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RAPESEED CAKE, GLYCERIN AND DISTILLERS DRIED GRAINS WITH SOLUBLES USED SIMULTANEOUSLY AS A SOURCE OF NUTRIENTS FOR HENS IN THEIR SECOND LAYING SEASON*

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Abstract

Bovans Brown laying hens in their second season of lay (from 81 to 100 weeks of age) were allocated to 8 groups with 18 replicates. Hens were kept in individual cages, at 14L:10D and fed *ad libitum*. All diets were isocaloric and isonitrogenous and contained 4% of rapeseed glycerin (RG), from 2% to 6% of rapeseed expeller cake (REC), and from 5% to 15% of distillers dried grains with solubles (DDGS). Control diet contained no biofuel co-products. The dietary crude fibre content increased from 3.5% in control group to 4.6% in experimental groups. The number and weight of eggs were registered daily, feed consumption was recorded monthly, and laying rate, daily egg mass, daily feed intake and feed conversion ratio per kg of eggs and per egg were calculated. One egg from each hen was collected to determine egg quality indices, and a further 8 eggs from each treatment were collected for sensory evaluation. The dietary levels of REC, RG and DDGS did not affect the laying rate, weight of laid eggs, feed intake, feed conversion ratio and egg quality indices (P>0.05). The flavour of boiled eggs from the control group was significantly better (P<0.05) than from the experimental groups with 10% DDGS and 4–6% REC. The taste of control eggs was significantly (P<0.05) better than that of eggs from the experimental groups. The results of this study indicate that performance of older layers does not deteriorate as a result of adding 4% RG, 2–6% REC and 5–10% DDGS to the diets. Sensory characteristics of boiled eggs from experimental groups were poorer than in control but nevertheless all eggs were suitable for consumption.

Key words: laying hens, rapeseed expeller cake, glycerin, distillers dried grains with solubles, laying performance, egg quality

The world production of renewable sources of energy from vegetable oils and grain starch has increased rapidly in recent years and is expected to further develop in the future. Rapeseed expeller cake, rapeseed glycerin and distillers dried grains with solubles as the main co-products from biofuel production are available to the

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feed industry. The European Union has supported biofuel production in order to diversify energy supplies, reduce greenhouse gas emissions and the dependency on oil, and to create additional employment in rural areas (Świątkiewicz and Koreleski, 2008).

Rapeseed expeller cake (REC) can be used as protein and energy feed in the diets of broiler chickens (Peter and Dänicke, 2003; Smulikowska et al., 2006) and laying hens (Świątkiewicz et al., 2010), and rapeseed glycerin (RG) as an energy source for broilers (Simon et al., 1996; Cerrate et al., 2006) and laying hens (Świątkiewicz and Koreleski, 2009). Distillers dried grains with solubles (DDGS) from modern ethanol plants are used in feeding of broiler chickens (Wang et al., 2007) and laying hens (Roberson et al., 2005; Świątkiewicz and Koreleski, 2006; Świątkiewicz and Koreleski, 2007).

To date there are no data available on simultaneous use of different co-products from biofuel production, as feed components of poultry diets. The aim of this study was to evaluate the effect of different levels of REC, RG and DDGS incorporated together into the diet of laying hens in their second season of lay on egg performance and egg quality.

Material and methods

The Local Kraków Ethic Committee for Experiments with Animals approved all experimental procedures relating to the use of live animals. In the experiment, 144 Bovans Brown laying hens in their second season of lay (from 81 to 100 weeks of age) were allocated to 8 groups, each with 18 hens (as replicates) kept in individual cages with 1 600 cm^2 of total floor space per bird, at 14L:10D and fed *ad libitum*. Control and experimental diets were isocaloric and isonitrogenous. Experimental diets contained 4% of rapeseed glycerin (RG), from 2 to 6% of rapeseed cake (REC), and from 5 to 15% of distillers dried grains with solubles (DDGS) incorporated together (Table 1). The levels of co-products of biofuel production used in the layer diets were based on the recommendations resulting from earlier papers (Świątkiewicz and Koreleski, 2006; Świątkiewicz and Koreleski, 2007; Świątkiewicz and Koreleski, 2009; Świątkiewicz et al., 2010). Control diet contain no biofuel co-products. The basal nutrient content in REC, RG and DDGS (Table 2) and in the diets (Table 3) was analysed using standard methods (AOAC, 1990) for dry matter (method 930.15), crude protein (984.13), crude fat (920.39), crude fibre (962.09) and ash (942.05). Glucosinolate content in REC dry matter was analysed by Agilent 1100 Series HPLC with Agilent Zorbax column ODS 4.6x250 mm, and 229 nm UV-Vis detector. The basal amino acids in REC and DDGS were analysed in acid hydrolysates, after initial performic acid oxidation of sulphur amino acids (AOAC, 1990, method 982.30). The ME_N values of the diets were calculated according to equations from European Tables (Janssen, 1989).

The number and weight of laid eggs were registered daily and feed consumption was recorded monthly. The laying rate, daily egg mass, daily feed intake and feed conversion ratio (FCR) per kg of eggs and per one egg were calculated. At 95 weeks of age, one egg from each hen was collected to determine egg quality indices using semiautomatic egg quality equipment QCM+, Technical Services and Supplies (TSS) York, UK. Further 8 eggs from each treatment were collected for panel sensory evaluation, and the flavour and taste were evaluated on a 4-point scale, from 2 (unacceptable) to 5 (very good).

All data were subjected to statistical analysis using one-way ANOVA. When significant differences in treatment means were detected by ANOVA (F-test), Duncan's multiple range test was applied to separate means. Differences were considered significant at $P<0.05$. All statistical analyses were performed with Statistica 5.0 PL software (Statsoft, Inc.).

Table 1. Design of experiment; level of biofuel co-products in the diets (in %)

Group	REC	RG	DDGS
I – control			
II	2	4	5
III	2	4	10
IV	4	4	5
V	4	4	10
VI	6	4	5
VII	6	4	10
VIII	6	4	15

REC – rapeseed expeller cake; RG – rapeseed glycerin; DDGS – distillers dried grains with solubles.

Results

The nutrient content of REC, RG and DDGS in this experiment was presented in Table 2. The content of glucosinolate in REC is relatively low when compared to standards accepted in EU and dietary level of 6% REC brought the diet up to 1.07 μMol/kg.

Table 2. Nutrient content of biofuel co-products used in experiment (in 1 kg, as is basis)

Item	Rapeseed expeller cake	Rapeseed glycerin	Distillers dried grains with solubles
Dry matter (g)	906	738	920
Crude protein (g)	308	0.4	300
Crude fat (g)	108	4	67
Crude fibre (g)	120		122
Crude ash (g)	65	37	17
Methionine	8.4		6.8
Lysine	19.1		6.4
Metabolizable energy (MJ)	10.25	16.61	10.69
Glucosinolate*	17.8		

*μMol per g of fat free dry matter.

Table 3. Composition and nutrient content of diets (%)

Component/Group	I	II	III	IV	V	VI	VII	VIII
Maize	38.00	30.80	34.00	32.00	34.80	33.60	36.80	34.80
Wheat	26.49	25.69	19.65	23.51	18.20	20.91	15.20	14.74
Soybean meal (45.7% c.p.[1])	22.50	19.50	17.30	18.50	16.00	17.50	15.00	12.20
Rapeseed expeller cake	-	2.00	2.00	4.00	4.00	6.00	6.00	6.00
Distillers dried grains with solubles	-	5.00	10.00	5.00	1.00	5.00	10.00	15.00
Rapeseed glycerine	-	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Rapeseed oil	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.70
Limestone	9.40	9.40	9.45	9.40	9.40	9.40	9.40	9.45
Monocalcium phosphate	1.20	1.15	1.10	1.15	1.10	1.15	1.10	1.05
NaCl	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL – Methionine (99%)	0.11	0.10	0.09	0.09	0.08	0.09	0.08	0.07
L-lysine HCl (78%)	-	0.06	0.11	0.05	0.12	0.05	0.12	0.19
Vitamin-mineral premix[2]	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Composition (on as is basis):								
Crude protein *				17.0				
Metabolizable energy (MJ/kg)				11.6				
Crude fibre*	3.47	3.78	4.06	3.91	4.18	4.04	4.31	4.57
Lys *				0.82				
Met *				0.37				
Ca **				3.7				
P available **				0.38				

*analysed, **calculated from tables.

[1]c.p. crude protein content in %.

[2]The premix provided, per kg of diet: vitamin A, 10,000 IU; vitamin D_3, 3,000 IU; vitamin E, 27.5 IU; vitamin K_3, 2 mg; vitamin B_1, 1 mg; vitamin B_2, 4 mg; vitamin B_6, 1.5 mg; vitamin B_{12}, 0.01 mg; Ca-pantothenate, 8 mg; niacin, 25 mg; folic acid, 0.5 mg; choline chloride, 250 mg; manganese, 100 mg; zinc, 50 mg; iron, 50 mg; copper, 8 mg; iodine, 0.8 mg; selenium, 0.2 mg, cobalt, 0.2 mg.

Table 4. Laying performance for the period from 80 to 100 weeks of age and egg quality

Item	I – control	II	III	IV	V	VI	VII	VIII	SEM
	DDGS dietary content (%)								
	0	5	10	5	10	5	10	15	
	REC dietary content (%)								
	0	2	2	4	4	6	6	6	
	RG dietary content (%)								
	0	4							
Laying performance (%)	71.5	76.0	80.7	76.2	77.1	72.5	72.2	75.5	0.940
Average egg weight (g)	65.0	66.4	65.1	63.5	67.2	67.0	66.5	65.6	0.034
Daily mass of eggs (g/hen)	46.5	50.4	52.5	48.5	51,7	48.6	48.2	49.7	0.721
Daily feed intake (g/hen)	110.0	111.5	112.2	111.4	112.6	112.7	111.5	111.2	0.247
FCR per one egg (g)	154.0	147.4	139.3	147.4	146.5	156.1	158.2	147.7	2.02
FCR per kg of eggs (kg)	2.37	2.22	2.14	2.33	2.18	2.33	2.39	2.26	0.034

Table 5. The results of egg quality measurement in chosen groups

	I – control	III	V	VII	VIII	SEM
	DDGS dietary content (%)					
	0	10	10	10	15	
	REC dietary content (%)					
	0	2	4	6	6	
	RG dietary content (%)					
	0	4				
Albumen height (mm)	5.18	5.02	5.33	5.73	5.07	0.114
Haugh units	66.3	65.6	67.2	70.2	66.2	1.03
Yolk colour (Roche points)	1.61	1.56	1.72	2.00	2.00	0.070
Eggshell thickness (mm)	0.363	0.384	0.382	0.380	0.381	0.034
Eggshell density (mg/cm^2)	81.9	87.6	85.4	86.7	87.1	0.796
Proportion of eggshell mass to egg mass	10.0	10.8	10.4	10.3	10.7	0.089
Eggshell breaking strength (N)	25.1	28.4	28.8	26.6	29.6	0.840
Smell of boiled eggs (points)	4.44 c	4.26 bc	3.92 a	4.12 ab	4.30 bc	0.037
Taste of boiled eggs (points)	4.54 c	4.18 b	3.90 a	3.84 a	4.26 b	0.044

a, b, c – $P<0.05$.

The dietary crude fibre content increased from 3.5% in control to 4.6% in experimental groups (Table 3) as a result of relatively high levels of CF in REC and DDGS. The differences between groups in performance, egg weight, feed intake and feed conversion ratio per egg or per kg of eggs (Table 4) were statistically not confirmed (P>0.05). Similarly, there were also no significant differences (P>0.05) in physical parameters of eggs from control and experimental hens (Table 5).

The differences were found, however, in the case of egg sensory analysis (Table 5). The eggs laid by hens fed control diet had, when boiled, a better flavour than eggs from groups with 10% DDGS and 4–6% REC in the diet (P<0.05). As regards the taste of boiled eggs, differences in relation to the control group were confirmed for eggs from all experimental groups (P<0.05). The poorest quality of eggs, taking into account both flavour and taste after boiling, was found for hens fed 4% RG and 10% DDGS together with 4% or 6% REC.

Discussion

The nutrient content of REC, RG and DDGS in this experiment was comparable to the composition of biofuel co-products used in earlier papers (Świątkiewicz and Koreleski, 2006; Świątkiewicz and Koreleski, 2009; Świątkiewicz et al., 2010). Relatively low content of glucosinolates in REC caused that the maximum 6% content of REC in the diet resulted in only 1.07 µMol/g, when the level of 1.5 µMol per g of the diet is the accepted level in feed mixtures for poultry (Smulikowska et al., 2006).

Commercial layer diets usually contain from 2.3 to 3.8% of crude fibre (Leeson and Summers, 1991) and high amounts of fibre may lower energy values unless fat is added (Leeson and Summers, 2001). The dietary level of 4.6% fibre in the case of diet with 6% REC, and 10–15% DDGS may be acknowledged as high for hens in the period of intensive laying. For this reason older birds in their second season of lay were placed in the present experiment, with laying performance from 71 to 81%.

The inclusion of different levels of REC, RG and DDGS used together in the isonitrogenous and isocaloric diets had no effect on egg production and FCR for eggs from hens in their second season of laying. Though no studies appear in the literature on the combined use of co-products from biofuel production in hen diets, the results of the present experiment may confirm the results obtained when each product was used separately. For example, it was stated that corn DDGS can be included in layer diets up to 10–15% without any detrimental effect on laying performance and egg quality (Lumpkins et al., 2005; Roberson et al., 2005; Świątkiewicz and Koreleski, 2006). Similarly to this experiment, the results of an earlier study demonstrated that REC may be incorporated to a level of 6% in the diet of laying hens with no detrimental effect on performance and quality of eggs; however, higher levels of REC (8%) negatively affected the utilization of Ca and P and the sensory properties of boiled eggs (Świątkiewicz et al., 2010). Also, 2–7.5% of glycerin included in the layer diet did not affect the production indices (Świątkiewicz and Koreleski, 2009;

Yalcin et al., 2010), but the level of 5 or 7.5% of glycerin had a negative effect on chemical composition of egg yolks (Yalcin et al., 2010).

In this similarity there is one exception concerning the effect of co-products used together in the diet on sensory analysis of boiled eggs. The low level of glucosinolates in REC may show that it could not be a factor limiting hen performance. The results of our experiment confirmed that opinion. In sensory analysis of boiled eggs no fishy taint was found. This could indicate that poorer taste and smell of eggs was not a result of possible trimethylamine accumulation in yolk. It should be stated here that despite the poorer sensory estimation of taste and smell, all eggs were suitable for consumption.

This study indicates that biofuel co-products used simultaneously in isonitrogenous and isocaloric diets of older hens may attain a level of 4% RG, 2–6% REC and 5–10% DDGS.

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Równoczesne stosowanie makuchu rzepakowego, gliceryny i suszonego pełnego wywaru zbożowego w żywieniu kur niosek w drugim sezonie nieśności

STRESZCZENIE

Kury Bovans Brown w wieku od 81 do 100 tygodni życia, będące w drugim sezonie nieśności zostały przydzielone do 8 grup, z których każda obejmowała 18 sztuk trzymanych w indywidualnych klatkach. Stosowano żywienie *ad libitum* oraz oświetlenie 14L:10D. Diety utrzymano na jednakowym poziomie energii i białka. Do mieszanek doświadczalnych wprowadzono 4% gliceryny rzepakowej (RG), od 2% do 6% makuchu rzepakowego (REC) oraz od 5% do 15% suszonego pełnego wywaru zbożowego (DDGS). Mieszanka kontrolna nie zawierała produktów z biopaliw, a zawartość surowego włókna wzrastała z 3,3% w grupie kontrolnej do 4,6% w grupach doświadczalnych. Liczba i masa zniesionych jaj była notowana codziennie, pobranie paszy rozliczane co miesiąc i na tej podstawie obliczano nieśność, średnią masę jaj, dzienne pobranie paszy oraz stopień wykorzystania paszy na kg jaj i na jedno jajo. Od każdej kury pobrano po 1 jaju do badań jakościowych oraz 8 jaj z każdej grupy posłużyło do oceny sensorycznej.

Wykazano, że użyte poziomy REC, RG i DDGS nie wpłynęły na nieśność, masę jaj, pobranie paszy i wskaźniki jakości jaj. Zapach jaj z grupy kontrolnej po ugotowaniu był istotnie lepszy ($P<0.05$) niż w grupie z udziałem 10% DDGS i 4–6% REC. Smak jaj od kur z grupy kontrolnej był lepszy ($P<0.05$) niż z wszystkich grup doświadczalnych. Wyniki wskazują, że wydajność produkcyjna starszych niosek nie ulega pogorszeniu w wyniku wprowadzenia do mieszanki paszowej 4% RG, 2–6% REC i 5–10% DDGS. Cechy sensoryczne gotowanych jaj z grup doświadczalnych były wprawdzie gorsze niż w grupie kontrolnej, niemniej jednak wszystkie jaja nadawały się do konsumpcji.