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Effects of Whole Flaxseed in Reduced Energy Diets on Broiler Chickens Meat Quality and Carcass Characteristics Under Heat Stress Condition

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Abstract

This study aimed to assess the impact of heat stress (HS) on broiler chickens provided with a low-energy diet including whole flaxseed, focusing on carcass characteristics and meat quality. A total of 250 one-day-old Ross 308 broiler chicks were randomly allocated into five groups (50 chicks per group), with two replicates for each group. The negative control treatment (T1) received a basal diet devoid of HS. The second treatment fed a basal diet under HS as a positive control (T2). In the third experiment, they fed a basal diet, including whole flaxseed, under heat-stress conditions (T3). The fourth treatment consisted of providing a low-energy diet with whole flaxseed under HS (T4). The fifth intervention was a reduced energy diet administered under HS (T5). The carcass characteristics and edible entrails in the T3 and T4 groups showed a significant improvement ($P \leq 0.05$) compared to the control groups. The meat quality in the T3 and T4 groups was considerably enhanced ($P \leq 0.05$) due to an increase in omega-3 fatty acid levels [α-linolenic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA)], as determined by GC mass spectrometry compared to the control group that had a corn-soybean diet. In conclusion, incorporating whole flaxseeds into a low-energy diet during HS augmented broiler chickens' productivity, improved carcass characteristics, and elevated omega-3 concentrations in the meat.

Keywords: Whole flaxseed, reduced energy, HS, and meat quality.

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Introduction

Commercially, feed costs can account for more than 70% of total broiler costs in a production cycle. Therefore, any reduction in feed costs while maintaining broiler health and performance will undoubtedly positively impact the price of broiler production cycles [1].

Various pressures may arise during poultry production, including nutritional, environmental, and viral factors. Extended exposure to stress results in diminished broiler performance, decreased body weight, reduced weight gain, lower feed intake, and heightened death rates [2 & 3]. Heat stress (HS) is recognized as a significant environmental concern for chickens, resulting in economic losses through decreased growth rates, decreased feed intake, reduced body weight gain, and increased mortality rates.

Flaxseed (*Linum usitassimum*) belongs to the Linaceae family and yields diminutive flat seeds with around 40% lipids, 20% proteins, 10–20% fiber, 4% ash, and 6% moisture. The chemical composition of the seeds varies depending on the variety and environmental conditions [4].

Flaxseed, abundant in omega-3 polyunsaturated fatty acids (n-3 PUFA), is linked to numerous health benefits for preventing human diseases. The nutritional enhancement of animal meat and eggs with n-3 PUFAs may increase the intake of these fatty acids [5].

Human diets exhibit a significant decrease in n-3 polyunsaturated fatty acids (PUFA) and an imbalance in the n-6 to n-3 PUFA ratio. The ratio of n-6 to n-3 fatty acids is roughly 10 to 20:1. However, the advised range is 1 to 4:1. The reduction in n-3 PUFA consumption is attributable to the diminished intake of marine fish, the primary source of n-3 PUFA. A viable solution for this issue is the development of appropriate functional meals with modified PUFA content, recognized for its nutritional benefits and advantageous physiological effects. The fortification of poultry meat with n-3 PUFA may offer a more readily available source of these acids in the human diet [6].

In addition, reducing protein or energy contents in the diet could reduce nitrogen excretion and lower ammonia emissions, potentially lending to lessening the environmental impact [7]. Thus, reduced-energy diets may decrease heat increment, less deposit fat in the carcass, and lower the feed cost and the meat [8].

The current study aimed to use whole flaxseed as an alternative source of energy and protein in a reduced-energy diet and study its effect on meat quality and carcass characteristics under heat stress.

Materials and Methods

Experiment design and dietary treatment

Experiment design: Two hundred fifty one-day-old unsexed broiler chicks (Ross-308) obtained from a commercial hatchery divided into five treatment groups, each with 50 birds. Each treated group was split into two replicates with 25 birds in each. Control negative (T1) is fed a corn-soybean diet without HS. Control positive (T2) fed corn-soybean diet under HS. Fed basal diet + flaxseed diet under HS (T3). Fed basal diet + flaxseed with reduced energy diet under HS (T4). Fed with reduced energy diet under HS (T5). At 35 days old, six birds from each treatment were selected at the end of the experiment, live body weight, then sacrificed to obtain the weight of the carcass without feather, carcass without visa, edible, gizzard, liver, and heart. They collected meat samples from the thigh and breast. All samples were determined Omega-3 fatty acid content in the meat. Fat was determined based on the method (AOAC 1995) [9] by using a fat extractor (Soxholet). The sample was prepared according to the method approved by (AOAC 1995), which is based on the esterification of fats.

Table (1) Ingredients and nutrients composition of broiler starter diets from 1-15 days.

Ingredient (%)	T1 & T2	T3	T4	T5
Yellow corn	52.1	49.2	47	51.2
Soybean meal	40.2	37.1	37.2	40.5
Flaxseed	0	7.5	7.5	0
Vegetable oil	2.9	1.4	0	0
Limestone	1.6	1.6	1.6	1.6
MCP[1]	0.6	2.5	2.5	2.5
Premix[2]	2.5	0.6	0.6	0.6
Antitoxin	0.1	0.1	0.1	0.1
Sand	0	0	3.5	3.5
Total	100	100	100	100

Nutrients				
Energy	2900	2900	2700	2700
Crude protein (%)	23			
Calcium	0.96			
Av. Phosphorus	0.54			
Av. Lysine	1.3			
Av. Methionine	0.65			
Av. Threonine	0.87			
Electrolyte	289			

Table 2 Ingredients and nutrients composition of broiler grower from 16-35 days.

Ingredient (%)	T1 & T2	T3	T4	T5
Yellow corn	59.1	55.2	53.7	60.3
Soybean meal	32.6	28.4	29	32.4
Flaxseed	0	10	10	0
Vegetable oil	4	2.1	0	0
Limestone	1.3	1.3	1.3	1.3
MCP[1]	0.4	0.4	0.4	0.4
Premix[2]	2.5	2.5	2.5	2.5
Antitoxin	0.1	0.1	0.1	0.1
Sand	0	0	3	3
Total	100			
Nutrients				
energy	3057	3075	2875	2875
Crude protein (%)	20			
Calcium	0.96			
Av. Phosphorus	0.54			
Av. Lysine	1.24			
Av. Methionine	0.63			
Eectrolyt	280			
Av. Threonine	0.82			

MCP1 GREENPHOSP/22.7% (Mono Calcium phosphate) cal 16% from BAF (An MCP1 GREENPHOSP/22.7% (Mono Calcium phosphate) cal 16% from BAF (Animal feed company), ADANA, Turkey animal feed company), ADANA, Turkey

Composition of Premix2: vitamin, 6,000,000 IU; vitaminD3,1,500,000 IU; vitamin E, 15,000mg; riboflavin, 3,00mg; pantothenic acid, 7,000mg; nicotinic acid, 25,000mg; folic acid,500mg; vitamin B12,15,000mg (Vit-VORM 6/1.5, supplied by Animedica, Horb, Germany). 4 compositions of trace elements premix supplied per kilogram of premix: Mn, 120,000 mg; Zn, 80,000 mg; Fe, 90,000; Cu,15,000 mg; I, 1,600 MG; Se, 500 mg (Spu"rElevor SGI, supplied by Animedica, Horb, Germany.

Results:

Carcass characterization:

At the end of the experiment (35 days), the results of this study show a significant ($p \leq 0.05$) increase in the live body weight, Carcass without feathers, and Carcass without visas. We notice an increase in the size of the heart, liver, and gizzard in the groups (T3) and (T4) when compared with other groups, as shown in Table (3).

Table (3) Effect of whole flaxseed and reduced energy-based diet on on carcass characteristic/ mean ±SD.

Groups / Parameters	T1	T2	T3	T4	T5
Live body Wight	1980.52±20.21 BC	1805.38±39.1 D	2138.70±62.55 A	2025.62±46.06 B	1938.58±40.13 C
Carcass Without feather	1825.52±20.21 BC	1645.10±43.12 D	2006.50±47.84 A	1872.62±46.06 B	1784.32±40.04 C
Carcass Without visra	1426.32±20.21 C	1246.70±40.86 D	1609.70±47.74 A	1474.52±46.12 B	1385.32± 40.04 C
Carcass with edible	1522.06±22.08 B	1334.66±43.87 D	1690.18±36.57 A	1564.62±46.06 B	1475.32±40.04 C
Gizzard	43.48±1.04 C	41.081.1.15 D	46.52±1.67 A	45.50±1.04 AB	44.46±.56 BC
Liver	37.10±.81 C	35.18±1.14 D	39.14±1.32 A	38.56±1.40 AB	37.66±.38 BC
Heart	12.04±.37 C	11.04±.24 D	13.46±.41 A	13.12±.81 AB	12.74±.33 B

Different letters among groups showed a significant difference at (p≤ 0.05). The control group (T1) fed a basal diet without any additives, (T2) fed a basal diet without any additives under heat stress, (T3) contained whole flaxseed under heat stress, (T4) contained whole flaxseed_ reduced energy, (T5) contain reduced energy.

Omega-3 contents in the meat

Omega-3 content in the meat: the current study showed a significant increase (p≤0.05) in Omega-3 meat content; ALA, EPA, and DHA were increased in T3 and T4, respectively groups, as compared to the other groups, while there was no significant difference among other groups as shown in table (4).

Table (4) Effect of whole flaxseed and reduced energy diet on Omega-3 content in the meat of broiler chickens

Parameters (%)	T1	T2	T3	T4	T5
Thigh					
ALA	8.16±.33 C	7.66±.37 C	11.79±.46 A	10.95±.56 B	7.92±.39 C
DHA	3.53±.20 B	3.02±.08 C	5.07±.14 A	4.98±.39 A	3.17±.27 C
EPA	4.49±.13 C	3.98±.16 D	6.80±.15 A	6.11±.16 B	4.00±.08 D
Breast					
ALA	3.39±.29 B	3.00±.09 C	5.28±.23 A	5.10±.14 A	3.32±.29 B
DHA	2.41±.25 B	2.25±.22 B	4.11±.06 A	4.01±.06 A	2.44±.21 B
EPA	4.19±.06 C	3.85±.18 D	5.39±.11 A	5.16±.13 B	3.99±.14 D

(Mean±SD).

Different letters among groups showed a significant difference at (p≤ 0.05). The control group (T1) was fed a basal diet without any additives, (T2) was fed a basal diet without any additives under heat stress, (T3) contained whole flaxseed under heat stress, (T4) contained whole flaxseed_ reduced energy, (T5) contain reduced energy.

Discussion

The increase in live body weight, carcass characteristics, and edible organ weight at 35 days of age as a result of using 10% whole flaxseed, as shown in Table 3, was probably due to the use of whole flaxseed in the poultry diet, which is rich in long-chain polyunsaturated fatty acids that have many benefits, including improving metabolism and enhancing the breakdown and absorption of lipoproteins and their fatty acid components [10]. In addition, the high oil content of flaxseeds enhances palatability, increases energy utilization and absorption of vitamins, and increases the absorption of all nutrients by reducing the rate of food passage through the intestines [11].

The improvement in live body weight, carcass characteristics, and edible organ weights may be due to enhanced expression of the IGF-1 gene, consistent with [12] the result of using n-3 PUFA in broiler chicken diets. The IGF-1 gene stimulates the proliferation, differentiation, and metabolism of muscle cell lines of various types.

The increase in live body weight, carcass characteristics, and edible organ weight was probably due to the enhancement of the MUC-2 gene responsible for producing the mucin layer that acts as a defensive factor against pathogens in the intestine, improving intestinal health and thus improving digestion, absorption, and weight. On the other hand, the improvement may have been due to the increase in the length of the villi, the surface area, and the depth of the crypts. This was in agreement with [13&14], which indicated that giving feed from one day old to 35 days old containing 10% flaxseed led to an increase in the improvement of the MUC2 gene and intestinal health.

The improvement in live body weight, carcass characteristics, and edible organ weight may affect the production of eicosanoids by their effect on reducing inflammatory effects and anti-inflammatory effects; this was in agreement with [15], which indicated flaxseed oil that regulates the ratio of omega-6 to omega-3 is having a significant impact on the production of various eicosanoids, as it participates in increasing the immune status and reducing inflammation.

On the other hand, the increase in carcass characteristics under heat stress may have been due to the antioxidant activity from using a flaxseed oil that benefits birds; this agrees with [16]. The increase in carcass characteristics under heat stress conditions may be due to the impact of polyunsaturated fatty acids on some metabolic mechanisms, as they significantly affect the metabolism of protein, fat, carbohydrates, and minerals in birds suffering from heat stress; this is consistent with [17], which concluded that polyunsaturated fatty acids work to reduce the metabolism of fats and carbohydrates while increasing the metabolism of protein.

The increase in omega-3 polyunsaturated fatty acids (n-3 PUFA) in meat, as shown in Table 4, may be due to using flaxseeds in broiler diets as a source of alpha-linolenic acid (ALA). Chickens possess the hepatic enzymes required to convert ALA to n-3. Therefore, applying flaxseeds in feeds enhances n-3 PUFA levels in poultry products [18].

Whole flaxseed contains 35%–45% oil, which is more than 70% α-linolenic acid (ALA); flaxseed is considered an essential source of fat in animal feeds, especially in n−3 fatty acid meat enrichment [19]. Dietary linolenic acid (LA) can be physiologically synthesized as a precursor into other beneficial n-3 PUFAs; therefore, reducing carcass body fat composition can be influenced by dietary PUFAs in poultry [20].

The enhancement in n-3 PUFA content is due to flaxseed oil increasing the ALA and n-3 PUFA levels in the meat. Where the majority of ALA deposition is in triglycerides (the main class of fat used as an energy source), while the vast majority of n-3 PUFA are selectively deposited in the phospholipid class (which constitute a low percentage of meat tissue fat) and have specific functional roles, and only a tiny percentage is deposited in the triglyceride fraction. Thus, altering the regulation of n-3 PUFA deposition to increase the accumulation of n-3 PUFA in the triglyceride fraction would be a practical approach to improving the total n-3 PUFA in broiler meat-fed high-ALA diets [21].

Conclusions:

There was an improvement in omega-3 levels in the muscle tissue of broilers fed flaxseed and a flaxseed reduced-energy diet in the treatment groups (T3) and (T4) relative to the control group. Also, there were increases in live body weight, carcass characteristics, and edible viscera weight in the treatment groups (T3) and (T4) relative to the control group. Adopting a reduced-energy diet will save feed costs and is beneficial in heat stress.

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