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The fatty acid content in the tissues of broiler chickens fed diets containing a brown-seed linseed var. Opal or the yellow-seed var. Linola

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ABSTRACT

Six groups of broiler chickens, 18 each, were fed from the first day of life to slaughter at the age of 7 weeks on wheat-soyabean diets supplemented with fat in the amount of 34 g/kg diet. The sources of fat were: rape seed oil, soyabean oil, a mixture of rape seed and soyabean oils, full-fat seeds of a brown-seed variety of linseed, Opal, or the yellow-seed variety Linola; the control diet was not supplemented with fat. Opal linseed contained (in % of total fatty acids) 15.9 linoleic acid (C 18:2 n-6) and 72.8 α-linolenic acid (C 18:3 n-3); the seeds of the Linola variety contained, respectively, 51.5 and 1.8. After slaughter, the breast muscle and abdominal fat were taken from 5 chickens in each group. In the birds fed the diet with Opal linseeds, the PUFA n-6/n-3 ratio was 3.1 in breast muscle lipids and 1.1 in abdominal fat, whereas the same ratios in the birds fed the diet with Linola seeds was 24.3 and 23.6, while in the control birds, 28 and 15.5. Adding Linola linseeds to diets for broiler chickens cannot be recommended as a means of improving the nutritional value of broiler meat tissues.

KEY WORDS: broiler chickens, linseed, fatty acids, breast muscle, abdominal fat

INTRODUCTION

The fatty acid profile in the body lipids of broiler chickens depends to a large extent on the composition of the fat contained in feed mixtures (Smulikowska et al., 1990; Barteczko and Kamiński, 1995). The addition of linseed increases the energy concentration in feeds and makes it possible to cover essential fatty acid requirements (Pinchasov and Nir, 1992; Barowicz et al., 1997; Niemiec et al., 1999; Borowiec et al., 2001). Due to their high α-linolenic acid (C 18:3n- 3) con-

tent, the addition of traditional varieties of linseed to feeds for broilers leads to a reduction in the n-6/n-3 ratio of fatty acids (FA) in feeds and broiler tissues. This may be advantageous for the health of poultry consumers, since a large excess of n-6 fatty acids in human diets is associated with the occurrence of numerous diseases (Barteczko et al., 1993; Kulasek and Bartnikowska, 1994; Singer, 1995). New varieties of linseed have been developed recently. They have yellow seeds and a modified fatty acid composition (Borowiec et al., 2001).

The objective of this study was to determine the effect of adding a brown-seed variety of linseed, Opal, and a yellow-seed variety, Linola™947, to diets, on the fatty acid profile and relative proportions of fatty acids in the lipids of the breast muscle and abdominal fat of broiler chickens.

MATERIAL AND METHODS

The study was conducted on Starbro broilers in six groups, 18 birds in each. From weeks 2 to 7 of life, the broilers were housed under standard conditions, individually in metabolic cages fitted with individual feeders and automatic drinkers. The birds were fed *ad libitum* with complete feeds, with 21% crude protein, according to Nutrient Requirements of Poultry (1996). The main components of the diets were wheat and soyabean meal, all of the feeds also contained 8% meat meal. The control feed (1) was not supplemented with fat, the remainder was supplemented with 3.4% fat in the form of: diet 2, a 1:1 mixture of rape seed and soyabean oils; diet 3, rape seed oil; diet 4, soyabean oil; diet 5, seeds of the brown-seed variety of linseed, Opal (7% of the diet); diet 6, seeds of the yellow-seed linseed variety, Linola™947 (7% of the diet). The metabolizable energy content in the diets for the experimental groups (2-6) was similar and equaled from 2980 to 2993 kcal AME_N/kg; the energy content in the control group (1) was lower and equaled 2806 kcal AME_N/kg. The diets were prepared weekly and fed in dry form.

The final body weight of the chickens ranged from 2206 in the control group to 2221-2365 g in the experimental groups. After completing 7 weeks of life, 5 chickens from each group were decapitated and the left breast muscle and abdominal fat were sampled. The samples were placed in plastic bags and stored at -18°C until analysis. The tissues from individual birds were homogenized and lipids were extracted by the method of Folch et al. (1957). The fatty acid profile was determined in the feed fats, diets, and tissue lipids using a Varian 3400 CX gas chromatograph equipped with a FID detector (the carrier gas was argon, the column, DB-23, column temperature, 100-205°C, sample injector, 200°C, detector, 240°C).

The results were subjected to statistical analysis using one-way analysis of variance. The Duncan test was used to determine the significance of differences between means for groups.

RESULTS

The fatty acid contents in the brown-seed variety Opal and the yellow-seed Linola were, respectively (in % of total FA): saturated FA (SFA) 9.7 and 10.9, unsaturated FA (UFA) 90.2 and 89.0, monounsaturated FA (MUFA) 22.7 and 14.3, polyunsaturated FA (PUFA) 67.4 and 74.7. The PUFA n-6 to PUFA n-3 ratio was 0.31 in the Opal variety, and 40 in Linola, since the Opal and Linola varieties contained, respectively (in % of total FA): 15.9 and 51.5 linoleic acid (C18:2n-6) and 72.8 and 1.8 α-linolenic acid (C18:3n-3).

Table 1 shows the profile of fatty acids in the diets (% of total acids). The addition of vegetable fat lowered the SFA content of the fat in the experimental diets in comparison with the control. In the diets with 7% brown-seed Opal and

TABLE 1

Fatty acid (FA) composition of experimental diets, % total FA

Fatty acids	Diet no/source of added fat					
	1	2	3	4	5	6
	control	rape seed oil+soya oil	rape seed oil	soya oil	linseed cv. Opal	linseed cv. Linola
SFA	27.34	17.56	15.78	19.12	13.78	14.56
UFA	72.66	82.44	84.22	80.88	86.22	85.44
MUFA	29.34	37.53	48.11	26.55	27.42	23.90
PUFA	43.32	44.91	36.11	54.33	58.80	61.54
UFA:SFA	2.65	4.68	5.33	4.21	5.99	5.85
MUFA:SFA	1.07	2.13	3.04	1.38	1.99	1.64
PUFA:SFA	1.58	2.55	2.28	2.83	4.26	4.21
PUFA n-6/n-3	2.58	3.09	2.00	5.02	0.71	5.78

SFA - total saturated FA, UFA - total unsaturated FA, MUFA - total monounsaturated FA, PUFA - total polyunsaturated FA

yellow-seed Linola, the PUFA:SFA ratio was similar, but the change in the content of linoleic and α-linolenic acid contents in the fat of linseed caused a change in the n-6/n-3 PUFA ratio in the diet lipids; this ratio equaled 0.7 in the group 5 diet, as compared with 5.8 in the group 6 diet.

Table 2 presents the content of fatty acids in the lipids of the breast muscle of broilers. The addition of vegetable fat or linseeds to the diets increased ($P<0.05$) the UFA:SFA and PUFA:SFA ratios in lipids in comparison with the control group. The ratio of n-6 PUFA to n-3 PUFA was the highest in the group fed the control diet, followed by the diet with the addition of yellow-seed Linola and the group fed the diet with added soyabean oil, it was the lowest in the group given the diet with the brown-seed Opal variety ($P<0.01$).

TABLE 2

Fatty acid composition of lipids from breast muscle of broilers fed diets with various supplemental fats

Fatty acids	Group/source of added fat					
	1	2	3	4	5	6
	control	rape seed oil+soya oil	rape seed oil	soya oil	linseed Opal	linseed Linola
SFA	33.91^{b}	32.18^{b}	29.76^{a}	31.79^{ab}	32.55^{b}	31.80^{ab}
UFA	63.24^{a}	65.10^{ab}	70.25^{b}	67.19^{b}	64.09^{a}	66.71^{b}
MUFA	44.94^{d}	41.77^{c}	50.07^{e}	38.44^{b}	38.61^{b}	35.55^{a}
PUFA	18.30^{a}	23.33^{c}	20.18^{b}	28.75^{e}	25.48^{d}	31.16^{f}
UFA:SFA	1.86^{a}	2.02^{b}	2.36^{c}	2.11^{b}	1.96^{ab}	2.09^{b}
MUFA:SFA	1.32^{b}	1.29^{b}	1.68^{c}	1.21^{ab}	1.18^{a}	1.11^{a}
PUFA:SFA	0.54^{a}	0.72^{bc}	0.68^{b}	0.90^{d}	0.78^{c}	0.98^{e}
PUFA n-6/ n-3	28.0^{F}	14.1^{C}	9.8^{B}	17.5^{D}	3.1^{A}	24.3^{E}

^{a,b,A,B} - means in rows determined with different letters are significantly different at:
^{a,b} $P<0.05$; $^{A,B}P<0.01$

Table 3 presents the fatty acid content of abdominal fat of broilers (% of total fatty acids). Similarly as in breast meat lipids, an increased ratio of UFA:SFA ($P<0.05$) and PUFA:SFA ($P<0.01$) was found in the birds fed diets supplemented with vegetable oils or linseed. The n-6 PUFA to n-3 PUFA ratio in abdominal fat was highest in the group given the diet with Linola seeds, followed by the control diet and the diet with soyabean oil. It was lowest in the group receiving the brown-seed variety, Opal. All of the differences were highly significant ($P<0.01$).

TABLE 3

Fatty acid composition of lipids from abdominal fat of broilers fed diets with various supplemental fats

Fatty acids	Group/source of added fat					
	1	2	3	4	5	6
	control	rape seed oil+soya oil	rape seed oil	soya oil	linseed Opal	linseed Linola
SFA	34.89^{b}	29.77^{a}	28.04^{a}	29.11^{a}	27.75^{a}	29.12^{a}
UFA	64.71^{a}	69.92^{b}	71.53^{b}	70.51^{b}	71.80^{b}	70.56^{b}
MUFA	55.47^{c}	50.10^{b}	54.87^{c}	45.77^{a}	47.01^{ab}	46.00^{a}
PUFA	9.24^{A}	19.82^{C}	16.66^{B}	24.74^{D}	24.79^{D}	24.56^{D}
UFA:SFA	1.85^{a}	2.35^{b}	2.55^{b}	2.42^{b}	2.58^{b}	2.42^{b}
MUFA:SFA	1.59^{a}	1.68^{a}	1.90^{b}	1.57^{a}	1.69^{a}	1.58^{a}
PUFA:SFA	0.26^{A}	0.66^{B}	0.59^{B}	0.85^{C}	0.89^{C}	0.84^{C}
PUFA n-6/n-3	15.5^{E}	6.2^{C}	4.8^{B}	9.5^{D}	1.1^{A}	23.6^{F}

- as in Table 2

DISCUSSION

Manipulation of the fatty acid composition of feeds makes it possible to improve the nutritional value of poultry meat (Smulikowska et al., 1990; Barowicz et al., 1997). The results of this experiment indicate that adding linseed or vegetable oils to the diets of broilers significantly increases the proportion of unsaturated fatty acids, especially PUFA in relation to SFA in broiler meat tissues. On the other hand, when trying to change the proportion of n-6 PUFA to n-3 PUFA in poultry meat, the ratio of these acids in the feed lipids should be taken into consideration.

Opal linseed, has a fatty acid profile similar to traditional varieties, in which the n-6 to n-3 PUFA ratio is 0.31. It therefore has a very favourable influence on the polyunsaturated fatty acid (n-3 PUFA) content in the lipids of broiler meat tissues. The yellow-seed linseed variety, Linola, which has a highly modified fatty acid composition in comparison with traditional varieties (the n-6 PUFA to n-3 PUFA ratio in this variety is 40), caused a substantial rise in the n-6 PUFA to n-3 PUFA ratio in breast meat lipids and abdominal fat of chickens to about 24. This deteriorated the dietary value of meat, since in human diets, the n-6 PUFA to n-3 PUFA ratio should be 1-5 (Kulasek and Bartnikowska, 1994). In terms of the nutritional value of the meat tissues, supplementing the diets of broiler chickens with rape seed oil is more beneficial than using soyabean oil.

CONCLUSIONS

Linseed is a good energy supplement for the diets of broiler chickens and modifies the fatty acid profiles of tissue lipids. Given the nutritional value of meat tissues and the need to reduce the n-6 PUFA to n-3 PUFA ratio, supplementing the diets of broiler chicken with the seeds of traditional linseed varieties or rape seed oil is more beneficial than using soyabean oil or animal fat. The seeds of the Linola variety of linseed, due to their modified fatty acid profile, should not be used in poultry nutrition because they cause a substantial increase in the proportion of n-6 PUFA to n-3 PUFA in the tissue lipids of poultry.

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STRESZCZENIE

Zawartość kwasów tłuszczowych w tkankach kurcząt brojlerów żywionych mieszankami z dodatkiem nasion lnu oleistego brązowonasiennej odmiany Opal i żółtonasiennej odmiany Linola

Sześć grup kurcząt brojlerów, po 18 ptaków w każdej, żywiono od pierwszego dnia życia do uboju w wieku 7 tygodni dietami pszenno-sojowymi uzupełnionymi tłuszczem w ilości 34 g/kg diety. Źródłem tłuszczu były: olej rzepakowy, olej sojowy, mieszanina oleju rzepakowego i sojowego, pełnotłuste nasiona lnu brązowonasiennej odmiany Opal lub żółtonasiennej odmiany Linola; do diety kontrolnej nie dodano tłuszczu. Nasiona lnu odmiany Opal zawierały (w % sumy kwasów tłuszczowych) 15,9 kwasu linolowego (C 18:2n-6) i 72,8 kwasu α-linolenowego (C 18:3n-3), w nasionach odmiany Linola zawartość tych kwasów wynosiła odpowiednio 51,5 i 1,8. Po uboju 5 kurcząt z każdej grupy pobrano mięśnie piersiowe i tłuszcz sadełkowy. U ptaków żywionych dietą zawierającą nasiona lnu odmiany Opal stosunek PUFA n-6/n-3 wynosił 3,1 w tłuszczu mięśni piersiowych i 1,1 w tłuszczu brzusznym; odpowiedni stosunek u ptaków żywionych dietą z dodatkiem nasion lnu Linola wynosił 24,3 i 23,6, u ptaków żywionych dietą kontrolną 28 i 15,5. Wprowadzenie nasion lnu odmiany Linola do mieszanek nie może być zalecane w celu poprawy wartości dietetycznej tuszek kurcząt brojlerów.