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EFFECT OF DIFFERENT SOURCE OF OILS ON FATTY ACID PROFILE AND ORGANOLEPTIC TRAITS OF EGGS

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ABSTRACT

The study was aimed at assessing effects of oils supplemented to layer diets on fatty acid profile and organoleptic traits of eggs (aroma, taste, presence of admixtures and overall impression). Three groups of hens were fed diets that contained 5% of soybean oil (control group), 2.5% of fish oil and 2.5% of linseed oil (experimental group E1), and 2.5% of fish oil and 2.5% of rapeseed oil (experimental group E2). After a 28-day production, samples of diets and five eggs were taken from each group for determination of fatty acids. For the purpose of assessing sensory traits of eggs, panelists graded aroma, taste, admixtures and overall impression with grades from 1 (bad) to 3 (good). The control group contained significantly more ($P < 0.05$) linoleic acid (C18:2n-6, LA), arachidonic acid (C20:4n-6) and total n-6 PUFA than other groups. Egg yolks of the E1 group contained the most ($P < 0.05$) total MUFA. Egg yolks of the E2 group contained the most ($P < 0.05$) αLNA (C18:3n-3) and total n-3 PUFA. The best ratio of n-6/n-3 PUFA was determined in egg yolks of the E2 group, which was statistically better ($P < 0.05$) than in other groups. On average, eggs from all groups were given satisfactory grades referring to aroma, taste, admixtures and overall impression. However, panelists gave the best grade to eggs of the control group. These eggs were given statistically significantly better ($P < 0.05$) grade for overall impression than eggs from experimental groups.

Key words: poultry / laying hens / animal nutrition / oils / eggs / composition / fatty acids / organoleptic traits

VPLIV RAZLIČNEGA IZVORA OLJ NA AMINOKISLINSKO SESTAVO IN SENZORIČNE LASTNOSTI JAJC

IZVLEČEK

Namen študije je bil določiti vpliv olj, dodanih v krmo nesnic, na maščobnokislinsko sestavo in senzorične lastnosti jajc (aroma, okus, prisotnost primesi in splošni vtis). Tri skupine kokoši so bile krmljene s krmo, ki je vsebovala 5 % sojinega olja (kontrolna skupina), 2,5 % ribjega olja in 2,5 % lanenega olja (poskusna skupina E1) in 2,5 % ribjega olja in 2,5 % repičnega olja (poskusna skupina E2). Osemindvajset dni po začetku krmljenja so bili odvzeti vzorci krme in pet jajc iz vsake skupine za določitev maščobnokislinske sestave. Z namenom določitve senzoričnih lastnosti jajc so ocenjevalci z ocenami od 1 (slabo) do 3 (dobro) ocenili stopnjo arome, okusa, primesi in splošni vtis. Kontrolna skupina je vsebovala značilno več ($P < 0,05$) linolne kisline (C18:2n-6, LA), arahidonske kisline (C20:4n-6) in skupnih n-6 VNMK v primerjavi z drugimi skupinami. Rumenjaki skupine E1 so vsebovali največ ($P < 0,05$) skupnih ENMK. Rumenjaki skupine E2 so vsebovali največ ($P < 0,05$) αLNK (C18:3n-3) in skupnih n-3 VNMK. Najboljše razmerje n-6/n-3 VNMK je bilo določeno v rumenjaku skupine E2 in je bilo statistično značilno boljše ($P < 0,05$) od ostalih skupin. V povprečju so imela jajca vseh skupin zadovoljivo stopnjo arome, okusa, primesi in za splošni vtis. Najbolje so bila ocenjena jajca iz kontrolne skupine kokoši. Ta jajca so imela statistično značilno boljšo stopnjo za splošni vtis kot jajca iz poskusnih skupin.

Ključne besede: perutnina / kokoši / nesnice / prehrana živali / olja / jajca / sestava / maščobne kisline / organoleptične lastnosti

INTRODUCTION

Supplementation of different oils originating from plants (sunflower, soybean, linseed, rapeseed) and animals (fish) to layer diets affects significant changes of the fatty acids composition in egg yolk (Kralik *et al.*, 2005; Škrtić *et al.*, 2006). There is an increased interest in dietary supplementation with some plant and animal oils to increase the n-3 PUFA content in animal products (meat, milk and eggs) because it was confirmed that n-3 PUFA have beneficial effects on human health (Simopoulos, 1998, 2001). Foodstuffs with n-6/n-3 PUFA ratio less than 4:1 are considered beneficial for human health (Meluzzi *et al.*, 2000; Simopoulos, 2001). In poultry production, favorable content of fatty acids in meat and eggs is achieved through feeding hens and broilers diets with high portion of n-3 PUFA of plant and animal origin. However, positive and high correlation between some long-chain acids, such as α-linolenic (C18:3n-3), eicosapentaenoic (C20:5n-3) and docosahexaenoic (C22:6n-3), was proved to have influence on some organoleptic traits, such as odor (so called "fishy odor") and color (lighter egg yolk) (Van Elswyk *et al.*, 1992; Caston *et al.*, 1994; Leeson *et al.*, 1998).

As influences of fish and rapeseed oils and of linseed on organoleptic traits of eggs have already been investigated (Van Elswyk *et al.*, 1992; Gonzalez-Esquerra and Leeson, 2000; Meluzzi *et al.*, 2000), we focused our study on assessing effects that combinations of different oils of plant and animal origin have on aroma, taste, overall impression and presence of admixtures in eggs. Therefore, the aim of our study was to determine effects of layer diet supplementation with animal oil (fish oil) combined with plant oils (linseed and rapeseed oils) on the content of fatty acids in egg yolks and on organoleptic traits of eggs, as well as to compare them with eggs produced by the group fed diets supplemented with soybean oil.

MATERIAL AND METHODS

The study into effects of different oils supplemented to layer diets was carried out on three groups of 90 Lohmann Brown hens (30 hens per group), being 33–36 weeks old. Hens were kept indoors, in cages. Over a 28-day long study period, hens were fed diets that differed only in content of supplemented oils (Table 1).

Table 1. Content of oils in diets

Content, %	Control group	Experimental groups	
		E1	E2
Soybean oil	5.00	-	-
Linseed oil	-	2.50	-
Rapeseed oil	-	-	2.50
Fish oil	-	2.50	2.50
Total:	5.00	5.00	5.00

Different diets did not have significant influence ($P > 0.05$) on production and weight of eggs, the results of which will be published in due time. Five eggs were taken from each group on the 28th day of production and brought to laboratory. Content of fatty acids in diets and in egg yolk lipids was determined in Chrompack CP-9000 chromatograph equipped with flame ionization detector (Csapo *et al.*, 1986). Portions of saturated acids (SFA), unsaturated acids (MUFA), and polyunsaturated fatty acids of n-6 (n-6 PUFA) and n-3 groups (n-3 PUFA) were presented as percentages of total fatty acids contained in egg yolk. The ratio of n-6/n-3 PUFA and the content of the following acids were determined: linoleic (C18:2n-6, LA), arachidonic (C20:4n-6, AA), α-

linolenic (C18:3n-3, αLNA), eicosapentaenoic (C20:5n-3, EPA), docosapentaenoic (C22:5n-3, DPA) and docosahexaenoic (DHA, C22:6n-3) acids.

After the 28th day of production, 105 eggs (35 per group) were sampled and stored at 4 °C for 14 days. The procedure of sampling and storing of eggs was repeated once a week for the next 3 weeks. Seven untrained panelists were involved in the assessment of organoleptic traits. All eggs sampled for the purpose of this study were put in water, heated up to a boiling point and boiled for 15 minutes. After cooling down, eggs were served to panelists in separate plates. Each panelist peeled egg and cut it in half, then assessed smell, taste, color, presence of admixtures and gave an average grade for each sample. Each panelist was served five eggs selected randomly from each of investigated groups of hens fed diets with supplemented oils in different amounts. Treatments were repeated for four times in the period of four weeks. Panelists assessed eggs organoleptically with grades from 1–3 according to the following schema (Table 2).

Table 2. Schema for egg assessment

Trait	Grades		
	1	2	3
Aroma	Strong fishy	Slightly fishy	Common for egg
Taste	Extremely tasteless	Tasteless	Acceptable
Admixtures	Irregularities	Spots	None
Overall impression	Bad	Good	Very good

Obtained results were analyzed by the variance analysis (ANOVA). It was determined that feeding treatment had effect on the fatty acid content in yolks, as well as on organoleptic traits of eggs. Investigated portions of fatty acids in egg yolks and organoleptic traits overviewed in tables were presented as average values and standard deviation ($\bar{x} \pm s$). Statistical significance was accepted at $P < 0.05$. In cases when the F-test was statistically significant, differences between groups were determined by the Fisher's LSD test and marked by relevant letters. Results were processed in computer software STATISTICA for Windows 7.1 (StatSoft, 2004).

RESULTS AND DISCUSSION

Table 3 presented content of fatty acids in diets and in egg yolk lipids. Somewhat higher content of SFA in layer diets fed to experimental groups was a consequence of fish oil supplementation. The highest content of MUFA was determined in the E1 group because of supplemented rapeseed oil, as this oil contains oleic acid (C18:1n-9) in significant amount. Diets fed to the control group contained high portion of LA (53.41%) and consequently, high portion of total n-6 PUFA (53.46%). The highest portion of αLNA was determined in diets of the E2 group (14.29%), which was three times and more higher than in the E1 group (4.46%) and in the control (4.08%).

Control group did not prove presence of long-chain n-3 PUFA (EPA, DPA and DHA). Groups E1 and E2 had almost equal portion of EPA, DPA and DHA because fish oil was supplemented to their diets in the same amount (2.5%). The highest portion of n-3 PUFA (18.51%) and the best ratio of n-6/n-3 PUFA (2.04:1) were determined in the E2 group.

Content of fatty acids in layer diets strongly affected the profile of fatty acids in egg yolks, therefore, statistically significant differences ($P < 0.05$) were determined for all fatty acids except for the content of SFA ($P = 0.466$) and DPA ($P = 0.243$). The highest content of MUFA was determined in egg yolks of the E1 group which was fed diets supplemented with rapeseed oil. In comparison with both experimental groups, statistically significantly higher portion ($P < 0.05$) of

LA, AA and n-6 PUFA was determined in egg yolks of the control group. The highest portion of αLNA was determined in the E2 group, being three times higher ($P < 0.05$) than in the control and E1 group. Experimental groups had higher portion of EPA, DPA and DHA than control ($P < 0.05$). The E2 group had the highest content of n-3 PUFA (7.22%), which are beneficial for human health. The content of n-3 PUFA in the E2 group was twice as high as in the E1 group and three times higher than in the control. Moreover, egg yolks of the E2 group had the best ratio of n-6/n-3 PUFA (2.93:1). According to results for eggs of the E2 group, they exhibited fatty acid profile favorable for human health (high portion of n-3 PUFA and good ratio of n-6/n-3 PUFA). Linseed oil combined with fish oil proved to have better effect on the profile of fatty acids than rapeseed oil combined with fish oil. Soybean oil proved to have negative effect on the content of fatty acids in egg yolks if considering recent nutritional trends (high portion of LA, AA and total n-6 PUFA, poor ratio of n-6/n-3 PUFA). Positive effects of fish and linseed oils on the profile of fatty acids in egg yolks was pointed out by some distinguished authors (Van Elswijk *et al.*, 1992; Caston *et al.*, 1994; Leeson *et al.*, 1998; Gonzalez-Esquerra and Leeson., 2000; Meluzzi *et al.*, 2000).

Table 3. Content of fatty acids in diets and in egg yolks

Fatty acid	Content of fatty acids in diets			Content of fatty acids in egg yolk			P-value
	C	E1	E2	C	E1	E2	
SFA	17.41	19.28	20.20	31.66 ± 0.84	31.80 ± 0.73	31.23 ± 0.58	0.466
MUFA	25.04	39.76	23.59	36.95^{c} ± 1.04	47.96^{a} ± 2.23	40.41^{b} ± 2.24	<0.001
C18:2n-6	53.41	31.15	37.06	26.34^{a} ± 0.81	16.30^{c} ± 1.12	19.84^{b} ± 2.32	<0.001
C20:4n-6	-	0.15	0.18	1.84^{a} ± 0.13	1.04^{b} ± 0.12	0.88^{c} ± 0.10	<0,001
n-6 PUFA	53.46	32.07	37.71	0.00^{b} ± 0.00	0.19^{a} ± 0.02	0.20^{a} ± 0.04	<0.001
C18:3n-3	4.08	4.46	14.29	1.17^{b} ± 0.13	1.11^{b} ± 0.07	4.33^{a} ± 0.53	<0.001
C20:5n-3	-	1.44	1.42	0.00^{b} ± 0.00	0.19^{a} ± 0.02	0.20^{a} ± 0.04	<0.001
C22:5n-3	-	0.08	0.11	0.16 ± 0.04	0.21 ± 0.02	0.27 ± 0.16	0.243
C22:6n-3	-	2.91	2.64	1.26^{b} ± 0.07	2.13^{a} ± 0.46	2.34^{a} ± 0.27	<0.001
n-3 PUFA	4.08	8.89	18.51	2.60^{c} ± 0.16	3.64^{b} ± 0.50	7.22^{a} ± 0.31	<0.001
n-6/n-3 PUFA	13.10	3.61	2.04	11.09^{c} ± 0.51	4.92^{b} ± 0.70	2.93^{a} ± 0.29	<0.001

a, b, c $P < 0.05$

Effects of different oils on organoleptic traits of eggs were overviewed in Table 4. On average, eggs from all groups were given satisfactory grades for aroma, taste, presence of admixtures and for overall acceptability. Eggs from the control group were given the best grades for aroma and taste. Furthermore, these eggs had statistically significantly better ($P < 0.05$) overall impression than eggs from the E1 and E2 group. Panelists assessed eggs from the E2 group as having the most admixtures.

Table 4. Effects of different oils on organoleptic traits of eggs

Trait	Control group	Experimental groups		P-value
		E1	E2	
Aroma	2.95^{a} ± 0.22	2.76^{b} ± 0.49	2.87^{a} ± 0.34	<0.001
Taste	2.77^{a} ± 0.44	2.52^{b} ± 0.61	2.63^{b} ± 0.53	<0.001
Admixtures	2.91^{a} ± 0.31	2.95^{a} ± 0.22	2.82^{b} ± 0.48	0.008
Overall impression	2.79^{a} ± 0.41	2.54^{b} ± 0.60	2.61^{b} ± 0.54	<0.001

a, b $P < 0.05$

Poorer overall impression and lower grades for aroma and taste for eggs of the E1 and E2 group can be related to higher content of n-3 PUFA in eggs. This conclusion was also pointed out by Van Elswyk *et al.*, 1992, Caston *et al.*, 1994, and Leeson *et al.*, 1998.

Negative effects of linseed oil and fish oil on organoleptic traits of eggs were also pointed out by Van Elswijk *et al.* (1992), Caston *et al.* (1994) and Marshall *et al*. (1994). Referring to assessed organoleptic traits (aroma, taste and overall impression), Gonzalez-Esquerra and Leeson (2000) reported on statistically significantly better ($P < 0.05$) grades of eggs originating from hens in the control (2% and 4% of animal and plant fat) than of eggs laid by hens fed 2% and 4% of cod-liver oil.

It was proved that industrially produced meat and eggs had bad profile of fatty acids and were poor in n-3 PUFA. Consumption of such products in developed countries is constantly growing, but due to unfavorable ratio of n-6/n-3 PUFA and low amount of n-3 PUFA in eggs, it can have bad influence on consumers' health. Production of eggs enriched with n-3 PUFA has significant contribution in efforts to promote healthy nutrition in developed countries. However, usage of feedstuffs rich in n-3 PUFA in layer diets requires great caution as sensory traits of egg quality need to be preserved. Consumers in developed countries are well informed to approve scientific efforts in production of food that is beneficial for human health, but are still not ready to tolerate bad aroma or taste of such food.

CONCLUSIONS

Based on results obtained in the study into effects of layer diet supplementation with different oils on fatty acid profile and organoleptic traits of eggs, the following can be concluded:

- egg yolks of the control group (5% of soybean oil supplemented to layer diets) had high content of linoleic acid (C18:2n-6), arachidonic acid (AA, C20:4n-6) and total n-6 PUFA, as well as unfavorable ratio of n-6/n-3 PUFA, which is considered bad for human health.
- linseed oil and fish oil have better effect on the profile of fatty acids in egg yolks than rapeseed oil and fish oil.
- egg yolks of the E2 group (2.5% of fish oil and 2.5% of rapeseed oil supplemented to layer diet) had the highest content of αLNA, total n-3 PUFA and the ratio of n-6/n-3 less than 4:1, which is considered good for human health.
- eggs from the control group (5% of soybean oil in layer diet) exhibited the best sensory traits.
- usage of feedstuffs rich in n-3 PUFA can have negative effects on sensory traits of eggs.

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