The effect of feeding untreated rapeseed and iodine supplement on egg quality

M. Lichovníková, L. Zeman, J. Jandásek

Department of Poultry Breeding, Faculty of Agronomy, Mendel University of Agriculture and Forestry, Brno, Czech Republic

ABSTRACT: The objective of the experiment was to evaluate the effect of the feeding of 80 g/kg (R8) and 100 g/kg (R10) of untreated rapeseed (RS) on egg quality including sensory quality in comparison with a control diet without rapeseed (R0). The addition of iodine (I) was also evaluated (1 mg/kg (R10) vs. 3 mg/kg (R10+I)). "Double zero" RS was used. The contents of energy and crude protein were almost the same in the diets. Laying hybrid ISABROWN was used in the experiment. The quality of eggs was analyzed 11 times every 28 days, from 19 to 64 weeks of age. 30 eggs per each group were always analyzed. Boiled eggs were assessed twice around the peak of egg production. Egg weight decreased ($P < 0.001$) with the increased level of RS (62.9 g, 61.8 g and 60.7 g, respectively). A reduction in egg weight in R8 and R10 diets resulted in the lower weight of albumen and eggshells. The addition of I to R10 diet increased ($P < 0.001$) egg weight (62.1 g vs. 60.7 g). The yolk proportion in egg weight was the highest (26.0%, $P < 0.001$) and the albumen weight ratio was the lowest (64.2%, $P < 0.001$) in group R8. Iodine supplementation improved ($P < 0.001$) yolk weight (15.7 g vs. 15.3 g). The proportion of RS in the diet did not affect the eggshell strength. An increase in the level of I improved ($P < 0.001$) eggshell quality (strength 36.1 N vs. 34.0 N and thickness 0.386 mm vs. 0.363 mm). Taste and overall acceptability were lower ($P < 0.05$) in eggs of hens fed RS. The addition of I did not affect flavour, odour, taste or overall acceptability.

Keywords: laying hens; sinapine; eggshell; taste

The nutrient profile of rapeseed (RS) makes it an ideal ingredient for high nutrient dense diets. Due to intensive breeding the content of glucosinolates in RS has been decreased ("00" varieties) and RS can be used at dietary doses up to 150 g/kg without any negative effect on egg production (Jeroch et al., 1999). But many factors affect the occurrence of fishy taint in "brown-shelled" eggs (Butler and Fenwick, 1984). The taint is due to the presence of trimethylamine in the yolks of hens with impaired ability to convert trimethylamine to the odourless and tasteless N-oxide. The deficiency of the enzyme oxidase is not strictly linked to shell colour as Butler (Butler and Fenwick, 1984) revealed. Roth-Maier and Kirchgessner (1995) found that 250 g/kg RS did not affect the quality (flavour and odour) of eggs of Lohmann White – LSL.

The presence of sinapine in RS or rapeseed meal is a source of trimethylamine. Goitrin (5-vinyl-oxazolidine-2-thione), a breakdown product of the glucosinolate progoitrin, also plays an important role in the production of egg taint because it inhibits trimethylamine oxidase (Butler and Fenwick, 1984) responsible for trimethylamine oxidation. Thiocyanates are also breakdown products of glucosinolates, but their negative effects can be reduced by the addition of extra iodine (McDowell, 1992). The aim of the study was to evaluate the effect of the feeding of rapeseed (with known goitrin and sinapine contents) and iodine supplement on egg quality, including sensory quality, in commercial hybrid ISABROWN.

MATERIAL AND METHODS

Three experiments (Exp) were conducted in three consecutive years. In Exp 1 the control diet (R0) was compared with a diet that contained 80 g/kg of RS (R8). In Exp 2 the control diet (R0) was compared with a diet containing 100 g/kg of RS (R10), whereas in Exp 3 the control diet (R0) was compared with diets that contained RS 100 g/kg (R10) and 100 g/kg plus 2 mg/kg of additional iodine (R10+I), (Table 1). Each experiment was conducted from 19 to 64 weeks of laying hen age. ISABROWN laying hybrid was used in all experiments. In each experiment each group comprised 405 laying hens. They were kept in four-storey cages with three hens in each cage. The environment in the poultry-house was controlled (ventilation, temperature, light intensity and day light (15 h). In all cases "double zero" RS was used. The rapeseeds were analyzed for goitrin (ISO 9167-1 (1992 E)) and sinapine contents (Kolovrat, 1990). The contents of energy and crude protein were almost the same in the diets (Table 2).

The quality of eggs was analyzed 11 times every 28 days, from 19 to 64 weeks of age. 30 eggs per each group were always analyzed. The quality of eggs was analyzed by determining the egg weight, yolk and albumen weight, yolk and albumen weight ratio, Haugh units, strength and thickness of eggshell, weight and weight ratio of eggshell. The strength of eggshells (N) was measured manually by a destructive method with an egg crusher (Veit Electronics, CZ). Eggs were compressed between two parallel plates by a steadily increasing load until the rupture occurred. The force was measured vertically to the axis. Thickness was evaluated as the average of both ends and in the middle including shell membranes with a micrometer (TSS, England). Albumen height was measured 1 cm from the yolk with an instrument for this measurement (TSS, England). For sensory evaluation eggs were boiled separately for 10 minutes. Eggs were cooled to remove the eggshell and eggs were

Table 1. The composition of diets (g/kg)

	Diets			
	R0	R8	R10	R10+I
Maize	400	400	400	400
Wheat	255	195	175	175
Soybean meal	205	205	205	205
Rapeseed	0	80	100	100
Fish meal	20	–	–	–
Rapeseed oil	12	12	12	12
Limestone	78	78	78	78
Sodium chloride	2	2	2	2
Dicalcium phosphate	15	15	15	15
DL-methionine 20%	4	4	4	4
Lysine 20%	4	4	4	4
Premix (minerals + vitamins)*	5	5	5	5
$Ca(IO_3)_2$ (mg/kg)	1	1	1	3

*the following amount of nutrients was added by premix per the 1 kg of mixture: vitamin A 8 000 IU; vitamin D3 2 250 IU; vitamin E 15 mg; vitamin K3 1.5 mg; vitamin B1 1.5 mg; vitamin B2 4 mg; vitamin B6 2 mg; vitamin B12 0.06 mg; folic acid 0.4 mg; choline chloride 250 mg; betaine 50 mg; Co 0.3 mg; Cu 6 mg; Fe 30 mg; I 0.7 mg, Mn 60 mg; Zn 50 mg; Se 0.2 mg

Table 2. Calculated analysis of the diets

Item	Diets			
	R0	R8	R10	R10+I
Dry matter (g/kg)	896.0	888.0	892.0	892.0
AME_N (MJ/kg)	11.3	11.8	11.9	11.8
Crude protein (N × 6.25, g/kg)	172	171	174	171
Methionine (g/kg)	4.1	4.1	4.4	4.1
Lysine (g/kg)	8.9	8.0	8.5	8.7
Calcium (g/kg)	34.0	34.6	35.0	34.5
Phosphorus (g/kg)	6.9	6.6	6.7	6.5
Sodium (g/kg)	1.1	0.9	1.0	0.9

evaluated immediately. A 100 mm unstructured line scale was used for all descriptors. The extreme points of descriptors were as follows: texture 0 – very soft, 100 – very hard; flavour 0 – typical, very pleasant, 100 – untypical, off-flavour; odour 0 – away, 100 – very intensive; taste 0 – typical, without off-taste, 100 – unpleasant, with off-taste; overall acceptability 0 – excellent, 100 – wrong. Thirty-one panellists described the descriptors in Exp 1, 44 panellists in Exp 2 and 40 panellists in Exp 3. Two panellists assessed each egg. The eggs were assessed in two sessions in each Exp around the peak of egg production.

The effect of rapeseed on egg quality was evaluated regardless of the experiment. Data on egg quality were analyzed by the one-way analysis of variance (ANOVA) using the software package UNISTAT® 5.0 (2000). Tukey-HSD test was used as the post hoc test for all possible pair-wise comparisons within groups. The nonparametric Mann-Whitney *U*-test was used to evaluate the effect of RS on the sensory descriptors.

RESULTS

The weight of eggs decreased ($P < 0.001$) with the increased level of RS (R0 62.9 g, R8 61.8 g, R10 60.7 g) – Table 3. The lower weight of eggs resulted in the lower weight of albumen and eggshells in R8 and R10. The addition of I increased ($P < 0.001$) the weight of eggs (R10 + I 62.1 g). The yolk weight ratio was the significantly highest ($P < 0.001$) in the group R8 (26.0%) and the albumen weight ratio was the significantly lowest ($P < 0.001$) there (64.2%). The iodine supplement significantly ($P < 0.001$) improved the weight of yolk (R10 + I 15.7 g vs. R10 15.3 g), but it did not affect the yolk weight ratio (R10 + I 25.2% vs. R10 25.1%). Haugh units were not affected by the feeding of RS (R0 74.2, R8 73.3, R10 75.7). The higher level of iodine had a positive effect on Haugh units (R10 + I 76.6). The amount of RS did not affect the eggshell strength (R0 33.3 N, R8 33.7 N, R10 34.0 N). The level of RS did not have a single valued effect on eggshell thickness, eggshell weight ratio and eggshell weight. But the higher level of iodine significantly ($P < 0.001$) improved eggshell quality in comparison with R10.

The contents of goitrin and sinapine in the used RS are shown in Table 4 together with sensory characteristics. The feeding of RS did not affect the texture of yolk. However, the content of goitrin and sinapine was higher in the RS fed in Exp 2 in comparison with Exp 1 (480 vs. 638 mg/kg and 65.4 vs. 74.4 μmol/g, respectively). The panellists did not find a significant ($P > 0.05$) difference in flavour and odour between R0 and R10, but they did between R0 and R8. Taste and overall acceptability were evaluated as significantly ($P < 0.05$) worse in the eggs of hens fed RS in each Exp. In spite of similar contents of sinapine and goitrin in the diets in Exp 2 and Exp 3 flavour and odour were evaluated differently by the panellists who noticed a difference in flavour and odour in Exp 3 ($P < 0.001$) but not in Exp 2.

Table 3. The effect of rapeseed on egg quality

	R0	R8	R10	R10+I	Significance
n (eggs)	990*	330*	660*	330*	
	mean ± SEM	mean ± SEM	mean ± SEM	mean ± SEM	
Egg weight (g)	62.9 ± 0.19^{c}	61.8 ± 0.28^{b}	60.7 ± 0.22^{a}	62.1 ± 0.31^{bc}	< 0.001
Yolk weight (g)	15.9 ± 0.08^{b}	16.1 ± 0.13^{b}	15.3 ± 0.10^{a}	15.7 ± 0.13^{b}	< 0.001
Yolk weight ratio (%)	25.2 ± 0.10^{b}	26.0 ± 0.16^{a}	25.1 ± 0.11^{b}	25.2 ± 0.14^{b}	< 0.001
Albumen weight (g)	41.0 ± 0.13^{a}	39.7 ± 0.21^{b}	39.7 ± 0.15^{b}	40.2 ± 0.20^{b}	< 0.001
Albumen weight ratio (%)	65.3 ± 0.10^{c}	64.2 ± 0.16^{a}	65.4 ± 0.11^{c}	64.8 ± 0.14^{b}	< 0.001
Haugh units	74.2 ± 0.48^{b}	73.3 ± 0.70^{b}	75.7 ± 0.59	76.6 ± 0.81^{a}	< 0.010
Eggshell weight (g)	6.0 ± 0.03^{b}	6.0 ± 0.04^{b}	5.7 ± 0.03^{a}	6.2 ± 0.03^{b}	< 0.001
Eggshell weight ratio (%)	9.5 ± 0.04^{c}	9.8 ± 0.07^{b}	9.4 ± 0.05^{ac}	10.0 ± 0.04^{b}	< 0.001
Eggshell thickness (mm)	0.381 ± 0.0015^{d}	0.402 ± 0.0022^{c}	0.363 ± 0.0019^{a}	0.386 ± 0.0021^{c}	< 0.001
Eggshell strength (N)	33.3 ± 0.28^{a}	33.7 ± 0.54^{a}	34.0 ± 0.33^{a}	36.1 ± 0.44^{b}	< 0.001

SEM = standard error of mean; *the effect of rapeseed on eggs quality was evaluated regardless to experiment

Table 4. The effect of rapeseed on sensory quality of eggs

	Rapeseed		n		Texture	Flavour	Odour	Taste	Overall acceptability
	goitrin* (mg/kg)	sinapine** (μmol/g)			mean ± SEM	mean ± SEM	mean ± SEM	mean ± SEM	mean ± SEM
Exp 1	480	65.4	31	R0	49.0 ± 4.20	21.6 ± 2.95	24.5 ± 4.54	16.3 ± 2.03	18.4 ± 2.76
			31	R8	53.2 ± 4.99	69.5 ± 4.39	65.9 ± 6.01	54.4 ± 4.41	72.0 ± 4.88
				significance	NS	< 0.001	< 0.001	< 0.001	< 0.001
Exp 2	638	74.4	44	R0	34.4 ± 2.13	37.0 ± 13.9	8.2 ± 2.63	22.8 ± 1.86	23.4 ± 1.68
			44	R10	37.0 ± 2.30	28.9 ± 2.44	11.0 ± 2.61	28.9 ± 2.37	29.6 ± 2.15
				significance	NS	NS	NS	< 0.05	< 0.05
Exp 3	661	81.5	40	R0	38.7 ± 3.83	14.2 ± 1.99	9.9 ± 1.83	17.6 ± 2.32	18.8 ± 1.79
			40	R10	39.1 ± 2.92	44.9 ± 4.85	40.8 ± 5.48	43.1 ± 4.75	45.9 ± 4.49
				significance	NS	< 0.001	< 0.001	< 0.001	< 0.001
Exp 3	661	81.5	40	R10	39.1 ± 2.92	44.9 ± 4.85	40.8 ± 5.48	43.1 ± 4.75	45.9 ± 4.49
			40	R10+I	50.0 ± 3.82	42.1 ± 4.72	34.3 ± 4.96	40.9 ± 3.71	41.2 ± 3.64
				significance	< 0.05	NS	NS	NS	NS

*5-vinyl-oxazolidine-2-thione; **fat free rapeseed; NS = not significant; SEM = standard error of mean

DISCUSSION

A negative effect of the feeding of RS on the weight of eggs is known. Roth-Maier and Kirchgessner (1995) and Richter et al. (1996) also reported that egg weight decreased with increasing proportions of rapeseed. On the other hand, Jeroch et al. (1999) observed a significant decrease in egg weight after the feeding of as much as 300 g/kg of RS. The decrease in egg weight can be useful mainly in the last third of egg production. The addition of iodine significantly increased the weight of eggs, which disagrees with Lichovníková and Zeman (2004), who did not observe any effect of I on egg weight, but the RS was treated hydrothermically in their experiments. Kaminska (2003) did not report any effect of the increasing amount of RS meal in the diet on the egg yolk percentage. In the experiments Haugh units were not affected by the feeding of RS, but Richter et al. (1996) noted lower Haugh units when RS or RS meal was offered. The feeding of RS did not affect the eggshell quality, neither did Kaminska (2003) report any significant effect of the level of RS meal (from 8% to 19% in the diet) on eggshell quality. But a higher level of iodine improved eggshell quality, which is in agreement with Lichovníková and Zeman (2004).

The effect of the goitrin and sinapine content on sensory quality of eggs was not single valued. This supports the hypothesis of Fenwick at al. (1981) that there is a genetic defect inducing the low activity of trimethylamine oxidase. On the other hand, Baker et al. (1963) demonstrated a threshold concentration range of over 100-fold between individuals for TMA in water. Pearson et al. (1979) reported that 5-vinyl-oxazolidine-2-thione *in vitro* did not cause significant inhibition of the enzyme and that its effect on TMA oxidation resulted from an impairment of the thyroid function and a consequent reduction in the synthesis of TMA oxidase, but the addition of iodine did not affect flavour, odour, taste or overall acceptability.

Due to intensive breeding the content of glucosinolates was significantly decreased ("00" RS) but there are no varieties of RS with reduced sinapine content. However, such breeding would be possible because as Voskerusa and Kolovrat (1989) found there is a great variability of sinapine content in winter rape strains, which is essential for genetic breeding. This method together with selective breeding of laying hens should be more interesting than the use of chemical treatment (Fenwick et al., 1979). Kaminska (2003) reported that only 3.4% of Hy-Line and 7.4% of ISABROWN laying hens produced eggs with a fishy odour when they received RS, which supports the possibility of selection against unpleasant taint in eggs.

Untreated RS (80 and 100 g/kg) in the diets decreased egg weight, which can be beneficial in the last part of the egg production cycle. Iodine supplementation improved the weight of egg and yolk and eggshell quality (strength, thickness, weight ratio), but did not affect the sensory quality of eggs fed RS. The feeding of RS (8 and 10%) significantly worsened the taste and overall acceptability of eggs.

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Corresponding Author

Ing. Martina Lichovníková, PhD., Department of Poultry Breeding, Mendel University of Agriculture and Forestry Brno, Zemědelská 1, 613 00 Brno, Czech Republic
Tel. +420 545 133 229, lichov@mendelu.cz