Black Cumin (*Nigella sativa* L.) Supplementation into the Diet of the Laying Hen Positively Influences Egg Yield Parameters, Shell Quality, and Decreases Egg Cholesterol[1]

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ABSTRACT The objective of this study was to determine the effects of various levels of dietary black cumin seed on egg production, egg weight, feed conversion ratio, egg shell quality, and egg yolk cholesterol. In this study, eighty 27-wk-old laying hens (Hyline-5 White) were randomly assigned into 4 groups with 4 replicates of 5 birds each (20 laying hens per group) and fed diets supplemented with 1, 2, or 3% black cumin. Eggs were collected and weighed daily. Laying performance, egg quality, and feed conversion ratio were evaluated. Laying hens fed the diet supplemented with 3% black cumin had greater egg production than the control. Diets supplemented with 2 or 3% black cumin increased egg weight compared with other groups. Yolk weights of the eggs from hens fed diets containing 1, 2, and 3% black cumin were significantly greater than those from the control group. Shell thickness of the eggs from chickens fed 2 or 3% black cumin seed was significantly greater than those from chickens fed diets supplemented with 0 or 1% black cumin seed. Also, shell strength of the eggs from hens fed diets supplemented with 3% black cumin seed was significantly greater than the control. In addition, diets supplemented with 2 or 3% black cumin significantly decreased egg cholesterol per gram of yolk compared. No level of black cumin seed supplementation had any effect on live weight, feed consumption, feed conversion ratio, organ weights, and abdominal adipose tissue. This study 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.

Key words: black cumin, egg parameter, feed conversion ratio, egg cholesterol, chicken

2008 Poultry Science 87:2590–2595
doi:10.3382/ps.2008-00097

INTRODUCTION

Recently, feed additives of plant origin such as essential oils or extracts of aromatic plants have received considerable attention as alternatives to the traditional antibacterial feed additives. Antibacterial feed additives such as antibiotics have been used for years to improve the profitability of poultry production by helping to control pathogen bacteria in the gut mucosa, thereby improving weight gain, feed conversion ratio (**FCR**), and uniformity. However, there is a potential development of resistance by several pathogenic bacteria when antibiotics are used in the animal diets (Wegener et al., 1998). It was also reported that the widespread use of antimicrobial agents has led to the emergence of antimicrobial drug resistance organisms (Shea, 2003). Therefore, feed antibiotics, which have been used for promoting growth in the farm animals, were banned in the European Union. Removal of antibiotics from the diet may negatively affect profitability of the animals. Therefore, the feed industry will have to research alternatives for the antibiotics (Hertrampf, 2001; Humphrey et al., 2002). One of the alternatives used as feed additives is black cumin. Black cumin (*Nigella sativa* L.) is also known as black seed and 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 (El-Tahir et al., 1993) and as an antitumor agent (El-Daly, 1998). The seed has been reported to have many biological properties including antiparasitic (Mahmoud et al., 2002), antidiabetic (Al-Hader et al., 1993), and diuretic effects (Zaoui et al., 2000). A few studies showed that black cumin also has antibacterial activity (El-Kamali et al., 1998; Mouhajir et al., 1999; Nair et al., 2005).

Received March 1, 2008.
Accepted July 14, 2008.
[1]This study was supported by the scientific research project committee of Kahramanmaras Sutcu Imam University, Turkey, grant no. 2006/2-13.
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Table 1. Composition of the diets[1,2]

Feed ingredient	%
Corn	56.94
Corn gluten feed	5.8
Wheat middlings	6.0
Soybean meal	17.64
Limestone	7.00
Dicalcium phosphate	4.19
DL-Methionine	0.08
Vegetable oil	2.0
NaCl	0.35
Calculated analysis (%)	
Calcium	3.5
Available phosphorus	1.0
Methionine	0.33
Lysine	0.7
Cysteine	0.31

[1]Diets contained 2,700 kcal/kg of ME and 16% CP. Also contained per kilogram of diet: vitamin A, 8,000 IU/kg; vitamin D, 1,500 IU/kg; riboflavin, 4 mg/kg; cobalamin, 10 μg/kg; vitamin E, 15 mg/kg; vitamin K, 2 mg/kg; choline, 500 mg/kg; niacin, 25 mg/kg; manganese, 60 mg/kg; zinc, 50 mg/kg.

[2]Black cumin seeds were crushed and added into the basal diet at the level of 0, 1, 2, or 3%. Proximate analysis of black cumin (Turkish) source (g/kg DM basis): moisture, 42; ash, 44; CP, 207; ether extract, 406; crude fiber, 58; nitrogen-free extract, 285; ME, 5,622 kcal (Takruri and Dameh, 1998).

There are some studies conducted on the effects of dietary black cumin or oils on the performance of poultry. 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 BW positively in the broilers (Halle et al., 1999). However, in the second experiment of the same study, no positive results related to those parameters were found (Halle et al., 1999). In another study conducted with the Hibro broiler chicks, it was reported that diet supplemented with 10% black cumin seed had no adverse effects on performance (Al-Homidan et al., 2002). However, there have been a limited number of studies associated with the effect of diets supplemented with black cumin or oil on laying hen performance, feed conversion ratio, egg parameters, and egg cholesterol in poultry. Therefore, the objective of this study was to study the effects of black cumin seeds on egg production, egg weights, egg quality characteristics, shell quality, and egg cholesterol.

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 27-wk-old laying chickens (Hyline-5 White) were randomly assigned into 4 groups with 4 replicates of 5 birds each (20 laying hens per group) and fed diets supplemented with 0 (control), 1, 2, or 3% black cumin seeds for 5 wk. Table 1 presents the composition of the experimental diets.

Black cumin seeds were obtained from a local store in Kahramanmaras and used in the diets after grinding. Water and feed were provided ad libitum during the study. The photoperiod was set at 16L:8D throughout the study. Body weights of laying hens were determined at the beginning and end of the study. At the end of the study, 4 chickens per group (1 hen per replicate) were killed with carbon dioxide exposure, and organ weights were measured.

Feed consumption was recorded on a replicate basis at weekly intervals. Feed conversion ratio was calculated on a weekly basis for every group in the study. 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 (3 eggs/each replicate) were collected at the end of the study for measuring egg components and parameters. Egg weights, albumen weights, yolk weights, and shell weights were measured. Shell thickness (with shell membrane) of the eggs was measured by micrometer (0.01 mm, Mitutoyo, Kawasaki, Japan). Shell thickness was a mean value of measurements at 3 locations on the eggs (air cell, equator, and sharp end) by using a dial pipe gauge. Breaking strength of uncracked eggs was measured with an Instron testing machine (model 1140, Instron Ltd., Bucks, UK). A constantly increasing load was applied to an egg lying lengthways until it broke. The applied load at the time of breakage is the measured strength.

At the end of study, 4 eggs from replicates of all groups (16 eggs per group) were analyzed for egg cholesterol. The cholesterol contents of the egg yolks were determined according to the methods (Hammad et al., 1996; Kaya et al., 2001). Yolks were separated from albumen, and 0.1-g samples of yolks were weighed in a tube. Yolk lipids were extracted with isopropanol (4 mL), vortexed for 2 to 3 min, and then centrifuged at $907 \times g$ for 10 min. The yolk cholesterol concentration (mg of cholesterol/g of egg yolk) was determined in the filtered samples by ultraviolet spectrophotometer using commercial kits and calculated by the method of Boehringer Mannheim GmbH Biochemica (1989).

Data were analyzed by SPSS version 10.0 for Windows (SPSS Inc., Chicago, IL). The differences between means were determined by ANOVA. When the differences were significant ($P < 0.05$), Tukey multiple range test was performed.

RESULTS

Table 2 represents the effect of different levels of black cumin on the BW, daily feed intake (g/d per hen), FCR, egg production, and egg weights in chickens. Diets supplemented with 1, 2, or 3% black cumin had no significant effects on BW, feed intake, and FCR. Inclusion of crushed black cumin seeds at the level of 3% in the diet significantly ($P < 0.05$) improved egg production compared with the control. Egg production

Table 2. The effects of crushed black cumin supplementation[1] on BW, feed conversion ratio, egg production, and egg weight[2]

	Black cumin supplementation (%)			
Item	0	1	2	3
Initial BW (g)	1,336 ± 33.1	1,377 ± 25.0	1,407 ± 25.4	1,340 ± 53.2
Final BW (g)	1,386 ± 21.6	1,464 ± 18.5	1,432 ± 42	1,436 ± 14.5
Daily feed intake (g/hen)	101.20 ± 2.51	105.26 ± 4.4	103.75 ± 2.3	103.53 ± 1.4
Feed conversion ratio	2.57 ± 0.1	2.62 ± 0.1	2.65 ± 0.2	2.42 ± 0.1
Egg production (%)	76.57[b] ± 1.8	80.57[ab] ± 1.8	78.15[ab] ± 2.0	83.71[a] ± 1.9
Egg weight (g)	51.11[b] ± 0.2	51.70[b] ± 0.2	54.15[a] ± 0.2	54.16[a] ± 0.2

[a,b]Values without a common superscript are significantly different within a row ($P < 0.05$).

[1]Values are expressed as means.

[2]Basal diets contained 0, 1, 2, or 3% crushed black cumin and were fed for 5 wk.

(%) in the chickens fed a diet supplemented with 0, 1, 2, or 3% black cumin was approximately 77, 81, 78, or 84%, respectively. The weights of eggs from chickens fed a diet supplemented with 2 and 3% black cumin were found to be significantly ($P < 0.05$) greater than in the chickens fed control or a diet supplemented with 1% black cumin (Table 2). There were approximately 3 g of increase in the egg weights from laying hens fed 2 and 3% black cumin-supplemented diets compared with the control group.

Table 3 shows the effects of diets supplemented with black cumin seeds on egg weight, yolk weight, albumen weight, shell weight, shell thickness, and shell strength. Eggs from laying hens fed a diet supplemented with 1, 2, or 3% black cumin seed had significantly ($P < 0.05$) greater yolk weights compared with those from the control group. In this study, there were no adverse effects of feeding any levels of black cumin seeds used on the quality of the eggs. Feeding diets supplemented with black cumin seeds did not influence albumen index, yolk index, or shape index (not shown). Although shell weights of the eggs in the dietary groups were not influenced, supplementing diets with 2 or 3% crushed black cumin significantly ($P < 0.05$) increased shell thickness. Also, a diet supplemented with 3% black cumin significantly ($P < 0.05$) increased shell strength (kg/cm^2) of the eggs. There were no negative effects observed from feeding black cumin-supplemented diets in the organ weights of laying hens compared with the control group.

Figure 1 shows the effect of black cumin supplementation on the egg yolk cholesterol. Egg yolk cholesterol was decreased significantly ($P < 0.05$) by supplementation of black cumin in the diet of the layer. The concentration (mg/g) of cholesterol of the eggs from the laying hens fed a diet supplemented with 1% black cumin did not differ compared with the control group. The concentration (mg/g) of cholesterol in the eggs from hens fed diets containing 0, 1, 2, or 3% black cumin was 14.65 ± 0.26, 13.86 ± 0.65, 11.40 ± 0.82, and 10.69 ± 0.45 mg/g, respectively. Inclusion of 2 or 3% black cumin in the rations significantly ($P < 0.05$) decreased the concentration of cholesterol in the egg yolk.

DISCUSSION

Data regarding the effects of dietary black cumin on BW of chickens and FCR are controversial. In a study conducted in chickens, El-Bagir et al. (2006) showed that dietary black cumin at the level of 1 or 3% signifi-

Table 3. The effects of diets[1] supplemented with different levels of crushed black cumin seeds on the egg parameters[2]

	Black cumin supplementation (%)			
Item	0	1	2	3
Egg weight (g)	52.93[b] ± 0.41	55.07[ab] ± 0.98	53.91[ab] ± 0.87	56.10[a] ± 0.74
Yolk weight (g/egg)	12.49[b] ± 0.33	13.76[a] ± 0.31	13.59[a] ± 0.23	13.39[a] ± 0.24
Albumen weight (g/egg)	33.32 ± 0.33	34.21 ± 0.78	33.16 ± 0.68	35.39 ± 0.53
Shell weight (g/egg)	7.12 ± 0.15	7.10 ± 0.11	7.16 ± 0.19	7.32 ± 0.22
Eggs (%)				
Yolk	23.60[b] ± 0.56	24.99[ab] ± 0.37	25.21[a] ± 0.45	23.87[ab] ± 0.40
Albumen	62.95 ± 0.59	62.12 ± 0.40	61.51 ± 0.40	63.08 ± 0.38
Shell	13.45 ± 0.24	12.89 ± 0.30	13.28 ± 0.27	13.05 ± 0.33
Shell thickness (mm·10^{-2})	0.34[b] ± 0.01	0.34[b] ± 0.01	0.36[a] ± 0.01	0.38[a] ± 0.01
Shell strength (kg/cm^2)	1.51[b] ± 0.19	1.86[ab] ± 0.23	1.68[ab] ± 0.16	1.95[a] ± 0.15

[a,b]Values without a common superscript are significantly different within a row ($P < 0.05$).

[1]Basal diets were supplemented with 0, 1, 2, or 3% crushed black cumin and were fed for 5 wk.

[2]Values are expressed as means of 12 eggs per group.

cantly ($P < 0.01$) increased final BW of laying hens. However, other studies showed that addition of black cumin seeds into the diet significantly decreased BW of the chickens (El-Sheikh et al., 1998; 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 (Akhtar et al., 2003). Conversely, the results of the present study showed that supplementation of the diet with black cumin did not negatively influence final BW of the laying chickens. Akhtar et al. (2003) also showed that inclusion of black cumin in the diets of the laying hens improved FCR per dozen eggs from 1.97 to 1.50 and FCR per kilogram of egg mass from 2.90 to 2.22 (Akhtar et al., 2003). However, in the present study, inclusion of black cumin in the layer diet did not improve FCR.

Inclusion of black cumin seeds in the diet to a level of 1.5% was shown to raise hen-day egg production from 59 to 77% (Akhtar et al., 2003). The findings in the present study related to the percentage of egg production are in agreement with those reported by Akhtar et al. (2003). In the present study, dietary black cumin at the level of 3% was effective to increase egg production significantly ($P < 0.05$) compared with the control. In contrast, El-Bagir et al. (2006) reported that supplementation of 1 or 3% black cumin to diet decreased egg production by approximately 9 or 16%, respectively. Inclusion of black cumin into the diet of laying hens also was shown to increase egg weights (Akhtar et al., 2003). In the study conducted in laying chickens, it was shown that supplementation of diet with black cumin at the level of 0.5, 1, or 1.5% significantly increased egg weight (Akhtar et al., 2003). In this study, inclusion of 2 or 3% black cumin in the diets also significantly increased egg size compared with the control group. These results are in agreement with those reported by Akhtar et al. (2003), who showed that supplementation of black cumin in the diet of laying chickens increased egg weights. In the present study, yolk weights (g) of the eggs also increased significantly ($P < 0.05$) in the groups fed diets supplemented with 1, 2, or 3% black cumin.

Black cumin supplementation into the diets was also shown to influence egg shell thickness (Akhtar et al., 2003). Inclusion of black cumin at the level of 0.5, 1.0, or 1.5% significantly ($P < 0.05$) increased shell thickness of the eggs (Akhtar et al., 2003). In the present study, a diet supplemented with 2 or 3% black cumin significantly increased shell thickness of the eggs. In the present study, black cumin supplementation also increased shell strength (kg/cm^2) of the eggs.

Eggs are an excellent source of amino acids, fatty acids, vitamins, and minerals and also contain approximately 213 mg of cholesterol (USDA, 1991). Since 1972, poultry scientists have been seeking ways to decrease egg cholesterol concentrations, because of recommendations to limit egg consumption by the public to no more than 3 eggs per week, not to exceed cholesterol intake of 300 mg/d (McNamara, 2000). Although there is no clear evidence relating egg consumption and cardiovascular diseases, recommendations on dietary cholesterol and egg intake led to the cholesterol phobia all over the world. As a result, egg consumption has declined in most developed countries (Zeidler, 2000). In the United States, increasing public concern over dietary cholesterol is reflected in annual per capita egg consumption, which has declined from 303 to 256 during the past 35 yr (USDA, 2002). During the past 4 decades, research

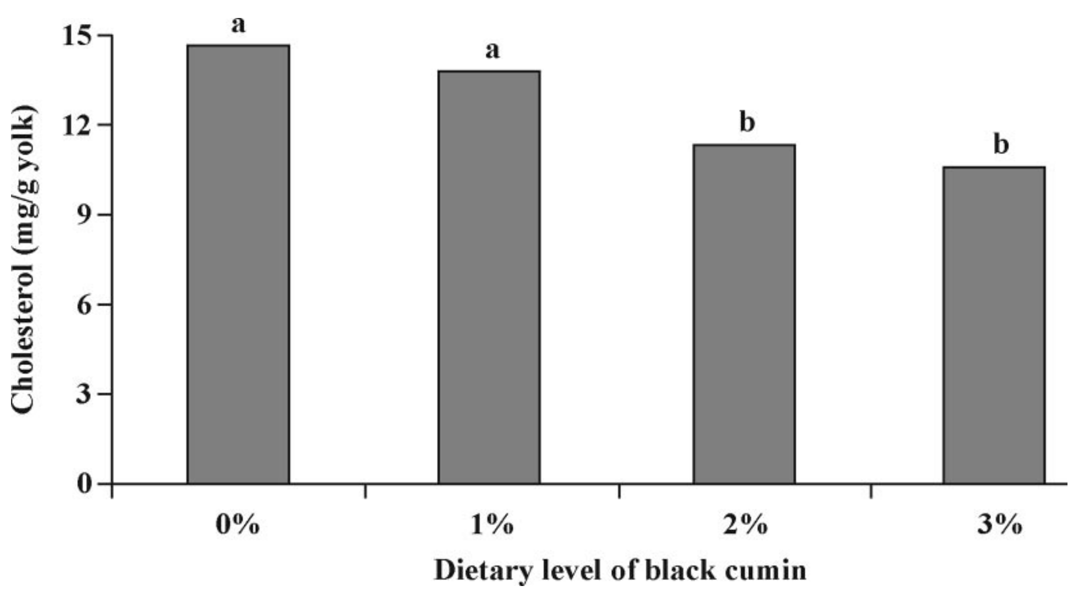

Figure 1. The effects of diets supplemented with different levels of black cumin seeds on the egg cholesterol. Basal diets were supplemented with 0, 1, 2, or 3% crushed black cumin and were fed for 5 wk. Eggs were obtained at the end of the study. Values are expressed as means of 4 eggs from replicates of all groups (16 eggs per group). Values without a common letter are significantly different ($P < 0.05$).

efforts directed toward decreasing shell egg cholesterol content have centered on genetic selection or alteration of the diet of laying hens with various nutrients, natural products, nonnutritive factors, or pharmacological agents (Elkin, 2007). However, efforts to modify egg cholesterol contents have demonstrated that it is extremely difficult to decrease egg cholesterol by ordinary means. It is known that dietary manipulations decreasing yolk cholesterol also decrease egg size and egg production. In a study in which egg production was relatively unaffected, oral administration of pravastatin significantly lowered egg and yolk weight while decreasing egg cholesterol in laying hens (Kim et al., 2004). Kim et al. (2004) also reported that dietary pravastatin did not significantly influence the level of plasma cholesterol in chickens. Black cumin supplementation was shown to decrease serum triacylglycerol, serum total cholesterol, and increased serum high-density lipoprotein cholesterol in laying hens (Akhtar et al., 2003). Inclusion of black cumin also was shown to decrease egg cholesterol in chickens (Akhtar et al., 2003). Similarly, another study showed that dietary black cumin significantly decreased total egg lipid and yolk cholesterol (El Bagir et al., 2006). In the present study, we showed that a diet supplemented with 2 or 3% black cumin significantly ($P < 0.05$) decreased the concentration of egg yolk cholesterol. The mechanism by which black cumin decreases yolk cholesterol is not known yet. Further research is needed to determine the actual mode of action in decreasing the egg yolk cholesterol. Cholesterol is primarily biosynthesized in the liver of laying hens and incorporated into vitellogenin and very low density lipoprotein particles, which are secreted into the bloodstream and subsequently taken up by growing oocytes via receptor-mediated endocytosis (Elkin, 2006). Therefore, it was suggested that the decrease in the egg yolk cholesterol is dependent on the decrease in cholesterol synthesized in the liver.

In conclusion, this study showed that black cumin at the level of 2 or 3% would positively influence egg production, egg weight, shell quality, and decrease the concentration of cholesterol in the egg yolk. In the present study, inclusion of black cumin into the diet of the laying hen significantly ($P < 0.05$) decreased the concentration of egg yolk cholesterol while not influencing egg parameters, such as egg production and egg weights. The supplementation of black cumin has potential commercial applications for production of low-cholesterol eggs with positive effect on egg production, egg weight, or shell strength.

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