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Research Article

Effects of Terebinth *(Pistacia terebinthus* L.) Fruit Oil Supplementation to Diets on Fattening Performance, Carcass Characteristics, Blood Parameters and Breast Meat Fatty Acid Composition in Japanese Quails *(Coturnix coturnix Japonica)* [1]

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Abstract

The objective of this study was to determine effects of terebinth fruit oil (TFO) supplementation to diet on growth performance, carcass characteristics, some blood parameters and composition of breast meat fatty acids in Japanese quails. Totally 240 unsexed daily Japanese quail chicks were assigned randomly to three treatment groups. Each group divided into 4 replicates, each containing 20 birds. A group was fed with basal starter diet for 1-21th days and grower diet for 22-42th days (Control). Treatment groups were also fed same diets additionally their ration added by 130 (Group A) or 260 mg/kg TFO (Group B) during the study. At 42 d of study, 20 quails (5 quails from each subgroup) from each group slaughtered for determination of carcass traits, blood parameters and fatty acid composition of breast meat. As a result of this study, final live weight of quails in Group B was found higher than Control and Group A ($P<0.05$). There were no differences on the average live weight gains of the birds among the groups. Average feed intake in Group A was found lower than Control and Group B on basis of whole study period ($P<0.05$). Average feed conversion ratio in Group A was found better than Control on basis of whole study period ($P<0.05$). Carcass weight in Group B was found higher than Group A ($P<0.05$). There were no differences on carcass yield and breast-, leg-, wing-, heart-, liver- and gizzard ratio to carcass weights of the birds in all groups. Serum total cholesterol, high density lipoprotein, aspartate amino transferase, alkaline phosphatase, total protein, albumin and globulin did not differ among the groups. There were no differences on composition of breast meat fatty acid profiles. In conclusion, due to supplementation of 260 mg/kg TFO enhanced live weight and carcass weight, and 130 mg/kg TFO decreased feed intake and improved feed conversion ratio, TFO could be used as a supplement at indicated doses for quail fattening rations.

Keywords: *Quail, Pistacia terebinthus fruit oil, Growth performance, Carcass, Blood parameters, Fatty acids*

Japon Bıldırcınlarının *(Coturnix coturnix Japonica)* Rasyonlarına Menengiç *(Pistacia terebinthus* L.) Meyvesi Yağı İlavesinin Besi Performansı, Karkas Karakteristikleri, Kan Parametreleri ve Göğüs Eti Yağ Asitleri Kompozisyonuna Etkileri

Özet

Bu çalışmanın amacı Japon bıldırcını rasyonlarına menengiç meyvesi yağı (MMY) ilavesinin büyüme performansı, karkas özellikleri, bazı kan parametreleri ve göğüs eti yağ asidi kompozisyonuna etkilerini belirlemekti. Toplam 240 karışık cinsiyetteki bıldırcın civcivi rastgele üç deneme grubuna ayrıldı. Her grup her birinde 20 civciv bulunan 4 alt gruba ayrıldı. Gruplardan biri başlangıç (1-21. günler) ve büyütme döneminde (22-42.günler) temel rasyonla beslendi (Kontrol). Deneme grupları deneme süresince temel rayona ilave olarak rasyonlarına 130 (Grup A), ya da 260 mg/kg MMY (Grup B) ilave edilerek beslendi. Araştırmanın 42. gününde her gruptan 20 adet (her alt gruptan 5 adet) bıldırcın karkas özellikleri, kan parametreleri ve göğüs eti yağ asidi kompozisyonunu belirlemek için kesildi. Çalışma sonucunda Grup B'nin deneme sonu canlı ağırlığı Kontrol ve Grup A'dan yüksek bulundu ($P<0.05$). Ortalama canlı ağırlık artışı bakımından gruplar arasında farklılık yoktu. Deneme geneli itibariyle Grup A'nın ortalama yem tüketimi Kontrol ve Grup B'den düşük bulundu ($P<0.05$). Deneme genelinde ortalama yemden yararlanma oranı Grup A'da Kontrol grubuna göre daha iyi bulundu ($P<0.05$). Grup B'nin karkas ağırlığı Grup A'dan daha yüksek bulundu ($P<0.05$). Gruplar arasında karkas oranı ile göğüs, but, kanat, kalp, karaciğer ve taşlık ağırlığının karkasa oranı bakımından farklılık yoktu. Serum total kolesterol, yüksek dansiteli lipoprotein, aspartat amino transferaz, alkalin fosfataz, total protein, albumin ve globulin miktarları gruplar arasında farklı değildi. Göğüs eti yağ asidi kompozisyonu bakımından gruplar arasında farklılık yoktu. Sonuç olarak; bıldırcın rasyonlarına 260 mg/kg MMY ilavesinin canlı ağırlığı ve karkas ağırlığını artırması, 130 mg/kg ilavesinin yem tüketimini azaltması ve yemden yararlanma oranını iyileştirmesinden dolayı her iki dozda da bıldırcın besi rasyonlarında kullanılabilir.

Anahtar sözcükler: *Bıldırcın, Menengiç meyvesi yağı, Büyüme performansı, Karkas, Kan parametreleri, Yağ asitleri*

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INTRODUCTION

Various subtherapeutic antibiotics have been used as feed additives since 1940's to enhance growth performance and to prevent disease in livestock, particularly in poultry. Usage of antibiotics as feed additives was banned in European Union in 2006 due to the antibiotic residue risk in animal products and the potential evolving of antibiotic resistant bacteria [1]. This banning has led to acceleration of research on alternative natural feed additives, such as probiotics, prebiotics and organic acids, in animal production [2]. Certain aromatic plants or essential oils (EO) derived from these plants have also increasingly been used for such purpose. Essential oils have antimicrobial [3], antioxidant [4] and digestive enzyme stimulant affect [5,6].

Pistacia terebinthus L. (terebinth or turpentine tree), is a small tree, widely distributed in the Mediterranean region and west Asia [7-10]. It commonly grows on dry rock slopes and hillsides areas, pine forest, and maquis vegetation in the Mediterranean-, Aegean-, Black sea-, and Southeastern Anatolia region of Turkey [11-13]. Fruits of terebinth (known as menengiç, çitlenbik, çıtlık) are very nutritious and have been used as an appetiser in Turkey. The fruits are consumed also as coffee and the oil extracted from the fruits is used as cooking oil as well as in making soap (known as bıttım sabunu) in Turkey [11]. In addition, it has anti-inflammatory, antipyretic, antiparasitic, expectorant, and spasmolytic effects [11]. Matured fruits of terebinth are small globular and dark greenish [14], it includes 35.26-47.52% ether extracts [15-17], 6.4% crude protein and 1.5% crude ash [17]. There has been 0.1% essential oils [17], and 0.06-0.73% volatile fatty acids in fruits of terebinth [7,18]. It also contains macro- (Ca, P, K, Na, Mg, S) and microelements (Fe, Al, Zn, Cu, Mn, Se, Co, Cr) [8,17] as well as tocopherols, tocotrienols and sterols [9,15]. Pharmacologically active substances in the mature fruit of terebinth are α-pinene, limonene, α-felandrene, terpinolene, p-cymen-8-ol and caryophyllene oxide [7,18]. It also contains phenolic and flavonoids such as; quercetin and α-tocopherol, which are antioxidant compounds [9].

There have been a lot of researches on usage of certain aromatic plants/herbs/spices by alone or essential oils (EO) derived from these plants or commercially produced EO as feed additives in the poultry feeding. According to our knowledge, there is no research on the usage of terebinth fruit oil (TFO) in poultry feeding. This study aimed to assess supplementation of TFO to diet on growth performance, carcass traits, some blood parameters and fatty acid composition of breast meat in quails.

MATERIAL and METHODS

The ethical committee approval of Kafkas University (KAÜ-HADYEK: 2015-078) was taken in order to conduct this study.

Birds, Experimental Design, Housing Environment and Diets

Totally 240 unsexed one day old Japanese quail chicks *(Coturnix coturnix japonica)* were divided into randomly to three dietary groups. Each group consisted of 4 subgroups, each subgroup included 20 birds. The experimental diets were an unsupplemented basal diet *(Table 1)*. Basal diets were supplemented with 0 (Control), 130 mg/kg (Group A), or 260 mg/kg TFO (Group B). The TFO was firstly mixed into the vegetable oil component of the ration, and then the oil mixture was added to the basal diets. The birds were housed in cages, in an environmentally controlled room. The environmental temperature in the room was maintained 31-33ºC and gradually reduced by 2-3ºC every week until 21-22ºC in the final week. Experimental diets were prepared according to NRC requirements for quails [19].

Table 1. *Ingredients and nutrient content of the basal diets used in the starter and grower period, (dry matter basis, %)*[1]

Item	Starter (d 1-21)	Grower (d 22-42)
Ingredients		
Corn	40.00	37.00
Wheat	6.15	20.25
Vegetable oil (sunflower)	5.00	4.30
Soybean meal, 44% CP	38.00	25.00
Sunflower meal, 32% CP	8.00	10.00
Dicalcium phosphate	0.65	1.32
Limestone	1.35	1.28
Vit./min. premix[2]	0.35	0.35
Salt	0.30	0.30
DL-Methionine	0.20	0.20
Calculated analysis		
Metabolizable energy, kcal/kg [3]	3000	3000
Crude protein	23.92	20.49
Calcium	0.80	0.90
Total phosphor	0.65	0.70
Lysine	1.42	1.11
Methionine + Cysteine	0.77	0.67
Linoleic acid	1.55	1.49
Analysed nutrient composition		
Dry matter	88.99	89.03
Crude protein	23.92	20.49
Ether extract	7.09	6.48
Crude fibre	4.35	4.10

[1] The basal diets were the same in the all groups. Treatment diets were supplemented with 130 or 260 mg/kg of terebinth fruit oil; [2] Supplied per kg diet: Vit A, 8400 IU; vit D_3, 4480 IU; vit E, 56 mg; vit K_3, 2.24 mg; vit B_1, 1.68 mg; vit B_2, 4.48 mg; niacin, 33.6 mg; cal.D-pantothenate, 10 mg; vit B_6, 2.8 mg; vit B_{12}, 9 µg; D-biotin, 0.112 mg; folic acid, 1.12 mg; vit C, 56 mg; manganese, 59 mg; iron, 47 mg; zinc, 47 mg; copper, 47 mg; cobalt, 0.112 mg; iodine, 0.56 mg; selenium, 0.100 mg; molybdenum, 0.582 mg; [3] Calculated based on NRC [19] data of feedstuffs nutrient tables

Experimental diets were in mash form and offered *ad libitum* during the both starter period (d 1-21) and grower period (d 22-42). Clean and fresh water was available throughout the study.

Terebinth Fruit Oil

The TFO used in this study obtained from local firm in Siirt city, TURKEY. Terebinth fruits were also obtained from the same firm for determination of crude nutrient analyses.

Making of Terebinth Oil

Terebinth fruit oil is made traditional method in Turkey, according to following way. The fruits are grind by a mill. They put into a large metal basin, and boiled water adds, to achieve the dough consistency. When the grinded fruit reaches the dough consistency, knead by manpower for 90-120 minutes. Then basins incline in half horizontally and waited for leakage of oil from the kneaded material. Accumulated oil in the bottom of the basins is taken.

Growth Performance, Carcass Traits, Blood Serum and Breast Meat Samples

Individual live weights of the birds and offered feed for each replicate pen was recorded at the beginning of the study and then at the end of each period. Feed conversion ratio (gain: feed) per pen were calculated at 21 d and 42 d of study. At 42 d of the study, 20 birds (5 birds from each replicate) similar body weight were selected from the each group, weighed and slaughtered for determination of the carcass traits and internal organ weights. In the slaughtering process blood samples were also taken. Blood samples were centrifuged at 3000 g for 10 min, and serum samples were stored -20°C for analyses. From the middle of 1 to 3 both side of the breast meat, meat samples were taken for fatty acid analyses and samples were stored at -20°C until analysis [20].

Analytical Procedures

Dry matter, crude protein, crude fat, crude fibre and crude ash in the diets were made according to AOAC methods [21]. Concentrations of blood serum total cholesterol, high density lipoprotein (HDL), aspartate amino transferase (AST), alkaline phosphatase (ALP), total protein, albumin and globulin were analysed by an auto analyser (Beckman Coulter AU5800, Beckman Coulter, Inc. USA), using the commercial kits belonging the same firm.

Extraction of the terebinth oil for determination of individual fatty acids, in line with Agilent Technologies Firm proposal, was made with the method described by Ichihara et al.[22]. Concentrations of individual fatty acids of terebinth oil were analysed using a gas chromatography (Agilent Technologies 7890A GC/5975C MS) equipped with an auto sampler according to methods described by Paquot [23]. One microlitre of the sample volume was injected using the splitless mode. Chromatographic separations were accomplished with an Optima delta-6 capillary column (0.25 mm i.d. x 60 m, film thickness 0.25 µm). Analysis was carried out using nitrogen as the carrier gas. The column temperature was arranged from 1 min in 50°C to 50°C to 300°C at 3°C/min for 5 min. The detector temperature was 250°C. The separated components were identified by retention time of matching standard fatty acid methyl esters. External standard method was used as standard. Quantitative determination was carried out based on peak area integration.

Statistical Analyses

All data were subjected to one-way ANOVA using the SPSS software package, version 19.00 (SPSS Inc., Chicago, IL, USA) [24]. When significant treatment effects were disclosed, Duncan's multiple range test was performed [25].

RESULTS

Crude nutrient contents of the fruit of terebinth used in this study for making TFO were analysed as follows; 94.36% dry matter, 38.91% crude fat, 10.07% crude protein and 3.26% crude ash, in dry matter basis. Individual fatty acid composition of the TFO used in this study is shown in *Table 2*. The highest fatty acid in the TFO was oleic acid (46.82%). The other fatty acids were linoleic- (23.07%), palmitic- (22.00%), stearic- (4.61%), palmitoleic- (2.14%), and linolenic acid (1.36%).

As shown in *Table 3*, average body weight of the birds in the Group B was significantly higher than those of the birds in the Control and Group A at the end of the starter period ($P<0.001$) and as well as the grower period ($P<0.05$). There were no statistical differences on the average weight gain of the birds in all groups both at starter- and grower periods. However, average weight gain of the birds in the Group B was higher than those of the birds in the Control and Group A in overall the study ($P<0.001$). There were no statistical differences on average daily feed intake of the birds in all groups both starter- and grower periods, but average daily feed intake of the birds in the Group A was lower than those of the birds in the Control and Group B in overall the study ($P<0.05$). There were no statistical differences on feed conversion ratio of the birds in all the groups both starter and grower periods, but feed conversion ratio of the birds in the Group A was lower than those of the birds in the Control group in overall the study ($P<0.05$).

Average slaughter body weights of the birds in the Group B were higher ($P<0.05$) than those of the birds in the Control and Group A *(Table 4)*. Average carcass weights of the birds in the Group B were higher than those of the birds in the Group A ($P<0.05$). There were no statistical differences on carcass ratio and breast-, leg-, wing-, heart-,

Table 2. *Fatty acid composition of terebinth fruit oil used in this study*

Amount	Fatty Acids					
	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3
%	22.00	2.14	4.61	46.82	23.07	1.36

C16:0= *Palmitic acid,* ***C16:1***= *Palmitoleic acid,* ***C18:0*** = *Stearic acid,* ***C18:1*** = *Oleic acid,* ***C18:2*** = *Linoleic acid,* ***C18:3*** = *Linolenic acid*

Table 3. *Effects of 0 (Control), 130 (Group A) and 260 mg/kg (Group B) terebinth fruit oil supplementation to diet on performance of quails during the 42 d of study*

Parameters	Control	Group A	Group B	SEM	Sig.
Body weight, g					
1 d	8.6	8.6	8.5	0.05	NS
21 d	92.8^{b}	90.1^{b}	98.6^{a}	0.78	***
42 d	194.1^{b}	194.7^{b}	204.5^{a}	1.64	*
Daily weight gain, g/d					
1 to 21 d	3.98	3.89	4.13	0.06	NS
22 to 42 d	4.88	5.10	5.09	0.06	NS
1 to 42 d	4.43^{b}	4.49^{b}	4.61^{a}	0.04	***
Daily feed intake, g/d					
1 to 21 d	7.69	7.43	8.03	0.14	NS
22 to 42 d	19.25	18.27	18.99	0.24	NS
1 to 42 d	13.47^{a}	12.70^{b}	13.55^{a}	0.17	*
Feed conversion ratio, g/g					
1 to 21 d	1.93	1.91	1.95	0.02	NS
22 to 42 d	3.95	3.59	3.74	0.07	NS
1 to 42 d	3.04^{a}	2.83^{b}	2.94^{ab}	0.04	*

NS: *Non significant (P>0.05);* ^{ab}*Mean values in the same row with a common letter are significantly different. * P<0.05, ***P<0.001*

Table 4. *Effects of 0 (Control), 130 (Group A) and 260 mg/kg (Group B) terebinth fruit oil supplementation to diet on carcass yield traits of quails slaughtered at 42 d*

Parameters	Control n=20	Group A n=20	Group B n=20	SEM	Sig.
Body weight, g	194.2^{b}	194.8^{b}	204.1^{a}	1.69	*
Carcass weight, g	134.5^{ab}	131.3^{b}	137.7^{a}	1.06	*
Carcass ratio, %	69.33	67.51	67.56	0.46	NS
The relative organ ratio to the carcass weight, %					
Breast	32.11	32.37	32.61	0.40	NS
Leg	23.12	22.74	22.43	0.23	NS
Wing	10.62	10.18	10.91	0.15	NS
Heart	1.54	1.57	1.58	0.02	NS
Liver	3.35	3.93	4.13	0.15	NS
Gizzard	3.59	3.69	3.44	0.07	NS

^{ab}*Mean values in the same row with a common letter are significantly different. * P<0.05;* ***NS:*** *Non significant (P>0.05)*

Table 5. *Effects of 0 (Control), 130 (Group A) and 260 mg/kg (Group B) terebinth fruit oil supplementation to diet on serum parameters of quails slaughtered at 42 d*

Parameters	Control n= 20	Group A n= 20	Group B n= 20	SEM	Sig.
Total cholesterol, mg/dL	230.3	201.4	212.0	8.16	NS
HDL, mg/dL	135.7	115.0	83.0	10.04	NS
AST, IU/L	280.1	310.6	299.3	14.47	NS
ALP, IU/L	786.8	936.0	813.3	30.07	NS
Total protein, g/dL	2.81	2.77	3.22	0.10	NS
Albumin, g/dL	0.98	1.00	1.10	0.04	NS
Globulin, g/dL	1.83	1.77	2.13	0.07	NS

NS: *Non significant (P>0.05)*

Table 6. *Effects of 0 (Control), 130 (Group A) or 260 mg/kg (Group B) terebinth fruit oil supplementation to diet on fatty acid composition (%) of breast meat of quails slaughtered at 42 d*

Parameters	Control n=20	Group A n=20	Group B n=20	SEM	Sig.
C14:0	0.49	0.53	0.44	0.03	NS
C16:0	26.09	24.16	25.42	0.37	NS
C17:0	0.21	0.16	0.17	0.06	NS
C18:0	18.06	16.41	17.30	0.54	NS
Σ SFA	**44.80**	**41.26**	**43.28**	0.83	NS
C16:1	2.48	3.02	2.89	0.23	NS
C18:1	15.81	18.11	14.64	0.89	NS
Σ MUFA	**17.78**	**21.13**	**17.53**	1.09	NS
C18:2	27.76	27.47	28.41	0.32	NS
C18:3	2.20	2.18	1.82	0.35	NS
C20:4	6.49	6.93	8.00	0.35	NS
Σ PUFA	**36.45**	**36.58**	**38.23**	0.81	NS
Σ PUFA/Σ SFA	**0.82**	**0.90**	**0.88**	0.02	NS

C14:0 = *Myristic acid,* ***C16:0*** = *Palmitic acid,* ***C16:1*** = *Palmitoleic acid,* ***C17:0*** = *Heptadecanoic acid,* ***C18:0*** = *Stearic acid,* ***C18:1*** = *Oleic acid,* ***C18:2*** = *Linoleic acid,* ***C18:3*** = *Linolenic acid,* ***C20:4*** = *Arachidonic acid,* ***SFA*** = *Saturated fatty acids,* ***MUFA*** = *Monounsaturated fatty acids,* ***PUFA*** = *Polyunsaturated fatty acids;* ***NS:*** *Non significant*

liver- and gizzard ratio to carcass weight in all groups.

There were no statistical differences on concentrations of serum total cholesterol, HDL, AST, ALP, total protein, albumin and globulin in all groups *(Table 5)*.

As seen from the *Table 6*, there were no statistical differences on both individual fatty acids composition and total saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), and polyunsaturated fatty acids (PUFA) as well as the total PUFA:SFA ratio in all the groups. The mostly found fatty acids were palmitic- and stearic acids in the SFA, oleic acid in the MUFA, and linoleic- and arachidonic acids in the PUFA of breast meat of birds.

DISCUSSION

Analysed fatty acid composition results of TFO used in this study showed that oleic-, linoleic, palmitic-, stearic-, palmitoleic- and linolenic acids were major oil components *(Table 2)*. In many previous studies have reported 34.8 to 52.67% oleic-, 19.91 to 23.58% palmitic-, 17.30 to 20.95% linoleic- and 0.17 to 0.79% linolenic acids for TFO [8,15-17]. Our results in this study for the oleic- and palmitic acids are in accordance with above literature reports; but, the linoleic- and linolenic acids are higher.

In the present study, supplementation of 260 mg/kg TFO to diet induced a significant increase on live weight of the birds both at the end of the starter period and the grower period as compared to the birds in the Control and 130 mg/kg TFO supplemented group *(Table 3)*. Weight gain of the birds in the 260 mg/kg TFO supplemented group also was higher than those of the other groups in overall the study. The results on the live weight and weight gain of the birds indicated that supplementation of high level TFO (260 mg/kg) to diet improved live weight and weight gain, but not low level TFO (130 mg/kg). The improvement on the live weight and live weight gain in the high level TFO supplemented group may be related to the antibacterial agents, such as luteolin, luteolin-7-glucoside [10] and α-pinene [26], antioxidant compounds, such as quercetin and α-tocopherol [9], and high linoleic acid content of the TFO used in this study [8,16,17]. In other hand, Jang et al.[27] reported that a commercial blend of EO showed a marked increase in digestive enzyme activities of the pancreas and intestinal mucosa from broiler chickens, leading in a significant growth performance. Further, Hernandez et al.[5] indicated that two different plant extracts improved the digestibility of the feeds for broilers. Similar results were also reported by Lee et al.[28] and Lee et al.[29] which indicates that EO in diets encourages secretions of endogenous digestive enzymes, which then enhance nutrient digestion and gut passage rates in chickens. Live weights of the birds were similar in the Control and 130 mg/kg TFO supplemented groups. This situation may be related to the basal diets used in the present study, which had adequate and balanced nutrient content, high digestibility, and optimum environmental conditions during the research. It has been proposed that dietary EO supplementation as growth stimulators could not give positive effect when chickens are raised at optimal condition such as highly digestible diets and clean condition [30].

In this study, supplementation of 130 mg/kg TFO induced lower feed intake than those of the other groups in overall the study *(Table 3)*. However, Kamel [31] suggested that herbs, spices and various plant extracts have appetiser and digestion-stimulating properties. Supplementation of 130 mg/kg TFO also improved feed conversion ratio as compared to Control group in overall the study *(Table 3)*. Küçükyılmaz et al.[32] have conducted two experiments to determine the effects of supplementation EO, which contains certain active substances found also in the TFO (such as; terpinene, α-pinene, limonene, caryophyllene), on growth performance in broilers. In experiment I (within October - November period); they have not found differences on the live weight, feed intake, and feed conversion ratio among the groups. However, in experiment II (including April to May); they have determined higher live weight and improved feed conversion in the EO supplemented group than the Control group. Likewise, Khosravinia [33] has made a study in broilers on the usage of *Satureja khuzistanica* oils, which contains some essential oils available in the TFO. He found 0.5, 1.0, 1.5, 2.0 and 2.5 g/L oil supplementation via by drinking water negatively affected weight gain, feed intake and feed conversion of the birds as compared to Control. Alçiçek et al.[34] found that supplementation of 24 mg/kg EO did not affect growth performance of broilers, but 48 and 72 mg/kg EO supplementation improved live weight and feed intake.

Slaughter body weight of birds in the 260 mg/kg TFO supplemented group was higher than the birds when compared to other groups *(Table 4)*. The carcass weight of birds in the 260 mg/kg TFO supplemented group was higher than that of the birds in the 130 mg/kg TFO supplemented group. Higher slaughter body weight and carcass weight in the 260 mg/kg TFO supplemented group than those of the other groups originated from the higher final live weight of the birds at the end of the study in this group. There were no differences on the carcass ratio and, carcass parts and visceral organ ratio to carcass weight among the groups. Similar results were found by Küçükyılmaz et al.[32] in broilers. Khattak et al.[35] reported that 300, 400 and 500 g/ton EO supplementation to broiler diet increased carcass weight but not 100 and 200 mg/kg. They also determined that 300 and 400 mg/kg EO supplementation induced higher breast ratio as compared to other groups. Alçiçek et al.[2] found that 36 mg/kg EO supplementation did not affect carcass ratio, but 48 mg/kg supplementation increased. Similarly, 24 mg/kg EO supplementation to diet did not affect carcass ratio but 48 and 72 mg/kg increased [34]. Results on the carcass traits in this study and other studies indicated that oil or essential oil type and their doses could be alter some carcass traits of birds.

It was determined that 130 or 260 mg/kg TFO supplementation to diet did not affect blood serum parameters *(Table 5)*. Similar to present study, Lee et al.[28] found no differences on total cholesterol and HDL cholesterol concentrations in broilers fed with supplemented EO diets. Khattak et al.[35] reported that no significant effect on the total cholesterol concentration depending on the supplementation of EO, and they speculated that this situation could be associated either ineffective in inhibiting hepatic 3-hydroxy-3-methylglutaryl coenzyme A reductase or due to their fast degradation rate in the

liver of broilers. In other hand, the absence or presence of hypo-cholesterolaemic effects of components in animals depend on breed, gender, age and also on the composition of the diet.

In the present study, 130 or 260 mg/kg TFO supplementation to diet did not affect fatty acid composition of the breast meat in quails *(Table 6)*. Total SFA amounts in the breast meat of birds fed with 130 or 260 mg/kg TFO supplemented birds were 7.90 and 3.39 % lower than those of the birds in the Control group, respectively. The decrease in the total SFA amount in the both TFO supplemented group were originated from the decrease in the palmitic-, heptadecanoic- and stearic acids amount in these groups as compared to Control. The numerical decrease in the total SFA of breast meat of quail fed with both TFO supplemented group may be related to the numerical decrease in the serum total cholesterol concentrations of these birds *(Table 5)*. In contrast the total SFA, 130 or 260 mg/kg TFO supplementation to diets induced a 0.36 and 4.88 % increase in the total PUFA amount as compared to Control, respectively. The numerical increase in the total PUFA in the both TFO supplemented group were primarily related to increase in the arachidonic acid. The numerical decrease in total SFA but numerical increase in the total PUFA in both TFO supplemented groups have indicated that fatty acid consumption of carcass from these birds may be poses a lower risk of coronary heart disease. PUFA accepts a more vulnerable indicator to lipid peroxidation. Although there were no statistical differences ($P<0.062$), it is worth to state that, the PUFA: SFA ratio was numerically higher in the both TFO supplemented group than Control.

Finally, supplementation of 260 mg/kg TFO to diet increased body weight and weight gain of birds, as compared to the Control and 130 mg/kg TFO supplemented groups. Yet, supplementation of 130 mg/kg TFO decreased feed intake of the birds, as compared to the Control and 260 mg/kg TFO supplemented groups. Supplementation of 130 mg/kg TFO improved feed conversion ratio, as compared to the Control. Supplementation of 260 mg/kg TFO induced higher slaughter body weight as compared to other groups. Supplementation of TFO at both doses had no effect on the carcass ratio, carcass parts and visceral organ ratio, blood serum parameters and fatty acid composition of breast meat. These affirmative results have indicated that TFO may be used as an alternative supplement at these doses in quail diets. Additionally, first findings on usage of TFO as feed additives in quails were demonstrated with this study.

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