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Research article

EFFECT OF THE SUPPLEMENTATION OF THE LAYING QUAILS RATION WITH SESAME (*SESAMUM INDICUM*) SEEDS AND OIL ON EGG QUALITY TRAITS

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ABSTRACT: The aim of this study was to determine the influence of feeding diet containing different levels of sesame seeds and oil on egg quality of laying quail. A total of 120, 10 weeks old were randomly assigned to 1 of 5 dietary groups, and were fed for 12 weeks diets containing 0 % sesame seeds + 0 % sesame oil (control group; C) or 0.5 % sesame oil (T1), 1 % sesame oil (T2), 1 % sesame seeds (T3), and 2 % sesame seeds (T4). The study was terminated when the birds were 22 weeks of age. Egg quality characteristics involved in the present study were egg weight, yolk diameter, yolk height, yolk weight, albumen height, albumen weight, Haugh unit, shell weight, shell thickness, shell percentage, yolk percentage, and albumen percentage. The addition of sesame seeds and oil to the diets of laying quail (T1; T2; T3; T4) resulted in significant improvement in the total means of the traits and the mean of trait during all periods of study respecting egg weight, yolk diameter, yolk height, yolk weight, albumen height, albumen weight, Haugh unit, shell weight, shell thickness, shell percentage, yolk percentage, and albumen percentage in comparison with control group (C), with the exclusion of shell percentage when has been observed that there was no significant difference between treatments C and T1 during period 4 and between treatments C, T1, and T2 during period 5. The results obtained in this study suggested that the inclusion of sesame seeds and its' oil into laying quail diets caused significant positive effect on egg quality criteria. Therefore, incorporation of sesame seeds and oil into the diets of Japanese quail may have practical value in manipulating egg quality.

Key words: Sesame seeds and oil, egg quality traits, laying quail.

INTRODUCTION

Lipids are necessary for normal growth and reproduction. The composition of lipids supplied in the diet can have a marked effect on the composition of the lipids within the animals. If the proper fatty acids are not supplied within the diet, or if the proper ratio of various fatty acids is not provided, the problems such as impairments in growth and / or reproduction can occur (Baucells *et al*., 2000). Birds are oviparous and lipids represent 7 to 8 % of whole eggs. The lipids are extremely important for embryonic development, serving as a source of energy as well as essential nutrients. The lipid composition of the egg is influenced by dietary lipid composition of the hen (Zhang *et al*., 2009). Polyunsaturated fatty acids of both n-3 and n-6 series play essential roles in embryonic and neonatal development. The primary function of these fatty acids related to development of neural tissue (Speake *et al*., 1998).

Sesame is described to have originated from Africa and it is thought to be the oldest oil seed known to man. It is the seed of annual herb, *Sesamum indicum*. Sesame plant grows in tropical and subtropical regions with a dry and a rainy season. It is grown in many parts of the world today for its important uses as edible oil, spices, insecticides, medicines, soap, green manure and ornaments. The oil of sesame seed is very resistant to rancidity due to the presence of natural anti – oxidants such as sesamolin, sesamin, and sesamol. It is therefore useful in increasing the shelf life of margarine and other vegetable oil products (Obiajunwa *et al*., 2005). It has been suggested that sesame seeds and oil could have a positive effect on cholesterol levels because of its remarkable antioxidant function. Also sesame seeds and oil have a very high level of omega – 6 polyunsaturated fatty acids, especially linoleic acid, which is assumed to have reducing effect on plasma cholesterol, as well as on coronary heart disease (Rama Rao *et al*., 2008). Linoleic acid can convert to arachidonic acid by α – linolenic acid. A dietary supply of linoleic acid can satisfy the need for arachidonic acid (Dalton, 2000).

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Sesame seeds have a positive amino acid structure - high level of methionine and low level of lysine, this makes it an excellent protein complement to other plant proteins (El-Tinay *et al*., 2007).
The aim of the present study was to evaluate the influence of dietary sesame seeds and oil on egg quality in Japanese quail (*Coturnix coturnix japonica*). Japanese quail are a good model for research due their small size, early sexual maturity (6-7 weeks), ability to produce 3 or 4 generations a year, and the relative ease of maintaining a colony.

MATERIALS AND METHODS

This study was conducted to determine the effect of dietary supplementation with different levels of sesame seeds and oil on egg quality traits of laying quail. One hundred and twenty 10 weeks old Japanese quail (*Coturnix coturnix japonica*) hens were used in this study. Following one week of adaptation period the quails were weighed to provide an equal live weight in all groups at the beginning of the study. They were evenly allotted to 5 treatment groups with 4 replicates per group containing 6 quail each. The birds were housed in wire cages (89 × 60 × 44 cm) in an experimental house on a 16 h lighting schedule. All the birds were fed corn and soybean – meal based diets formulated to meet the nutrient requirements of laying quails. Diets were formulated to be isocaloric and isonitrogenous. The following 5 dietary treatments were used: Group not supplemented with additives served as control (C); T1 and T2: Control diet supplemented with 0.5 % or 1 % sesame oil, respectively; while T3 and T4 represented control diet supplemented with 1 % or 2 % sesame seeds, respectively. The birds received diet and water *ad libitum*. All birds were kept under uniform management conditions throughout the experimental period. The experiment was terminated when the birds were 22 weeks of age. The ingredients and chemical composition of the diets were presented in Table 1. However, the fatty acid composition of sesame oil used in the current study is presented in Table 2.
Egg quality parameters (egg weight, yolk diameter, yolk height, yolk weight, albumen height, albumen weight, Haugh unit, shell weight, shell thickness, shell percentage, yolk percentage, and albumen percentage) were determined fortnightly, using 20 eggs from each experimental group. These traits of egg quality were measured according to Guclu *et al*. (2008).
Data were statistically analysis using the general linear model for analysis of variance (SAS, 2000). Test of significance for the difference levels within each classification was done by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Results of this study clearly revealed that treated laying quails with sesame oil and seeds (T1; T2; T3; T4) resulted in significant increases in the total means of traits and means of traits during all periods of experiment in respect to egg weight, yolk diameter, yolk height, yolk weight, albumen height, albumen weight, Haugh unit, shell weight, shell thickness, shell percentage, yolk percentage, and albumen percentage as compared with control group (C), with an exception for shell percentage where we noticed that there was no significant difference between treatments C and T1 during period 4 and between treatments C, T1, and T2 during period 5 (Tables 3 – 14).
The positive results obtained with relation to all egg quality criteria included in this study may be explained by that sesame seeds and oil contain high level of linoleic acid (22.1 % and 55.03 %, respectively). El-Yamany *et al*. (2008) concluded that inclusion of vegetable oils rich in linoleic acid and linolenic acid to the quail diet get a higher economic efficiency without adverse effects on the productive performance and improve the physiological traits of these birds. Aydin *et al*. (2006) showed that adding conjugated linoleic acid (CLA) to quail diet at a level of 2 % and higher affected egg weight significantly compared to control group.

(1) Tabarak Abu – Al –Deek protein concentrate provided per kg: 42% crude protein; 2200 ME / kg; 9% crude fat; 4.5% crude fiber, 9% calcium, 2.3% available phosphorus; and other nutrients (vitamins + minerals) meet with NRC (15) specification.

(2) Sesame seeds contain 49% total fat; 22.1% linoleic acid; 20.6% oleic acid; 6.4% stearic acid, 6.94% total saturated fatty acids; 21.8% total polyunsaturated fatty acids; 18.7% mono unsaturated fatty acids; 0% cholesterol; 0.45% total omega – 3 fatty acids; 25% total omega – 6 fatty acids and 55.5 omega - 6 / omega – 3 fatty acids ratio.

(3) Calculated composition was according to NRC (1994)

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Table-1: Ingredients and calculated composition of the diets fed to the laying quails.

	Control diet (C)	0.5% sesame oil (T1)	1% sesame oil (T2)	1% sesame seeds (T3)	2% sesame seeds (T4)
Ingredients (%)					
Yellow corn	31	31	31	58.8	57.4
Soybean meal (44%)	18.7	18.7	18.7	21.9	22.3
Wheat	32	32	32	-	-
Protein concentrate (1)	10	10	10	10	10
Hydrogenated vegetable fat	1	0.5	-	1	1
Sesame oil	-	0.5	1	-	-
Sesame seeds (2)	-	-	-	1	2
Lime stone	7	7	7	7	7
Salt	0.3	0.3	0.3	0.3	0.3
Calculated composition (3)					
ME kcal / kg	2803	2803	2803	2801	2801
Crude protein (%)	19.6	19.6	19.6	19.58	19.59
Lysine	0.96	0.96	0.96	0.96	0.97
Methionine	0.35	0.35	0.35	0.36	0.37
Methionine + Cystine	0.64	0.64	0.64	0.68	0.69
Calcium (%)	3.63	3.63	3.63	3.64	3.66
Available phosphorus (%)	0.30	0.30	0.30	0.32	0.33

Table-2: Fatty acids composition (%) of sesame oil included in the diets of quails.

Numeric name	Common name	Fatty acids content (%)
C12:0	Lauric acid	0.016
C14:0	Myristic acid	0.64
C15:0	None	0.04
C16:0	Palmitic acid	18.72
C17:0	Margaric acid	0.14
C18:0	Stearic acid	2.69
C20:0	Arachidic acid	0.24
C21:0	None	0.01
C22:0	Behenic acid	0.22
C23:0	None	0.02
C24:0	Lignoceric acid	0.11
C14:1	Myristoleic acid	-
C15:1	None	-
C16:1	Palmitoleic acid	0.49
C17:1	None	0.09
C18:1 n9	Oleic acid	20.34
C20:1 n9	Gadoleic acid	0.26
C22:1 n9	Erucic acid	-
C24:1 n9	Nervonic acid	0.06
C18:3 n3	Alpha linolenic acid	0.72
C20:3 n3	None	0.01
C20:5 n3	Eicosapentenoic acid (EPA)	0.20
C22:6 n3	Docosahexaenoic acid (DHA)	0.06
C18:2 n6	Linoleic acid	55.03
C18:3 n6	Gamma linolenic acid	0.05
C20:2 n6	11, 14 – Eicosadienoic acid	0.06
C22:2 n6	13, 16 – Docosadienoic acid	-
Total of saturated fatty acids		22.84
Total of mono unsaturated fatty acids		21.23
Total of polyunsaturated fatty acids		55.91
Total of omega – 3 fatty acids		0.984
Total of omega – 6 fatty acids		54.94
Total of omega – 6 / total omega – 3 fatty acids ratio		55.8

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Table-3: Effect of feeding diets containing different levels of sesame oil and sesame seeds on egg weight (g) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	9.39 ± 0.82 [c]	10.60 ± 0.46 [b]	11.12 ± 0.50 [a]	10.18 ± 0.30 [b]	9.86 ± 0.39 [b]	*
2	11.08 ± 0.80 [b]	11.30 ± 0.48 [a]	11.57 ± 0.54 [a]	11.50 ± 0.70 [a]	11.47 ± 0.31 [a]	*
3	10.84 ± 0.69 [b]	11.98 ± 0.20 [a]	11.41 ± 0.14 [a]	11.76 ± 0.28 [a]	11.33 ± 0.73 [a]	*
4	10.96 ± 0.66 [c]	12.38 ± 0.29 [a]	11.94 ± 0.92 [b]	12.05 ± 0.79 [a]	12.82 ± 0.90 [a]	*
5	11.79 ± 0.31 [b]	12.79 ± 0.25 [a]	12.73 ± 0.25 [a]	12.60 ± 0.13 [a]	12.44 ± 0.46 [a]	*
Total mean	10.81 ± 0.52 [c]	11.81 ± 0.34 [a]	11.75 ± 0.36 [a]	11.61 ± 0.37 [b]	11.58 ± 0.55 [b]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

Table-4: Effect of dietary supplementation with sesame oil and sesame seeds on yolk diameter (mm) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	20.48 ± 0.73 [c]	22.57 ± 0.37 [a]	23.53 ± 1.29 [a]	21.97 ± 0.30 [b]	21.32 ± 0.57 [b]	*
2	20.11 ± 0.70 [c]	22.20 ± 0.97 [a]	21.77 ± 0.43 [b]	22.46 ± 1.24 [a]	22.38 ± 0.29 [a]	*
3	20.98 ± 0.79 [c]	23.13 ± 0.99 [a]	23.14 0.16 [a]	22.41 ± 0.34 [b]	22.58 ± 0.37 [b]	*
4	21.72 ± 1.71 [c]	23.69 ± 0.37 [b]	23.30 ± 0.99 [b]	24.75 ± 0.89 [a]	23.63 ± 0.63 [b]	*
5	21.75 ± 0.74 [b]	23.12 ± 0.56 [a]	23.25 ± 0.52 [a]	23.22 ± 0.03 [a]	22.80 ± 0.16 [a]	*
Total mean	21.00 ± 0.69 [b]	22.94 ± 0.59 [a]	23.00 ± 0.47 [a]	22.96 ± 0.05 [a]	22.54 ± 0.16 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
*** : $p<0.05$.**

Table-5: Effect of feeding diets containing different levels of sesame oil and sesame seeds on yolk height (mm) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	11.00 ± 0.56 [c]	11.68 ± 0.21 [b]	12.34 ± 0.59 [a]	11.74 ± 0.25 [b]	11.35 ± 0.20 [b]	*
2	12.03 ± 0.38 [b]	12.40 ± 0.30 [a]	12.48 ± 0.49 [a]	12.40 ± 0.24 [a]	12.94 ± 0.41 [a]	*
3	11.33 ± 0.26 [c]	11.59 ± 0.13 [b]	12.27 ± 0.11 [a]	11.91 ± 0.30 [ab]	11.66 ± 0.34 [b]	*
4	10.92 ± 0.46 [b]	11.85 ± 0.14 [a]	11.91 ± 0.29 [a]	11.64 ± 0.11 [a]	11.84 ± 0.14 [a]	*
5	11.33 ± 0.11 [c]	12.27 ± 0.24 [a]	12.37 ± 0.20 [a]	11.87 ± 0.32 [b]	11.88 ± 0.02 [b]	*
Total mean	11.32 ± 0.11 [c]	11.96 ± 0.16 [b]	12.27 ± 0.19 [a]	11.91 ± 0.20 [b]	11.93 ± 0.08 [ab]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

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Table-6: Effect of dietary supplementation with sesame oil and sesame seeds on yolk weight (g) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	3.21 ± 0.28 [c]	3.76 ± 0.10 [b]	3.90 ± 0.27 [a]	3.69 ± 0.20 [b]	3.94 ± 0.06 [a]	*
2	3.96 ± 0.49 [b]	4.20 ± 0.50 [a]	4.19 ± 0.34 [a]	4.17 ± 0.28 [a]	4.23 ± 0.51 [a]	*
3	3.15 ± 0.28 [c]	3.89 ± 0.14 [a]	3.84 ± 0.56 [a]	3.45 ± 0.40 [b]	3.89 ± 0.13 [a]	*
4	3.78 ± 0.39 [b]	4.67 ± 0.49 [a]	4.56 ± 0.16 [a]	4.42 ± 0.52 [a]	4.91 ± 0.66 [a]	*
5	3.45 ± 0.10 [b]	4.39 ± 0.42 [a]	4.33 ± 0.70 [a]	4.10 ± 0.22 [a]	4.38 ± 0.17 [a]	*
Total mean	3.49 ± 0.18 [c]	4.18 ± 0.23 [ab]	4.18 ± 0.30 [ab]	3.96 ± 0.03 [b]	4.27 ± 0.20 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c]: Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

Table-7: Effect of feeding diets containing different levels of sesame oil and sesame seeds on albumen height (mm) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	4.14 ± 0.15 [c]	5.54 ± 0.23 [a]	5.56 ± 0.05 [a]	4.64 ± 0.38 [b]	5.30 ± 0.14 [a]	*
2	4.92 ± 0.06 [b]	5.37 ± 0.19 [a]	5.52 ± 0.10 [a]	4.54 ± 0.18 [a]	5.37 ± 0.34 [a]	*
3	3.68 ± 0.25 [c]	4.93 ± 0.36 [b]	5.40 ± 0.07 [a]	4.85 ± 0.24 [b]	4.76 ± 0.19 [b]	**
4	4.11 ± 0.62 [c]	4.42 ± 0.21 [b]	4.56 ± 0.42 [b]	4.89 ± 0.43 [b]	5.23 ± 0.18 [a]	*
5	4.28 ± 0.17 [b]	4.90 ± 0.07 [a]	5.12 ± 0.12 [a]	4.73 ± 0.16 [a]	4.81 ± 0.13 [a]	**
Total mean	4.47 ± 0.17 [b]	5.03 ± 0.08 [a]	5.23 ± 0.11 [a]	4.93 ± 0.15 [a]	5.09 ± 0.14 [a]	**

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$; [**]: $p<0.01$.

Table-8: Effect of dietary supplementation with sesame oil and sesame seeds on albumen weight (g) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	5.31 ± 0.40 [c]	6.09 ± 0.28 [b]	6.52 ± 0.20 [a]	6.29 ± 0.51 [a]	6.54 ± 0.33 [b]	*
2	6.32 ± 0.42 [b]	6.50 ± 0.08 [a]	6.68 ± 0.19 [a]	7.07 ± 0.38 [a]	6.79 ± 0.45 [a]	*
3	6.26 ± 0.97 [c]	7.63 ± 0.06 [a]	6.75 ± 0.67 [b]	7.50 ± 0.31 [a]	7.24 ± 0.62 [a]	*
4	6.30 ± 0.76 [c]	7.31 ± 0.15 [b]	7.35 ± 1.01 [b]	7.69 ± 0.57 [a]	7.83 ± 0.15 [a]	*
5	7.00 ± 0.37 [c]	7.60 ± 0.19 [a]	7.63 ± 0.43 [a]	7.77 ± 0.22 [a]	7.82 ± 0.34 [a]	*
Total mean	6.23 ± 0.43 [c]	7.03 ± 0.05 [b]	6.99 ± 0.21 [b]	7.16 ± 0.13 [a]	7.24 ± 0.32 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

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Table-9: Effect of feeding diets containing different levels of sesame oil and sesame seeds on Haugh unit (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	90.53 ± 0.75 [c]	95.59 ± 0.91 [a]	95.37 ± 0.50 [a]	91.31 ± 1.85 [b]	95.39 ± 0.84 [a]	*
2	92.19 ± 0.90 [c]	94.28 ± 1.12 [b]	94.86 ± 0.68 [ab]	95.00 ± 0.55 [a]	94.15 ± 1.59 [b]	*
3	85.38 ± 1.15 [c]	91.49 ± 2.06 [b]	94.38 ± 0.36 [a]	91.24 ± 1.44 [b]	91.14 ± 0.51 [b]	*
4	88.19 ± 3.13 [d]	88.47 ± 1.18 [c]	89.59 ± 1.87 [b]	91.22 ± 2.35 [ab]	92.56 ± 1.27 [a]	*
5	88.17 ± 0.73 [c]	90.86 ± 0.48 [b]	92.07 ± 0.57 [a]	90.06 ± 0.85 [b]	90.59 ± 0.85 [b]	*
Total mean	88.89 ± 0.69 [d]	92.23 ± 0.51 [b]	93.31 ± 0.54 [a]	91.82 ± 0.80 [c]	92.78 ± 0.68 [ab]	*

Each period represented 14 days.

C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.

[a, b, c] : Means within a row lacking a common superscript differ significantly.

* : $p<0.05$; [**]: $p<0.01$.

Table-10. Effect of dietary supplementation with sesame oil and sesame seeds on shell weight (g) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	0.58 ± 0.081 [d]	0.76 ± 0.119 [b]	0.84 ± 0.102 [a]	0.70 ± 0.102 [c]	0.88 ± 0.017 [a]	*
2	0.60 ± 0.065 [d]	0.70 ± 0.048 [c]	0.75 ± 0.023 [b]	0.86 ± 0.086 [a]	0.82 ± 0.032 [a]	*
3	0.64 ± 0.043 [c]	0.86 ± 0.027 [a]	0.82 ± 0.036 [b]	0.81 ± 0.104 [b]	0.85 ± 0.053 [a]	*
4	0.77 ± 0.067 [d]	0.80 ± 0.118 [c]	0.94 ± 0.017 [b]	0.94 ± 0.019 [b]	1.08 ± 0.111 [a]	*
5	0.79 ± 0.049 [d]	0.82 ± 0.050 [c]	0.87 ± 0.024 [b]	0.88 ± 0.107 [a]	0.94 ± 0.022 [a]	*
Total mean	0.67 ± 0.054 [d]	0.79 ± 0.011 [c]	0.84 ± 0.021 [b]	0.83 ± 0.060 [b]	0.91 ± 0.026 [a]	*

Each period represented 14 days.

C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.

[a, b, c] : Means within a row lacking a common superscript differ significantly.

* : $p<0.05$.

Table-11: Effect of feeding diets containing different levels of sesame oil and sesame seeds on shell thickness (mm) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	0.140 ± 0.015 [d]	0.177 ± 0.018 [c]	0.170 ± 0.011 [c]	0.200 ± 0.015 [a]	0.193 ± 0.005 [b]	*
2	0.153 ± 0.012 [d]	0.160 ± 0.006 [c]	0.187 ± 0.009 [b]	0.190 ± 0.015 [a]	0.191 ± 0.011 [a]	*
3	0.167 ± 0.012 [d]	0.187 ± 0.003 [a]	0.180 ± 0.012 [b]	0.177 ± 0. 013 [c]	0.183 ± 0.015 [ab]	*
4	0.163 ± 0.009 [d]	0.176 ± 0.022 [c]	0.227 ± 0.009 [ab]	0.213 ± 0.015 [b]	0.243 ± 0.017 [a]	*
5	0.163 ± 0.009 [d]	0.173 ± 0.015 [c]	0.199 ± 0.021 [b]	0.201 ± 0.003 [b]	0.223 ± 0.009 [a]	*
Total mean	0.157 ± 0.010 [e]	0.174 ± 0.001 [d]	0.192 ± 0.002 [c]	0.196 ± 0.012 [b]	0.206 ± 0.003 [a]	*

Each period represented 14 days.

C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.

[a, b, c] : Means within a row lacking a common superscript differ significantly.

* : $p<0.05$

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Table-12: Effect of dietary supplementation with sesame oil and sesame seeds on shell percentage (%) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	6.17 ± 1.13 [d]	7.16 ± 0.79 [b]	7.55 ± 0.59 [b]	6.87 ± 1.02 [c]	8.92 ± 0.26 [a]	*
2	5.41 ± 0.96 [c]	6.19 ± 0.60 [b]	6.48 ± 0.16 [b]	7.47 ± 0.38 [a]	7.14 ± 0.09 [a]	*
3	5.90 ± 0.74 [d]	7.17 ± 0.20 [b]	7.18 ± 0.41 [b]	6.88 ± 0.74 [c]	7.50 ± 0.84 [a]	*
4	7.02 ± 1.14 [c]	6.46 ± 1.12 [c]	7.87 ± 0.57 [b]	7.80 ± 0.71 [b]	8.42 ± 0.31 [a]	*
5	6.70 ± 0.56 [c]	6.41 ± 0.44 [c]	6.83 ± 0.30 [bc]	6.98 ± 0.80 [b]	7.55 ± 0.44 [a]	*
Total mean	6.24 ± 0.69 [d]	6.67 ± 0.23 [c]	7.18 ± 0.04 [b]	7.20 ± 0.46 [b]	7.90 ± 0.18 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

Table-13: Effect of feeding diets containing different levels of sesame oil and sesame seeds on yolk percentage (%) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	34.18 ± 1.79 [d]	35.47 ± 1.06 [c]	35.07 ± 1.40 [c]	36.24 ± 2.88 [b]	39.95 ± 0.78 [a]	*
2	35.74 ± 2.30 [c]	37.16 ± 2.77 [a]	36.21 ± 1.25 [b]	36.26 ± 0.85 [b]	36.87 ± 4.12 [a]	*
3	29.05 ± 4.41 [e]	32.47 ± 0.68 [c]	33.65 ± 5.07 [b]	29.33 ± 2.89 [d]	34.33 ± 0.76 [a]	*
4	34.48 ± 3.57 [d]	37.72 ± 3.19 [b]	38.94 ± 3.53 [a]	36.68 ± 2.92 [c]	38.29 ± 2.64 [a]	*
5	29.26 ± 1.25 [d]	34.32 ± 2.68 [b]	34.01 ± 4.74 [b]	32.53 ± 1.42 [c]	35.20 ± 0.61 [a]	*
Total mean	32.45 ± 2.11 [d]	35.42 ± 1.24 [b]	35.57 ± 2.14 [b]	34.20 ± 0.55 [c]	36.92 ± 1.05 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$; [**]: $p<0.01$.

Table-14: Effect of dietary supplementation with sesame oil and sesame seeds on albumen percentage (%) (Mean ± SE) of laying quail.

Periods	Treatments					Level of significance
	C	T1	T2	T3	T4	
1	56.54 ± 0.90 [d]	57.45 ± 0.48 [c]	58.63 ± 1.45 [c]	61.78 ± 3.53 [b]	66.32 ± 0.93 [a]	*
2	57.03 ± 2.05 [d]	57.52 ± 2.38 [c]	57.73 1.19 [c]	61.47 ± 1.23 [a]	59.19 ± 4.10 [b]	*
3	57.74 ± 5.13 [c]	63.68 ± 0.68 [a]	59.15 ± 5.35 [b]	63.77 ± 3.57 [a]	63.90 ± 1.58 [a]	*
4	57.79 ± 4.06 [d]	59.04 ± 2.33 [c]	61.55 ± 4.09 [b]	63.81 ± 2.91 [a]	61.07 ± 2.94 [b]	*
5	59.37 ± 1.80 [c]	59.43 ± 2.26 [b]	59.93 ± 4.44 [b]	61.66 ± 2.22 [a]	62.86 ± 0.79 [a]	*
Total mean	57.69 ± 2.36 [c]	59.42 ± 1.01 [b]	59.39 ± 2.13 [b]	62.49 ± 0.64 [a]	62.66 ± 1.19 [a]	*

Each period represented 14 days.
C: Control diet; T1 and T2: Diet supplemented with 0.5% or 1% sesame oil, respectively; and T3 and T4: Diet supplemented with 1% or 2% sesame seeds, respectively.
[a, b, c] : Means within a row lacking a common superscript differ significantly.
* : $p<0.05$.

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Dalton (2000) found that the use of soybean oil as a source of linoleic acid in quail diet resulted in significant increase in egg weight, shell weight, albumen weight, yolk weight, percentage of albumen dry matter, and percentage of yolk dry matter. Bozkurt *et al*. (2008) reported that supplementation of sunflower oil at the level of 1.5 % as a source of linoleic acid to the corn – soybean meal diet of broiler breeder may affect egg production, egg weight, fertility, chick weight, hatch of egg set without any adverse effect on body weight and egg settable characteristics. Guclu *et al*. (2008) indicated that the supplementation of sunflower, soybean, cottonseed and maize oils as sources of linoleic acid resulted in significant increase in egg weight, specific gravity, egg yolk index and the Haugh unit. Midilli *et al*. (2009) demonstrated that sunflower oil and poppy seed oil supplementation into quail diets as sources of linoleic acid caused positive effects due to decreasing of saturated fatty acids and increasing of unsaturated fatty acids in egg yolk without adverse effects on laying performance, fertility, hatchability and egg quality traits (egg weight, shell thickness, albumen index, yolk index, and Haugh unit) of laying quails. Rama Rao *et al*. (2008) reported that the biological effect of the n-6 fatty acids are largely mediated by their conversion to n-6 eicosanoids that bind to diverse receptors found in every tissue of the body. The conversion of tissue linoleic acid (18:2 n-6) to arachidonic acid (20:4 n-6) and then to n-6 prostaglandin and n-6 leukotriene hormones provides targets for pharmaceutical drug development and treatment to diminish excessive n-6 action in atherosclerosis, asthma, arthritis, vascular disease, thrombosis, immune – inflammatory processes and tumor proliferation. Diarra and Usman (2008) found that replacing soybean meal with soaked sesame seed meal at a level of 12.5 % in the diet of laying hens will meet their methionine requirement without adverse effects on performance and health status.

On the other hand, the significant improvement concerning egg quality traits recorded in the present study when diets of laying quail were supplemented with sesame seed and oil might be account for their content of other active components. Snaker *et al*. (2006) indicated that sesame oil and seeds have long been categorized as a traditional health food in India and other East Asian countries. Sesame oil and seeds have been found to contain considerable amounts of the sesame lignans: sesamine, episesamine, and sesamolin. Sesame also contains vitamin E (30 – 50 mg / 100 g), 40 – 60 percent of PUFA, and 20 – 40 percent MUFA. The lignans present in sesame are thought to be responsible for many of its unique chemical and physiological properties, including its antioxidant and antihypertensive properties. Moazzami and Kamal-Eldin (Moazzami and Kamal Eldin, 2006) found that sesame oil and seeds had an average of 0.63 and 0.39 lignans, respectively, making them a rich source of dietary lignans. Lignans are phytoestrogens with estrogenic or anti – estrogenic activity. Lignans may also have antioxidant activity. Plant lignan compounds are converted in the intestine to form of lignans (enterolignans) the human and animal body can assimilate. Some studies have reported a positive association between high level of lignans in the body with reduced risks of prostate cancer, ovarian cancer, breast cancer, osteoporosis, and cardiovascular disease (Midler *et al*., 2005). Abdul-Rahman *et al*. (2009) reported that treatment broiler breeder hens with sesame seed capsules (250 and 500 mg / kg of body weight) given orally daily for 4 weeks enhanced erythropoiesis, FSH and LH activity and some productive parameters. Cooney *et al*. (2001) showed that consumption of moderate amounts of sesame seeds appears to significantly increase plasma gamma – tocopherol and alter plasma tocopherol ratios in humans and is consistent with the effects of dietary sesame seeds observed in rats leading to elevated plasma gamma – tocopherol and enhance vitamin E bioactivity. Zhang *et al*. (2008) indicated that CLA enhances the activity of antioxidant enzymes including total superoxide dismutase and catalase. Supplementation of CLA has been show to ameliorate the antioxidant balance and performance of chicks during oxidative stress. Sesame seed are loaded with powerful antioxidant: IP-6 (AKA: Phytate; one of the most powerful antioxidants yet found, and one of the most potent natural anti cancer substances, especially abundant in grain and sesame), lignans, sesamin, sesaminol, sesamolinol, sesamolin, pinoresinol, vitamin E, lecithin, myristic acid, and linoleate. Lignans are fat – soluble antioxidants such as, sesaminol, sesamolinol and sesamolin. They prevent free radical formation, and scavenge free radicals that already form (Nakai *et al*., 2003). However, Fazel *et al*. (2009) summarized the advantages of sesame antioxidants as follows: Sesamolin inhibits lipid peroxidation (free radical formation), sesame has a variety of effective antioxidants, antioxidant activity of sesaminol in defatted sesame flour protects against oxidative stress from dietary cholesterol, sesamine decreases formation of inflammatory prostaglandins, sesame enhances antioxidant activity of vitamin E.

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Sesame lignans have a sparing effect on vitamin E, preventing damage to vitamin E, DHA (from fish oils) decreases vitamin E level, sesame raises it, DHA (from fish oils) create lipid peroxidation (free radicals), damage red blood cells. Sesame decreases the damage to fats and red blood cells, raises vitamin E levels; sesamin decreases breakdown of vitamin E, sesame provides gamma – tocopherol (an especially helpful form of vitamin E). Sesame lignans lower cholesterol levels, flax lignans don't, sesame muffins significantly raised gamma – tocopherol levels. Muffins containing the same amount of gamma – tocopherol from soy or walnut didn't do anything. Gamma tocopherol is a very effective form of vitamin E, sesaminol more effective antioxidant than alpha – tocopherol (most common form of vitamin E), sesame seed and oil contain several important antioxidants that are believed to promote the integrity of body tissues in the presence of oxidizing compounds. The antioxidants sesaminol and sesamolinol maintain fats, including low density lipoproteins (LDL), in an unoxidized state. Sesamolin and sesamol are also antioxidants found in sesame seed oil, sesaminol and sesamin found in sesame seed and oil increases vitamin E activity dramatically, acting synergistically with vitamin E to provide antioxidant compounds known as eicosanoids, promote a balanced immune and auto – immune response, and sesame lignans may promote healthy liver and strengthen the heart and nervous system (Yamashita *et al*., 1992). However, in females vitamin E accumulates in the granulose and theca cells. Like β – carotene and ascorbic acid, it breaks down proxyl radicals and other highly reactive oxygen species that are formed increasingly during maturation of tertiary follicles. HDL is closely involved in the transport of vitamin E into the ovaries. The number of HDL receptors in tertiary follicles is increased by LH hormone. Vitamin E is also required for the normal growth and development of embryos (Hunton, 1995). Obiajunwa *et al*. (2005) reported that sesame seed not only are very good source of manganese and cupper, but they are also good source of calcium, magnesium, iron, phosphorus, vitamin B1, tryptophan, methionine, zinc and dietary fiber. In addition to these important nutrients, sesame seeds contain two unique substances: sesamin and sesamolin. Both of these substances belong to a group of special beneficial fibers called lignans, and have been shown to have cholesterol – lowering effect, and to prevent high blood pressure and increase vitamin E supplies in human and animals. Sesamin has also been found to protect the liver and heart from oxidative damage (Sirato *et al*., 2001).

CONCLUSION

The data suggest that feeding laying quail with diets containing sesame oil and seeds recorded the best results regarding egg quality parameters included in this study. Therefore, incorporation of these feed stuffs into the diets of laying quail may have practical value in improvement egg quality of these birds.

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