T.R.
KAHRAMANMARAŞ SÜTÇÜ İMAM UNIVERSITY
GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCE

THE USE OF BLACK CUMIN (*Nigella sativa*L.) OIL IN THE DIETS OF LAYING JAPANESE QUAIL

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ÇÖREKOTU (*Nigella sativa* L.) YAĞININ YUMURTACI JAPON BILDIRCIN RASYONLARINDA KULLANIMI

ÖZET

Bu çalışma, farklı düzeylerde çörek otu yağı içeren rasyonların Japon bıldırcınlarında yem tüketimi, performans, yumurta yağ asidi kompozisyonu ve yumurta kolesterol düzeyi üzerine etkilerini belirlemek amacıyla yapılmıştır. Bu amaçla altı haftalık yaşta 84 adet dişi bıldırcın rastgele 4 gruba (3 tekerrür/grup) ayrılarak %3 fındık yağı (Grup K, Kontrol), %2 fındık yağı artı %1 Çörek otu yağı (Grup L), %1 fındık yağı artı %2 Çörek otu yağı (Grup M), veya %0 fındık yağı artı %3 Çörekotu yağı (Grup N) içeren rasyonlarla 7 haftalık beslenmişlerdir. Çalışmada yumurtalar günlük olarak toplanıp tartılmıştır. Yumurta verimi, yumurta kalitesi ve yem tüketimi de değerlendirilmiştir. Yağ asidi kompozisyonu için çalışmanın son haftasında tekerrür başına 3 yumurta analiz edilmiştir. Ayrıca yumurta kolesterolü için her bir gruptan rastgele 3 yumurta ayrılarak analiz edilmiştir. Gruplardan on ikişer yumurta alınarak yumurta sarı ve beyaz ağırlığı, kabuk ağırlığı, kabuk kalınlığı, sarı rengi ve Haugh üniteleri gibi parametreler de ölçülmüştür. Çalışmada, çörek otu yağının yem tüketimi, yumurta verimi yumurta kütlesi ve Haugh ünitesi üzerine önemli bir etkisinin olmadığı belirlenmiştir. Kontrol grubuyla kıyaslandığında, çörek otu yağı ilavesi yapılan gruplardan elde edilen yumurtaların ağırlıklarının önemli şekilde arttığı bulunmuştur. M gurubundan elde edilen yumurtaların kabuk ağırlığı ve kabuk kalınlığı, kontrol gurubuna göre önemli artış sağlamıştır. Diyete %2 (Gurup M) oranında çörek otu yağının ilavesi yumurta renginin önemli bir şekilde artışına neden olmuştur. M grubundan elde edilen yumurtaların diğer gruplara göre daha fazla SFA içerdiği belirlenmiştir. L grubu yumurtaların diğer gruplara göre önemli miktarda MUFA düzeyine sahip olduğu gözlenmiştir. Grupların kolesterol içeriklerinde ise herhangi bir fark gözlenmemiştir.

Anahtar Kelimeler: Çörek otu yağı, Japon bıldırcını, yumurta parametreleri, yumurta kolesterolu ve yağ asidi kompozisyonu

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THE USE OF BLACK CUMIN (*Nigella sativa* L.) OIL IN THE DIETS OF LAYING JAPANESE QUAIL

ABSTRACT

The objective of this study was to determine the effects of feeding different levels of *Nigella sativa L.* oil on feed intake, laying hen performance, egg fatty acid content and egg cholesterol level in Japanese quail. Eighty four birds at 6 weeks of age were randomly assigned into 4 groups (3 replicates/each group) and fed a diet supplemented with 3% hazelnut oil with no *Nigella sativa* oil (Group K, Control), 2% hazelnut oil plus 1% *Nigella sativa* oil (Group L), 1% hazelnut oil plus 2% *Nigella sativa* oil (Group M) or 0 % hazelnut oil plus 3% *Nigella sativa* oil (Group N) for 7 weeks. In the study, eggs were collected and weighted daily. Laying performance, egg quality and feed consumption were also evaluated. At the end of the last week, 3 eggs per replicate were separated for egg yolk fatty acid analysis. Also for egg yolk cholesterol, 3 eggs per group were analyzed. Twelve eggs per group were used for egg parameters such as yolk and albumen weight, shell weight, shell thickness, yolk color, and Haugh unit. Results showed that *Nigella sativa* oils had no significant effect on feed intake, hen day egg production, egg mass, Haugh unit and body weight. Egg weight was significantly increased in the groups L, M, and N compared to the control. Shell thickness and shell weight in the eggs from M group were found significantly greater than the ones from the Group K. There was no significant change in the cholesterol level of eggs. Adding 2% *Nigella sativa* oil to the diet (Group M) significantly increased yolk color ($P<0.05$). Eggs from the group M had higher levels of SFA than others groups. Eggs from group L had a significantly higher levels of MUFA compared to the ones from group K ($P<0.05$). Cholesterol content of the eggs from quails from the groups K, L, M or N was similar.

Key words: *Nigella sativa* oil, laying Japanese quail, egg parameter, cholesterol, egg fatty acid composition.

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1. INTRODUCTION

The natural feed additives are given to animals/birds to improve their productive performance under normal or stress conditions. A number of feed additives including antibiotics have been widely used in the poultry industry for several decades. The use of antibiotics in sub-therapeutic levels as growth promoters in poultry diets was started around 60 years ago (Nasir and Grashorn, 2006). Meanwhile, the use of sub-therapeutic levels of antibiotics for growth promotion and disease prevention are suspected to increasing the risk of bacteria acquiring resistance to specific antibiotics (Nasir and Grashorn, 2006). In another hand, usage of antibiotics has a negative effect on animal's health and production such as residual in the tissues long withdrawal period and resistance in microorganism's allergies and genotoxicity that is serious threat to human health (Castanon, 2007). Recently, the concerns about possible antibiotic residues and disease resistance have aroused great caution in use of antibiotics in the animal industry (Jang et al. 2007). Usage of antibiotics as growth promoters has been prohibited in the European Union since 2006 (Nasir and Grashorn, 2006). Therefore, prohibition of antibiotic use in poultry feed has forced investigators to research new alternatives.

Essential oils or extracts from herbs have received considerable attention as replacements for antibiotic growth promoters. One of the alternatives used as feed additives is black cumin. Black cumin (*Nigella sativa* L.), also known as "black seed", grows in Asian and Mediterranean countries. The seed of *Nigella sativa L.* has been used for centuries in the Middle East, Northern Africa, Far East, and Asia for the treatment of asthma and as an anti-tumor agent. The seed also has been reported to have many biological properties including anti-parasitic, anti-diabetic, diuretic effects, and antibacterial activity. Also, the oil extracted from these seeds was shown to have antibacterial (Hanafy and Hatem, 1991), antioxidant (Mansour, 2000), immunopotentiating (Swamy and Tan, 2000) and hepatoprotective (Daba and Abdel Rehman 1998) activities. It was also reported that the oil extracted from the seeds of the black seed prevented lipid-peroxidation induced liver damage in diabetic rats (Meral et al.2001). Furthermore, it was found that the essential oil of black seeds inhibited the growth of *Escerichia coli*, *Bacillus subtilis*and *Streptococcus feacalis* (Saxena and Vyas,1986).

1.1 Nigella sativa

The genus *Nigella* contains about 20 species of annual herbs indigenous to the Mediterranean region through West Asia to Northern India, and has long been domesticated.

The Black seeds originate from the common fennel flower plant (*Nigella sativa*) of the buttercup (Ranunculaceae) family (Figure 1). The seeds themselves are known by many different names, depending on which country where they are located such as fennel flower, nutmeg flower, black cumin, black caraway, black sesame, Roman coriander, black seed or even coriander seeds in English language and perhaps most commonly, Al-Habba Al-Sauda or Al-habba al barakah and AlkamounAlaswad in Arabic. In some countries it is known by the names Shuniz and Khodhira and *Kalvanji* in Urdu and çörekotu *in Turkish* and siyah daneh in Persian. The genus *Nigella*, belonging to the family *Ranunculaceae*, is represented by species of Mediterranean–western Asian origin. These are generally short-lived annuals, typical of disturbed soils or natural communities of semi-arid areas, with a dominance of therophytes. In the natural forms, flowers are bluish, with a variable number of sepals, and characterized by the presence of nectaries. The gynoecium is composed of a variable number of multi-ovule carpels, developing into a follicle after pollination, with single fruits partially connected to form a capsule-like structure. Seeds, of generally small size (1–5 mg), dark grey or black in color and with corrugated integuments, represent the useful product (Figure 2).

Figure 1. *Nigella sativa L.*

Figure 2. *Nigella sativa L.* seeds

Black cumin seeds have been used as herbal medicine by various cultures and civilizations to treat and prevent a number of diseases. Recent research also witnessed the presence of *Nigella sativa* seeds some 3000 years ago at Uliburun, off the southwest coast of Turkey (Black et al. 2006). It is also famous for the saying of the Prophet Muhammad (SAW) "Hold on to use of the black cumin seed, for it has a remedy for every illness except death" (Bukhari, 1985). The historical tradition of black cumin seed in medicine is also substantial; identified as curative black cumin in the Bible, and mentioned as Melanthion by Hippocrates and Dioscorides and Pliny called it as the Gith (Atta-ur-Rahman et al. 1985a,b).

In the religion of Islam, the plant has been given a great importance because of its number of uses. As per the religion it is one of the greatest healing plants. Avicenna, most famous for his volumes called The Canon of Medicine, refers to *Nigella* as the seed that stimulates the body's energy and helps recovery from fatigue and dispiritedness. In the Indian system of medicine, the seeds are used as astringent, bitter, stimulant, diuretic, emmenagogue, anthelmintic, jaundice, intermittent fever, dyspepsia, paralysis, piles and skin diseases (Warrier et al. 2004).

1.3 **Pharmaceutical and therapeutic effects**

As an aromatic plant, *Black cumin* (*Nigella sativa*) is widely grown in different parts of the world and the seeds of black cumin have been used to promote health for countries especially in the Middle East and Southeast Asia. Black cumin seeds have been widely used in traditional medicine as diuretic and antihypertensive (Zaoui et al. 2000), digestive and appetite stimulant (Gilani et al. 2004), antidiarrheal (Gilani et al. 2001), anti-parasitic

(Mahmoud et al. 2002), analgesic (Khanna et al. 1993; Khan et al. 1999), anthelmintic (Agarwal et al. 1979; Chowdhury et al. 1998) and antibacterial agents (Ferdous et al. 1992; El-Kamali et al, 1998). Additionally, recent studies have shown black cumin to be antidiabetic (Meral et al. 2001), anticancer (Abuharfeil et al. 2001), antibacterial and antifungal (Rathee et al. 1982), anti-inflammatory (Al-Ghamdi, 2001), hepatoprotective (Janbaz et al. 2003), and renal protective (Badary et al. 2000) and antioxidant properties.

1.4 Compound of *Nigella Sativa*

The general chemical composition of the seeds is shown in Table 1. Like most other herbs; the composition of black cumin varies with geographic distribution, time of harvest and agronomic practices. Its health enhancing potential has been attributed to the active ingredients that are mainly concentrated in fixed or essential oil (Ramadan, 2007). Black cumin fixed oil is lipid fraction containing fatty acids, fat-soluble vitamins and volatile constituents, whereas its essential oil comprises of only volatiles.

Black cumin seeds contain substantial amounts of alkaloids like nigellicine, nigellidine and nigellimine; reported as cholesterol lowering agents (Atta-ur-Rahman et al. 1985a,b; 1992; Ali et al. 2008). Likewise, it's essential oil is a rich source of antioxidants including thymoquinone, ρ-cymene, carvacrol, t-anethole and 4-terpineol (Nickavar et al. 2003). Several pharmacological investigations explored that thymoquinone is effective against oxidative stress, cancer, immune dysfunction and diabetic complications. Furthermore, it alsoregulates several haematologicaland serological functions; maintains body homeostasis and bears hypocholesterolemic effect (Gali-Muhtasibet al. 2004, 2006).

Table 1 .The general chemical composition of *Nigella sativa* L. seeds (El-Din et al. 2006)

Constituent	**% Range (w/w)**
Oil	31-35.5
Protein	16-19.9
Carbohydrates	33-34
Fibre	4.5-6.5
Ash	3.7-7
Saponins	0.013
Moisture	5-7

1.5 Minerals in Nigella sativa

Minerals such as calcium, phosphorus and iron were found to be in appreciable amounts, while zinc, calcium, magnesium, manganese and copper in meager quantities (Nergiz and Ötles, 1993; Ali and Blunden, 2003). Iron, copper, sodium, potassium, calcium, zinc, phosphorous and magnesium contents lie in the range of 9.1-15.40, 1.5-3.75, 41.2-55.0, 442.3-675.0, 154.4-305.0, 3.36-6.6, 378.12-576.9 and 134.92- 147.05mg/100g of seed, respectively (Ashraf et al. 2006; Cheikh-Rouhouet al. 2007). Likewise it was reported that iron, copper, sodium, potassium, calcium, zinc and phosphorous were present in the quantities of 105, 18.4, 496.0, 5257, 1859, 60.4 and 5265mg/kg, respectively (Ashraf et al. 2006; Cheikh-Rouhou et al. 2007).

1.6 Fatty Acid Composition of *Nigella sativa* L.

Fats and oils are important component of animal diet that play pivotal role in fulfilling energy requirements. Oils from plant sources are beneficial in many aspects; source of unsaturated fatty acids and bioactive molecules like tocopherols and phytosterols. Quality and quantity of fatty acids are important traits that vary from crop to crop and with harvesting conditions (Ross et al. 1996; Palaniswamy et al, 2001).

The yield of black cumin seed fixed oil ranges from 22.0 to 40.35% (Sener et al. 1985; Ali and Blunden, 2003; Cheikh-Rouhou et al. 2007). Black cumin fixed oil is important in many aspects as it is rich in unsaturated fatty acids such as linoleic and oleic acids. Additionally, it also contains some minor quantities of linolenic, arachidic and eicosenoic acids (Atta, 2003; Ramadan and Mörsel, 2004; Ashraf et al. 2006; Cheikh-Rouhou et al. 2007). Polyunsaturated fatty acids constitute the bulk of the oil with quantities ranging from 48-70%, while monounsaturated and saturated fatty acids are comparatively in lesser proportions (Ustun et al. 1990; Nergiz and Ötles, 1993; Ramadan and Mörsel, 2003). Furthermore, presence of dihomolionolenic acid (1.9-2.3%) accredited for its antioxidant and lipid lowering potential. Recently, Cheikh-Rouhou et al. (2007) reported that it contains 49.8-50.7% of polyunsaturated fatty acids, 25.0-26.6% of mono unsaturated fatty acids, while saturated fatty acids account for 22.7-25.5% of its oil contents (Nickavar et al. 2003; Ashraf et al, 2006). Black cumin has been probed as a source of polyphenols and selenium (Weinreb et al. 2004; Ustun et al.1998; Dandik and Aksoy, 1996). Fat-soluble vitamins comprised more than 0.2% of total oil content (Ramadan and Mörsel, 2002a). Similarly, Al-Saleh et al. (2006) reported the concentrations of selenium, DL-α-tocopherol, DL-γ-tocopherol and all-trans-retinol in *N. sativa* seeds as 0.177, 9.027, 5.427, 0.277mg/kg seed, respectively. Formerly,

Ramadan and Mörsel(2002a) reported that one gram of black cumin fixed oil contains 284, 40, 225, 48μg of α-Tocopherol, β-Tocopherol, γ- Tocopherol and δ-Tocopherol, respectively. They also reported the presence of β-carotene in amounts of 593μg/g oil.

The utilization or addition of black cumin seed oil in diet, mixed dishes and desserts could have positive impact on the amount of fat-soluble vitamins and phytosterols in the diet (Ramadan and Mörsel, 2002b; Ramadan and Mörsel, 2004). Essential oil extracted from black cumin is also of functional importance as it is naturally bestowed with antioxidant rich volatiles (0.40-1.50%); contain 18.4-24% thymoquinone and 46% monoterpenes (Al-Jassir 1992; El-Tahir et al. 1993; Ashraf et al. 2006; Ali et al. 2008). Likewise, Burits and Bucar (2000) analyzed essential oil using GC-MS and characterized many components like thymoquinone (27.8–57.0%), ρ-cymene (7.1–15.5%), carvacrol (5.8–11.6%), tanethole (0.25–2.3%), 4-terpineol (2.0–6.6%) and 1.0–8.0% of longifoline (Nickavar et al. 2003; Ashraf et al. 2006). Recently, Wajs et al. *(*2008) determined ρ-cymene as a major component in black cumin seed essential oil. Several scientists explored the antioxidant potential of black cumin oil and its fractions containing active ingredients. Burits and Bucar (2000) observed IC50 value in DPPH (2, 2-diphenyl-1-picrylhydrazyl) assay for black cumin essential oil, thymoquinone and carvacrol i.e. 460.0, 211.0 and 28.8mg/mL, respectively. Later, Singh *et al*. (2005) indicted that DPPH radical scavenging effect of black cumin fixed oil in the range of 82 to 95%, comparable to butylatedhydroxyanisole (BHA), butylatedhydroxytoluene (BHT) and propyl gallate (PG). Black cumin seeds inhibited DPPH radical formation and mean IC50 (μM) was found to be 515 ± 20.1mg/mL (Erkan et al. 2008). Lately, Khattak et al. (2008) reported DPPH scavenging activity remained in the range of 70-90% and 60-80% for 5mg/mL of black cumin methanolic and water extract, respectively. Aqueous and 80% methanolic extract of black cumin resulted in marked inhibition of DPPH radicals with IC50 (mg dry wt) of 2.80±0.10 and 1.24±0.10, respectively (Thippeswamy and Naidu, 2005).

2. LITERATURE REVIEW

The effects of using *Nigella Sativa* meal as a feed additive (0, 1, 2 and 3%) was studied in on broiler performance broilers (Khalifah, 1995). The results showed no significant differences in body weight gain among broiler fed the experimental diet but at 1% level both feed conversion and protein efficiency were improved.

Osman and El- Barody (1999) found that addition of *Nigella sativa* seeds addition at levels (0.2, 0.4, 0.6, 0.8, 1 %) in broiler diets had insignificant effect on average body weight at all age intervals. While, the high levels of Nigella sativa (0.8 % or 1%), reduced feed consumption and improved feed conversion at 4 and 6 weeks of age.

In 2 experiments of a study conducted in the broiler, the effects of diets supplemented with essential oil (0.1 or 1 g/kg) or oilseed (10 or 50 g/kg) of black cumin on body performance were determined (Halle et al.1999). In the first experiment, it was reported black cumin and oil affected feed intake and body weight positively in the broilers and in the second experiment of the same study, no positive results related to those parameters were found.

Japanese quails fed 2% of whole crushed *Nigella sativa* seeds had the highest body weight at 21 and 42 day of age, and the birds fed 1% of *Nigella sativa* oil had the highest body weight at 35 day of age (Sabria and Abou El-Soud 2000).

Al- Homidan et al. (2002) reported in the study conducted with the Hibro broiler chicks,it was reported that diet supplemented with 10% black cumin seed had no adverse effects on performance.

Akhtar et al. (2003**)** demonstrated that different levels of *Nigella* seed supplementation to the diets of laying hens significantly increased egg production, egg weight, egg shell thickness, Hough units ($p<0.05$), whereas the cholesterol content of the egg yolks was significantly decreased ($p<0.05$).

Nasir et al. (2005) demonstrated that *Nigella sativa* seeds supplementation in layer diets improved egg production, egg weight, egg shell thickness and Haugh unit value.

(Aydin et al ,2006) carried out a study in which the impact of 3 different levels (%1,% 2,% 3) of *Nigella* seeds added to the diet of laying hens during 49 days on egg performance, egg quality and feed conversion ratio was studied. They showed that the black seeds didn't affect BWG, egg production, feed consumption, FCR, egg yolk and white index in the laying hen.

Black seed extract at the level of 0.1% significantly increased egg weight, shell weight and shell thickness. It was also shown that diet supplemented with 0.5% black seed extract increased albumen height, albumen length and yolk height in the quail (Denli et al. 2004).

Feeding of the diets with 1 and 3% black cumin seeds for a period of three months reduced egg yolk total cholesterol by 34 and 42%, respectively (El Bagir et al. 2006). Serum cholesterol concentrations averaged for the whole feeding period were lowered by 15 and 23% after feeding the diets with 1 and 3%black cumin seeds, respectively. Black cumin seeds in the diet of laying hens also caused a lowering of serum and egg-yolk concentrations of triacylglycerols and phospholipids. Inclusion of black cumin seeds in the diet caused a significant reduction in egg production, without any effect on egg width and length, while there was a significant increase in hen's body weight.

Attia et al. (2008) showed that Japanese quail chicks and hens can be fed a diet containing 10% NSOM. Moreover, this level can be increased to 20% when supplemented with enzyme. However, higher levels of NSM depressed growth and feed utilization.

In a study conducted, 3 different levels (%1, % 2, % 3) of *Nigella* seeds were added to the diet of laying hens on egg production, egg weight, feed conversion ratio, egg shell quality, and egg yolk cholesterol (Aydin et al. 2008). They showed that black cumin at the level of 2 or 3% would positively influence egg production, egg weight, and shell quality and decrease the concentration of cholesterol in the egg yolk (Aydin et al. 2008).

In a study conducted in laying chickens, Bölükbaşi et al. (2009) reported there was no significant difference in feed intake; feed conversion ratio, egg production and egg weight from the groups fed a diet supplemented with Nigella sativa oil. Also, the addition of *Nigella sativa* oil to the diet had no impact on yolk, albumen and shell percentage of egg on this study. The diet with 3 ml/kg black seed oil had induced decreased Haugh unit by 6.5% compared to control group (Bölükbaşi et al. 2009). The control group and 1ml/kg *Nigella sativa* oil group showed the highest average concentration of E. coli in the feces (Bölükbaşi et al. 2009). The addition of 3 ml/kg *Nigellasativa* oil to the basal diet significantly reduced triglyceride ratio of egg yolk compared with the other groups. The other hand, supplementing 3 ml/kg *Nigella sativa* oil to the basal diet increased ($P < 0.01$) cholesterol ratio of egg yolk above the control (Bölükbaşi et al. 2009).

Abbas and Ahmed (2010) who reported using whole crushed *Nigella sativa* seeds in broiler chicks. That bird offered a diet supplemented with 1% or 2% black cumin showed significantly lower body weight gain, whereas FCR was not affected.

Diet supplemented with 2.5% or 5.0% Nigella sativa seed had no deleterious effects on their performance, immunity, serum biochemical constituents or hematological indices in broiler chickens (Khan et al. 2012). Nigella sativa seed at levels of 4% or 5% positively was shown to influence egg production, egg weight and shell quality (Khan et al. 2013). Furthermore, it was shown that the concentration of serum LDL cholesterol and egg yolk cholesterol concentrations declined and immunity against Newcastle disease virus was enhanced (Khan et al. 2013).

2.1 **Objectives of the study**

There have been a limited number of studies associated with the effect of diets supplemented with *Nigella sativa* oil on laying quail performance, feed conversion ratio, egg parameters, egg yolk composition, and yolk cholesterol. Therefore, the objective of this study was to study the effects of *Nigella sativa* oil on egg production, egg weights, egg quality characteristics, shell quality, and egg cholesterol and egg fatty acids in Japanese quail.

3. MATERIALS AND METHODS

This study was conducted in the research farm at the Faculty of Agriculture, in Kahramanmaras Sutcu Imam University, Turkey. In this study, eighty four 6 week-old laying Japanese quail were randomly assigned into 4 groups with 3 replicates of 7 birds each (21 Japanese quails per group) and fed diets supplemented with 3% hazelnut oil with no *Nigella sativa* oil (Group K, Control), 2% hazelnut oil plus 1% *Nigella sativa* oil (Group L), 1% hazelnut oil plus 2% *Nigella sativa* oil (Group M) or 0 % hazelnut oil plus 3% *Nigella sativa* oil (Group N) for 7 weeks. Water and feed were provided ad libitum during the study. The photoperiod was set at 16L: 8D throughout the study. Body weights of laying quails were determined at the beginning and end of the study. Feed consumption was calculated on a weekly basis for every replicate in the groups. The FCR was expressed as kilograms of feed consumed per kilogram of egg produced. Eggs were examined for interior and exterior quality. Twelve eggs per group (4 eggs/each replicate) were collected at the end of the study for measuring egg components and parameters. At the end of study, 2 eggs per each replicate were collected and analyzed for egg cholesterol in TUBITAK.

3.1 Source of *Nigella sativa* oil

Nigella sativa oil used in this study was purchased from a local company in Urmiya City, Iran. Nigella sativa oil was analyzed for fatty acid analysis and consisted of 0.098% C14:0; 0.017% C6:0; 0.004% C14:0; 0.006% C14:1; 11.563% C16:0; 0.671% C16:1; 2.66% C18:0; 69.454% C18:1, n-9; 3.954% C18:2, n-6t; 9.499% C18:2 n-6c; 0.439% C18:3 n-3; 0.517% C20:0; 0.314% C20:1n-9; 0.132% C20:4 n-6; 0.024% C22:1 n-9; 0.271% C22:6, n-3; 0.021 % C24:0; 0.018% C24:1 n-9 and other fatty acids.

3.2 Experimental diets

In this study, eighty four female Japanese quails at 6 weeks of age were assigned into 4 groups (3 replicates per group). Each group contained 21 birds (7 birds per replicate) and fed a diet supplemented with 3% hazelnut oil with no *Nigella sativa* oil (Group K, Control), 2% hazelnut oil plus 1% *Nigella sativa* oil (Group L), 1% hazelnut oil plus 2% *Nigella sativa* oil (Group M) or 0 % hazelnut oil plus 3% *Nigella sativa* oil (Group N) for 7 weeks. Diets were isocaloric and isonutrigenous (Table 2). Diets contained 2,900 kcal/kg of ME and 20 % CP. Vegetable oil was contained *Nigella sativa* oil or hazelnut oil at the levels of 0, 1, 2, or 3%.

Table 2. Composition of Basal Diet

Nutrients	%
Corn grain	60.00
Soybean meal (48% CP)	25.85
Calcium carbonate	5.31
DCP	2.06
Lysine	2.22
DL-Methionine	0.21
[b]Vegetable oil	3
NaCl	0.35
Vitamin	1

Feed contained 2900 M cal/kg energy and 20% crude protein (CP).

3.3 **Housing and equipments**

The birds breed in the cages having 5 floors each floor. The cages were provided with feeder and waterer. The feeder and waterer space requirements during the brooding period are 6.5 cm respectively and 3 nipples in each box that it contained 7 birds. Continuous lighting is necessary for laying Japanese quail production birds and they had 16 hours per day.

3.4 Egg productivity and quality traits

3.4.1 Egg production rate

Eggs were collected and weighed daily. At the end of the study, 3 eggs per each replicate was collected and analyzed for yolk fatty acid analysis in TUBITAK. Hen day egg production of laying quails in all treatments weekly was calculated as the following equation (Al- Zubaidi, 1986)

$$\text{Hen Day Egg Production (H. D.) \%} = \frac{X}{\text{Y} * \text{Z}} * 100$$

X = the number of eggs produced during a certain period.
Y = length of time in days for the same period.
Z = number of birds at the end of the period.

3.4.2 Egg Mass

Egg mass calculated by the following equation:

Rate of egg mass (g) = Accumulative number of eggs (egg/bird) * average weight of the egg.

3.4.3 Feed intake (FI)

Feed intake (g / bird / day) by calculating the feed remaining at the end of weeks of feed provided at the beginning of the week during egg production.

$$\text{Average daily feed intake (g / hen)} = \frac{\text{Amount of feed intake (g)}}{\text{Number of birds per replicate} * \text{length of time (days)}}$$

3.4.4 Feed conversion ratio (FCR)

FCR was calculated on a weekly basis for every group in the study. FCR was expressed as kg of feed consumed per kg of egg produced. FCR was calculated as in the two equations:

$$\text{FCR (g feed / g eggs)} = \frac{\text{Feed intake (g / bird)}}{\text{Egg mass (g / bird)}}$$

$$\text{FCR (g feed/egg)} = \frac{\text{Feed intake (g / bird)}}{\text{Accumulative number of eggs (egg/bird)}}$$

3.4.5 **Egg parameters measurements**

To measure internal and external quality of eggs 3 eggs from each replicate were broken on a flat glass dish and following parameters were measured.

Egg weight (g), shell weight (g), yolk weight (g), albumin weight (g), albumin height (mm), yolk color, Haugh unit, egg width (mm), egg length (mm), thickness of shell (mm), yolk diameter (mm), yolk height (mm), length of albumin (mm).

3.4.6 **Egg weight**

Eggs were weighed and recorded each day using a scale.

3.4.7 **HaughUnit**

Haugh unit measured by the following equation (Nesheim *et al.* 1979).

Haugh Unit = 100 Log (H + 7.57–1.7 $^{w0.37}$); H =albumen height (mm) and w = egg weight (g)

3.4.8 **Egg shell weight**

Egg shells of the eggs were separated from yolks and albumen and weighed with a digital scale in all replications of the groups.

3.4.9 **Egg yolk color index**

Nine egg yolks in every treatment bring close to Yolk Color Fan that composed of (1-15) color grading, the Yolk Color Fan put close to the yolk than record the number of colors that's close to the yolk in each treatment.

3.4.10 **Egg Yolk Fatty Acid Analysis**

Three random samples of eggs from each dietary group were obtained for fatty acid analysis at the end of the feeding study and analyzed in TUBITAK.

3.5 **Statistical Analysis**

All data are expressed as means of standard error of the mean (M ±SE) and statistical analysis was carried out using an available software (SPSS Version 21). Data analysis was made using one-way analysis of variance. The comparison between methods and extracts were done using Duncan-test. Differences were considered significant at the level of $P<0.05$.

4. RESULTS and DISCUSSION

4.1 Effect of different levels of *Nigella sativa* oil on feed intake in laying quail

Table 3 shows the effect of *Nigella sativa* oil on feed intake in laying quail. The dietary supplementation in all treatments showed non-significant effect on feed intake (*p>0.05*) when quails fed a diet supplemented with different ratio of *Nigella sativa* oil 0, 1%, 2%, and 3 %.

Table 3. Effect of different levels of *Nigella sativa* oil on laying quails feed intake (g)

Weeks	K	L	M	N	Mean	S.L.
1	32.30 ± 1.94	29.09 ± 1.02	31.24 ± 0.59	29. 5 ± 1.35	30.64 ± 0.67	N.S.
2	31.99 ± 3.93	25.62 ± 2.65	30.38 ± 2.00	26.09 ± 2.72	28.52 ± 1.49	N.S
3	25.97 ± 1,39	24.58 ± 0.37	24.20 ± 0.68	24.99 ± 0.81	24.94 ± 0.43	N.S
4	28.11 ± 0.88	26.05 ± 2.03	31.28 ± 3.21	29.10 ± 0.93	28.63 ± 1.02	N.S
5	31.57 ± 1.01	28.87 ± 3.07	33.97 ± 1.71	31.06 ± 1.54	31.37 ± 1.00	N.S
6	30.28 ± 0.38	26.21 ± 2.60	28.85 ± 1.41	28.84 ± 3.03	28.54 ± 1.00	N.S
7	29.35 ± 0.62	29.85± 0.93	28.52 ± 1.55	28.12 ± 1.14	28.96 ± 0.51	N.S
total	209.58 ± 4.43	190.30 ± 1.51	208.46 ±10.08	198.17 ± 6.02	201.63 ± 3.59	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil

M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

Similarly to the present study, a study was conducted to determine the effects of various levels of dietary *Nigella sativa* oil (0, 1, 2, 3 ml/kg) on performance, egg quality, triglyceride, and cholesterol (Bölükbaşı et al. 2008). Dietary supplementation of *Nigella sativa* oil was reported to have no significant effect on feed intake, feed conversion ratio, egg weight, and egg production, ratio of yolk, albumen and shell. In another study conducted in broilers, it was shown that inclusion of 1% of *Nigella sativa* meal significantly improved feed conversion rate (Khalifah 1995).

It was reported that essential oils have a stimulating effect on animal digestive system (Langhout, 2000; Williams and Losa 2001) and postulated that these effects could be due to

the increased production of digestive enzymes and the improved utilization of digestive products through enhanced liver functions (Langhout 2000; Williams and Losa 2001). However, the results of the present study showed that supplementation of the diet with *Nigella sativa* oil had no effect on feed intake, feed conversion, and egg production compared to the control group.

4.2 The effects *Nigella sativa* oil on egg parameters in Japanese quail

Table 4 shows the effects of various levels of *Nigella sativa* oil on egg parameters. The degree of yolk color increased by adding 2% of *Nigella sativa* oil (M group) ($P<0.05$). At the same time quails fed a diet supplemented with 3% of *Nigella sativa* oil did not have any change in yolk color. Different levels of *Nigella sativa* oil did not have any significant effect on other egg parameters such as shell weight, yolk weight, albumin weight, albumin height and Haugh unit. In the present study, diet supplemented with 2% Nigella sativa oil significantly influenced shell thickness and shell weight ($P<0.05$).

Table 4 .Effect of various levels of *Nigella sativa* oil on egg parameter in Japanese quail

	K	**L**	**M**	**N**	**S.L.**
Egg weight	10.90 ± 0.17	10.82 ± 0.18	10.63 ± 0.39	10.43 ± 0.41	N.S
Shell weight	1.46 ± 0.05b	1.59 ± 0.05ab	1.66 ± 0.04a	1.52 ± 0.07ab	**
Shell Thickness	0.32±0.03b	0.40±0.03ab	0.41±0.03a	0.34±0.03ab	**
Yolk weight	3.75±0.11	3.41±0.10	3.34±0.19	3.45±0.19	N.S
Albumin weight	5.68±0.15	5.80±0.13	5.62±0.23	5.44±0.22	N.S
Albumin height	4.86±0.24	4.64±0.20	4.50±0.19	4.24 ± 0.06	N.S
Yolk color	7.66 ± 0.23^{b}	8.33 ± 0.28^{ab}	8.66 ± 0.33^{a}	7.55±0.24b	**
Haugh unit	57.52±3.96	56.11±4.51	53.58±7.77	55.70±5.73	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil
** = ($p\leq0.05$)

In a study conducted in laying hens, 1-3% of *Nigella sativa* seed supplemented diets were shown to improve physical properties of the eggs, such as shell thickness, shell weight, and Haugh unit (Akhtar et al. 2003). However, Islam et al. (2011) reported that different level of *black cumin* powder (0, 1.5, 3.5 or 4.5%) had no significant effects on egg laying performances, and physical properties of eggs. Similarly to the present study, the addition of *Nigella sativa* oil to the diet was shown not to have any impact on yolk, albumen weights of egg (Bölükbaşi et al. 2009). Haugh unit was significantly influenced by the treatment. The diet with 3 ml/kg black seed oil had induced decreased Haugh unit by 6.5% compared to control group (Bölükbaşi et al. 2009).

Addition of 1 g/kg *Nigella sativa* extracts in diets of laying quails was shown to improve ($P<0.05\%$) egg production and egg weight (Denli et al. 2004). Similarly, EL-Sheikh et al. (1998) recommended using 0.5–1.0% black seeds in layer diets to improve laying performance. It was shown that supplementing diets with *Nigella sativa* seeds (1 and 1.5%) significantly improved egg production and egg weight (Nasir et al. 2005). Akthar et al. (2003) reported that inclusion of black cumin seeds in the diet at a level of 1.5% raised hen-day egg production from 59 to 77%. In contrast, EL Bagir et al. (2006) reported that black cumin (1 and 3%) supplementation in layer diets significantly ($P<0.05$) decreased egg production. Also, Akthar et al. (2003) and Nasir et al. (2005) reported that *Nigella sativa* seeds supplementation in layer diets significantly ($P<0.05$) improved Haugh unit value. In a study conducted in quails, it was shown that addition of 1 g/kg *Nigella sativa* extracts in diets of laying quails increased ($P<0.05$) weight of yolk and shell in quail egg (Denli et al. 2004).

4.3 **Effect of different levels of *Nigella sativa* oil on hen day egg production**

The effect of different levels of *Nigella sativa* oil hen day egg production in Japanese quail was shown in Table 5. No significant effects were found among groups K, L, M, and N on hen day egg production during the study.

Table 5. Effect of different levels of *Nigella sativa* oil on hen day egg production

	K	L	M	N	Mean	S.L.
W1	76.86 ± 10.94	61.90 ± 2.45	61.22 ± 5.13	68.80 ± 3.78	67.17 ± 3.34	N.S
W2	93.87 ± 1.17b	73.46 ± 4.24a	81.62±10.27ab	78.22 ± 2.45ab	81.79 ± 3.33	N.S
W3	84.35 ± 10.56	72.10 ± 3.78	68.02 ± 5.56	70.06 ± 4.76	73.63 ± 3.43	N.S
W4	82.31 ± 15.69	62.58 ± 3.40	55.21 ± 2.15	61.22 ± 8.24	65.33 ± 4.94	N.S
W5	92.51 ± 5.56b	65.64 ± 4.17a	71.88±5.11ab	71.99 ± 8.61ab	75.51 ± 4.01	N.S
W6	88.43 ± 3.59	74.14 ± 7.19	79.81 ± 5.61	81.51 ± 3.08	80.98 ± 2.67	N.S
W7	90.47 ± 7.57	80.67 ± 3.69	89.00 ± 4.65	83.22 ± 3.56	85.48 ± 2.50	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

In contrast to the present study, however, Akthar et al. (2003) reported that inclusion of black cumin seeds in the diet at a level of 1.5% raised hen-day egg production from 59 to 77%. Also, it was shown that *Nigella sativa* seeds supplementation in layer diets improved egg production, egg weight, egg shell thickness and Haugh unit value (Nasir et al. 2005). Denli et al. (2004) reported that addition of 1 g/kg *Nigella sativa* extracts in diets of laying quails improved ($P<0.05$) egg production, feed efficiency and egg weight. It was found that *Nigella sativa* seeds (1 and 1.5%) supplementation in layer diets significantly ($P<0.05$) improved egg production and egg weight (Nasir et al. 2005). Yalçın et al. (2009) used *Nigella sativa* at level 0.5, 1 and 1.5% in laying hens they reported diets containing 1.5% *Nigella sativa* increased egg weight. It was found that the diet of hens with 1, 2 or 3% Nigella sativa seed induced a significant increase in their egg laying performance (Aydin et al. 2008).

In a study conducted in laying hens, it was shown that black cumin oil at the levels of 1, 2 or 3 ml/kg feed did not cause any differences in the egg weight (Bölükbaşi et al. 2009).

4.4 Effect of different levels of *Nigella sativa* oil on egg weight

Table 6 represents the effects of various levels of *Nigella sativa* oil on egg weight. This study showed that *Nigella sativa* oil did not have any significant effect on egg weights

by weekly intervals. When all eggs produced were included in the study it was observed that egg weights from the Nigella sativa oil supplemented groups (groups L, M, and N) were significantly greater than the control (P<0.01).

Table 6. The effect of different levels of *Nigella sativa* oil egg weight

Dietary Groups					
	K	**L**	**M**	**N**	**Effect**
W1	11.25 ± 0.24	11.52 ± 0.35	11.31 ± 0.12	11.48 ± 0.13	N.S
W2	11.52 ± 0.26	11.61 ± 0.18	11.81 ± 0.19	11.46 ± 0.32	N.S
W3	11.12 ± 0.15	11.48 ± 0.40	11.55 ± 0.07	11.29 ± 0.43	N.S
W4	11.10 ± 0.09	11.06 ± 0.31	10.39 ± 0.50	10.79 ± 0.59	N.S
W5	11.28 ± 0.10	11.41 ± 0.26	11.26 ± 0.36	11.25 ± 0.62	N.S
W6	11.71 ± 0.19	12.13 ± 0.37	12.18 ± 0.18	12.07 ± 0.43	N.S
W7	11.92 ± 0.12	12.19 ± 0.41	12.18 ± 0.18	12.13 ± 0.34	N.S
Egg weight in whole study	11.44b	11.70a	11.69a	11.63a	P<0.01

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

Nasir et al. (2005) demonstrated that supplementation *of Nigella sativa* seeds in layer diets improved egg weight. Bölükbasi et al. (2009) that supplementation of the diet with *Nigella sativa* oil had no effect on egg weight compared with controls. In a study conducted in laying quails, Denli et al. (2004) reported that addition of 1 g/kg *Nigella sativa* extracts in the diets improved egg production and egg weight significantly (P<0.05). EL-Sheikh et al. (1998) recommended using 0.5–1.0% *Nigella sativa* seeds in layer diets to improve performance. It was found that *Nigella sativa* seeds (1 and 1.5%) supplementation in layer diets significantly (P<0.05) improved egg production and egg weight (Nasir et al. 2005). *Nigella sativa* at level 0.5, 1 and 1.5 % in laying hen diets and reported that diet containing 1.5% *Nigella sativa* increased egg weight (Yalcın et al. 2009) (P<0.01). Egg weight is among the most important

parameters not only for consumers, but for egg producers as well, due to the economic benefit and market requirement.

4.5 Effect of different levels of *Nigella sativa* oil on laying quails body weight and body weight gain

Table 7 represents the effect of different levels of *Nigella sativa* oil on laying quails body weight. In the present study, final body weights of the birds from the groups were the same.

Table 7 .Effect of different levels of *Nigella sativa* oil on laying quails body weight

Effect of different levels of *Nigella sativa* oil on laying quails body weight.

	K	L	M	N	Average all Mean	S.L.
Initial BW	251.85 ± 5.27	253 ± 4.32	258.57 ± 5.19	245 ± 6.5	252.30 ± 2.68	NS
Final BW	269.76 ± 6.25	261.89 ± 5.88	265.46 ± 7.03	257.55 ± 9.22	263.65 ± 3.61	NS

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

Similarly, in a study conducted by Aydin et al. (2008), it was shown that supplementation of dietary black seed at the levels of 1, 2 or 3% had no effect on body weight in Japanese quails. In another study in laying hens, supplementation of *Nigella sativa* in the diets at level 0.5, 1 or 1.5 % not have any significant effect on body weight (Sakine et al, 2009). However, it was shown that dietary black cumin at the level of 1 or 3% significantly ($P<0.01$) increased final body weight of laying hens (El-Bagir et al. 2006). In contrast to the study by El-Bagir et al. (2006), some researchers reported that addition of black cumin seeds into the diet significantly decreased body weights of the chickens (El-Sheikh et al. 1998; Akhtar et al. 2003). Diets supplemented with 1, 2, or 3% black cumin had no significant effects on body weight (Aydin et al. 2008). The effect of different level of *N. sativa* seed powder (0, 1.5, 3.5 or 4.5%) on diet had no significant effects on body weight (Akhtar et al. 2003). Because increase in body mass of laying hens was negatively correlated with egg production, reduction of body mass in layers fed diets supplemented with black cumin can be considered a favorable factor in increasing egg production.

4.6 **Effect of different levels of *Nigella sativa* oil on laying quails FCR:**

Table 8 shows the effect of different levels of *Nigella sativa* oil on feed conversion ratio. The results showed that adding *Nigella sativa* oil to diet as dietary supplementation did not affect the feed conversion for layer quails. And no significant differences (*p>0.05*) were found between groups and control.

Table 8. Effect of different levels of *Nigella sativa* oil on laying quails feed conversion ratio.

	K	**L**	**M**	**N**	**Mean**	**S.L.**
W1	3.90 ± 0.64	4.19 ± 0.57	4.59 ± 0.51	3.81 ± 0.21	4.12 ± 0.20	N.S
W2	2.99 ± 0,31	3.01 ± 0.30	3.27 ± 0.51	2.94 ± 0.42	3.05 ± 0.17	N.S
W3	2.89 ± 0.36	3.06 ± 0.25	3.22 ± 0.33	3.25±0.30a	3.10 ± 0.14	N.S
W4	3.33 ± 0.67	3.77 ± 0.28	5.85 ± 0.97	4.45 ± 0.93	4.35 ± 0.43	N.S
W5	3.06 ± 0.18	3.89 ± 0.64	4.17 ± 0.35	3.70 ± 0.41	3.70 ± 0.22	N.S
W6	2.92 ± 0.17	2.93 ± 0.32	2.91 ± 0.24	2.96 ± 0.12	2.93 ± 0.09	N.S
W7	2.73 ± 0.21	2.98 ± 0.17	2.61 ± 0.03	2.74 ± 0.10	2.76 ± 0.07	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

Akhtar et al. (2003) demonstrated that different levels of *Nigella* seed supplementation to the diets of laying hens have improved FCR\eggs from 1.97 to 1.5 and FCR\kg egg mass from 2.90 to 2.22. Inclusion of 1.5% crushed *Nigella sativa* seeds in broilers ration improved growth and feed conversion rate (Al-Beitawi and El-Ghousin 2008). In a study carried out in chickens, it was shown that 3 different levels (%1, %2, % 3) of *black cumin* added in the diets (Aydin et al. 2008) had no significant effects on feed intake, and feed conversion rate.

4.7 **Effect of different levels of *Nigella sativa* on quail's egg mass:**

Table 9 refers to the effect of different levels of *Nigella sativa* oil on weekly and final egg mass. There was no significant effect of *Nigella sativa* oil on egg mass from 48 days of age to 97 days of age in the treated groups compared to the control group.

Akhtar et al. (2003) demonstrated that different levels of *Nigella* seed supplementation to the diets of laying hens have increased egg mass from 229.9 to 303.6 g/bird/ week and similar result obtained by (El-Shaikh et al. 1998).

Table 9. Effect of different levels of *Nigella sativa* oil on laying quails egg mass

	K	**L**	**M**	**N**	**Mean**	**S.L.**
W1	8.62 ± 1.18	6.94 ± 0.33	6.92 ± .62	7.90 ± 0.65	7.60 ± 0.38	N.S
W2	10.66 ± 0.18	8.52 ± 0.43	9.62 ± 1.15	8.97 ± 0.43	9.44 ± 0.37	N.S
W3	9.34 ± 1.40	8.14 ± 0.63	7.68 ± 0.82	7,82 ± 0.85	8.25± 0.45	N.S
W4	9.11 ±1.67	6.90 ± 0.18	5.44 ± 0.32	7.14 ± 1.45	7.15 ± 0.62	N.S
W5	10.36 ± 0.45	7.63 ± 0.85	8.29 ± 0.92	8.62 ± 1.06	8.72 ± 0.47	N.S
W6	10.44 ± 0.66	9.10 ± 1.22	9.98 ± 0.74	9.69 ± 0.69	9.80 ± 0.39	N.S
W7	10.85 ± 0.72	10.04 ± 0.53	10.94 ± 0.73	10.29 ± 0.64	10.53 ± 0.30	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil) L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil

4.8 Effect of different levels of *Nigella sativa* oil on cholesterol content and fatty acid composition in quail's egg:

Table10 refers to the effect of different levels of *Nigella sativa* oil on fatty acid and cholesterol contain in Japanese quail egg from 49 days of age to 97 days of age. *Nigella sativa* oil had a significant effect ($P<0.05$) on the ratio of total saturated fatty acid (SFA). Some types of SFA such as C15:0 and C17:0 did not show significant effect by adding *Nigella sativa* to the diet. Results in the table18.showed *Nigella sativa* oil had significant effect on total MUFA. Some types of MUFA such as C24:1 did not show significant effect by adding *Nigella sativa* to the diet. Also adding *Nigella sativa* oil to the diet had a significant effect on the ratio of PUFA in the egg. Finally adding *Nigella sativa* oil to the diet did not record significant effect on the level of cholesterol in the quail's egg. Triglyceride and cholesterol of egg yolk of laying hens were shown to be significantly reduced by diet including 1 and 2 ml/kg *Nigella sativa* oil (Bölükbaşi *et al*. 2009). However, the feeding of

powdered black cumin seeds to laying hens was shown to lower serum cholesterol and triacylglycerol concentrations, which indeed was associated with a decrease in egg yolk cholesterol contents (Akhtar *et al*. 2003). Also, El-Bagir et al. (2006) reported that feeding diets supplemented with 1 and 3% black cumin seeds for a period of three months reduced egg yolk total cholesterol by 34 and 42%. Aydin et al. (2008) showed that diets supplemented with 2 or 3% black cumin significantly ($P < 0.05$) decreased the concentration of egg yolk cholesterol. In a study conducted in laying hens, diets supplemented with different level of *N. sativa* seed powder (0, 1.5, 3.5 or 4.5%) significantly decreased the levels of serum triglycerides and egg yolk cholesterol of laying hens. *Nigella sativa* seeds (1 and 1.5%) supplementation in layer diets significantly ($P < 0.05\%$) reduced serum and yolk total cholesterol, LDL-cholesterol, triglycerides content and increased HDL-cholesterol (Nasir et al. 2005). Diets containing 10 and 15gr/kg *Nigella sativa* was shown to decrease egg yolk cholesterol, saturated fatty acids and the ratio of saturated to unsaturated fatty acids ($P<0.05$) compared to the control group (Yalçın et al. 2009).

Table 10 . Effect of different levels of *Nigella sativa* oil on fatty acid composition and cholesterol content in quail's egg

Fatty Acids	K	L	M	N	S.L.
C14:0	0.60 ± 0.01a	0.41 ± 0.01ab	0.40 ± 0.01c	0.47 ± 0.02b	**
C15:0	0 .02 ± 0.0	0.01 ± 0.0	0.02 ± 0.0	0.02 ± 0.0	N.S
C16:0	26.68 ± 0.29a	25.11 ± 0.17b	25.84 ±0.14ab	26.11 ± 0.60ab	**
C17:0	0.06 ± 0.0	0.05 ± 0.0	0.08 ± 0.	0.06 ± 0.0	N.S
C18:0	5.50 ± 0.04a	5.87 ± 0.43b	8.37 ± 0.82a	5.33 ± 0.34b	**
C14:1	0.09 ± 0.0ab	0.08 ± 0.0ab	0.05 ± 0.0b	0.11 ± 0 .02a	**
C16:1	5.05 ± 0.07ab	5.15 ± 0.06ab	3.92 ± 0.53b	6.03 ± 0.62a	**
C18:1(n-9c)	54.47 ± 0.50b	57.37 ± 0.18a	54.11 ± 0.32b	54.66 ± 1.16b	**
C20:1(n-9)	0.12 ± 0.0ab	0.13 ± 0.0a	0.09 ± 0.01c	0.10 ± 0.0bc	**
C24:1	0.05 ± 0.0	0.04 ± 0.0	0.03 ± 0.0	0.04± 0.0	N.S
C18:2(n-6c)	6.01 ± 0.05a	4.40 ± 0.46c	5.73 ± 0.12ab	5.07 ± 0.10bc	**
C18:3(n-3)	0.10 ± 0.0	0.08 ± 0.0	0.10 ± 0.0	0.09 ± 0.01	N.S
gC18:3(n-6)	0.09 ±0.0a	0.07 ± 0.0a	0.08 ± 0.0ab	0.08 ± 0.0b	**
C20:3 (n-6)	0.06 ± 0.0a	0.03 ± 0.0b	0.03 ± 0.0 b	0.02 ± 0.0b	**
C20:4 (n-6)	0.34 ± 0.0	0.41 ± 0.04	0.37 ± 0.04	0.48 ± 0.03	N.S
C22:6 (n-3)	0.02 ± 0.0	0.03 ± 0.0	0.03 ± 0.0	0.03 ± 0.0	N.S
% SFA	32.87 ± 0.31b	31.46 ± 0.60b	34.72 ± 0.73a	31.99 ± 0.46b	**
% MUFA	59.80 ±0.42bc	62.78±0.18a	58.22± 0.87c	60.95 ± 0.52b	**
% PUFA	6.64 ± 0.04a	5.03 ± 0.50b	6.36 ± 0.08a	5.79 ± 0.10ab	**
Total FA	99.31 ± 0.12	99.27 ± 0.80	99.31 ± 0.05	98.75 ± 0.62	N.S
Cholesterol	588.78 ± 5.41	592.02 ±6.05	585.56 ± 11.43	595.75 ± 9.04	N.S

K= Control (3% hazelnut oil + 0% *Nigella sativa* oil)L= (2%hazelnut oil + 1% *Nigella sativa* oil
M=1% hazelnut oil + 2% *Nigella sativa* oil N= 0% hazelnut oil + 3% *Nigella sativa* oil ** = ($p \leq 0.05$)

5. **CONCLUSIONS**

In conclusion, *Nigella sativa* oil supplemented diet significantly changed egg fatty acid composition without affecting feed intake, body weight and physical parameters of the eggs compared to the control diet (group K) supplementation of *Nigella sativa* oil. Egg weight significantly increased in the groups L, M, and N compared to the control group. Also, in the present study shell thickness and shell weight in the eggs from the group M were found to be greater than the control. Taken together, our results suggest that supplementation of *Nigella sativa* seed oil in diets may have a potential as commercial applications.

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