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Influence of vegetable oil sources on quality parameters of broiler meat

Einfluß der pflanzlichen Fettquelle im Futter auf die Qualitätsmerkmale von Broilerfleisch

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Introduction

The use of different vegetable oils in animal nutrition has allowed the producer to obtain highly energetic diets at very low costs, while offering an optimum and well-appreciated product to the consumer. Nowadays, numerous efforts are undertaken to enrich poultry meat with poly-unsaturated fatty acids (PUFA) and, especially, with omega-3 fatty acids, because of the proven benefits on human health (KINSELLA et al., 1990; KNAPP, 1991). But, up to now there have not been done complementary studies dealing with the influence of such nutritive improvements on the different technological characteristics of poultry meat. Besides this, there also exist few experiments dealing with the influence of the enrichment with PUFA on the subjective parameters of organoleptic quality. Those experiments are usually more related to the use of fish ingredients in animal diets.

The aim of the present experiment was to study the effects of different vegetable oils (rapeseed, soybean, sunflower and linseed) on the technical, nutritive and organoleptic quality of chicken meat, and on the profiles of essential fatty acids (EFA) in the cloacal fat and in the tissues.

Materials and Methods

Animals and diets

A trial with 2,240 one-day-old unsexed broiler chickens of the Cobb breed, distributed into four different dietary treatments and randomly arranged in eight boxes per treatment (70 birds per box) has been performed in a controlled environment chamber in the Unterer Lindenhof experimental station at the University of Hohenheim. Feed and water were given ad libitum. The composition of diets is described in Table 1. The diets were formulated by adding 8% of soybean oil (SO), rapeseed oil (RO), sunflower oil (SFO) or linseed oil (LO) to a basal diet which met the requirements recommended by the National Research Council (1994). The fatty acid (FA) profiles of the experimental diets are shown in Table 2.

At the age of 5 wk, all the animals were weighed and marked individually by wing tacs. The slaughtering was done at the poultry slaughter facility at the research station 'Unterer Lindenhof' of the University of Hohenheim. Weights of bled, scalded, plucked and eviscerated (removal of gastrointestinal tract, head, neck and feet, as well as of the abdominal fat, considered as the fat extending within the ischium, surrounding the cloaca, and adjacent to the abdominal muscle) carcasses were recorded. The carcass yield and the proportion of the abdominal fat were calculated as percent of live weight. The fresh carcasses were dissected for further analyses and the weights of the valuable parts (breast muscle and thighs) were recorded.

The tissue samples for FA analysis (5 thighs and 5 samples of abdominal fat per treatment), were freeze-dried (FTS Systems model) before analyses. The total diet lipids and tissues (excluding skin) were extracted according to FOLCH et al. (1957) and methylated with 5% boron trifluoride methanol complex in methanolic solution (MORRISON and SMITH, 1964). The lipid composition was determined at the Animal Nutrition and Feeding Unit of the Universitat Autònoma de Barcelona by means of gas chromatography in a Shimadzu GC-14A chromatograph[3] equipped with a BPX70 fused silica capillary column (SGE capillary column, length 30 m, I.D. 0.53 mm, 0.5 mm; 70% cyanopropyl polysilphenylene-siloxane stationary phase) film and a flame ionization detector. The operating conditions of the Gas Chromatograph were as follows: the initial temperature was 75 °C, increasing by 4 °C/min to 148 °C; from 148 to 158 °C, the temperature was increased by 2.5 °C/min; from 158 to 225 °C the temperature was increased at the rate of 5 °C/min. The temperature of the injector and the detector remained stable at 280 °C. The column head pressure of the conductor gas (Helium) was 1.30 g/cm^2. The FA percentage was integrated and calculated using the CLASS-Unipac Program, by Shimadzu Europa GmbH (HPLC Group)[4], by means of direct normalisation of the peak areas. Each FA was identified in the form of a methyl ester by comparing the retention times with the standard of Sigma Química S.A.[5]

Moreover, 10 samples per treatment of each kind of tissue (breast and abdominal fat) were separated after quartering and stored at −20 °C until analyses of TBArs were made (both tissues a week later and breast samples also after twelve months of storage) according to the methodology described by TARLADGIS et al. (1960).

15 breasts and 12 thighs per treatment were also separated and frozen at −20 °C until sensory analyses were carried out. The sensory analysis of the samples of breast

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Table 1. Percentage composition of experimental diets
Zusammensetzung der Versuchsrationen (%)

Ingredients	%
Extruded Soybean (48% C.P.)	36.11
Wheat	35.79
Wheat Starch	10.00
Added fat[1]	8.20
Oats	5.00
Dicalcium phosphate	1.86
Calcium propionate	1.00
Limestone	0.48
Sodium bicarbonate	0.36
DL-Methionine	0.27
Salt	0.26
Vitamin Premix[b]	0.23
Choline chlorate	0.20
Trace Elements Premix[c]	0.06
L-Lysine	0.06
Threonine	0.06
Monensin- Sodium	0.05
Antioxidant Buthylhydroxytoluol	0.02
Calculated Nutrient Content	
ME, kcal/kg	3190
Crude Protein	25.12
Fat	9.95
Calcium	1.02
Available P	0.50
Met + Cys	0.95
Lysine	1.35

Chemical Analyses of diets	SO	RO	SFO	LO
Dry Matter	90.01	90.24	89.99	90.34
Crude Protein	25.12	24.99	25.07	24.97
Crude Fat	6.12	6.01	6.30	6.32
Ash	10.41	10.95	10.27	11.08
Crude Fiber	3.12	2.95	2.91	3.06
Crude Energy, kcal/kg	4580	4602	4525	4681

[1] SO: diet with 8.2% Soybean Oil; RO: diet with 8.2% Rapeseed; SFO: diet with 8.2% Sunflower Oil, LO: diet with 8.2% Linseed Oil
[a] Vitamin and mineral content of diets gave as follows per kilogram of diet: vitamin A, 13,500 IU; vitamin D_3, 3375 IU; vitamin E, 34 mg; riboflavin, 6 mg; pantothenic acid, 16 mg; nicotinic acid, 56 mg; choline, 2000 mg; folic acid, 1.13 mg; vitamin B_{12}, 34 µg; Mn, 72 mg; Zn, 48 mg
[b] Composition of Vitamin Premix Vit-Vorm 6/1.5 gave as follows per kilogram of Premix: vitamin A, 6,000,000 IU; vitamin D_3, 1,500,000 IU; vitamin E, 15,000 mg; riboflavin, 3,000 mg; pantothenic acid, 7,000 mg; nicotinic acid, 25,000 mg; folic acid, 500 mg; vitamin B_{12}, 15,000 µg. Supplied by Animedica (Horb, Germany)
[c] Composition of Trace Elements Premix SpürElevor SG1 gave as follows per kilogram of Premix: Mn, 120,000 mg; Zn, 80,000 mg; Fe, 90,000 mg; Cu, 15,000 mg; I, 1,600 mg; Se, 500 mg; Co, 600 mg Supplied by Animedica (Horb, Germany)

and thigh muscles, which had been prepared according to the World's Poultry Science Association (1987) methodology, was carried out by a trained sensory panel composed of six trained individuals. The panel assessed the subjective parameters of meat quality in a triangular test (Seemann, 1981) on the basis of flavor and general impression.

The objective parameters of meat quality were conducted 48 h after slaughtering of the animals on all the left breasts of 16 individuals per treatment. These analyses included juiciness, carried out according to the methodology of Grau and Hamm (1953) using the modified technique of the 'Braunschweiger Model' (Grashorn, 1995). The grill losses were determined by difference of weight of all the left breasts of the samples, before and after cooking them, wrapped in aluminium foil, in a double-plated grill at 200 °C. The internal temperature of the portions was controlled and samples were kept into the grill until 85 °C of internal temperature was reached. Besides, tenderness was conducted on cooked samples of breast (circular portions of 2 cm in diameter, prepared according to the technique described by Seemann, 1985) by following the methodology of Ehinger (1977). Texture of samples was measured using the Warner Brazler shear tool in an INSTRON Model 4301. Maximum shear force and total energy required were calculated using the Software Serie IX of INSTRON (version 4.09a).

Statistical Analysis

The performance and analytical data obtained were subjected to an analysis of variance using the GLM procedure of the SAS program (SAS Institute; 1994). For statistically significant differences, means were compared using the LSD method. The sensory data were analysed according to the methods described by Seemann (1981).

Table 2. FA composition of experimental diets
Fettsäureprofile der Versuchsrationen (in % der Gesamtfettsäuren)

Fatty Acid	experimental diets[1]			
	SO	RO	SFO	LO
	(% of the total methyl esters of fatty acids)			
14:0	0.08	0.13	0.07	0.05
14:1 ω7	0.00	0.00	0.00	0.00
14:1 ω5	0.00	0.00	0.00	0.00
15:0	0.00	0.00	0.00	0.00
16:0	9.97	7.21	8.26	5.38
16:1 ω7	0.09	0.29	0.00	0.04
17:0	0.08	0.05	0.00	0.00
17:1 ω7	0.01	0.00	0.00	0.00
18:0	3.49	2.00	3.07	3.10
18:1 ω9	23.94	57.82	22.17	17.62
18:1 ω7	0.17	0.00	0.00	0.04
18:2 ω6	52.71	23.06	63.12	14.62
19:0	0.00	0.00	0.00	0.00
18:3 ω6	0.57	0.06	0.32	0.34
18:3 ω3	6.96	6.10	1.08	57.37
18:4 ω3	0.08	0.11	0.05	0.03
20:0	0.31	0.45	0.23	0.13
20:1 ω9	0.38	0.90	0.14	0.10
20:2 ω6	0.00	0.00	0.00	0.00
20:3 ω6	0.00	0.00	0.00	0.00
20:4 ω6	0.00	0.00	0.02	0.00
20:3 ω3	0.00	0.00	0.00	0.05
20:4 ω3	0.00	0.00	0.00	0.00
20:5 ω3	0.00	0.40	0.42	0.00
22:0	0.38	0.40	0.50	0.00
22:1 ω9	0.17	0.17	0.31	0.00
22:3 ω6	0.00	0.00	0.00	0.00
22:4 ω6	0.00	0.00	0.00	0.00
22:4 ω3	0.00	0.00	0.00	0.00
22:5 ω3	0.00	0.54	0.00	0.08
22:6 ω3	0.00	0.31	0.11	0.00
Total SAT	14.31	10.24	12.13	8.66
Total MONO	24.76	59.18	22.62	17.80
Total PUFA	60.32	30.58	65.12	72.49
Total ω6	53.28	23.12	63.46	14.96
Total ω3	7.04	7.46	1.66	57.53
ω6/ω3	7.57	3.10	38.23	0.26

[1] SO = Diet with 8% Soybean oil;
RO = Diet with 8% Rapeseed oil;
SFO = Diet with 8% Sunflower oil;
LO = Diet with 8% Linseed oil

Results and Discussion

Performance Parameters

Final weights, carcass yields and percentages of peri-cloacal fat as a reflection of the total abdominal fat of the animals shown in Table 3.

In accordance with previous results from Zollitsch et al. (1997) using rapeseed and soybean oils, there were no statistically significant differences in final weights of the animals (with values ranging from 1.96 kg — RO — to 2.07 kg — SFO), as well as in the carcass yield recordings, that were similar among treatments and showing a range from 70.7% (SFO) to 71.9% (LO). On the other hand, as previously showed by Scaife et al. (1994), who did not found differences among percentages of abdominal fat in broilers after the use of diets with different levels of PUFA (polyunsaturated fatty acids), in the present work there were no differences in the relative weight of the peri-cloacal fat. The only differences were between treatments including linseed and sunflower oils, both of them with a high and similar PUFA content. The cloacal fat was significantly higher ($p < 0.01$) in the carcasses of animals fed with LO (2.16%) when compared to the animals fed with SFO (1.66%). Even though, differences did not exceed 0.5 points as percentage.

Quality Meat Parameters

The results from the different technological analyses of the meat are shown in Table 4. There occured only few differences. Though differences in juiciness were minimal, a lower value ($p < 0.01$) was observed in meat from animals fed with RO (0.47), the diet with the highest content in MUFA, when compared to the rest of treatments. These ones showed values that ranged from 0.55 (SO) to 0.59 (SFO). So, a different balance of ω6/ω3 in the used diets does not seem to have an influence on the studied parameters of quality. Certainly, these parameters are more influenced by factors such as age of the animals, fattening condition, stunning technics, scalding, feathering and storing conditions of the carcasses (Grashorn, 1995).

On the other hand, the analyses of TBA, considered as parameters of the oxidative state of the meat, did not show statistically significant differences in fresh breast muscle samples among treatments, although they occured in fresh abdominal fat samples (SO: 0.83; RO: 0.45; SFO: 0.21; LO: 0.91, $p < 0.01$) and in breast muscle tissue after twelve months of storage ($p < 0.01$). Among these, values obtained in SO and LO samples were the highest in comparison to RO and SFO (SO: 2.12; RO: 0.98; SFO: 0.42; LO: 2.49, $p < 0.01$).

Fatty Acid Profile of thigh and abdominal fat

No FA of more than 22 carbon atoms were found. As expected, the FA profile of the samples reflected the variations of the diets (Tables 5 and 6).

The content of saturated FAs (SAT) as a percentage of total FAs nearly did not show variations among treatments for the abdominal fat (20.2%, RO – 22.0%, SO). But, there were observed, slightly but statistically significant differences ($p < 0.05$) in thigh samples. Among these, values ranged from 22.2% (LO) to 26.6% (RO). The most important saturated FA was palmitic acid (C16:0) followed by stearic acid (C18:0).

The percentage of total monounsaturated FAs (MUFA) was slightly higher ($p < 0.01$) in animales fed the RO diet (59.2% MONO in diet) in both tissues, being more pronounced in abdominal fat samples. The different chemical structure of both lipid depots could easily explain that fact, as shown below. The increase in MUFA in RO samples was mainly due to the increase in oleic acid.

Table 3. Carcass yield and final weight of the animals
LSQ-Mittelwerte für die Schlachtausbeute und die Lebendgewichte bei der Schlachtung

Variable	SO	RO	SFO	LO	S.E.	Sig.
Final weight, kg	1.99	1.96	2.07	2.00	0.069	N.S.
Carcass yield[2], %	71.8	71.3	70.7	71.9	0.67	N.S.
Cloacal fat[3], %	1.72^{ab}	1.84^{ab}	1.66^{b}	2.16^{a}	0.320	$p < 0.01$

[1] SO = Diet with 8% Soybean oil; RO = Diet with 8% Rapeseed oil
SFO = Diet with 8% Sunflower oil; LO = Diet with 8% Linseed oil
[2] Carcass yield, without head, neck either feet
[a,b,c,d] Values in the same row and variable with no common superscript are significantly different ($p < 0.05$, 0.01 or 0.001)

Table 4. Quality meat parameters
LSQ-Mitttelwerte für die Fleischqualitätsparameter

Variable	SO	RO	SFO	LO	S.E.	Sig.
Cooking losses (%)	22.4	24.50	21.2	22.6	5.510	N.S.
Juiciness	0.55^{a}	0.47^{b}	0.59^{a}	0.57^{a}	0.086	$p < 0.01$
Tenderness						
Maximal Thoughness (N)	20.5	20.9	20.9	20.5	9.25	N.S.
Total Energy (J)	392.0	398.0	407.0	372.0	155.00	N.S.
TBArs (mg MDA/ kg)						
fresh abdominal fat	0.83^{a}	0.45^{b}	0.21^{b}	0.91^{a}	0.107	$p < 0.01$
fresh breast	0.54	0.29	0.17	0.29	0.098	N.S.
breast after 12 months storage	2.12^{a}	0.98^{b}	0.42^{c}	2.49^{a}	0.186	$p < 0.01$

[1] SO = Diet with 8% Soybean oil; RO = Diet with 8% Rapeseed oil
SFO = Diet with 8% Sunflower oil; LO = Diet with 8% Linseed oil
[a,b,c,d] Values within the same row and variable with no common superscripts are significantly different ($p < 0.05$, 0.01 or 0.001)

Table 5. FA composition of abdominal fat samples
Fettsäuremuster des Abdominalfetts (in % der Gesamtfettsäuren)

Fatty acid	SO	RO	SFO	LO	S.E.	Sig.
	(% of total methyl esters of fatty acids)					
14:0	0.33	0.34	0.34	0.34	0.014	N.S.
14:1 ω7	0.04^{ab}	0.00^{b}	0.00^{b}	0.07^{a}	0.015	$p < 0.01$
14:1 ω5	0.00	0.06	0.02	0.00	0.018	N.S.
15:0	0.00	0.00	0.01	0.00	0.006	N.S.
16:0	16.34	15.56	16.18	15.87	0.475	N.S.
16:1 ω	0.35^{b}	0.58^{a}	0.32^{b}	0.37^{b}	0.026	$p < 0.01$
16:1 ω7	2.36	2.89	2.31	2.64	0.180	N.S.
17:0	0.16^{a}	0.07^{b}	0.15^{a}	0.08^{b}	0.013	$p < 0.01$
17:1 ω7	0.07^{a}	0.01^{b}	0.01^{b}	0.03^{b}	0.014	$p < 0.05$
18:0	5.18^{a}	4.10^{b}	5.03^{a}	4.49^{b}	0.151	$p < 0.01$
18:1 ω9	27.63^{c}	50.11^{a}	28.48^{bc}	34.61^{b}	0.455	$p < 0.01$
18:1 ω7	0.00	0.44	0.00	0.00	0.263	N.S.
18:2 ω6	30.84^{b}	18.81^{c}	43.02^{a}	17.41^{d}	0.501	$p < 0.01$
19:1 ω9	0.27^{b}	0.15^{c}	0.32^{a}	0.09^{d}	0.010	$p < 0.01$
18:3 ω6	0.11^{a}	0.15^{a}	0.00^{b}	0.14^{a}	0.023	$p < 0.01$
18:3 ω3	14.87^{b}	5.27^{c}	2.64^{d}	22.31^{a}	0.563	$p < 0.01$
18:4 ω3	0.21^{b}	0.14^{c}	0.10^{d}	0.28^{a}	0.009	$p < 0.01$
20:0	0.02^{ab}	0.09^{a}	0.05^{ab}	0.00^{b}	0.022	$p < 0.05$
20:1 ω9	0.33^{c}	0.79^{a}	0.32^{c}	0.49^{b}	0.026	$p < 0.01$
20:2 ω6	0.21^{a}	0.14^{b}	0.26^{a}	0.11^{b}	0.019	$p < 0.01$
20:3 ω6	0.07^{a}	0.03^{b}	0.10^{a}	0.00^{b}	0.011	$p < 0.01$
20:4 ω6	0.23^{b}	0.15^{c}	0.33^{a}	0.10^{d}	0.017	$p < 0.01$
20:3 ω3	0.13^{b}	0.00^{c}	0.00^{c}	0.17^{a}	0.009	$p < 0.01$
20:5 ω3	0.00^{c}	0.07^{b}	0.00^{c}	0.23^{a}	0.013	$p < 0.01$
22:1 ω9	0.16^{a}	0.05^{b}	0.00^{b}	0.00^{b}	0.017	$p < 0.01$
22:6 ω3	0.13^{b}	0.00^{c}	0.00^{c}	0.15^{a}	0.005	$p < 0.01$
Total SAT	22.02	20.16	21.76	20.78	0.524	N.S.
Total MONO	31.19^{c}	55.08^{a}	31.79^{c}	38.30^{b}	0.575	$p < 0.01$
Total PUFA	46.79^{a}	24.76^{c}	46.43^{a}	40.91^{b}	0.806	$p < 0.01$
Total ω6	31.45^{b}	19.28^{c}	43.70^{a}	17.77^{d}	0.513	$p < 0.01$
Total ω3	15.33^{b}	5.48^{c}	2.74^{d}	23.14^{a}	0.568	$p < 0.01$
ω6:ω3	2.08^{c}	3.52^{b}	16.00^{a}	0.77^{d}	0.174	$p < 0.01$

[1] SO = Diet with 8% Soybean oil; RO = Diet with 8% Rapeseed oil
SFO = Diet with 8% Sunflower oil; LO = Diet with 8% Linseed oil
[a,b,c,d] Values within the same row with no common superscripts are significantly different ($p < 0.05$, 0.01 or 0.001)

On the other hand, the different contents of PUFA in the diets were reflected in the analysed samples of tissues. The highest PUFA ($p < 0.01$) level was given by treatments SO, SFO and LO when compared to RO. There are many references confirming a higher polyunsaturated rate in animal tissues in response to the intake of high concentrations of PUFA in the ration (e.g. Olomu and Baracos, 1991; Pinchasov and Nir, 1992; Scaife et al., 1994).

In the PUFA group, the highest ($p < 0.01$) level of omega-3 FA was shown by LO samples above the rest of treatments. Chanmugam et al. (1992) and Scaife et al. (1994) observed a proportional and increasing level of LNA and even of its derivatives in different kinds of tissues, when comparing diets with different percentages of linseed oil. This seems to happen when a defined level in the relationship omega-3/omega-6 is exceeded in the diets. In this experiment the highest levels of EPA and DHA were achieved in LO samples, probably obtained by elongation and desaturation of linolenic from the diet, due to its scarce content in all dietary treatments (from 0.0% to 0.4% EPA/from 0.0% to 0.3% DHA). Though an evident conversion of LNA to EPA and DHA, it seems to be rather limited (Hawrysh et al., 1980, 1982; Chanmugam et al., 1992). In two previously conducted works (López-Ferrer et al., 1997), it was found that the replacement of fish oils with linseed or rapeseed oils in diets during the last or both last two weeks prior to slaughtering of the animals (at 35 days of age) could not keep the high levels of EPA, DPA and DHA in tissues achieved by feeding fish oil throughout the whole experimental period. These FAs were up to 17% of the total FAs in the tissues from these animals, while other treatments lost almost 50% of such FA in samples of breast and thigh with only one week of withdrawal of the fish oil from the diet.

It is pointed out that the highest ($p < 0.01$) proportion of omega-3 FAs was found in thigh samples rather than in abdominal fat samples. The difference in such proportion can be explained by the distribution of the different kinds of lipids (mainly phospholipids and tryacylglycerols) in tissues with different functions and compositions: the level of the first ones is higher in thighs – because of its high content in cell membranes – and the tryacylglycerols are the main fat compound of the adipocyte. The selective vehiculation of the EFAs (essential fatty acids) in the enterocyte towards the formation of phospholipids via the acyltransferases path allows them to be used as membrane lipids rather than as reserve lipids (Bézard et al., 1994). Long-Chain ω3 and ω6 PUFA, generated through elongation and desaturation in the enterocytes and liver cells from their precursors (LNA and LA, given with diets) will be primarily vehiculated towards the formation of membrane phospholipids, too (Lowe et al., 1987; Caselli et al., 1993; Bézard et al, 1994).

Omega-6 PUFA were present in a different way according to the analysed tissue, too. These were higher, like the omega-3 FA, in thigh samples and, among them, in those obtained from animals fed the SFO diet, that contained a higher proportion of these PUFAs (63.5%, mainly as linoleic

Table 6. FA composition of thigh samples

Fatty acid	SO	RO	SFO	LO	S.E.	Sig.
	(% of total methyl esters of fatty acids)					
12:0	0.22	0.23	0.18	0.12	0.074	N.S.
14:0	1.20	1.29	1.06	1.05	0.075	N.S.
14:1 ω7	0.39	0.36	0.27	0.28	0.073	N.S.
14:1 ω5	0.07	0.14	0.24	0.08	0.073	N.S.
15:0	0.29	0.16	0.22	0.14	0.062	N.S.
16:0	20.18	20.62	18.25	17.08	0.957	N.S.
16:1 ω9	0.81	1.07	0.84	0.84	0.074	N.S.
16:1 ω7	4.82^{ab}	5.31^{a}	3.51^{c}	3.86^{bc}	0.379	$p < 0.05$
17:0	0.12	0.07	0.11	0.09	0.015	N.S.
17:1 ω7	0.12	0.08	0.05	0.07	0.018	N.S.
18:0	3.38	3.97	4.28	3.56	0.324	N.S.
18:1 ω9	18.00^{b}	27.18^{a}	16.96^{b}	18.56^{b}	1.222	$p < 0.01$
18:1 ω7	0.28^{b}	1.46^{a}	0.28^{b}	0.00^{b}	0.302	$p < 0.05$
18:1 ω5	0.58^{b}	0.03^{b}	2.14^{a}	0.11^{b}	0.222	$p < 0.01$
18:2 ω6	25.96^{b}	26.47^{b}	42.03^{a}	22.29^{b}	1.909	$p < 0.01$
19:0	0.14^{b}	0.25^{ab}	0.58^{a}	0.00^{b}	0.136	$p < 0.05$
19:1 ω9	0.47	0.32	0.12	0.38	0.143	N.S.
18:3 ω6	0.51	0.00	0.00	0.94	0.285	N.S.
18:3 ω3	15.23^{b}	7.13^{c}	4.19^{c}	25.18^{a}	1.674	$p < 0.01$
18:4 ω3	1.10^{a}	0.36^{b}	0.21^{b}	0.62^{ab}	0.187	$p < 0.05$
20:0	0.05	0.00	0.00	0.00	0.013	N.S.
20:1 ω9	1.21	0.64	0.19	0.28	0.337	N.S.
20:1ω7	0.18	0.00	0.08	0.00	0.062	N.S.
20:2 ω6	0.13	0.13	0.18	0.22	0.045	N.S.
20:3 ω6	0.14^{bc}	0.13^{c}	0.23^{ab}	0.25^{a}	0.032	$p < 0.05$
20:4 ω6	0.97^{c}	1.81^{b}	2.80^{a}	1.30^{bc}	0.240	$p < 0.01$
20:3 ω3	0.12^{b}	0.02^{c}	0.04^{c}	0.24^{a}	0.018	$p < 0.01$
20:4 ω3	0.08^{b}	0.00^{c}	0.00^{c}	0.13^{a}	0.009	$p < 0.01$
22:0	0.10^{a}	0.00^{b}	0.00^{b}	0.12^{a}	0.012	$p < 0.01$
20:5 ω3	0.34	0.23	0.08	0.85	0.238	N.S.
22:1 ω9	2.43^{a}	0.19^{b}	0.13^{b}	0.50^{a}	0.682	N.S.
22:3 ω6	0.07	0.00	0.03	0.00	0.036	N.S.
22:4 ω6	0.05^{b}	0.06^{b}	0.25^{a}	0.00^{b}	0.045	$p < 0.01$
22:5 ω6	0.00	0.00	0.03	0.00	0.012	N.S.
22:4 ω3	0.00	0.00	0.18	0.08	0.053	N.S.
22:5 ω3	0.33^{a}	0.19^{b}	0.13^{b}	0.00^{c}	0.043	$p < 0.05$
22:6 ω3	0.33^{b}	0.15^{b}	0.17^{b}	0.76^{a}	0.065	$p < 0.01$
Total SAT	25.67^{a}	26.58^{a}	24.67^{ab}	22.15^{b}	1.003	$p < 0.05$
Total MONO	29.35^{b}	36.76^{a}	24.79^{b}	24.97^{b}	2.223	$p < 0.01$
Total PUFA	45.35^{a}	36.66^{b}	50.51^{a}	52.86^{a}	2.630	$p < 0.01$
Total ω6	27.83^{b}	28.59^{b}	46.54^{a}	25.00^{b}	2.082	$p < 0.01$
Total ω3	17.52^{b}	8.08^{c}	4.98^{c}	27.86^{a}	1.639	$p < 0.01$
ω6:ω3	1.69^{c}	4.23^{b}	9.20^{a}	0.90^{c}	0.770	$p < 0.01$

LS Means ± S.E.
[1] SO = Diet with 8% Soybean oil; RO = Diet with 8% Rapeseed oil
SFO = Diet with 8% Sunflower oil; LO = Diet with 8% Linseed oil
[a,b,c,d] Values within the same row with no common superscripts are significantly different ($p < 0,05$, 0,01 or 0,001)

acid – LA). The content in arachidonic acid (AA) of the samples relied on the level of its precursor (LA) in the diet, being achieved by elongation and desaturation from it when its content in the fat of the diets was minimal, as already pointed by Ajuyah et al. (1993) and Scaife et al. (1994). So, decreasing values of LA (SFO > SO > RO > LO) in diets corresponded with lower levels of AA in abdominal fat, while that influence of the precursor was not clear when seeing the AA content of thigh, since the concentration of AA seems to depend on the level of LNA in the diet, too. It has been referred before (Ajuyah et al., 1993) that a competition established between LA and LNA for the same enzymes in the liver cells allows the comprehension of the metabolism of these FAs. In thighs, lower AA values ($p < 0.01$) were observed in animals fed diets with a higher omega-3 content, as LNA (LO and SO diets), partly because of a lower LA content and of the already mentioned competition. Chanmugam et al. (1992) found the lowest depositions of AA when using diets with menhaden and linseed oil.

In conclusion, the results seem to confirm the competition between LA (given by SFO) and LNA (mainly given by LO and SO) for the same elongation and desaturation

Table 7. Sensory Panel: Contrasts among treatments
Sensorische Bewertung von Brust- und Schenkelfleisch

Contrast	Breast	Thigh
RO × SO	0.05	0.05
RO × SFO	0.05	N.S.
RO × LO	0.05	N.S.
SO × SFO	N.S.	N.S.
SO × LO	N.S.	N.S.
SFO × LO	N.S.	N.S.

SO: Diet with 8% Soybean oil
RO: Diet with 8% Rapeseed oil
SFO: Diet with 8% Sunflower oil
LO: Diet with 8% Linseed oil

paths to their derivatives EPA and DHA. The highest amounts of EPA and DHA will be achieved when the precursor is given in the diet. Besides, it can be stated that an efficient synthesis of such derivatives is not warranted when giving a high content of the precursor. This reinforces the theory of the limited ability of broiler chickens to transform LNA into EPA and DHA. Therefore, it seems to be more appropriate to enrich the diets directly with EPA and DHA rather than to enrich them with their precursors.

Organoleptic Tests of Samples of Breast and Thigh

The results obtained from the sensory pannel reflected differences according to the tissues (Table 7): the only samples of breast meat identified as different in a statistically way were the RO samples when compared to the rest of treatments. Moreover, only little differences were found when comparing thigh samples. There occured only a significant difference between treatments RO and SO. Obviously, a low level of polyunsaturation could be identified for breast muscles by the panelists, since the RO samples (with a higher MUFA level) were identified in almost all the comparisons that were carried out and there was a positive scoring by the panelists.The positive scoring may also be the result of bitter components of the rapeseed. In general, for nearly all comparisons it was not possible to find any statistically significant differences according to the ω3/ ω6 relationship, as previously proved by Cameron and Enser (1991) in pork meat.

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Summary

An experiment was conducted to assess the effect of using different vegetable oil sources in diets on performance of broilers, meat quality parameters, fatty acid (FA) composition of tissues and sensoric characteristics of broiler meat. A diet enriched with 8% of vegetable fat was fed to the birds the whole growth period of 35 days. As fats were used: soybean oil (SO), rapeseed oil (RO), sunflower oil (SFO) and linseed oil (LO). Texture, water holding capacity and cooking losses of meat were determined as quality parameters. The FA profiles of abdominal fat and thigh samples were analysed. TBAR's were determined in the abdominal fat and in the breast muscle. A sensoric evaluation of breast and thigh muscles was done.

Meat quality parameters almost did not show any differences between treatments, although juiciness of samples from the RO treatment was lower in comparison to the other treatments. TBArs values were higher in LO and SO fresh abdominal fat and in 12-months stored breast samples in comparison to fresh samples of breast muscle.

The highest omega-3 PUFA level was observed in LO samples for both kind of tissues. Eicosapentaenoic acid (EPA, C20:5ω3), docosapentaenoic acid (DPA, C22:5ω3) and docosahexaenoic acid (DHA, C22:6ω3) content of the LO samples was higher, due to a possible conversion from its precursor, linolenic acid (LNA, C18:3ω3), which attributed to more than 50% of total fatty acids in that dietary treatment. In thighs, higher levels of omega-3 fatty acids were determined than in the abdominal fat samples. Thighs from SFO treatment showed the highest content of omega-6 FAs. The predominant ω6 long chain PUFA was the arachidonic acid (AA, C20:ω6), due to the high amount of its precursor linoleic acid (LA, C18:2ω6) in the diet. A lower AA content was found in the samples from diets with the higher omega-3 FA content (LO, SO), confirming the competition established between both omega-3 and omega-6 precursors, LNA and LA, in synthesizing their long-chain derivatives.

A low level of polyunsaturation could be identified by the sensory panelists, since the RO samples (rich in monounsaturated FA, MUFA) were identified as different in flavor in almost all the comparisons that were carried out.

Keywords

Broiler, meat quality, vegetable oil, PUFA, omega-6 fatty acid, omega-3 fatty acid

Zusammenfassung

In dem vorliegenden Experiment wurde der Einfluß unterschiedlicher Futterfettquellen auf die Leistung von Masthühnern sowie auf Qualitätseigenschaften, Fettsäuremuster und sensorische Charakteristika des Fleisches untersucht. Hierzu wurde eine gemeinsame Grundration verwendet, die 8% pflanzliches Fett enthielt und über die gesamte Mastperiode von 35 Tagen eingesetzt wurde. Folgende Fettquellen wurden verwendet: Sojaöl (SO), Rapsöl (RO), Sonnenblumenöl (SFO) und Leinöl. Als Parameter der Fleischbeschaffenheit wurden gemessen: Textur, Safthaltevermögen und Grillverluste. Die Fettsäuremuster wurden im Abdominalfett und im Schenkelmuskel bestimmt. Der Grad der Fettoxidation (TBAR's) wurde im Abdominalfett und im Brustmuskel gemessen. Der sensorische Vergleich wurde für Brust- und Schenkelfleisch durchgeführt.

Für die Fleischqualitätsparameter konnten keine Einflüsse der Behandlungen festgestellt werden, obwohl das Safthaltevermögen bei der Behandlung Rapsöl etwas geringer war als bei den anderen Behandlungen. Der Grad der Fettoxidation war für Leinöl und Sojaöl in frischem Abdominalfett und in 12 Monate gelagertem Brustfleisch höher als in frischem Brustfleisch.

Die höchsten Gehalte an Omega-3-Fettsäuren wurden für die Behandlung Leinöl im Abdominalfett und im Brustfleisch ermittelt. Der höhere Gehalt an Eicosapentaensäure (EPA, C20:5n3), Docosapentaensäure (DPA, C22:5n3) und Docosahexaensäure (DHA, C22:6n3) in dieser Behandlung ist auf den hohen Gehalt an der Vorstufe Linolensäure (LNA, C18:3n3) im Lein zurückzuführen. Der Anteil der Linolensäure im Lein beträgt etwa 50% der gesamten Fettsäuren. Im Schenkelfleisch wurden höhere Gehalte an Omega-3-Fettsäuren ermittelt als im Abdominalfett. Der höchste Gehalt an Omega-6-Fettsäuren wurde in der Behandlung Sonnenblumenöl registriert. Die häufigste Fettsäure war hier auf Grund der hohen Gehalte an der Vorstufe Linolsäure (LA, C18:2n6) im Futter die Arachidonsäure (AA, C20:4n6). In den Behandlungen mit höheren Gehalten an Omega-3-Fettsäuren in den Geweben (LO, SO) wurden geringere Gehalte an Arachidonsäure beobachtet. Dies bestätigt die Konkurrenz der Omega-3- und Omega-6-Vorstufen, LNA und LA, um die Enzyme im Prozeß der Bildung der längerkettigen Fettsäurederivate.

Ein geringerer Gehalt an mehrfach-ungesättigten Fettsäuren in den Geweben, wie dies für die Rapsölfütterung (reich an einfach-ungesättigten Fettsäuren) der Fall war, führte zu geschmacklichen Veränderungen. Diese Veränderungen wurden von den Testpersonen in nahezu allen Vergleichen erkannt.

Stichworte

Broiler, Fleischqualität, Pflanzenöle, PUFA, Omega-6-Fettsäuren, Omega-3-Fettsäuren

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