quality is determined by many complex factors, such as tenderness, water-holding capacity-WHC and textural properties (Desai et al., 2016). WHC is defined as the ability of meat to retain water during storage, heating, grinding, pressing, etc. It is considered one of the main factors affecting meat quality and economic value (Huang et al., 2016). The better water-holding capacity guarantees excellent technological qualities of the meat. In the results of the present experiment, the water-holding capacity-WHC% was significantly better in breast samples of broilers fed 15% corn DDGS and 15% corn DDGS with probiotic compared to the control group at P=0.001. According to this indicator, we did not find any reliable differences in the studied groups of chickens for thighs meat. We found the lowest percentage of cooking loss in breast and thighs meat from chickens fed 15% corn DDGS and probiotic. Significantly the greatest cooking loss was found in both breast and thighs meat in broilers with 15% DDGS and the control group and lowest in the 15% DDGS and probiotic group. While studies by Jiang et al. (2014) and Shim et al. (2018) reported no effect of DDGS inclusion in broiler feed on cooking loss. In an earlier study, Corzo et al. (2009) also noted that the use of DDGS in broiler compound feeds had no effect on color, pH, cooking loss of breast and leg meat.

CONCLUSION

The inclusion of 15% corn DDGS and 15% corn DDGS+probiotic in the feed of broiler chicks fattened to 35 days of age under floor conditions did not positively affect chick weight compared to the control group. At the end of the experiment on the 35th day, birds from the control group outperformed the two experimental groups in terms of live weight: by 8.45% in the group with 15% corn DDGs and probiotic and by 11.76% in the 15% corn DDGs group at P=0.023. Differences in feed consumption per 1 kg of growth over the 35-day fattening period between the control and experimental groups were small and unreliable.

Feeding diets with 15% DDGS from corn significantly decreased carcass weight, grill, thighs, and wing weight in experimental broiler chickens compared to control chickens. No significant differences in slaughter yield were found between the study groups in this experiment.

Under the conditions of the experiment conducted (floor rearing, up to 35 days of age), it can be concluded that 15% DDGS from corn and 15% DDGS from corn + probiotic in the combined feeds improved the WHC (%) of breast meat in broilers (at P=0.001) and the lowest cooking loss was observed in breast and thigh meat of chickens fed with 15% DDGS and probiotic (P<0.05).

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