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Effect of fish and soybean oils feed supplementation on the characteristic of Romanov crossbred lamb meat*

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Summary

This study was conducted to investigate the effects of roughage and/or fattening feed rations and CLA-rich fish oil and soybean-supplemented diets on meat quality parameters (pH, color and fatty acids) of crossbred Romanov lambs. As compared to the control group, soybean and fish oil-supplemented groups had almost 3 times greater feed conversion ratios. The amount of feed consumed for 1 kg of live weight during the fattening period was 4.77 kg in the soybean oil-supplemented group, 5.70 kg in the fish oil-supplemented group and 13.33 kg in the control group. In terms of *M. longissimus dorsi* (MLD) area and thickness, treatment groups all had similar values. Soybean and fish oil-supplemented groups had superior pH and color (L*, a*, b*) values. In the thiobarbituric acid (TBA) test, measuring malonaldehyde (MDA) produced due to the oxidation of fatty acids, results revealed that soybean and fish oil-supplemented groups yielded more ideal outcomes for TBARS values and fatty acid profiles.

Keywords: Romanov crossbreed, CLA, fatty acid, meat quality

Conjugated linoleic acids (CLA) were first described in 1985 (28) and include various, isomers of linoleic acid largely encountered in meat and dairy products (5, 9, 25, 26, 28, 33). Researchers have recently focused on CLA because of several health benefits. CLA has been reported to have anti-carcinogenic, antioxidant, anti-atherosclerotic and immuno-supportive effects (9, 16, 29, 33). Moreover, anti-obesity properties and potential mechanisms and activities of CLA have been comprehensively studied. CLA reduces body fat mass and improves lean mass. It was reported that CLA decreased fat accumulation in adipose tissue cells through preadipocyte differentiation and decreased fat intake and increased lipolysis and apoptosis (25).

CLA is naturally found in foods obtained from ruminants. It is produced as a mediator in biohydrogenation of polyunsaturated fatty acids (PUFA) with the action of various anaerobic bacteria in the rumen. Another mediator in ruminal biohydrogenation is synthesized in mammary gland with the effect of Δ-9 desaturase enzyme on vaccenic acid (20, 24).

Conjugated linoleic acid (CLA) is a family of at least 28 linoleic acid isomers found especially in meat and dairy products obtained from ruminants (14). Therefore, the number of studies attempting to increase CLA level in meat and meat products with dietary manipulations and direct supplementations have increased in recent years (16). Meat and dairy products constitute the primary source of CLA in human diets (17, 29). CLA quantity of meat and dairy products largely relies on ruminant diets (5, 9). CLA quantities of dairy products vary between 3.3 and 8 mg/g of fat (26). CLA is not synthesized in the human body. Therefore, it should be taken from meat and dairy products to be included in human diets (29). Defining dairy products as a good source of CLA may increase the positive nutritional image of these foodstuffs (26). Consumption of milk and dairy products should be encouraged and more of them included in standard daily diets. Various methods have been investigated to increase the quantity of this beneficial compound in fermented dairy products. Starter cultures with CLA-producing strains are recommended to be used during manufacture of dairy products. (20).

Ruminant diets are supplemented with polyunsaturated fatty acids to increase meat CLA contents. Soybean oil has a high CLA isomer content, thus it is commonly used as a precursor of CLA in rumen (5). Fish oil was also reported to increase rumen propionate (C3) concentration and thus suggested as a powerful rumen methane inhibitor (31).

This study was conducted to investigate the effects of roughage and/or fattening feed rations and CLA-rich fish oil and soybean-supplemented diets on meat

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Tab. 1. Treatment groups and experimental design

Groups	Group I (Control)	Group II (Soybean oil group)	Group III (Fish oil group)
N	30	30	30
Duration (day)	50	50	50
Feeding program	Alfalfa hay	Alfalfa hay + concentrated feed (Hogget Fattening Pellets: 500 g/animal/day) + 50 ml/animal/day soybean oil	Alfalfa hay + concentrated feed (Hogget Fattening Pellets: 500 g/animal/day) + 50 ml/animal/day fish oil

quality parameters (pH, color and fatty acids) of crossbred Romanov lambs.

Material and methods

The experimental protocol was approved by the Animal Experiments Local Ethics Committee of Ataturk University with the protocol number of 2014-36643897-42.

Animal material. The research was conducted on 4-6 months old crossbreed Romanov lambs raised in Sheep Breeding Res&Dev farm of ER-GEN Biotechnologies operating at Ata Teknocity of Ataturk University, Erzurum (39°55' N, 41°17' E and 1820 m altitude). Of the lambs that were grazed in natural pastures for 90 days and did not receive any additional feeding, 30 male lambs formed the first group of the study (Group I: Control) and they were fed only with dry alfalfa hay of 4.3% of their live weight (15). The second group of lambs (Group II: Soybean oils, 30 male lambs) were fed with concentrated feed (hogget fattening pellets: 500 g/animal/day), in addition to dry alfalfa hay and concentrated their feed was supplemented with 50 ml/animal/day of soybean oil. The third group of lambs (Group III: fish oil, 30 male lambs) were fed with concentrated feed (hogget fattening pellets: 500 g/animal/day), in addition to dry alfalfa hay and concentrated their feed was supplemented with 50 ml/animal/day fish oil. Following 15 days of adaptation period, feeding programs were initiated and lasted for 50 days. Feedings were practiced as group feeding. Clean water and mineral supplements (licking stones) were supplied *ad libitum*. Soybean oil to be supplemented into the diets of the second group was supplied from a local manufacturer (Elita feed Inc, Sunar Soybean oil, Adana, Turkey). Fish oil to be supplemented into the diets of the third group was supplied from a local fish feed manufacturer (Sibal Inc. Black Sea Feed, Sinop, Turkey). Fattening starting weight, 15-day live weight gains, and end of fattening weights were determined by weighing with a bascule (± 100 g) before morning feeding. The experimental design is provided in Table 1 and chemical composition of feed materials is provided in Table 2.

Tab. 2. Chemical composition of experimental feeds (% on dry matter basis)

Components	Alfalfa	Concentrated feed
Dry matter	91.70	88
Crude protein	19.68	12
Crude fat	1.96	–
Crude cellulose	23.37	12
Crude ash	7.48	9
Calcium	1.8	1.1
Phosphorus	0.4	0.4
Sodium	0.1	0.25
Salt	not determined	1
Energy	–	2750 kcal/kg

Commercial slaughter and carcass traits. From each group, 3 animals were slaughtered in accordance with 'Halal' slaughter procedures. Animals were slaughtered 12 hours after the last feeding. Following the slaughter, hot carcass weight was determined, then the carcass was placed into a cold storage and chilled there at +4°C for 48 hours and cold carcass weight was determined. Hot and cold dressing percentages were determined with the use of the carcass and live weight of the animals. The cold carcass was dissected in accordance with standard carcass jointing method. *M. longissimus dorsi* (MLD) muscle samples taken from each group were transported to Atatürk University, Faculty of Agriculture, Food Engineering Department in cold chain and samples were subjected to sectional area, pH, color and fatty acid profile analyses.

Determination of pH value. About 10 g sample was homogenized in 100 ml distilled water with the use of a homogenizer (IKA Werk T25, Germany) and pH of resultant homogenate was measured with a pH meter (ATI ORION 420, MA 02,129, USA).

Determination of color values. The color parameters of L* (brightness), a* (redness) and b* (yellowness) were measured with the use of a colorimeter device (CR-200, Minolta Co, Osaka, Japan) in accordance with CIE criteria. Total color change (ΔE) was calculated with the use of measured L*, a* and b* values (23):

$$\Delta E = \sqrt{(L_0 - L^*)^2 + (a_0 - a^*)^2 + (b_0 - b^*)^2}$$

where the subscript "$_0$" indicates reading made on control sample.

Determination of oxidative stability (TBARS). About 2 g homogenized sample was supplemented with 12 ml trichloroacetic acid (TCA) solution (7.5% TCA, 0.1% EDTA, and 0.1% Propyl gallate). Resultant mixture, was filtered through Whatman No. 1 filter paper. About 3 ml filtrate was then supplemented with 3 ml TBA (0.02 M) solution and kept in water bath for 40 minutes. Samples were cooled in cold water for 5 minutes and centrifuged at 2,000 rpm for 5 minutes. Absorbance readings were performed in a spectrophotometer (Aquamate Thermo electron corporation, England) at 530 nm (11). TBARS value was calculated from a standard curve of 1,1,3,3-tetraethoxypropane (TEP; Sigma-Aldrich) and expressed in mg malondialdehyde/kg meat.

Determination of fatty acid composition. Fats were extracted in accordance with the method specified in Folch et al. (4). Fatty acid methyl esters were prepared in accordance with the method specified in Metcalfe and Schmitz (13). About 1 g extract was supplemented with 1.5 mL 2 M methanolic NaOH. Samples were saponified at 80°C

for 1 hour. Following sufficient cooling, samples were supplemented with 2 mL BF3 methanol and left at 80°C for 30 minutes. Cooled samples were then supplemented with 1 mL hexane and 1 mL deionized water, vortexed and centrifuged at 6000 rpm for 10 minutes. The supernatant was transferred to new tubes supplemented with sodium sulfate. Samples were supplemented with 1 mL hexane and 2 mL supernatant was transferred to amber vials, kept at –18°C until the relevant analyses. Fatty acid profiles were determined in a gas chromatography (GC, Agilent Technologies 6890N) device with an FID detector. The GC system was equipped with a capillary column (DB23, 60 m × 250 µm × 0.15 µm). The oven temperature gradient was set as 5°C/min from 100°C to 200°C and 4°C/min from 200°C to 250°C. Injection block temperature was 250°C and dedector temperature was 280°C. Helium was used as the carrier gas and flow rate was 1.2 mL/min. A fatty acid methyl ester mix (Supelco, FAME-mix, 4–7801, Bellefonte, PA, USA) was used as the standard.

Statistical analyses. Experimental data were subjected to to analysis of variance with the use of General Linear Model procedure of Minitab (21.1, Minitab LLC) statistical software (21) and significant means were compared with the use of Tukey's test ($\alpha = 0.05$).

Results and discussion

Various supplements and diets have been used in livestock operations to improve carcass yield and meat quality. Consumers usually buy visually appealing meats from market shelves. Meat quality is designated by various parameters, such as intermuscular fat ratio, fat color, marbling degree, texture, water holding capacity, sensory attributes, growing and fattening conditions (27).

Fattening performance and carcass traits. Animals were fed on different rations supplemented with soybean and fish oil for 50 days. The fattening start-weight, end-weight and average daily gain (ADG) values of three experimental groups are provided in Table 3. As compared to the control group (140.0 ± 56.9 g), greater ADG values were recorded in soybean (324.0 ± 44.0 g) and fish oil supplemented groups (320.0 ± 40.2) ($p < 0.05$) (Tab. 3).

In a previous study that compared the growth and carcass traits of Lori-Bakhtiari (LL) lambs and crossbred Romanov (RL) lambs after 75-day weaning, 80-day fattening and 10-day *ad libitum* feeding, daily live weight increases of two genotypes were found to be different (ADG, LL: 296.50 ± 11.57 vs RL: 249.11 ± 12.92 g/day). Present daily weight gains were found to be higher in the groups fed with rations supplemented with soybean and fish oil. For LL and RL genotypes, the following values were reported, respectively: carcass weight (kg) 28.65 ± 0.38; 26.17 ± 0.44 ($p < 0.05$); carcass weight without tail fat (kg) 22.82 ± 0.35; 25.18 ± 0.40 ($p = 0.01$); carcass yield (%) 54.04 ± 0.65; 47.52 ± 0.72 ($p = 0.001$) and carcass yield with tail fat (%) 43.39 ± 0.62; 46.12 ± 0.69 ($p = 0.01$) (8). Hot carcass weight was measured as 19.49 ± 0.848 kg in the soybean oil-supplemented group, 17.90 ± 1.18 kg in the fish oil-supplemented group and 19.96 ± 1.04 kg in the control group. Cold carcass weight was measured as 18.60 ± 1.18 kg in soybean oil-supplemented group, 16.19 ± 0.848 kg in fish oil-supplemented group and 17.17 ± 1.52 kg in the control group. Carcass yield (%) was measured as 37.22 ± 1.46 in the soybean oil supplemented group, 36.08 ± 1.46 in the fish oil-supplemented group and 34.69 ± 1.88 in the control group (Tab. 3). These findings on carcass weights were greater than the present values (8).

Male lambs produced from the mating of Romanov ewes with Suffolk and Charollais rams were transported to the slaughter house at 31 kg live weight (31.79 kg for CH 50 RO 50 and 31.22 kg for SF 50 RO 50); the age of slaughter was 129.4 days for Charollais v. Romanov crossbreeds and 146.8 days for Suffolk v. Romanov crossbreeds. Daily live weight gain was 221.3 g and 190.4 g; cold carcass weight was 13.74 and 13.21 kg and carcass yield (%) was 43.26 and 42.33, respectively. Although daily live weight gain and cold carcass weights were lower than the present values, carcass yields were greater with the effect of sire breeds (10).

In terms of feed conversion ratios, soybean and fish oil-supplemented groups had almost 3 times improvements. While the amount of feed consumed per kg of live weight was 4.77 and 5.70 kg in soybean and fish oil-supplemented groups, respectively; this value was measured as 13.33 kg in the control group (Tab. 3).

MLD area is an important indicator of carcass development. This value was measured as 14.310 ± 0.496 cm^2 in the soybean oil-supplemented group, 14.080 ± 0.496 cm^2 in the fish oil-supplemented group and 15.575 ± 0.607 cm^2 in the control group. There were no significant differences in MLD area of the experimental groups. Since the control group had the greatest fatting starting weight, higher MLD values of the control group were thought to be normal (Tab. 4).

Tab. 3. Fattening and carcass weights of treatment groups (mean ± standard deviation)

Treatment groups	Fattening start-weight (Kg)	Feed conversion ratio	Fattening end-weight (kg)	ADG (g)	Hot carcass weight (kg)	Cold carcass weight (kg)	Carcass yield (%)
Soybean oil	36.545 ± 0.621[a]	4.77 ± 1.62[a]	53.00 ± 1.97	324.0 ± 44.0[a]	19.49 ± 0.848	18.60 ± 1.18	37.22 ± 1.46
Fish oil	36.800 ± 0.651[a]	5.70 ± 1.48[a]	52.33 ± 1.80	320.0 ± 40.2[a]	17.90 ± 1.18	16.19 ± 0.848	36.08 ± 1.46
Control	45.33 ± 1.19[b]	13.33 ± 2.09[b]	52.33 ± 2.55	140.0 ± 56.9[b]	19.96 ± 1.04	17.17 ± 1.52	34.69 ± 1.88
P-value	0.000	0.018	0.964	0.049	0.760	0.298	0.584

Explanations: a, b (→) Means indicated with different letters within the same row are significantly different

Tab. 4. Carcass traits of treatment groups (mean ± standard deviation)

Treatment groups	*Musculus longissimus dorsi* area (cm^2)	MLD thickness	pH	L * (lightness)	a * (redness)	b* (lowness)	ΔE	TBARS
Soybean oil	14.310 ± 0.496	2.333 ± 0.141	5.577 ± 0.114	37.40 ± 3.24	16.500 ± 0.257^{ab}	6.663 ± 0.248	1.9895	0.187 ± 0.0096^{a}
Fish oil	14.080 ± 0.496	1.833 ± 0.141	5.900 ± 0.114	37.42 ± 3.24	16.933 ± 0.257^{a}	7.137 ± 0.248	2.443	0.193 ± 0.0096^{a}
Control	15.575 ± 0.607	2.250 ± 0.173	5.835 ± 0.390	35.82 ± 3.97	15.550 ± 0.315^{b}	5.915 ± 0.304	0.00	0.095 ± 0.0118^{b}
P-value	0.231	0.112	0.205	0.942	0.049	0.068	–	0.003

Explanation: as in Tab. 3

Color is an important visual assessment parameter for meat quality. In Mediterranean countries, light meat colors indicate that meat belonged to young animals and consumers generally prefer light-color meats. On the other hand, consumers of the other countries are less sensitive to dark meat colors. Meat color is influenced by several internal (gender, race, slaughter age and weight, muscle type, meat pH, oxygen consumption ratio) and external (temperature, oxygen, light, packaging, microorganism activity) factors. The pH and color values (L*, a*, b*) of *M. longissimus dorsi* were used to assess meat quality (Tab. 4).

In a previous study where Romanov ewes were mated with Suffolk and Charollais rams, it was found that genotype had a significant effect on meat L* and b* values. Meat from Suffolk crossbreeds was lighter (48.23), yellower (12.28) and less red (7.74) ($p < 0.05$) than meat from Charollais crossbreeds (46.6; 8,26; 11.81, respectively) (10). In another study, Texel hybrid female and male lambs (mean age of 5-8 months and with carcass weight of 17.2 kg) showed differences in carcass and meat quality. The pH value reached after 24 hours in samples taken from *M. longissumus dorsi* muscle after slaughter was higher (male: 5.74, female: 5.60) and a* (13.8) and L* (33.2) values were lower (6). Present pH values obtained from crossbred Romanov lambs were similar to pH values of Texel race and a* and L* values were found to be higher. In a previous study, L*, a* and b* values of Ile de France lambs fed in pasture and closed system were respectively reported as 46.1, 7.60 and 9.79; 49.23, 7.35 and 10.71. On the other hand, average pH value was 5.46-5.75 at the end of 24 hours from the slaughter (19). Present findings were lower than some values and higher than some others reported by Priola (19). In a study conducted on Karya lambs that were sent to slaughter after 70 days of fattening in the form of pasture, feeding in addition to pasture and intensive feeding, pH0 and pH24 values were reported as 6.58 and 5.7, respectively. The highest brightness value was determined in the group with the highest intensive feeding (39.54) and the lowest value was determined in the pasture group (36.02). These values were 37.37 and 38.59, respectively, in male and female lambs. The a* value was reported as 12.50 and 12.96 in the group fed in pasture, feeding in addition to pasture and intensive feeding (34). Crossbred Romanov lambs were found to be superior to the native Karya race in a* value.

Turkish Standards Institute (TSI) recommended TBA test of malonaldehyde type to determine lipid oxidation occurring in chicken body meats and reported that the maximum TBA count must be 1 μg malonaldehyde per 1 g meat. Present findings revealed that better results for both color and TBARS values were achieved in lambs fed on soybean and fish oil-supplemented diets. Increasing meat TBARS values indicate advanced lipid oxidation. Elevated levels of TBARS are associated with off-odors and off-flavors. Such items have negative effects on sensory properties of meat and decrease the shelf-life and nutritional values of meat (1). TBARS values were measured as 0.187 ± 0.009 mg MDA/kg in soybean oil-supplemented group, 0.193 ± 0.0096 mg MDA/kg in fish oil-supplemented group and 0.095 ± 0.0118 mg MDA/kg in the control group. In terms of TBARS values, experimental groups were significantly different from the control group ($p < 0.05$) (Tab. 4). However, present values were still quite below the threshold value of 1 mg MDA/kg specified for fresh meat (12).

Fatty acid profile. Table 5 shows the fatty acid composition of MLD muscles of lambs fed with rations supplemented with soybean and fish oil.

Myristic acid values of the control group were two or three times higher than the values of groups fed on soybean and fish oil supplemented diets. Myristic acid is a common saturated fatty acid with the molecular formula of $CH_3(CH_2)_{12}COOH$. Myristic acid contents, thus rate of saturated fat, decreased with fish and soybean oil supplementations in the rations. Excessive consumption of saturated fats adversely affects cardiovascular diseases. Saturated fatty acids are also effective in formation of diseases such as obesity, insulin resistance and Type 2 diabetes. Numerous studies reported that excessive intake of saturated fatty acids increased the risk of cancer (32). Therefore, both unhealthy and healthy individuals should reduce their consumption of saturated fats. Significant differences were seen in C17:1 and C18:1 (monounsaturated fatty acids) contents of the treatment groups ($p < 0.05$). In all three groups, major fatty acids were identified as palmitic acid (17.04-25.59%) and steaic acid (10.93-15.32%). These values were close to palmitic acid (20.20-21.36%) and stearic acid (17.26-18.45%) contents of kid meat. In Previous studies (18, 22), fatty acid compositions of the longissimus dorsi muscle of kids from various races were determined and the major fatty acids were reported as

Tab. 5. Fatty acid profiles of treatment groups (mean ± standard deviation) (% of total identified fatty acids)

Fatty acid		Soybean Oil	Fish Oil	Control	P-value
Capric acid	C10:0	1.457 ± 0.116	1.088 ± 0.116	1.462 ± 0.142	0.056
Lauric acid	C12:0	0.0793 ± 0.0047^{b}	0.1005 ± 0.0047^{a}	0.08750 ± 0.0057^{ab}	0.012
Myristic acid	C14:0	9.63 ± 2.13^{a}	6.75 ± 2.13^{a}	19.96 ± 2.61^{b}	0.002
Miristoleic acid	C14:1	0.376 ± 0.153	0.056 ± 0.153	0.559 ± 0.187	0.114
Pentadecanoic acid	C15:0	2.106 ± 0.433	1.566 ± 0.433	2.294 ± 0.530	0.520
cis-10 pentadecanoic acid	C15:1	0.652 ± 0.134	0.686 ± 0.134	0.792 ± 0.164	0.799
Palmitic acid	C16:0	19.61 ± 1.29^{b}	25.59 ± 1.29^{a}	17.04 ± 1.58^{b}	0.000
Palmitoleic acid	C16:1	1.731 ± 0.153	1.648 ± 0.153	1.700 ± 0.187	0.927
Heptadeconoic acid (margaric)	C17:0	1.607 ± 0.290	1.085 ± 0.290	1.4140 ± 0.355	0.448
Heptadesenoic acid	C17:1	3.922 ± 0.851^{ab}	5.393 ± 0.851^{a}	1.93 ± 1.04^{b}	0.050
Stearic acid	C18:0	15.324 ± 0.928^{a}	10.927 ± 0.928^{b}	13.33 ± 1.14^{ab}	0.009
Oleic acid	C18:1n9t	0.505 ± 0.191^{b}	3.228 ± 0.191^{a}	0.348 ± 0.234^{b}	0.000
Linoleic acid	C18:2n6c	5.867 ± 0.466^{a}	3.903 ± 0.466^{b}	4.220 ± 0.571^{ab}	0.014
Linolelaidic acid	C18:2n6t	0.0845 ± 0.0167	0.0627 ± 0.0167	0.0851 ± 0.0204	0.585
α-linolenic acid	C18:3n3	0.1636 ± 0.0832^{b}	0.6335 ± 0.0832^{a}	0.094 ± 0.102^{b}	0.000
Arachidonic acid	C20:0	0.0500 ± 0.0106	0.0542 ± 0.0106	0.0235 ± 0.0130	0.176
cis-11 eicosapentaoic acid	C20:1n9	0.965 ± 0.108	1.156 ± 0.108	0.871 ± 0.132	0.229
Heneicosanic acid	C21:0	0.1599 ± 0.0308	0.1054 ± 0.0308	0.0478 ± 0.0377	0.085
Eicosapentaoic acid	C20:3n6	0.2368 ± 0.0174	0.2304 ± 0.0174	0.1740 ± 0.0214	0.068
Erucic acid	C22:1n9	0.1523 ± 0.0283	0.1223 ± 0.0283	0.0879 ± 0.0346	0.364
Tricosanoic acid	C23.0	1.058 ± 0.297^{ab}	0.306 ± 0.297^{b}	1.535 ± 0.364^{a}	0.038

Explanation: as in Tab. 3

oleic acid, followed by palmitic and stearic acids. The differences in C10:0, C15:0, C17:0, and C20:0 ratios of the treatments groups were not found to be significant ($p > 0.05$).

There were significant differences in C17:1 and C18:1 contents of the treatment groups ($p < 0.05$). The highest values of these two fatty acids were obtained from the fish oil-supplemented group.

The monounsaturated fatty acid commonly found in foods is oleic acid and the polyunsaturated fatty acid is linoleic acid. Although saturated fatty acids and monounsaturated fatty acids can be synthesized in the human and animal body, polyunsaturated fatty acids cannot be synthesized and are therefore essential. The most important long-chain polyunsaturated fatty acids are linoleic acid (LA) [C18:2 (n-6 omega) with 18 C atoms and 2 double bonds]; α-linolenic acid (α-LN), [C18:3 (n-3 omega) with 18 C atoms and 3 double bonds]; arachidonic acid (AA), (C20:4 n-6 omega with 20 C atoms and 4 double bonds); eicosapentaenoic acid (EPA) (C20:5 n-3 with 20 C atoms and 5 double bonds) and docosahexaenoic acid (DHA), [C22:6 n-3 with 22 C atoms and 6 double bonds]. Studies report that dietary LN could be converted into EPA and DHA; AA, LN and LA long-chain and polyunsaturated fatty acids have a significant effect on biochemical and physiological changes in the body, are important for health and nutrition, and are essential. These are commonly found in large quantities in some fish species. These essential fatty acids are the only source for prostaglandin production. They control blood vessels and the other body functions. Thus, very long-chain polyunsaturated fatty acids (C18-22) and n-3 omega fatty acids are widely considered as a part of modern nutrition due to their beneficial effects on metabolism (3). In the present study, the greatest α-linolenic C18: 3n3 ratio (0.63%) ($p < 0.05$) was obtained from lambs fed on fish oil-supplemented rations, it was followed by the lambs fed on soybean oil-supplemented rations (0.16%) and the lowest value (0.09%) was obtained from the control group animals.

Alpha-linolenic, docosahexaenoic and eicosapentaenoic acids are examples of omega-3 fatty acids. Linoleic acid and arachidonic acid are among the omega-6 fatty acids. Oleic and erucic acid are among the omega-9 fatty acids. Stearic and oleic acids are 18-carbon fatty acids. The difference is that the stearic acid is saturated whereas the oleic acid is unsaturated and has two fewer hydrogens. Rate of fatty acids with positive effects on human health was generally high in the present study.

Arslan (2) reported that sheep fatty acids contained 29-30% palmitic acid 4% linoleic and linolenic acids, which are essential fatty acids. Present palmitic acid ratios of the fish oil-supplemented group were quite close to values reported by Arslan (2), whereas the group with soybean oil-supplemented and the control group had lower values. Likewise, linoleic acid ratios reported for native breeds were close to 6% in crossbred Romanov

lambs fed with rations supplemented with soybean oil. Keskin (7) investigated fatty acid profiles of lambs and reported the palmitic acid ratio as 25.0%, stearic acid as 25.0%, oleic acid as 39.0%, linoleic acid as 4.0%, linolenic acid as 0.5% and arachidonic acid as 1.5%. In another study investigating fatty acid profiles of tail fat and palmitic acid ratio was identified as (21.9%), stearic acid as (22.6%), oleic acid as (28.7%), linoleic acid as (1.3%) and alpha linoleic acid as (0.97%) (30).

Functional foods have been a cornerstone of food-related innovations over the past few years. Foods that are consumed in the form of food in a daily diet, that do not contain synthetic compounds, that have the ability to reduce the risk of disease formation with different active ingredients as well as their nutritive effect, and have health and well-being-enhancing elements are defined as functional foods. Functional meat products are meat-derived nutrients that are enriched with functional compounds. Consumption of meat and meat products has an important place in daily nutrition of the people. Within the scope of this study, possible production of functional lamb meat enriched in essential fatty acids through various feeding regimes and rearing models was investigated.

In conclusion, present palmitic acid ratios of crossbred Romanov lambs were found to be lower than the other native races of Turkey. Such a low rate of this desirable trait may be linked to the short tail of Romanov sheep. It was concluded based on present findings that meat yield and quality of crossbred Romanov lambs raised in partially open barns of Eastern Anatolia Region of Turkey could be increased with soybean and fish oil-supplemented rations.

Present findings revealed that crossbred Romanov lambs exhibited high fattening performance with limited feeding. Fattening was carried out in a partially-open barn during the winter months and it was concluded that crossbred Romanov lambs could be preferred by livestock operations of the region.

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