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Different Dietary Levels of Rapeseed Meal Effects on Egg Quality Characteristics in Indigenous Breeding Hens

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ABSTRACT

This experiment was conducted to investigate the effect of feeding 5 experimental diets containing 0, 5, 10, 15 and 20% rapeseed meal on egg quality characteristics of Iranian indigenous breeding hens at different ages. The experimental period started at 25 weeks followed by 4 periods of 28-day cycle to 41 weeks of age. The egg and eggshell quality indices (egg weight, yolk weight, yolk index, Haugh unit, eggshell weight, eggshell thickness, and eggshell strength) were determined 4 times at 28, 32, 36 and 40 weeks of age. The proportion rate of rapeseed meal in the diet did not affect egg weight, yolk weight, yolk weight ratio and yolk color index. Increasing the dietary level of rapeseed meal led to a significant improvement of Haugh units ($p<0.05$). The highest and lowest eggshell weight, eggshell weight ratio, eggshell thickness and eggshell strength were recorded in control and 5% rapeseed meal groups, respectively ($p<0.05$). Egg weight, yolk weight, yolk weight ratio, eggshell weight increased and eggshell thickness decreased as the hens age increased ($p<0.05$). Interaction of the rapeseed meal and age was not significant for any of traits. The results showed that 15 to 20% soybean meal substitution with rapeseed meal can improve Haugh units without inducing any adverse effects on egg weight, yolk weight and yolk color index in Iranian indigenous breeding hens.

Keywords: Rapeseed meal, Indigenous breeding hen, Egg quality, Hen age

INTRODUCTION

Rapeseed meal consists of whole seeds and contains about 40% crude protein (on DM basis). Rapeseed meal protein is less digestible than soybean meal (72 vs. 88%), but its amino acid balances are similar or even better than soybean meal (particularly the sulphur amino acids) (Ciurescu, 2009). Rezvani *et al*. (2012) reported that mean essential amino acid digestibility of rapeseed meals varied between 0.78 and 0.84 in laying hens. Furthermore, multiple regression analysis in their study showed that the concentrations of crude protein and ash together were the major factors considered to explain variation in digestibility of the essential amino acids. In another study Toghyani *et al*. (2009) also reported that as inclusion of rapeseed meal increased dietary protein digestibility significantly decreased. The use of rapeseed meal in poultry feeding is limited by the presence of certain anti nutritional substances like glucosinolate and their hydrolytic products, sinapine, tannins, erucic acid and phytates (Thanaseelaan *et al*., 2007). These anti nutritional substances are probably the primary factors responsible for some reported adverse effects such as hemorrhagic liver (Campbell and Slominski, 1991), decreased feed intake and egg size in laying hens (Summers *et al*., 1988), leg problems in broilers (Summers *et al*., 1990a, 1992b) and also blood level decrease of free triiodothyronine in turkeys (Mikulski *et al*., 2012). Furthermore, Khajali and Slominski (2012) reported that glucosinolate have more severe adverse effects in laying hens than in broiler chickens. Additionally, other factors such as digestibility of key essential amino acids and mineral dietary balance in rapeseed meal have been reported to account for the foregoing damages in poultry (Summers and Bedford., 1992). In addition, age (Arpasova *et al*., 2010), diet (Peebles *et al*., 2002), genotype, housing and oviposition time (Tumova *et al*., 2007; Tumova *et al*., 2009; Tumova and Gous, 2012) are of the major factors affecting egg and eggshell quality characteristics.

Indigenous hens used in the present study are dual-purpose breeding hens and have been genetically improved for body weight, egg weight and egg production rate during 14 continual generations. This population kept in an intensive condition for distribution of their offspring in rural areas. Their average egg production, egg weight and feed conversion ratio during a laying period (24 to 71 weeks of age) in intensive conditions are about 70%, 56 g and 4.5, respectively. Thus, the aim of this study was to evaluate the effects of feeding different levels of rapeseed meal and also hen age on egg and eggshell quality characteristics of the indigenous breeding hens.

MATERIALS AND METHODS

Birds, Housing and Diets

One hundred and fifty uniform indigenous pullets aged 20 weeks were randomly divided into 30 pens (140×120 cm) of 5 birds each. All birds were fed the experimental diets on a restricted feeding program to achieve target body weight gain from 20 to 24 weeks as prelaying and adaptation period. Accordingly, the experimental period began at 25 weeks followed by 4 periods of 28-day cycle to 41 weeks of age. Lighting program was also 16L:8D during laying period. The portion of offered diet for all birds were 105g/bird/day at the initiation of laying (25 weeks) and by weekly increment of 5 g/bird/week to 125 g/bird/day at 29 weeks of age. Feed allocation of 125 g/bird/day continued to 35 weeks and then reduced to 120 g/bird/day to the end of the experiment (41 weeks of age). The five experimental diets used in this study included: control diet (without rapeseed meal) and 4 diets containing either 5, 10, 15 or 20% rapeseed meal. Diets were isocaloric and isonitrogenus (Table 1) to meet nutrient requirements obtained from the previous experiments on the indigenous hens in intensive conditions (Gheisari, 2005). All birds received the same quantities of ME and CP during the laying period.

Table1. Composition and calculated analysis of the experimental diets

	Dietary rapeseed meal inclusion rate (%)				
Ingredients (%)	0	5	10	15	20
Corn	51	51	51	51	51
Soy bean meal (42.5%)	22	18.72	15.2	12	8.5
Rape seed meal(2)	0	5	10	15	20
Barley	7	7	7	7	7
Wheat Bran	8.89	7.2	5.73	3.96	2.49
Monocalcium phosphate (17%P)	1.1	1.1	1.1	1.1	1.1
$Caco_3$	9	9	9	9	9
Sodium chloride	0.3	0.3	0.3	0.3	0.3
- Mineral premix(3)	0.5	0.5	0.5	0.5	0.5
DL- Metionine	0.11	0.08	0.06	0.03	0
L-lysin hydrochloride	0	0	0.01	0.01	0.01
Vitamin D_3	0.1	0.1	0.1	0.1	0.1

[1]All diets Contain 2500 kcal ME kg $^{-1}$, 15% Cp, 3.2% ca, 0.4% Available P, 0.6% Methionine+Cystein and 0.7% Lysine.
[2]Contains 86.4% dry mater, 33.9% crud protein, 1% crude fat,12.8% crude fibre, 0.73% ca and 1% total phosphorus.
[3]Supplied per kilogram diet: 12000 IU Vitamin A; 3000IU Vitamin D3; 100 IU Vitamin E; 6 mg Vitamin K; 4 mg vitamin B1; 12 mg Vitamin B2; 15 mg Vitamin B3; 55 mg Vitamin B5; 5 mg Vitamin B6; 2 mg vitamin B9; 0.04mg Vitamin B12; 0.25mg Vitamin H2; 375 mg Choline chloride; 60 mg Mn; 100 mg Zn; 80 mg Fe; 14 mg Cu; 2 mg I; 0.2 mg Se, 375 mg Choline chloride.

Egg Quality Analysis

Eggshell quality (weight, thickness and strength) and egg interior quality (yolk weight, yolk index and Haugh units) were analyzed immediately after each collection time every 28 days, from 25 to 41 weeks of age. Three eggs per each replicate (18 eggs per treatment) were analyzed at 28, 32, 36, and 40 weeks. For determination of dry egg shell weight, at first, the egg content was extracted, then the eggshell dried in fresh air for 72h and finally weighted. The shell breaking strength was measured manually by eggshell intensity meter (OSK 13473). Eggs were compressed between 2 parallel plates by a steadily increasing load until the rupture occurred. The force was measured vertically to the axis. Eggshell thickness was evaluated as the average of both ends and in the middle including shell membranes with a micrometer (OSK, 17469). Albumin height was measured using micrometer (OSK, 13470) to determine the height of the thick albumen.

Haugh units were calculated as follows:

Haugh unit= $100\times\log(H+7.57-1.7W^{0.37})$

Where H is albumen height (mm) and W is egg weight (g). Yolk color was determined with a commercially available 'yolk color fan' according to the CIE standard colorimetric system (Yolk Colour Fan, the CIE standard colorimetric system, F. Hoffman-La Roche Ltd., Basal, Switzerland).

Statistical Analysis

Since, the plot of hen layers performance for all these traits against the period of time is curve-linear, the correlation between each two adjacent time points are more likely to be higher than two further points. Here, we applied a repeated record model to consider association between repletion. The following mixed model was used for data analysis.

$y_{ijk}= \mu+TRT_i+PRD_j+TRT\times PRD(ijk)+ \delta_{ijk}+e_{ijk}$

where, µ, TRT, PRD and TRT*PRD were the fixed effects of trait mean, treatment, period of time and the interaction of treatment and period, respectively. δ and e were error random effects between and within subjects, respectively. Least square means (LSM) were compared by ‘‘tukey hoc’’ considering p<0.05 as significant level.

RESULTS

Table 2 indicates the egg quality traits of the birds. The dietary treatments did not affect egg weight, yolk weight, yolk weight ratio and yolk color index. However, the Haugh units improved (p<0.05) with increasing dietary level of rapeseed meal, the difference between control (87.4%) and 20% rapeseed meal group (90.7%) was significant (p<0.05). The shell quality, indicated by eggshell weight, eggshell weight ratio, eggshell thickness and eggshell strength was significantly affected by feeding of rapeseed meal (p<0.05). In this regard, comparisons between treatment means showed that control group had the highest values, while hens fed diet containing 5% rapeseed meal produced eggs with the poorest shell quality.

Table 2. Effect of different dietary levels of rapeseed meal on means ±SE[1] egg quality characteristics of Iranian indigenous breeding hens

Rapeseed meal (%)	0	5	10	15	20	Significance
Egg weight (g)	52.6 ± 0.77	52.9 ± 0.70	53.0 ± 0.70	52.7 ± 0.70	51.4 ± 0.70	NS
Yolk weight (g)	14.7 ± 0.17	14.7 ± 0.16	14.7 ± 0.16	14.6 ± 0.16	14.5 ± 0.16	NS
Yolk weight ratio (%)	27.9 ± 0.29	27.8 ± 0.26	27.8 ± 0.26	27.7 ± 0.26	28.3 ± 0.26	NS
Yolk colour index	6.8 ± 0.16	6.8 ± 0.14	6.5 ± 0.14	6.4 ± 0.14	6.7 ± 0.14	NS
Haugh units	87.4 ± 1.15^{b}	88.4 ± 1.05^{ab}	88.5 ± 1.05^{ab}	88.7 ± 1.05^{ab}	90.7± 1.05^{a}	<0.05
Eggshell weight (g)	4.90 ± 0.06^{a}	4.65 ± 0.06^{b}	4.79± 0.06^{ab}	4.71 ± 0.06^{ab}	4.72 ± 0.06^{ab}	<0.05
Eggshell weight ratio (%)	9.30 ± 0.12^{a}	8.78 ± 0.11^{c}	9.03 ± 0.11^{abc}	8.93 ± 0.11^{bc}	9.18 ± 0.11^{ab}	<0.05
Eggshell thickness (mm)	0.391 ± 0.003^{a}	0.366 ± 0.003^{c}	0.376 ± 0.003^{b}	0.376 ± 0.003^{b}	0.376 ± 0.003^{b}	<0.05
Eggshell strength (kg/cm^2)	2.64 ± 0.073^{a}	2.21 ± 0.067^{c}	2.37 ± 0.067^{bc}	2.42 ± 0.067^{b}	2.53 ± 0.067^{ab}	<0.05

[1]SE = Standard error of means
[a-c]Means with different superscript within a column are significantly different (p<0.05).

In the present study, all of the recorded traits were influenced by hens age (Table 3). Egg weight, yolk weight and yolk weight ratio increased as the hens aged (p<0.05). Yolk color index was higher significantly in week 32 (p<0.05) than 28, 36 and 40 weeks of age (7.7 vs. 6.3, 6.6, 6.0, respectively). Haugh unit decreased significantly (p<0.05) in weeks 32, 36 and 40 compared to week 28. In this experiment eggshell weight increased, but eggshell weight to total egg weight ratio significantly decreased as hens age increased (p<0.05). Eggshell thickness also alleviated as the hens age increased (p<0.05). Eggshell strength was significantly affected by the age of hens, but did not have a constant trend as the hens age increased. The results did not show any interaction for age × rapeseed meal levels on egg quality characteristics.

Table 3. Effect of age on means ±SE[1] egg quality characteristics of Iranian indigenous breeding hens

Age (week)	28	32	36	40	Significance
Egg weight (g)	49.9 ± 0.36[d]	52.8 ± 0.36[c]	53.2 ± 0.38[b]	54.3 ± 0.40[a]	<0.05
Yolk weight (g)	13.2 ± 0.17[d]	14.6 ± 0.17[c]	15.0 ± 0.17[b]	15.8 ± 0.17[a]	<0.05
Yolk weight ratio (%)	26.6 ± 0.29[d]	27.7 ± 0.23[c]	28.2 ± 0.21[b]	29.1 ± 0.21[a]	<0.05
Yolk colour index	6.3 ± 0.07[b]	7.7 ± 0.15[a]	6.6 ± 0.13[b]	6.0 ± 0.14[b]	<0.05
Haugh units	91.7 ± 0.90[a]	86.3 ± 0.91[b]	88.4 ± 0.98[b]	88.6 ± 1.15[ab]	<0.05
Eggshell weight (g)	4.68 ± 0.04[b]	4.69 ± 0.06[b]	4.72 ± 0.04[b]	4.92 ± 0.05[a]	<0.05
Eggshell weight ratio (%)	9.37 ± 0.07[a]	8.88 ± 0.09[b]	8.87 ± 0.08[b]	9.06 ± 0.09[b]	<0.05
Eggshell thickness (mm)	0.391 ± 0.003[a]	0.382 ± 0.002[a]	0.372 ± 0.002[b]	0.362 ± 0.003[c]	<0.05
Eggshell strength (kg/cm^2)	2.25 ± 0.093[b]	2.61 ± 0.062[a]	2.36 ± 0.061[b]	2.51 ± 0.068[ab]	<0.05

[1]SE = Standard error of means ,

[a-c]Means with different superscript within a column are significantly different (p<0.05).

DISCUSSION

Feeding rapeseed meal up to 20% did not have any adverse effects on egg weight, yolk weight and yolk weight ratio. These results suggested that the utilization of nutrients from rapeseed meal diets was similar to that of control (corn-soybean) and support the supposition that the nutrients in rapeseed meal are being well-utilized by the birds, particularly indigenous hens (Gheisari *et al*., 2011). It is generally accepted that consideration of amino acids digestibility in feed formulation can improve the overall efficiency of protein digestibility. Rezvani *et al*. (2012) also reported that the overall amino acid digestibility of rapeseed meal is high and the combination of high methionine concentration and high methionine digestibility suggests rapeseed meal as a good protein source for laying hens. On the contrary, Ciurescu (2009) showed that with increasing dietary inclusion of rapeseed meal up to 15%, egg weight decreased but no significant differences were observed for yolk weight. There was no significant effect of the treatments on overall yolk color index however, Haugh units value increased (p<0.05) with the increased level of rapeseed meal. Najib and Al-khteeb (2004) also observed significant increase in Haugh units with increasing the proportion of canola seed in diets of layers but Riyazi *et al*. (2009) did not report any effect of increasing amount of dietary rapeseed on Haugh units. Eggshell quality traits were significantly (p<0.05) higher when birds were fed control diets (without rapeseed meal). It seems that the presence of phytic acid in rapeseed meal forms insoluble complex with proteins and several minerals (eg. Ca, Fe, Zn, Mn, Mg) to render them biologically unavailable (Kjajali and Slominski, 2012) and consequently lead to the deficiency of these minerals, protein and other nutrients in poultry (Sasyte *et al*., 2006). Phytic acid in rapeseed meal can also change Na partitioning and as a consequence may affect the gut capacity for Na-dependent transport of nutrients including glucose and peptides (Kjajali and Slominski, 2012). In addition, the high levels of sulfur in rapeseed meal cause tribulation in Ca digestion and absorption (Summers *et al*., 1992). The other reason that might influence egg shell quality traits is the pH increase in the small intestinal contents of the rapeseed meal fed birds compared with soybean meal diets (Zdunczyk *et al*., 2013). The biological digestibility of the canola meal essential amino acids for absorption in the small intestine of poultry is 10% lower than those for soybean meal (NRC, 1994). Consequently, lower essential amino acids are used for egg membrane formation (Najib and Al-khateeb, 2004). Riyazi *et al*. (2009) reported that addition of 10% rapeseed meal to diets increased eggshell weight, but Kaminska (2003) reported no significant effect of the increasing levels of rapeseed meal on eggshell quality, which is in disagreement with our findings in the present study. Egg weight, yolk weight and yolk weight ratio increased significantly (p<0.05) with hens age (Table 3). Egg weight and eggshell quality vary according to the age (O'Sullivan *et al*., 1991). Peebles *et al*. (2000) also reported that egg weight increased progressively with hens' age. There was a significant effect of hen's age on yolk index. Hens' age also significantly affected the haugh unit which was the lowest in week 40. The results are in agreement with Lapao (1999) who reported that albumen height was significantly higher in young hens compared to old hens and albumen height decreased with age of the hens. In this experiment eggshell weight increased, but eggshell weight to whole egg weight ratio significantly decreased as the hens age increased. It seems that the significant decrease in the percentage of eggshell weight was due to the slight increase in egg weight in association with a relatively constant eggshell weight. Eggshell thickness decreased as the hens age increased. This effect may be explained by the slightly increased progressively egg weight with hens age and negative relation between egg weight and eggshell thickness during laying period. Eggshell strength was significantly affected by hen's age, but did not have a constant trend as the hens age increased. In agreement with this result, Peebles (2000) also reported that eggshell quality fluctuated variably with age. Interaction of rapeseed meal and period was not significant for all traits.

In conclusion, the results showed that dietary inclusion of rapeseed meal up to 15-20% can improve Haugh units without any adverse effects on egg weight, yolk weight and yolk color index in Iranian indigenous breeding hens.

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