Etlik Vet Mikrobiyol Derg, 2023; **34 (1):** 67-72
doi: https://doi.org/10.35864/evmd.1148128

Original Article
Özgün Araştırma

Effect of supplemental dietary sweet almond oil on performance, carcass parameters, blood values and meat quality of Japanese quails

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Geliş Tarihi / Received: 25.07.2022, **Kabul Tarihi** / Accepted: 22.12.2022

Abstract: In this study, the effects of two different levels of sweet almond supplementation (2,500 and 5,000 mg/kg) to growing Japanese quails' diets (Coturnix coturnix Japonica) on performance, carcass group, blood values and meat quality were examined. For this purpose, 72 one-day-old Japanese quails were randomly distributed under control and two different experimental groups for 35 days experiment, and their body weight and feed consumption were evaluated. At the end of the study, a total of 8 animals from each group were selected and slaughtered. Hot carcass yield, relative weights of liver, heart, spleen, gizzard, proventriculus and bursa of Fabricius to body weight were determined in slaughtered animals. Total cholesterol, triglyceride, low-density lipoprotein, high-density lipoprotein, and lipase levels in blood serum samples and water holding capacity, pH, malondialdehyde, L, a*, and b* values in breast meat samples were investigated. As a result of the study, it was observed that the addition of sweet almond oil had no statistical chance on performance, carcass traits and meat quality values, compared to the control group. In the meantime, it was detected lipase levels of blood serum were decreased in the groups fed with sweet almond oil-supplemented diets, and 2,500 mg/kg sweet almond oil supplementation reduced the ratio of proventriculus to body weight. To sum up, it was found that the addition of sweet almond oil to Japanese quail rations had a positive effect on performance and feed consumption; it also appears to reduce blood serum lipase value and proventriculus weight.

Keywords: Quails, lipid, meat quality, performance, sweet almond oil

Rasyona ilave edilen tatlı badem yağının Japon bıldırcınların performans, karkas parametreleri, kan değerleri ve et kalitesi üzerine etkisi

Özet: Bu çalışma ile rasyonlarına iki farklı düzeyde (2,500 ve 5,000 mg/kg) tatlı badem yağı ilavesinin gelişmekte olan Japon bıldırcınlarında (*Coturnix coturnix Japonica*) performans, karkas parametreleri, kan değerleri ve et kalite özellikleri üzerine etkisi incelenmiştir. Bu amaçla 72 adet 1 günlük Japon bıldırcını 35 gün süreyle kontrol ve iki farklı deneme grubu altında rastgele dağıtılarak takip edilmiş, canlı ağırlık ve yem tüketimleri değerlendirilmiştir. Çalışmanın sonunda her gruptan toplam 8 hayvan seçilerek kesilmiştir. Kesilen hayvanlarda sıcak karkas randımanı, karaciğer, kalp, dalak, taşlık, bezli mide ve bursa Fabricius'un canlı ağırlığa oranı belirlenmiştir. Alınan kan serumu örneklerinde toplam kolesterol, trigliserit, düşük yoğunluklu lipoprotein, yüksek yoğunluklu lipoprotein ve lipaz düzeyleri ile göğüs eti örneklerinde su tutma kapasitesi, pH, malondialdehit, L, a* ve b* değerleri incelenmiştir. Çalışma sonucunda tatlı badem yağı ilavesinin kontrol grubuna göre, performans, karkas özelikleri ve et kalite değerleri üzerinde istatistiki bir değişikliğe yol açmadığı gözlemlenmiştir. Bununla birlikte, rasyonlarına tatlı badem yağı ilave edilen gruplarda kan serumunda lipaz düzeyinin düştüğü ve 2,500 mg/kg tatlı badem yağı ilavesinin karaciğer ve bezli midenin canlı ağırlığa oranını azalttığı tespit edilmiştir. Sonuç olarak; Japon bıldırcın rasyonlarına tatlı badem yağı ilavesinin performans ve karkası etkilemeksizin; kan serumu lipaz değeri ve karaciğer ile bezli mide ağırlığını azalttığı görülmektedir.

Anahtar kelimeler: Bıldırcın, et kalite, lipid, performans, tatlı badem yağı.

Introduction

Aromatic plants and essential oils have become prominent in animal feeding research after the ban of antibiotics as growth promoters by the European Commission in 2006 (Lee et al. 2003). Herbal oils, in particular, have received great attention in recent years for their potential use as natural antioxidants (Al-Attar 2020). Essential oils of spices and herbs which are a collection of aromatic components are known for their antimicrobial, antifungal, antiparasitic, and antiviral properties, along with the stimulant effect on digestion (Krishan and Narang 2014).

Almond is a local fruit tree native to the hot climates from Iran to the Sahra Desert (Ahmad 2010).

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Almond nuts (*Prunus amygdalus*) are divided into two groups; sweet almonds (*Prunus amygdalus Dulcis)* and bitter almonds (*Prunus amygdalus Amara*) (Arjomandi et al. 2015; Moradi Yeganeh et al. 2021). Almond production has been increasing rapidly in the last decade reaching 4.1 million metric tons (MT) in 2020 according to Food and Agriculture Organization of the United Nations data. With 159,187 MT volume, Turkey is the fifth country in almond producing across the world (FAOSTAT 2022). The almond oil contains mostly poly and monounsaturated fatty acids with oleic, linoleic, palmitic acid, and oil-soluble components such as phytosterols and tocopherols (Ouzir et al. 2021). It is believed that almond oil improved intestinal transport of nutrients and increased high-density lipoprotein (HDL) while decreasing low-density lipoprotein (LDL) in the blood (Ahmad 2010). It also has antioxidant potential due to its rich unsaturated fatty acid and phytochemical contents (Al-Attar 2020; Zhao et al. 2022).

The studies conducted in broiler chickens showed that full-fat almond (Kim et al. 2021) and sweet almond meal (Moradi Yeganeh et al. 2021) improved growth performance. Furthermore, using sweet almond meal as protein source in broiler (Moradi Yeganeh et al. 2021) and quail (Arjomandi et al. 2015) diets decreased blood lipid values. On the other hand, there is no available report regarding the use sweet almond oil (SAO) in poultry diets. Additionally, although there is a relationship between blood lipid levels and meat quality, and it's known that SAO has antioxidant properties; no study has been practiced on the effect of almond supplementation in poultry on the meat quality. Therefore, the purpose of the present study was to determine the effect of augmenting amounts of SAO as feed additives on performance, carcass traits, blood lipid profile and meat quality stats in growing Japanese quails.

Material and Method

A total of 72 unsexed Japanese quails (*Coturnix coturnix Japonica*) were randomly distributed into three groups. Each group consisted of 4 replicates with 6 quails in each. All replicates were balanced according to initial live weight. Japanese quails were handled in battery cages in a temperature-controlled room with 23 hours florescent lighting. The room temperature was set at 35ºC for the first week and decreased 2-3ºC every week until it was reduced to 24-25ºC. The experiment was conducted at a local quail farm in Karaman province, Turkey for 5 weeks.

Table 1. Ingredients and chemical and calculated content of the basal diet of growing Japanese quail.

Ingredients (%)	
Barley	10.00
Vegetable Oil	0.50
Maize	49.27
Corn gluten meal	1.72
Soybean meal	35.28
Dicalcium phosphate	0.73
DL-methionine	0.15
Coccidiostat	0.08
L-lysine hydrochloride	0.15
Limestone	1.37
Sodium bicarbonate	0.10
Salt	0.40
Vitamin and mineral premix[1]	0.25
TOTAL	**100.00**
Chemical composition (%)	
Dry matters	88.74
Crude protein	21.60
Crude fat	2.01
Crude ash	7.11
Crude fiber	5.93
Calculated composition	
Sodium, (%)	0.23
Calcium, (%)	0.85
Available phosphorus, (%)	0.31
Lysine, (%)	1.34
Methionine + Cysteine, (%)	0.93
ME (kcal/kg) [2]	2,533

[1] 1 Kg Vitamin-Mineral Premix contains; 8,800 IU vitamin A, 2,200 IU vitamin D_3, 11 mg vitamin E, 44 mg nicotinic acid, 8.8 mg Calcium D-Pantothenate, 4.4 mg riboflavin, 2.5 mg thiamin, 6.6 mg vitamin B_{12}, 1 mg folic acid, 0.11 mg D-biotin, 220 mg choline, 80 mg manganese, 60 mg iron, 5 mg copper, 60 mg zinc, 0.20 mg cobalt, 1 mg iodine, 0.15 mg selenium.

[2] Metabolizable energy content of diets calculation was conducted according to the equation of Carpenter and Clegg (1956).

Growing quail feeds were calculated according to the animals' needs (National Research Council 1994). All animals were fed with a basal ration which contains 24% crude protein and 2.900 kcal/kg metabolizable energy (Table 1). The control group had basal diet and the treatment groups were fed with a basal ration supplemented with 2,500 and 5,000 mg/kg sweet almond oil respectively. Feed and water were provided to the animal *ad libitum*. Body weight (BW), body weight gain (BWG), feed intake (FI) and feed conversion rate (FCR) of each replicate were determined at the end of the experiment.

Two quails from each replicate (8 for each group) were randomly selected, weighed, and sacrificed at the end of the experiment. Heart, liver, gizzard, proventriculus, spleen, and bursa of Fabricius (BF) were removed from the carcass and weighed. Hot carcass yield (HCY) was also recorded. Relative organ weights were calculated by dividing the organ weights into live weights.

Blood samples from the slaughtered Japanese quails were centrifuged at 5,000 rpm for 10 minutes to separate the serum. Total cholesterol (TC), triglycerides, HDL, LDL, and lipase levels were determined with an autoanalyzer using commercial kits (Beckman Coulter OSR).

Breast samples harvested from the slaughtered birds were divided into 4 pieces. After 24 hours from the sacrifice, a Minolta colorimeter (CR-200, Minolta Co., Osaka, Japan) was used to determine CIE L* (lightness), a* (redness), and b* (yellowness) parameters of the meat. Other pieces grinned into mince. pH values of the breast meat in 1st and 30th days after slaughter were detected with a portable pH/temperature meter (Milwaukee MW102, USA). Water holding capacity (WHC) was determined by 1 g meat sample was weighted and centrifuged covered with a piece of filter paper in a centrifuge tube and final weight was observed after drying at 70°C. WHC was determined by the following formula: (weight after centrifugation – weight after drying) / initial weight × 100. Malondialdehyde (MDA) levels were received from the method described by Zeb and Ullah (2016).

The obtained data were analyzed statistically using the IBM SPSS Statistics 22 computer program. The differences between the mean of the groups were determined using the One-Way ANOVA analysis of variance and the post-hoc Duncan test. The significance level was established at $P<0.05$.

Results

The effect of dietary SAO supplementation on the performance of growing Japanese quails is shown in Table 2. In the present study, no difference was observed between the control and treatment groups fed with SAO supplemented diets in terms of BW at 35th day of the experiment, BWG, FI, and FCR values between 0 to 35 days of the study ($P>0.05$).

Based on the results on carcass traits on the 35th day of the treatment (Table 3), it can be established that dietary SAO supplementation did not affect HCW and relative weights of heart, gizzard, spleen, and BF in growing Japanese quails ($P>0.05$). However, in compression to the control, 5000 mg/kg SAO supplementation statistically decreased the relative weight of proventriculus and liver in Japanese quails ($P<0.05$).

Table 2. Performance parameters of the Japanese quails fed with SAO supplemented diets.

Parameters[1]	SAO supplementation (mg/kg diet)			p values[2]		
	0	2,500	5,000	C	L	Q
0st Day BW, g	8.41±0.11	8.59±0.08	8.51±0.06	0.387	0.429	0.262
35th Day BW, g	124.44±16.73	137.46±12.57	134.37±10.43	0.713	0.556	0.581
0-35 Days BWG, g	116.03±16.63	128.87±12.51	125.86±10.42	0.717	0.558	0.585
0-35 Days FI, g	455.24±70.38	479.03±19.97	462.05± 43.37	0.940	0.924	0.742
0-35 Days FCR, g/g	3.90±0.06	3.72±0.13	3.66±0.05	0.187	0.086	0.569

[1] BW: Body Weight; BWG: Body Weight Gain; FI: Feed Intake; FCR: Feed Conversation Rate
[2] Data were analyzed using combined (C), linear (L), and quadratic (Q) regression models of SPSS.

Tablo 3. Carcass traits of the Japanese quails fed with SAO supplemented diets.

Parameters[1]	SAO supplementation (mg/kg diet)			p values[2]		
	0	2,500	5,000	C	L	Q
Hot Carcass, %	56.41±1.69	61.31±5.30	58.67±4.16	0.118	0.331	0.057
Heart, %	1.00±0.16	0.92±0.07	0.88±0.12	0.172	0.066	0.677
Liver, %	2.78±0.39[a]	2.39±0.26[b]	2.90±0.35[a]	0.016	0.522	0.006
Gizzard, %	2.49±0.46	2.38±0.23	2.40±0.34	0.818	0.625	0.664
Proventriculus, %	0.61±0.18[a]	0.46±0.08[b]	0.61±0.08[a]	0.039	0.958	0.012
Spleen, %	0.07±0.02	0.10±0.03	0.12±0.08	0.204	0.079	0.857
BF, %	0.12±0.03	0.11±0.02	0.12±0.03	0.786	0.908	0.507

[1]BF: Bursa of Fabricius. [2] Data were analyzed using combined (C), linear (L), and quadratic (Q) regression models of SPSS.
a-b Means in the same row with no superscript letters after them or with a common superscript letter are not significantly different ($P<0.05$).

Table 4 demonstrates the effect of SAO supplementation in growing Japanese quails fed with SAO supplemented diets. Dietary supplementation of SAO linearly reduced lipase enzyme activity in the quails' blood serum (P<0.05). On the other hand, other lipid metabolism values, TC, triglyceride, HDL, and LDL did not differ between the control and treatment groups (P>0.05).

Tablo 4. Blood biochemical parameters of the Japanese quails fed with SAO supplemented diets.

Parameters[1]	SAO supplementation (mg/kg diet)			p values[2]		
	0	2,500	5,000	C	L	Q
TC, mg/dl	162.29±11.19	165.63±20.21	180.13±52.94	0.560	0.317	0.713
Triglycerides, mg/dl	164.71±20.61	157.38±25.17	212.75±95.96	0.162	0.136	0.245
HDL, mg/dl	89.77±10.48	91.73±8.28	95.46±24.81	0.794	0.513	0.903
LDL, mg/dl	49.26±10.61	59.03±14.83	54.40±29.18	0.653	0.628	0.426
Lipase, U/L	124.43±80.72^{a}	44.50±14.71^{b}	52.88±20.16^{b}	0.007	0.008	0.043

[1]TC, Total cholesterol; HDL, High-density lipoprotein; LDL, low-density lipoprotein.
[2] Data were analyzed using combined (C), linear (L), and quadratic (Q) regression models of SPSS.
a-b Means in the same row with no superscript letters after them or with a common superscript letter are not significantly different (P<0.05).

Tablo 5. Meat traits of the Japanese quails fed with SAO supplemented diets.

Parameters[1]	SAO supplementation (mg/kg diet)			p values[2]		
	0	2,500	5,000	C	L	Q
pH, 1st Day	5.48±0.10	5.46±0.10	5.54±0.10	0.338	0.290	0.352
pH, 30th Day	5.52±0.10	5.55±0.13	5.54±0.11	0.819	0.641	0.649
L	42.61±3.05	40.56±3.94	40.20±2.44	0.364	0.183	0.562
a* (Redness)	8.02±1.51	7.53±1.57	8.17±1.76	0.717	0.870	0.440
b* (Yellowness)	9.94±2.16	7.88±2.08	8.39±1.14	0.126	0.131	0.128
WHC, %	64.74±2.75	60.65±5.95	62.49±3.36	0.249	0.355	0.144
MDA, mg/kg	0.17±0.04	0.14±0.02	0.14±0.02	0.686	0.443	0.676

[1]WHC: Water Holding Capacity; MDA: Malondialdehyde.
[2] Data was analyzed using combined (C), linear (L), and quadratic (Q) regression models of SPSS.

The effect of SAO supplementation in growing Japanese quails on meat quality parameters is shown in Table 5. No difference was observed between the control and treatment groups in terms of pH values at 1st and 30th days after the slaughter, WHC, L, a* (redness), b* (yellowness) and malondialdehyde levels in breast meat of the birds (P>0.05).

Discussion and Conclusion

In the current study, dietary SAO supplementation did not affect BW at 35th day of the experiment, BWG, FI and FCR traits between 0-35 days of the experiment, significantly. The effects of dietary almond and almond products on the performance of poultry were variable in previous reports. Arjomandi et al. (2015) reported 100, 200 and 300 g/kg sweet almond meal supplementation in Japanese quail diets did not differ the performance of the birds. Furthermore, Moradi Yeganeh et al. (2021) described that sweet almond meal in broilers diet in levels of 7 and 14% improved BWG and FCR traits however 21 and 28% negatively impacted the performance. Another study on broilers showed full-fat almond supplementation improved BW, BWG, FI and FCR (Kim et al. 2021). In the current study, SAO supplementation decreased FCR not statistically but numerically. Other studies conducted on oleic acid rich dietary oil supplementation improved feed utilization in broilers (Baldizán et al. 2010; Ezeokeke et al. 2010; Long et al. 2018). Rat and human studies highlighted almond oil improved bowel transit (Ahmad 2010). Eupeptic properties of SAO might be the reason of improving FCR in the current study.

Results of the experiment indicated that the hot carcass yield and relative weights of heart, gizzard, spleen, and Bursa of Fabricius at 35 days were not altered by dietary treatments, however proventriculus and liver weight was statistically decreased in the group fed with 2,500 mg/kg SAO supplemented diets. Moradi Yeganeh et al. (2021) showed that sweet almond meal supplementation in broiler diets also did not statistically differ the relative weights of liver and gizzard. Moreover, other studies found no significant effect of dietary vegetable oil supplementation on the relative organ weights in broilers (Biricik et al. 2012) and quails (Ozdemir et al. 2015). On the other hand, relative weight of proventriculus was significantly decreased in the quails fed with 2,500 mg/kg SAO supplemented diet. Likewise, Shahryari et al. (2019) found using free fatty acids as dietary fat source in broilers also reduced proventriculus size. Gharejanloo et al. (2017) also stated that broilers fed with turmeric essential oil enriched diet had significantly lower proventriculus and gizzard compared to the control. Ezeokeke et al. (2010) also found dietary palm oil supplemented diets decreased proventriculus and gizzard weights in broilers. Almond oil was associated with improving food passage through digestive system (Ahmad 2010). The result might be related with decreasing feed passage time in digestive system with oil supplementation that caused muscular hypertrophy in proventriculus of growing Japanese quails.

From our observations, no statistical difference was detected between groups in terms of TC, triglycerides, LDL, and HDL concentrations in Japanese quails' blood serum. Likewise, Spiller et al. (1992) found raw almond supplementation in humans did not differ plasma lipid profile in terms of very low-density lipoprotein, HDL and triglycerides. Almond oil is abundant with phytosterols which can reduce blood total cholesterol and LDL levels by reducing absorption of cholesterol in intestines (Ouzir et al. 2021). A similar trend was observed in the experiments conducted in quails (Arjomandi et al. 2015) and broilers (Moradi Yeganeh et al. 2021) which are fed with almond cake supplemented diets. In the current study, augmenting the amount of SAO in growing Japanese quails diminished lipase concentration in blood serum. Whereas, other researchers observed that almond meal in rohu fish diets (Goswami et al. 2020) and dietary supplementation of raw and roasted almond to rats (Liu et al. 2016) increased lipase activity. Lipoprotein lipase is an extracellular enzyme that mostly hydrolyze triglycerides to free fatty acids. Lipid absorption preventive effect of SAO might also decrease lipase activity in blood serum during our study.

According to our results, no difference between groups was observed in fresh meat pH and WHC values. Similar to current findings, Arjomandi et al. (2015) did not observe any effect of sweet almond meal on breast meat pH in Japanese quails. Cázares-Gallegos et al. (2019) found no difference in terms of WHC in breast meats of the broilers fed with different amounts of Mexican oregano oil. Arulnathan et al. (2020) also reported omega-3 rich oil supplementation did not differ breast meat pH and WHC values in growing Japanese quails. It was defined that different oil sources in diet did not affect meat cell integrity nor chemical composition of the meat (Arulnathan et al. 2020). This might be the reason of the statistically insignificant dissimilarity between groups.

Sweet almond also has potential as a natural antioxidant however, SAO supplementation did not alter MDA levels in current study. Arjomandi et al. (2015) observed that even though sweet almond meal caused no significant difference between groups in fresh breast meat, it also decreased MDA concentration in frozen meat. Furthermore, Al-Attar (2020) demonstrated SAO supplementation in mice exposed to lead toxicity diminished MDA levels in blood. Certainly, almond product type, doses, environmental conditions, and species of the experimental animal can differ the results of the studies. We also did not find any significant difference between breast meat L, a* and b* traits in our experiment. Similarly, Arjomandi et al. (2015) found any statistical difference between control and the groups fed with different levels of omega-3 rich oil supplemented diets. It is accepted that there is an intense correlation between lipid peroxidation and meat pigmentation in poultry. Insignificancy of MDA values between groups might be associated with undifferentiation of breast meat color.

It may be concluded that the supplementation of 2,500 and 5,000 mg/kg SAO to growing Japanese quails did not affect performance and meat quality negatively. Moreover, SAO addition in the quails' diet improved relative weight of proventriculus and liver, and lipase level in blood serum. Further studies are needed to determine the effect of SAO supplementation on digestive enzyme activities and antioxidant effect in poultry with regard to various environmental conditions.

Ethical Statement: The quails are all kept and handed under the European Council Directive 98/58/EC. The design of the experiment was approved by the local ethical committee of the Veterinary Faculty at Selçuk University (Protocol No: 2021-94).

Acknowledge: The author would like to thank Behlul Sevim for the meat color analysis.

Financial Support and Conflict of interest: There is no person/institution funding the work, and the author has no conflicts of interest.

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