Linseed oils with different fatty acid patterns in the diet of broiler chickens

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ABSTRACT: The effect of 1, 3, 5 or 7% of linseed oil on the performance and content of nutrients in meat was studied in an experiment with broiler chickens from 25 to 40 days of age. Oils made either of seeds of the cultivar Atalante (A; groups A1; A3; A5; A7) with a high content of α-linolenic acid or of the cultivar Lola (L) with a predominating content of linoleic acid (L1; L3; L5; L7) were used. The diets were formulated to maintain a constant energy/protein ratio. As compared with the groups receiving 1% and 3%, body weight gains were higher in the groups receiving 5% and 7% of oils in the feed mixture ($P < 0.01$). A lower feed consumption per unit of weight gain was also recorded in the groups with 7% and 5% of oils than in the groups receiving 1% and 3% ($P < 0.01$). The content of protein in breast meat in the group with 7% was lower than in the groups with 1% and 5% ($P < 0.05$). There were no differences in the contents of protein in thigh meat. Similarly, no differences were found out in the contents of fat in thigh and breast meat. In thigh meat, the values of ether extract were always significantly higher ($P < 0.01$) and those of protein content significantly lower ($P < 0.01$) than in breast meat. There were no significant differences in basic production parameters, breast and thigh meat percentages in body weight, and in the dry matter, ether extract and crude protein contents in meat between the groups receiving linseed oil with different levels of n-6 and n-3 polyunsaturated fatty acids.

Keywords: chickens; linseed oil; linoleic acid; α-linolenic acid; meat yield; meat composition

The use of feeding fats enables to increase the concentration of energy in diets. When formulating feed mixtures, it is important to consider not only the total level of fat in the diet but also its composition, particularly the content of linoleic and α-linolenic acids, which belong to essential nutrients.

Linseed oil made of common flax varieties contains ca. 14% of linoleic acid and more than 60% of α-linolenic acid of all fatty acids (Zelenka et al., 2003). However, relatively recently plant breeders have selected some flax cultivars that contain more than 70% of linoleic acid and only 2% of α-linolenic acid. Under conditions of the Czech Republic, production of flax for oil can be increased practically without limits and at relatively low costs. The average yield of linseed is usually about 1.8 t per hectare and under optimal conditions it is possible to obtain yields of as much as 2.3 t/ha with approximately 40% of oil.

The objective of this experiment was to evaluate the effect of increasing doses of linseed oil produced from seeds of varieties with markedly different proportions of n-6 and n-3 polyunsaturated fatty acids (PUFA) on basic production parameters of broilers and on the content of nutrients in poultry meat.

MATERIAL AND METHODS

An experiment was performed with 192 cockerels of Ross 308 hybrid combination which were fattened in cage batteries from Day 25 to Day 40

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of age. Chickens received feed mixtures containing 1; 3; 5 and 7% of linseed oil made either of seeds of the cultivar Atalante with a predominating content of α-linolenic acid (673 g/kg) or of seeds of the cultivar Lola with a predominating content of linoleic acid (708 g/kg). To maintain the required nutrient ratios the feed mixtures with a higher content of energy were fortified also with higher levels of crude protein. All mixtures were formulated in such a way that the energy/protein ratios remained practically unchanged, viz. 69.3–69.7 kJ of AME_n per 1 gram of crude protein (Table 1). The supplement of oils changed the contents of essential fatty acids in individual diets.

The experimental scheme involved altogether 16 groups of chickens: 4 groups in two replications received increasing amounts of linseed oil produced from the cultivar Atalante (A1; A3; A5; A7) while the other 4 groups (also in two replications) were fed a mixture containing linseed oil with a low percentage of α-linolenic acid (L1; L3; L5; L7). The feed mixture was supplied *ad libitum* and its consumption was recorded.

Eight chickens with the body weight which was close to the average body weight of their group, were slaughtered at the age of 40 days. Breast and thigh muscles without skin were separated from carcasses after cooling. All visible external fat was

Table 1. Composition of the diets (g/kg)

	Diets							
	A1	A3	A5	A7	L1	L3	L5	L7
Components								
Maize meal	400	400	400	400	400	400	400	400
Wheat meal	100	100	100	100	100	100	100	100
Soybean meal	276.4	296	315.7	335.3	276.4	296	315.7	335.3
Maize starch	173.2	133.3	93.2	53.3	173.2	133.3	93.2	53.3
Linseed oil Atalante	10	30	50	70	0	0	0	0
Linseed oil Lola	0	0	0	0	10	30	50	70
DL-methionine	3	2.9	2.9	2.8	3	2.9	2.9	2.8
L-lysine	1.4	1.1	0.8	0.5	1.4	1.1	0.8	0.5
Ground limestone	9	9.2	9.4	9.6	9	9.2	9.4	9.6
Mono- + dicalcium phosphate	15	15.5	16	16.5	15	15.5	16	16.5
Sodium chloride	2	2	2	2	2	2	2	2
Supplementary premix[1)]	10	10	10	10	10	10	10	10
Nutrient composition								
AME_n (calculated) (MJ)	12.4	12.7	13.0	13.3	12.4	12.7	13.0	13.3
Crude protein	178.6	183.2	186.4	191.5	177.9	182.5	187.3	191.9
E/P ratio[2)]	69.4	69.3	69.7	69.5	69.7	69.6	69.4	69.3
linoleic acid	7.57	9.89	12.01	14.53	14.22	28.78	43.13	58.44
α-linolenic acid	6.48	18.72	30.97	43.21	0.44	0.83	1.23	1.65
Σ (n-3) PUFA	6.50	18.79	31.07	43.36	0.51	0.92	1.34	1.78
Σ (n-6) PUFA	7.57	9.90	12.02	14.54	14.23	28.78	43.14	58.45

[1)]the premix supplied (mg/kg diet): retinyl acetate 4.47; cholecalciferol 0.125; DL-α-tocopherol acetate 50; menadione 3; thiamine 5; riboflavin 7; pyridoxine 6; hydroxycobalamine 0.02; niacin amide 75; pantothenic acid 14; biotin 0.2; folic acid 2; choline chloride 250; betaine 100; ethoxyquin 100; Lasalocid sodium 125; copper 20; iron 50; zinc 80; manganese 100; iodine 1; cobalt 0.4; molybdenum 1; selenium 0.3

[2)]AME_n (kJ/kg)/crude protein (g/kg); PUFA – polyunsaturated fatty acids removed from sample muscles while the intermuscular fat remained intact. The skin and the subcutaneous fat were separated as well. Breast and thigh meat was then weighed and their percentages of body weight were calculated.

Dry matter content of meat was determined by a method with sea sand and the total nitrogen according to Kjeldahl using Kjeltec 2300 (Tecator, Sweden). The crude protein content was calculated using the factor 6.0 (N × 6) pertinent to meat. The content of crude fat was determined gravimetrically after extraction with diethyl ether under reflux for 6 hours.

The data from all the determinations were subjected to analysis of variance by means of Statistical Package Unistat, version 5.1. applicable for two-factorial experiments (Snedecor and Cochran, 1989) and comparisons of means were made using Duncan's Multiple Range Test. Significance was considered at $P \le 0.05$.

RESULTS AND DISCUSSION

The main production parameters of chickens are presented in Table 2. There were no significant differences between the groups fed Atalante oil and Lola oil in energy intake, weight gain, feed conversion ratio and consumption of AME_n per kg of weight gain. The content of oils in the feed mixture did not influence the intake of energy and consumption of energy per unit of weight gain.

Weight gains of chickens receiving 1% of oil were highly significantly lower ($P < 0.01$) than in cockerels fed rations containing 5 or 7% of oil. In groups with 3% of oil, weight gains were highly significantly lower ($P < 0.01$) and significantly lower ($P < 0.05$) than in groups of chickens fed 5 and 7% of oil, respectively. The other differences were not significant. The supply of 70 g oil per kg of the diet was already too high.

The highest values of feed conversion ratio were recorded in groups receiving 1% of oils. Highly significant ($P < 0.01$) differences existed between 1% and 5%, 1% and 7% and 3% and 7%. The difference between 3% and 5% was significant ($P < 0.05$).

Breast and thigh meat percentages in body weight (Table 3) were independent of the fat source as well as of the dietary fat level. Zollitsch et al. (1997) and Sanz et al. (1999) also reported that the proportion of breast meat was not dependent on the composition of fat offered to animals.

Composition of breast and thigh meat is presented in Table 3. The dry matter content in the

Table 2. Basic production parameters

Factor		*n*	Initial body weight (g)	Final body weight (g)	Weight gain (g)	*n*	Feed conversion ratio	AME_n consumption (MJ)	AME_n consumption per kg of weight gain (MJ)
Oil	Atalante	96	1 271.3^a	2 385.3^a	1 114.0^a	16	1.8043^a	27.617^a	24.796^a
	Lola	96	1 263.7^a	2 383.1^a	1 119.3^a	16	1.8412^a	28.366^a	25.562^a
Level of oil (g/kg):	10	48	1 259.4^a	2 257.3^a	997.9^a	8	1.9536^b	25.957^a	25.939^a
	30	48	1 265.0^a	2 338.8^a	1 073.8^a	8	1.8921^b	27.918^a	26.294^a
	50	48	1 273.7^a	2 490.4^b	1 216.7^b	8	1.7598^a	29.833^a	24.472^a
	70	48	1 272.0^a	2 450.2^b	1 178.2^b	8	1.6855^a	28.257^a	24.011^a
PSEM[1)]			6.54	19.30	17.65		0.02146	0.5510	0.4864
Main effects: oil			NS	NS	NS		NS	NS	NS
	level of oil		NS	**	**		**	NS	NS

[1)]pooled standard error of the means

[ab]means within a column and under each main effect with no common superscripts differ significantly

NS = not significant; **$P < 0.01$

Table 3. Meat percentage in body weight and meat composition

Tissue	Factor		*n*	Body weight (%)	Dry matter (g/kg)	Ether extract (g/kg)	Crude protein (N × 6; g/kg)
Breast meat	Oil	Atalante	32	18.99^{a}	254.4^{aA}	11.4^{aA}	222.6^{aA}
		Lola	32	18.61^{a}	252.9^{aA}	11.5^{aA}	219.7^{aA}
	Level of oil (g/kg)	10	16	19.22^{a}	255.1^{aA}	9.9^{aA}	223.4^{bA}
		30	16	18.62^{a}	253.2^{aA}	12.4^{aA}	219.8^{abA}
		50	16	18.63^{a}	253.4^{aA}	10.8^{aA}	223.4^{bA}
		70	16	18.72^{a}	253.1^{aA}	12.8^{aA}	217.9^{aA}
	PSEM[1)]			0.185	0.62	0.53	0.83
	Main effects: oil			NS	NS	NS	NS
	level of oil			NS	NS	NS	*
Thigh meat	Oil	Atalante	32	14.39^{a}	247.8^{aA}	43.5^{aB}	184.0^{aB}
		Lola	32	13.94^{a}	247.7^{aA}	46.5^{aB}	181.4^{aB}
	Level of oil (g/kg)	10	16	14.53^{a}	243.4^{aB}	39.6^{aB}	184.4^{aB}
		30	16	14.17^{a}	249.6^{aA}	47.7^{aB}	181.3^{aB}
		50	16	13.86^{a}	249.5^{aA}	45.7^{aB}	184.5^{aB}
		70	16	14.11^{a}	248.5^{aA}	47.0^{aB}	180.7^{aB}
	PSEM[1)]			0.166	1.13	1.38	0.74
	Main effects: oil			NS	NS	NS	NS
	level of oil			NS	NS	NS	NS

[1)]pooled standard error of the means

^{ab}means within a column and under each main effect with no common superscripts differ significantly

^{AB}means with different superscripts in breast and thigh meat composition of chickens on the same diet differ highly significantly ($P < 0.01$)

NS = not significant, *$P < 0.05$

same tissue was not different at different sources and contents of oil in the feed mixture.

The fat content in breast and thigh meat did not change in dependence on the increasing content of oil in the diet. Similarly like in studies performed by Huyghebaert et al. (1991) and Plavnik et al. (1997), in which the amino acid/energy ratios were maintained, in our experiments the increasing energy contents did not influence the content of carcass fat significantly.

In chickens receiving 7% of oil, the content of crude protein in breast meat was significantly lower ($P < 0.05$) than in groups with 1% and 5%. All other differences were not significant.

In thigh meat, the ether extract was always highly significantly higher ($P < 0.01$) and the crude protein content highly significantly lower ($P < 0.01$) than in breast meat. Nearly all authors conducting studies on this theme published similar results.

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