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# EFFECT OF SOYBEAN AND LINSEED OIL CONTENTS IN MIXTURES FOR BROILER CHICKENS ON THE CONTENTS OF TRIGLYCERIDES AND CHOLESTEROL IN SERUM AND ON MEAT QUALITY

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***Summary.*** *The feeding experiment on five broiler chicken groups of ROSS 308 strain (I-C; II; III; IV; V), counting 30 birds each (5 repetitions of 6 birds in each group) was conducted. The broiler chickens were fed Starter mixtures (12.69 MJ of ME; 224 g of total protein) in the first three weeks, and then Grower mixtures (12.95 MJ of ME; 202 g of total protein) in the next three weeks. The mixtures contained wheat and maize (50/50), extracted soybean meal, mineral-vitamin-amino acid supplements as well as soybean and linseed oils. The oils were the experimental factor and they were applied in mixtures as follows: I group (control) – 6% of soybean oil; II – 4% of soybean oil and 2% of linseed oil; III – 3% of soybean and 3% of linseed oils; IV – 2% of soybean oil and 4% of linseed oil; V – 6% of linseed oil. Significantly less triglycerides in serum of chickens fed mixtures containing only linseed oil (6%) than those in the control group was found, however, there was no effect of feeding on the level of total cholesterol and its fractions HDL and LDL. Together with the increase in linseed oil content in mixtures, the level of linolenic acid (C18:3 n-3) also increased (4-14 times) in meat of experimental chickens, but organoleptic traits of their meat became worse. The most favourable ratio of polyunsaturated fatty acids PUFA n-3 to PUFA n-6 (1:3.91) in chicken muscles of the III group was proved.*

***Key words:*** *broiler chickens, soybean and linseed oils, cholesterol, fatty acids, gustatory value of meat*

## Introduction.

An introduction of polienic fatty acids: linoleic (C18:2 n-6) and α-linolenic acids (C18:3 n-3) into mixtures for broiler chickens is a good way to improve the dietetic value of poultry meat, because it increases in their contents in bird tissues (Osek et al. 2001, 2004; Rymer and Givens 2006; Ferrini et al. 2008). The acids are the precursors of superior indispensable unsaturated fatty acids and they have anticholesterol and antisclerotic effects (Goodnight, 1993). Linseed oil among vegetable fats, in which α-linolenic n-3 acid composes above 50% of total acid content (% of sum), is the best source of the acids (Osek et al. 2005). Adding linseed oil to mixtures for broiler chickens causes favourable narrowing of the ratio between polyunsaturated fatty acids of the homologous

lines n-3 and n-6, which in human diet, according to World Health Organization (WHO) should amount to 1:4. In order to satisfy chicken energetistic needs, it is necessary to introduce into mixtures at least 5-7% of oil and in general it must be soybean oil. After applying such amount of linseed oil, on one hand the level of PUFA n-3 in lipids of chicken meat significantly increases, which improves its dietetic value, on the other hand sensory traits become worse (Osek et al. 2005).

The aim of the study was to estimate the effect of soybean and linseed oil contents in mixtures for broiler chickens on triglycerides and cholesterol contents in serum and on meat quality.

**Material and methods**

A compact experiment on 150 one-day old broiler chickens of ROSS 308 strain, which were randomly divided into five groups of 30 birds each (5 subgroups x 6 chickens) was carried out. During the test two mixtures were applied: Starter (12.69 MJ of ME; 224 g of total protein; 12.5 g of lysine) in the first three weeks and Grower (12.95 MJ of ME; 202 g of total protein; 11.4 g of lysine) in the next three weeks. Wheat and maize (50/50), extracted soybean meal and mineral-vitamin supplements were introduced into all mixtures, and the content of soybean and linseed oils was the factor that differentiated the groups. The control group received mixtures only with soybean oil (6%), II group – 4% of soybean and 2% of linseed oil, III – 3% of soybean and 3% of linseed oils; IV – 2% of soybean and 4% of linseed oils; V – 6% of linseed oil. After finishing the rearing period 5 hens and 5 cocks were slaughtered in each group. During the slaughtering process the bird blood was taken in order to test the level of triglycerides and total cholesterol with fractions by enzymatic method. After plucking and roping, all carcasses were chilled for 24 hours, then the dissection was conducted and samples of breast muscles from each bird were taken so as to analyze the fatty acid content (% of sum) in lipids by gas chromatography of methyl esters using the gas chromatograph CHROM-5, equiped with the flame ionization detector. Moreover, organoleptic evaluation of meat according to the method presented by Baryłko-Pikielna (1975), which was tested by a group of 7 people, was conducted. The obtained results were statistically calculated by means of one-factor analysis of variance, and Duncan test was applied in order to estimate the significance of differences between means in groups.

**Results**

The results of fatty acid composition in oils, which were used in mixtures, were presented in table 1. It was found that soybean oil compared to linseed oil, contained almost 3 times more palmitic acid and twice more miristic acid, which are thought to be hypercholesterolemic acids (OFA). On the other hand, above 10 times more α-linolenic acid and twice less linoleic acid in linseed oil were found. The ratio between polyunsaturated fatty acids (PUFA) of the homologous lines n-3 and n-6 in soybean oil was wide (1:15) and unfavourable from the dietetic point of view, in comparison with linseed oil (1:0.5). The application of

the tested oils in different contents into mixtures significantly affected the level of triglycerides in chicken serum (tab. 2). The largest content (21 mg/dl) of the triglycerides in birds that were fed mixtures containing only soybean oil was found, whereas the least TG (16.2 mg/dl) was proved in broiler chickens fed mixtures with 6% of linseed oil. The statistically significant ($P \leq 0.05$) difference between the groups was stated, while an average level of TG (about 18 mg/dl) in other birds was found. Larger differentiation among hens than cocks was also obtained, but there were no significant differences between them ($P > 0.05$). Effects of feeding on the total cholesterol content (157-172 mg/dl) and its fractions HDL (71-77 mg/dl) and LDL (82-91 mg/dl) neither among hens nor cocks were found ($P > 0.05$). It could be concluded that the 6-week period of applying the oil was too short to affect the amount of the compounds in serum. The increasing content of linseed oil (2,3,4,6%) had a significant ($P \leq 0.01$) effect on the fatty acid profile in breast muscle lipids in broiler chickens (tab. 3). The largest content of linolenic acid (C18:3 n-3) in muscles of chickens given mixtures containing only linseed oil (6%) was proved and it was 14 times more than in birds of the first group (control). The introduction of only 2% of the oil (II group) resulted in the 4 times increase in C18:3 n-3 compared to the control group. Larger content (4 and 6%) of linseed oil significantly ($P \leq 0.01$) decreased the level of C16:0 acid, which was considered to be hypercholesterolemic acid as well as the level of oleic and linoleic acids. For poultry meat consumers the most favourable ratio between polyunsaturated PUFA n-3 and PUFA n-6 was stated in chickens that were fed mixtures containing a mixture of soybean and linseed oils at the same levels (3%/3%), whereas the worst ratio was proved in birds of the control group. The obtained results were similar to those presented by other authors, who applied different compositions of oils and estimated their effect on fatty acid profile in muscles, skin with subcutaneous fat and abdominal fat (Nguyen et al. 2003; Osek et al. 2004; Rymer and Givens 2006; Ferrini et al. 2008). In consideration of gustatory value (flavour, juiciness, tenderness and palatability) meat in chickens given mixtures with more soybean than linseed oil was better evaluated and the means of all 4 traits of the meat, in the 5-point scale, amounted to 4.2 points, which was by 0.3 points more than in the IV group ($P \leq 0.05$) and by 0.6 points more than in the V group ($P \leq 0.01$). The reason why organoleptic traits of meat became worse together with the increase in linseed oil content in mixtures could be caused by significantly higher, but favourable for consumers, level of polyunsaturated fatty acids (PUFA) in lipids of birds in the groups. Similar dependence was also shown by Barteczko et al. (2004) and Osek et al. (2004).

**Table 1.** Content [% of sum] of fatty acids in vegetable oils

| Fatty acids | Oil | |
|---|---|---|
| | soybean | linseed |
| $C_{14:0}$ miristic | 0,06 | 0,03 |
| $C_{16:0}$ palmitic | 13,63 | 4,87 |
| $C_{18:0}$ stearic | 1,75 | 1,47 |
| $C_{18:1}$ oleic | 20,05 | 14,66 |
| $C_{18:2n-6}$ linoleic | 60,25 | 27,70 |
| $C_{18:3n-3}$ linolenic | 4,00 | 51,01 |
| $C_{20:1}$ eicosenic | 0,13 | 0,21 |
| Others | 0,13 | 0,05 |
| Neutral or hypocholesterolemic (DFA) | 86,18 | 95,05 |
| Hypercholesterolemic (OFA) | 13,69 | 4,90 |
| PUFA n-3/PUFA n-6 | 1: 15 | 1: 0,5 |

DFA (UFA + $C_{18:0}$); OFA ($C_{14:0}$ + $C_{16:0}$)

**Table 2.** Contents of triglycerides, total cholesterol and its fractions in serum ($mmol \cdot l^{-1}$)

| *Item* | *Groups* | | | | | SEM |
|---|---|---|---|---|---|---|
| | I-K | II | III | IV | V | |
| **Total cholesterol** | | | | | | |
| ♂ | 174,3 | 161,3 | 175,3 | 162,0 | 167,7 | 11,59 |
| ♀ | 169,3 | 165,3 | 162,3 | 152,7 | 166,0 | 10,42 |
| ♂ + ♀ | 171,8 | 163,3 | 168,8 | 157,3 | 166,8 | 7,12 |
| **HDL** | | | | | | |
| ♂ | 76,7 | 72,3 | 82,0 | 70,0 | 77,7 | 7,09 |
| ♀ | 78,3 | 81,7 | 72,3 | 71,7 | 76,7 | 3,93 |
| ♂ + ♀ | 77,5 | 77,0 | 77,7 | 70,8 | 77,2 | 3,94 |
| **LDL** | | | | | | |
| ♂ | 94,00 | 85,67 | 90,33 | 88,00 | 86,67 | 6,15 |
| ♀ | 87,67 | 79,33 | 85,67 | 76,67 | 85,67 | 7,57 |
| ♂ + ♀ | 90,83 | 82,50 | 88,00 | 82,33 | 86,17 | 4,44 |
| **Triglicerydes** | | | | | | |
| ♂ | 18,7 | 16,7 | 17,3 | 19,3 | 16,3 | 1,16 |
| ♀ | $21,0^{a}$ | $19,7^{ab}$ | $19,0^{ab}$ | $20,0^{ab}$ | $16,0^{b}$ | 1,23 |
| ♂ + ♀ | $19,8^{Aa}$ | $18,2^{ABab}$ | $18,2^{ABb}$ | $19,7^{Aa}$ | $16,2^{Bb}$ | 0,81 |

*means in rows with different letters differed significantly at $^{a,b}$- P≤0.05; $^{A,B}$ - P≤0.01*

**Table 3**. Composition and content of fatty acids (% of sum) of breast muscles

| Item | Groups | | | | | SEM |
|---|---|---|---|---|---|---|
| | I - K | II | III | IV | V | |
| 14:0 | 0,06$^{a}$ | 0,07$^{ab}$ | 0,08$^{ab}$ | 0,10$^{a}$ | 0,09 $^{ab}$ | 1,03 |
| 14:1 | 0,02 | 0,02 | 0,02 | 0,02 | 0,02 | 2,88 |
| 16:0 | 22,77$^{A}$ | 21,62$^{AB}$ | 21,86$^{AB}$ | 20,82$^{B}$ | 18,89$^{C}$ | 0,58 |
| 16:1 | 1,37$^{b}$ | 1,72$^{a}$ | 1,32$^{b}$ | 1,46$^{ab}$ | 1,53$^{ab}$ | 9,60 |
| 18:0 | 5,15$^{ab}$ | 5,12$^{ab}$ | 5,64$^{a}$ | 4,91$^{b}$ | 4,45$^{c}$ | 0,35 |
| 18:1 | 30,90$^{A}$ | 31,01$^{A}$ | 30,61$^{A}$ | 29,57$^{B}$ | 28,33$^{C}$ | 0,35 |
| 18:2(n-6) | 37,55$^{A}$ | 33,88$^{B}$ | 31,69$^{C}$ | 31,42$^{C}$ | 26,39$^{D}$ | 0,54 |
| 18:3(n-3) | 1,38$^{E}$ | 6,01$^{D}$ | 8,15$^{C}$ | 11,12$^{B}$ | 19,84$^{A}$ | 0,42 |
| 20:1 | 0,04 | 0,03 | 0,03 | 0,03 | 0,04 | 5,14 |
| 20:2 | 0,05 | 0,05 | 0,03 | 0,04 | 0,03 | 5,61 |
| 20:3(n-3) | 0,04$^{Aa}$ | 0,02$^{Ab}$ | 0,02$^{Ab}$ | 0,02$^{Ab}$ | 0,01$^{Bb}$ | 3,82 |
| 20:4(n-6) | 0,50$^{A}$ | 0,22$^{B}$ | 0,25$^{B}$ | 0,22$^{B}$ | 0,11 $^{C}$ | 4,05 |
| 22:0 | 0,06$^{Cd}$ | 0,10 $^{Bcd}$ | 0,18$^{Aa}$ | 0,16$^{Aab}$ | 0,13$^{Bbc}$ | 0,01 |
| Others | 0,11 | 0,13 | 0,12 | 0,11 | 0,14 | 1,61 |
| Total | 100,00 | 100,00 | 100,00 | 100,00 | 100,00 | - |
| DFA | 77,00$^{b}$ | 78,08$^{ab}$ | 77,76$^{ab}$ | 78,81$^{ab}$ | 80,75$^{a}$ | 0,88 |
| OFA | 22,83$^{a}$ | 21,69$^{ab}$ | 21,94$^{ab}$ | 20,92$^{ab}$ | 18,98$^{b}$ | 0,85 |
| PUFA n-3/n-6 | 26,80$^{A}$ | 5,66$^{B}$ | 3,91$^{BC}$ | 2,84$^{C}$ | 1,34$^{D}$ | 0,39 |

*means in rows with different letters differed significantly* $^{a,b,c,d}$ – P≤0,05; $^{A,B,C,D,E}$ – P≤0,01

**Table 4.** Results of sensory evaluation of broilers breast muscles (scores)

| Item | Group | | | | | SEM |
|---|---|---|---|---|---|---|
| | K | 4/2 | 3/3 | 2/4 | 6 | |
| Flavour | | | | | | |
| ▪ intensity | 3,6 | 3,7 | 3,9 | 3,6 | 3,6 | 0,19 |
| ▪ desirable | $4,1^{a}$ | $3,9^{ab}$ | $4,0^{a}$ | $3,7^{ab}$ | $3,3^{b}$ | 0,22 |
| Juiciness | $4,3^{a}$ | $4,4^{a}$ | $4,3^{a}$ | $4,0^{ab}$ | $3,6^{b}$ | 0,20 |
| Tenderness | $4,4^{a}$ | $4,5^{a}$ | $4,3^{ab}$ | $4,2^{ab}$ | $3,8^{b}$ | 0,17 |
| Palatability | | | | | | |
| ▪ intensity | $4,1^{a}$ | $4,2^{a}$ | $4,0^{ab}$ | $3,8^{ab}$ | $3,5^{b}$ | 0,17 |
| ▪ desirable | $4,1^{a}$ | $4,3^{a}$ | $4,1^{ab}$ | $4,0^{ab}$ | $3,5^{b}$ | 0,19 |
| Mean of 4 traits | $4,2^{ABa}$ | $4,2^{Aa}$ | $4,1^{ABa}$ | $3,9^{ABab}$ | $3,6^{Bb}$ | 0,14 |

*means in rows with different letters differed significantly at $^{a,b}$- P≤0.05; $^{A,B}$ - P≤0.01*

## Conclusions

1. Applying only linseed oil (6%) in mixtures for broiler chickens resulted in significant decrease of the level of triglycerides, in comparison with the control birds (P≤0.05), but it had no effect on the total cholesterol content and the contents of HDL and LDL fractions in serum.
2. The growing content of linseed oil in mixtures increased (from 4 to 14 times) the level of C18:3 n-3 acid in chicken breast muscles, but gustatory values of the meat became worse.
3. The mixture of 3% of soybean oil and 3% of linseed oil could be recommended in mixtures for broiler chickens due to the most favourable ratio between polyunsaturated fatty acids PUFA n-3 and PUFA n-6 (1:3.91), which was found in chickens of the III group, and because of the value of other analyzed traits, which were similar to the control group (6% of soybean oil).

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