

FEEDING WHEAT DISTILLERS DRIED GRAINS WITH SOLUBLES (DDGS) TO LAYING HENS AND ITS EFFECT ON PERFORMANCE AND EGG QUALITY*

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Abstract

The purpose of this experiment was to determine the effect of wheat DDGS as a feed ingredient on the performance of laying hens and their egg quality. ISA Brown laying hens were administered a feed mixture containing 15% (E1) or 20% (E2) wheat DDGS for 12 weeks. The hens from the control group (C) received a standard diet based on soybean meal as the main protein source only. Laying performance (laying %), average egg weight (g), average daily feed intake (g/hen), and feed conversion ratio (kg/kg eggs) were recorded over the study period. Egg quality traits (egg weight, thick albumen quality, yolk colour, yolk percentage, shell percentage and shell thickness) were evaluated twice: before the start and at the end of the experiment. There was no effect of dietary DDGS on laying performance or on feed intake. The average egg weight was significantly lower in both experimental groups and the feed conversion ratio was lower compared to the control group. Dietary wheat DDGS did not affect the main egg quality parameters except for thick albumen quality. Eggs from hens fed the diet with DDGS had higher values of Haugh unit than those from the control hens. These results suggest that wheat DDGS can be used in amounts of up to 20% as a component of feed mixtures for flocks of laying hens.

Key words: DDGS, wheat, laying hens, egg production, egg quality

Distillers dried grains with solubles (DDGS) are a distillation waste product, but in animal nutrition they can be a valuable plant protein raw material. According to Brzóska (2004), the production of 225 million litres of raw spirit enables obtaining 180–200 thousand tons of DDGS, which can replace 10–15% of soybean meal. In North America corn is the major raw material used in the production of DDGS. In our climatic zone, these could also be native cereal grains (Koreleski and Świątkiewicz, 2007; Cozannet et al., 2010).

*Author's project of the State Committee for Scientific Research, project no. R12 059 03.

The nutritional value of DDGS varies depending on the quality of the base material and its formulation (Cozannet et al., 2010). Usually, it is three times higher compared with the raw material except for metabolizable energy, the content of which diminishes after starch extraction (Spiehs et al., 2002; Koreleski and Świątkiewicz, 2007). This prompts the need to take an account of the nutritional value of particular batches of DDGS when balancing the nutritional value of feed.

The purpose of this experiment was, therefore, to investigate the feasibility of applying wheat DDGS left after the production of ethanol as a substitute for soybean meal fed to laying hens, and to determine the effect of wheat DDGS as a feed ingredient on the performance of laying hens and their egg quality.

Material and methods

The study was conducted on 144 ISA Brown laying hens at the age of 40 weeks at the onset of the experiment. The study was carried out over 12 weeks (20–31 weeks of production). The layers were kept in individual cages of a three-tier battery. Lighting programme and temperature in the building were according to the ISA Brown Management Guide (www.hendrix-genetics.com, 2008 b). These conditions were the same as before the experiment.

The experiment was conducted in three feeding groups with 48 hens per group: E1 and E2 (experimental) and C (control). Both experimental groups received a feed mixture containing 15% (E1) or 20% (E2) of wheat DDGS as a replacement for part of soybean meal. The hens from the control group (C) were given a standard laying diet based on soybean meal as the main protein source only. Control feed was the same as that fed to hens before the experiment. The composition of feed mixtures and their nutritional value are presented in Table 1.

Feed formulas were prepared by the Feed Production Plant in Baniocha based on its raw materials accepted as the standard feed. Experimental feed formulas were developed taking into account the result of the proximate analysis of wheat DDGS (Tables 2 and 3). All the other components, including the humin preparation, used in feeds were the same as in the standard feed produced by this manufacturer.

The chemical composition was determined according to AOAC methods (AOAC, 2005). Amino acid analyses were performed with a Beckman high pressure AA analyser System Gold (Beckman Instruments, Inc. Fullerton, CA, USA) after acid hydrolysis, methionine and cystine after oxidation with performic acid, and tryptophan after hydrolysis with barium hydroxide (Buraczewska and Buraczewski, 1984).

All birds were individually weighed just before the start (40 weeks of age) and at the end of the experiment (51 weeks of age).

Daily egg production, daily egg weight and weekly feed intake were noted in each group in each successive week. Based on this data, calculations for each week were performed for laying performance (laying percentage), average egg weight (g), egg production per hen per day (g), average daily feed intake (g per hen), and feed conversion ratio (kg of feed per kg of egg weight). The total egg mass (kg) produced in each group during the study was also calculated.

Table 1. Composition (%) and nutritional value of feed mixtures used in the experiment

Item	Content in diet (%)		
	Group C	Group E1	Group E2
Ingredients:			
corn	16.00	16.00	16.00
wheat	41.08	38.03	35.81
wheat bran	8.00	2.00	2.00
soybean meal	19.94	12.00	9.00
wheat DDGS		15.00	20.00
soybean oil	1.06	2.50	2.90
monocalcium phosphate	1.10	1.26	1.26
CaCO ₃	9.80	10.00	9.80
lysine	0.01	0.15	0.18
methionine	0.11	0.10	0.09
threonine		0.04	0.04
salt	0.40	0.42	0.42
vitamin-mineral premix *	1.00	1.00	1.00
humobentofet **	0.50	0.50	0.50
humokarbowit **	1.00	1.00	1.00
Nutritional value:			
ME MJ/kg	11.31	11.32	11.27
total protein (%)	16.40	16.46	16.46
crude fibre (%)	3.53	4.55	5.03
total Ca (%)	4.14	4.20	4.11
P available (%)	0.39	0.39	0.38
Lysine (%)	0.795	0.808	0.793
Methionine (%)	0.408	0.412	0.406
Methionine + Cystine (%)	0.703	0.750	0.759
Threonine (%)	0.580	0.586	0.575
Tryptophan (%)	0.200	0.135	0.114
Linoleic acid (%)	1.186	1.992	2.215

* Standard 1.0% mineral-vitamin premix for laying hens: vitamin A – 1350000 IU; vit. D₃ – 300 000 IU; vitamin E – 3 500 mg; vitamin K – 250 mg; vitamin B₁ – 250 mg; vitamin B₂ – 800 mg; vitamin B₆ – 300 mg; vitamin B₁₂ – 3 000 mcg; biotin – 25 000 mcg; pantothenic acid – 1200 mg; nicotinic acid – 2500 mg; folic acid – 150 mg; choline – 35000 mg; Fe – 5000 mg; Cu – 800 mg; Zn – 7500 mg; Mn – 8000 mg; J – 100 mg; Se – 30 mg; Co – 40 mg; Mg – 10 g; Ca – 300 g; antioxidant – 500 mg.

** Humic preparations containing humic and fulvic acids, phytohormones and phytoenzymes, trace minerals and trace elements.

Table 2. Nutritional value of wheat DDGS (data from feed analysis)

Nutritional value	Content (%)
Dry matter	95.21
Total protein	32.65
Crude fat	5.29
Crude fibre	14.64
Crude ash	2.16
ME MJ/kg *	8.474

*Calculated by method of Smulikowska (1996).

Table 3. Amino acid content in wheat DDGS (g/16 g N or g/100 g protein)

ASP	5.44
THR	3.11
SER	4.83
GLU	33.23
PRO	8.54
GLY	4.01
ALA	4.08
VAL	4.62
ILE	3.80
LEU	7.51
TYR	2.41
PHE	4.61
HIS	2.17
LYS	3.05
ARG	4.83
CYS	2.56
MET	1.73

Just before the start (40 weeks of age) and at the end of the experiment (51 weeks of age) all daily laid eggs from each group were collected. Eggs were subjected to standard quality control with the use of EQM system, version 1.0. Parameters estimated in fresh eggs on both dates were egg weight (g), thick albumen quality (Haugh units), yolk colour (Roche colour fan), yolk content in egg (%), and shell thickness (mm). In order to determine dry egg shell percentage, the shells were cleaned and dried for 24 h at 110°C.

The data for each trait were analysed by one-way analysis of variance calculated by the least squares method, separately for different factors: group and age (SPSS 14.0, GLM procedure).

Results

Over the experimental period, no deaths were recorded in any of the groups compared. Both at the beginning and at the end of the experiment, average body weight of layers in all groups was similar (Table 4), and the significance of differences between the groups was not confirmed statistically on any of the dates. The average body weight gain of hens during the experiment decreased with the increasing proportion of wheat DDGS in the feed (C – 91 g, E1 – 79 g, E2 – 63 g). It can thus be concluded that the dietary inclusion of DDGS slightly reduced weight gain in the hens. In all groups hens were significantly heavier at the end of the experiment when compared to the beginning (Table 4).

Shown in Figure 1 is the hens' laying production, with minor deviations, which was maintained in all groups within the standard for this line of laying hens (www.hendrix-genetics.com, 2008a), but the results reported in Table 5 indicate slightly

lower laying performance in group E2 (difference not significant), which was fed a diet containing 20% DDGS. Pronounced differences occurred in the egg weight (Figure 2). The average egg weight in the control group (except for weeks 2 and 4 of the experiment) was always above the standard, while the group fed a diet containing DDGS was below the standard for ISA Brown hens, and the differences between the control and experimental groups were statistically significant ($P \leq 0.01$) (Table 5). Nonetheless, the content of DDGS in the feed was irrelevant. A similar trend was observed with regard to egg mass per hen per day, and the total egg mass (kg) produced during the study decreased with the increasing proportion of wheat DDGS in the feed (C – 231.7 kg, E1 – 227.9 kg, E2 – 223.9 kg). The dietary inclusion of DDGS did not affect daily feed intake, which is consistent with the observations of Masa'deh et al. (2011), but feed conversion ratio per kg of egg weight was significantly ($P \leq 0.01$) higher in the control group compared to the other groups.

Table 4. Hens' body weight (g) before the start and after the end of experiment

Group	Body weight at the start of experiment (g)		Body weight at the end of experiment (g)		Gain (g)	Significance of differences
	LSM	SE	LSM	SE		
K	1713	22.5	1804	19.8	91	**
D1	1685	22.5	1764	19.8	79	**
D2	1711	22.5	1774	19.8	63	*

Values in rows – non significant differences.

Values in columns differ significantly: ** at $P \leq 0.01$; * at $P \leq 0.05$.

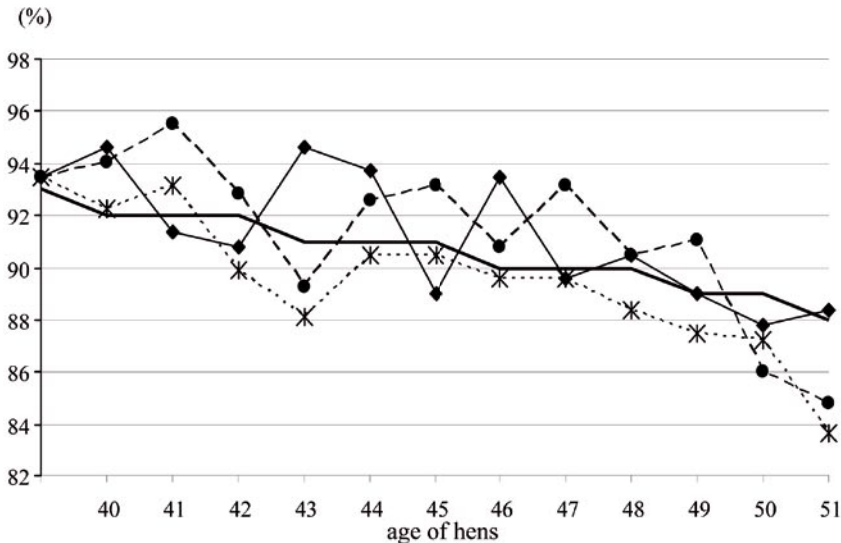


Figure 1. ISA Brown laying production (%) over the experimental period

Table 5. Production results over the period of 12 weeks

Parameters	Group C		Group E1		Group E2	
	48		48		48	
Number of hens	LSM	SE	LSM	SE	LSM	SE
Laying percentage	91.1	0.76	91.1	0.76	89.2	0.76
Mean egg weight (g)	63.4 A	0.19	62.0 B	0.19	62.3 B	0.19
Egg production (g) per hen per day	57.7 A	0.42	56.5 AB	0.42	55.5 B	0.42
Feed intake (g) per hen per day	113.5	42.03	113.6	42.03	113.8	42.03
Feed conversion per kg egg weight (kg)	1.97 A	0.1	2.01 AB	0.1	2.05 B	0.1
Total egg mass (kg)*	232.685		227.941		223.935	

A, B – Values in rows with different letters differ significantly ($P \leq 0.01$).

* Data without statistical analysis.

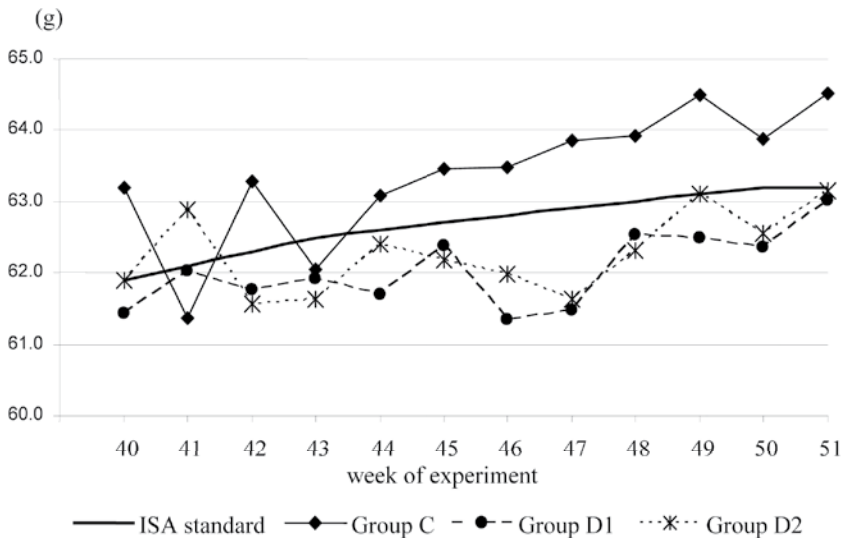


Figure 2. ISA Brown egg weight (g) over the experimental period

Results of the standard evaluation of egg quality before and at the end of the experiment are shown in Table 6. Over the experimental period, egg weight was observed to increase in all groups, yet the increase was not significant. At the end of the experiment there were no statistically significant differences between groups either; however, lower values of this trait in the experimental groups confirmed the results discussed above (Figure 2, Table 5) suggesting the negative impact of dietary DDGS on egg weight.

The quality of thick albumen expressed in Haugh units (HU) decreased during the experiment, and differences between the values in all groups were statistically significant ($P \leq 0.01$) (Table 6). The greatest reduction in thick albumen quality – about 12.31 HU – was recorded in the control group, while in groups E1 and E2 the values were lower, i.e. 8.18 and 8.10 HU, respectively. On the second date of evalu-

ation, in the groups fed a diet containing DDGS the thick albumen quality was better, and the differences between the control and experimental groups were statistically significant ($P \leq 0.01$) (Table 6).

Table 6. Egg quality parameters analysed on two dates: before the experiment (date I) and at the end of the experiment (date II)

Trait	Group	Date I			Date II			Significant differences between dates
		n	LSM	SE	n	LSM	SE	
Egg weight (g)	C	46	61.59	0.68	45	63.18	0.80	NS
	E1	44	59.27	0.69	39	61.15	0.86	NS
	E2	45	60.10	0.68	38	61.91	0.87	NS
Thick albumen quality (HU)	C	46	86.83	1.18	45	74.52 a	1.35	**
	E1	44	87.57	1.21	39	79.39 b	1.45	**
	E2	45	85.63	1.19	38	78.59 b	1.47	**
Yolk colour (RCF)	C	46	10.26	0.13	45	5.16	0.08	**
	E1	44	10.21	0.13	39	5.23	0.09	**
	E2	45	10.31	0.13	38	5.34	0.09	**
Yolk content (%)	C	46	24.65	0.25	45	25.92	0.29	**
	E1	44	24.96	0.26	39	26.50	0.32	**
	E2	45	25.14	0.25	38	26.36	0.32	**
Shell content (%)	C	46	9.97 a	0.11	45	9.85	0.13	NS
	E1	44	10.38 b	0.11	39	9.78	0.14	**
	E2	45	10.34 b	0.11	38	9.70	0.14	**
Shell thickness (mm)	C	46	0.371	0.004	45	0.372	0.005	NS
	E1	44	0.377	0.004	39	0.360	0.005	**
	E2	45	0.379	0.004	38	0.359	0.005	NS

a, b – Values in rows with different letters differ significantly ($P \leq 0.05$).

** – Values in columns differ significantly ($P \leq 0.01$); NS – non significant difference.

Significant ($P \leq 0.01$) differences in the values of both egg yolk quality parameters were determined between eggs assessed before and at the end of the experiment (Table 6). At the end of the experiment egg yolk was significantly lighter in colour than before the study because all experimental feeds did not contain any pigments so as not to influence the results. The egg yolk content increased significantly in all groups during the experiment. However, on neither date were the differences significant between the groups in yolk colour or yolk content of egg.

The quality of egg shells, expressed by their thickness and content in the egg, was good irrespective of the age of laying hens and feed mixture administered to the birds (Table 6). At the beginning of the experiment, chickens from the control group, despite the random selection, were characterized by a significantly ($P \leq 0.05$) lower content of the egg shell in comparison with the other groups, while in the second period of evaluation there were no longer any significant differences between the groups compared. In the case of thick shells there were no significant differences on any of the dates.

Discussion

Previously conducted studies have not determined the impact of alcohol-distilling brew on the body weight of adult hens, whereas the effect of DDGS was tested for body weight of broiler chickens. However, it is difficult to compare adult hens with broilers. Koreleski and Świątkiewicz (2004) showed that adding 10% DDGS to the diet led to lower body weight gains in broilers and feed efficiency deterioration. Similar trends were also reported in layers.

The observed small and non-significant reduction in laying capacity in the group with 20% wheat DDGS is consistent with previous findings. A review by Świątkiewicz and Koreleski (2008) cites a study in which a 20% proportion of wheat or barley DDGS had no effect on performance in laying hens. However, the authors quoted above emphasize that the application of DDGS used as a substitute for soybean protein required balancing the essential amino acids by supplementing them with synthetic equivalents, and this concerns mainly lysine. Dale and Batal (2003) point out that the administration of a feed with a slightly lower level of energy but with DDGS may lead to a slight reduction in egg laying. The laying diets containing more than 20% corn DDGS reduced the average values of egg production reported by Ghazalah et al. (2011).

Increased linoleic acid content in experimental feeds should increase the weight of eggs (Sauveur, 1988), but this was not observed in the present experiment. In most studies conducted around the world use was made of corn DDGS. Jensen et al. (1978) and Dale and Batal (2003) found no impact of DDGS on egg weight. However, Roberson et al. (2005) reported that in some periods of the experiment the mass of eggs laid in groups receiving dietary DDGS was slightly lower than in the control group. Masa' deh et al. (2011) found that increasing corn DDGS level in the diet beyond 15% caused a reduction in weight of eggs laid between 24 and 47 week of age. Also Ghazalah et al. (2011) reported decreasing egg mass after replacing yellow corn with 20% DDGS. On the other hand, the administration of DDGS derived from rye yielded negative effects on the daily mass of egg production and feed efficiency per egg (Świątkiewicz and Koreleski, 2007).

When discussing the effect of feeding DDGS to hens on egg quality, attention should be paid to the simultaneous operation of two factors: experimental feed and age of hens, which independently affect the quality of egg production. The typical changes that appear in the quality of eggs as a result of increased age are growth of the egg and yolk mass and deterioration in quality of thick albumen and egg shell (Sauveur, 1988). Since this pattern was found in all feeding groups, the changes observed in egg quality can be clearly ascribed to the age of hens (Table 6). We can therefore conclude that the age of laying hens affects the quality of eggs. Yolk colour, on the other hand, is a characteristic determined solely by the content and type of pigments in the feed (Sauveur, 1988). The evaluation of egg quality before the start of the experiment was performed in all groups of hens when they were still fed a standard feed containing a pigment that assured yolk colour of >9 points on the Roche colour fan, while the experimental feed contained pigments originating exclusively from the feed components. This is the

reason why egg yolk was significantly less stained at the end of the experiment (Table 6).

The higher HU values (compared with group C) identified at the end of the study in the experimental groups clearly indicate a positive effect of wheat DDGS. The increase in Haugh units when the hens were administered the DDGS diet was reported earlier by Jensen et al (1978) and Sauveur (1988), all of whom considered that the products of fermentation of grains added to the feed contributed positively to the quality of thick albumen. According to these authors, this is the likely effect of increased amounts of micronutrients. However, Lumpkins et al. (2005) did not confirm this effect.

The lack of significant differences in the colour of egg yolks evaluated at the end of the experiment indicates that wheat DDGS (which are not a source of pigment) did not affect this trait. Although Roberson et al. (2005) and Masa'deh et al. (2011) have demonstrated a beneficial effect of dietary DDGS on egg yolk colour, a study by Lumpkins et al. (2005) did not confirm it. However, in their study the authors used wheat DDGS rather than corn DDGS.

The egg shell contribution to egg mass was slightly lower compared to the values found in literature, for the shell weight was determined after drying, while in other works the weight of fresh shells was accepted as the baseline value (Table 6). A significant ($P \leq 0.01$) decrease of egg shell in egg weight due to the ageing of hens in the experimental groups was not observed in group C, which suggests the negative impact of dietary DDGS on the quality of the shell, all the more so because a similar, though less clear relationship was reported for the thickness of the shell (the difference between the dates significant at $P \leq 0.01$ only in group E1). Similarly, previous studies by Dale and Batal (2003), Roberson et al. (2005) and Świątkiewicz and Koreleski (2008) have shown no significant influence of dietary inclusion of DDGS on the quality of egg shells.

The results obtained indicate that wheat DDGS can be used in amounts of up to 20% as a component of feed for flocks of laying hens. However, it should be noted that the nutritional value of DDGS varies and should thus be taken into account when formulating feeds.

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Accepted for printing 21 XI 2011

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Zastosowanie pszennego wywaru gorzelnianego (DDGS) w żywieniu kur niosek a wyniki produkcyjne i jakość jaj

STRESZCZENIE

Celem doświadczenia było określenie wpływu pszennego wywaru gorzelnianego zastosowanego jako składnik paszy dla niosek na wydajność nieśną kur i jakość jaj. Kury nioski ISA Brown przez 12 tygodni były żywione mieszkanką zawierającą 15% (E1) i 20% (E2) wywaru pszennego. Kury z grupy kontrolnej (C) otrzymywały typową paszę bez udziału DDGS, w której główne źródło białka stanowiła poekstrakcyjna śruta sojowa. W okresie doświadczenia kontrolowano wydajność nieśną (% nieśności), średnią masę jaja (g), średnie dzienne spożycie paszy (g/szt./dzień) oraz wykorzystanie paszy (kg/1 kg jaj). Jakość jaj (masa jaja, jakość białka gęstego, kolor żółtka, procent żółtka, procent skorupy i grubość skorupy) oceniano dwukrotnie: przed rozpoczęciem i na koniec doświadczenia. Nie stwierdzono wpływu DDGS w paszy na wydajność nieśną ani na spożycie paszy. Średnia masa jaj była

istotnie niższa w obydwu grupach doświadczalnych, a zużycie paszy na 1 kg jaj wyższe w porównaniu do grupy kontrolnej. Udział DDGS w paszy nie wpłynął na główne cechy jakości jaj z wyjątkiem białka gęstego. Jaja od kur żywionych paszą z udziałem wywaru pszennego charakteryzowała wyższa wartość jednostek Haugha niż jaja z grupy kontrolnej. Uzyskane wyniki sugerują, że DDGS z pszenicy w ilości do 20% może być stosowane jako komponent paszy dla kur niosek.