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Effects of Fish Oil on Growth Performance and Carcass Characteristics of Broiler Chicks Fed a Low-protein Diet

BAHMAN NAVIDSHAD[1]
Animal Science Department, University of Mohaghegh Ardabili, Ardabil, Iran
Corresponding author's e-mail: bnavidshad@yahoo.com

ABSTRACT

Four hundred fifty, one-day-old broiler chickens were used in the study. The experiment was conducted in a 2 × 3 factorial arrangement with two dietary crude protein (CP) level (21 & 19% for grower & finisher phases, respectively) and 10% diluted CP (18.9 & 17.1 for grower & finisher phases, respectively) and three levels of fish oil inclusion (either 0, 2 or 4%). Weight gain of broiler chickens decreased by fish oil inclusion (P<0.05). A 10% reduction in dietary CP level decreased the weight gain (P<0.05) of chickens but didn't affect the feed intake. Feed conversion ratio of chicks fed the crude protein diluted diets was higher (P<0.05) than chicks fed recommended CP level. Abdominal fat pad weight was not affected by different diets. Fish oil inclusion at 4% level increased the thigh, breast, liver and small intestine weights as a percent of live weight (P<0.05). Reduction in dietary crude protein level, increased the breast ether extract concentration (P<0.05). The chicks fed diets containing 4% fish oil (FO) had a significantly lower ether extract in breast, but a higher ether extract concentration in thigh (P<0.05). There was no significant interaction between experimental factors indicating that the dietary crude protein level and polyunsaturated fatty acids type act independently on performance traits and carcass fat concentration.

Key Words: Broiler chickens; Fish oil; Low protein diet

INTRODUCTION

Dietary n-3 polyunsaturated fatty acids (PUFA) and in particular, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), have well known effects on human health (Kinsella *et al.*, 1990; Knapp, 1991). Numerous research activities have been focused to enhancing the levels of these fatty acids in widely consumed products of animal origin (Hargis *et al.*, 1991; Huyghebaert, 1995). Fish oils have a high amount of EPA and DHA, so are valuable ingredients to enrich poultry meat (Chanmugam *et al.*, 1992; Pinchasov & Nir, 1992).

Previous reports have indicated that inclusion of fish oil in the diets caused no adverse effects on the productive efficiency of the animals, either in terms of mortality, final body weight, or feed conversion ratios, as compared with the inclusion of vegetable oils throughout the experimental period (Huang *et al.*, 1990; Phetteplace & Watkins, 1990; Nash *et al.*, 1995). There are some contrasting reports too. Hulan *et al.* (1988) observed that feeding with diets containing fish oil 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. Dietary fatty acid profile can affect carcass and abdominal fat deposition. Sanz *et al.* (1999) found less abdominal fat in broilers fed sunflower oil than in those fed tallow or lard.

In poultry, 60 to 65% of the ingested dietary N is excreted via excreta (Aletor *et al.*, 2000 & 2002). This means that only 35 to 40% of dietary protein is retained by animals. Low protein diets supplemented with synthetic amino acids resolved this problem. Although acceptable productive performance can be achieved by feeding low-protein diets, this will be associated whit an increase in abdominal and whole-body fat deposition (Aletor *et al.*, 2000 & 2002). It is well known that low-protein diets promote higher rates of de novo hepatic lipid synthesis in chickens than high protein diets (Donaldson, 1985).

The purpose of this experiment was to study the effect of different dietary levels of fish oil (ω-3 rich) and soybean oil (ω-6 rich) on performance parameters, carcass characteristics, abdominal fat alterations and breast and thigh fat deposition in broiler chickens.

MATERIALS AND METHODS

Four hundred fifty, one-day-old mixed sex broiler chickens of the Ross 308 strain were obtained from a commercial hatchery and were placed in 18 floor pens of 3 × 3 m with 25 birds per pen. All chicks were fed a commercial starter diet from 0 to 10 d and were allowed free access to water and food. Chicks were fed the experimental diets from 11 to 24 d (grower phase) and 24-42 d (finisher phase). The experimental design was completely randomized design with a 2 × 3 factorial arrangement with

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two dietary crude protein (CP) level [recommended by Ross 308 manual (21 & 19% for grower & finisher phases, respectively) and 10% diluted CP (18.9 & 17.1 for grower & finisher phases, respectively)] and Three levels of fish oil (ω-3 rich) inclusion (either 0, 2 or 4%). Soybean oil (ω-6 rich) used as the alternative oil source in isoenergetic diets.

The Ingredients and nutrient analysis for experimental diets is shown in Table I and the fatty acid profiles of supplemented fats are shown in Table II. The weights of birds were recorded at 42 d of age. At the end of the experimental period, weights and feed intakes per pen were recorded. Birds were deprived of feed 12 h before being weighed. Four birds (two male & two female) per pen were killed (via neck cutting) on 42nd day of experiment.

Carcass characteristics and internal organs were weighted and abdominal fat pad (including fat surrounding gizzard, bursa of Fabricius, cloaca & adjacent muscles) was removed and weighed individually for 12 males and 12 females per treatment. Breast and thigh muscles of chickens were removed and were weighed individually. Samples were stored at -20°C until analysis. Twelve samples of muscle per treatment were taken from the breast and thigh and three mixed sample per organ were used to crude fat determination. Fat was extracted by the Folch *et al.* (1957) method and was determined gravimetrically.

Performance parameters were analyzed using triplicate pens data. Results of abdominal fat and dressing percentage were analyzed by using every chick as a replicate. Thighs and breasts crude fat contents were analyzed using the mixed samples of 4 chicks as a replicate. The general linear model (GLM) of the SAS software (SAS institute, 1997) was used for the statistical processing of data. Differences were considered significant at P<0.05 and means were compared by Duncan test.

RESULTS

Final body weight and daily weight gain of broiler chickens decreased by fish oil inclusion in diets (P<0.05), but dietary fish oil level did not affect daily feed intake and feed conversion ratio (Table II). A 10% reduction in dietary crude protein level decreased the final body weight and daily weight gain (P<0.05) of chickens but did not affect the daily feed intake. Feed conversion ratio of chicks fed the crude protein diluted diets was higher (P<0.05) than chicks fed recommended 21% CP level. No significant interaction found between dietary crude protein level and fish oil inclusion.

Carcass percentage, proventriculus, pancreas, spleen, heart and abdominal fat pad weights (as a percent of live weight) were not affected by the different diets (Table III). Fish oil inclusion at 4% level, increased the thigh, breast, liver and small intestine weights (as a percent of live weight) (P<0.05). The Dietary crude protein dilution at 10% rate, increased the percent of thigh, liver, gizzard and small intestine (P<0.05).

A 10% reduction in dietary crude protein level, increased the breast ether extract percent (P<0.05). The chicks fed diets containing 4% FO had a significantly lower ether extract in breast, but a higher ether extract concentration in thigh (P<0.05). No significant interaction was found in between effects of dietary crude protein and fish oil levels on tissue ether extract (Table IV).

DISCUSSION

A number of researches have examined the effects of dietary long-chain PUFA, such as those contained in fish oil. On performance and carcass composition of the broiler chickens (Hulan *et al.*, 1988; Phetteplace & Watkins, 1990;

Table I. Ingredients and chemical composition of experimental diets

Ingredients %	Starter	Grower						Finisher					
CP* (%)		21			18.9			19			17.1		
FO (%)		0	2	4	0	2	4	0	2	4	0	2	4
Corn	57.79	56.68	56.5	56.53	62.79	62.71	62.64	62.48	62.4	62.32	68.75	68.67	68.59
Soybean Meal	32.89	28.95	28.98	28.88	24.01	24.02	24.04	24.29	24.31	24.32	18.77	18.78	18.79
Fish Meal	2.69	5.74	5.74	5.74	5	5	5	5	5	5	5	5	5
Fish Oil	-	0	2	4	0	2	4	0	2	4	0	2	4
Soybean Oil	2.81	5.42	3.52	1.55	4.57	2.63	0.69	5.21	3.27	1.33	4.18	2.25	0.31
DCP	1.6	1	1	1	1.14	1.14	1.14	1	1.01	1.01	1.06	1.06	1.06
Oyster shell	1.18	1.03	1.03	1.03	1.05	1.05	1.05	0.99	0.99	0.99	1	1	1
Salt	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0..3	0.3	0.3
DL- Methionine	0.11	0.13	0.13	0.13	0.2	0.2	0.2	0.05	0.05	0.05	0.1	0.1	0.1
HCl-Lysine	0.06	0.1	0.1	0.1	0.3	0.3	0.3	0.02	0.02	0.02	0.2	0.2	0.2
Min&Vit premix	0.5	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Chemical composition													
AME (kcal/kg)	2988	3175	3175	3175	3175	3175	3175	3225	3225	3225	3225	3225	3225
Crude Protein	21	21	21	21	18.9	18.9	18.9	19	19	19	17.1	17.1	17.1
Calcium	1	0.9	0.9	0.9	0.9	0.9	0.9	0.85	0.85	0.85	0.85	0.85	0.85
Phosphorous	0.5	0.45	0.45	0.45	0.45	0.45	0.45	0.425	0.425	0.425	0.425	0.425	0.425
Sodium	0.2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Metionine	0.46	0.5	0.5	0.5	0.53	0.53	0.53	0.39	0.39	0.39	0.416	0.416	0.416
Met+Cys	0.89	0.97	0.97	0.97	0.97	0.97	0.97	0.83	0.83	0.83	0.83	0.83	0.83
Lysine	1.2	1.25	1.25	1.25	1.25	1.25	1.25	1.05	1.05	1.05	1.05	1.05	1.05

*CP= Crude Protein, FO= Fish Oil, DCP= Dicalcium Phosphate, Met= Methionine, Lys= Lysine, Cys= Cystine

Table II. Effects of dietary fish oil level and crude protein concentration on performance traits of broiler chickens

Item	Final weight (g)	Body weight gain (g/bird/d)	Feed intake (g/bird/d)	Feed conversion ratio
FO=0%, CP= recommended	2174^{a}	58.9^{a}	120.9	2.05^{c}
FO=2%, CP=recommended	2044^{b}	57.1^{b}	121.2	2.13^{b}
FO=4%, CP= recommended	2021^{b}	52.3^{c}	114.1	2.20^{b}
FO= 0%, CP=10% lower	1909^{c}	51.7^{c}	117.4	2.27^{b}
FO=2%, CP=10% lower	1851^{d}	49.9^{d}	123.8	2.48^{a}
FO=4%, CP= 10% lower	1864^{d}	48.7^{d}	119.6	2.46^{a}
SE	16	0.82	1.4	0.07
P value (FO × CP)	0.38	0.59	0.38	0.68
P value (treatment)	0.0001	0.012	0.4	0.007
FO=0%	2041^{a}	55.3^{a}	119.1	2.16
FO= 2%	1947^{b}	53.5^{ab}	122.5	2.30
FO= 4%	1943^{b}	50.5^{b}	116.9	2.33
P value (fish oil level)	0.035	0.08	0.24	0.11
CP= recommended	2080^{a}	56.1^{a}	118.7	2.12^{b}
CP= 10% lower	1875^{b}	50.1^{b}	120.2	2.41^{a}
P value (CP level)	0.0001	0.001	0.57	0.0005

a–dValues in the same column in each comparison group, with no common superscript differ significantly (P<0.05). FO=Fish oil, CP= Crude protein

Table III. Effects of dietary fish oil level and crude protein concentration on carcass characteristics of broiler chickens

Item	Carcass	Tight	Breast	Liver	Proventriculus	Pancreas	Gizzard	Spleen	Heart	Small intestine	Abdominal fat pad
FO=0%, CP= recommended	70.1	26.0^{d}	21.0	2.03	0.44	0.24	1.87^{c}	0.12	0.55	4.65^{c}	2.83
FO=2%, CP=recommended	71.0	26.3^{cd}	19.0	2.00^{d}	0.47	0.24	2.19^{b}	0.11	0.53	4.52^{c}	2.77
FO=4%, CP= recommended	72.2	28.8^{b}	22.5	2.20^{c}	0.52	0.26	2.21^{b}	0.14	0.63	5.24^{b}	2.97
FO= 0%, CP=10% lower	73.9	28.8^{b}	21.5	2.17^{c}	0.56	0.27	2.65^{a}	0.14	0.64	5.22^{b}	2.41
FO=2%, CP=10% lower	73.3	28.4^{bc}	21.3	2.30^{b}	0.42	0.23	2.11^{b}	0.13	0.64	5.30^{b}	2.89
FO=4%, CP= 10% lower	74.1	32.8^{a}	24.9	2.48^{a}	0.55	0.30	2.56^{a}	0.15	0.67	5.68^{a}	2.91
SE	1.7	0.93	0.66	0.07	0.02	0.01	0.07	0.01	0.02	0.14	0.19
P value (FO × CP)	0.97	0.92	0.03	0.88	0.18	0.42	0. 5	0.95	0.83	0.88	0.16
P value (treatment)	0.97	0.04	0.23	0.04	0.19	0.29	0.02	0.22	0.33	0.01	0.23
FO=0%	72.1	27.4^{b}	21.3^{ab}	2.10^{b}	0.50	0.26	2.26	0.13	0.59	4.93^{b}	2.62
FO= 2%	72.2	27.4^{b}	20.2^{b}	2.15^{b}	0.45	0.24	2.15	0.12	0.59	4.91^{b}	2.98
FO= 4%	73.2	30.8^{a}	23.7^{a}	2.34^{a}	0.53	0.28	2.38	0.15	0.65	5.46^{a}	2.94
P value (fish oil level)	0.96	0.02	0.09	0.03	0.19	0.17	0.39	0.11	0.40	0.02	0.19
CP= recommended	71.1	27.0^{b}	20.9	2.07^{b}	0.48	0.25	2.09^{b}	0.12	0.57	4.80^{b}	2.86
CP= 10% lower	73.8	30.0^{a}	22.6	2.31^{a}	0.51	0.26	2.44^{a}	0.14	0.65	5.40^{a}	2.83
P value (CP level)	0.42	0.01	0.20	0.01	0.35	0.37	0.01	0.11	0.06	0.04	0.87

a–d Values in the same column in each comparison group, with no common superscript differ significantly (P<0.05). FO=Fish oil, CP= Crude protein

Nash *et al*., 1995), the adverse effect of dietary fish oil on performance traits of broiler chickens are reported by other authors, but there are some controversies. Hulan *et al.* (1988) observed that the feeding of fish oil containing 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. In current study, the negative effects of fish oil were related to birds weight gain so that, feed intake and feed conversion ratio didn't affect by datary oil type. These results contrast the findings of the other authors, indicated that, in no case did the inclusion of fish oil in the diets cause 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 vegetable oils (Huang *et al.*, 1990; Phetteplace & Watkins, 1990; Nash *et al.*, 1995). The feed conversion ratio of chicks fed diets containing less crude protein increased, because of the adverse effects of a protein deficiency on body weight gain.

Table IV. Effects of dietary fish oil level and crude protein concentration on breast and thigh ether extract concentration of broiler chickens

Item	Breast ether extract	Thigh ether extract
FO=0%, CP= recommended	1.13^{b}	1.96^{cd}
FO=2%, CP=recommended	1.17^{b}	2.08^{c}
FO=4%, CP= recommended	0.97^{c}	2.21^{b}
FO= 0%, CP=10% lower	1.37^{a}	1.72^{d}
FO=2%, CP=10% lower	1.46^{a}	1.66^{d}
FO=4%, CP= 10% lower	1.04^{bc}	2.48^{a}
SE	0.06	0.09
P value (FO × CP)	0.15	0.19
P value (treatment)	0.04	0.04
FO=0%	1.25^{a}	1.84^{b}
FO= 2%	1.22^{a}	1.87^{b}
FO= 4%	1.04^{b}	2.34^{a}
P value (fish oil level)	0.01	0.03
CP= recommended	1.09^{b}	2.08
CP= 10% lower	1.29^{a}	1.95
P value (CP level)	0.04	0.15

a–d Values in the same column in each comparison group, with no common superscript differ significantly (P<0.05). FO=Fish oil, CP= Crude protein

Experimental results suggest that dietary fatty acid profile could affect abdominal fat deposition and there are several reports on the effects of polyunsaturated fatty acids on abdominal fat pad reduction in broiler chickens (Vila & Esteve-Garcia, 1996; Sanz *et al.*, 1999). In this study the fish oil (ω-3 enrich) and soybean oil (ω-6 enrich) had no superiority on abdominal fad pad reduction.

It is well known that excessive dietary amino acids promote hepatic lipogenic enzymes and lipogenesis (Katsurada *et al.*, 1986). On the other hand, it seems that low-protein diets stimulate higher rates of de novo hepatic lipid synthesis in chickens than high protein diets (Donaldson, 1985). It seems that the 10% dilation on dietary crude protein concentration in current study was not sufficient to affect the abdominal fat pad deposits of experimental birds. On the other hand, in contrary to this finding, a 10% reduction in dietary crude protein level increased the breast ether extract percent with no change in tight ether extract concentration. This implied that special fat deposits of chick body follow different alteration in response to dietary crude protein supply. One other aspect of this finding is related to the effect of dietary fish oil on tissues fat deposition, so that, the chicks fed diets containing 4% FO had a significantly lower ether extract in breast, but a higher ether extract concentration in thigh.

In conclusion, no significant interaction between experimental factors in this research indicated the dietary crude protein level and PUFA type act independently on performance traits and carcass fat concentration.

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