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The Effects of Dietary Poppy Seed Oil and Sunflower Oil on Performance, Reproduction and Egg Quality Parameters and Fatty Acid Profile of Egg Yolk in the Japanese Quail

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Abstract: The present experiment, was carried out to evaluate the effects of dietary Popy Seed Oil (PSO) and Sunflower Oil (SFO) alone or in combination in quail diets on the performance, reproduction and egg quality parameters and fatty acid composition of egg yolk. Totally 196 female and 56 male Japanese quails of 7 weeks of age were individually weighed. The initial body weight was comparable. The birds were randomly assigned to 1 of 7 dietary treatments, with each treatment replicated 4 times randomly among the batteries with 7 female and 2 male quails for replicate. Control group was fed a diet unsupplemented PSO and/or SFO. The diets of treatment groups were supplemented PSO and SFO as follows: Group I; 15 g kg^{-1} PSO, Group II; 15 g kg^{-1} SFO, Group III; 7.5 g kg^{-1} PSO + 7.5 g kg^{-1} SFO, Group IV; 30 g kg^{-1} PSO, Group V; 30 g kg^{-1} SFO and Group VI; 15 g kg^{-1} PSO + 15 g kg^{-1} SFO, respectively. The birds received water and feed *ad libutum* during the study. The addition of PSO and SFO alone or in combination did not significantly affect performance, hatchability and fertility, egg quality traits (egg shell thickness, egg albumen index, egg yolk index and egg haugh unit). However, dietary PSO, SFO and PSO + SFO supplementation significantly ($p<0.05$) caused to decrease on saturated fatty acid levels in egg yolk. On the other hand PSO, SFO and PSO + SFO supplementation to the experimental diets resulted in increase ($p<0.001$) on unsaturated fatty acid in egg yolk. The results of this study, demonstrated that PSO, SFO and PSO + SFO supplementations into quail diets caused significant positive effects due to decreasing of saturated fatty acids and increasing of unsaturated fatty acids in egg yolk without adverse effects on laying performance, hatchability, fertility and egg quality traits of laying quails.

Key words: Poppy seed oil, sunflower oil, quail, performance, fatty acid

INTRODUCTION

Fats and oils are commonly added to poultry diets to increase the energy density as an economic means of producing energy-rich formulations. They show different constitution in terms of fatty acids structure fatty acids contain carbon, oxygen and hydrogen and are classified as Saturated Fatty Acids (SFA), Monounsaturated Fatty Acids (MUFA), or Polyunsaturated Fatty Acids (PUFA). Animal fats contain especially palmitic acid as a long-chain saturated fatty acids except for fish oil. Whereas vegetable oils contain a great many quantities of long-chain unsaturated fatty acids. The fat content and the composition of fatty acids in egg lipids have been implicated in human health (Chow, 1992). Norum (1992) based on epidemiological studies, observed a direct relationship between intake of SFA and incidence of cardiovascular diseases. Brisson (1986) indicated that increasing the ratio of PUFA to SFA of the diet reduced the plasma concentration of cholesterol, whereas Grundy (1986) reported positive effects from the intake of MUFA, such as oleic acid (OLE; C18:1 n-9) and of n-3 fatty acids on health, with reduced triglyceride concentration in blood. Although, the relationship between fatty acids content of the food and health is not fully clarified, there is an opportunity to develop new foods based on eggs with dietetic properties closer to what consumers demand (Hargis and Van Elswyk, 1993). Initially, most efforts were

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centered on reducing the cholesterol content of final products and were met with limited success (Naber, 1976; Griffin, 1992), but recently, research has focused on dietary changes to modify the fatty acids composition of foods. This strategy has proved to be viable and is currently, applied to market eggs in several countries. Modifications of the fatty acids composition of the egg yolks may improve the health image of eggs and could enhance their added value. Studies have shown that type of dietary lipids of the laying hen, can drastically alter the lipid profile of the egg-yolk (Yang *et al*., 2000; Grobas *et al*., 2001). *Papaver somniferum* (poppy) is cultivated as an annual crop in countries such as China, India, Czechoslovakia or Turkey. This crop is placed among the important industrial oil plants in Turkey (Koc, 2002). Poppy seed oil appears to be of good quality for human consumption since it is generally rich in PUFA (Luthra and Singh, 1989; Bozan and Temelli, 2003). A little information of poultry performance, egg quality traits and fatty acids of egg yolk of poppy seed oil has been carried out so far.

Several experiments have been carried out using sunflower oil in laying quail diet. However our best knowledge no work has been published evaluating the influence of poppy seed oil supplementation to diet. This prompted us to perform the present study on the effect of feeding diets with poppy seed oil, sunflower oil and combination of their several levels on laying performance, reproduction, egg quality traits and fatty acid levels of egg yolk in the Japanese quail.

MATERIALS AND METHODS

Birds, housing and diets: A total of 196 female and 56 male Japanese breeder hens of 7 weeks of age were individually weighed. The initial body weight was comparable. The birds were randomly assigned to 1 of 7 treatments, with each treatment replicated 4 times randomly among the batteries with 7 female and 2 male quails for replicate in the cage equipped with nipple drinkers and trough feeders.

All the birds were fed corn and soybean meal-based diets formulated to meet or exceed the nutrient requirements of laying quail hens (NRC, 1994). Diets were formulated to be isocaloric and isonitrogenous. The following 7 dietary treatments were used: Group not supplemented with additives served as control; 15 g kg^{-1} PSO, 15 g kg^{-1} SFO, 7.5 g kg^{-1} PSO + 7.5 g kg^{-1} SFO, 30 g kg^{-1} PSO, 30 g kg^{-1} SFO and 15 g kg^{-1} PSO + 15 g kg^{-1} SFO. Feed and water were provided *ad libitum*.

A regime of 16 h constant lighting and continuous ventilation were provided and all layers were kept under uniform management conditions throughout the experimental period. The experiment was terminated when the hens were 19 weeks of age. The ingredients and chemical composition of the diets are presented in Table 1.

Performance measurements: Body weight gain was determined by comparing individual measurements taken

Table 1: Ingredients and chemical composition of the diets fed to quail hens (dry matter basis)

	Dietary treatments						
Item (kg/1000 kg)	Control	1.5% PSO	1.5% SFO	0.75% PSO + 0.75% S FO	3% PSO	3% SFO	1.5% PSO + 1.5% SFO
Corn	477.00	470.0	470.00	470.00	429.0	429.0	429.00
Wheat	124.00	150.0	150.00	150.00	150.0	150.0	150.00
Soybean meal (44% CP)	200.00	224.0	224.00	224.00	180.0	180.0	180.00
Fish meal (64% CP)	53.00	50.0	50.00	50.00	40.0	40.0	40.00
Sunflower Oil (SFO)	-	-	15.00	7.50	-	30.0	17.50
Poppyseed Oil (PSO)	-	15.0	-	7.50	30.0	-	17.50
Sunflower meal	-	20.0	20.00	20.00	100.0	100.0	100.00
Fullfat soybean	75.00	-	-	-	-	-	-
Dicalcium phosphate	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Limestone	53.00	53.00	53.00	53.00	53.00	53.00	53.00
Sodium chloride	2.50	2.50	2.50	2.50	2.50	2.50	2.50
DL-Methionine	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Vitamin-mineral premix[1]	3.50	3.50	3.50	3.50	3.50	3.50	3.50
Chemical composition (g kg^{-1}, calculated)							
Crude Protein (CP)	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Ether axtract	41.80	43.60	43.60	43.60	56.30	56.30	56.30
Metabolizable energy, (MJ kg^{-1})	11.90	11.90	11.90	11.90	11.90	11.90	11.90
Calcium	25.00	25.00	25.00	25.00	25.00	25.00	25.00
Available phosphorus	3.60	3.60	3.60	3.60	3.60	3.60	3.60

[1]Supplied kg^{-1} of diet: 10,000 IU vitamin A, 2,400 IU vitamin D_3, 30 IU vitamin E, 2.5 mg vitamin K_3, 3 mg vitamin B_1, 7 mg, Vitamin B_2, 22 mg niacin, 8 mg calcium D-pantothenate, 4 mg vitamin B_6, 0.015 mg vitamin B_{12}, 1 mg folic acid, 0.045 mg D-biotin, 50 mg, vitamin C, 125 mg choline chloride, 60 mg manganese, 80 mg iron, 60 mg zinc, 5 mg copper, 0.2 mg cobalt, 0.5 mg iodine, 0.15 mg selenium

at the beginning and end of the study. Eggs were collected daily and egg production was calculated on a bird-day basis. Eggs were weighted individually twice a week. Feed not consumed was weighed biweekly and average hen consumption was then calculated by dividing total feed consumed during 14 day by number of hens per cage. Feed conversion ratio was calculated as kg feed per kg egg. Mortality was recorded as it occurred.

Reproduction parameters: The birds were housed in cages at a ratio of two male to seven females. The diets for the seven groups were the same to those in the egg production experiment. A total of 672 eggs at 15 weesk of age and 336 eggs at 19 week of age were collected and used to investigate reproduction parameters. Eggs were collected daily over a 7 days period and were randomly inserted into Petersime Model 5 incubator after numbering and individualy weighing. Egss were incubated at a temperature of 37.8°C with 55%. Relative Humidity (RH) for 14 days. They were then transferred at random to Hatcher trays (which were located in the bottom of the same incubator) and were maintained at 37.2°C and 75% RH until hatching. The numbers of hatched chicks were counted after 18 days of incubation and than the hatchability of total eggs and fertility in the groups were determined.

Egg quality characteristics: Twelve uniform egg samples from each group (3 eggs from each replicate) were randomly chosen from the eggs laid during the last 3 consecutive days of each 30 day laying period and kept at 4°C to determine the egg quality traits. Individual eggs were weighted and shell thickness was measured. The values of yolk height, albumen height, yolk width, albumen width and albumen length were determined. Using these values, yolk index, albumen index and Haugh unit were calculated (Card and Nesheim, 1972).

Diet and fatty acid analyses: Diet and oil samples were analyzed for nutrients levels according to the Association of Official Analytical Chemists (1990). Poppy seed oil and SFO were purchased from two different local oil factory in Afyonkarahisar and Edirne (Turkey). Samples for fatty acid profiles of the PSO and SFO were prepared with using of method described by Paquot (1979). The fatty acid methyl esters were analysed using a Perkin Elmer Autosystem XL Gas Chromotograpy equipped with SP 2330 capillary column of silica.

Samples of 5 eggs from each replicates were obtained at 19 weeks of age and kept at +4°C before fatty acid analysis. Lipids were extracted from the egg yolks using the Folch *et al.* (1957) method and the Fatty Acid Methyl Esters (FAME) were prepared according to Hammond (1991) and analyzed with gas chromatograph (Thermo Quest, 2000, Milan, Italy) equipped with a flame ionization detector. A fused silica capillary column DB-23 (60 m×0.25 mm i.d., film thickness of 0.25 μm) was used. Injection, detector and oven temperatures were 240, 240 and 225°C, respectively. The carrier gas was helium at a flow rate of 20 mL min^{-1} and the split ratio was 1:60. Peaks were identified by comparing their retention times with Supelco 37 Component FAME mix standard mixture.

Statistical analyses: All analyses were performed with SPSS for Windows (version 10.0, 1999, SPSS Inc., Chicago, Illinois). Significant differences among treatment were determined using Duncan (1955) multiple range test with a 5% level of probability.

RESULTS AND DISCUSSION

The fatty acid profiles of the experimental oils are given in Table 2. Data in Table 3 show the effect of dietary PSO and/or SFO on performance, reproduction parameters and egg quality criters for a 12 weeks experimental period. Fatty acids compositions of egg yolk are summarised in Table 4.

Body weight and body weight gain were not affected by the addition of oils to the diet. This non significant difference was probably due to similar effect of these additives on feed intake. The absence of a response to the dietary inclusion of oils of plant origin on the body weight of quail ($p>0.05$) confirmed the findings of studies conducted using laying hens (Baucells *et al.*, 2000; Shafey *et al.*, 2003) and broilers (Newman *et al.*, 2002). Average daily feed intakes were similar in all treatment groups. It is well known that feed intake in layer quails shows differences depending on some factors such as species, live weight and energy level of diet. The lack of a significant difference in feed intake might have been the result of being nearly the same of these factors. This result is agreement with the results of Filardi *et al.* (2005), who declared that sunflower oil did not change the feed intake in the layers. Egg production remained

Table 2: Fatty acid profiles of poppy seed oil and sunflower oil (%)

Item	Poppy seed oil	Sunflower oil
Total saturated fatty acids	11.07	10.25
C14:0 Myristic acid	0.06	0.07
C16:0 Palmitic acid	8.74	6.38
C18:0 Stearic acid	2.27	3.80
Total unsaturated fatty acids	88.93	89.75
C16:1 Palmitoleic acid	0.10	0.13
C18:1 Oleic acid	16.98	32.29
C18:2n-6 (LA) Linoleic acid	71.73	57.08
C18:3α n-3 (LNA) Linolenic acid	0.12	0.25

Table 3: Effect of dietary treatments on the performance and reproduction parameters and of egg quality criters (mean±standart error)

	Dietary treatments							
Item	Control	1.5% PSO	1.5% SFO	0.75% PSO + 0.75% SFO	3% PSO	3% SFO	1.5% PSO + 1.5% SFO	p-value
Performance parameters								
Initial body weight (g)	197±1.11	201±1.53	199±1.7	202±3.52	203±1.60	204±2.00	200±2.01	ns
Final body weight (g)	220±0.89	225±2.46	223±2.12	227±2.77	228±2.09	224±3.21	222±1.46	ns
Feed intake (g/d/bird)	29.3±0.28	28.4±0.32	28.4±0.23	28.6±0.26	28.7±0.44	28.3±0.68	29.2±0.77	ns
Hen-day Egg production (%)	85.6±1.44	89.4±1.69	86.4±2.04	86.8±1.97	86.3±1.65	85.9±2.80	86.2±1.35	ns
Egg weight (g)	11.84±0.14	11.99±0.11	11.70±0.07	11.72±0.17	11.80±0.08	12.00±0.09	11.81±0.15	ns
Feed conversion ratio (g feed g^{-1} egg)	2.89±0.07	2.65±0.13	2.81±0.12	2.81±0.15	2.82±0.18	2.75±0.19	2.87±0.12	ns
Reproduction parameters								
Hatchability of total eggs (%)	75.15±3.20	78.97±3.44	80.13±2.86	86.13±3.72	75.63±4.52	76.71±4.49	75.36±2.35	ns
Fertility (%)	88.09±4.65	91.06±2.50	90.17±3.51	94.55±1.78	87.70±3.85	89.26±3.70	90.19±2.52	ns
Egg quality criters								
Egg shell thickness (μm)	19.98±0.58	20.11±0.33	19.30±0.47	20.12±0.42	19.85±0.34	19.34±0.26	19.63±0.45	ns
Egg albumen index	9.38±0.14	9.13±0.11	9.43±0.16	8.49±0.12	9.76±0.10	9.08±0.19	8.72±0.09	ns
Egg yolk index	48.02±0.24	46.96±0.29	47.04±0.31	46.71±0.36	47.69±0.42	46.49±0.25	46.08±0.44	ns
Egg haugh unit	83.87±2.81	83.30±1.27	83.70±1.33	81.79±2.45	83.95±2.33	82.80±1.38	81.92±1.27	ns

ns: not significant

Table 4: Egg fatty acid levels (%) of the groups (mean±standard error)

	Dietary treatments							
Item	Control	1.5% PSO	1.5% SFO + 0.75% SFO	0.75% PSO	3% PSO	3% SFO	1.5% PSO + 1.5% SFO	p-value
C14:0 Myristic acid	0.92±0.07	0.86±0.06	0.88±0.02	0.89±0.04	0.79±0.05	0.80±0.01	0.85±0.03	ns
C16:0 Palmitic acid	29.54±0.83^{a}	27.92±0.86^{a}	26.08±2.43^{ab}	26.09±1.26^{ab}	25.81±0.68^{ab}	22.32±1.18^{b}	23.07±1.36^{b}	0.014
C18:0 Stearic acid	6.22±0.76^{a}	5.84±0.31^{ab}	5.96±0.58^{ab}	5.63±0.37^{ab}	4.05±0.26^{c}	5.59±0.35^{ab}	4.55±0.48^{bc}	0.021
C16:1 Palmiteloic acid	6.62±0.30^{c}	7.40±0.38^{bc}	8.25±0.70^{ab}	8.07±0.35^{ab}	8.34±0.44^{ab}	8.82±0.42^{a}	8.39±0.66^{ab}	0.036
C18:1n9 Oleic acid	40.15±0.84^{c}	43.53±0.96^{b}	47.92±1.92^{b}	45.76±0.97^{b}	49.45±1.49^{b}	53.99±1.26^{a}	45.36±1.01^{b}	0.001
C18:2n6 Linoleic acid	9.82±0.32^{d}	12.39±1.14^{bc}	9.97±0.35^{cd}	11.11±1.05^{bcd}	15.22±0.66^{a}	13.26±0.81^{ab}	14.92±0.78^{a}	0.001

$^{a-e}$Mean values within a row having different superscripts are significantly different by least significant difference test (*p<0.05) and (***p<0.001), ns: not significant

uninfluenced (p>0.05) over the course of the study regardless of dietary treatment. In this study, average egg production ranged from 85.60-89.40%. Several workers (Jiang *et al*., 1991; Balevi and Coskun, 2000) also indicated that addition of sunflower oil to the diet at rate of 2.5% did not effect egg production. There were also minimal and non significant differences in egg weight and FCR. However numerical positive improvements were noted by dietary oils on FCR. The lowest FCR (2.65) was seen in group consumed diet added 1.5% PSO. Non significant effect of oils tested on FCR could possibly be due to unchanged body weight and feed intake. Similar result was noticed by Alarslan *et al*. (1997), who indicated 2 and 4% of sunflower oil supplementation did not significantly change FCR. Although, it is known that oil supplementation to up to 4% sunflower oil in the diet has positive effects on egg weight in some studies (Inal *et al*., 1994; Coskun *et al*., 1996), results obtained in the current study and of Celebi and Utlu (2006), who used 4% sunflower oil in the diet showed that oils had no effect on avarege egg weight. Differences results using these oils among the studies could be due to the use of different birds and strains, bird age, diet composition and fatty acid profiles of oils added to diets in experiments.

Normal embryonic growth and development depends on a complete supply of all required nutrients within the egg. This supply of nutrients originates in the maternal diet and metabolism (Lillie *et al*., 1951). The fatty acid composition of the diet has been shown to affect the fatty acid composition of the yolk, which in turn can affect embryonic development and hatchability (Vilchez *et al*., 1990). Hatchability and fertility of groups ranged from 75.15 (control) to 86.13% (0.75% PSO + 0.75% SFO) and from 87.70 (3% PSO) to 94.55% (0.75% PSO + 0.75% SFO), respectively. The differences among hatchability and fertility values of groups were not statistically significant (p>0.05). The present results show that changes in dietary oil levels without any associated change in energy are not able to influence hatchability of total eggs and fertility. However both hatchability and fertility in the group added 0.75% PSO + 0.75% SFO were seen to be tended to increase. However, this improvement can provide an economic profit in intensive poultry production. Data confirmed results of Ceylan *et al*. (2004), who declared that utilization of sunflower oil at 1.5 and 3% levels in quail hens diets did not affect hatchability and fertility. However, the reproductive performance observed in current study, was higher than results reported by Balevi *et al*. (2003), who found signinificant differences in reproductive parameters when quail were fed diets containing sunflower oil. Differences among the groups could be due to factors such as differing incubator types or the genotypes and age of the birds (Narahari *et al*., 1988).

All quail hens showed similar egg shell thickness, egg albumen index, egg yolk index and egg haugh unit parameters. Egg quality characteristics were not significantly influenced ($p>0.05$) by the addition of PSO and/or SFO to the diet. Reduced shell quality over time is a common observation and is often associated with the corresponding increase in egg size. No significant egg shell deformation (data not shown) could be result of similar egg size in the groups. Normal egg shell quality may be attributed, in part, to sufficient intestinal calcium uptake. Data for these parameters were similar the results obtained by Celebi and Macit (2003), who declared that utilization of sunflower oil. Although, the present study did not show an effect on eggshell quality parameters, Grobas *et al.* (2001) observed better egg shell quality in eggs derived from layers fed diets containing soybean oil. On the other hand, Mazelli *et al.* (2004) found the lowest eggshell percentage by the addition of sunflower oil. Differences could be releated to various levels of dietary energy and fatty acid compositions, bird strain and age.

Several attempts have been made to reverse the decline in egg consumption by changing egg composition through feeding hens modified diets. This study confirms that the fatty acid composition of the diet of laying quails influences the fatty acid composition of their eggs. The magnitude of change was different for the fatty acid type. Results showed that the concentrations of saturated and unsaturated fatty acids in the egg yolks were significantly ($p<0.001$) influenced except for the concentrations of the C14:0 (Myristic acid) by the addition of PSO and/or SFO to the diets. Palmitic acid was the predominant in saturated fatty acid in this experiment. Dietary 3% SFO and 1.5% SFO+1.5% PSO caused a decrease in palmitic acid level in egg yolk. The lowest ($p<0.05$) palmitic acid concentration was obtained with the addition of 3% sunflower oil. The lowest ($p<0.05$) level of stearic acid was obtained in the group with the addition of 3% poppy seed oil.

Linoleic acid and oleic as the principal fatty acids in the sunflower and poppy seed oil were reflected in the fatty acid composition of the eggs. Polyunsaturated fatty acid composition is determined by the concentrations of linoleic acid, α-linolenic acid and decosahexanoic acid. In the present study, linoleic acid level in the yolk was significantly ($p<0.001$) increased by the supplementation of 3% popy seed oil. Significantly, increase in oleic acid level was observed all dietary treatments with exception 1.5% PSO. Moreover, the highest level of linoleic acid was found by the addition of 3% poppy seed oil. As reported in the several experiments (Baucells *et al.*, 2000; Grobas *et al.*, 2001), the results of the present study, shown that fatty acid profile of the egg yolk can be successfuly modified by using appropriate supplemental oil in laying quail diets.

CONCLUSION

The compositions of fatty acids of eggs prepared for human consumption could be said to be altered by dietary oil treatments in quial diets. Decrease in satured fatty acids and increase in linoleic and oleic acids are importants results waiting in the experiment. These desired results for fatty acid profile in egg are beneficial for human nutrition. Linoleic and α-linolenic acids are critical because they are precursors of the longer n-6 and n-3 PUFA in order to decrease heart health risk. This change in enriched eggs may respond the consumer demands and provide additional nutrients for human diets.

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