PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2018.512.517

Research Article
Effect of Dietary Flaxseed Oil on Growth Performance and Serum Lipid Profiles in Broilers

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Abstract

Objective: The present study was conducted to investigate the effect of flaxseed oil supplementation on broiler growth performance and serum lipid profiles. **Materials and Methods:** Two-hundred broiler chicks (age: 1 day) were randomly allocated to five experimental groups and fed isoenergetic and isonitrogenous diets containing 0, 2.5, 5.0, 7.5, or 10 g kg^{-1} flaxseed oil for 35 days. Blood was then sampled from the bronchial vein and the serum was isolated to examine serum lipid profiles. **Results:** Daily flaxseed oil supplementation decreased body weight gain and feed intake, but increased the feed conversion ratio. Flaxseed oil also decreased total cholesterol, triglyceride and very-low-density (VLDL) and low-density lipoprotein (LDL) levels in serum and increased high-density lipoprotein) HDL (levels. Dietary flaxseed oil treatment significantly reduced the weight gain in broilers. **Conclusion:** Addition of flaxseed oil in broiler diets reduced weight gain, increased feed conversion ratios and improved serum lipid profiles.

Key words: Flaxseed oil, growth performance, broilers, serum, lipid profiles, supplementation of broilers, omega-3

Received: February 18, 2018 Accepted: July 06, 2018 Published: October 15, 2018

Citation: Ali H. Al-Hilali, 2018. Effect of dietary flaxseed oil on growth performance and serum lipid profiles in broilers. Pak. J. Nutr., 17: 512-517.

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Competing Interest: The author has declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Lipids (fats) are essential for the growth of broilers[1]. Since broiler diets typically consist of corn and/or soybean meal, supplementation with fats and oils is a common economic way to increase the efficiency of the ration[2]. Fats and oils not only help improve feed quality, but they also reduce the amount of dust produced by dry feed stuff (prevent particle separation), increase palatability and act as a digestive lubricant (emulsification and rate of food passage), thereby increasing digestibility[3]. Physiologically, fats are important for thermal insulation, fat-soluble vitamin and nutrient absorption, nervous system structure and function and composition of the cell membrane[4].

Fatty acids are lipids that serve both structural and metabolic functions within poultry[4]. In particular, fatty acids can be divided into saturated and unsaturated groups, which can be further subdivided into mono- and polyunsaturated forms[5]. Flaxseed is one of the most unique oil seed crops because of its exceptionally high content of the omega-3 polyunsaturated fatty acid (PUFA) α-linolenic acid (ALA; 45-52%)[6]. While flaxseed is usually grown for its oil (350-450 g kg^{-1}) and fiber (dietary, 250-280 g kg^{-1}), it also provides a source of essential amino acids and proteins (200-240 g kg^{-1}), lignins, lecithin, vitamins and minerals[7].

In the last two decades, nutritionists have become more aware of certain foods that play an important role in maintaining and/or improving physical and mental health. Beyond meeting basic nutritional needs, dietary factors are generally considered to modulate the detrimental development of some chronic diseases. With the increased consumption of highly saturated fatty foods worldwide, it has become clear that modern diets do not meet healthy eating guidelines and lack certain long chain omega-3 fatty acids among other important nutrients. It is widely accepted that inadequate intake of omega-3 PUFAs, such as ALA and docosahexaenoic acid (DHA), adversely affects cardiovascular function[8]. Flaxseed is a rich source of omega-3 PUFAs and has been shown to help prevent cardiovascular disease and lowering the risk of cancer, especially of the breast and colon[9,10]. However, flaxseed also contains antinutritional factors, which may limit its utilization in poultry diets, including mucilage from hulls, linatin dipeptides (vitamin B6 antagonist), cyanogenic glycosides, trypsin inhibitors and phytic acid[6].

Chemically, ALA is converted to stearidonic and eicosatetraenoic acids in order to synthesize eicosapentaenoic acid (EPA) with the same enzymes used to synthesize arachidonic acid (AA). EPA is then metabolized to DHA and/or an eicosanoid. Incorporation of omega-3 fatty acids into eggs and meat by feeding flaxseed to animals is an efficient way to increase their PUFA content[11]. The present study investigated the effect of daily supplementation of different amounts of dietary flaxseed oil on growth performance and serum lipid profiles of broilers.

MATERIALS AND METHODS

Experimental design: Two-hundred Hubbard strain broiler chicks (one-day-old unsexed birds) were purchased from a commercial hatchery in Muthana, Iraq. The chicks were weighed individually and then randomly and equally divided into five experimental treatment groups of 40 birds each (20 birds per one cage). The birds were vaccinated with infectious bronchitis (IB) and Newcastle disease (ND) live vaccine at day 7 and 14 using an intraocular route. Flaxseed oil treatments were as follows: 0 g kg^{-1} (T0, control), 2.5 g kg^{-1} (T1), 5.0 g kg^{-1} (T2), 7.5 g kg^{-1} (T3), or 10.0 g kg^{-1} (T4). Each experimental group was split equally into two units of 20 birds each in order to replicate each flaxseed treatment twice. Birds were kept in a student-reserved research room containing 10 pens (20 Birds in each pen) (13.38 m^2 each)). The room and pens were cleaned thoroughly and the walls were painted white and then disinfected with formalin (1:12) inside and outside before introducing birds or starting experiments. A layer of sawdust was used as litter in each pen and was stirred regularly during the experiment to keep it dry. The temperature of the experimental room was maintained at 35°C during the first week and then lowered in 5°C increments until reaching 24±2°C. Light and proper ventilation was provided in the experimental room 24 h a day throughout the experimental period. The same type of standard feed was given to all birds from the time of hatching (day 1) until the end of the experiment (day 35); however, the amount of corn oil in each experimental diet was adjusted to keep the total oil content at 15 g kg^{-1}. Feed together with fresh and clean water were given *ad libitum* two times per day. Experimental birds were reared to five weeks of age. During the first two weeks, chicks were fed control feed without flaxseed oil. From weeks 3-5, the feed was supplemented with different amounts of flaxseed oil. The composition of the broiler diets is shown in Table 1.

Sample and data collection: The body weight of each bird and feed intake (FI) were recorded per replication weekly. Live weight gain and feed conversion ratio (FCR) were also calculated. At 18 and 35 days of age, six broilers were

Table 1: Composition of broiler diets

	Flaxseed oil treatment groups				
Feed ingredients (g kg^{-1})	T0	T1	T2	T3	T4
Flaxseed oil (supplemental)	0.00	2.50	5.00	7.50	10.00
Corn oil	15.00	12.50	10.00	7.50	5.00
Yellow corn	400.00	400.00	400.00	400.00	400.00
Soybean meal (48% protein)	280.00	280.00	280.00	280.00	280.00
Wheat	200.00	200.00	200.00	200.00	200.00
Protein concentrate*	50.00	50.00	50.00	50.00	50.00
Premix**	2.00	2.00	2.00	2.00	2.00
Lime stone	10.00	10.00	10.00	10.00	10.00
Salt	30.00	30.00	30.00	30.00	30.00
D,L-methionine	2.00	2.00	2.00	2.00	2.00
Dicalcium phosphate***	10.00	10.00	10.00	10.00	10.00
L-Lysine	1.00	1.00	1.00	1.00	1.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Metabolizable energy (kcal kg^{-1})	3090.00	3090.50	3090.50	3090.50	3090.80
Crude protein (%)	20.60	20.60	20.60	20.60	20.60
Calcium (%)	0.80	0.80	0.80	0.80	0.80
Available phosphorus	0.58	0.58	0.58	0.58	0.58
Methionine (%)	0.50	0.50	0.50	0.50	0.50
Lysine (%)	1.60	1.60	1.60	1.60	1.60

*Produced by Intraco, Ltd. (Antwerp, Belgium) containing 40% crude protein, 2100 kcal kg^{-1} metabolizable energy, 3.5% crude fat, 1% crude fiber, 6% calcium, 3% available phosphorus, 3.25% lysine, 3.5% methionine, 3.9% cysteine, 2.2% sodium, 1000 mg iron, 100 mg copper, 1200 mg manganese, 800 mg zinc, 15 mg iodine, 2 mg selenium, 6 mg cobalt, 200,000 IU vitamin A, 40,000 IU vitamin D3, 500 mg vitamin E, 15 mg vitamin B1, 10 mg vitamin B2, 20 mg vitamin B6, 300 mg vitamin B12, 30 mg vitamin K3, 5000 mg choline chloride, 10 mg folic acid, 100 mg biotin, 900 mg antioxidants. **Produced by VAPCO, Ltd. (Amman, Jordan) containing 8,000,000 IU vitamin A, 31,500,000 IU vitamin D, 1000 IU vitamin E, 500 mg vitamin B1, 500 mg vitamin B2, 200 mg vitamin B6, 8 mg vitamin B12, 2000 mg vitamin K3, 400 mg calcium pantothenate, 6000 mg nicotinamide, 50 mg folic acid, 13 mg methionine, 61 mg lysine, 92 mg aspartic acid, 166 mg glutamic acid, 1 mg cysteine, 40 mg valine, 9 mg tyrosine, 382 mg glycine, 117 mg arginine, 48 mg leucine, 40 mg phenylalanine, 0.40 g manganese sulfate, 0.15 mg zinc sulfate, 0.50 mg iron sulfate, 0.04 g copper sulfate and 0.01 g cobalt chloride. ***Dicalcium phosphate produced in Jordon (Vapco) containing 18% available phosphorus and 22% calcium

randomly selected from each dietary treatment and euthanized. Blood samples were collected at 35 days to measure the plasma lipid profile.

Lipid profile analysis: When birds were 35 days old, blood samples were randomly taken from the bronchial vein of three birds in each replicate unit (n = 6 per treatment) and placed directly into test tubes without anticoagulant. Blood samples were allowed to clot at room temperature before centrifuging for 10 min at 2500 rpm to obtain serum; serum samples were stored at -20°C until they were analyzed for total cholesterol, triglyceride, high-density lipoprotein (HDL), low-density lipoprotein (LDL) and very-low-density lipoprotein (VLDL) levels. The total cholesterol (Tch), TG and high density lipoprotein (HDL-C) from blood plasma were analyzed using an Automatic analyser 902 (Hitachi, Germany). Serum very low density lipoprotein cholesterol (VLDL-C) and low density lipoprotein cholesterol (LDL-C) were determined using the Friedewald Equation as previously described by Loh *et al.*[12]:

$$\text{LDL cholesterol} = \text{Total cholesterol-(HDL cholesterol+VLDL cholesterol)}$$

Where:

$$\text{VLDL cholesterol} = \frac{\text{Triglycerides}}{5}$$

The total serum cholesterol concentration was measured according to a previous method described by Allain *et al.*[13] using a) sigma aldrich kit, USA (that involved three enzymes (cholesterol esterase, cholesterol oxidase and peroxidase). Serum triglyceride, LDL, VLDL and HDL concentrations were also measured according to previous methods described by Bucolo and David[14], Friedewald *et al.*[15] and Alen *et al.*[16].

Statistical analysis: Data were analyzed using a completely random design. The data were presented as Mean±standard errors. Significant differences between means were calculated using least significant differences. The data were analyzed by SPSS software version 21.0 for Windows 7) SPSS Inc., Chicago, IL, USA)[17].

RESULTS AND DISCUSSION

The effect of daily supplementation with different amounts of flaxseed oil on live body weight, weight gain, feed consumption and FCR of broilers is summarized in Table 2. Different flaxseed oil treatments had a significant effect on weight gain. Birds in the T0 group (0 g kg^{-1} flaxseed oil) had the highest weight gain (1830 g), followed by T1 (1740.8 g), T2 (1455 g), T3 (1440 g) and T4 (1344 g).

Table 2: Effect of dietary flaxseed oil supplementation on broiler performance

Flaxseed oil treatment groups	Body weight day 1 (g)	Body weight day 35 (g)	Total weight gain	Feed intake (kg)	Feed conversion ratio (%)
T0	40.0±0.02	1870.0±12.4^{a}	1830.0±12.6^{a}	3.30±0.70^{a}	1.80±0.04^{d}
T1	40.2±0.25	1781.0±13.2^{b}	1740.8±13.6^{b}	3.22±0.75^{a}	1.85±0.06^{c}
T2	40.10±0.28	1495.1±12.85^{b}	1455.0±13.3^{c}	2.90±0.85^{b}	1.99±0.07^{b}
T3	40.20±0.26	1480.2±13.06^{b,c}	1440.0±12.4^{c}	2.89±0.75^{b}	2.00±0.05^{b}
T4	40.2±0.30	1380.2±12.5^{c}	1344.0±12.5^{d}	2.80±0.88^{c}	2.08±0.03^{a}

Data presented as Mean±standard error. $^{a-c}$Means within the same columns that lack a common superscripted letter differ significantly at p<0.05

Table 3: Effect of dietary flaxseed oil supplementation on serum lipid profiles in broilers

Flaxseed oil treatment groups	Cholesterol	Triglycerides	HDL	LDL	VLDL
	(mg dL^{-1})				
T0	140.50±6.3^{a}	137.50±4.1^{a}	30.7±3.2^{c}	82.40±4.7^{a}	27.5±1.53^{a}
T1	128.60±6.5^{b}	116.40±4.3^{b}	33.6±3.6^{b}	75.80±3.8^{b}	25.4±1.6^{a}
T2	118.45±4.5^{b,c}	109.80±5.6^{b,c}	35.8±2.3^{a}	66.90±3.2^{c}	21.5±1.3b
T3	110.32±5.1^{c,d}	98.45±6.3^{d}	36.2±2.5^{a}	56.50±3.4^{d}	19.5±1.53^{b,c}
T4	103.90±5.9^{d}	96.50±4.9^{d}	36.7±2.6^{a}	49.20±3.3^{d}	17.6±1.65^{c}

Data presented as Mean±standard error. $^{a-c}$Means within the same row that lack a common superscripted letter differ significantly at p<0.05. HDL: High-density lipoprotein, LDL: Low-density lipoprotein, VLDL: Very-low-density lipoprotein

The weight gain of broilers was negatively affected by the increased level of flaxseed oil in the diet, which is consistent with the findings of a previous study[18]. This decrease in weight gain appears to be due to poor energy intake[19], decrease in feed intake affected by flaxseed oil supplementation in a concentration-dependent manner. Feed intake decreased with increased flaxseed oil content; birds in the T0 group showed the highest feed intake (3.3 kg), followed by T1 (3.22 kg), T2 (2.9 kg), T3 (2.89 kg) and T4 (2.8 kg). These results are consistent with those of a previous study[20]. This reduction in feed intake may be related to the increase in flaxseed oil content of the diet. Another contributing factor could be the presence of antinutritional factors present in the oil, even after removal of the seed.

The FCR is the ratio of weight gain to feed intake and represents the efficiency with which birds convert feed into body weight. The results showed that flaxseed oil supplementation had a significant effect on the FCR of broilers. FCR values increased with increasing flaxseed oil amount, with T4 showing the highest FCR (2.08), followed by T3 (2.0), T2 (1.99), T1 (1.85) and T0 (1.80). A high FCR value in this case is due to a reduction in weight gain with increasing dietary flaxseed oil concentration. These results are consistent with a previous report[21].

The effect of daily supplementation with different amounts of flaxseed oil on total serum cholesterol and triglycerides in broilers is shown in Table 3. A significant (p<0.05) decline in total serum cholesterol and triglyceride levels was found with increasing dietary flaxseed oil concentration.

The decrease in total cholesterol may be related to the fact that flaxseed oil is rapidly absorbed by the intestine, which is helpful in lowering saturated fatty acid absorption. Another important point is that essential fatty acids in flaxseed oil inhibit the liver enzyme hydroxyl methylglutaryl-CoA (HMG-CoA) reductase, which is rate-limiting enzyme of cholesterol synthesis. The activity of HMG-CoA reductase plays an important role in the regulation of cholesterol synthesis[22]. The significant decrease (p<0.05) of triglycerides in flaxseed oil-treated birds compared to controls (T0) may be associated with the high ALA content within flaxseed oil[10, 23].

A significant increase (p<0.05) in HDL levels was observed in all treated groups supplied with flaxseed oil compared to the control (T0). This increase may be due to the fact that flaxseed oil is a major source of omega-3 PUFAs (ALA, EPA and DHA), which control expression of specific genes that raise the activity of HDL in the liver[17]. Present study also showed a significant decrease (p<0.05) in LDL and VLDL with all flaxseed oil supplementation concentrations compared to control group (T0 birds). The decrease in LDL and VLDL levels may be because flaxseed oil significantly decreases serum triglycerides. In addition, their effect on the expression of specific genes could lead to a decrease in hepatic synthesis and secretion of VLDLs[24] On the other hand, flaxseed oil contains omega-3 PUFAs, which are known to suppress lipoprotein lipase activity[25]. Lipoprotein lipase is known to regulate adipose tissue growth in broilers. However, the abdominal fat pad is not necessarily representative of other depots despite being used in a number of studies as a measure of adipose tissue metabolism[26]. Finally, results of the present study suggest that the use of flaxseed oil in the diets of broilers is important for their health. Additional studies assessing the effects of flaxseed on broiler meat as well as overall qualities (texture, color, etc) are still needed.

CONCLUSION

Flaxseed oil supplementation decreased body weight gain and feed intake, but increased feed conversion ratio values. Flaxseed oil also decreased total cholesterol, triglyceride, VLDL and LDL levels in serum, but increased HDL levels. Dietary flaxseed oil treatment also had a significant effect on weight gain in broilers.

SIGNIFICANCE STATEMENT

This study discovered the effect of flaxseed oil supplementation on growth performance and serum lipid profiles of broiler that may be beneficial to the health of those that consume their meat. This study will help researchers uncover critical areas of broiler production related to human health that many researchers have not yet explored. Thus, a new theory regarding supplementation of broiler diets with different functional foods may be arrived at.

ACKNOWLEDGMENTS

This study has been supported by University of Muthana. I appreciate the invaluable technical support of the Ministry of Science and Technology in Iraq.

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