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Effects of different dietary oil sources on fatty acid composition and malondialdehyde levels of thigh meat in broiler chickens[1]

Einfluss verschiedener Futterfettquellen auf das Fettsäurenmuster und die Gehalte an Malondialdehyd im Schenkelfleisch von Broilern

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Introduction

Quite a number of laboratories carried out experiments to enrich broiler meat with n-3 fatty acids (PHETTEPLACE and WATKINS, 1989; CHANMUGAN et al., 1992; SCAIFE et al., 1994; LOPEZ-FERRER et al., 1999, 2001a, 2001b; ABAS et al., 2003; ÖZPINAR et al., 2003). This was achieved by including different oils, fish meal or full-fat oil seeds, e.g. linseed, in the broiler diets (SCAIFE et al., 1994; AHN et al., 1995). Main sources of α-linolenic acid (18 : 3, n-3) are linseed and green leaves and for linoleic acids (18 : 2, n-6) sunflower seeds and soy oil (WISEMAN, 1997; KRASICKA et al., 2000). The use of vegetable oils in dietary programs for poultry to increase the ratio of polyunsaturated to saturate fatty acids and to improve the nutritive value of meat (by increasing the n-3 content) has been recommended (MERCIER et al., 2001).

The most important n-3 long chain polyunsaturated fatty acids (PUFA) are eicosapentaenoic acid (EPA, 20 : 5, n-3) and docosahexaenoic acid (DHA, 22 : 6, n-3) (AN et al., 1997; KRASICKA et al., 2000; LOPEZ-FERRER et al., 2001a and 2001b). Fish oils, which contain EPA and DHA in abundance, have been shown to be effective in reducing the risk factors of cardiovascular disease, cancer and allergies in humans. However, due to the high unsaturation level, EPA and DHA are easily oxidized. In general, oxidation is influenced by fat composition (HUANG et al., 1990) and quality (SHEEHY et al., 1993) and by the type of muscle involved (e.g. dark or white poultry muscle) (AJUYAH et al., 1993).

The objectives of the present study were to determine the effect of feeding various fat sources (fish oil, linseed oil, sunflower oil and soy oil) and different oil supplementation levels (2, 4 and 8%) on the fatty acid composition of chicken muscles and, especially, on the n-6/n-3 ratio in broiler thigh meat. Furthermore, the effects of the different fatty acid sources on oxidative stability of broiler meat as indicated by malondialdehyde (MDA) levels were investigated.

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Materials and Methods

Animals and Diets

Nine hundred and sixty one-day-old unsexed chickens of the breed Cobb 500, obtained from a local hatchery, were used in this experiment, which lasted for 6 weeks. At the beginning of the trial, all chickens showed a similar average body weight (39.78–40.96 g). The chickens were divided into twelve dietary groups of 80 chickens each, with four replicates within each dietary group (20 birds per replicate). Chickens were kept in a floor system in pens with controlled environmental conditions. During the starter period the chicks were housed in electrically heated battery brooders placed in a temperature-controlled room. Twenty-four hours of lighting per day was provided.

Diets were formulated to meet or exceed all the nutritional requirements of the growing chick (NRC, 1994). Birds were given access to water and diets *ad libitum*. Diets were formulated by using fish oil (A), linseed oil (B), sunflower oil (C) and soybean oil (D), singly or in combination and by adding 2, 4 or 8% oil to a basal diet (Table 1). Diet D served as a control. The diets were prepared in mash form. All chickens up to the 3rd week of life were fed a starter diet. Following this period until the end of the experiment each group was fed an individual grower diet with approximately similar contents of crude protein and metabolizable energy.

Sample collection and laboratory analyses

Diets were chemically analysed for nutrients according to the methods of the AOAC (1984). Determined levels of nutrients and calculated metabolizable energy (ME, MJ/kg) are presented in Tables 2 and 3. The fatty acids profiles ((myristic acid, C14 : 0; palmitic acid, C16 : 0; palmitoleic acid, C16 : 1n7c; stearic acid, C18 : 0; oleic acid, C18 : 1n9c; linoleic acid, C18 : 2n6; α-linolenic acid, C18 : 3n3; arachidonic acid, C20 : 4n6; eicosapentaenoic acid (EPA), C20 : 5n3 and docosapentaenoicacid (DHA), C22 : 6n3; saturated (myristic acid, palmitic acid, and stearic acid); MUFA (palmitoleic acid and oleic acid); PUFA (linoleic acid, α-linolenic acid, arachidonic acid, EPA, and DHA); n-3 (linolenic acid, EPA and DHA); n-6 (linoleic acid and arachidonic acid)) of the starter and grower diets are presented in Tables 2 and 3.

Table 1. Composition of broiler starter (0–3 weeks) and grower (4–6 weeks) diets (%)
Zusammensetzung der Starter- (0–3 Wochen) und Grower-Rationen (4–6 Wochen) (%)

Ingredients	Starter (0–3 weeks, %)			Grower (4–6 weeks, %)		
	Groups [1]					
	A_1, B_1, C_1, D_1	A_2, B_2, C_2, D_2	A_3, B_3, C_3, D_3	A_1, B_1, C_1, D_1	A_2, B_2, C_2, D_2	A_3, B_3, C_3, D_3
Corn	57.55	43.55	29.55	48.59	49.66	37.64
Wheat	1.00	10.00	13.00	10.00	10.00	10.00
Wheat bran	1.50	3.00	11.00	1.00	1.00	10.60
Extracted soybean meal (45%)	26.10	29.10	20.10	17.40	26.40	28.80
Full fatt soybean	–	–	–	17.90	5.80	1.80
Extracted corn meal	8.00	5.00	6.00	–	–	–
Meat and bone meal	0.50	2.00	9.00	–	–	–
Oil	2.00	4.00	8.00	2.00	4.00	8.00
Limestone		1.20		1.12	0.88	1.00
Dicalcium phosphate		1.10		0.80	1.06	1.00
Vitamin + mineral premix [2]		0.20		0.25	0.25	0.25
Salt		0.25		0.30	0.27	0.25
DL-Methionine		0.20		0.19	0.19	0.19
L-Lysine		0.20		0.23	0.27	0.25
Anticoccidial [3]		0.10		0.12	0.12	0.12
Antioxidant [4]		0.10		0.10	0.10	0.10

[1] Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
[2] Composition of vitamin premix per kilogram of premix: vitamin A 30 000 IU; vitamin D_3 7500 IU; vitamin E 50 mg; vitamin K_3 12.5 mg; vitamin B_1 5 mg; vitamin B_2 15 mg; niacin 75 mg; Ca pantothenate 25 mg; vitamin B_6 7.5 mg; vitamin B_{12} 0.05 mg; folic acid 1.25 mg; D-biotin 0.2 mg; choline 10 mg
Composition of trace elements premix supplied per kilogram of premix: Mn 212.5 mg; Fe 125 mg; Cu 12.5 mg; Zn 150 mg; Co 1.25 mg; Iodine 5 mg; Se 0.375 mg
[3] Anticoccidial – Narasin 70 g/kg premix
[4] Antioxidant – Oxistop® Premix (Etoxiquinin, BHT, citric acid mixture)

Table 2. Nutrients content (%), energy levels (ME MJ/kg) and fatty acid composition (% of total methyl esters of fatty acids) of starter (0–3 week) diets
Nährstoffgehalt (%), Umsetzbare Energie (MJ/kg) und Fettsäuremuster (in% der Gesamtfettsäuren) der Starter-Rationen (0–3 Wochen)

	Groups [1]											
	A1 (2%)	A2 (4%)	A3 (8%)	B1 (2%)	B2 (4%)	B3 (8%)	C1 (2%)	C2 (4%)	C3 (8%)	D1 (2%)	D2 (4%)	D3 (8%)
Dry matter, %	87.80	88.50	89.90	88.20	88.80	89.70	88.10	88.50	89.50	88.30	88.80	89.40
Crude protein, %	22.70	22.40	21.50	22.30	22.70	21.00	22.00	22.30	20.70	22.40	22.40	20.70
Crude fibre, %	2.80	3.00	4.30	2.80	4.00	4.30	3.00	3.30	4.40	3.10	3.40	4.00
Ether extract, %	4.90	6.70	10.70	5.80	6.80	10.70	5.60	6.30	10.60	5.00	6.40	10.50
Ash, %	5.10	4.60	6.10	4.60	4.60	6.00	4.90	5.10	6.20	4.20	4.60	5.50
Nitrogen free extract, %	52.30	51.80	47.30	52.70	50.70	47.70	52.60	51.50	47.60	53.60	52.00	48.70
Sugar, %	4.70	6.00	4.80	5.10	5.40	4.50	5.10	5.30	4.50	5.00	4.90	4.30
Starch, %	39.30	33.80	29.50	37.30	33.70	31.30	37.40	35.50	32.40	39.80	38.30	34.30
ME MJ/kg [2]	12.37	12.19	12.55	12.34	12.18	12.74	12.24	12.23	12.84	12.48	12.70	13.10
Fatty acid composition												
C14 : 0	2.55	3.83	5.29	1.30	2.83	3.76	2.10	1.63	2.07	0.31	–	0.26
C16 : 0	13.08	14.47	16.04	11.65	13.59	14.84	12.26	11.89	11.18	10.81	10.72	10.38
C16 : 1n7c	2.86	4.54	6.13	1.48	3.29	4.26	2.26	1.82	2.34	0.52	0.23	0.32
C18 : 0	2.63	3.51	4.01	2.97	3.62	4.16	3.03	3.67	3.47	2.86	3.35	3.87
C18 : 1n9c	18.99	15.31	14.40	21.70	16.76	16.93	18.66	20.99	23.09	21.50	21.77	21.77
C18 : 2n6c	33.09	22.65	14.36	42.22	30.85	26.30	35.95	39.78	40.62	49.11	50.39	50.91
C18 : 3n3	1.76	1.79	1.37	2.65	3.15	2.88	2.68	2.89	3.00	3.99	5.26	6.21
C20 : 4n6	0.23	0.45	0.64	–	0.35	0.36	–	–	–	–	–	–
C20 : 5n3	0.71	1.07	1.58	–	–	–	0.18	–	–	–	–	–
C22 : 6n3	3.69	5.55	7.73	0.48	0.85	1.15	0.81	0.46	0.53	–	–	–
Total SFA [3]	30.27	33.59	32.91	28.23	36.60	37.68	33.87	29.51	25.23	24.07	21.40	18.92
Total MUFA [4]	23.57	22.98	24.77	26.06	26.65	29.79	25.47	26.59	29.85	22.51	22.76	23.25
Total PUFA [5]	45.82	41.25	39.35	45.58	36.09	31.72	39.83	43.59	44.48	53.10	55.65	57.22
Total n-6	33.21	23.16	15.17	42.22	31.20	26.48	35.96	39.79	40.63	49.11	50.39	50.91
Total n-3	12.61	18.10	24.18	3.36	4.89	5.24	3.87	3.81	3.85	3.99	5.26	6.31
n-6/n-3	2.64	1.28	0.63	12.59	6.40	5.07	10.19	10.45	10.67	12.32	9.58	8.07

[1] Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
[2] ME MJ/kg (WPSA) = (0.03431 × g/kg fat) + (0.01551 × g/kg crude protein) + (0.01669 x g/kg starch) + (0.01301 × g/kg sugar)
[3] SFA = saturated fatty acid; [4]MUFA = monounsaturated fatty acid; [5]PUFA = polyunsaturated fatty acid

Table 3. Nutrients content (%), energy levels (ME MJ/kg) and fatty acid composition (% of total methyl esters of fatty acids) of grower (4–6 week) diets
Nährstoffgehalt (%), Umsetzbare Energie (MJ/kg) und Fettsäuremuster (in% der Gesamtfettsäuren) der Grower-Rationen (4–6 Wochen)

	Groups[1]											
	A1 (2%)	A2 (4%)	A3 (8%)	B1 (2%)	B2 (4%)	B3 (8%)	C1 (2%)	C2 (4%)	C3 (8%)	D1 (2%)	D2 (4%)	D3 (8%)
Dry matter, %	88.70	88.80	89.30	88.80	88.50	89.80	88.60	88.50	89.90	89.10	89.20	90.30
Crude protein, %	20.20	20.30	20.20	20.40	20.50	20.70	20.40	20.40	19.80	19.80	20.90	20.00
Crude fibre, %	4.00	3.60	4.20	3.60	3.80	4.30	3.50	3.30	4.30	3.90	3.30	4.20
Ether extract, %	7.30	7.80	9.20	8.40	8.60	9.70	7.80	7.90	10.10	6.10	6.80	9.80
Ash, %	4.90	4.40	5.00	4.70	4.90	5.20	5.20	4.90	5.60	4.70	4.80	5.40
Nitrogen free extract, %	52.30	52.70	50.70	51.70	50.70	49.90	51.70	52.00	50.10	54.60	53.40	50.90
Sugar, %	4.70	5.30	4.70	5.10	4.90	5.30	4.90	4.90	4.80	4.90	6.00	5.40
Starch, %	39.80	40.80	32.90	36.80	38.30	34.50	39.10	40.50	34.10	38.60	37.90	34.50
ME MJ/kg[2]	12.89	13.32	12.39	12.85	13.16	12.99	13.00	13.27	12.85	12.24	12.68	12.92
Fatty acid composition												
C14 : 0	1.89	3.56	5.44	1.22	2.56	3.17	0.73	1.33	1.68	1.24	0.22	0.21
C16 : 0	12.41	13.99	16.10	11.94	12.78	13.72	11.37	11.19	11.97	11.57	10.85	10.72
C16 : 1n7c	2.12	4.15	6.03	1.37	2.91	3.71	0.89	1.56	1.92	1.42	0.28	0.19
C18 : 0	3.59	3.31	3.50	3.72	3.21	3.50	3.76	3.36	3.67	3.70	3.74	3.76
C18 : 1n9c	19.18	16.59	14.35	19.62	18.05	16.53	20.13	21.08	18.36	18.89	20.73	20.50
C18 : 2n6c	40.40	28.76	18.51	44.86	36.36	28.37	46.63	42.08	40.32	42.77	48.78	50.36
C18 : 3n3	4.38	2.67	1.88	5.03	3.70	3.24	5.31	3.51	4.82	4.89	5.38	6.31
C20 : 4n6	0.24	0.45	0.57	0.13	0.30	0.40	–	0.13	0.20	–	–	–
C20 : 5n3	0.17	0.34	0.48	0.15	0.18	7.39	1.37	3.22	4.12	–	–	–
C22 : 6n3	2.83	5.48	7.54	1.93	3.87	–	1.07	2.09	2.63	–	–	–
Total SFA[3]	27.08	34.99	42.02	23.97	29.34	28.35	23.54	23.88	24.04	25.64	23.13	21.30
Total MUFA[4]	26.27	29.43	32.31	24.88	27.59	23.60	22.08	24.03	22.25	21.92	22.05	21.78
Total PUFA[5]	46.24	34.45	24.51	50.89	42.12	46.13	54.38	51.81	53.15	52.14	54.83	56.93
Total n-6	40.64	29.28	19.18	44.97	36.78	28.92	46.63	42.15	40.53	42.85	48.78	50.36
Total n-3	5.60	5.16	5.33	5.92	5.33	17.21	7.75	9.67	12.62	9.29	5.91	6.57
n-6/n-3	7.26	5.67	3.60	7.60	6.90	1.68	6.02	4.36	3.21	4.76	8.27	7.68

[1] Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
[2] ME MJ/kg (WPSA) = (0.03431 × g/kg fat) + (0.01551 × g/kg crude protein) + (0.01669 × g/kg starch) + (0.01301 × g/kg sugar)
[3] SFA = saturated fatty acid; [4] MUFA = monounsaturated fatty acid; [5] PUFA = polyunsaturated fatty acid

At the end of starter and grower period, respectively (21st and 42nd day) two male broilers from each pen were randomly selected and slaughtered. Their legs were separated, vacuum packed and stored at −20 °C until analysis. The meat samples were analysed with double replicates of the same samples for fatty acids composition and lipid oxidation (thiobarbituric acid reactive substances, TBARS) levels.

Determination of fatty acids

Fatty acid in the diets and muscle tissues were determined by gas chromatography. For saponification and esterification of lipids a modified method of FOLCH et al. (1957) was used.

Exactly 1 g of diet and/or 1 g of meat were weighed into an Erlenmeyer flask. After supplementation of 25 ml chloroform: methanol mixture (2 : 1, v/v) the flask was stirred for 50 min. Then the sample was filtered into a 50 ml centrifuge tube. The filtered sample was covered with 5 ml H_2O bidest., stirred with a glass bar and centrifuged for 20 min in a Heraeus Multifuge 3 L-R at 2200 rpm under cooling to 4 °C. After centrifugation the solvent was removed and transferred to 100 ml gas bottle including NS 14. The solvent was then removed under vacuum 45 °C in a rotation evaporator until a small residue of 1 to 2 ml remained. The sample was dried in an excicator under vacuum for 2 hours using phosphor pentoxide.

After drying, the extracted fat was dissolved in 4 to 5 ml diethylether and transferred to a 10 ml screw glass. The solvent was removed under nitrogen. For derivatisation samples were boiled for 30 min. and boiled to 30 to 40 °C under running water. Fatty acids were esterified using boron trifloride-methanol (10%, Fluka Chemie, Switzerland). Samples were boiled again for 15 min., cooled to room temperature, 1 ml n-heptane was added and samples were vortexed twice. Samples were centrifuged for 1 min. at 4000 rpm and fatty acid methyl esters dissolved in the n-heptane phase were transferred to the glass vials. Samples were then frozen at −24 °C. An aliquot of each sample was diluted by 1 : 5 with n-heptane. 1 µl of this solution was injected manually into a Varian 3700 gas chromatograph (Varian Inc., Paolo Alto, USA) equipped with a DB 23 column (30 m × 0.25 mm × 25 µm; J&W Scientific, Folsom, USA). The stationary phase was (50%-cyanopropyl)-methylpolysiloxan. Nitrogen 5.0 was used as a carrier with flow rate of 1 ml/min. The temperature programme was as follows: 140/224 °C held 5 min., rate of heating was 3 °C/min. Temperature of injector and Flame Ionisation Detector (FID) was 200 °C and 260 °C, respectively.

The chromatograms were evaluated using the software Varian Star Chromatography Workstation Version 4.51. Fatty acid methyl esters were identified by retention times using Supelco 37 (Supelco, Bellefonte, USA) as an external standard.

Determination of TBARS

Determination of TBARS was done according to a modified method of KORNBRUST and MAVIS (1980). To 1 g of pooled meat sample 9 ml of 1.15% KCl was added. The

Table 4. Fatty acid composition (%) of broiler thigh muscle lipids (21. day)
Fettsäuremuster des Schenkelfleischs am 21. Lebenstag (%)

Fatty acid	Groups[1]												SEM[5]	P
	A			B			C			D				
	A1 (2%)	A2 (4%)	A3 (8%)	B1 (2%)	B2 (4%)	B3 (8%)	C1 (2%)	C2 (4%)	C3 (8%)	D1 (2%)	D2 (4%)	D3 (8%)		
C14 : 0	1.95^{bA}	2.31^{b}	3.89^{aA}	0.82^{AB}	1.65	1.69^{B}	1.14^{AB}	1.22	1.62^{B}	0.51^{B}	0.42	0.66^{B}	0.150	***
C16 : 0	18.48	19.18	17.32	19.52^{a}	19.18^{a}	15.01^{b}	19.00^{a}	16.92^{ab}	14.53^{b}	18.11	16.81	16.24	0.314	***
C16 : 1n7c	5.16	5.55	6.97^{A}	5.01	4.91	3.87^{B}	4.70	3.97	3.39^{B}	3.77	3.25	2.96^{B}	0.202	***
C18 : 0	6.29	6.94	5.56	6.27	6.73	5.41	6.17	6.15	6.02	6.34	5.50	6.73	0.153	*NS*
C18 : 1n9c	26.93	25.71	19.89	31.71	28.37	22.89	28.69	26.14	23.13	29.60	29.97	25.85	0.676	*NS*
C18 : 2n6c	20.23	17.50^{B}	13.95^{B}	22.45	21.68^{AB}	28.34^{AB}	20.98	24.74^{AB}	29.99^{AB}	26.30	29.63^{A}	30.46^{A}	0.881	***
C18 : 3n3	1.44	1.18^{B}	1.23^{B}	1.30	1.63^{AB}	2.62^{AB}	1.25	1.60^{AB}	1.88^{AB}	1.72	2.76^{A}	2.95^{A}	0.116	***
C20 : 4n6	1.19^{B}	1.10	1.02	1.24^{B}	0.96	1.45	1.21^{B}	1.41	1.40	2.07^{A}	1.53	1.49	0.057	**
C20 : 5n3	3.45^{b}	3.62^{b}	7.58^{aA}	0.72^{b}	2.36^{ab}	5.03^{aAB}	1.29	1.83	2.94^{B}	–	–	–	0.481	***
C22 : 6n3	2.37^{A}	1.54	2.34^{A}	0.41^{B}	0.63	1.16^{AB}	1.05^{AB}	1.14	0.45^{B}	–	0.42	0.47^{B}	0.156	***
Total SFA[2]	35.72	38.21	37.26	33.85	35.12	31.76	37.70	35.75	33.25	33.40	29.58	33.06	0.784	*NS*
Total MUFA[3]	35.31	35.55	35.26	39.30	37.49	31.73	36.17	33.18	30.60	35.28	34.86	30.94	0.636	*NS*
Total PUFA[4]	28.36	25.54	26.43	26.22	26.83	35.52	25.45	30.42	35.75	30.50	34.63	35.43	0.888	*NS*
Total n-6	21.12	19.28^{B}	15.18^{B}	23.80	22.64^{AB}	29.88^{A}	22.28	26.19^{AB}	31.31^{A}	28.61	31.45^{A}	32.10^{A}	0.920	***
Total n-3	7.24	6.26	11.25^{A}	2.42	4.20	5.64^{AB}	3.17	4.24	4.44^{B}	1.89	3.19	3.32^{B}	0.496	**
n-6/n-3	4.53^{B}	3.66	2.03^{B}	10.55^{AB}	6.21	6.38^{AB}	8.40^{AB}	7.10	8.56^{AB}	15.16^{A}	10.37	10.61^{A}	0.623	***

[1] Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
[2] SFA = saturated fatty acid;
[3] MUFA = monounsaturated fatty acid;
[4] PUFA = polyunsaturated fatty acid
[5] Values are means of twelve observations per treatment and their pooled SEM.
(a–b) Means within the same row with no common superscript differ significantly according to the fatty acid level ($p < 0.05$)
(A–B) Means within the same row with no common superscript differ significantly according to the fatty acid source ($p < 0.05$)
** $P < 0.01$; *** $P < 0.001$

Table 5. Fatty acid composition (%) of broiler thigh muscle lipids (42. day)
Fettsäuremuster des Schenkelfleischs am 42. Lebenstag (%)

Fatty acid	Groups[1]												SEM[5]	P
	A			B			C			D				
	A1 (2%)	A2 (4%)	A3 (8%)	B1 (2%)	B2 (4%)	B3 (8%)	C1 (2%)	C2 (4%)	C3 (8%)	D1 (2%)	D2 (4%)	D3 (8%)		
C14:0	1.21^{b}	1.80^{bA}	3.02^{aA}	0.99	1.47^{A}	1.82^{B}	0.70	0.83^{AB}	1.25^{BC}	0.51	0.35^{B}	0.40^{C}	0.122	***
C16:0	15.94	16.74	16.56^{A}	14.62	16.19	14.76^{AB}	16.79	14.48	13.95^{AB}	14.01	14.62	12.27^{B}	0.283	**
C16:1n7c	3.60	4.41^{A}	5.53^{A}	2.70	4.66^{A}	4.07^{AB}	3.57	2.92^{AB}	2.76^{BC}	2.06	2.15^{B}	1.54^{B}	0.196	***
C18:0	5.75	6.06	6.00	6.56	5.29	5.58	5.66	5.78	5.38	5.51	6.00	5.47	0.095	*NS*
C18:1n9c	22.59	19.89	15.91	18.43	23.78	19.43	24.79	21.68	20.23	22.15	25.03	20.17	0.635	*NS*
C18:2n6c	23.12^{aB}	16.36^{bC}	12.65^{bD}	25.40^{B}	23.08^{AB}	20.04^{C}	26.40^{AB}	24.66^{B}	28.47^{B}	32.90^{A}	28.70^{A}	36.46^{A}	0.975	***
C18:3n3	2.19^{abB}	1.20^{bB}	1.04^{aC}	2.23^{B}	2.18^{AB}	2.05^{BC}	2.44^{AB}	1.91^{AB}	2.79^{B}	3.32^{abA}	2.62^{bA}	3.89^{aA}	0.121	***
C20: 4n6	1.66	1.56^{B}	1.32	2.71	1.48^{B}	1.50	2.31	2.38^{AB}	1.53	2.73	3.67^{A}	2.61	0.129	***
C20: 5n3	2.05^{b}	3.34^{bA}	7.44^{aA}	1.56^{b}	2.85^{abAB}	3.87^{aB}	0.85	1.24^{B}	2.08^{C}	0.75	1.59^{AB}	0.29^{C}	0.306	***
C22: 6n3	2.57^{cA}	4.52^{bA}	8.30^{aA}	2.84^{bA}	3.33^{bAB}	5.19^{aB}	1.71^{AB}	2.22^{B}	2.72^{C}	0.75^{B}	0.70^{C}	0.95^{D}	0.321	***
Total SFA[2]	40.11	46.40	45.78	43.35	35.74	40.52	36.64	40.61	37.80	33.01	37.46	32.18	0.968	*NS*
Total MUFA[3]	26.25	24.83	20.87	20.86	28.75	23.56	28.36	24.60	23.02	24.29	27.24	21.75	0.701	*NS*
Total PUFA[4]	32.77	27.68^{B}	32.42^{B}	34.71	34.00^{AB}	34.54^{B}	33.92	33.71^{AB}	38.35^{AB}	41.07^{ab}	35.63^{bA}	44.77^{aA}	0.732	***
Total n-6	25.07^{aB}	17.87^{bC}	13.53^{bD}	28.30^{aB}	24.76^{abB}	21.62^{bC}	28.58^{B}	27.16^{AB}	30.03^{B}	36.12^{abA}	31.96^{bA}	39.45^{aA}	1.054	***
Total n-3	8.70^{b}	10.98^{bA}	18.90^{aA}	7.54^{b}	9.24^{abAB}	12.93^{aB}	6.00	6.56^{B}	8.33^{C}	4.94	3.68^{C}	5.31^{C}	0.621	***
n-6/n-3	2.89^{B}	1.61^{B}	0.73^{C}	4.23^{B}	3.61^{B}	1.74^{BC}	4.77^{AB}	4.21^{B}	3.99^{B}	7.47^{A}	8.83^{A}	7.56^{A}	0.382	***

[1] Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
[2] SFA = saturated fatty acid;
[3] MUFA = monounsaturated fatty acid;
[4] PUFA = polyunsaturated fatty acid
[5] Values are means of twelve observations per treatment and their pooled SEM.
(a–c) Means within the same row with no common superscript differ significantly according to the fatty acid level ($p < 0.05$)
(A–D) Means within the same row with no common superscript differ significantly according to the fatty acid source ($p < 0.05$)
** $P < 0.01$; *** $P < 0.001$

sample was shortly homogenized in an Ultra-Turrax T 25 at 9,000 rpm. 0.1 ml of sample homogenate was added to a screw tube with 0.5 ml of 80 mM tris-malat-buffer (pH 7.4), 0.2 ml of 5 mM iron sulphate solution and 0.2 ml of 2 mM ascorbic acid. In two tubes 0.1 ml 1.15 of% KCl was added instead of the homogenate for determination of blind values. All samples were then treated in the same way. 2 ml of TBA-TCA-HCl reagent (150 g trichlor acetic acid and 3.75 g thiobarbituric acid solved in 1 l of 0.25 n HCl) were added to each sample, tubes were closed and strongly vortexed for 30 sec. Samples were then boiled for 30 min. and cooled in ice to stop the reaction. After centrifugation of samples at 2200 rpm at 4 °C for 20 min., samples were measured in a glass cuvette at a wave length of 535 nm using a Zeiss PM 2 DL photometer. TBARS were calculated as nmol malondialdehyde (MDA)/mg of meat as MDA = (6.4102 × 1000 × 3 × extinction)/100.

Statistical Analysis

Data were analysed by ANOVA, using two-way procedure of General Linear Model's (MINITAB, 1991). Differences between means were determined using the TUKEY (HSD) multiple range test. All statements of significance are based on a probability of less than 0.05 (SNEDECOR and COCHRAN, 1980).

Results

Analysed nutrients, calculated metabolizable energy (ME MJ/kg) levels of broiler diets are shown in Tables 2 and 3. The differences in contents of crude protein, ether extracts and ME of starter and grower diets probably occurred by random. A clear increase in ME contents was observed for increasing oil supplementation levels only for treatment D (soybean oil). The fatty acids profiles of the starter and grower diets varied in the expected way according to the dietary oil source and levels (Table 2 and 3, respectively). Only diets with fish oil contained some relevant proportions of EPA and DHA.

The profiles of fatty acids determined in broiler thigh meat are summarized in Table 4 for the 21st day and in Table 5 for the 42nd day, respectively. Effect of fat source on lipid composition of thigh meat was more pronounced than the level of fat supplementation (2, 4 and 8%). Fatty acid profiles in thigh meat differed significantly on the 21st day (Diet A, B and C) and on the 42nd day (Diet A, B and D) ($p < 0.05$). The effects were greater on day 42 than on day 21. Fatty acid profiles in thighs were similar to the respective profiles in diets. According to both fat source and fat level, the broiler group fed with 8% oil (A3, B3, C3 and D3) showed the highest n-3 fatty acid content in thigh meat in comparison to the other oil levels (2 and 4%). Important statistical differences ($p < 0.05$) for the thigh meat were observed between treatments for myristic acid, palmitic and EPA on day 21 and myristic acid, linoleic acid, linolenic acid, EPA, DHA, n-6, n-3 and PUFA on day 42. Furthermore, there were statistical differences between palmitic acid, stearic acid, and oleic acid, MUFA and PUFA on day 42 depending on the fatty acid source added to the diet.

Linoleic acid, linolenic acid and arachidonic acid levels in the thigh meat samples taken at the 21st and 42nd days from the groups fed the diet with soybean oil supplementation (Diet D) were statistically higher ($p < 0.05$) than the other groups (A, B and C). Generally, broilers fed with diets including fish oil (A, B and C) had statistically higher EPA and DHA levels in thigh meat than broilers fed with soybean oil (Diet D). Also, thigh meat of the soybean oil group (Diet D) showed a high level of n-6 fatty acids and thigh meat of the fish oil group showed a high level of n-3 fatty acids. Due to this, the ratio of n-6/n-3 PUFA was found to be lower at the 21st and 42nd day for broilers fed with diets including fish oil with different levels ($p < 0.05$).

The results on lipid peroxidation as indicated by the level of malondialdehyde (MDA, nmol/mg) are presented in Table 6 for the 21st and 42nd day. The fatty acid profile of the dietary fat as well as the level of fat supplementation was important for the MDA level. Thigh meat from birds fed with diets including fish oil showed higher MDA levels than thigh meat of the soybean oil fed chickens. This effect was more evident in thigh meat taken at the end of the experiment. In most cases treatment as well as incubation time were revealed statistical differences ($p < 0.05$). In-group A3, where 8% of fish oil alone was used, the oxidation levels were quite high from the beginning of the test on day 21 and on day 42. The critical level of 1 nmol/mg meat, which is indicates rancidity, was not reached on day 21 in the soybean oil treatment with a supplementation level of 2% (D1). For the fish oil treatments the critical level was achieved already with 15 min. of incubation for all supplementation levels. A very early onset of oxidation was also observed for the combination of fish oil, linseed oil and sunflower oil. In general, oxidation levels after 150 min. of incubation on day 42 were lower than on day 21 for almost all treatments.

Discussion

It is well known that the dietary fat content affects the *de novo* synthesis of triglycerides and hence influences the fatty acid pattern of adipose tissues. The determined fatty acid composition of diets reflected the composition of the supplemented oils (Table 2 and 3). In our study, linoleic acid in broiler starter feeds varied between 14.36–50.91% and in grower feeds between 18.51–48.78%, respectively. High-level linoleic acid diets increase the degree of unsaturation in tissues and by this increases the oxidation sensitivity of meat (LOPEZ-BOTE et al., 1997; ZOLLITSCH et al., 1997; SANZ et al., 1999). In our study the corn content was 29.55–57.55% in the starter diet and 37.64–49.66% in the grower diet. The wheat contents were 1.0–13.0% and 10.0% in starter and grower diets (Table 1). Corn oil has more than 50% linoleic acid compared to wheat and for this reason linoleic acid level was higher in corn based broiler diets (WISEMAN, 1997). Saturated fatty acids levels in starter diets were determined as 18.92 to 37.68% and in grower diets this level varied between 21.30 and 42.02%.

As expected, the profile of the dietary oils was reflected by the fatty acid composition of the various lipid fractions in the thigh meat of broiler chickens (Table 4 and 5). Fat source influenced lipid composition of thigh meat more than level of dietary fat (2, 4 and 8%). According to the fat source added to the diet on day 21 (Diet A, B and C) and on day 42 (Diet A, B and D) significant differences of thigh meat fatty acid levels ($p < 0.05$) were observed. The broiler group fed with 8% oil (A3, B3, C3 and D3) showed fatty acid profile in thigh meat different from the other oil levels (2 and 4%). Oils added to broiler diets influence carcass fat quality due to their fatty acid content (PHETTEPLACE and WATKINS, 1989 and 1990; SKLAN and AYAL, 1989; FRITSCHE et al., 1991; OLOMU and BARACOS,

Table 6. Malondialdehyde (MDA) concentrations in thigh muscle of broiler (nmol/mg)
Gehalte an Malondialdehyd (MDA) im Schenkelfleisch (nmol(mg)

Minute	Groups*												SEM**	P
	A			B			C			D				
	A1 (2%)	A2 (4%)	A3 (8%)	B1 (2%)	B2 (4%)	B3 (8%)	C1 (2%)	C2 (4%)	C3 (8%)	D1 (2%)	D2 (4%)	D3 (8%)		
	21. day													
0	0.55^{b}	0.65^{b}	1.64^{aA}	0.31	0.68	0.66^{B}	0.43	0.42	0.82^{B}	0.16	0.21	0.41^{B}	0.064	***
15	1.45^{b}	1.49^{ab}	2.88^{aA}	0.52	1.32	1.46^{B}	1.01	1.04	1.64^{AB}	0.37	0.47	0.76^{B}	0.113	***
30	1.54	1.74	2.89^{A}	0.66	1.70	1.77^{AB}	1.13	1.42	2.05^{AB}	0.45	0.74	0.80^{B}	0.125	***
45	1.99	2.03	3.49^{A}	0.80	1.83	2.20^{AB}	1.43	1.66	2.23^{AB}	0.53	0.65	1.15^{B}	0.138	***
60	2.11^{abA}	1.67^{b}	3.38^{aA}	0.95^{AB}	2.04	2.33^{AB}	1.51^{AB}	1.90	2.33^{AB}	0.56^{B}	0.70	1.26^{B}	0.137	***
90	2.52^{A}	1.85^{AB}	3.47^{A}	0.90^{bB}	2.41^{aA}	2.20^{abAB}	1.69^{AB}	1.98^{AB}	2.58^{AB}	0.67^{B}	0.83^{B}	1.57^{B}	0.140	***
120	2.60^{A}	2.08^{AB}	3.19	1.17^{bB}	2.69^{aA}	2.16^{ab}	1.86^{AB}	2.17^{AB}	2.63	0.78^{B}	1.07^{B}	1.69	0.122	***
150	2.91^{A}	2.34^{AB}	3.03	1.34^{bB}	3.01^{aA}	2.33^{ab}	1.96^{AB}	2.37^{AB}	2.87	0.90^{B}	1.31^{B}	1.82	0.123	***
	42. day													
0	0.44^{b}	0.62^{b}	1.44^{aA}	0.42	0.62	0.72^{B}	0.19	0.27	0.76^{AB}	0.23	0.18	0.22^{B}	0.065	***
15	0.76^{b}	1.11^{b}	2.50^{aA}	0.72^{b}	1.21^{ab}	1.85^{aAB}	0.33	0.63	1.31^{BC}	0.38	0.25	0.43^{C}	0.116	***
30	1.00^{b}	1.29^{b}	2.81^{aA}	0.82^{b}	1.44^{ab}	2.26^{aAB}	0.45^{b}	0.73^{ab}	1.65^{aBC}	0.50	0.40	0.53^{C}	0.129	***
45	1.67^{b}	1.50^{bAB}	2.95^{aA}	0.89^{b}	1.82^{abA}	2.22^{aAB}	0.50^{b}	0.92^{abAB}	1.74^{aBC}	0.57	0.43^{B}	0.71^{C}	0.130	***
60	1.27^{b}	1.57^{bAB}	3.02^{aA}	1.16^{b}	1.79^{abA}	2.33^{aAB}	0.53^{b}	1.02^{abAB}	1.83^{aBC}	0.79	0.49^{A}	0.74^{C}	0.128	***
90	1.56^{b}	1.79^{bA}	2.92^{aA}	1.33	1.96^{A}	2.36^{A}	0.68^{b}	1.89^{abAB}	2.11^{aAB}	0.93	0.65^{B}	0.96^{B}	0.118	***
120	1.90^{A}	1.94^{A}	2.63^{A}	1.47^{bAB}	2.02^{abA}	2.57^{aA}	0.88^{bB}	1.35^{abAB}	2.25^{aA}	1.22^{AB}	0.84^{B}	1.15^{B}	0.104	***
150	1.86	2.02^{A}	2.81^{A}	1.61	2.34^{A}	2.42^{A}	1.21^{b}	1.36^{abAB}	2.33^{aA}	1.41	0.94^{B}	1.26^{B}	0.099	***

* Groups: A) fish oil (FO); B) 2/3 FO + 1/3 linseed oil (LO); C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO); D) soy oil (SO)
** Values are means of twelve observations per treatment and their pooled SEM.
(a–b) Means within the same row with no common superscript differ significantly according to the fatty acid level ($p < 0.05$)
(A–C) Means within the same row with no common superscript differ significantly according to the fatty acid source ($p < 0.05$)
*** $P < 0.001$

1991; CHANMUGAM et al., 1992; SCAIFE et al., 1994; SANZ et al., 1999; ÖZPINAR et al., 2003). Especially vegetable oil improves the quality of meat (LOPEZ-FERRER et al., 1999) due to the desaturation and elongation occurring during lipid metabolism for membrane formation (YAU et al., 1991).

Meat samples taken at the end of the starter period (21st day) showed statistically significant differences between the groups ($p < 0.05$) for myristic acid, palmitic acid and EPA in respect of fatty acid level. Also, at the end of the experiment (42nd day), fatty acids composition of thigh meats was significantly different between the broiler groups, especially for content of myristic acid, linoleic acid, linolenic acid, EPA, DHA, n-6, n-3 and PUFA ($p < 0.05$). In this experiment, the highest linoleic acid (C18 : 2n6) level was found in broiler meat of the soybean oil groups ($p < 0.05$). It is known that arachidonic acid (C20 : 4n6) is a specific component of animal tissues, whereas, linoleic acid is mainly found in vegetable oils, especially in soy oil (WISEMAN, 1997). The arachidonic acid content in the thigh meat was higher than in the diet, although this finding was not closely associated with the linoleic acid content in the diet, as suggested by LOPEZ-FERRER et al. (2001a), SCAIFE et al. (1994) and YAU et al. (1991). A minimum of arachidonic acid might remain constantly in tissues to ensure certain metabolic processes (LOPEZ-FERRER et al., 2001a).

On day 42 of the experiment, n-6 fatty acids and n-6/n-3 ratio in thigh meat of group A, B and C, where fish oil was used in the diet, was lower, and n-3 level was higher than in the group D. This result is in accordance with the study of HARGIS and VAN ELSWYK, 1993. They found out that if poultry is fattened with diets containing fish oil, n-6 fatty acids and n-6/n-3 PUFA ratio decreased significantly and n-3 PUFA content increased in comparison with the soy oil group (Diet D).

Many studies have examined the effects of dietary long chain polyunsaturated fatty acids (PUFA), supplied by fish oil or fish meal, on the fatty acid composition of broiler carcasses (PHETTEPLACE and WATKINS, 1989; LOPEZ-FERRER et al., 1999). These studies have clearly demonstrated that muscle tissues can be enriched by n-3 PUFA.

It was found that if linseed oil (Diet B and C) is used instead of only fish oil (Diet A) in the diet, the amount of n-6 fatty acid in meat's increase. Also, when the proportion of fish oil decreased and vegetable oil was added to the diet, the saturation of meat fatty acids decreased. Related to this, in another study (LOPEZ-FERRER et al., 1999 and 2001b) where linseed oil was used instead of fish oil in the diet, n-6 fatty acids in meat increased and saturation decreased. Using different levels of linseed oil in the diets, CHANMUGAM et al. (1992) found that fatty acid composition in meat was altered significantly. In the present study, according to the type of oil and the level of supplementation, the highest n-6/n-3 fatty acids ratio was observed at the highest supplementation level. This was primarily due to a considerable accumulation of α-linolenic acid in the birds fed fish oil and linseed oil (Diet B and C).

Omega-6/omega-3 ratio was lowest for fish oil ($p < 0.05$) and the PUFA level changed depending on the type of oil and dietary level. In the study, birds supplemented with linseed or fish oil showed a significant decrease in the n-6/n-3 fatty acid ratio in thigh muscle lipids compared to the Diet D. BOUDREAU et al. (1991) has indicated that the dietary n-6/n-3 fatty acid ratio may be more important than the absolute amount of dietary n-3 fatty acids in the inhibition of arachidonic acid metabolism. A high n-6/n-3 ratio leads to a high level of arachidonic acid production, which may inhibit the synthesis of eicosanoids of the n-3 fatty acid family and restrict the conversion of α-linolenic acid to long-chain n-3 fatty acids (EPA and DHA) (AJUYAH et al., 1993).

Oxidation of lipid components in muscle tissues is a major cause of quality deterioration and short shelf life after slaughter. The TBARS values, expressed as MDA concentration, are a good index reflecting the degree of oxidation (GUO et al., 2001). In this study tissues from broilers fed fish oil diets had a statistically higher lipid peroxidation level ($p < 0.05$). The high lipid peroxidation level (MDA) determined at the 21st days in Group A and B. At the 42nd day in the groups' (A, B and C) thigh meat lipid peroxidation level was higher than in soybean oil group (D) because fish oil is rich in unsaturated fatty acids (Table 6). This fact can be attributed to the polyunsaturated fatty acids content of which are known to be very prone to oxidation. It is reported that a high level of linoleic acid in the ration causes a higher degree of unsaturation in the fat tissue and increases the oxidation sensitivity of meat (LOPEZ-BOTE et al., 1997; ZOLLITSCH et al., 1997).

On the other hand, EPA is among the most biologically important fatty acids included in the human diet. A high EPA content would improve not only the meat but also the regulation of human lipid metabolism (KINSELLA et al., 1990; KNAPP, 1991). This improvement requires assessment of the oxidative control of the n-3 long chain PUFA enriched meat; highly polyunsaturated meat is highly susceptible to oxidative processes, which may harm human health (HAMILTON, 1989).

The results of the current study indicate that feeding a diet containing an oil source leading to a desired fatty acid composition of the resulting tissue might customize the fatty acid profiles of broiler tissues. But, using fish oil and vegetable oil rich in long chain unsaturated fatty acids in broiler diets may result in an increased fatty acid oxidation in meat compared to dietary oil sources.

Summary

The aim of the experiment was to determine the effect of feeding various fat sources (fish oil, linseed oil, sunflower oil and soy oil) and different oil levels (2, 4 and 8%) on the fatty acid composition of chicken muscles and, to raise the content of long chain n-3 PUFA (EPA and DHA) to decrease the n-6/n-3 ratio in broiler carcasses. Furthermore, the effects of the different fatty acid sources on oxidation stability of broiler meat as indicated by malondialdehyte (MDA) levels should be investigated.

Nine hundred and sixty one-day-old unsexed chickens of the breed Cobb-500 were used this experiment, which lasted for 6 weeks. The chickens were divided into twelve dietary groups, 80 chickens in each, with four replicates (20 birds per replicate). Birds were given access to water and diets *ad libitum* that were formulated adding 2, 4 and 8% oil to a basal diet. Four dietary fat sources or combinations were applied: 1/1 fish oil (FO; diets A1, A2, A3); 2/3 FO + 1/3 linseed oil (LO; diets B1, B2, B3); 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO; diet C1, C2, C3); and 1/1 soy oil (SO; diets D1, D2, D3) were used.

Fat source influenced lipid composition of thigh meat more than level of fat (2, 4 and 8%). According to the fat source added to the diet at the 21st day (diet A, B and C) and at the 42nd day (A, B and D), significant differences of thigh meat fatty acid levels were observed ($p < 0.05$). Thigh meat from broiler groups fed with 8% oil (A3, B3,

C3 and D3) showed a different fatty acid profile to the other oil levels (2 and 4%).

Broilers fed with fish oil (A, B and C) had statistically higher EPA and DHA levels in thigh meat ($p < 0.05$) than broilers fed with soy oil (Diet D). Also, thigh meat of the soybean oil fed group (Diet D) showed a high-level n-6 group fatty acid and the fish oil group's thigh meat showed high-level of n-3 fatty acids. The n-6/n-3 ratio was lowest for fish oil ($p < 0.05$) and the PUFA level changed depending on the type of oil and dietary level.

The MDA level in the thigh meat was more affected by the dietary fatty acid source than by the level of fat. MDA level in thigh meat was increased ($p < 0.05$) with the increasing of the percentage of the dietary oil.

The results of the current study indicate that feeding a diet containing an oil source leading to a desired fatty acid composition of the resulting tissue might customize the fatty acid profiles of broiler tissues. But, using fish oil and vegetable oil rich in long chain unsaturated fatty acids in broiler diets may result in an increased fatty acid oxidation in muscle tissues.

Keywords

Broiler, nutrition, linseed oil, fish oil, sunflower oil, soybean oil, fatty acids, malondialdehyde, TBARS

Zusammenfassung

Einfluss verschiedener Futterfettquellen auf das Fettsäurenmuster und die Gehalte an Malondialdehyde im Schenkelfleisch von Broilern

Das Ziel der Untersuchung war die Bestimmung der Auswirkung verschiedener Futterfettquellen (Fischöl, Leinöl, Sonnenblumenöl, Sojaöl), die den Rationen in unterschiedlichen Kombinationen und Mengen (2, 4, 8%) zugesetzt wurden, auf das Fettsäuremuster der Muskelgewebe von Broilern im Hinblick auf eine Erhöhung des Gehaltes an langkettigen, mehrfach ungesättigten Omega-3 Fettsäuren (EPA und DHA) und auf eine Verminderung des Omega-6/Omega-3-Verhältnisses. Ferner sollten die Effekte der Fettsäuren auf die Oxidationsstabilität des Fleisches anhand der Gehalte an Malondialdehyd (MDA) untersucht werden.

In dem Versuch wurden 960 unsortierte Eintagsküken der Herkunft Cobb 500 verwendet. Der Versuch dauerte 6 Wochen und umfasste 12 Behandlungen. Jede Behandlung umfasste 80 Tiere, die auf je vier Wiederholungen a 20 Tiere aufgeteilt waren. Die Broiler erhielten Wasser und Futter ad libitum. Folgende Fettquellen bzw. Kombinationen von Fettquellen, die in der Höhe von 2, 4 und 8% eingemischt wurden, wurden eingesetzt: 1/1 Fischöl (FO) (Rationen A1, A2, A3); 2/3 FO + 1/3 Leinöl (LO) (Rationen B1, B2, B3); 1/3 FO + 1/3 LO + 1/3 Sonnenblumenöl (SFO) (Rationen C1, C2, C3); 1/1 Sojaöl (SO) (Rationen D1, D2, D3).

Die Fettquelle wirkte sich stärker auf die Lipidzusammensetzung im Schenkelfleisch aus als die Höhe der Fettzulage (2, 4 oder 8%). Signifikante Unterschiede ($P < 0,05$) im Fettsäuremuster des Schenkelfleischs wurden am 21. Lebenstag für die Rationen A, B und C und am 42. Lebenstag für die Rationen A, B und D registriert. Das Schenkelfleisch der Tiere, die eine 8%ige Fettzulage zur Ration (A3, B3, C3, D3) erhielten, wies im Vergleich zu den anderen Fettzulagestufen (2 und 4%) ein unterschiedliches Fettsäuremuster auf.

Mit Fischöl (Rationen A, B und C) gefütterte Broiler wiesen signifikant höhere Gehalte an EPA und DHA im Schenkelfleisch auf ($P < 0,05$) auf als mit Sojaöl gefütterte Broiler (Ration D). Das Schenkelfleisch der mit Sojaöl gefütterten Tiere hatte einen höheren Gehalt an Omega-6 Fettsäuren und das Schenkelfleisch der mit Fischöl gefütterten Tiere einen höheren Gehalt an Omega-3 Fettsäuren. Das geringste n-6/n-3 Verhältnis wurde für Fischöl ($P < 0,05$) registriert. Der Gehalt an PUFA variierte in Abhängigkeit von der Futterfettquelle und der Zulagenhöhe.

Die Fettquelle hatte einen größeren Einfluss auf den MDA-Gehalt im Schenkelfleisch als die Zulagenhöhe. Dennoch nahm mit der Höhe der Fettzulage im Futter der MDA-Gehalt im Schenkelmuskel zu.

Die Ergebnisse der vorliegenden Untersuchung deuten darauf hin, dass durch eine entsprechende Wahl der Futterfettquelle das Fettsäuremuster in den Geweben in einer positiven Richtung verändert werden kann. Allerdings erhöht die Verwendung von Fischöl oder Pflanzenölen mit hohen Gehalten an PUFA das Risiko der Fettoxidation in den Muskelgeweben.

Stichworte

Broiler, Fütterung, Leinöl, Fischöl, Sonnenblumenöl, Sojaöl, Malondialdehyd, TBARS

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