

The Effects of Supplementing Different Vegetable Oils in the Diet of Quails on Growth, Carcass Traits and Serum Biochemical Parameters

Zeynep KARA¹, Tuba BÜLBÜL^{2*}

¹Veterinary, Isparta, Turkey

²Muğla Sıtkı Koçman University, Faculty of Milas Veterinary Medicine, Department of Animal Nutrition and Nutritional Disease, Muğla, Turkey

ABSTRACT

A six weeks long study trial was conducted on Japanese quails to evaluate the growth performance, carcass traits, some blood parameters and oxidative status when different vegetable oils were supplemented through diet. A total of 400, 3 days old, Japanese quails, were randomly divided into four different groups and each consisting of 100 quails. Each of the main group was further divided into five replicates and each replicate was composed of 20 quails. Soybean oil, sunflower oil, safflower oil and olive oil was supplemented to experimental diets separately at level of 3%. The results showed that there were no changes in terms of growth performance and carcass traits as well as alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total protein, triglyceride and cholesterol levels in all experimental groups with soybean oil, sunflower oil, safflower oil and olive oil supplementation ($p>0.05$). However it was observed that, the serum malondialdehyde level was decreased, whereas serum antioxidant activity level was significantly increased ($p<0.05$) in the safflower oil treatment group. From the results, it could be concluded that supplementation of soybean, sunflower, safflower and olive oil in quail diets had neither harmful nor beneficial effects on the growth performance, carcass traits, serum biochemical parameters and oxidation status of breast meat. Furthermore, it can also be stated that prevention of serum lipid oxidation might be more effective by supplementation of safflower oil in quails.

Keywords: Growth performance, oxidation, quail, vegetable oil.

Bıldırcın Rasyonlarına Katılan Farklı Yağ Kaynaklarının Büyüme, Karkas Özellikleri ve Serum Biyokimyasal Parametrelere Etkisi

ÖZ

Altı hafta sürdürülen çalışma farklı bitkisel yağların rasyonlara katılmasının Japon bıldırcınlarında büyüme performansı, karkas özellikleri, bazı kan parametreleri ve oksidatif durum üzerine etkisini belirlemek amacıyla yapıldı. Toplam 400 Japon bıldırcını, her biri üç günlük ve 100 adetten oluşan dört farklı gruba ayrıldı. Her bir grup da başlıca 20 bıldırcın içeren beş alt gruba bölündü. Deneme rasyonlarına % 3 düzeyinde soya yağı, ayçiçeği yağı, aspir yağı ve zeytin yağı ayrı olarak katıldı. Araştırmada soya yağı, ayçiçeği yağı, aspir yağı ve zeytin yağı grupları arasında büyüme performansı, karkas parametreleri ile alkalik fosfataz, alanin aminotransferaz, aspartat aminotransferaz, total protein, trigliserit ve kolesterol düzeyleri üzerinde istatistik fark tespit edilmedi ($p>0.05$). Buna karşın aspir yağı grupta serum malondialdehit düzeyinin azalırken, serum antioksidan aktivite düzeyinin arttığı belirlendi ($p<0.05$). Araştırmada bıldırcın rasyonlarına soya, ayçiçeği, aspir ve zeytin yağı katımının büyüme performansı, karkas özellikleri, serum biyokimyasal parametreler ve göğüs etindeki antioksidan duruma herhangi bir zarar verici ya da fayda sağlayıcı bir etkisi olmadığı sonucuna varılabilir. Ayrıca, bıldırcınlarda serum lipit oksidasyonunun önlenmesinde aspir yağı katımının daha etkili olabileceği de ifade edilebilir.

Anahtar Kelimeler: Bıldırcın, bitkisel yağ, büyüme performansı, oksidasyon.

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ORCID ID; Z.K: 0000-0002-7878-6360, T.B: 0000-0002-8610-362X

*Corresponding author e-mail: tubabulbul@mu.edu.tr

INTRODUCTION

The vegetable oils from various sources are added to different feedstuff of poultry birds to meet their energy deficiencies. In this regard soybean oil, sunflower and canola oil are among some of the important vegetable oils used in poultry production to coup up the energy deficiencies (Ahiwe et al. 2018). In this context, a number of research trials have been conducted on the use of oils from different sources in poultry (Jalali et al. 2015). However the findings of such studies were contradictory in a way that the supplementation proved to be effective in some trials whereas didn't prove to be effective in some other research trials. In a trial conducted by (Erener et al. 2007) it was reported that the soybean oil, hazelnut oil supplementation of feedstuff had no statistically significant effects on body weight (BW), feed intake (FI), and feed conversion ratio (FCR) whereas similar results were obtained when feed was supplemented with sunflower oil, fish oil (Maniila et al. 1999). In another study which the diet of quails was supplemented with 3% linseed oil, sunflower oil and olive oil, similar findings were reported that the supplementation did not affect the performance parameters including BW, FI, FCR and carcass yield (El-Yamany et al. 2008).

The quail meat may be considered as a competitive source against the broiler meat. According to some studies, it is believed that quail meat is nearly a chicken and even better than it. Quail meat includes high protein, polyunsaturated fatty acids and essential trace minerals and fat. Because of high metabolic activity in this bird, the amount of glycogen stored in muscles increased, resulting in high quality (Boni et al. 2010). Lipid oxidation is a deteriorating process that leads to the development of various oxidants formed in double bonds in unsaturated fatty acids and can lead to formation of degradation products such as acids, ketones, alcohols and aldehydes. The fact that poultry meat is rich in long chain polyunsaturated fatty acids; increases the sensitivity of this product and makes it more prone to lipid oxidation. Oxidation, which results during processing, cooking and refrigeration of meat, adversely affects its taste, smell, nutritional value and shelf life. Besides, further oxidative deterioration leads to the formation of short-chain aldehydes,

ketones and other oxidative compounds, impairing the overall quality of the product (Domínguez et al. 2019).

Although, there are many similar studies with our study on the use of different vegetable oil at various levels as energy sources in mixed feeds of poultry (Balevi and Coskun 2000; Crespo and Esteve-Garcia 2001), as far as we know, there are no studies conducted with the same oil sources in quail diets during their growing period. In this context, the effects of different vegetable oil sources on growth performance, carcass yield, serum biochemical parameters and oxidative status in quails during the growing period was evaluated.

MATERIAL and METHODS

Animals, Diets and Experimental Design

This study was conducted at the Animal Research Center of Afyonkarahisar University, Turkey, following the approval of the ethical committee (AKUHADYEK-303-13). A total of 400, three-day-old, Japanese quails (*Coturnix coturnix japonica*) were selected for the research trial. The birds were randomly divided into four groups, each containing 100 quails. Each group was sub-divided into five replicates containing 20 quails each. The quails were weighed individually and placed in 44×30×20 cm cages. The feed ingredients including corn, sunflower meal, soybean meal, wheat, and other feedstuff were obtained from Tinaztepe Feed Factory (Afyonkarahisar, TURKEY). The diets with corn, soybean meal, sunflower meal, wheat and vegetable oils were analyzed and formulated to meet the nutritional requirements according to the recommendations of NRC (1994). Sunflower, safflower, soybean and olive oil were supplemented to the diet of each group separately at the level of 3%. Automatic nipple water system was set up in each cage while. Feed and water were given daily ad libitum. The chemical composition of the diet is shown in Table 1.

The nutrient content of the diet was determined according to the AOAC (2010). The metabolizable energy (ME) level of the diet was calculated according to Leeson and Summers (2001) (Table 1). Fatty acid composition of the vegetable oils was analyzed by GC/MS method in Orucoglu Oil Factory (Table 2).
 $ME, \text{kcal/kg} = 53 + 38 [(crude \text{ protein, \%}) + (2.25 \times crude \text{ fat, \%}) + (1.1 \times starch, \%)] + (1.05 \times sugar, \%)]$.

Table 1. Ingredients and chemical compositions of the diets used in the study (%).

Ingredients	%
Corn	34.00
Wheat	18.20
Soybean meal	26.00
Sunflower meal	16.00
Vegetable oil	3.00
Limestone	1.30
Dicalcium phosphate	0.80
Salt	0.30
L-Lysine	0.15
Vitamin premix*	0.15
Mineral premix**	0.10
Chemical composition (analyzed)	
Dry matter, %	90.21
Crude ash, %	6.61
Crude protein, %	23.82
Crude fat, %	6.27
Crude fiber, %	6.9
Chemical composition (calculated)	
Nitrogen free extract, %	46.61
Calcium, %	0.86
Phosphorus, %	0.34
Metabolizable energy, kcal kg ⁻¹	2985

*Vitamin premix: Composition per 2.5 kg; A vitamini 12.000.000 IU; D3 vitamini 2.000.000 IU; E vitamini 35.000 mg g; K3 vitamini 4.000 mg; B1 vitamini 3.000 mg; B2 vitamini 7.000 mg; niasin 20.000 mg; kalsiyum D-pantotenat 10.000 mg; B6 vitamini 5.000 mg; B12 vitamini 15 mg, 8 g; folic acid 1.000 mg; D-biotin 45 mg; C vitamini 50.000 mg, choline chloride 125.000 mg; canthaxanthin 2.500 mg; apo carotenoic acid ester 500 mg.

**Mineral premix: Composition per 1 kg; Mn 80.000 mg; Fe 60.000 mg; Zn 60.000 mg; Cu 5.000 mg; Co 200 mg; I 1.000 mg; Se 150 mg

Table 2. Fatty acid composition of the vegetable oils used in the study (%).

Fatty acids	Soybean oil	Sunflower oil	Safflower oil	Olive oil
Myristic acid (14:0)	0.05	0.08	6.65	0.02
Palmitic acid (16:0)	10.59	6.39	0.12	12.36
Stearic acid (18:0)	4.65	3.26	2.71	2.87
Oleic acid (18:1)	24.87	31.96	11.91	72.61
Linoleic acid (18:2 n-6)	52.22	56.96	77.37	9.29
α -Linolenic acid (18:3 n-3)	6.41	0.08	0.11	0.63
Arachidonic acid (20:0)	0.40	0.23	0.29	0.48
Eicosenoic acid (20:1)	0.23	0.19	0.19	0.33
Behenic acid (22:0)	0.35	0.52	0.19	0.10
Palmitoleic acid (16:1)	0.10	0.15	0.11	0.95
Margaric acid (17:0)	0.10	0.04	0.05	0.13
Heptadesenoic acid (17:1)	0.06	0.04	0.04	0.18
Erucic acid (22:1)	-	-	0.18	0.02
Lignoceric acid (24:0)	0.08	0.09	0.017	-
Total saturated fatty acids	16.12	10.61	10.08	15.96
Total unsaturated fatty acids	83.89	89.38	89.91	84.01
Mono unsaturated fatty acids	25.26	32.34	12.43	74.09
Poly unsaturated fatty acids	58.63	57.04	77.48	9.92
Omega-6 fatty acid	52.22	56.96	77.37	9.29
Omega-3 fatty acid	6.41	0.08	0.11	0.63
Omega-6/omega-3 fatty acid	8.15	712	703.4	14.75

Fattening Performance Traits

The quails were weighed individually on weekly basis. Feed intake was measured for two times in a week among the groups. Feed conversion ratio was calculated biweekly by calculating the amount of feed consumed for BW gain in kg.

Carcass Quality Traits

At the end of trial, from each group, 5 male and 5 female quails were randomly selected and slaughtered. The slaughtered birds were opened, internal organs were removed, body fat and feathers were also removed and carcass weight was calculated for each bird. The weights of some internal organs were divided into body weights before slaughter, and relative organ weights were calculated. The cold carcass weight was determined after the carcasses were stored at +4 °C for 18 hours. The hot and cold carcass yields were calculated by dividing the weight of the hot and cold carcasses by pre-slaughter weights.

Collection and Storage of Serum and Breast Meat Samples

After slaughtering the blood was taken from each quail and taken in test tubes having anticoagulant and kept refrigerated for 24 hours at 4 °C. Subsequently, the blood was centrifuged at 3000 rpm for 15 minutes to obtain serum. The serum samples were stored at -18 °C. Besides, 10 samples of breast meat from each group were weighed to determine malondialdehyde (MDA) level.

Determination of Serum Biochemical Parameters

In the stored blood samples taken from quails at the end of the study, serum alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), total protein, triglyceride and cholesterol levels were measured using an autoanalyzer (ILab 300 Plus) with commercial kits (Instrumentation Laboratory Company, Milan, Italy). All procedures were conducted in the Pharmacology Department of the Faculty of Veterinary Medicine of the Selcuk University.

Determining the Serum Antioxidant Activity and Breast Meat MDA Levels

Serum MDA level was determined using the double boiling of free radicals MDA resulting from free radicals reported by Draper and Hadley (1990). Serum antioxidant activity (AOA) level was determined calorimetrically in the serum using the method described by Koracevic et al. (2001). The MDA level in breast meat was determined by the method of Botsoglou et al. (2002).

Statistical Analysis

The Variance Analysis Method was used to evaluate differences between the mean values of the groups in the study, and the Tukey test was used to estimate the significance of differences between the groups (SPSS 13.0, Inc., Chicago, IL, USA). $p < 0.05$ value was considered statistically significant for every statistical analysis.

RESULTS

The fatty acid composition of the vegetable oil samples used in the study are presented in Table 2. The vegetable oil supplementation didn't statistically affect the performance parameters e.g. FCR, FI, BW, body weights ($p > 0.05$; Table 3).

Hot and cold carcass weights and relative weights of some organs and abdominal fat were not affected by the supplementation of vegetable oils ($p > 0.05$; Table 4).

The supplementation had no any statistical effect on serum ALP, ALT, AST, total protein, triglyceride, and cholesterol levels among the treatment groups ($p > 0.05$; Table 5). Serum MDA level was observed to be decreased ($p < 0.05$) in the safflower oil-supplemented group, whereas serum AOA level increased ($p < 0.05$) in the same group compared with soybean, sunflower, safflower and olive oil supplementation groups. No significant difference was observed ($p > 0.05$) among the groups in term of MDA level of breast meat (Table 6).

Table 3. The effects of dietary vegetable oils supplementation on fattening performance in quails.

Parameters	Soybean oil	Sunflower oil	Safflower oil	Olive oil	P
Initial body weight (g)	10.98±0.41	10.74±0.19	10.84±0.36	10.48±0.18	0.707
Final body weight (g)	191.15±3.23	188.41±3.29	187.32±3.15	191.44±2.22	0.717
Body weight gain (g)	180.17±3.16	177.67±3.22	176.48±3.07	180.96±2.26	0.686
Feed intake (g)	715.18±12.08	694.36±18.59	693.89±16.66	727.51±25.10	0.523
Feed conversion ratio (g feed/g)	3.97±0.03	3.90±0.07	3.93±0.03	4.01±0.09	0.647

Statistically not significant ($p > 0.05$).

Table 4. The effects of dietary vegetable oils supplementation on carcass weights (g), carcass yields (%), relative inert organ weights and abdominal fat (%) in quails.

Parameters	Soybean oil	Sunflower oil	Safflower oil	Olive oil	P
Hot carcass weight	121.29±5.10	120.22±4.73	120.94±3.02	124.36±4.20	0.271
Cold carcass weight	115.99±8.16	114.57±4.64	112.28±3.24	115.23±4.22	0.924
Hot carcass yield	72.13±3.32	66.83±0.96	70.10±1.14	68.81±1.08	0.467
Cold carcass yield	64.09±3.18	64.49±0.99	65.65±0.96	65.16±1.01	0.892
Liver	2.31±0.184	2.53±0.13	2.28±0.172	2.31±0.13	0.654
Heart	0.936±0.048	0.858±0.02	0.949±0.027	0.853±0.015	0.076
Spleen	0.112±0.034	0.142±0.034	0.086±0.012	0.145±0.045	0.856
Gizzard	1.99±0.066	2.18±0.13	2.05±0.038	1.77±0.22	0.230
Proventriculus	0.411±0.016	0.467±0.02	0.436±0.020	0.391±0.02	0.124
Abdominal fat	1.39±0.21	1.43±0.23	1.56±0.26	1.54±0.18	0.563

Statistically not significant ($p>0.05$); $n=5$.

Table 5. The effects of dietary vegetable oils supplementation on serum ALP (IU/L), ALT (IU/L), AST (IU/L), total protein (g/dL), triglyceride (mg/dL) and cholesterol (mg/dL) levels in quails.

Parameters	Soybean oil	Sunflower oil	Safflower oil	Olive oil	P
ALP	992.42±33.23	1057.88±45.84	990.12±45.39	1040.22±62.40	0.706
ALT	15.34±1.96	11.77±2.20	11.33±0.91	13.11±1.76	0.454
AST	274.28±10.08	260.44±42.51	273.37±21.80	250.88±23.08	0.929
Total protein	8.34±0.79	9.27±1.00	9.34±1.17	8.00±1.61	0.812
Triglyceride	624.14±39.80	873.33±107.14	735.87±58.89	730.77±78.47	0.212
Cholesterol	352.28±13.87	399.88±34.65	340.28±15.58	332.55±14.54	0.158

Statistically not significant ($p>0.05$); $n=5$.

ALP: Alkaline phosphatase, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase

Table 6. The effects of dietary vegetable oils supplementation on serum MDA (nmol/L), breast meat MDA (nmol/L) and serum AOA (mmol/L) levels in quails.

Parameters	Soybean oil	Sunflower oil	Safflower oil	Olive oil	P
Serum MDA	2.03±0.50 ^{ab}	2.42±0.92 ^a	1.67±0.78 ^b	1.88±0.74 ^{ab}	0.039*
Breast meat MDA	6.48±0.16	7.64±0.25	6.04±0.133	7.55±0.13	0.356
Serum AOA	7.55±0.33 ^b	7.44±0.24 ^b	8.98±0.26 ^a	8.17±0.33 ^{ab}	0.02*

a,b: Different letters in the same line indicate statistically significant. (*): $p<0.05$; $n=5$.

MDA: Malondialdehyde, AOA: Antioxidant activity

DISCUSSION and CONCLUSION

The vegetable oils used in this study trial were rich in unsaturated fatty acids (average 86.8%). In addition, it was observed that soybean, sunflower and safflower oils were rich in linoleic acid (52.22%, 56.96% and 77.37% respectively) from polyunsaturated fatty acids. On the other hand, olive oil was rich in oleic acid (72.61), a monounsaturated fatty acid (Table 2). Fatty acid profile obtained in this study was found to be consistent with some previous findings using these oils (Balevi and Coskun 2000; Açıkgöz et al. 2003). In previous studies, it has been noted that the fatty acid composition of the oils used was considerably effective in determining the fatty acid profile of the obtained product (Lopez-Ferrer et al. 1999; Sanz 1999).

However, it has been reported that supplementing fat sources rich in polyunsaturated fatty acids to poultry diets increases polyunsaturated fatty acids in meat (Pinchasov and Nir 1992). Similarly, Scaife et al. (1994) observed a significant increase in the amounts of breast meat linoleic, eicosadienoic and arachidonic acid in broilers, which were fed soybean oil supplemented diets. Moreover, some studies reported that the supplementation of sunflower oil to broiler diets increased linoleic acid levels, in breast meat (Newman et al. 2002), leg and breast meat (Crespo and Esteve-Garcia 2001). In another study, it was reported that soybean oil supplementation in broiler diets increased linoleic acid levels in leg skin, breast meat and abdominal fat (Azman et al. 2005). In this study although not evaluated, yet it was assumed that the oils used in diets were rich in fatty acids such as high omega-6 or oleic acid, suggesting that these oils could be used as a suitable source of essential fatty acids for quails.

The results obtained revealed that the supplementation of vegetable oils did not affect the BW, BW gain, FI and FCR in quail ($p > 0.05$, Table 3). Similarly, El-Yamany (2008) demonstrated that supplementation of linseed, sunflower and olive oil to growing quail diets did not affect BW, FI and FCR. The results of the present study were similar to the findings of Midilli et al. (2009). Results of the current study showed that the carcass weights and yields, relative weight of some organs and abdominal fat were not affected by dietary vegetable supplementation in quails ($p > 0.05$, Table 4) and the results obtained by El-Yamany (2008) were aligned to those obtained in our study trial.

The presence of liver enzymes e.g. ALT, AST, ALP, etc, in blood, heart muscles and skeletal muscles indicates the dysfunction of liver and hepatobiliary obstruction whereas on the other hand the supplementation of vegetable oils plays a pivotal role in regulating the liver function (Kerr 2008; Senanayake et al. 2015). In this study, it is observed that vegetable oil (rich in unsaturated fatty acids)

supplementation didn't affect the liver enzymes so it concluded that the vegetable oils used in our trial didn't affect the liver of quails (Mahmoud et al. 2012). In this context, the current study suggests that vegetable oils added to quail rations did not produce any change in the levels of enzymes used in determination of liver functions ($p > 0.05$, Table 4). Similar to liver enzymes, there was no difference in serum triglyceride and cholesterol levels among groups, indicating that four different oil sources did not alter serum lipid profile ($p > 0.05$, Table 5). Lee et al. (2000) demonstrated that plasma triglyceride levels were significantly reduced in humans fed with olive oil ($p < 0.05$); Baba et al. (2000) observed that canola, olive, soybean and sesame oil did not cause differences in cholesterol levels in rats, whereas triglyceride levels decreased in the groups which were given canola and soybean oil. In addition, it is reported that oils containing polyunsaturated fatty acids such as omega-3 and omega-6 (fish oil, sunflower oil, corn oil) are more effective in lowering cholesterol levels than oils containing monounsaturated fatty acids (olive oil, canola oil) (Mohamed et al. 2002). It has been shown in this study, that omega-3 fatty acid supplementation decrease plasma cholesterol levels (Atakisi et al. 2009).

Poultry meat is an animal product with a high level of unsaturated fatty acids, especially polyunsaturated fatty acids (Chmiel et al. 2019). Therefore, enrichment of meat by these fatty acids reduces resistance to lipid oxidation (Cortinas et al. 2005). Lipid peroxidation is a highly deleterious chain reaction for all biomolecules. The unsaturated bonds of the fatty acids in the membrane can easily react with free radicals, leading to the formation of peroxidation products. The formation of MDA, which is the most important indicator of lipid peroxidation, leads to the deterioration of membrane structure, producing reactive aldehydes and damaging other cell components (Domínguez et al. 2019). Along with lipid oxidation, sensory properties of meat are deteriorated, nutritional values are lost and shelf life is shortened. As a result of advanced and severe oxidative degradation, the quality of the product is also adversely affected, resulting in the formation of short chain aldehydes, ketones and other oxidative compounds (Botsoglou et al. 2002).

Many studies on this subject have indicated that lipid oxidation in poultry meat (Boni et al. 2010; Biricik et al. 2012) and serum (Bulbul et al. 2014, Yesilbag et al. 2012) may be prevented by the supplementation of aromatic oils or extracts to the diet. It is stated that the antioxidant properties of aromatic plants are derived from phenolic compounds which are responsible for scavenging free radicals in the structures and for creating compounds with metal ions by reducing the formation of singlet oxygen (Domínguez et al. 2019). In addition to this, it has

been shown that vegetable oils can prevent oxidation in meat and the sensitivity of chicken meat to oxidation enriched with unsaturated fatty acids can be eliminated especially with the use of vitamin E, which is a natural antioxidant (Lopez-Ferrer et al. 1999). Serum MDA level, the final product of lipid peroxidation, was found to be lowest in the group fed with safflower oil ($p < 0.05$; Table 6). Serum AOA level was found to have increased in the same group compared to groups containing soybean and sunflower oils ($p < 0.05$; Table 6). It is thought that the strong antioxidant effect of safflower oil could be due to the high level of vitamin E contained in this oil and the polyphenolic compounds in its seed.

According to the results, it can be concluded that the supplementation of soybean, sunflower, safflower and olive oil to quail diets did not affect growth performance, carcass traits, liver enzymes, total protein, lipid profile and breast meat MDA. When soybean, sunflower, safflower and olive oils used in the research are compared, safflower oil is recommended in case of any stress; otherwise, the cheaper one should be preferred in quail diets.

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REFERENCES

Açıkgöz Z, Altan Ö, Bayraktar H. Karma yeme asit yağ ilavesinin etlik piliç performansı üzerine etkileri. *Hayvansal Üretim*, 2003; 44:1-8.

Ahiwe EU, Omede AA, Abdallah MB, Iji PA. Managing Dietary Energy Intake by Broiler Chickens to Reduce Production Costs and

Improve Product Quality. *Animal Husbandry and Nutrition*, 2018; 115-145.

AOAC Association of Official Analytical Chemists. Official Methods of Analysis of the Association of Official Analytical Chemists. AOAC International, 2000; Maryland, USA.

Atakisi E, Atakisi O, Yaman H, Arslan I. Omega-3 fatty acid application reduces yolk and plasma cholesterol levels in japanese quails. *Food Chem Toxicol.* 2009; 47:2590-2593.

Azman MA, Çerçi IH, Birben N. Effects of various dietary fat sources on performance and body fatty acid composition of broiler chickens. *Turk J Vet Anim Sci.* 2005; 29:811-819.

Baba NH, Ghossoub Z, Habbal Z. Differential effects of dietary oils on plasma lipids, lipid peroxidation and adipose tissue lipoprotein lipase activity in rats. *Nutr Res*, 2000; 20:1113-1123.

Balevi T, Coskun B. Effects of some oils used in broiler rations on performance and fatty acid compositions in abdominal fat. *Revue Med Vet.* 2000; 151:937-944.

Biricik H, Yesilbag D, Gezen S, Bulbul T. Effects of dietary myrtle oil (*Myrtus Communis L.*) supplementation on growth performance, meat oxidative stability, meat quality and erythrocyte parameters in quails. *Revue Med Vet.* 2012; 163:134-138.

Boni I, Nurul H, Noryati I. Comparison of meat quality characteristics between young and spent quails. *Int Food Res J.* 2010; 17:661-666.

Botsoglou NA, Florou-Paneri P, Christaki E, Fletouris DJ, Spais AB. Effect of dietary oregano essential oil on performance of chickens and on iron-induced lipid oxidation of breast, thigh and abdominal fat tissues. *Br Poult Sci.* 2002; 43:223-230.

Bulbul T, Yesilbag D, Ulutas E, Biricik H, Gezen SS, Bulbul T. Effect of myrtle (*Myrtus Communis L.*) oil on performance, egg quality, some biochemical values and hatchability in laying quails. *Revue Med Vet.* 2014; 165:280-288.

Chmiel M, Roszko M, Adamczak L, Florowski T, Pietrzak D. Influence of storage and packaging method on chicken breast meat chemical composition and fat oxidation. *Poult Sci.* 2019; 36:69-75.

Cortinas L, Barroeta A, Villaverde C, Galobart J, Guardiola F, Baucells MD. Influence of the dietary polyunsaturation level on chicken meat quality: Lipid Oxidation. *Poult Sci.* 2005; 84:48-55.

- Crespo N, Esteve-Garcia E.** Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. *Poult Sci.* 2001; 80:71-78.
- Domínguez R, Pateiro M, Gagaoua M, Barba FJ, Zhang W, Lorenzo JMA.** Comprehensive review on lipid oxidation in meat and meat products. *Antioxidants (Basel)*, 2019; 8:429.
- Draper HH, Hardley M.** Malondialdehyde determination as index of lipid peroxidation. *Methods Enzymol.* 1990; 186:421-30.
- El-Yamany AT, El-Allawy HMM, Abd El-Samee ELGhamry AA.** Evaluation of using different levels and sources of oil in growing Japanese quail diets. Evaluation of using different levels and sources of oil in growing Japanese quail diets. *Amer Euras J Agric Envir Sci.* 2008; 3:577-582.
- Erener G, Ocak N, Garipoglu AV.** The influence of dietary hazelnut kernel oil on the performance and fatty acid composition of broilers. *J Sci Food Agric.* 2007; 87:689-693.
- Jalali SMA, Rabiei R, Kheiri, F.** Effects of dietary soybean and sunflower oils with and without L-carnitine supplementation on growth performance and blood biochemical parameters of broiler chicks. *Arch Anim Breed.* 2015; 58:387-394.
- Kerr MG.** *Veterinary Laboratory Medicine: Clinical Biochemistry and Haematology.* 2nd Edition. Blackwell Science Ltd, 2008; London
- Koracevic D, Koracevic G, Djordjevic V, Andrejevic S.** Method for the measurement of antioxidant activity in human fluids. *J Clin Pathol.* 2001; 54:356-361.
- Lee A, Thurnham DI, Chopra M.** Consumption of tomato products with olive oil but not sunflower oil increases the antioxidant activity of plasma. *Free Radic Bio Med.* 2000; 29:1051-1055.
- Leeson S, Summers J.** *Nutrition of the Chicken.* University Books. Guelph, Ontario, 2001; Canadá, P67.
- Lopez-Ferrer S, Baucells MD, Barroeta AC, Grashorn MA.** Influence of vegetable oil sources on quality parameters of broiler meat. *Archiv Geflug.* 1999; 63:29-35.
- Mahmoud H, Haggag A, El-Gebaly H.** Toxicological studies of malathion on Japanese quail (*Coturnix japonica*). *Life Sci J.* 2012; 9:1725-1732.
- Maniila HA, Husvéth F, Németh K.** Effects of dietary fat origin on the performance of broiler chickens and on the fatty acid composition of selected tissues. *Acta Agraria Kaposvariensis,* 1999; 3:47-57.
- Midilli M, Bayram I, Erol H, Cetingul IS.** The effects of dietary poppy seed oil and sunflower oil on performance, reproduction and egg quality parameters and fatty acid profile of egg yolk in the Japanese quail. *J Anim Vet Adv.* 2009; 8:379-384.
- Mohamed AI, Hussein AS, Bhatena SJ, Hafes YS.** The effect of dietary menhaden, olive, and coconut oil fed with three levels of vitamin E on plasma and liver lipids and plasma fatty acid composition in rats. *J Nut Biochem.* 2002; 13:435-441.
- Newman RE, Bryden WL, Fleck E, Ashes JR, Buttemer WA, Storlien LH, Downing JA.** Dietary N-3 and N-6 fatty acids alter avian metabolism: metabolism and abdominal fat deposition. *Br J Nutr.* 2002; 88:11-18.
- NRC (National Research Council) Nutrient Requirements of Dairy Cattle.** 7th rev. ed. National Academy Press, 2001; Washington, DC.
- Pinchasov Y, Nir I.** Effect of dietary polyunsaturated fatty acid concentration on performance, fat deposition, and carcass fatty acid composition in broiler chickens. *Poult Sci.* 1992; 71:1504-1512.
- Sanz M.** Higher lipid accumulation in broilers fed on saturated fats than in those fed on unsaturated fats. *Br Poult Sci.* 1999; 40:95-101.
- Scaife JR, Moyo J, Galbraith H, Michie W, Campbell V.** Effect of different dietary supplemental fats and oils on the tissue fatty acid composition and growth of female broilers. *Br Poult Sci.* 1994; 35:107-118.
- Senanayake S, Ranasinghe J, Waduge R, Nizanantha K, Alexander A.** Changes in the serum enzyme levels and liver lesions of broiler birds reared under different management conditions. *Trop Agric Res.* 2015; 264:584-595.
- Yesilbag D, Gezen S, Biricik H, Bulbul T.** Effect of a rosemary and oregano volatile oil mixture on performance, lipid oxidation of meat and haematological parameters in Pharaoh quails. *Br Poult Sci.* 2012; 53:89-97