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EFFECT OF VEGETABLE OILS ON PRODUCTIVE PERFORMANCES AND LIPID FATTY ACID COMPOSITION OF CHICKEN ABDOMINAL FAT

V.Ž. Stanaćev[1], D. Milić[1], N. Milošević[2], V.S. Stanaćev[2*], Z. Pavlovski[3], Z. Škrbić[3] M. Vukić-Vranješ[4]

[1]Perutnina-Topiko, 24300 Bačka Topola, Serbia
[2]University of Novi Sad, Faculty of Agriculture, Department of Animal Science, Trg Dositeja Obradovića 8, 21000 Novi Sad, Serbia.
[3]Institute for Animal Husbandry Belgrade - Zemun, Autoput 16, 11080 Zemun, Serbia.
[4]Institut for Science Application in Agriculture – Beograd, Bul. Despota Stefana 68b, Belgrade, Serbia
*Corresponding author: vidica.stanacev@stocarstvo.edu.rs
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Abstract: This paper investigates the effect of soybean, flax and rapeseed oil on productive performance and lipid fatty acid composition of broiler chickens. Six groups of 40 one day-old chicks hybrid line Cobb 500, with five replications were formed. Three mixtures with 21, 20 and 18% protein were used. The first 14 days groups were fed with the starter mixture. The control group was based on the 4% and 8% soybean oil while in the experimental groups were included the same concentration of flax and rapeseed oil. The experiment lasted 42 days. At the end of the experiment 10 chickens from each group were sacrificed for examination of fatty acid composition of lipids. The control group achieved weight of 2704g and 2695g, and the experimental group in 2735, 2645, 2735 and 2670g, respectively. Feed conversion was improved with increasing the amount of oil in the diet. The usage of flax and rapeseed oil changed the fatty acid composition of lipids. Substituting soybean oil with rapeseed oil reduces the percentage of palmitic, stearic, and linoleic acids, and increases participation of oleic and linoleic acids in abdominal fat. The inclusion of flaxseed oil in the diet of chickens in the amount of 4% and 8%, increases the amount of linoleic acid by 63% and 203%, which is a statistically high and significant difference for the control group I and II, while the amount of linoleic acid is reduced by 14% and 33 %, which presents a statistically significant difference compared to group II.

Key words: nutrition, flax oil, rapeseed oil, chicken, fatty acids

Introduction

Studies have shown that increased energy intake, or dietary fat leads to decreased feed consumption and improved conversion in broilers (*Harms et al., 2000; Bryant et al., 2005*). Addition of fat in food exerts energy role and enhances the absorption of liposoluble vitamins, increases the palatability of meals and efficiency of energy use. It also leads to reduced passage of digestion of the gastrointestinal tract, allowing better absorption of nutrients in food. Today, most commonly used energy source in the diet of broiler chickens are oils and they are added in the amount of 5-7%. For this purpose the most often used one is soybean oil, although in recent years it has been replaced with flax and rapeseed oil, for desire to improve the nutritional value of chicken meat. Since the oil rich in ω-3 (α-linolenic) and ω-6 (linoleic) fatty acids significantly increased the content of lipids in chicken meat and hence improve anticholesterolemic and antisclerotic effect (*Goodnight, 1993*). However, exacerbate the sensory properties of the same, according to the *Osek et al. (2001); Osek et al. (2004); Rymer and Givens (2006); Ferrini et al. (2008); Zelenka et al. (2006).* The best source of polyunsaturated fatty acids among vegetable oils is flaxseed oil, which contains about 50% α-linolenic acid and 20% of linoleic acid of the total fatty acid amount (*Osek et al., 2005; Zelenka et al., 2003*). Addition of flaxseed oil to the chicken diet leads to a desirable relationship between polyunsaturated fatty acids and homologous ω-3 and ω-6 fatty acids, which in the human diet according to the World Health Organization (WHO) should be at 1:4 ratios. In addition, rapeseed oil is a good source of polyunsaturated fatty acids, although the linolenic acid is found in much smaller amounts (8%), which contributes to reduced oxidation of the oil. The most common is oleic acid (55%), and linoleic acid is approximately as in flaxseed oil. Such a composition of the oil significantly improves the nutritional quality of meat and performance optimization (*Sim, 1990; Yang et al., 2000; Bezard et al., 1994*).

Given the above, the aim of this study was to examine the broilers production parameters, when fed with different amounts of soybean, flaxseed and rape seed oil, and fatty acid composition of abdominal fat.

Materials and Methods

Experiments were conducted under production conditions on the experimental estate "Pustara" in Temerin, on the floor system posture. At the beginning, six groups of 40 one day-old chicks hybrid line Cobb 500 were formed with five replications. Three mixtures with 21, 20 and 18% protein were used for chicken nutrition. The first 14 days was a preparatory period of chicken, in which all groups were fed with starter mixture of standard composition and quality. Then in the next 21 days, grower mixture with different sources and amounts of oil were used. The last 7 days chickens were fed with finisher diets with the same addition of oil (Table 1). The control group was based on the 4% and 8% soybean oil while in the experimental groups were included 4% and 8% flax, or 4% and 8% rapeseed oil (Table 2). In mixtures with lower oil amount was added 100 mg/kg tocopherol acetate as an antioxidant, and in mixtures with higher oil supplemented period, 200 mg/kg of antioxidants to prevent oxidation and maintain oil quality. During the experiment, which lasted 42 days, chicks were fed and watered *ad libitum* and micro-climatic conditions constantly monitored. Body weight control and feed consumption was carried out every seven days. At the end of the experiment, after 12 hours of fasting, 10 birds (5 males and 5 females), of average body weight, marked with tags were sacrificed for examination of fatty acid composition of lipids in abdominal fat. Then bleeding, scalding, plucking, evisceration and cooling were conducted. Analysis of fatty acid composition of abdominal fat was made by gas chromatography method. The same method was used to analyse fatty acid composition of soybean, rapeseed and linseed oils. Evaluations were conducted on the basis of yield and weight of certain body parts. For proper interpretation of the results appropriate statistical methods such as ANOVA and Tucky post-hoc test were used with the statistics software package 12.

Table 1. Composition of used mixtures

Feedstuffs	Starter	Grower		Finisher	
		4% oil	8% oil	4% oil	8% oil
Corn, grain	50,00	56,50	44,00	60,60	51,00
Wheat floor	4,00	1,00	6,00	5,00	5,50
Vegetable oil	0,00	4,00	8,00	4,00	8,00
Soybean meal (44%)	17,40	34,00	33,00	26,00	23,00
Soybean grits	21,00	0,00	0,00	0,00	0,00
Sunflower meal (33%)	0,00	0,00	4,50	0,00	8,00
Yeast, Torula	3,00	0,00	0,00	0,00	0,00
Monocalcium phosphate	1,50	1,50	1,40	1,50	1,50
Solt (NaCl)	0,30	0,30	0,30	0,25	0,30
Chalk	1,50	1,50	1.50	1,50	1,50
Lysine-L (78%)	0,10	0,00	0.10	0,00	0,00
Methionine-DL (99%)	0,20	0,20	0,20	0,15	0,00
B-Mikrovit-ŽKNB, premix	1,00	1,00	1,00	1,00	1,00
Total	*100,00*	*100,00*	*100,00*	*100,00*	*100,00*
Nutrient amount					
Proteins, %	22,01	20,04	20,90	18,00	18,46
Fat, %	6,09	6,54	10,33	6,79	10,53
Fibre, %	3,96	3,92	4,89	3,78	4,89
ME, MJ/kg	12,88	13,13	13,59	13,30	13,73

Table 2. Experiment design

Group and Treatment	Control, I (T5)	Control, II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
Source of oil	Soybean	Soybean	Flaxseed	Flaxseed	Rapeseed	Rapeseed
In grower	4%	8%	4%	8%	4%	8%
In finisher	4%	8%	4%	8%	4%	8%

Results and Discussion

Based on the obtained results it can be concluded that the introduction of various types and quantities of vegetable oils in the diet of broilers did not affect the intensity of growth (Table 3). During the preparatory period, chicks had a uniform body weight in all groups. However, the experimental period in the third and fourth week results shows statistically significant ($P<0.05$) and highly significant ($P<0.01$) difference in body weight between the experimental and control groups. In the fifth week of age it is observed a very small depression on treatment with 4% of rapeseed oil (V), while the other groups (III, IV, and VI) were superior to the control groups (I and II). In the sixth week, the body mass of chicks had no statistically significant differences ($P>0.05$) between the groups, but body weight in groups of 8% of the oil in the diet was lower in relation to the weight of chickens who were on treatment with a lower level of oil in the diet.

Table 3. Body weight of chickens, g

Chicken age (weeks)	Group, treatment and oil amount					
	I (T5)	**II (T6)**	**III (T1)**	**IV (T2)**	**V (T3)**	**VI (T4)**
	4%-soy	**8%-soy**	**4%-flax**	**8%-flax**	**4%-rape**	**8%-rape**
Preparation period (1 – 14 days)						
Initial weight	42	42	42	42	42	42
1	185	185	183	190	187	190
2	468	469	468	468	469	469
Index, %	*100*	*100*	*100*	*99,78*	*100,21*	*100*
Experimental period (15 – 42 days)						
3	986	967^{b}	989	997^{B}	995	977
4	1457^{bD}	1422^{ABCD}	1523^{A}	1532^{B}	1515^{C}	1575^{D}
5	2122^{E}	2053^{ae}	2164^{A}	2094	2121	2081^{a}
Index, %	*100*	*100*	*101,97*	*101,99*	*99,95*	*101,36*
6	2704	2695	2735	2645	2735	2670
Index, %	*100*	*100*	*101,14*	*98,14*	*101,15*	*99,07*

The same capital letters in the same row = highly significant ($P<0.01$); same capital and small letters in the same row = significantly ($P<0.05$)

The literature states that feed consumption is negatively correlated with the amount of oil in the feed, which was confirmed by this experiment (Table 4). Feed consumption in the experimental groups varied by periods compared to the control group, and at the end of the experiment the average consumption was lower in all groups for 0.76; 0.60; 1.46 and 1.47% compared to the group with soybean oil. Hypothesis comes to the fore in the sixth week of the fattening where feed consumption is lower by 20%. Consumption was lowest in group IV and VI, in the last seven days when the chickens consumed finisher mixture. Group IV on treatment with 8% flax oil, consumption was reduced by 19.34% and in group VI on treatment with 8% rapeseed oil is decreased by 12.93%, while in the group with 4% oil in diet was increased by 1.34% and was equal to the control group.

Table 4. Feed consumption, g/day

Period	Treatment and oil amount					
	I (T5)	II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
	4%-soy	8%-soy	4%-flax	8%-flax	4%-rape	8%-rape
14-35 days	389,8	371,5	383,5	396,7	381,7	380,3
Index, %	*100*	*100*	*98,38*	*106,78*	*97,92*	*102,36*
35-42 days	186,3	208,9	188,8	168,5	186,2	181,9
Index, %	*100*	*100*	*101,34*	*80,66*	*99,94*	*87,07*
Average	572,1	566,9	567,8	563,5	563,8	558,6
Index, %	*100*	*100*	*99,24*	*99,40*	*98,54*	*98,53*

Table 5. Feed conversion, kg

Period	Treatment and oil amount					
	I (T5)	II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
	4%-soy	8%-soy	4%-flax	8%-flax	4%-rape	8%-rape
Preparation period (1 – 14 days)						
1	1,13	1,16	1,14	1,12	1,14	1,08
2	1,35	1,34	1,30	1,35	1,36	1,33
Index, %	*100*	*100*	*96,29*	*100,74*	*100,74*	*99,25*
Experimental period (15 – 42 days)						
3	1,38	1,36	1,39	1,42	1,41	1,41
4	1,49	1,48	1,41	1,50	1,47	1,50
5	1,62	1,61	1,60	1,68	1,60	1,63
Index, %	*100*	*100*	*98,76*	*104,34*	*98,76*	*101,24*
6	1,87	2,09	1,85	1,83	1,83	1,85
Index, %	*100*	*100*	*98,93*	*87,55*	*97,86*	*88,51*
3-6	1,59	1,63	1,56	1,60	1,57	1,59
Index, %	*100*	*100*	*98,11*	*98,15*	*98,74*	*97,54*

Unlike consumption, feed conversion is improved with increasing the amount of oil in the diet. Thus, at the end of the sixth week in group IV with 8% flax oil there was 1.83 kg/kg gain, and in the sixth group with the same amount of rapeseed oil there was 1.85 kg/kg gain, which is 12.45% and 11.49%, compared to the control group with the same amount of soybean oil (Table 5). Average values of the conversion of the whole experiment were slightly lower compared to the control group with soybean oil and amounted to 1.56 respectively; 1.60; 1.57; 1.59 kg/kg gain, while the control groups I and II ranged were 1.59 and 1.63 kg/kg gain.

When it comes to a fatty acid composition, eleven fatty acids were detected. Their percentage in abdominal fat lipids is shown in Table 6. Enrichment of chicken meat with linoleic and linolenic acid can be achieved using other types and levels of added oil (*Božić, 199*7), although not resulting in an increase level of mandatory and adequate conversion of fatty acids with 20 and 22 carbon atoms (*Moore et al., 1995; Sprecher et al., 1995; Lopez-Ferrer et al., 200*1).

These differences have a significant effect on the fatty acid composition of abdominal fat (Table 6). Flax oil is the richest in linoleic acid, which has as many as 7-8 times higher than soybean oil and rapeseed. Followed by linoleic acid 3 times a small amount compared to soybean oil, and stearic acid present in a lesser amount than in the same oil. The concentration of palmitic acid is close to rapeseed oil.

Based on data on fatty acid composition in abdominal fat, shown in Table 6, it can be noted that the use of flax and rapeseed oil changing the fatty acid composition of lipids. Substituting soybean oil with rapeseed oil at a rate of 4% in diets for chickens, reduces the percentage of palmitic, stearic, and linoleic acids, and increased participation of oleic and linoleic acids in abdominal fat. These changes are directly correlated with the fatty acid composition of the oil. Increase in linoleic acid in group with 5.89% to 6.83% is highly statistically significant ($P<0.01$). By increasing the amount of oil in diets for chickens to 8%, retains the same tendency acids exept stearic, whose participation has increased in group VI. Reduction of linoleic acid was significantly higher ($P<0.01$) in comparison to the second (control) group, and the increase of linoleic acid is a significant different ($P<0.05$) compared with II (control) group.

The inclusion of flaxseed oil in the diet of chickens in the amount of 4% and 8%, increases the amount of linoleic acid by 63% and 203%, with statistically significant difference compared to the control groups I and II, while the amount of other acids are decreased. From the above it can be determined that the linoleic acid is reduced by 14% and 33%, with statistically significant difference ($P<0.01$) compared to the second (control) group.

Reduced feed consumption in groups of 8% of the oil has had an impact on the amount of fatty acids in abdominal fat. All groups with higher oil amount showed a lower proportion of acid, but with the same oil, but the differences were not statistically significant ($P>0.05$).

It is well known that birds do not synthesize linoleic and linolenic acid (*Pinchasov and Nir, 1992*) and their presence in the body is result of their presence in the feed and was attended by oxidation in the tissues. Of total energy input in the diet of chickens, at least 3% must be essential fatty acids, of which 1/3 fatty acids should be linoleic acid. Similar results with the addition of other types of oil reached *Cherian et al. (1996) and Scaife et al. (1994)*.

Fatty acid composition in samples of abdominal fat (Table 6) is almost identical to the meat lipids only with different participation of stearic acid (C18). Its share has increased in all groups compared to the lipids of muscle tissue, according *Stanaćev et al. (2011).*

Analyses of variance and Tucky post-hoc test showed highly significant differences (P<0.01) between I, II and IV group of linolenic acid, then significant differences (P<0.05) between II and IV, II and VI group of linoleic acid.

Table 6. Fatty acid composition of chicken abdominal fat, 42 day

Fatty acids	Treatments and fatty acid composition of abdominal fat, %					
	Control, I (T5)	Control, II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
	4%-Soy	8%-Soy	4%-Flax	8%-Flax	4%-Rape	8%-Rape
C14:0	$0,04^{d}$	$0,01^{abD}$	$0,07^{A}$	$0,07^{B}$	$0,03^{C}$	$0,10^{CD}$
C16:0	$17,75^{DE}$	$14,66^{AcE}$	$18,39^{A}$	16,35	$16,87^{C}$	$14,59^{AcD}$
C16:1	3,28	2,83	3,83	3,46	3,41	2,79
C18:0	5,23	4,75	5,06	4,72	4,67	5,34
C18:1	35,45	33,57	35,72	34,37	37,07	37,46
C18:2	$29,22^{E}$	$37,07^{ABCDE}$	$25,13^{A}$	$24,81^{B}$	$27,48^{Ac}$	$26,52^{cD}$
C18:3	$5,89^{B}$	$4,75^{aB}$	$9,61^{A}$	$14,54^{aB}$	$6,83^{B}$	$9,18^{b}$
C20:0	0,07	0,10	0,07	0,09	0,09	0,08
C20:1	0,46	0,41	0,42	0,33	0,49	0,56
C22:0	0,06	$0,00^{d}$	0,01	0,09	0,08	$0,09^{D}$
C24:0	$0,01^{D}$	$0,00^{cD}$	$0,00^{A}$	$0,00^{B}$	$0,05^{abC}$	$0,08^{ABD}$

The values in the table are the mean ± SD (n = 5); same capital letters in the same row = highly significant (P<0.01); same capital and small letters in the same row = significantly (P<0.05)

Conclusion

Based on these results it can be concluded that the use of 4% and 8% flax and rapeseed oil shows no significant differences in body weight in comparison to the control group that received diet with addition of 4% to 8% soybean oil. Groups with lower amount of oil had a higher body weight at the end of the experiment. The control group achieved weight of 2704g and 2695g, and the experimental group in a row 2735, 2645, 2735 and 2670g. Feed consumption was lowest in the last week, when the chickens consumed finisher mixture and feed conversion improved with increasing the amount of oil in the diet.

The usage of flax and rapeseed oil change the fatty acid composition of lipids. Substituting soybean oil with rapeseed oil at a rate of 4% in diets for chickens, reduces the percentage of palmitic, stearic, and linoleic acids, and increased participation of oleic and linoleic acids in abdominal fat. By increasing the amount of oil in the diets to 8%, it retains the same tendency of6acids.

The inclusion of flaxseed oil in the diet of chickens in the amount of 4% and 8% increases the amount of linoleic acid by 63% and 203%, which is high statistically significant difference from the control group I and II, while the amount of other acids decreases. From the above we can also conclude that linoleic acid is reduced by 14% and 33%, with high statistically significant difference ($P<0.01$) compared to group II.

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Efekat različitih izvora biljnih ulja na proizvodne performanse i masnokiselinski sastav abdominalne masti brojlerskih pilića

V.Ž. Stanaćev, D. Milić, N. Milošević, V.S. Stanaćev, Z. Pavlovski, Z. Škrbić, M. Vukić-Vranješ

Rezime

Za normalno odvijanje metaboličkih procesa u ljudskom organizmu, neophodne su esencijalne masne kiseline. Pošto organizam nije u mogućnosti da ih sintetiše, moraju se unositi hranom u dovoljnoj količini, obično konzumiranjem namirnica životinjskog porekla. Istraživanja su pokazala da se odabirom lipida u hrani za piliće može značajno uticati na masnokiselinski sastav lipida pilećeg mesa. Značaj ovog odabira je u toliko veći, jer se istovremeno postižu dva efekta, izuzetno važna sa nutritivnog i sa aspekta zdravstvene bezbednosti namirnica. Jedan efekat se odnosi na povećanje učešća polinezasićenih masnih kiselina, linolne i linolenske kiseline, koje zajedno sa oleinskom predstavljaju direktne prekursore za višestruko nezasićene masne kiseline sa 20 i 22 atoma ugljenika i jednom dvostrukom vezom u položaju n-3, n-6 ili n-3 i cis konfiguracijom, koje se takođe ubrajaju u esencijalne (Pokorn, 1990). A drugi, na smanjenje učešća masnih kiselina sa dokazanim štetnim efektima (C10:0, C12:0, C14:0).

Polinezasićene masne kiseline n-3 familije i njihove poznate prednosti sa aspekta zdravstvene bezbednosti, dovele su do razvoja proučavanje efekta masnokiselinskog sastava lipida u hrani za živinu, na deponovanje masnih kiselina u lipidima pilećeg mesa i konzumnih jaja (*Cherian and Sim, 1991; Scaife et al., 1994*). Glavni izvori polinezasićenih masnih kiselina dugog lanca su ulja morskih riba. Međutim, njihovo dodavanje u hranu za piliće narušava organoleptička svojstva proizvoda, stoga se pribegava obogaćivanju pilećeg mesa polinezasićenim

masnim kiselinama sa 18C atoma dodavanjem biljnih ulja bogatih ovim kiselinama (*Leeson i Summers, 1997*).

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