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RESEARCH ARTICLE

Effect of Cereal Grains on the Total Lipid, Cholesterol Content and Fatty Acid Composition of Liver and Muscle Tissues in Native Geese

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Summary

In this study we evaluated the effect of cereal grains on total lipid, cholesterol content and fatty acid composition of liver and muscle tissues in native geese. The thirty five geese used in the study were divided into five groups of seven. The groups of geese feed with barley, wheat, rye and corn, respectively. The first group was used as the control group. Water and feed were provided for ad libitum consumption for 6 weeks. While the level of total cholesterol in the liver tissue decreased (P<0.001) in barley and wheat groups, it of the thigh muscle decreased (P<0.001) in all groups. While the total lipid content of the liver tissue increased in rye and corn groups (P<0.001), it of the thigh muscle increased (P<0.001) in wheat and rye groups. While the total lipid content of the back muscle decreased in barley and wheat groups (P<0.001), it of the breast muscle decreased (P<0.001) in wheat, rye and corn groups. Although the amount of palmitic acid in the liver tissue increased (P<0.001) in the rye group, the amount of stearic decreased (P<0.001) in the barley group. The amount of arachidonic, docosahexaenoic, PUFA, n-3 and n-6 acids in the liver tissue increased (P<0.001) in the wheat, rye and corn groups. Consequently, in addition to other foods, rye could be used as a valuable nutrition of the geese diet.

Keywords: *Cereal Grains, Cholesterol, Total lipid, Liver, Muscle, Geese Diet*

Yerli Kazlarda Karaciğer ve Kas Dokularının Total Lipit, Kolesterol İçeriği ve Yağ Asidi Kompozisyonu Üzerine Tahıl Tanelerinin Etkisi

Özet

Bu çalışmada yerli kazlarda karaciğer ve kas dokusunun total lipit, kolesterol içeriği ve yağ asidi kompozisyonu üzerine tahıl tanelerinin etkisini inceledik. Çalışmada kullanılan 35 kaz 5 gruba ayrıldı. Kaz grupları sırasıyla arpa, buğday, çavdar ve mısır ile beslendi. İlk grup kontrol grubu olarak kullanıldı. Su ve besin 6 hafta boyunca ad libitum olarak verildi. Karaciğer dokusundaki total kolesterol seviyesi arpa ve buğday gruplarında azalış (P<0.001) gösterirken, but kasında tüm gruplarda (P<0.001) azalmıştır. Karaciğer dokusundaki total lipit içeriği çavdar ve mısır gruplarında artış (P<0.001) gösterirken, but kasında buğday ve çavdar gruplarında (P<0.001) artmıştır. Sırt kasındaki total lipit içeriği arpa ve buğday gruplarında azalış (P<0.001) gösterirken, göğüs kasında buğday, çavdar ve mısır gruplarında (P<0.001) azalmıştır. Karaciğer dokusunda palmitik asit miktarı çavdar grubunda arttığı (P<0.001) halde, stearik asit miktarı arpa grubunda (P<0.001) azalmıştır. Karaciğer dokusundaki araşidonik, dokosahekzaenoik, PUFA, n-3 ve n-6 asitleri buğday, çavdar ve mısır gruplarında artmıştır (P<0.001). Sonuç olarak, diğer besinlere ek olarak çavdar kaz diyetinde değerli bir besin olarak kullanılabilir.

Anahtar sözcükler: *Tahıl taneleri, Kolesterol, Total lipit, Karaciğer, Kas, Kaz diyeti*

INTRODUCTION

Poultry meat is a consumption material which is preferred by a lot of people. There has been growing interest over recent years in the modulation of the cholesterol content and fatty acid composition in poultry products because occurrences of cardiovascular heart disease have been closely related to the dietary intake of cholesterol and saturated fatty acid (SFA) content [1]. To lead a healthy life is to reduce intake of cholesterol and saturated fatty acids [2].

The study of avian nutrition, which was the focus of much biochemistry for the early part of this century, was carried out of mainly using chicks, ducks, quail and geese.

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Geese are commercially produced for meat, fatty liver and feathers [3]. Geese production is broadly free-range production system in Turkey [4].

From 1940s to nowadays, nutritional science has been neglected by the majority of biochemists; contents of the diet have been defined and in most cases their biochemical role is known. Although with humans the emphasis is on improving health and longevity, in the domestic poultry and the other domesticated birds, the emphasis of nutritional studies has been largely directed towards optimizing growth [5].

A controlled feeding can modulate the fat development. The studies of the nutritionist are to define means to achieve a good of carcass fattening and to increase output in lean meat while considering the impact of genetic, nutritional and economic factors [6]. These factors contribute to the tendency of boiler and geese to accumulate excess body fat. Therefore, improving carcass quality with feed additives has become a main focus of nutrition research [7]. Depending on the source of energy in the diet (starch or lipids) the fatty acid profile of muscle in fowl reflects a balance between hepatic steatosis and dietary lipids [6]. In all birds, fatty acids are mainly synthesized in the liver and then exported to peripheral tissues, including the muscles [8].

In domestic birds, i.e. geese and duck, they are used to commercial production of fatty liver ('foie gras') which has their specific capacity [9]. In the goose, the liver weight may increase 10-fold in two or three weeks and account for up to 10% of body weight [10] . Actually, the relative importance of the liver steatosis and the peripheral fat deposition results from a poise which may be controlled by the efficiency of lipid transfer between adipose tissues and muscles [11].

The mechanism of dietary-induced fatty liver of birds remains puzzling. In response to overfeeding, de novo hepatic lipogenesis from dietary carbohydrates is sensationally made better in the goose [12].

Cholesterol is a very important organic molecule to cellular function [13].

The aim of the present study was to compare the effects of feeding different cereal grains on the total lipid, cholesterol and fatty acid composition of muscle and liver tissues in native geese.

MATERIAL and METHODS

Animals

All experiments were conducted in accordance with the principles and guidelines approved by the Fırat University of Technology Animal Care and Use committee (No: MKÜ-HADYEK-2012/30). Thirty-five adult male and female native geese *(Anser anser)* were bought in Kars/Turkey. At the start of the experiment, the geese weighed 2450-2850 g. Geese were randomly assigned to five groups. They were placed in groups of 7 geese in metal cages (200 cm long x 200 cm wide x 200 cm high). The environmental conditions were control for ventilation. The room temperatures were set at 31 and 30°C, respectively, during the six weeks. They were provided ad libitum access to drinking water and experimental diets for 6 weeks. The weekly amount of feed provided was 7 kg for each group *(Table 1)*. The first group was used as control (CON) and fed with fresh meadow grass. We choose fresh meadow grass in control group for geese is fed naturally in grasslands of Kars. The second group was only fed with barley (BA), the third group with wheat (WH), the fourth group with rye (RY) and the fifth group with corn (COR).

Table 1. *Percent composition of diets, (%)*
Tablo 1. *Diyetin yüzde kompozisyonu*

Feed Ingredients	Groups				
	Control	Barley	Wheat	Rye	Corn
Fresh meadow grass	99.40	-	-	-	-
Barley	-	99.10	-	-	-
Wheat	-	-	99.10	-	-
Rye	-	-	-	99.10	-
Corn	-	-	-	-	99.10
Salt	0.60	0.60	0.60	0.60	0.60
Vitamin[1]	-	0.20	0.20	0.20	0.20
Mineral[2]	-	0.10	0.10	0.10	0.10

[1] ***Vitamin added per kilogram:*** *vitamin A, 2.000.000 IU; Vitamin D_3, 400.000; D-Biotin, 6.50 mg Vitamin E,; 2.600 mg; Vitamin B_1, 520 mg; Vitamin B_2, 1.320 mg; Vitamin B_5, 2.000 mg; Vitamin B_6, 660 mg; Vitamin B_{12} 2.50 mg*
[2] ***Vitamin added per kilogram:*** *Niacin, 2.600 mg; Mn, 6.500 mg; Fe, 6.500 mg; $C_5H_{14}CINO$, 26.65 mg; Zn, 6.500 mg; Cu, 1.320 mg; Na, 180.000 mg; I, 100 mg; Se,26.50 mg; Co, 26.50 mg*

At the end of the feeding period, geese were slaughtered muscle and liver tissues were removed, weighed and refrigerated at 4°C. After weighing of the tissues, a ~10 g sample was taken from part of the thigh, back, and breast of each group and were kept at -20°C until the lipid extraction and further analysis.

Preparation of Fatty Acid Methyl Ester and Gas Chromatographic Analysis

Total lipids were extracted with hexane-isopropanol (3:2 v/v) as described by Hara and Radin [14]. About 1 g of the samples were taken and homogenized with homogenizer (Bosch, Germany).

Fatty acids in the lipid extracts were converted into methyl esters by means of 2% sulphuric acid (v/v) in methanol [15]. The mixture was incubated at 55°C for 17 h. Nonlipid contaminants in lipid extracts were removed by NaCl solution. Fatty acid methyl esters were treated with 1 ml 2% KH_2CO_3 solution. The hexane phase was evaporated by the nitrogen flow and then by dissolving in 1 mL fresh hexane, they were taken to auto sampler vials.

Then the methyl esters were separated and quantified by gas chromatography and flame- ionization detection (Shimadzu GC 17 Ver. 3) coupled to a Glass GC 10 software computing recorder. Chromatography was performed with Machery-Nagel (Germany) capillary column (25 m in length) and 0.25 mm in diameter. The temperatures of the column was kept at 120-220°C, injection temperature was kept at 240°C and the detector temperature was kept at 280°C. The colon temperature program was adjusted from 120-20°C and then 5°C min until 200 and 4°C min from 200-220°C. It was kept at 220°C for 8 min and the total duration was set as 35 min and nitrogen gas was used as the carrier gas. Identification of the individual methyl esters was performed by frequent comparison with authentic standard mixtures that were analyzed under the same conditions [16].

Cholesterol Analysis

Total lipids were extracted with hexane-isopropanol (3:2 v/v) as described by Hara and Radin [14]. About 1g of the samples were taken and homogenized.

The 5 ml supernatant was taken to tubes and 5 ml KOH was added to it. The mixture was incubated for 30 min at 85°C. It was then cooled under room condition and 5 ml of distilled water was added. Hexane-isopropanol extracts were combined and evaporated. The residue was dissolved in 1 ml of acetonitrile: methanol centrifuged and the supernatant was used for cholesterol content determination.

For the analysis cholesterol content were used the fully automatic High Performance Liquid Chromatography equipment (HPLC) [17]. The equipment for HPLC consisted of a pump (LC-10ADVP), a UV-vis detector (SPD-10AVP) a column oven (CTO-10ASVP), an auto sampler (SIL-10ADVP) a degasser unit (DGU-14A) and a computer system with Class VP software (Shimadzu, Kyoto, Japan). Discovery RP-Amide C16 column (150 mm×4.6 mm, 5µm; Sigma, USA) was used as the HPLC column and 50 mM $NaClO_4$ 0.1% H_3PO_4 was used as the mobile phase and flowrate 1 ml/min. Detection was performed at 215 nm by UV-vis detector and 40°C column oven.

Statistical Analysis

Values have been reported as the mean±SEM. Statistical analysis was done with SPSS 16.0 software. Analysis of variance (ANOVA) and Duncan test were used to compare the experimental groups with the controls.

RESULTS

The purpose of this study in the province of Kars/Turkey, geese reared in different foods (barley, wheat, rye, and corn), some biochemical parameters of nutrition as a result of changes in muscle and liver tissue was investigated.

Fatty Acid Content of Diet

Palmitic acid (16:0) level was found to be rather low compared to other groups in control. Barley, wheat and rye show a significant difference is determined. However, a significant increase was observed in corn. Palmitoleic acid (16:1n-7) compared to the control level except for rye was increased. This increase was found to be quite high, especially corn.

Stearic acid (18:0) significantly reduced the amount of wheat was compared with the control. Barley and maize were increased compared to the control. Oleic acid (18:1n-9) levels of corn and rye, is very high compared to other groups *(Table 2)*.

Linoleic acid (18:2n-6) compared to control all the feed increased the amount of this increase, especially in corn were found to be more specific. Linolenic acid (18:3n-3) according to the amount of other feeds in the control was very much reduced.

Total Lipid and Cholesterol Content

In this study, it was found that the total lipid content of liver tissue was between 137.14±1.87-267.96±2.14 mg/100 g and total cholesterol content was 63.94±1.52-87.54±1.22 mg/100 g wet tissue. The content of total lipid and cholesterol in muscle and liver tissues of native geese are shown in *Table 3*.

While the cholesterol levels and the lipid content of liver tissue decreased in barley (BA) and wheat (WH) groups, it increased in rye (RY) and corn (COR) groups. The cholesterol levels of thigh tissue decreased in all groups.

Table 2. *Fatty acid content of diets (mg/100 g, n=7)*
Tablo 2. *Diyetlerinin yağ asidi içeriği (mg/100 g, n=7)*

Fatty Acids	Control	Barley	Wheat	Rye	Corn
16:0	9.89	36.64	38.23	30.80	83.11
18:0	1.03	21.81	0.22	1.65	11.42
16:1n-7	1.27	5.00	9.30	1.11	22.00
18:1n-9	2.00	2.93	6.10	38.88	179.50
18:2n-6	10.94	104.26	149.05	120.42	470.33
18:3n-3	44.41	13.56	15.36	20.41	12.08
18:4n-3	1.00	1.83	2.05	3.57	1.62

Table 3. *Total lipid and cholesterol content in liver and muscle tissues of native geese (n=7)*
Tablo 3. *Yerli kazların karaciğer ve kas dokularındaki total lipit ve kolesterol içeriği (n=7)*

Parameters	Groups				
	Control	Barley	Wheat	Rye	Corn
Liver (mg/100 g)					
Total lipid	211.22±1.84^{d}	137.14±1.87^{e}	197.99±2.11^{c}	267.96±2.14^{a}	215.80±1.92^{b}
Cholesterol	74.41±1.33^{b}	64.99±1.33^{c}	63.94±1.52^{c}	87.54±1.22^{a}	86.54±4.34^{a}
Muscle Total Lipid (mg/100 g)					
Thigh	302.97±3.67^{d}	209.98±3.20^{e}	948.32±1.67^{a}	449.26±2.47^{c}	848.87±1.77^{b}
Back	256.63±0.69^{a}	490.23±1.90^{c}	500.53±2.12^{c}	559.82±3.60^{c}	729.94±2.48^{cd}
Breast	489.79±2.79^{a}	597.62±3.04^{c}	481.86±1.94^{a}	988.89±2.83^{cd}	739.04±2.86^{cd}
Muscle Cholestrol (mg/100 g)					
Thigh	29.30±1.16^{a}	27.11±0.29^{b}	24.24±1.81^{c}	23.31±0.81^{c}	25.29±1.12^{b}
Back	29.17±2.63^{d}	20.84±2.37^{c}	22.47±2.04^{b}	30.05±5.42^{a}	26.00±3.19^{a}
Breast	37.41±0.25^{c}	35.35±0.64^{c}	30.83±0.25^{c}	32.69±0.15^{a}	26.72±0.70^{b}

Differences between the groups comprising different letters in the same line is statistically significant (P<0.001)

While the cholesterol levels of back tissue decreased in BA and WH, it of breast tissue decreased in WH, RY and COR. While the lipid content of thigh tissue decreased in BA, it increased in WH, RY and COR. Total lipid content of back tissue was increased (P<0.001) in all groups. Total lipid content of breast tissue was increased (P<0.001) in BA, RY and COR *(Table 3)*.

The present data confirm that, when food intake is kept identical in native geese, lipid metabolism and amount of the total cholesterol is very different as compared to control (CON) group. They effect markedly in the proportions and the total lipid content of liver and muscle tissue.

The total cholesterol level of all muscles slightly decreased (P<0.001) in WH and COR, at the end of the feeding period. Fournier et al.[18] was reported that there was no significant difference between Landes and Poland geese, with the exception of the percentage of cholesteryl esters, which was higher in the Landes goose.

Fatty Acid Content of Liver and Muscle Tissue Lipids

The influence of the dietary treatment on the liver and muscle tissues of individual fatty acids is shown in *Table 4*. In liver tissues, the amount of palmitic acid increased significantly in RY, but stearic acid decreased significantly in BA. The amount of oleic acid increased significantly in WH, RY and COR. The amount of linoleic acid increased (P<0.05) significantly in WH and COR when compared to COR. The amount of arachidonic, docosahexaenoic, poly-unsaturated, n-3 and n-6 acids decreased significantly in BA when compared to CON, but they increased significantly in WH, RY and COR.

The amount of fatty acids in thigh muscle is shown in *Table 5*. In thigh muscles, the amount of palmitic, stearic, oleic, linoleic, linolenic, arachidonic, SFA, PUFA and n-3 acids decreased significantly (P<0.001) in BA when compared to control group but they increased significantly in WH, RY and CORN. The amount of palmitoleic acid increased in BA and COR when compared to CON. The amount of docosahexaenoic acid increased in WH when compared to control group.

The amount of fatty acids in back muscle is shown in *Table 6*. In back muscles, the amount of oleic, linoleic, SFA, MUFA, PUFA and n-6 acids increased significantly

Table 4. *Amounts of fatty acids in liver (mg/100 g, wet tissue)*
Tablo 4. *Karaciğerdeki yağ asidi miktarı (mg/100 g, yaş ağırlık)*

Fatty Acids	Groups				
	Control	Barley	Wheat	Rye	Corn
16:0	41.41±3.28^{bc}	27.64±2.38^{c}	37.87±3.14^{b}	46.92±1.59^{a}	39.58±3.23^{b}
18:0	39.85±2.16^{ab}	25.04±1.72^{c}	34.52±3.36^{b}	49.13±2.73^{a}	42.91±2.00^{a}
SFA[1]	81.25±5.27^{a}	52.68±3.88^{c}	72.39±0.92^{b}	96.05±3.01^{a}	82.49±5.13^{a}
18:1n-9	38.60±0.94^{c}	34.58±1.48^{c}	47.28±1.81^{ab}	55.10±2.18^{a}	45.08±2.62^{b}
18:2n-6*	26.86±1.33^{b}	32.22±1.32^{ab}	33.86±1.25^{a}	29.80±3.15^{ab}	37.22±2.44^{a}
20:4n-6	42.50±2.40^{bc}	24.39±1.54^{d}	38.73±2.73^{c}	52.00±2.61^{a}	46.66±1.20^{ab}
22:6n-3	13.99±1.47^{b}	6.87±0.64^{c}	9.72±1.11^{c}	20.24±1.79^{a}	20.69±2.34^{a}
PUFA[2]	77.33±0.59^{d}	63.49±1.10^{e}	82.32±0.87^{c}	102.04±1.02^{a}	118.55±1.56^{a}
Σn-3	13.99±1.13^{b}	6.87±0.20^{d}	9.72±0.85^{c}	20.24±0.47^{a}	20.69±1.05^{b}
Σn-6	69.37±2.90^{c}	56.61±1.94^{d}	72.60±1.10^{c}	81.79±2.78^{b}	97.85±3.09^{a}

** P<0.05, Other groups are P<0.001, [1] **SFA**= Saturated fatty acid, [2] **PUFA**= Polyunsaturated fatty acid*

Table 5. *Amounts of fatty acids in thigh muscle (mg/100g, wet tissue)*
Tablo 5. *But kasındaki yağ asidi miktarı (mg/100g, yaş ağırlık)*

Fatty Acids	Groups				
	Control	Barley	Wheat	Rye	Corn
16:0	53.17±3.44^{d}	43.60±2.92^{e}	120.85±2.58^{b}	89.48±2.16^{c}	197.88±2.45^{a}
18:0	25.59±1.02^{c}	18.24±2.70^{d}	40.88±2.14^{b}	40.81±2.73^{b}	61.04±1.33^{a}
SFA[1]	78.79±1.65^{d}	68.26±9.07^{d}	161.73±3.66^{b}	130.29±3.22^{c}	258.92±8.30^{a}
16:1n-7	12.46±0.47^{b}	8.53±1.52^{bc}	26.48±1.97^{a}	7.31±1.04^{c}	25.60±0.95^{a}
18:1n-9	83.00±1.21^{e}	77.61±2.67^{d}	197.65±3.58^{b}	154.93±1.76^{c}	312.83±1.70^{a}
MUFA[2]	95.47±2.13^{e}	86.15±2.83^{d}	224.13±7.19^{b}	162.25±4.42^{c}	340.86±2.71^{a}
18:2n-6	44.53±0.70^{d}	28.68±2.52^{e}	69.82±3.67^{b}	56.87±1.45^{c}	102.75±5.13^{a}
18:3n-3	20.42±1.99^{c}	12.79±0.83^{d}	24.93±1.43^{b}	25.06±0.98^{b}	31.75±1.47^{a}
20:4n-6	20.70±2.80^{c}	13.11±0.22^{d}	38.40±2.05^{b}	37.61±2.33^{b}	48.77±2.69^{a}
22:6n-3	3.80±1.74^{bc}	1.17±1.10^{c}	19.98±1.47^{a}	8.14±1.72^{bc}	8.09±1.25^{b}
PUFA[3]	89.44±1.35^{e}	55.76±2.70^{d}	153.13±7.19^{b}	126.26±4.09^{c}	184.35±4.70^{a}
Σn-3	24.21±4.65^{c}	14.08±3.35^{d}	44.91±1.83^{a}	33.20±5.08^{c}	39.11±1.91^{b}
Σn-6	65.23±8.27^{d}	41.68±9.94^{e}	108.22±6.53^{b}	94.48±9.71^{c}	145.23±3.76^{a}

Differences between the groups comprising different letters in the same line is statistically significant (P<0.001)
*[1] **SFA** = Saturated fatty acid, [2] **MUFA** = Monounsaturated fatty acid, [3] **PUFA** = Polyunsaturated fatty acid*

(P<0.001) in all groups when they compared to CON. The amount palmitoleic acid were not statistically significant (P>0.05) in all groups when they compared to CON. The amount of stearic acid increased significantly in BA, WH and COR. While arachidonic acid increased in BA, RY and COR, docosahexaenoic acid increased (P<0.01) in WH and COR when compared to CON.

The amount of fatty acids in breast muscle is shown in *Table 7*. In breast muscles, the amount of stearic, linoleic and docosahexaenoic acids increased significantly (P<0.001) in RY and COR when they compared to CON. While palmitoleic acid decreased in BA and RY, linolenic acid increased significantly (P<0.05) in RY and COR. The amount of palmitic acid decreased significantly in WH but it increased in BA, RY and COR. Arachidonic, MUFA and n-6 increased in all groups. While the amount of SFA increased significantly in BA, RY and COR, the amount of PUFA increased significantly in WH, RY and COR.

DISCUSSION

The fatty acid components are in general C_{16} and C_{18} fatty acids and a typical proportion of saturated: monosaturated: polyunsaturated fatty acids in broilers is 0.31:

Table 6. *Amounts of fatty acids in back muscle (mg/100 g, wet tissue)*
Tablo 6. *Sırt kasındaki yağ asidi miktarı (mg/100 g, yaş ağırlık)*

Fatty Acids	Groups				
	Control	Barley	Wheat	Rye	Corn
16:0	50.09±0.45^{d}	111.23±0.72^{c}	107.36±2.02^{c}	114.79±2.10^{b}	156.41±3.17^{a}
18:0	26.46±0.88^{c}	41.50±0.50^{b}	40.22± 1.96^{b}	29.59±2.68^{c}	49.97±1.42^{a}
SFA	76.55±1.31^{d}	153.22±1.68^{b}	147.58±1.54^{bc}	144.38±1.88^{c}	203.38±3.34^{a}
16:1n-7*	4.38±0.42^{b}	6.92±1.15^{ab}	7.19±1.15^{ab}	5.96±1.18^{ab}	8.56±1.37^{a}
18:1n-9	76.83±0.42^{d}	159.72±2.18^{a}	170.49±0.96^{a}	111.45±2.09^{c}	153.71±1.65^{b}
MUFA	78.00±1.04^{d}	166.63±1.57^{b}	177.68±2.82^{a}	117.68±3.69^{c}	162.27±2.78^{b}
18:2n-6	36.68±1.76^{d}	56.53±3.86^{c}	64.94±0.86^{b}	58.69±3.37^{bc}	75.77±1.08^{a}
18:3n-3	14.72±1.70^{bc}	11.42±2.41^{c}	34.26±2.14^{a}	19.34±1.20^{b}	15.40±1.46^{bc}
20:4n-6	23.40±1.72^{c}	35.10±1.56^{b}	26.15±0.55^{c}	36.63± 0.82^{b}	45.52±1.07^{a}
22:6n-3**	3.14±1.48^{b}	3.83±2.42^{b}	3.59±1.75^{b}	10.25±1.98^{a}	8.91±0.44^{a}
PUFA	77.94±1.19^{d}	105.87±0.87^{c}	128.94±1.34^{b}	124.90±0.97^{b}	172.59±3.69^{a}
Σn-3	17.86±0.87^{c}	14.25±1.58^{d}	37.85±2.44^{a}	29.58±2.27^{b}	24.31±1.74^{b}
Σn-6	60.08±1.26^{c}	91.62±1.31^{b}	91.09±1.21^{b}	95.32±1.40^{b}	148.90±2.48^{a}

** P>0.05, ** P<0.01, The other groups are P<0.001*

Table 7. *Amounts of fatty acids in breast muscle (mg/100g, wet tissue)*
Tablo 7. *Göğüs kasındaki yağ asidi miktarı (mg/100g, yaş ağırlık)*

Fatty Acids	Groups				
	Control	Barley	Wheat	Rye	Corn
16:0	112.60±1.98^{d}	139.19±1.67^{bc}	101.60±3.41^{cd}	211.47±1.77^{a}	139.76±3.53^{b}
18:0	42.53±1.50^{c}	47.25±1.17^{a}	42.87±2.70^{c}	77.15±2.96^{c}	62.23±1.44^{b}
SFA	155.14±0.90^{d}	186.44±1.17^{bc}	130.47±1.28^{cd}	288.62±1.74^{a}	201.75±4.35^{b}
16:1n-7*	14.24±1.42^{a}	9.21±0.40^{b}	6.93±1.06^{b}	13.16±2.18^{ab}	11.28±1.08^{ab}
18:1n-9	155.14±2.22^{d}	204.56±1.5^{bc}	144.21±2.15^{cd}	340.64±2.78^{a}	211.59±3.30^{b}
MUFA	166.55±2.58^{d}	213.76±3.38^{bc}	151.14±2.60^{cd}	353.80±2.06^{a}	222.88±2.94^{b}
18:2n-6	68.21±2.80^{c}	70.85±1.80^{bc}	68.12±1.02^{bc}	123.98±2.75^{a}	81.45±0.94^{b}
18:3n-3	29.81±2.27^{b}	20.17±1.15^{c}	29.58±3.13^{b}	40.02±2.23^{a}	22.75±2.25^{c}
20:4n-6	27.99±2.49^{c}	42.00±0.66^{b}	36.99±1.58^{b}	65.10±1.82^{a}	45.07±1.30^{b}
22:6n-3	4.54±1.24^{d}	6.74±1.33^{cd}	7.11±1.85^{c}	27.21±1.07^{a}	15.98±0.33^{b}
PUFA	130.54±1.10^{d}	139.77±1.26^{d}	141.81±2.43^{c}	160.69±2.20^{b}	165.54±1.66^{a}
Σn-3	34.35±1.74^{bc}	26.91±2.02^{c}	36.69±2.54^{b}	67.23±1.93^{a}	38.73±0.30^{b}
Σn-6	96.19±1.48^{c}	112.85±3.32^{b}	105.12±3.51^{b}	189.07±2.13^{a}	126.81±1.40^{b}

** P<0.05, The other groups are P<0.001*

0.45:0.23 [19]; a similar distribution is found in jungle poultry and dove [20]. This is a considerably higher proportion of polyunsaturated fatty acids than occurs in mammalian tissues. Shifts in favor of polyunsaturated fatty acids can be accomplished by feeding domestic poultry a high proportion of dietary polyunsaturated fats. In quail, the proportion of saturated to unsaturated fatty acids is also affected by environmental temperature [21,22]. The most ample fatty acids in quail are palmitic, stearic, myristic, palmitoleic, oleic, linoleic, eicosatrienoic and arachidonic acids, and the same is probably true for other domesticated birds [23].

Fatty acids influence many structural metabolic and regulatory components of cells [24]. As essential amino acids and fatty acids cannot be synthesized by animals and humans, they are taken from diets and have to be turned into within the body [25]. Hermier et al.[26] reported that

geese contained mostly oleic (18:1n-9, ~45%), palmitic (16:0, ~30%) and stearic (18:0, ~11-14%) acids, which are the main products of the de novo hepatic lipogenesis. In contrast, polyunsaturated fatty acids (PUFA) are essential and must be provided by the diet. The increase in total lipid content caused by genotype or by overfeeding mainly resulted from a deposition of triglycerides and MUFA. Oleic and palmitoleic acids are the primary fatty acids synthesized per birds [27]. SFA also increased, chiefly palmitic and stearic acids rendered per feed. In spite of large amounts of linoleic acid representing 57% of total fatty acids rendered by the overfeeding diet [28], PUFA amounts in thigh muscle slightly increased. Lipid composition in muscle was therefore mainly influenced by lipogenesis than feed composition.

Mourot et al.[29] was reported that *P. major* (breast) muscle was higher in 18:0 and lower 14:0 and 16:1n-7 in Landes geese. The fatty acids disclosed an increase in saturated fatty acids and a decrease in linoleic acid content [30,31]. The data shown that palmitic (16:0), oleic (18:1) and linoleic (18:2) acids formed a majority of the fatty acid content in muscle tissues *(Table 4-7)*.

Gabarrou et al.[32] reported that the concentration of stearic acid decreased, whereas oleic acid increased noticeably from 10 to 26.3%. The concentrations of (n-6) polyunsaturated fatty acid concentration decreased from 5 to 3.7% for linoleic acid and, more sensationally, from 18.1 to 7.1% for arachidonic acid. Our data found that the fatty acid composition of muscle tissue contains greater n-6 than n-3 fatty acids *(Table 4-6)*. In addition, the n-6 fatty acid content of muscle tissues were higher than liver.

The present study demonstrated that the nature of one's habitual diet with respect to both the amount and type of fatty acids related to the fatty acid composition of structural and stored lipids in liver and muscle tissue. Rye-based diet is resembled with corn-based diet, and rye is one of overfeeding ingredients instead of corn. More research is needed to determine the physiological mechanism by which rye affects geese growth and to identify the optimum method to include rye in geese diets so as to improve bird development. This research can be for the public knowledge regarding an important international meat source for many and the healthfulness of that product.

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