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Effect of different dietary fat sources and their levels on performance of broilers[1]

Einfluss verschiedener Futterfettquellen und ihrer Einsatzmengen auf die Leistung von Broilern

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Introduction

The genetic potential for maximum protein accretion of modern broilers can be realized only if the demand for all essential nutrients and for energy is met. Basically, broilers try to consume an amount of feed that is sufficient to cover their energy requirements (NRC, 1994). Due to the limited capacity of the digestive tract and the achieved genetic improvement of broiler hybrids, animal or vegetable fats or mixtures of these have become commonly used components in broiler diets. Besides their role as a source of energy, certain (polyunsaturated) fatty acids, of which vegetable fats contain a higher percentage than animals' fats, are essential for both animals and humans. Diets deficient in these fatty acids will cause metabolic disorders (FARRELL and GIBSON, 1990; GURR, 1992). Depressed growth (especially in male chickens) may be the first sign of an inadequate supply of essential fatty acids. Abnormalities in the structure of membranes, capillaries and skin as well as a general depression of immunity are among the most important consequences of major deficiencies (WISEMAN, 1984).

Differences in the digestibility of various fats will potentially affect animal performance (ZOLLITSCH et al., 1997). Especially in nonruminants, the composition of dietary lipids is an important factor for the digestibility of the fat and therefore the extent to which it can be used as a source of metabolizable energy in chickens (WISEMAN, 1984). This is especially the case if the diet contains high amounts of fat. Usually, fats with a high percentage of unsaturated fatty acids are better absorbed than highly saturated lipids, with the possibility of synergistic effects between fats of different compositions (HULAN et al., 1984; ZOLLITSCH et al., 1997). In addition, the age of young broiler chickens is another important factor for the ability to digest fats: initially, the potential production of liver enzymes is not sufficient (WISEMAN, 1984) and the digestion of animal fat especially improves significantly with increasing age (KROGDAHL, 1985).

The most important aspects of the decision as to which fat sources to use for the formulation of broiler diets are the costs and quality of the respective fats as well as the effects which can be expected on both animal performance and carcass quality. Therefore, the objective of the present study was to determine the effect of feeding various fat sources (fish oil, linseed oil, sunflower oil and soy oil) and different levels (2, 4, 6 and 8%) on the growth performance of broiler chicks.

Materials and Methods

Animals and Diets

This trial was run at a private company at Malkara/Tekirdağ – Turkey. Sixteen hundred day-old unsexed chickens (Cobb – 500) were used for this experiment during 6 weeks. They were obtained from a local hatchery. The chickens were divided into sixteen dietary groups, 100 chickens in each, with five replicates (20 birds per replicate). Chickens were kept in a floor system, in 80 pens (0.80 × 1.50) with controlled environmental conditions. The chicks were housed under 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), respectively. Birds were given access to water and diets *ad libitum.* Diets were formulated by using fish oil, linseed oil, sunflower oil and soybean oil singly or in combination and by adding 2, 4, 6 and 8% total fat to a basal diet. Compositions of the broiler starter and grower diets are given in Tables 1 and 2. The diets were prepared in mash form. All chickens up to 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. Diets were chemically analyzed for nutrients according to the methods of the AOAC (1984). According to the results of chemical analyses of broiler diets, determined nutrients and calculated metabolizable energy (ME, MJ/kg) levels are presented in Table 3. The fatty acid profiles of broiler diets are shown in Table 4. Determination of fatty acids profiles was done according to ÖZPINAR et al. (2003).

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Table 1. Composition of broiler starter diets (0–3 weeks, %)
Zusammensetzung der Starter-Rationen (0 bis 3 Wochen; %)

Ingredients	Groups*															
	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3	A4	B4	C4	D4
Corn			57.55				43.55				35.55				29.55	
Wheat			1.00				10.00				13.00				13.00	
Wheat bran			1.50				3.00				8.00				11.00	
Extracted soybean meal (45%)			26.10				29.10				21.10				20.10	
Extracted corn meal			8.00				5.00				7.00				6.00	
Meat and bone meal			0.50				2.00				6.00				9.00	
Fat			2.00				4.00				6.00				8.00	
Fish oil (FO)	2.00	1.333	0.666	–	4.00	2.666	1.333	–	6.00	4.00	2.00	–	8.00	5.333	2.666	–
Linseed oil (LO)	–	0.666	0.666	–	–	1.333	1.333	–	–	2.00	2.00	–	–	2.667	2.666	–
Sunflower oil (SFO)	–	–	0.666	–	–	–	1.333	–	–	–	2.00	–	–	–	2.666	–
Soy oil (SO)	–	–	–	2.00	–	–	–	4.00	–	–	–	6.00	–	–	–	8.00
Limestone								1.20								
Dicalcium phosphate								1.10								
Vitamin + mineral premix**								0.20								
Salt								0.25								
DL-Methionine								0.20								
L-Lysine								0.20								
Anticoccidial***								0.10								
Antioxidant								0.10								

* Groups: A) fish oil (FO); B) fish oil + linseed oil (LO); C) FO + LO + sunflower oil (SFO); D) soy oil (SO).
** 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; I. 5 mg; Se. 0.375 mg.
*** Anticoccidial – Narasin. 70 g/kg premix.

Data collection

Broilers were weighed individually at hatch and at the 21st and 42nd day of age. Feed consumption was determined per replication group at the end of starter (0–3 weeks) and grower (4–6 weeks) periods on pen basis. Feed conversion rate was also calculated on replication group basis. Birds were removed from feed, but not water, for 12 h before weighing. Dead birds were weighed for correction of feed conversion data.

Statistical Analysis

Data were analyzed by ANOVA, using two-way procedure of General Linear Models (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).

Table 2. Composition of broiler grower diets (4–6 weeks, %)
Zusammensetzung der Grower-Rationen (4 bis 6 Wochen; %)

Ingredients	Groups*															
	A1	B1	C1	D1	A2	B2	C2	D2	A3	B3	C3	D3	A4	B4	C4	D4
Corn			48.59				49.66				45.42				37.64	
Wheat			10.00				10.00				10.00				10.00	
Wheat bran			1.00				1.00				4.50				10.60	
Extracted soybean meal (45%)			17.40				26.40				29.50				28.80	
Full fatt soybean			17.90				5.80				1.34				1.80	
Fat			2.00				4.00				6.00				8.00	
Fish oil (FO)	2.00	1.333	0.666	–	4.00	2.666	1.333	–	6.00	4.00	2.00	–	8.00	5.333	2.666	–
Linseed oil (LO)	–	0.666	0.666	–	–	1.333	1.333	–	–	2.00	2.00	–	–	2.667	2.666	–
Sunflower oil (SFO)	–	–	0.666	–	–	–	1.333	–	–	–	2.00	–	–	–	2.666	–
Soy oil (SO)	–	–	–	2.00	–	–	–	4.00	–	–	–	6.00	–	–	–	8.00
Limestone			1.12				0.88				0.96				1.00	
Dicalcium phosphate			0.80				1.06				1.10				1.00	
Vitamin + mineral premix**			0.25				0.25				0.25				0.25	
Salt			0.30				0.27				0.25				0.25	
DL-Methionine			0.19				0.19				0.19				0.19	
L-Lysine			0.23				0.27				0.27				0.25	
Anticoccidial***			0.12				0.12				0.12				0.12	
Antioxidant			0.10				0.10				0.10				0.10	

* Groups: A) fish oil (FO); B) fish oil + linseed oil (LO); C) FO + LO + sunflower oil (SFO); D) soy oil (SO).
** 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; I. 5 mg; Se. 0.375 mg.
*** Anticoccidial – Narasin. 70 g/kg premix.

Table 3. Nutrients content (%) and energy levels (ME MJ/kg) of broiler diets
Nährstoff- (%) und Energiegehalte (ME MJ/kg) der Versuchsrationen

Group	Dry matter	Crude protein	Crude fibre	Ether extract	Ash	Nitrogen free extract	Sugar	Starch	ME MJ/kg*
Starter period (0–21 day)									
A1	87.80	22.70	2.80	4.90	5.10	52.30	4.70	39.30	12.37
A2	88.50	22.40	3.00	6.70	4.60	51.80	6.00	33.80	12.19
A3	89.00	21.80	4.40	9.80	5.70	47.30	5.00	33.50	12.99
A4	89.90	21.50	4.30	10.70	6.10	47.30	4.80	29.50	12.55
B1	88.20	22.30	2.80	5.80	4.60	52.70	5.10	37.30	12.34
B2	88.80	22.70	4.00	6.80	4.60	50.70	5.40	33.70	12.18
B3	89.60	20.80	5.00	10.60	7.50	45.70	4.10	33.10	12.92
B4	89.70	21.00	4.30	10.70	6.00	47.70	4.50	31.30	12.74
C1	88.10	22.00	3.00	5.60	4.90	52.60	5.10	37.40	12.24
C2	88.50	22.30	3.30	6.30	5.10	51.50	5.30	35.50	12.23
C3	88.90	20.70	3.70	9.20	6.80	48.50	4.20	34.70	12.70
C4	89.50	20.70	4.40	10.60	6.20	47.60	4.50	32.40	12.84
D1	88.30	22.40	3.10	5.00	4.20	53.60	5.00	39.80	12.48
D2	88.80	22.40	3.40	6.40	4.60	52.00	4.90	38.30	12.70
D3	89.00	20.20	3.80	9.00	6.30	49.70	4.20	37.70	13.06
D4	89.40	20.70	4.00	10.50	5.50	48.70	4.30	34.30	13.10
Grower period (22–42 day)									
A1	88.70	20.20	4.00	7.30	4.90	52.30	4.70	39.80	12.89
A2	88.80	20.30	3.60	7.80	4.40	52.70	5.30	40.80	13.32
A3	89.20	20.50	3.40	9.00	5.20	51.10	5.50	37.10	13.17
A4	89.30	20.20	4.20	9.20	5.00	50.70	4.70	32.90	12.39
B1	88.80	20.40	3.60	8.40	4.70	51.70	5.10	36.80	12.85
B2	88.50	20.50	3.80	8.60	4.90	50.70	4.90	38.30	13.16
B3	89.00	20.20	3.30	8.80	4.30	52.40	5.80	38.20	13.28
B4	89.80	20.70	4.30	9.70	5.20	49.90	5.30	34.50	12.99
C1	88.60	20.40	3.50	7.80	5.20	51.70	4.90	39.10	13.00
C2	88.50	20.40	3.30	7.90	4.90	52.00	4.90	40.50	13.27
C3	88.80	20.50	3.30	7.90	5.30	51.80	5.50	37.70	12.90
C4	89.90	19.80	4.30	10.10	5.60	50.10	4.80	34.10	12.85
D1	89.10	19.80	3.90	6.10	4.70	54.60	4.90	38.60	12.24
D2	89.20	20.90	3.30	6.80	4.80	53.40	6.00	37.90	12.68
D3	89.90	20.80	3.40	7.80	4.20	53.70	5.40	37.40	12.85
D4	90.30	20.00	4.20	9.80	5.40	50.90	5.40	34.50	12.92

Groups:
A) Fish oil (FO). A1) 2%. A2) 4%. A3) 6%. A4) 8%.
B) 2/3 FO + 1/3 linseed oil (LO). B1) 2%. B2) 4%. B3) 6%. B4) 8%.
C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO). C1) 2%. C2) 4%. C3) 6%. C4) 8%.
D) Soy oil (SO). D1) 2%. D2) 4%. D3) 6%. D4) 8%.
* ME. MJ/kg = (0.03431 × g/kg fat) + (0.01551 × g/kg crude protein) + (0.01669 × g/kg starch) + (0.01301 × g/kg sugar).

Results

Tables 5, 6 and 7 show the influence of dietary treatments on chick performance. For feeding periods of 0–42 days differences were observed among treatments in weight gain, feed consumption, or feed efficiency ($p < 0.05$).

Average body weight

At the beginning of the trial all chickens had a similar ($p > 0.05$) average body weight (39.8–41.0 g) (Table 5). At the end of the starter period (day 0–21) the highest average body weight was recorded in chickens fed diets with 4% oil inclusion. The lowest body weight (531 g) was observed in chickens fed 8% fish oil (Diet A4). A significant effect of the fat source was observed for the 6% fat inclusion level. The highest body weight was reached in the soybean oil group. At the end of the grower period (day 22–42) the highest average life mass (2.186 g) was achieved by chickens fed diets with 0.666% fish oil (FO) + 0.666% linseed oil (LO) + 0.666% sunflower oil (SFO) (Diet C1). The lowest final body weight (1866 g) reached the chickens fed diets with 8% soybean oil (Diet D4). Significant effects of oil inclusion were observed for treatments A and C ($p < 0.05$).

Feed consumption

For feeding periods (0–3, 3–6 and 0–6 weeks) the differences in feed consumption between treatments were significant ($p < 0.05$). Table 6 shows feed consumptions of experimental group chicks for their feeding periods. During starter period (0–3 week) the highest feed intake was observed in chickens fed the diet with 1.333% FO + 1.333% LO + 1.333% SFO (Diet C2) (883 g) and 1.333% FO + 0.666% LO (Diet B1) (881 g). For treatments A, B and C significant effects for the fat inclusion level were obvious. In general, with increasing fat inclusion levels the feed intake was reduced. However, during the grower period (3–6 week) and the end of the experiment, the highest feed intake (respectively, 2869 and 3637 g) was recorded for chickens fed diets including 2.666% FO + 2.666% LO + 2.666% SFO (Diet C4). A significant effect of the fat inclusion was observed for the soybean oil treatment (D) in the way that the highest feed

Table 4. Fatty acid composition of broiler diets, (% of total methyl esters of fatty acids)
Fettsäurenmuster der Versuchsrationen (in Prozent der gesamten Fettsäuremethylester)

Groups*	SFA**	MUFA	PUFA	n-6	n-3	n-6/n-3
Starter (0–3 week)						
A1	20.89	26.74	51.95	37.65	14.29	2.63
A2	25.63	25.73	46.19	25.93	20.26	1.28
A3	27.83	26.82	42.62	18.31	24.31	0.75
A4	28.80	26.26	41.74	16.09	25.65	0.63
B1	17.59	26.87	55.39	46.65	8.75	5.35
B2	22.59	24.78	51.88	34.47	17.41	1.98
B3	25.24	26.15	45.72	27.35	18.37	1.49
B4	25.09	25.91	48.13	28.14	19.99	1.41
C1	20.42	25.35	52.40	40.50	12.90	3.18
C2	18.96	26.66	54.04	43.63	10.41	4.19
C3	19.95	28.42	51.10	40.02	11.07	3.61
C4	17.42	28.21	53.90	42.31	11.59	3.65
D1	15.46	24.80	59.54	54.47	5.07	10.91
D2	15.18	24.55	60.05	54.37	5.68	9.58
D3	17.17	24.89	57.76	51.06	6.70	7.62
D4	15.01	24.34	60.65	53.14	7.51	7.08
Grower (4–6 week)						
A1	19.51	24.33	55.73	42.19	13.54	3.12
A2	23.18	25.04	50.59	30.61	19.98	1.53
A3	25.88	24.90	47.15	22.92	24.23	0.95
A4	27.59	25.58	45.46	19.94	25.53	0.78
B1	17.78	23.83	58.11	46.69	11.42	4.09
B2	20.10	24.70	54.20	38.31	15.90	2.41
B3	22.07	25.28	50.15	32.10	18.05	1.78
B4	23.05	25.35	49.55	31.06	18.49	1.68
C1	17.04	23.86	58.89	50.05	8.83	5.68
C2	17.33	25.87	56.24	45.67	10.57	4.32
C3	18.96	23.76	56.91	44.23	12.68	3.49
C4	18.75	23.22	56.44	43.04	13.40	3.21
D1	18.03	23.60	57.90	46.15	11.75	3.93
D2	15.99	23.86	60.04	53.05	6.99	7.59
D3	15.35	23.18	61.36	54.70	6.66	8.22
D4	15.65	23.09	61.17	53.60	7.57	7.08

* Groups:
A) Fish oil (FO). A1) 2%. A2) 4%. A3) 6%. A4) 8%.
B) 2/3 FO + 1/3 linseed oil (LO). B1) 2%. B2) 4%. B3) 6%. B4) 8%.
C) 1/3 FO + 1/3 LO + 1/3 sunflower oil (SFO). C1) 2%. C2) 4%. C3) 6%. C4) 8%.
D) Soy oil (SO). D1) 2%. D2) 4%. D3) 6%. D4) 8%.
** SFA = saturated; MUFA = monounsaturated; PUFA = polyunsaturated.

intake was recorded for inclusion levels of 4 and 6%. Within the 8% fat inclusion level treatments B and C resulted in the highest feed intake.

Feed Conversion

Feed-to-gain ratios for the experimental period are shown in Table 7. During the starter period the best feed conversion ratios were observed for treatments D2, A1, D3 and B3, whereas, the worst feed conversion ratio was in treatments D4 and B4. For treatments A, B and D significant effects for the fat supplementation levels were observed in the way that lower levels of fat inclusion resulted in a better feed conversion ratio. A significant effect of the fat sources occurred for a fat inclusion level of 6% with the best FCR for soybean oil. At the grower period (3–6 week) no significant differences regarding feed conversion were found. The chickens fed diets containing 1.333% FO + 1.333% LO + 1.333% SFO (Diet C2) showed the best feed conversion ratio (1.59 kg/kg) all over the experiment, although this was not significant, neither for the fat sources nor for the fat supplementation levels.

Discussion

Fats are important raw materials for inclusion into diets of high-energy concentration for poultry although they have other benefits including, for example, diet palatability and provision of essential fatty acids. The dietary energy value of fats is variable and based essentially upon their chemical composition, which has a profound influence upon the overall digestive process (WISEMAN, 1997). Some studies with different fat sources have shown that performance of broilers may be influenced by the type of supplementary fat in the diet (HULAN et al., 1984; CMILJANIC et al., 1997; PANJA, 1997; ZOLLITSCH et al., 1997; DÄNICKE et al., 2000; LOPEZ-FERRER et al., 2001a). Other authors (ATTEH et al., 1989; SKLAN and AYAL, 1989; OLOMU and BARACOS, 1991; PINCHASOV and NIR, 1992; LOPEZ-FERRER et al., 1999; KRASICKA et al., 2000; LOPEZ-FERRER et al., 2001b) found no differences in performance among broilers fed different types of fat with different degrees of saturation. However, the investigations (BARTOV, 1987; CMILJANIC et al., 1987; KETELS and DEGROOTE, 1989; ATTEH et al., 1989) also showed that in chicken optimum use of energy from diets is not only affected by the level but also by the source of energy in the diet.

Table 5. Average body weight of broilers (g)
Durchschnittliches Körpergewicht der Broiler (g)

Groups	Fat Level, %												P
	2			4			6			8			
	n	x	SD	n	x	SD	n	x	SD	n	x	SD	
Initial													
A	100	39.8	0.54	100	41.0	0.94	100	40.6	0.66	100	40.4	1.02	NS
B	100	40.5	1.08	100	40.8	1.21	100	40.6	1.02	100	40.3	1.00	NS
C	100	40.5	0.64	100	40.5	0.64	100	40.2	1.01	100	40.8	0.82	NS
D	100	40.5	0.44	100	40.6	0.64	100	40.1	0.84	100	40.1	1.55	NS
P		NS			NS			NS			NS		
3. week													
A	97	578^{A}	23.8	99	591^{A}	22.6	95	573^{abA}	19.4	93	531^{B}	10.2	**
B	98	602^{A}	20.5	94	602^{A}	13.7	99	581^{abAB}	22.6	99	552^{B}	16.0	***
C	99	579^{AB}	21.4	95	605^{A}	47.4	97	552^{bB}	29.4	98	549^{B}	14.4	**
D	96	549^{B}	44.2	99	618^{A}	35.3	99	598^{aA}	34.1	99	543^{B}	58.2	***
P		NS			NS			*			NS		
6. week													
A	92	2136^{abA}	80.1	97	2048^{AB}	126	84	2071^{A}	62.3	93	1946^{bB}	53.2	*
B	98	2040^{b}	71.6	94	2093	64.7	98	2065	48.8	98	2009^{ab}	89.0	NS
C	98	2186^{aA}	86.0	93	2064^{B}	134	95	2031^{B}	152	98	2060^{aB}	69.5	***
D	93	1999^{c}	132	99	2172	99.6	98	2115	100	99	1866^{c}	120	NS
P		***			NS			NS			***		

ANOVA

	Initial	3. week	6. week
Fat source (FS)	NS	NS	NS
Fat level (FL)	NS	***	***
FS × FL	NS	NS	***

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)
$^{a-c}$ Means within sub columns with no common superscripts differ significantly ($p < 0.05$)
$^{A-C}$ Means within sub rows with no common superscripts differ significantly ($p < 0.05$)
NS (non significant); * ($p < 0.05$); ** ($p < 0.01$); *** ($p < 0.001$)

There exists a concept of synergism between animal fats and vegetable oils added to the diet (HULAN et al., 1984; KETELS and DEGROOTE, 1989). The addition of small amounts of vegetable oil to animal fats results in a much higher AME of the fat mixture than expected from calculated values (MATEOS and SELL, 1981; KETELS and DEGROOTE, 1989). In contrast, in the present study feed utilization was not statistically improved with the increase in dietary fat sources (Table 7). The mixture provides a balanced fatty acid make-up, thereby enhancing absorption (HULAN et al., 1984).

As reported by other authors (HUANG et al., 1990; PHETTLEPLACE and WATKINS, 1990; LOPEZ-FERRER et al., 1999), in no case the inclusion of fish oil in the diets caused adverse effects on the productive efficiency of the animals, either in terms of final weight, or feed conversion rates, as compared with the inclusion of fish oils throughout the experimental period in the present research (A3 and B2). These results are in contrast to the adverse effects observed by other authors. HULAN et al. (1988) observed that the feeding of isoenergetic and isonitrogenous redfish meal and redfish oil diets to broilers caused lower feed consumption and body weights and poorer feed conversion efficiency than feeding the control diet. These authors attributed the reduced performance levels to lower palatability and higher calcium levels.

The feed consumption was not improved by a higher percentage of polyunsaturated fatty acids in the diets as has been described by PINCHASOV and NIR (1992). Diets with a high content of saturated, long-chain fatty-acids show a lower metabolizability of fat and hence result in a higher excretion of these fatty acids and in decreased growth-performance (ZOLLITSCH et al., 1997). The use of higher PUFA levels in diets and the effect on the performance parameters of broiler chickens, e.g., higher feed intake and feed: gain ratio has been described elsewhere (ZOLLITSCH et al., 1997), although other authors have reported contradictory results (AJUYAH et al., 1993).

It is concluded that fat sources and levels had an effect on performance parameters (body weight gain, feed consumption) except for feed conversion ratio. A combination of vegetable oil with fish oil had a marked beneficial effect on performance, which was attributed to the synergistic effect of combining fatty acids, which apparently enhance the metabolic process, particularly intestinal absorption.

Summary

The aim of this study was to determine the effect of feeding various fat sources (fish oil, linseed oil, sunflower oil and soy oil) and different fat inclusion levels (2, 4, 6 and 8%) on body weight gain, feed consumption and feed efficiency of broiler chicks.

Table 6. Average feed intake of broilers (g)
Durchschnittliche Futteraufnahme je Tier (g)

Groups	Fat Level, %								P
	2		4		6		8		
	x	SD	x	SD	x	SD	x	SD	
0–3. week									
A	814^{bB}	22.9	874^{A}	16.3	842^{A}	9.24	815^{B}	32.1	*
B	881^{aA}	9.4	874^{A}	7.72	833^{B}	13.1	863^{A}	20.2	*
C	858^{aAB}	17.9	883^{A}	9.1	843^{BC}	17.4	833^{C}	9.9	***
D	849^{ab}	34.1	870	17.2	853	16.9	844	19.3	NS
P		***		NS		NS		NS	
3–6. week									
A	2826	535.8	2543	284.7	2673	199,4	2625^{ab}	424.6	NS
B	2601	195.0	2536	172.4	2699	267.8	2761^{a}	377.3	NS
C	2791	310.3	2465	296.3	2512	301.0	2869^{a}	419.1	NS
D	2390^{AB}	331.1	2675^{A}	272.0	2727^{A}	215.6	2191^{bB}	265.3	*
P		NS		NS		NS		*	
0–6. week									
A	3540	387.1	3391	294.1	3472	220.6	3246^{ab}	312.1	NS
B	3430	212.3	3348	169.6	3506	291.1	3598^{a}	415.4	NS
C	3619	269.0	3215	211.8	3279	317.4	3637^{a}	355.7	NS
D	3123^{B}	187.0	3516^{A}	264.2	3553^{A}	214.0	3011^{bB}	249.4	**
P		NS		NS		NS		**	

ANOVA

	0–3. week	3–6. week	0–6. week
Fat source (FS)	***	NS	NS
Fat level (FL)	***	NS	NS
FS × FL	***	*	***

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)
$^{a-c}$ Means within sub columns with no common superscripts differ significantly ($p < 0.05$).
$^{A-C}$ Means within sub rows with no common superscripts differ significantly ($p < 0.05$).
NS (non significant); * ($p < 0.05$); ** ($p < 0.01$); *** ($p < 0.001$).

Sixteen hundred day-old unsexed chickens (Cobb – 500) were used for this experiment during 6 weeks. The chickens were divided into sixteen dietary groups, 100 chickens in each, with five replicates (20 birds per replicate). Diets, containing 2, 4, 6 and 8% fish oil (FO) (respectively, Diet A1, A2, A3 and A4); 1.333% FO + 0.666% linseed oil (LO) (Diet B1); 2.666% FO + 1.333% LO (Diet B2); 4% FO + 2% LO (Diet B3); 5,333% FO + 2.666% LO (Diet B4); 0.666% FO + 0.666% LO + 0.666% sunflower oil (SFO) (Diet C1); 1.333% FO + 1.333% LO + 1.333% SFO (Diet C2); 2% FO + 2% LO + 2% SFO (Diet C3); 2.666% FO + 2.666% LO + 2.666% SFO (Diet C4) and 2, 4, 6 and 8% soy oil (SO) (respectively, Diet D1, D2, D3 and D4) were used.

It is concluded that fat sources and inclusion levels affected performance parameters (body weight gain, feed consumption) except for feed conversion ratio. A combination of vegetable oil with fish oil had a marked beneficial effect on performance, which was attributed to the synergistic effect of combining fatty acids.

Keywords

Broiler, fat sources, fat level, fatty acids, performance

Zusammenfassung

Einfluss verschiedener Futterfettquellen und ihrer Einsatzmengen auf die Leistung von Broilern

Das Ziel der vorliegenden Untersuchung war, den Einfluss verschiedener Fettquellen (Fischöl, Leinöl, Sonnenblumenöl, Sojaöl) und Fettzulagestufen (2, 4, 6, 8%) zum Futter auf die Gewichtszunahmen, die Futteraufnahme und die Futterverwertung von Broilern zu untersuchen.

Insgesamt wurden 1600 nicht nach Geschlecht sortierte Broiler der Herkunft Cobb 500 verwendet, die über 6 Wochen gemästet wurden. Die Broiler wurden hierzu auf 16 Behandlungen aufgeteilt, die jeweils fünfmal wiederholt wurden. Eine Wiederholung bestand aus 20 Tieren. Die Behandlungen waren wie folgt: Ration A1, A2, A3 und A4 – 2, 4, 6 and 8% Fischöl (FO); B1 – 1.333% FO + 0.666% Leinöl (LO), B2 – 2.666% FO + 1.333% LO, B3 – 4% FO + 2% LO, B4 – 5,333% FO + 2.666% LO; C1 – 0.666% FO + 0.666% LO + 0.666% Sonnenblumenöl (SFO), C2 – 1.333% FO + 1.333% LO + 1.333% SFO, C3 – 2% FO + 2% LO + 2% SFO, C4 – 2.666% FO + 2.666% LO + 2.666% SFO; D1, D2, D3 und D4 – 2, 4, 6 and 8% Sojaöl (SO).

Es konnte der Schluss gezogen werden, dass sich die eingesetzten Fettquellen und deren Zulagenhöhe signifikant auf die Lebendgewichte und die Futteraufnahme ausgewirkt haben, während die Futterverwertung nicht deutlich beeinflusst wurde. Die Kombination von pflanzlichen Fetten mit Fischöl hatte einen deutlichen positiven Einfluss auf die Leistung, was auf die synergistische Wirkung der Kombination der Fettsäuren zurückgeführt wurde.

Table 7. Feed conversion ratio (g/g)
Futterverwertung (g/g)

Groups	Fat Level,%								P
	2		4		6		8		
	x	SD	x	SD	x	SD	x	SD	
0–3. week									
A	1.52^{B}	0.07	1.59^{AB}	0.05	1.56^{bB}	0.04	1.66^{A}	0.08	**
B	1.57^{B}	0.05	1.59^{B}	0.06	1.54^{bB}	0.06	1.69^{A}	0.03	**
C	1.60	0.09	1.57	0.14	1.65^{a}	0.07	1.64	0.06	NS
D	1.67^{AB}	0.12	1.51^{B}	0.06	1.53^{bAB}	0.08	1.70^{A}	0.23	*
P		NS		NS		*		NS	
3–6. week									
A	1.81	0.30	1.75	0.16	1.79	0.16	1.86	0.34	NS
B	1.81	0.09	1.71	0.11	1.82	0.22	1.89	0.18	NS
C	1.74	0.20	1.70	0.26	1.71	0.28	1.89	0.19	NS
D	1.66	0.31	1.73	0.24	1.80	0.11	1.67	0.28	NS
P		NS		NS		NS		NS	
0–6. week									
A	1.69	0.15	1.69	0.12	1.71	0.13	1.71	0.18	NS
B	1.71^{AB}	0.05	1.64^{B}	0.06	1.74^{AB}	0.18	1.82^{A}	0.14	**
C	1.69	0.14	1.59	0.13	1.65	0.19	1.80	0.11	NS
D	1.60	0.14	1.65	0.15	1.75	0.08	1.65	0.17	NS
P		NS		NS		NS		NS	

ANOVA

	0–3. week	3–6. week	0–6. week
Fat source (FS)	NS	NS	NS
Fat level (FL)	***	NS	NS
FS × FL	*	NS	NS

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)
$^{a-c}$ Means within sub columns with no common superscripts differ significantly ($p < 0.05$).
$^{A-C}$ Means within sub rows with no common superscripts differ significantly ($p < 0.05$).
NS (non significant); * ($p < 0.05$); ** ($p < 0.01$); *** ($p < 0.001$)

Stichworte

Broiler, Fettquelle, Fettzulage, Fettsäuren, Leistung

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