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EFFECT OF FODDER ENRICHMENT WITH PUFAs ON QUAIL EGGS

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Two experimental groups of eggs collected from Japanese quails (*Coturnix coturnix Japonica*) at the age of 20-24 weeks kept on the farm in Radomsko (Poland) were studied. Birds were fed with the standard fodder for farming quails (control group) and with fodder enriched with PUFA by the addition of 1% of linseed oil and 0.5% of fish oil. Experimental material was analysed as fresh and after 4 weeks of storage at room temperature. Eggs were analysed for cholesterol and retinol content and fatty acid composition (GC/MS), as well as a sensory analysis by a trained panel based on 5-grade scale was conducted. The results of the study indicate that quail eggs have a good storage ability. The content of fatty acids differed significantly among the experimental blocks. Eggs collected from birds fed with enriched fodder were characterised by higher amount of fatty acids, especially LNA (1.3%) and DHA (1.34%). Moreover, the ratio of n6/n3 fatty acids in the control and in enriched eggs equalled 17.7 and 4.0, respectively. Sensory analysis of studied eggs did not revealed any significant differences between groups. The storage time had a negative effect only on flavour of boiled eggs. The study shows that it is possible to produce designed quail eggs, which can be used for marketing purposes.

INTRODUCTION

In recent years, it has been observed in the poultry breeding that quails were benefited as much as hens, both for their meat and eggs, therefore, commercial quail breeding have become widespread [Altinel *et al*., 1996]. At present, the consumption of quail eggs is limited in Poland mainly because of the lack of proper advertisements. Moreover, quail eggs are less appreciated due to lower level of consumer's awareness. In future, quail products could become more popular as a conventional food – source of vitamins, minerals, proteins and fatty acids, in the human diet, due to wider availability on the market and consumer needs for changing eating habits. Hen eggs, most frequently used for human consumption, have already been thoroughly studied but there is still not enough information on the profile of fatty acids in eggs, especially from quail eggs. The content of fatty acids in hen egg is *ca*. 26.6 g/ 100 g yolk. Monounsaturated (MUFA) fatty acids – 46.9% and polyunsaturated (PUFA) acids – 22.4% are the dominant ones, whereas saturated acids (SFA) constitute the remaining 30.7% [Dobrzański, 2000; Pisulewski, 2000]. Fatty acids are elements of cell membranes, where they influence the permeability of nutrients to the cells of human organism [Ziemlański, 1997]. More and more attention has recently been paid to the role of polyunsaturated fatty acids (PUFA), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), in human and animal nutrition [Bartnikowska & Kulasek, 1994]. They play an important role in human nutrition e.g. they help to reduce the incidence of such lifestyle diseases as coronary artery diseases, hypertension and diabetes, as well as certain inflammatory diseases as arthritis and dermatitis [Simopoulos, 2000].The role of PUFAs becomes more important as they are not synthesized in human organism and have to be delivered with food [Bartnikowska & Kulasek, 1994; Ziemlański & Budzyńska-Topolowska, 1991; Pisulewski, 2000]. Favorable effect on human health is achieved by consuming of only 0.5 g/day of PUFA n-3 [Mantzioris, 2000].

Enrichment of n-3 PUFA in eggs of laying hens or quails is a successful strategy to ensure an adequate supply of n-3 PUFA for the greater population. Production of such eggs can be realized by adding common sources of n-3 PUFA (*i.e.* fish oil, marine algae, or linseed) to the layer diet [Baucells *et al*., 2000].

The objective of the study was to investigate the effects of laying quails diets, containing 1% of linseed oil and 0.5% of fish oil and identify fatty acids profile and quantify the cholesterol and vitamin (A) contents, as well as sensory properties of boiled eggs.

MATERIALS AND METHODS

The experiment was carried out on 20-24-week old laying Japanese quails (*Coturnix coturnix Japonica*), divided into two groups. The first one – control group were fed *ad libitum* with a control diet (consist of 29.25% of saturated, 39.27% of monounsaturated and 29.13% of n-6 and 1.66% n-3 polyunsaturated fatty acids, n-6/n-3 ratio equaled 17.5, energy 2600 MJ per kg). Experimental group received diets

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which contained also 1% of linseed oil and 0.5% of fish oil (consist of 23.46% of saturated, 36.24% of monounsaturated and 31.36% of n-6 and 9.05% n-3 polyunsaturated fatty acids, n-6/n-3 ratio equaled 3.5, energy 2750 MJ per kg). After 3 months of feeding with supplemented diet, eggs (108 per group) were collected automatically and transfer to the Wroclaw University of Environmental and Life Sciences. Experimental material was analysed as fresh and after 4 weeks of storage at the room temperature (18°C).

The eggs (average weight of one egg – 11.6 g) were manually broken and separated into egg white and yolk. Lipids were then extracted from egg yolks with standard procedure [Folch *et al.,* 1957] using methylene chloride and methanol (2:1). After methylation (14% BF_3 in ethanol), the analysis of fatty acid profile was performed in a gas chromatograph with a spectroscopy mass detector (Agilent 6890N Series, 5973 MS Detector). The separation of fatty acids was carried out in a column DB-225 MS (60; 0.25; 0.25). Cholesterol content was analyzed using liquid chromatographic method (Agilent 1100 Series) in a column XDB-C18. The vitamin A (retinol) concentration was determined and performed in liquid chromatograph and the absorbance of the solutions was monitored at 292 nm. Sensory properties of boiled eggs were evaluated by trained panel according to 5-grade scale of acceptance, where 1-totally unacceptable, 5-very acceptable.

The data collected in this experiment were subjected to statistical analysis as Duncan test.

RESULTS AND DISCUSSION

Incorporation of n-3 PUFA in egg yolks by changing hen diets has been found successful and has been reported in a number of studies [Lopez-Bote *et al*., 1998; Ayerza & Coates, 2000; Baucells *et al*., 2000; Grobas *et al*., 2001; Milinsk *et al*., 2003; Punita *et al*., 2000]. In this experiment it was also noted that supplementation of linseed and fish oil increased polyunsaturated fatty acids content in quail's egg yolk. The content of SFA, MUFA and PUFA (% of total fatty acids in quail's egg yolk) is shown in Table 1. Eggs from experimental group contained significantly less MUFA in lipids fraction of yolk in comparison to control group (47.05% and 49.57%, respectively). As it was expected, supplementation of linseed and fish oil in quail diets affected a significant increase of n-3 PUFA in yolk lipids of experimental group, which was 2.88% compare to the control that had 0.67%. When analysing fatty acids, it is the most important, from the nutritional point of view, to determine the n-6/n-3 PUFA ratio. This, according to the British Nutrition Foundation [1992] should rated between 4:1 and 6:1. Results collected in the study showed that ratio n-6/n-3 PUFA in fresh enriched quail eggs equaled 4:1, thus they can be suggested for consuming daily in order to assure a healthy diet. It was already proved by Kaźmierska *et al*. [2005], that free range quails produce eggs with low ratio between n-6/n-3 PUFA (5.6). However, in this study fresh quail eggs were characterized by quite high value of analysed parameters (17.7), which was probably caused by different housing conditions, especially feeding regime. Anyway, through supplementation of different sources of polyunsaturated fatty acids to quail diet, it was possible to lower the ratio n-6/n-3 PUFA to the satisfactory level, *i.e.* 4.0. The results of the study confirmed the possibility of modifying the ratio n-6/n-3 fatty acids families [Koreleski *et al.,* 1998]. Storage of eggs at room temperature even for 4 weeks did not significantly influence fatty acids profile of both analysed groups (Table 1). However, a tendency to lower concentration of monounsaturated fatty acids and higher content of either n-6 or n-3 PUFA, was observed in control group of eggs. From the marketing point of view, it was the key observation, that the proportion of n-6 and n-3 PUFA in quail eggs enriched with polyunsaturated fatty acids were not effected by storage of eggs for 4 weeks. That is why, they can be recommended for long period consumption.

TABLE 1. Content of fatty acids in fresh and stored egg yolk (%).

Group Fatty acids	Control diet		Supplemented diet	
	fresh eggs	stored eggs	fresh eggs	stored eggs
SFA	37.93[a]	38.04[a]	38.29[a]	38.91[a]
MUFA	49.57[b]	47.36[a]	47.05[a]	46.74[a]
n-6 PUFA	11.85[a]	13.75[b]	11.64[a]	11.58[a]
n-3 PUFA	0.67[a]	0.81[b]	2.88[c]	2.87[c]
n-6/n-3 Ratio	17.7[b]	16.9[b]	4.0[a]	4.0[a]

One of the limitation in egg consumption is the possible relationship between cholesterol content and coronary heart diseases. There were many research focused on the possibility to reduce cholesterol level and to change fatty acid contents of egg yolk [Maurice *et al*., 1994; Ayerza & Coates, 2000; Grobas *et al*., 2001; Milinsk *et al*., 2003; Bragagnolo & Rodriguez-Amaya, 2003; Mirghelenj *et al*., 2004]. However, it was extremely difficult to decrease yolk cholesterol either by genetic selection or by feeding modification. This was also confirmed in the presented study (Table 2), where cholesterol concentration in eggs from the supplemented group was similar to the control. Results obtained in this study showed that analysed quail eggs contained higher cholesterol amount than those reported by Kaźmierska *et al*. [2005]. It can be explained by different source of eggs, *i.e*. genotype, housing conditions, feeding, etc. However, cholesterol level analysed in the experimental material was comparable to data published by Bragagnolo & Rodriguez-Amaya [2003], which found approx 12 mg cholesterol per g yolk. Anyway, there are some data reported much higher cholesterol content in quail eggs, even more than 20 mg/g yolk [Baumgartner & Simeonova, 1992].

Egg yolk, including quail egg, can be a source of vitamin A [Pisulewski, 2000; Czekalski, 2000]. Retinol content in quail eggs analysed by HPLC showed that vitamin A was present in egg yolk at the concentration of 10 μg/g yolk in case of control group (Table 2). Quails fed with fodder supplemented with polyunsaturated fatty acids sources produced eggs almost twofold richer in retinol. Due to vitamin A is fat-soluble

TABLE 2. Cholesterol and retinol levels of fresh and stored quail eggs.

Group	Control diet		Supplemented diet	
	fresh eggs	stored eggs	fresh eggs	stored eggs
Cholesterol (mg/g yolk)	12.1[a]	12.0[a]	11.5[a]	10.7[a]
Retinol (μg/g yolk)	9.8[a]	10.0[a]	18.5[b]	17.5[b]

TABLE 3. Sensory analysis of boiled fresh and stored for 1 month quail eggs.

Group	Control diet		Supplemented diet	
	fresh eggs	stored eggs	fresh eggs	stored eggs
Taste	4.8[b]	4.4[a]	4.7[ab]	4.4[a]
Smell	4.3[a]	3.9[a]	4.3[a]	3.9[a]
Overall appearance	4.8[b]	4.4[a]	4.8[b]	4.4[a]
Egg white consistency	4.7[a]	4.8[a]	4.7[a]	4.8[a]
Egg yolk consistency	4.7[a]	4.6[a]	4.7[a]	4.6[a]
Colour	3.8[a]	4.3[b]	3.8[a]	4.2[b]

and lipids of plant origin are usually rich in this substance, it was probably the reason for analyzing higher amount of retinol in enriched eggs. And this was an additional positive effect of the supplementation of quail diet with oils, especially linseed oil. After storage of the material for 4 weeks at room temperature no significant differences in retinol content were observed in both groups of analysed eggs. This observation confirmed good storage ability of quail eggs.

Sensory properties of food are the most crucial for consumer's choice. There are many papers concerning sensory properties of enriched eggs, but presented results are varied from one another and they are sometimes controversial [Farrell, 1998, Caston *et al.*, 1994, Hammershøj, 1995; Melluzi *et al*., 2001]. The results collected in this study did not reveal any significant differences between control and enriched quail eggs, when analysed fresh, except yolk colour (Table 3). Panelists stated that yolk of enriched eggs was characterised by intensive orange-yellowish colour, which was more desired and acceptable. They also observed slight tendency for better consistency of enriched egg white and yolk. Egg stored at room temperature for 4 weeks were found to have worse taste and smell in both analysed groups. It was connected with typical changes occurring during storage of this biological material. Moreover, higher intensity of undesired sensory changes was observed in eggs enriched with polyunsaturated fatty acids, which was probably connected with higher fat level and more advanced oxidation processes. It can be reduced by implementation of natural substances with antioxidant properties to quail diet, such as vitamin E, selenium, different plants rich in polyphenols [Ahn *et al*., 1995; Galobart *et al*., 2001; Meluzzi *et al*., 2001; Łukaszewicz *et al*., 2007]. Anyway, the rate of unacceptable changes in sensory quality of eggs during storage was not big enough, thus the panelist graded stored eggs as acceptable.

CONCLUSIONS

The results of the study indicate that quail eggs have a good storage ability. The fatty acids profile of quail eggs yolk can be changed by feeding modification, however cholesterol concentration remained on the stable level. Enriched eggs were characterised by relevant, from nutritive point of view, ratio between n-6 and n-3 polyunsaturated fatty acids. Sensory analysis of studied eggs did not reveal any significant differences between groups. The storage time had a negative effect only on flavour of boiled eggs. The study shows that it is possible to produce designed quails eggs, which can be used for marketing purposes.

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WPŁYW WZBOGACANIA PASZY W POLIENOWE KWASY TŁUSZCZOWE NA WYBRANE CECHY JAJ PRZEPIÓRCZYCH

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Badania prowadzono w dwóch grupach żywieniowych przepiórek japońskich w wieku 20-24 tygodni na fermie przepiórek w Radomsku. Ptaki żywiono paszą standardową oraz paszą z dodatkiem 1% oleju lnianego oraz 0,5% oleju rybnego.

Analizie chemicznej i sensorycznej poddano materiał świeży oraz po 4 tygodniach przechowywania w temp. 18°C. Badano cechy jakościowe jaj, zawartość ogólnego cholesterolu, witaminy A oraz profil kwasów tłuszczowych żółtka, a ocenę sensoryczną przeprowadził panel oceniający w oparciu o 5- punktową skalę akceptacji.

Wyniki badań wskazują na istotne różnice w zawartości kwasów tłuszczowych pomiędzy grupą kontrolną a materiałem otrzymanym od stada żywionego paszą z dodatkiem oleju lnianego oraz rybnego. Odnotowano znaczący wzrost ilości polienowych kwasów tłuszczowych, zwłaszcza LNA (1,3%), DHA (1,34%) oraz korzystne obniżenie stosunku n-6/n-3 z 17,7 do 4,0. W ocenie sensorycznej nie wykazano istotnych różnic pomiędzy materiałem kontrolnym a jajami wzbogaconymi. Po 4 tygodniach przechowywania jaj w temperaturze pokojowej stwierdzono, istotne pogorszenie zapachu jaj po ugotowaniu (4,3- świeże i 3,9 przechowywane). Na podstawie przeprowadzonych badań stwierdzono dobrą zdolność przechowalniczą jaj przepiórczych w temperaturze pokojowej. Ponadto wykazano znaczące możliwości produkcji wzbogaconych jaj przepiórczych, co może mieć istotne znaczenie marketingowe.