Biotechnology in Animal Husbandry 30 (4), p 677-685, 2014
Publisher: Institute for Animal Husbandry, Belgrade-Zemun
ISSN 1450-9156
UDC 636.086:637.05'65
DOI: 10.2298/BAH1404677S

EFFECTS OF DIETARY SOYBEAN, FLAXSEED AND RAPESEED OIL ADDITION ON BROILERS MEAT QUALITY

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Original scientific paper

Abstract: The aim of this paper is was to investigate the effects of soybean oil, flax and rapeseed oil on the body weight, fatty acid composition of lipids and sensory characteristics of chicken breast meat. At the beginning, six groups with 40 one day old chicks Cobb 500 hybrid line, with five replications was formed. Chickens were fed with three mixtures of 21, 20 and 18% protein, respectively. The experiment lasted 42 days. The use of different types of oils in the diet did not exhibited statistically significant (P>0.05) differences in body weight of chickens. The control group achieved final body weight of 2704 g and 2695 g, and the experimental groups in a row 2735, 2645, 2735 and 2670g. The use of flax oil and rapeseed oil changes the fatty acid composition of lipids. Replacing rapeseed with soybean oil reduces the percentage of palmitic, stearic and linoleic acids, and increases the share of oleic and linolenic acids in the abdominal fat pad. The inclusion of flax oil in the diet of chickens in an amounts of 4% and 8% increase the amount of linoleic acid to 63% and 203%, which was statistically highly significant (P<0.01) difference compare to the control groups I and II, whereas the amount of linoleic acid is reduced by 14% and 33%. Dietary addition of vegetable oils in this experiment did not show any improvement of chicken breast meat sensory quality, but lipids of meat was improved with the higher levels of PUFAs which contributes to a higher quality of gained chicken meat.

Key words: oils, meat, quality, PUFA, nutrition, broilers

Introduction

Quality may be defined as the sum of demands of the consumer concerning foodstuffs. According to *Wrick (1995),* the expectation of the consumer for meat is

that it should be healthy, rich in protein, low in fat, tender, and have a typical flavour. Currently, dietary recommendations favour the consumption of less saturated fat. For this reason, an increase in unsaturated fat in meat would be of direct nutritional benefit to the consumer (*Ruiz et al., 2001*).

The content of polyunsaturated fatty acids (PUFA) in poultry meat depends on their content in the diet to a great extent. Enrichment of poultry products with n-3 PUFA may provide an excellent alternative source of these acids in the human diet (*Zelenka et al., 2008*). Unsaturated lipids readily undergo oxidation to produce peroxides and aldehydes. The oxidative stability of unsaturated lipids decreases as their degree of unsaturation increases. Poultry meat with enhanced linolenic acid content is more susceptible to oxidative damage than meat with a similar concentration of linoleic acid. The balance of volatile compounds resulting from an oxidative breakdown of n-3 PUFA causes the occurrence of fishy aroma and off-taste characteristic of the meat of poultry fed a higher level of n-3 PUFA (*Rymer and Givens, 2005*).

Lipid oxidation is a major cause of quality deterioration in meat and meat products and can give rise to rancidity and the formation of undesirable odours and flavours, which affect the functional, sensory, and nutritive values of meat products (*Gray et al., 1996*).

The positive effect of replacing n-6 rich soybean oil with n-3 rich linseed oil and rapeseed oil on the nutritional value of chicken meat has been documented (*Haug et al., 2007; Pappas et al., 2012*).

The use of vegetable oils rich in n-3 fatty acids in chicken diets to increase the deposition of PUFA in tissues has led to concerns related to the increased liability of these fatty acids to oxidation and the effect this may have on organoleptic properties. In the study of *Nyquist et al. (2013)* there were no differences in flavor or taste for the chicken breast meat from the different dietary groups fed with addition of linseed and rapeseed oil and other vegetable oil combination, after six months of storage at -20°C. *Betti et al. (2009)* reported no effect on perceivable sensory characteristics when enriching a chicken diet with n-3 rich linseed meal for less than 16 to 20 days. *Haug et al. (2007)* found no differences in antioxidant status or organoleptic properties of meat from chickens fed low and high Se levels combined with rapeseed and linseed oil.

The aim of this study was to investigate the effect of dietary soybean, flaxseed and rapeseed oil addition on chicken body weight, abdominal fat pad fatty acid composition and sensory properties of breast meat.

Materials and Methods

Tests were conducted in production condition on the experimental estate »Pustara" in Temerin, in the floor system posture. At the beginning of experiment, six groups of the 40 one day old chicks Cobb 500 hybrid line, were formed. The

experiment was performed in five replicates, in total of 200 chickens per treatment. Chickens were fed with three mixtures of 21, 20 and 18% protein, respectively. The first 14 days was a preparatory period of chicken in which all groups were fed with starter mixture of standard composition and quality. Next 21 days of fattening period the grower mixtures were used with the different source and the amounts of oils. Last 7 days chicks were fed with finisher diets with the same addition of oil (Table 1). The control group was fed a mixtures based on 4 and 8% soybean oil, and in the experimental groups was included 4 and 8% flax and rapeseed oil. In the mixtures with low levels of oil tocopherol acetate as antioxidant was added in amount of 100mg/kg, and the mixtures with a higher level of oil is supplemented received 200mg/kg of antioxidant to prevent oxidation and to maintain the quality of the oil. During the experiment, which lasted 42 days, the chicks were fed and watered *ad libitum*, and microclimate conditions was regularly monitored. Control of body weight and feed consumption was performed every seven days.

Table 1. Experimental design

Group and Treatment	Control, I (T5)	Control, II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
Source of oil	Soy	Soy	Flax	Flax	Rapeseed	Rapeseed
Grover	4%	8%	4%	8%	4%	8%
Finisher	4%	8%	4%	8%	4%	8%

At the end of the experiment, after 12 hours of fasting, from each group was collected 10 chickens (5 males and 5 females) of mean body weight, marked with stamps and sacrificed for the purpose of testing the fatty acid composition of lipid in abdominal fat pad. Analyses of fatty acid composition of abdominal fat pad were performed by gas chromatography (GC). The scoring for the sensory characters such as smell, taste, juiciness and gentleness was done on a 7 point hedonic scale (Table 2).

Table 2. Sensor analysis of thermally processed chicken meat

Mark	Thermal processed meat			
	Smell	Taste	Juiciness	Gentleness
1	Extremely bad (weak, not prominent, strange, overemphasized)	Extremely bad (weak, not prominent, strange, overemphasized)	Extremely bad (very dry or very juicy)	Extremely bad (very rough or very soft)
2	Very bad	Very bad	Very bad	Very bad
3	Bad	Bad	Bad	Bad
4	Not good, not bad	Not good, not bad	Not good, not bad	Not good, not bad
5	Good	Good	Good	Good
6	Very good	Very good	Very good	Very good
7	Very good (optimal)	Very good (optimal)	Very good (optimal)	Very good (optimal)

Analysis of variance (ANOVA) was applied to the data sets comprising the investigated traits. The experiments were repeated five times and the data were analysed using Statistica 12 and the differences between the means were compared with in Tucky post-hoc test at the significance levels of 0.05 and 0.01.

Results and Discussion

Based on the obtained results it can be concluded that the introduction of various types and levels of vegetable oil in the diet of broilers did not affect the intensity of growth (Table 3).

Table 3. Body weight of chickens, g

Age of chickens (weeks)	Group, the treatment and the amount of oil					
	I (T5)	II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
	4%-soy	8%-soy	4%-flax	8%-flax	4%-rapeseed	8%-rapeseed
	Preparatory period of chickens without experimental oil addition					
Initial weight	42±2.08	42±3.20	42±1.41	42±2.50	42±2.08	42±2.16
1	185±7.16	185±7.25	183±10.68	190±6.07	187±7.16	190±6.02
2	468 ± 35.3	469 ± 38.1	468 ± 28.3	468 ± 33.2	469 ± 42.5	469 ± 33.6
Index,%	*100*	*100*	*100*	*99.78*	*100.21*	*100*
	Periods with experimental nutrition of chickens with oil addition					
3	986 ± 57.2	967 ± 58.3^{b}	989 ± 52.8	997 ± 54.7^{B}	995 ± 64.5	977 ± 55.4
4	1457 ± 155.3^{BD}	1422 ± 134.1^{ABCD}	1523 ± 127.3^{A}	1532 ± 125.6^{B}	1515 ± 154.1^{C}	1575 ± 90.8^{D}
5	2122 ± 231.5^{E}	2053 ± 212.0^{ae}	2164 ± 260.2^{A}	2094 ± 231.5	2121 ± 255.1	2081 ± 223.7^{A}
Index,%	*100*	*100*	*101.97*	*101.99*	*99.95*	*101.36*
6	2704 ± 310.6	2695 ± 308.8	2735 ± 336.9	2645 ± 311.5	2735 ± 309.5	2670 ± 303.7
Index,%	*100*	*100*	*101.14*	*98.14*	*101.15*	*99.07*

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

During the preparatory period, chicks had a uniform body weight in all groups. However, in the due course of the experimental period, in the third and fourth week statistically significant (P<0.05) and highly significant (P<0.01) difference in the body weight between the control and experimental groups were recorded. In the fifth week of age very small depression in the treatment with 4% of rapeseed oil (V) was observed, while the other groups (III, IV, and VI) were superior to the control groups (I and II). In the six week of age, body weight of chicks exhibited significant differences (P>0.05) between the groups, but body weight in the groups with 8% of oil in the diet was lower, relative to the weight of

chickens that were on treatment with lower oils amounts in the diet. Similar results when the chicken growth performance is in question were reported by Lopez-*Ferrer et al. (1999)* with use of fish oil and rapeseed oil in the diet, followed by Nguyen et al. (2003) with the use of flaxseed and rapeseed oil, as well as in the investigation of *Kavouridou et al. (2008)* with a mixture of different vegetable oils.

Based on the data on the content of fatty acids in abdominal fat pad, as shown in Table 4, it can be noted that the use of flax oil and rapeseed oil changes the fatty acid composition of lipids.

Table 4. Fatty acid composition of chicken abdominal fat pad

Fatty acid	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%-rapeseed	8%- rapeseed
C14: 0	0.04 ± 0.01 ^{d}	0.01 ± 0.01 ^{ABD}	0.07 ± 0.03 ^{A}	0.07 ± 0.05 ^{B}	0.03 ± 0.00 ^{C}	0.10 ± 0.02 ^{CD}
C16: 0	17.75 ± 0.87^{DE}	14.66 ± 1.12 ^{AcE}	18.39 ± 0.94^{A}	16.35 ± 0.75	16.87 ± 1.00 ^{C}	14.59 ± 1.50^{ACD}
C16: 1	3.28 ± 0.81	2.83 ± 1.41	3.83 ± 0.35	3.46 ± 0.39	3.41 ± 0.53	2.79 ± 0.61
C18: 0	5.23 ± 0.53	4.75 ± 0.93	5.06 ± 0.37	4.72 ± 0.23	4.67 ± 0.51	5.34 ± 1.85
C18: 1	35.45 ± 0.98	33.57 ± 1.93	35.72 ± 1.54	34.37 ± 3.50	37.07 ± 1.15	37.46 ± 2.69
C18: 2	29.22 ± 0.76 ^{E}	37.07 ± 2.73^{ABCDE}	25.13 ± 0.38^{A}	24.81 ± 3.49 ^{B}	27.48 ± 1.72^{aC}	26.52 ± 2.46 ^{cD}
C18: 3	5.89 ± 0.46 ^{B}	4.75 ± 0.35 ^{aB}	9.61 ± 0.72 ^{A}	14.54 ± 3.63^{aB}	6.83 ± 2.60 ^{B}	9.18 ± 3.46 ^{b}
C20: 0	0.07 ± 0.04	0.10 ± 0.01	0.07 ± 0.05	0.09 ± 0.09	0.09 ± 0.02	0.08 ± 0.03
C20: 1	0.46 ± 0.16	0.41 ± 0.03	0.42 ± 0.02	0.33 ± 0.02	0.49 ± 0.05	0.56 ± 0.13
C22: 0	0.06 ± 0.04	0.00 ± 0.00 ^{d}	0.01 ± 0.03	0.09 ± 0.08	0.08 ± 0.02	0.09 ± 0.05 ^{D}
C24: 0	0.01 ± 0.01 ^{D}	0.00 ± 0.00 ^{cD}	0.00 ± 0.00 ^{A}	0.00 ± 0.00 ^{B}	0.05 ± 0.03^{ABC}	0.08 ± 0.05 ^{ABD}

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

Replacing soybean oil with rapeseed oil in an amount of 4%, in the chickens diet, reduces the percentage of palmitic, stearic and linoleic acids, and increases the share of oleic acid and linolenic acid in the abdominal fat. These changes are directly correlated with the fatty acid composition of the oil. An increase in the linoleic acid in V group, from 5.89% to 6.83% was statistically highly significant (P<0.01). By increasing the amount of oil in the diet mixtures to 8%, the same acids tendency is maintained except stearic acid, whose participation is increased in the VI group. Reduction of linoleic acid was significantly higher (P<0.01) as compared to the second (control) group, while an increase in linoleic acid had significant difference (P<0.05) compared to II (control) group. The inclusion of flaxseed oil in the diet of chickens in amount of 4% and 8% increase

the amount of linoleic acid to 63% and 203%, which is a statistically significant difference ($P<0.01$) compared to control group I and II, while the amount of the other acid were reduced. From the above it can be determined that linoleic acid is reduced by 14% and 33%, with statistically significant difference ($P<0.01$) compared to the second (control) group. Decreased feed consumption in groups with 8% of the oil had an impact on the amount of fatty acids in the abdominal fat. All groups with a higher level of oil had a lower proportion of acid in the same oil, except for the dominate acid. Analysis of variance and Tucky post-hoc test showed significant differences ($P<0.05$) between I and V groups; II and IV of linolenic acid, followed by a highly significant difference ($P<0.01$) between the II and IV; II and VI group of linoleic acid. Chickens fed a diet supplemented with flaxseed and rapeseed grain with significantly different concentrations of monounsaturated fatty acids and polyunsaturated fatty acids had no significant effect on the deposition of fatty acids in chicken breast meat (*Rahimi et al., 2011*). It has been found that the flaxseed oil is an excellent source of polyunsaturated fatty acids of the n-3 family, which can be very efficiently converted from phospholipids in tissues lipids of poultry (*Ferrer-Lopez et al., 2001*).

Table 5 shows the results of sensory characteristics of thermally processed chicken meat. From the given results it can be seen that addition of soybean oil in chicken diet led to a good smell of chicken meat ranged from scores of 4.87 (T5) and 4.69 (T6), with the similar scores of the taste. Introduction of flaxseed and rapeseed oil led to adverse effects of smell and taste, but when the gentleness is in question, treatment T1 with the addition of 4% of flaxseed oil achieved the highest score of 6.80 what have classified it as very good. Dietary addition of vegetable oils in this experiment did not show any remarkable improvement of chicken breast meat quality, but lipids of meat was improved with the higher levels of PUFAs which contributes to a higher quality of chicken meat.

Table 5. Marks of sensory characteristics of thermal processed chicken breast meat

	Treatments and marks of thermal processed chicken breast meat					
	Control, I (T5)	Control, II (T6)	III (T1)	IV (T2)	V (T3)	VI (T4)
	4%-soy	8%-soy	4%-flax	8%-flax	4%-rapeseed	8%-rapeseed
Smell	4.87 ± 0.22	4.69 ± 0.51	4.40 ± 0.18	3.83 ± 0.26	3.28 ± 0.29	3.35 ± 0.24
Taste	4.60 ± 0.26	4.54 ± 0.42	3.75 ± 0.28	3.65 ± 0.36	3.23 ± 0.21	3.17 ± 0.23
Juiciness	5.30 ± 0.61	5.32 ± 0.71	6.65 ± 0.54	4.14 ± 0.21	3.51 ± 0.05	3.01 ± 0.04
Gentleness	6.27 ± 0.25	6.37 ± 0.22	6.80 ± 0.41	6.02 ± 0.06	6.03 ± 0.06	6.08 ± 0.09

In the study of *Nyquist et al. (2013)* there were no differences in taste for the chicken breast meat fed with red palm oil, palm oil or rendered animal fat in combinations with flaxseed oil, rapeseed oil and two levels of selenium. The same authors reported, however, some differences when it came to odour. The high rapeseed and flaxseed oil dietary group had the highest intensity for acidulous odour, and lowest intensity for stale odour. Acidulous taste and smell relates to a fresh, sweet and sour experience while a stale taste and smell relates to lack of freshness, low aromatic, nauseous or oversweet experience. In their research *Betti et al. (2009)* reported no effect on perceivable sensory characteristics when enriching a chicken diet with n-3 rich flaxseed meal for less than 16 to 20 days.

Conclusion

Based on the obtained results it can be concluded that the use of 4% and 8% flax oil and rapeseed oil did not showed significant differences in body weight compared to the control group. Groups with lower oil addition had a higher body weight at the end of the experiment. The use of flax oil and rapeseed oil changes the fatty acid composition of lipids. Replacing soybean oil with rapeseed oil in an amount of 4%, reduces the percentage of palmitic, stearic and linoleic acids, and increases the share of oleic acid and linolenic acid in the abdominal fat pad. Addition of these types of oil did not improved sensor quality of chicken breast meat but has led to a significant improvement of lipids fatty acid composition.

Acknowledgments

This paper is a part of the project TR 31033 which is financed by Ministry of Education, Science and Technological Development of Republic of Serbia.

Efekat sojinog, lanenog i repičinog ulja u ishrani brojlera na kvalitet mesa

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Rezime

Cilj rada je bio da se ispitaju efekti sojinog, lanenog i repičinog ulja u ishrani brojlerskih pilića na telesnu masu, masnokiselinski sastav lipida i senzorni kvalitet mesa grudi. Na početku eksperimenta je formirano šest grupa od po 40 jednodnevnih pilića hibrine linije Cobb 500 u pet ponavljanja. Za ishranu pilića su

korišćene tri različite smeše sa 21, 20 i 18% sirovih proteina. Eksperiment je trajao 42 dana. Upotreba različitih vrsta biljnih ulja u ishrani nije ispoljila statistički značajne razlike (P>0,05) u završnoj telesnoj masi pilića. Završna telesna masa pilića u kontrolnim grupama je iznosila 2704 i 2695 g, dok je u eksperimentalnim iznosila za redom 2735, 2645, 2735 i 2670 g. Upotreba lanenog i repičinog ulja je uticala na promenu sastava lipida. Zamena sojinog ulja repičinim je dovela do smanjenja udela palmitinske, stearinske i linolne masne kiseline i povećanja udela oleinske i linolenske kiseline u abdominalnoj masti. Uvođenje lanenog ulja u ishranu pilića u količini od 4 i 8% je dovelo do povećanja sadržaja linolenske kiseline za 63 i 203%, sa statistički visoko značajnom razlikom (P<0,01) u poređenju sa kontrolnim grupama I i II, dok se sadržaj linolne kiseline smanjio za 14 i 33%. Upotreba biljnih ulja u ovom eksperimentu nije dovela do poboljšanja senzornih karakteristika mesa grudi, ali je dovela do značajnog poboljšanja masnokiselinskog sastava mesa u vidu povećanog sadržaja PUFA kiselina, što doprinosi značajnom poboljšanju nutrtivnog kvaliteta mesa pilića.

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Received 28 November 2014; accepted for publication 25 December 2014