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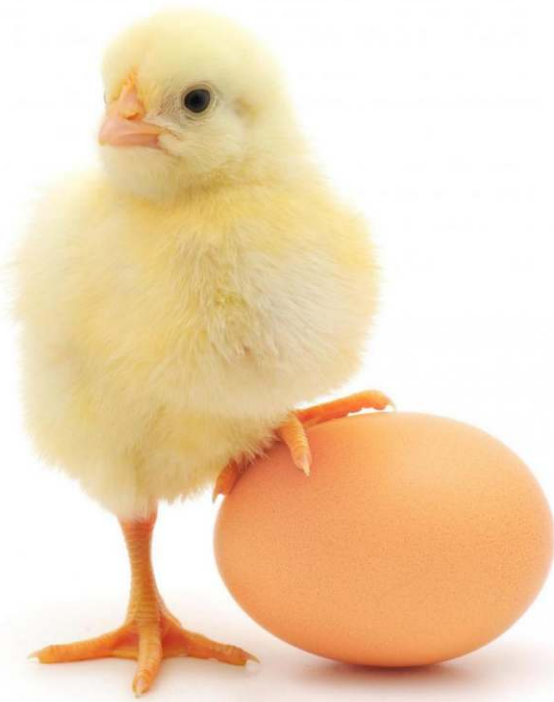

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Influence of Source of Oil Added to Diet on Egg Quality Traits of Laying Quail

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Abstract: This experiment was performed to investigate the influence of different oils in the diets of laying quail on their egg quality characteristics. One hundred and twenty 7-wk old Japanese quails (*Coturnix coturnix japonica*) were allocated to four groups with three replicates containing 10 quail each (30 quail per each treatment group). They were fed for 13 weeks (including one week of adaptation period) on diets containing 3% oil from different sources, viz. either sunflower (T1), linseed (T2), maize (T3), or fish oil (T4). Inclusion the diet of laying quail with fish oil (T4) and maize oil (T2) resulted in significant increase with respect to egg weight, yolk weight, albumen weight, yolk diameter, yolk height, albumen diameter, albumen height, shell thickness and Haugh unit during all periods of experiment and in total means of these parameters. However, the addition of different oil sources used in this experiment to quail diets did not significantly affect total means of shell weight, relative weight of albumen and relative weight of shell, while total means of relative weight of yolk, yolk index and albumen index were higher in the birds receiving diets containing fish (T4) and maize (T2) oil than in other treatments (T1 and T3). The results of this experiment clearly demonstrated that supplementation the laying quail diet with fish and maize oil improved most criteria of egg quality. Therefore, incorporation of fish and maize oil into the diets of Japanese quail may have practical value in manipulating egg quality.

Key words: Different oil sources, laying quail, egg quality traits

INTRODUCTION

Fats and oils are commonly supplemented to poultry rations to increase the energy density as an economic tool of producing energy-rich formulations. It was shown that there was 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 long-chain saturated fatty acids except for fish oil. Whereas vegetable oils contain a great many quantities of long chain unsaturated fatty acids (Midilli *et al*., 2009). The fat content and the composition of fatty acids in egg lipids have been implicated in human health (Chow, 2008). Norum (1992) based on epidemiological experiments 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. Concerning nutrition, one of the methods developed to change the lipid profile of eggs has been the use of different oil sources that are commonly used as energy sources in the diet of laying hens (Cabrera *et al*., 2005). Some of the oil sources are rich in long chain PUFA that can change the proportion of the constituents of egg yolk (Eseceli and Kahraman, 2004). Although some plant oils used in animal diets contain the same or similar concentrations of fatty acids, they may differ significantly from each other in relation to their physical properties due to the ratio of fatty acids and triglycerides in their structures. These differences may be caused by many factors such as climate, soil type, vegetative stage and the genetics of plant (Guclu *et al*., 2008). Enrichment of hens' diets with sources rich in linolenic acid (LNA) has resulted in the production of eggs with significantly increased levels of yolk LNA and small but significantly higher increases in the 20-carbon family (long chain; LC) of n-3 fatty acids (LC-PUFA), mainly as eicosapentanoic acid (EPA) and docosahexanoic acid (DHA) (Baucells *et al*., 2000). When compared with the increased levels of Epa and DHA reported by Hargis *et al*. (1991) in response to relatively low amounts (3%) of dietary fish oil, the significantly smaller increases in the n-3 LC-PUFA observed when higher dietary fat levels in the form of flax and canola seed were supplied emphasizes the limited efficiency of conversion of LNA to EPA and DHA in birds (Aymond and Van Elswyk, 1995). Not all dietary n-3 FA biologically equivalent (Reinhart, 1996) and what should be considered is not only the total amount of n-3 fatty acids, but also the specific fatty acids provided by food sources enriched with n-3 fatty acids when developing health-modified products. To compare the beneficial effects of fish oil on egg quality characteristics with the effects when other oil sources were used in egg production, an experiment with laying quail was carried out. The goal of this study was to improve knowledge about the relationship between precursors of n-3 and n-6 PUFA families given in the diet and egg quality traits. Birds were fed with fish oil or with alternative oil sources (linseed oil, maize oil, or sunflower oil) at level of 3% to attain a different amount of n-3 and n-6 PUFA in the diet of laying quail.

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Table 1: Ingredients and chemical composition of the diet fed to laying quails

Ingredients (%)	Sunflower oil (T1)	Linseed oil (T2)	Maize oil (T3)	Fish oil (T4)
Yellow corn	12.00	12.00	8.50	10.00
Wheat	47.70	47.70	51.50	50.00
Soybean meal	20.00	20.00	19.70	19.70
Protein concentrate*	10.00	10.00	10.00	10.00
Lime stone	7.00	7.00	7.00	7.00
Oil	3.00	3.00	3.00	3.00
Sodium chloride	0.30	0.30	0.30	0.30
Calculated content**				
Crude protein (%)	21.05	21.05	21.10	21.05
Metabolizable energy (kcal/kg)	2888.00	2879.00	2881.00	2885.00
Total calcium (%)	3.60	3.60	3.60	3.60
Available phosphorus (%)	0.30	0.30	0.30	0.30
Methionine (%)	0.35	0.35	0.34	0.34
Lysine (%)	1.00	1.00	0.99	0.99
Cystine (%)	0.27	0.27	0.27	0.27

*Golden protein concentrate provided per kg: : 2500 ME/kg; 40% crude protein; 9% crude fat; 4.5% crude fiber; 9% calcium; 2.3% available phosphorus; 2.3% lysine; 1.25 methionine; 1.8% methionine + cystine; 100000 IU vit A; 10 mg vit B1; 100 mg vit B12; 20 mg vit K_3; 50 mg copper; 700 mg manganese; 2 mg selenium; 200 mg vit E; 0.5 mg biotin; 5 mg folic acid; 200 mg niacin; 80 mg pantothenic acid; 10 mg iodine; 25000 IU vit D3; 500 mg iron; 10 mg cobalt; 600 mg zinc; 10 mg vit B6.

**Calculated composition was according to NRC (1994)

MATERIALS AND METHODS

Birds and treatments: One hundred and twenty 7-weeks old Japanese quail (*Coturnix coturnix japonica*) hens were used in this experiment. Following one week of adaptation period on experimental conditions and treatments diets the quail were weighed to provide an equal live weight in all groups at the beginning of the experiment. They were evenly distributed into 4 treatments groups with three replicates per group containing 10 hens each. For 13 weeks (including adaptation period) the laying quail were fed diet containing 3% oils from sunflower (T1), linseed (T2), maize (T3) or fish (T4). The birds were allowed free access to food and water. The quail were housed in stainless steel wire cages with 10 laying quail for each cage. Ingredient and chemical composition of diet were shown in Table 1. However, the fatty acid composition of oils used in this experiment is presented in Table 2. A regime of 17 h constant lighting and continuous ventilation were provided and all birds were kept under uniform management conditions throughout the experimental period.

Egg quality evaluation: Egg quality criteria (egg weight, yolk weight, albumen weight, shell weight, yolk diameter, yolk height, albumen diameter, albumen height, relative weight of yolk, relative weight of albumen, relative weight of shell, shell thickness, Haugh unit, yolk index and albumen index) were measured at 9^{th}, 11^{th}, 13^{th}, 15^{th}, 17^{th} and 19^{th} week of bird age, using 25 eggs from each experiment group. These characteristics of egg quality were determined according to Guclu *et al.* (2008).

Statistical analysis: The data were analyzed statistically using the General Linear Models procedure of SAS (2000). Significant differences between treatment means are separated using the Duncan's multiple range test with 5% and 1% probability (Duncan, 1955).

RESULTS

In this study, fish oil represented oil from animal and sunflower, linseed and maize oil, the plant oils. The fatty acid composition of the oils is presented in Table 2. Fish oil contain higher levels of docosahxaenoic acid (C22:6n3) (10.73%) and eicosapentaenoic acid (C20:5n3) (10%) than the plant oils while its linoleic acid (C18:2n6) level (1.02%) was lower. The highest linolenic acid (C18:3n3) concentration was recorded in linseed oil, while the highest concentrations of linoleic acid (C18:2n6) were shown in sunflower and maize oil. The linoleic acid levels of these two oils were 56% and 60%, respectively. The highest levels of palmitic acid (C16:0) and total saturated fatty acids were measured in fish, maize and sunflower oil while linseed oil contained the lowest level. However, the highest total omega-3 fatty acid levels were shown in linseed and fish oil, whereas the highest total omega-6 fatty acid levels were shown in sunflower and maize oil (Table 2). Furthermore, the lowest ratio of total omega-6/total omega-3 fatty acids was recorded in fish and linseed oil. These finding were similar to the results of previous studies using the same oils (Eseceli and Kahraman, 2004; Cabrera *et al.*, 2005). However, the slight differences obtained in the fatty acid composition of the oil sources used in this study compared to published values might be due to many factors such as production of the crops in different climates and differences on the vegetation stage of the plants that could have affected the fatty acid composition of oils (Senkoylu, 2001).

Egg weight, yolk weight, albumen weight, yolk diameter, yolk height, albumen diameter, albumen height, shell thickness and Haugh unit determined at different ages of laying quail are shown in Tables 1, 2, 3, 5, 6, 7, 8, 12 and 13. Laying quail fed fish oil (T4) and linseed oil (T2) added diets produced highest egg weight, yolk weight, albumen weight, yolk diameter, yolk height, albumen

Table 2: Fatty acid composition (%) of oils included in the diets of laying quails

Numeric name	Common name	T1	T2	T3	T4
C12:0	Lauric acid	-	-	-	0.090
C14:0	Myristic acid	0.060	0.12	0.06	5.41
C15:0	None	0.020	0.08	0.03	0.47
C16:0	Palmitic acid	6.250	6.00	11.01	14.05
C17:0	Margaric acid	0.030	0.11	0.09	1.73
C18:0	Stearic acid	3.580	2.50	1.91	2.87
C20:0	Arachidic acid	0.238	0.50	0.36	0.15
C21:0	None	0.008	0.01	0.01	0.04
C22:0	Behenic acid	0.587	0.23	0.15	0.02
C23:0	None	0.028	0.02	0.02	0.06
C24:0	Lignoceric acid	0.203	0.08	0.16	0.15
C14:1	Myristoleic acid	-	-	-	0.03
C15:1	None	0.010	0.01	-	0.19
C16:1	Palmitoleic acid	0.090	0.40	0.13	8.25
C17:1	None	0.040	0.03	0.04	0.36
C18:1 n9	Oleic acid	23.000	19.00	24.00	21.94
C20:1 n9	Gadoleic acid	0.255	0.28	0.36	11.22
C22:1 n9	Erucic acid	0.007	0.01	0.01	7.65
C24:1 n9	Nervonic acid	0.005	0.02	0.12	2.30
C18:3 n3	Alpha linolenic acid	0.108	57.29	1.26	0.50
C20:3 n3	None	0.025	0.05	0.03	0.05
C20:5 n3	Eicosapentenoic acid (EPA)	0.118	0.63	0.09	10.00
C22:6 n3	Docosahexaenoic acid (DHA)	0.012	0.00	0.02	10.73
C18:2 n6	Linoleic acid	65.000	12.18	60.00	1.02
C18:3 n6	Gamma linolenic acid	0.016	0.02	0.06	0.13
C20:2 n6	11, 14-Eicosadienoic acid	0.155	0.08	0.06	0.19
C22:2 n6	13, 16-Docosadienoic acid	0.155	0.003	0.001	0.38
Total of saturated fatty acids		11.000	9.65	13.80	25.04
Total of mono unsaturated fatty acids		23.400	19.75	24.66	51.94
Total of polyunsaturated fatty acids		65.580	70.55	61.52	23.00
Total of omega-3 fatty acids		0.260	58.27	1.40	21.28
Total of omega-6 fatty acids		65.320	12.28	60.12	1.72
Total of omega-6/total omega-3 fatty acids ratio		251.230	0.21	42.94	0.08

T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil

Table 3: Effect of dietary supplementation with different oils on egg weight (g) (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	11.49±0.18^d	11.61±0.29^b	11.45±0.16^c	11.91±0.17^a
2	11.24±0.24^d	11.86±0.27^b	11.34±0.17^c	11.83±0.23^a
3	10.44±0.20^d	10.68±0.43^b	10.61±0.32^c	11.89±0.28^a
4	10.98±0.19^d	11.17±0.20^b	11.05±0.73^c	11.85±0.53^a
5	11.36±0.22^d	11.82±0.19^b	11.52±0.23^c	11.91±0.11^a
6	11.03±0.13^d	11.90±0.25^b	11.19±0.24^c	11.89±0.23^a
Mean	11.07±0.38^d	11.50±0.29^b	11.19±0.52^c	11.88±0.98^a

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 4: Effect of dietary supplementation with different oils on yolk weight (g) (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	3.86±0.17^c	3.91±0.37^b	3.71±0.12^c	3.99±0.41^a
2	3.69±0.23^c	3.88±0.22^b	3.70±0.65^c	4.08±0.30^a
3	3.74±0.11^c	3.97±0.29^b	3.73±0.34^c	4.11±0.28^a
4	3.71±0.13^c	3.99±0.41^b	3.75±0.29^c	4.13±0.19^a
5	3.65±0.15^c	3.89±0.47^b	3.74±0.35^c	4.33±0.31^a
6	3.77±0.19^c	4.14±0.39^b	3.79±0.21^c	4.55±0.22^a
Mean	3.70±0.17^c	3.96±0.42^b	3.73±0.34^c	4.19±0.40^a

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

diameter, albumen height, shell thickness and Haugh unit during all periods of experiment and regarding the total means of these traits as compared with sunflower oil (T1) and maize oil (T3) added diets. Data in Tables 4, 10 and 11 shows the effect of dietary supplementation with different oil sources on shell weight, relative weight of albumen and relative weight of shell for 12 weeks experimental periods. Total means of shell weight, relative weight of albumen and relative weight of shell were not affected (p>0.05) by the addition of oils to the diet. Results of this experiment also revealed that the addition of fish oil (T4) and linseed oil (T2) to the diet of laying quail resulted in significant increase in relation to total means of relative weight of yolk, yolk index and albumen index in comparison with sunflower oil (T1) and maize oil (T3) (Tables 9, 14 and 15).

Table 5: Effect of dietary supplementation with different oils on albumen weight (g) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	5.91±0.11^{d}	6.03±0.72^{b}	5.90±0.61^{c}	6.09±0.38^{a}
2	5.85±0.19^{d}	6.08±0.50^{b}	5.93±0.53^{c}	6.11±0.11^{a}
3	5.99±0.17^{d}	6.11±0.55^{b}	5.97±0.62^{c}	6.13±0.17^{a}
4	6.00±0.22^{d}	6.09±0.63^{b}	6.03±0.52^{c}	6.18±0.29^{a}
5	5.97±0.18^{d}	6.13±0.58^{b}	6.11±0.51^{c}	6.25±0.13^{a}
6	6.08±0.21^{d}	6.17±0.33^{b}	6.13±0.57^{c}	6.39±0.12^{a}
Mean	5.96±0.30^{d}	6.10±0.45^{b}	6.01±0.60^{c}	6.19±0.10^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 6: Effect of dietary supplementation with different oils on shell weight (g) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	1.90±0.11^{a}	1.67±0.17^{b}	1.84±0.22^{a}	1.83±0.31^{a}
2	1.70±0.09^{a}	1.90±0.25^{a}	1.71±0.28^{a}	1.64±0.27^{a}
3	0.71±0.13^{b}	0.60±0.11^{b}	0.91±0.27^{b}	1.65±0.22^{a}
4	1.27±0.15^{b}	1.09±0.19^{b}	1.27±0.19^{b}	1.54±0.33^{a}
5	1.74±0.08^{a}	1.80±0.23^{a}	1.67±0.26^{a}	1.33±0.19^{a}
6	1.18±0.05^{b}	1.59±0.31^{a}	1.27±0.28^{b}	0.95±0.28^{c}
Mean	1.41±0.26^{a}	1.45±0.35^{a}	1.44±0.31^{a}	1.49±0.30^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 7: Effect of dietary supplementation with different oils on yolk diameter (mm) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	23.75±0.41^{c}	24.18±0.32^{b}	23.53±0.13^{c}	25.06±0.45^{a}
2	23.79±0.75^{c}	24.17±0.33^{b}	23.61±0.27^{c}	25.19±0.17^{a}
3	23.77±0.24^{c}	24.23±0.53^{b}	23.67±0.45^{c}	25.30±0.30^{a}
4	23.91±0.37^{c}	24.31±0.35^{b}	23.97±0.50^{c}	25.91±0.27^{a}
5	23.95±0.35^{c}	24.60±0.36^{b}	23.85±0.29^{c}	25.96±0.19^{a}
6	24.02±0.16^{c}	24.81±0.30^{b}	24.11±0.42^{c}	25.99±0.45^{a}
Mean	23.86±0.13^{c}	24.38±0.32^{b}	23.70±0.28^{c}	25.56±0.42^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 8: Effect of dietary supplementation with different oils on yolk height (mm) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	10.80±0.22^{c}	10.99±0.11^{b}	10.71±0.56^{c}	11.93±0.39^{a}
2	10.73±0.32^{c}	11.08±0.33^{b}	10.79±0.50^{c}	12.03±0.27^{a}
3	10.83±0.29^{c}	11.02±0.28^{b}	10.69±0.44^{c}	11.99±0.21^{a}
4	10.89±0.40^{c}	11.27±0.45^{b}	10.83±0.52^{c}	12.16±0.47^{a}
5	10.97±0.39^{c}	11.43±0.26^{b}	10.93±0.50^{c}	12.23±0.52^{a}
6	11.08±0.51^{c}	11.56±0.52^{b}	11.11±0.32^{c}	12.59±0.36^{a}
Mean	10.88±0.43^{c}	11.22±0.60^{b}	10.84±0.52^{c}	12.15±0.49^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil. ^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 9: Effect of dietary supplementation with different oils on albumen diameter (mm) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	37.55±1.18^{c}	38.11±1.79^{b}	37.24±1.29^{c}	39.06±2.55^{a}
2	38.03±1.27^{c}	38.23±1.65^{b}	37.19±2.13^{c}	39.98±3.11^{a}
3	37.97±2.15^{c}	38.19±1.99^{b}	37.36±1.97^{c}	39.11±1.09^{a}
4	38.11±1.33^{c}	38.25±2.18^{b}	37.48±2.25^{c}	39.25±2.18^{a}
5	37.08±1.50^{c}	38.61±1.90^{b}	37.42±1.35^{c}	39.27±3.25^{a}
6	37.13±1.19^{c}	39.17±1.77^{b}	37.49±1.44^{c}	39.20±1.16^{a}
Mean	37.64±3.16^{c}	38.42±2.16^{b}	37.36±2.23^{c}	39.14±2.88^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 10: Effect of dietary supplementation with different oils on albumen height (mm) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	3.15±0.92^{b}	4.10±0.62^{a}	3.20±0.55^{b}	4.21±0.95^{a}
2	3.29±0.85^{b}	4.13±0.27^{a}	3.18±0.55^{b}	4.35±0.99^{a}
3	3.52±0.77^{b}	4.08±0.51^{a}	3.55±0.68^{b}	4.27±0.63^{a}
4	3.38±0.62^{b}	4.25±0.32^{a}	3.52±0.67^{b}	4.41±0.52^{a}
5	3.77±0.19^{b}	4.27±0.48^{a}	3.69±0.82^{b}	4.59±0.88^{a}
6	3.85±0.90^{b}	4.39±0.29^{a}	3.91±0.91^{b}	4.78±0.60^{a}
Mean	3.49±0.72^{b}	4.20±0.36^{a}	3.50±0.59^{b}	4.43±0.77^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 11: Effect of dietary supplementation with different oils on relative weight of yolk (%) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	32.02±1.50^{b}	33.67±2.62^{a}	32.40±2.59^{b}	33.80±4.60^{a}
2	32.82±3.33^{c}	32.91±1.87^{b}	32.62±1.62^{c}	34.48±1.52^{a}
3	35.82±2.42^{b}	37.17±3.71^{a}	35.15±4.55^{b}	34.56±2.59^{b}
4	33.78±3.51^{b}	35.72±2.82^{a}	33.93±2.42^{b}	34.85±3.41^{a}
5	32.13±4.48^{b}	32.91±1.76^{b}	33.42±2.71^{b}	36.35±2.72^{a}
6	34.17±1.63^{b}	34.78±2.65^{b}	33.86±1.48^{b}	38.26±3.66^{a}
Mean	33.45±2.72^{c}	34.52±3.84^{b}	33.49±2.62^{c}	35.38±2.75^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 12: Effect of dietary supplementation with different oils on relative weight of albumen (%) (Mean±SE) of laying quail

Periods	Treatments T1	T2	T3	T4
1	51.43±2.87^{a}	51.93±2.34^{a}	51.25±2.92^{a}	51.13±2.31^{a}
2	52.04±3.63^{a}	51.26±1.28^{a}	52.29±3.87^{a}	51.64±2.28^{a}
3	57.37±4.55^{a}	57.20±3.11^{a}	56.26±2.96^{a}	51.55±3.42^{b}
4	54.64±2.91^{a}	54.52±2.16^{a}	54.57±2.90^{a}	52.15±3.36^{b}
5	52.55±3.79^{a}	51.86±4.13^{a}	53.03±2.80^{a}	52.47±2.28^{a}
6	55.12±4.83^{a}	51.84±2.25^{b}	54.78±1.10^{a}	53.78±2.33^{a}
Mean	53.85±2.72^{a}	53.10±3.22^{a}	53.69±2.98^{a}	52.12±2.19^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 13: Effect of dietary supplementation with different oils on relative weight of shell (%) (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	16.53±0.38^{a}	14.38±0.29^{a}	16.06±0.41^{a}	15.36±0.26^{a}
2	15.12±0.22^{a}	16.02±0.16^{a}	15.07±0.43^{a}	13.86±0.51^{b}
3	06.80±0.19^{b}	05.61±0.32^{b}	08.57±0.38^{b}	13.87±0.29^{a}
4	11.56±0.13^{a}	09.75±0.18^{a}	10.58±0.25^{a}	12.99±0.41^{a}
5	15.31±0.29^{a}	14.72±0.27^{a}	14.49±0.37^{a}	11.16±0.32^{a}
6	10.69±0.36^{a}	13.36±0.41^{a}	11.34±0.26^{a}	07.98±0.62^{b}
Mean	12.66±0.22^{a}	12.30±0.19^{a}	12.68±0.15^{a}	12.53±0.70^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 14: Effect of dietary supplementation with different oils on shell thickness (mm) (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	0.220±0.005^{c}	0.231±0.006^{b}	0.222±0.001^{c}	0.243±0.001^{a}
2	0.223±0.001^{c}	0.233±0.002^{b}	0.225±0.003^{c}	0.246±0.009^{a}
3	0.225±0.001^{c}	0.236±0.002^{b}	0.220±0.002^{c}	0.240±0.008^{a}
4	0.220±0.002^{c}	0.230±0.004^{b}	0.227±0.001^{c}	0.245±0.009^{a}
5	0.228±0.001^{c}	0.237±0.003^{b}	0.233±0.004^{c}	0.247±0.007^{a}
6	0.231±0.002^{c}	0.239±0.001^{b}	0.235±0.003^{c}	0.253±0.003^{a}
Mean	0.224±0.003^{c}	0.234±0.001^{b}	0.227±0.005^{c}	0.245±0.002^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 15: Effect of dietary supplementation with different oils on haugh unit (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	85.55±2.11^{c}	87.34±3.25^{b}	86.61±3.90^{c}	88.82±2.20^{a}
2	85.68±4.27^{c}	87.49±4.15^{b}	85.65±5.55^{c}	88.97±4.15^{a}
3	85.33±3.33^{c}	87.41±2.19^{b}	85.57±2.76^{c}	88.73±3.70^{a}
4	85.49±5.41^{c}	87.61±5.35^{b}	85.69±4.08^{c}	89.25±5.11^{a}
5	85.73±4.11^{c}	87.69±5.16^{b}	85.78±5.23^{c}	89.67±6.32^{a}
6	85.88±4.83^{c}	87.89±4.29^{b}	86.11±3.39^{c}	89.98±4.97^{a}
Mean	85.61±6.20^{c}	87.57±5.09^{b}	85.73±4.92^{c}	89.23±2.28^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 16: Effect of dietary supplementation with different oils on yolk index (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	45.47±3.19^{b}	45.45±2.70^{b}	45.51±1.63^{b}	47.60±3.31^{a}
2	45.10±6.22^{b}	45.84±1.50^{b}	45.70±2.15^{b}	47.75±3.85^{a}
3	45.56±4.08^{b}	45.48±3.38^{b}	45.16±1.40^{b}	47.39±2.79^{a}
4	45.54±3.09^{b}	46.36±4.52^{a}	45.52±3.65^{b}	46.93±2.71^{a}
5	45.80±5.85^{b}	46.46±4.43^{b}	45.82±3.79^{b}	47.11±3.09^{a}
6	46.12±3.80^{b}	46.59±4.05^{b}	46.08±3.90^{b}	48.44±1.17^{a}
Mean	45.59±6.30^{c}	46.03±6.29^{b}	45.63±5.20^{c}	47.53±4.23^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

Table 17: Effect of dietary supplementation with different oils on albumen index (Mean±SE) of laying quail

	Treatments			
Periods	T1	T2	T3	T4
1	8.38±0.97^{b}	10.75±0.65^{a}	8.59±0.52^{b}	10.79±0.92^{a}
2	8.65±0.88^{c}	10.80±0.63^{b}	8.55±0.73^{c}	11.15±0.81^{a}
3	9.27±0.91^{b}	10.68±0.72^{a}	9.50±0.40^{b}	10.91±0.85^{a}
4	8.86±0.65^{b}	11.11±0.43^{a}	9.39±0.62^{b}	11.23±0.90^{a}
5	10.16±0.42^{b}	11.05±0.55^{a}	9.86±0.91^{b}	11.68±0.73^{a}
6	10.36±0.79^{c}	11.20±0.82^{b}	10.42±0.82^{c}	12.19±0.65^{a}
Mean	9.28±0.99^{c}	10.93±0.21^{b}	9.38±0.79^{c}	11.32±0.36^{a}

Each period represented 14 days. T1: Sunflower oil; T2: Linseed oil; T3: Maize oil; T4: Fish oil.

^{a,b,c}Means within rows with different superscripts differ significantly at (p<0.05)

DISCUSSION

The positive results recorded in this study when diet of laying quail supplemented with fish oil (T4) and linseed oil (T2) as compared with sunflower oil (T1) and maize oil (T3) are in coordination with the results of Al-Daraji *et al.* (2010a) who found that dietary fish oil and flaxseed oil at the inclusion level of 3% exhibited the best results as concerns hen-day egg production, egg weight, egg mass, cumulative egg production, feed conversion ratio, fertility, hatchability and embryonic liveability. Bozkhurt *et al.* (2008) found that supplementation of fish oil at a level of 1.5% to the corn-soybean meal diet of broiler breeder chicken may affect egg production performance, fertility, egg weight, chick weight, hatch of egg set and specific gravity without any adverse effect on body weight and settable egg characteristics. Al-Daraji *et al.* (2010b) reported that supplementing diet of laying quail with linseed at the levels of 25, 4%, or 6% resulted in significant improvement in total means of egg weight, yolk diameter, albumen height, shell thickness, Haugh unit, albumen percentage and albumen weight. Guclu *et al.* (2008) denoted that dietary oils (sesame, cottonseed, olive, hazelnut, maize, soybean or fish oil) affected egg weight and its specific gravity, the egg yolk index and the Haugh unit but had no effect on live weight, egg shell thickness and albumen index. However, fish and soybean oil increased the omega-3 fatty acid level of egg yolk and decreased serum lipid concentration. De Silva *et al.* (2009) indicated that n-3 fatty acid level was high in egg yolk of quail treated with 1.5, 3.0, or 5.0% flaxseed when compared to that of control group. The n-6/n-3 ratio decreased from 21.30 (control) to 4.52 (5.0% flaxseed), which is a better value from the nutritional viewpoint. Cherian (2008) reported that a significant decrease in egg weight, yolk weight, shell weight and yolk colour was observed for low n-3 when compared with high n-3 eggs (p<0.05). Dalton (2000) indicated that the decrease in the ratio of omega-6 to omega-3 fatty acids in Japanese quail diet resulted in significant improvement in egg size, egg production, egg quality, fertility, hatchability and decrease in early embryonic mortality. Important nutritionally-essential n-3 fatty acids are: Alpha-Linolenic Acid (ALA), EPA and DHA, all of which are polyunsaturated. The vertebrate body cannot synthesize n-3 fatty acids de nova, but it can form 20-carbon unsaturated n-3 fatty acids (like EPA) and 22-carbon unsaturated n-3 fatty acids (like DHA) from the 18-carbon n-3 fatty acid ALA. These conversions occur competitively with n-6 fatty acids, are closely related chemical analogues that are derived from Linoleic Acid (LA). Both the n-3 ALA and n-6 LA are essential nutrients which must be obtained from food. Synthesis of longer n-3 fatty acids from ALA within the body is competitively slowed by the n-6 analogues. Thus accumulation of long-chain n-3 fatty acids in tissues is more effective when they are obtained directly from food or when competing amounts of n-6 analogs do not greatly exceed the amount of n-3 (Culver, 2001; Midilli *et al.*, 2009). The 18 carbon ALA has not been shown to have the same health and cardiovascular benefits such as EPA or DHA. EPA and DHA are made by micro algae that live in sea water. These are then consumed by fish and accumulate to high levels in their internal organs. Fish oil stimulates blood circulation, increase the breakdown of fibrin, a compound involved in clot and scar formation and additionally has been shown to reduce blood pressure, reduce blood triglyceride levels, regular intake, reduce the risk of secondary and primary heart attack, treatment of rheumatoid arthritis and cardiac arrhythias, helpful in depression and anxiety and reduce the risk of ischemic and thrombotic stroke (Saunders *et al.*, 1997; Davidson *et al.*, 2007). The dietary imbalance in fatty acids (excessive omega-6 and insufficient omega-3) is a fundamental underlying cause of many chronic diseases including cardiovascular disease, many cancers, most inflammatory diseases, autoimmune disease and many physiological disturbances (Baucells *et al.*, 2000). A rich source of minerals, omega-3 fatty acids, phytoestrogens and soluble and insoluble fibers, gave abundant evidence that supports the value of linseed in preventing diverse illnesses such as heart disease and cancer as well as helping to address common aliments such as digestive irregularity and enhancing reproductive performance in both males and females (Guilliams, 2000). Leskanich and Noble (1997) reported that omega-3 fatty acids help lower blood triglycerides and cholesterol levels. However, omega-3 fatty acids are also required for normal growth and development, good production and distinguished reproductive performance. Linseed is higher in omega-3 fatty acids and lowers in saturated fatty acids than other grains. As a result, the eggs produced from hens on this formula are higher in omega-3 fatty acids (Pruuthi *et al.*, 2007).

Conclusion: The current work clearly shows that when fish oil and linseed oil are added to the diet of laying quail, it is more efficient in improving egg quality criteria compared with sunflower oil and maize oil. The poultry producers are then in the fortunate position of being able to respond to changes in consumer demand as nutritional advice changes in respect to research.

REFERENCES

Al-Daraji, H.J., H.A. Al-Mashadani, W.K. Al-Hayani, H.A. Mirza and A.S. Al-Hassani, 2010. Effect of dietary supplementation with different oils on productive and reproductive performance of quail. Int. J. Poult. Sci., 9: 429-435.

Al-Daraji, H.J., W.M. Razuki, W.K. Al-Hayani and A.S. Al-Hassani, 2010b. Effect of dietary linseed on egg quality of laying quail. Int. J. Poult. Sci., 9: 584-590.

Aymond, W.M. and M.E. Van elSWYK, 1995. Yolk thiobarbituric acid reactive substances and n-3 fatty acids in response to whole and ground flaxseed. Poult. Sci., 74: 1388-1394.

Baucells, M.D., N. Crespo, A.C. Barroeta, S. Lopez-Ferrer and M.A. Grashorn, 2000. Incorporation of different polyunsaturated fatty acids into eggs. Poult. Sci., 79: 51-59.

Bozkhurt, M., M. Cabuk and A. Alcicek, 2008. Effect of dietary fat type on broiler breeder performance and hatching egg characterstics. J. Appl. Poult. Res., 17: 47-53.

Brisson, G.J., 1986. Dietary Fat and HUMAN Health. Recent Advances in Animal Nutrition. In: Haresign, W. and D.J.A. Cole (Eds.). Butterworths, London, UK, pp: 3-23.

Cabrera, M.C., A. Saadoun, A. Grompone, T. Pagna, M. Sami, R. Olivero and M. del Pnerto, 2005. Enriching the egg yolk in n-3 fatty acids by feeding hens with diet containing horse fat produced in Uruguay. Food Chem., 98: 767-773.

Cherian, C., 2008. Egg quality and yolk polyunsaturated fatty acid status in relation to broiler breeder hen age and dietary n-3 oils. Poult. Sci., 87: 1131-1137.

Chow, K.C., 2008. Fatty acids in foods and their Health Implications. Marcel Dekker, New York.

Culver, J.N., 2001. Evaluation of tom fertility as affected by dietary fatty acid composition. M.Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University, USA.

Dalton, M.N., 2000. Effect of dietary fats on reproductive performance, egg quality, fatty acid composition of tissues in Japanese quail (*Coturnix coturnix japonica*). M.Sc. Thesis, Faculty of the Virginia Polytechnic Institute and State University, USA.

De Silva, W.A., A.H.N. Elias, J.A. Aricetti, M.I. Sakamoto, A.E. Murakami, S.T.M.G., J.V. Visentainer, N.E. de Souza and M. Matsushita, 2009. Quail egg yolk (*Coturnix coturnix japonica*) enriched with omega-3 fatty acids. Food Sci. Tech., 42: 660-663.

Davidson, M.H., E.H. Bays, K.C. Maki, R.T. Doyle, R.A. Shalwitz, C.M. Ballantyne and H.N. Ginsberg, 2007. Efficacy and tolerability of addition prescription omega-3 fatty acids 4 g/d to Simvastation 40 mg/d in hypertriglyceridemic patients: An 8-week, randomized, double-blind, placebo-controlled study. Clin. Therapeutics (Elsevier), 29: 1354-1367.

Duncan, D.B., 1955. Multiple range and multiple F-test. Biometrics, 11: 1-42.

Eseceli, H. and R. Kahraman, 2004. Effect of dietary supplementation of sunflower and fish oil with additive vitamin E or C on fatty acid composition of egg yolks and malondialdehyde levels in layer hens. Istanbul Univ. Vet. Fak. Derg., 30: 19-35.

Guclu, B.K., F. Uyank and K.M. Iscan, 2008. Effect of dietary oil sources on egg quality, fatty acid composition of egg and blood lipids in laying quail. S. Afr. J. Anim. Sci., 38: 91-100.

Guilliams, T.G., 2000. Fatty acids: Essential .... Therapeutic. A Concise Update of Important Issues Concerning Natural Health Ingredients, 3: 1-8.

Hargis, P.S., M.E. Van Elswyk and B.M. Hargis, 1991. Dietary modification of yolk lipid with menhaden oil. Poult. Sci., 70: 874-883.

Leskanich, C.O. and R.C. Noble, 1997. Manipulation of the n-3 polyunsaturated fatty acid composition and avian eggs and meat. World's Poult. Sci. J., 53: 155-183.

Midilli, M., I. Bayram, H. Erol, I.S. Cetingul, S. Cakir, E. Calikoglu and M. Kiralan, 2009. The effects of dietary poppy seed oil and sunflower oil on performance, reproduction and egg quality parameters and fatty acid profile of egg yolk in the Japanese quail. J. Anim. Vet. Adv., 8: 379-384.

Norum, K.R., 1992. Dietary fat and blood lipids. Nutr. Rev., 50: 30-37.

NRC, 1994. Nutrient Requirements of Poultry. 9th Rev. Edn., National Academy Press, Washington, DC.

Pruuthi, S., S.L. Thompson and P.J. Novotnn, 2007. Pilot evaluation of flaxseed for the management of hot flashes. J. Soc. Integr. Oncol., 5: 106-112.

Reinhart, G.A., 1996. In: Review of Omega-3 Fatty Acid and Dietary Influences on Tissue Concentrations. Recent Advances in Cannine and Feline Nutritional Research. Proc. 1996 Iams Int. Nutr. Symp. Iams. CO., ed., pp: 235-244.

Saunders, T.A.B., F.R. Oakley, G.J. Miller, K.A. Mitropouls, D. Crook and M.F. Oliver, 1997. Influence of n-3 versus n-6 polyunsaturated fatty acids in diets low in saturated fatty acids on plasma lipoproteins and hemostatic factors. Arter. Throm. Vasc. Biol., 17: 3449-3460.

Senkoylu, N., 2001. Feed Grade Fats. Trakya University, Faculty of Agriculture, Turkey,pp: 32- 57.

SAS, 2000. SAS/STAT User's Guide, Version 6.12. SAS. Inst. Inc., Tekirdag, Turkey, pp: 32-57.