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Original Article

Possibilities of Using Chia Oil as an Omega-3 Source in Laying Quail Diets

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ABSTRACT

This study aims to investigate the effects of different levels of chia (*Salvia Hispanica* L.) seed oil supplementation as omega-3 source to the diets of laying quails on yield performance, egg quality, and egg yolk fatty acid profiles. The study was conducted including 4 treatment groups as follows: C0 (0 g/kg diet), C1 (1 g/kg diet), C2 (2 g/kg diet), and C3 (3 g/kg diet). In the study, 96 female quails at the age of 18 weeks were used and the trial was carried out for 4 weeks. As a result, it was determined that chia seed oil supplementation to the diet was not effective on feed consumption, feed conversion ratio, egg yield, or egg weight of quails, but it was effective on the yolk index of egg quality characteristics ($p<0.05$). The most important effect of chia seed oil supplementation to the diet was determined to be on the omega-3/omega-6 ratio of egg yolk. Dietary chia seed oil increased the omega-3/omega-6 ratio ($p<0.01$). It can be stated that increasing the level of omega-3 in the diets, positively affects the polyunsaturated fatty acid (PUFA)/saturated fatty acid (SFA) ratio.

INTRODUCTION

Chia plant (*Salvia Hispanica* L.) is a plant from the Lamiaceae family and is cultivated for its seeds and oil (Bochicchio *et al.*, 2015). Also known as a superfood, Chia contains high levels of essential fatty acids, fiber, vitamins, and antioxidants (Chavan *et al.*, 2017). In 100 grams of Chia seeds, there are 60-62 g α-linolenic acid, 19-20 g linoleic acid, 7-8 g palmitic acid, 7-7.5 g oleic acid, and 3-4 g stearic acid (Ullah *et al.*, 2016). Chia seed oil consists of 11.12% saturated fatty acid (SFA), 7.29% monounsaturated fatty acid (MUFA), and 81.59% polyunsaturated fatty acid (PUFA) (Da Silva Marineli *et al.*, 2014). Muñoz *et al.* (2013) and Ullah *et al.* (2016) reported that approximately 90% of Chia seed oil consists of PUFA and 55-64% of which is omega-3 and 18-20% is omega-6 fatty acids.

PUFA is essential for humans and must be taken externally because it cannot be synthesized by the cells (Harauma *et al.*, 2017). When metabolized, it has the effect of reducing blood cholesterol and triglyceride levels (Santos *et al.*, 2017). However, high consumption of n-6, which is the PUFA content in the diet, brings with it various risks of diseases (Bhardwaj *et al.*, 2016). It is reported that the increase in the level of omega-6/omega-3 in the diet increases cardiovascular diseases, and this risk decreases with the increase in the rate of omega-3 in the diet (Antruejo *et al.*, 2011; Ahmed, 2019).

The fact that dietary fat properties and cholesterol levels are directly related to heart diseases and that the egg contains significant levels of fat and cholesterol, causes a reduction in egg consumption (Ayerza & Coates, 2002). For this reason, many studies have been carried out to change the fat and cholesterol content of egg yolk with the modification of diets, but the desired results could not be obtained in terms of cholesterol levels (Ayerza & Coates, 2002). Studies on the modification of egg yolk fatty acid composition have been more successful. Successful results have been achieved in increasing the omega-3 level of the egg, a food that can be considered poor in terms of omega-3 content (Ayerza & Coates, 2002; Ahmed, 2019).

Compared to other vegetable oils such as corn oil (76.5), canola oil (2.2), soybean oil (6.7), and olive oil (17.8), the n-6/n-3 ratio of Chia oil is relatively low (Álvarez-Chávez *et al.*, 2008). It can be expected that the low n-6/n-3 ratio of Chia oil would contribute to the increase of the n-3/n-6 ratio of the yolk and thus the functional egg production.

In the poultry industry, efforts to increase the feeding value of eggs are ongoing (Mustafa *et al.*, 2016). This is because foods rich in omega-3 have higher economic returns (Ahmed, 2019). Today, the effects of Chia seed oil, which has rich omega-3 content, on the performance characteristics and egg quality of poultry are an object of curiosity. In a study comparing the effects of supplementing the diets of laying hens with Chia seed oil, flaxseed oil, and fish oil, it was reported that the amount of n-3 fatty acids in the eggs of chickens consuming Chia seed oil increased by 100-120% compared to the eggs of chickens consuming other fats (Ayerza, 2008). Ahmed (2019) reported that for hens, the supplementation of fat sources high in omega-3 content, such as Chia oil, to the diet had positive effects on egg yield, egg weight, feed conversion ratio, and some egg quality criteria. It was found that Chia seeds supplemented to the diets of laying quails increased egg yolk PUFA levels by 2.96% and decreased n-6/n-3 and SFA/PUFA ratios (Castro-Tamayo, 2017). It was found that the supplementation of Chia seeds in the diets of broilers at 10-20% levels did not have a significant effect on blood cholesterol, it decreased the fat and palmitic acid levels in dark meat and increased the α-linolenic acid level significantly (Ayerza & Coates, 2002).

In this study, it was aimed to investigate the effects of increasing omega-3 by using different levels of chia oil in the diets on some performance traits and egg quality characteristics of quails.

MATERIALS AND METHODS

Experimental Design and Housing

A total of 96 laying Japanese quails aged 18 weeks were used in the experiment. The experiment was designed in four dietary treatments having four replications of each. In the study, 6 quails for each replication and 24 quails for each treatment group were used.

The study was conducted in the research farm of Bingol University, Faculty of Agriculture, Department of Animal Science, in Turkey. The study was conducted through September-October of 2019 and completed in 4 weeks. During the experiment, the temperature and humidity were recorded by data logger. The average temperature and relative humidity was measured as 24.8 °C and 37.6% respectively. The quails were housed in a 6-story cages during the experiment. The lighting program was applied as 16 hours light - 8 hours dark.

Diets

Nutrient analyses of all raw materials to be used in the diets were performed, and the experimental diets were prepared according to the results of these analyses (Table 1). Chia seed oil which was supplemented in different levels to the basal diet was supplied from a commercial firm. Fatty acids profiles of Chia seed oil used in the diets are shown in table 2. In the experiment, 4 different diets were used, one as the control diet and 3 as the treatment diets (containing 1 g/kg, 2 g/kg and 3g/kg Chia seed oil).

Table 1 - Experimental Diet.

Ingredients	C0	C1	C2	C3
Corn (%)	71.07	71.07	71.07	71.07
Soybean meal (%)	18.57	18.57	18.57	18.57
Sunflower oil (%)	1.35	1.35	1.35	1.35
Limestone (%)	5.49	5.49	5.49	5.49
Chia Oil (%)	0	0.1	0.2	0.3
Dicalcium Phosphate (%)	1.65	1.65	1.65	1.65
Methionine (%)	0.40	0.40	0.40	0.40
Lysine	1.00	1.00	1.00	1.00
Salt (%)	0.20	0.20	0.20	0.20
Vit-Min. (%)	0.25	0.25	0.25	0.25
Total (%)	100	100	100	100
Calculated Analysis				
Metabolizable Energy (kcal/kg)	2800	2800	2800	2800
Crude protein (%)	16	16	16	16
Ether extract (%)	3.81	3.81	3.81	3.81
Crude fiber (%)	2.5	2.5	2.5	2.5
Methionine (%)	0.4	0.4	0.4	0.4
Lysine (%)	1.01	1.01	1.01	1.01
Ash (%)	9.49	9.49	9.49	9.49

Each kg diet contains: Vit A 12000 IU, Vit D_3 2000 IU, Vit E 35 mg, Vit K_3 5 IU, Vit B_1 3 mg, Vit B_2 6 mg, Vit B_6 5 mg, Vit B_{12} 0.015 mg, Vit C 50 mg, D-Biotin 0.045 mg, Niacin 20 mg, Ca D-Pantothenate 6 mg, Folic acid 0.75 mg, Choline chloride 12.5 mg, Manganese 80 mg, Iron 60 mg, Zinc 60 mg, Copper 5 mg, Iodine 1 mg, Cobalt 0.2 mg, Selenium 0.15 mg, Canthaxanthin 15 mg, ß-apo-8′- Carotenoic acid ethyl ester 5 mg.

Table 2 – Fatty acids profiles of Chia Seed Oil.

C14:0 (Myristic acid)	0.05
C16:0 (Palmitic acid)	8.09
C17:0 (Heptadecanoic acid)	0.13
C18:0 (Stearic acid)	2.97
C 18:1 (Oleic acid)	5.93
C 18:2 (Linoleic acid)	19.21
C 18:3 (α- Linolenic acid)	59.78
C 20:0 (Arachic acid)	0.24
Undefined fatty acids	3.6
Total	100
SFA	11.48
MUFA	5.93
PUFA	78.99
PUFA/SFA	6.88
Omega-3/Omega-6	3.11

SFA: Saturated Fatty Acids, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids.

Parameters

In this study, feed consumption, feed conversion ratio, egg production, egg weight, egg quality and yolk fatty acid profile of quails were determined. Feed consumption, egg yield, and egg weight of the groups were measured daily. Egg quality characteristics were measured twice, in the 2nd and 4th weeks. Yolk fatty acid profiles were determined by the samples taken at 4 weeks according to Folch method (Folch *et al.* 1957).

Eggs were collected for 3 days in the 2nd and 4th weeks of the experiment. A total of 80 eggs, 20 from each group, were examined. The eggs being examined were collected for 3 times in a day and stored at room temperature for 24 hours before the measurements. The eggs were first numbered then weighed. The width and length of the eggs were then measured with a digital caliper. After these procedures, 10 minutes later the eggs were broken on the glass on the prepared table, yolk and albumen diameter measured with a digital caliper, yolk and albumen height measured with three leg micrometer. The yolk color of the eggs was determined using the DSM Yolk Color Fan. After that the weights of the egg yolks were determined by separating the yolks from the albumen. On the other hand, the egg shells were washed in water and dried at room temperature for 24 hours. The dried shells were first weighed together with the shell membranes, and their weights were determined. Then, the thickness of the shell was measured from three different places, namely the pointed, blunt, and middle parts of the egg with digital micrometer, and the shell thickness was determined by averaging these three measurements.

The necessary calculations were made by using the following formula,

Hen day egg production= Number of eggs produced / Number of laying hens x 100 %

Feed conversion ratio: Consumed Diet (kg) / Egg Production x Egg weight (kg)

Shape index = Egg width x 100 / egg length

Albumen weight = Egg weight - (shell weight + yolk weight)

Yolk index = Height of yolk (mm) / diameter of yolk (mm)

Albumen index = Albumen height (mm) x 100 / average of albumen length and width (mm)

Haugh Unit=100 log (H+7.57-1.7W0.37) H=Albumen height, W=Egg weight

Twelve eggs from each group were collected to determine their fatty acid profiles. Lipids were extracted from eggs by the method of the AOAC (1995). The fatty acid methyl esters were prepared from oil samples and from subsequent fatty acid profiles determined by gas chromatography. The method described by Folch *et al.* (1957) was used to determine the fatty acid profiles in egg yolks. For this purpose, an Optima brand delta-6-0.25 µm (100 m × 0.25 mm ID) column, an Agilent 7890A / 5970C brand Gas Chromatography / Mass Spectrometry (GC-MS) device, and an FID detector was used. Chromatographic conditions were as follows: Oven temperature started at 120ºC, reached 250ºC (5ºC/min), and was kept at this temperature for 3 minutes. Then it reached 270ºC (2ºC/min), it was kept at this temperature for 16 minutes, and this process lasted 55 minutes in total. The injection volume was 1 µl. Before and after each injection, the syringe was washed 5 times with hexane. The main sample was withdrawn after 2 samples were withdrawn and dropped into the waste bottle. Thus, contamination from the previous sample was prevented.

Egg production was recorded daily and feed consumption and egg weight were recorded weekly. Feed conversion ratio was calculated by determining the amount of feed consumed per one kg of egg (Sirovnik *et al.*, 2018).

Statistical Analyses

The experiment was designed as 4 groups and 4 replications and 20 eggs from each group were measured. The data obtained from the research were analyzed using SAS 9.1.3 program. One-way analysis of variance (ANOVA) was performed by using the PROC GLM command. The establishment of the difference between the average values of parameters was determined by applying Duncan's multiple range comparison tests, using a 5% significance level.

Mathematical model:

$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij}$

Y_{ij} : All observation

μ : Population mean

α_i : Treatment effect

ε_{ij} : Error

RESULTS AND DISCUSSION

According to the results of the research, no statistically significant differences were found between the control and treatment groups in terms of average daily feed consumption of laying quails (Table 3). The results of many studies conducted on this subject showed that the use of different fat sources in the diet did not significantly affect the feed consumption of quails (Güçlü *et al.*, 2008; Al-Daraji *et al.*, 2010) The results obtained in this study regarding feed consumption were similar to the findings reported by Castro-Tamayo (2017) and Antruejo *et al.* (2011).

Table 3 presents the 4-week feed consumption and feed conversion ratio of the groups. Similarly, the differences between the averages belonging to the treatment groups were not significant in terms of feed conversion ratio and it was found that supplementing the diet with Chia oil up to 3 g/kg did not affect feed conversion ratio. Results related to feed conversion ratio were similar to the results of Antruejo *et al.* (2011)'s study of supplementing the diets of laying hens with Chia oil.

Table 3 – Averages of daily feed consumption and feed conversion ratios of quails.

Groups	Periods			
	1st wk	2nd wk	3rd wk	4th wk
	Daily feed intake, (g)			
C0	29.85±0.51	28.15±0.36	31.32±1.44	32.55±1.01
C1	29.95±0.21	28.12±0.62	33.87±0.78	31.90±0.59
C2	30.05±0.28	27.17±0.68	32.30±0.65	31.05±0.25
C3	30.97±1.38	28.75±1.47	34.07±2.12	33.20±1.29
p	NS	NS	NS	NS
Feed conversion ratio, (g:g)				
C0	3.76±0.15	2.86±0.10	3.26±0.12	3.23±0.04
C1	3.43±0.21	2.98±0.10	3.26±0.07	3.37±0.11
C2	3.32±0.10	2.86±0.13	3.41±0.20	3.21±0.19
C3	3.18±0.06	3.12±0.20	3.59±0.02	3.44±0.05
p	NS	NS	NS	NS

Differences between means in the same column are insignificant. NS: insignificant. C0: Control, C1: 1 g/kg Chia oil, C2: 2 g/kg Chia oil, C3: 3 g/kg Chia oil.

Table 4 presents the egg yields and egg weights of the control and treatment groups. It was reported that egg yield is not affected by the supplementation of vegetable oils rich in n-3 to the diets of quails (Manohar & Edwin, 2016). While the results of this study were different from the results of the studies by Ayerza & Coates (1999) and Ayerza & Coates (2002) in which they supplemented the diets of laying hens with Chia seeds, they were similar to the results of studies by Ayerza & Coates (2001) and Castro-Tamayo (2017) and Antruejo *et al.* (2011) in which the diets of laying hens were supplemented with Chia oil.

It was determined that the supplementation of Chia oil up to 3 g/kg to the diet did not cause a statistically significant difference in terms of egg weight between the trial groups, that is, the egg weight was not affected by the application of Chia oil (Table 4). Results regarding the weights of the eggs were similar to the results of the studies by Ayerza & Coates (1999) and Ayerza & Coates (2001) in which the diets of laying hens were supplemented with Chia seeds and by Antruejo *et al.* (2011) in which the diet was supplemented with Chia oil.

Table 4 – Average egg yield and egg weight of quails.

Groups	Periods			
	1st wk	2nd wk	3rd wk	4th wk
	Egg yield, (%)			
C0	70.24±3.57	84.52±3.44	80.36±2.81	83.33±4.01
C1	77.98±4.49	80.95±2.17	86.31±3.28	80.35±2.25
C2	81.54±1.78	85.12±4.60	82.74±5.44	84.52±4.81
C3	83.33±7.14	79.76±10.71	82.14±5.95	80.95±2.38
p	NS	NS	NS	NS
Egg weight, (g)				
C0	11.35±0.17	11.71±0.15	11.96±0.20	12.11±0.15
C1	11.31±0.16	11.68±0.08	12.07±0.05	11.83±0.16
C2	11.13±0.25	11.25±0.20	11.58±0.20	11.55±0.22
C3	11.31±0.05	11.77±0.14	12.09±0.21	12.20±0.21
p	NS	NS	NS	NS

Differences between means in the same column are insignificant. NS: insignificant. C0: Control, C1: 1 g/kg Chia oil, C2: 2 g/kg Chia oil, C3: 3 g/kg Chia oil.

Internal and external quality measurements of the eggs of quails in the treatment groups yielded statistically significant differences at the end of the 4-week laying period in terms of yolk index and albumin weight (p<0.05, p<0.01). No significant differences were observed between the groups in terms of features such as shape index, yolk and shell weight, shell thickness, albumin index, yolk color, or Haugh unit. In some studies, it was reported that supplementing the diets of quails with different fat sources may affect egg quality (Güçlü *et al.*, 2008; Al-Daraji *et al.*, 2011). Ahmed (2019) reported that supplementing the diets of hens with omega-3 may affect egg quality parameters. Since the yolk contains all of the fat in the egg, it can be argued that the supplementation of a fat source to the diet will have an effect on the yolk (Genchev, 2012).

Table 5 presents the internal and external quality characteristics of all groups. The results obtained regarding the quality of the egg are partially similar to the results reported in the literature. The significant difference regarding the yolk index, which is one of the egg´s quality criteria, observed in this study can be explained by the fact that the egg quality depends not only on the diet but also on the age, genotype, and laying period (Duman *et al.*, 2016).

While the results for yolk weight were not compatible with Ayerza & Coates (1999), they were similar to the findings of Ayerza & Coates (2001), Ayerza & Coates (2002), and Antruejo *et al.* (2011). The findings regarding albumin weight were partially in line with the results reported by Ayerza & Coates (1999) and Ayerza & Coates (2001).

The yolk weight does not mean that the yolk index will be high. Increasing yolk weight does not mean that the yolk index will increase. The yolk index is related to the yolk quality. The higher the yolk index, means the higher the yolk quality (Karabayir *et al.*, 2010). The results obtained for the yolk index, however, differ from the findings of Güçlü *et al.* (2008), in which study the diets of laying quails were supplemented with different fat sources.

Table 5 – Exterior and interior quality traits of the treatment groups.

Groups	Shape index	Shell weight (g)	Shell thickness (mm)	Albumen weight (g)	Yolk weight (g)	Albumen index	Yolk index	Yolk color	Haugh unit
					2nd wk				
C0	77.95±0.70	0.95±0.02	0.21±0.00	6.65±0.08	3.27±0.07	12.93±0.37	49.83±0.72a	11.81±0.61	93.11±0.54
C1	77.52±1.15	0.97±0.01	0.21±0.00	6.68±0.08	3.44±0.08	13.29±0.39	47.95±1.02ab	11.81±0.38	92.83±0.65
C2	78.37±0.55	0.94±0.03	0.21±0.00	6.46±0.05	3.24±0.06	12.14±0.33	46.63±0.61b	12.19±0.24	92.55±0.58
C3	79.46±0.59	0.91±0.03	0.21±0.00	6.51±0.06	3.44±0.05	12.84±0.30	47.48±0.85ab	12.37±0.29	92.92±0.50
p	NS	NS	NS	NS	NS	NS	*	NS	NS
					4th wk				
C0	78.47±1.03	1.03±0.02	0.22±0.00	7.29±0.08b	3.89±0.08	11.91±0.25	47.41±0.74a	12.44±0.26	91.37±0.36
C1	78.16±0.68	1.06±0.03	0.22±0.00	7.33±0.07b	3.94±0.04	12.52±0.40	47.58±0.46a	11.81±0.21	92.94±0.70
C2	77.06±0.82	1.06±0.02	0.22±0.00	7.20±0.10b	4.08±0.07	12.12±0.46	45.25±0.81b	12.19±0.45	92.25±0.74
C3	77.68±0.90	1.07±0.02	0.22±0.00	7.58±0.06a	3.90±0.07	12.55±0.43	48.98±0.80a	12.75±0.19	93.32±0.64
p	NS	NS	NS	**	NS	NS	**	NS	NS

a,b: Differences between means in the same column are significant. NS: insignificant. *: $p<0.05$, **: $p<0.01$. C0: Control, C1: 1 g/kg Chia oil, C2: 2 g/kg Chia oil, C3: 3 g/kg Chia oil.

Table 6 presents the means and standard errors of the egg yolk fatty acid profiles of all groups. At the end of the trial period, egg samples from the control and treatment groups were analyzed. While no statistically significant differences were observed in terms of C14:0 (Myristic acid), C16:0 (Palmitic acid), C16:1 (Palmitoleic acid), C18:0 (Stearic acid), C18:1 (Oleic acid), C18:2 (Linoleic acid), C18:3 (Linolenic acid), C20:4 (Arachidonic acid), SFA, MUFA, PUFA, and PUFA/SFA levels, there were statistically significant differences between the groups regarding C22: 6 Docosahexaenoic acid and omega-3/omega-6 ratios ($p<0.05$, $p<0.01$).

It is known that some fat sources with a high PUFA level can change the components of egg yolk (Güçlü *et al.*, 2008). The PUFA level of Chia oil is around 90% and approximately 55-64% of this is made up of omega-3 fatty acids (Muñoz *et al.*, 2013; Ullah *et al.*, 2016). Docosahexaenoic acid (C22: 6), which was found in the fatty acid profiles of the analyzed egg yolk samples, is one of the omega-3 fatty acids. It can be argued that the reason for the difference between the treatment and control groups in terms of Docosahexaenoic acid levels is the high omega-3 content of Chia oil. Similarly, it was concluded that the high n-3 content of Chia oil was effective in the significance of the differences between the omega-3/omega-6 ratios of the treatment groups. Findings regarding the n-3/n-6 results were similar to the findings of Castro-Tamayo (2017), in which study the diets of laying quails were supplemented with Chia and flax seeds, and Ayerza & Coates (1999), where, the diets of laying hens were supplemented with Chia seeds. The results regarding Docosahexaenoic acid levels were compatible with the findings of Ayerza & Coates (2000) and Güçlü *et al.* (2008).

Norum (1992) reported that the level of SFA in the diet is directly related to cardiovascular diseases. Although the differences between the PUFA/SFA ratios of the analyzed egg samples are not statistically significant, the observed numerical changes are striking. It can be argued that by increasing the level of Chia oil supplemented to the diet (>3 g/kg/diet), the PUFA/SFA ratio may be positively affected. The findings regarding the PUFA/SFA ratio were in line with the findings reported by Castro-Tamayo (2017) and Ayerza & Coates (1999).

Table 6 – Fatty acid profile (%) in yolk of quails at the end of the experimental period.

Fatty acids	C0	C1	C2	C3	*p*
C14:0 (Myristic acid)	0.55±0.07	0.48±0.05	0.46±0.03	0.51±0.02	NS
C16:0 (Palmitic acid)	26.90±0.61	26.30±0.68	26.16±0.43	24.27±1.27	NS
C16:1 (Palmitoleic acid)	5.58±0.48	4.43±0.35	4.77±0.45	4.49±0.16	NS
C18:0 (Stearic acid)	13.08±0.61	14.08±1.06	13.47±0.39	15.45±1.27	NS
C18:1 (Oleic acid)	34.37±1.24	34.08±1.06	34.07±0.79	33.81±0.56	NS
C18:2 (Linoleic acid)	16.46±0.50	16.35±0.77	16.98±1.06	17.18±1.23	NS
C18:3 (α- Linolenic acid)	0.11±0.06	0.44±0.06	0.52±0.18	0.77±0.23	NS
C20:4 (Arachidonic acid)	2.54±0.17	2.82±0.04	2.90±0.20	2.06±0.69	NS
C22:6 (Docosahexaenoic acid)	0.38±0.14c	1.01±0.06ab	0.66±0.22bc	1.44±0.15a	*
SFA	40.54±1.26	40.86±0.69	40.09±0.44	40.23±1.87	NS
MUFA	39.96±1.22	38.51±0.99	38.84±1.20	38.31±0.57	NS
PUFA	19.5±0.44	20.62±0.87	21.07±1.18	21.45±1.68	NS
PUFA/SFA	0.48±0.02	0.50±0.02	0.52±0.03	0.54±0.07	NS
Omega-3/Omega-6	0.03±0.01c	0.07±0.00b	0.06±0.01b	0.11±0.01a	**

a,b,c: Differences between means in the same row with different letters are significant. NS: Non-significant. *: $p<0.05$, **: $p<0.05$. SFA: Saturated Fatty Acids, MUFA: Monounsaturated Fatty Acids, PUFA: Polyunsaturated Fatty Acids.

CONCLUSION

As a result, while the supplementation of different levels of Chia seed oil to the diets of laying quails did not affect the performance characteristics such as feed consumption, feed conversion ratio, egg yield, and egg weight, it significantly affected egg quality characteristics such as the yolk index and albumin weight. Dietary Chia oil significantly increased the amount of Docosahexaenoic acid, one of the yolk fatty acids, while having the most important effect on the omega-3/omega-6 ratio of the egg yolk. In parallel with the increase in the amount of Chia oil in the diet, the omega-3/omega-6 ratio also increased. It can be stated that adding up to 3 g/kg of Chia seed oil to the diets of laying quails has a positive effect especially in terms of the omega-3 levels of egg yolks. It can be suggested to investigate the effects of chia oil by adding more than 3 g / kg to the diet.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the author.

THE ANIMAL WELFARE STATEMENT

All animal care and procedures were in accordance with the ethical principles of animal use and care (European Community Council Directive 86/609/EEC on the Protection of Animals Used for Experimental and Other Scientific Purposes. The EU standards for the protection of animals used for scientific purposes and for feed legislation were followed.

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ERRATUM

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In page header 01 to 07 where it was written:

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The correct form is:

Possibilities of Using Chia Oil as an Omega-3 Source in Laying Quail Diets