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Research Article

Diet Supplemented with Sumac (*Rhus coriaria* L.) Influenced Fatty Acid Composition but not the Cholesterol Content of Eggs from Japanese Quail

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Abstract

The aim of this study was to investigate the effect of *Rhus coriaria* L. on body weight, feed intake, egg fatty acid and cholesterol content in Japanese quail. In this study, 84 laying quails were randomly assigned into 4 groups and fed a diet including 0 (Control), 0.25, 0.5, or 1% sumac for 48 days. Eggs were collected and weighed daily. Some eggs were obtained for egg parameters such as yolk and albumen weight, shell weight, yolk color, and Haugh unit. At the end of the study, 3 eggs/group were collected for yolk fatty acid. For yolk cholesterol, 2 eggs/group were analyzed. Adding 0.25 or 1% sumac to the diet increased body weights of the quails. Eggs weights in the group fed 0.25% sumac supplemented diet were found greater than the control group. Inclusion of sumac in the diet significantly increased the levels of C16:1(n-7) and C18:1(n-9) and decreased the levels of C16:0 and C18:0 in the egg yolk. The level of C18:2(n-6) in the eggs from the groups fed diet containing sumac also was significantly lower than the control. Supplementation of sumac did not affect cholesterol level in the egg yolk. This study showed that the supplementation of sumac to the laying quail's diet had a significant effect on the egg weight. By adding 0.25% sumac to the diet increased the egg weight significantly. Finally, inclusion of the sumac gradually increased the levels of MUFA and decreased the levels of SFA in the egg yolk.

***Keywords:** Sumac; Yolk Fatty Acid; Egg Cholesterol; Japanese Quail*

Introduction

Sumac (*Rhus coriaria* L.) is a perennial plant and contains over 250 individual species in the family of Anacardiaceae [1]. This plant grows wild and is native to Mediterranean and Southeastern Anatolian Region of Turkey [2]. The main compounds found in the sumac are tannins and flavonoids [3]. Sumac extracts have been shown to have some biological activities such as antioxidant, free radical scavenging, antimicrobial, antiviral, hypoglycemic and anti-mutagenic activities [4-10]. In a study conducted in heat-stressed broilers, it was shown that consumption of 0.5% sumac in the diet decreased the thiobarbituric acid reactive substance (TBARS) concentration in thigh meat [11]. Sumac extract was also shown to have a lipid-lowering effect in the hypercholesterolemic rats [12] and immun inducing effects in broilers [13]. A recent study showed that a diet supplemented with sumac increased the body weight gain of the broilers vaccinated against Newcastle disease [13]. The effect of using sumac powder in the broiler chicks were evaluated and it was shown that the group having sumac supplemented diet had a decreased *Escherichia coli* population and increased lactobacillus in the microbial population of intestine [14]. In a study conducted in laying chickens, it was shown that *Rhus coriaria* L. supplementation significantly reduced the cholesterol and crude fat content in the egg yolks compared to the control group [15].

There have been a limited number of studies associated with the effects of diets supplemented with sumac on the fatty acid composition and egg cholesterol in the poultry. A study was conducted to show the effect of sumac supplementation on fatty acid composition of the eggs in Hy-Line Brown laying hens [16]. Therefore, the objective of the present study was to evaluate the effects of sumac on egg fatty acid composition in Japanese quails. The effects of dietary sumac on egg production, egg weight, feed conversion ratio and yolk cholesterol content were also examined.

Materials and Methods

Diets and Animals

This experiment was conducted at the research farm in the Kahramanmaras Sutcu Imam University (KSU), Turkey. All procedures involving animals were approved by the Animal Care and Use Committee at the KSU. In the present study, eighty four 7-wk-old laying quails (*Coturnix coturnix japonica*) were randomly assigned into four dietary treatments. Each treatment consisted 3 replicates per group (21 birds/group). Quails were fed a basal diet supplemented with 0, 0.25, 0.5, or 1% sumac for 48 days. The sumac was purchased from a local company in the Akre city, Iraq and was used in the diets after grinding.

Diets were isocaloric and isonitrogenous and contained 12.13 MJ kg-1 and 20% crude protein (CP) (Table 1). Feed consumption was recorded on a replicate (seven birds/replicate) base at weekly intervals during the study. Feed conversion ratio (FCR) was calculated weekly for each group in the study and expressed as kilograms of feed consumed per kilograms of eggs produced. Egg production was recorded daily throughout the experimental study. During the experiment, feed and water were provided *ad libitum* and the photoperiod was set at 15L:9D throughout the study. Body weights of the quails were determined at the beginning and end of the study. After three weeks of feeding sumac, three eggs per each replicate (12 eggs per group) were checked for egg parameters such as yolk and albumen weight, height of albumen, shell weight, egg weight, yolk color and Haugh unit (a measurement of the height of the thick albumen of an egg and assesses quality of egg albumen). Yolk colour of the eggs (n = 9) was evaluated visually by means of the DSM Yolk Color Fan.

Ingredients	Diet (%)
Maize	60
[a]Soybean meal	25.85
Calcium carbonate	5.31
[b]DCP	2.06
Lysine	2.22
DL-Methionine	0.21
Vegetable oil	3
NaCl	0.35
Premix	1
Calculated analysis	
Dry matters, %	90
Metabolisable energy (MJ/kg)	12.13
Crude protein (CP, %)	20
Crude fat	5.53
Crude fiber	1.98
Lysine	0.875
Methionine	0.28
Methionine and Cysteine	0.54
Calcium	2.35
Phosphorus (total)	0.75

Table 1: *Composition of the basal diet (as dry-matter basis).*

[a]Soybeanmeal contained 48% CP.

[b]DCP, dicalcium phoshate

[c]Proximate analysis (%) of sumac: dry matter, 94.52; fat, 18.55; crude protein 3.73.

Analysis of egg yolk fatty acids and cholesterol

For egg yolk fatty acid analysis, at the final week of the study, three random samples of eggs from each dietary group were obtained and analyzed for fatty acid by gas chromatography (Hewlett–Packard 5890 Series II, Little Falls, Willmington, DE). Also, 2 eggs per group were obtained and analyzed for yolk cholesterol level. Briefly, 0.1 g samples of yolk separated from albumen were weighed in a tube and yolk lipids were extracted with isopropanol (4 ml), vortexed for 2-3 min and then centrifuged at 3000 rpm for 10 min. The yolk cholesterol concentration (mg g^{-1} cholesterol) was determined in the filtered samples by ultraviolet spectrophotometer (UV) using commercial kits.

Statistical Analysis

For the statistical analysis, a completely randomized experimental design was applied. The data in each experiment were subjected to Analysis of variance (ANOVA) procedures for a completely randomized design and the significance of differences between the means was estimated by using the Duncan test (Duncan's new multiple range test). Differences were considered significant at the level of P < 0.05. All statistical analyses were performed using Statistical Analysis System (SAS) program [17].

Results

The effects of various levels of the sumac on the body weight, egg production, feed conversion ratio, and egg cholesterol were shown in table 2. Initial body weights of the birds in the groups were similar. Supplementing basal diet with 0.25% or 1% sumac caused significant (P < 0.05) increase in the body weights of the laying quails compared to the control group. Hens fed diets supplemented different levels of sumac had similar hen day egg production compared to the control. FCR in the groups were found to be similar. FCR in the quails fed 0, 0.25, 0.5 and 1% sumac was 2.85, 2.95, 3.07, and 3.17, respectively. Inclusion of dietary sumac did not influence egg yolk cholesterol in the groups compared to the control (Table 2). The level of cholesterol concentration in the eggs from the laying quails fed diets supplemented with 0, 0.25, 0.5 or 1% sumac was 6.01, 5.78, 5.87, and 5.94 mg/g dried egg yolk, respectively.

	Dietary levels of Sumac (%)			
Parameter	0	0.25	0.5	1.0
Initial Body Weight (g)	251.38 ± 4,48	255.33 ± 5.14	240.57 ± 4.26	258.05 ± 6.18
Final Body Weight (g)	245.00 ± 5.36[b]	274.86 ± 6.29[a]	256.62 ± 5.73[b]	277.67 ± 4.59[a]
Egg Production (%)	89.29 ± 4.50	89.20 ± 4.66	80.74 ± 2.98	87.89 ± 1.51
Feed conversion ratio	2.85 ± 0.04	2.95 ± 0.12	3.07 ± 0.05	3.17 ± 0.18
Egg cholesterol (mg g^{-1})	6.01 ± 0.15	5.78 ± 0.11	5.87 ± 0.11	5.94 ± 0.17

Table 2: *The effects of diets supplemented with sumac on body weight, egg weight, egg production, feed efficiency, and yolk cholesterol content.*

Basal diets were contained 0, 0.25, 0.5, or 1% sumac and fed for 48 days.

Values are expressed as means ± SE.

[ab] Mean values in the same row with the same parameter with different letters were significantly different (P < 0.05).

Table 3 represents the effects of dietary sumac on egg parameters such as egg weight, yolk weight, albumen weight, shell weight, yolk color and Haugh unit. There were no adverse effects of the feeding sumac on the quality of the eggs. Supplementing quails' diet with 0.25% of sumac significantly increased egg weights compared to the control. Starting from second week of the experiment, dietary sumac at 0.25% level caused a significant (P < 0.05) increase in the egg weight compared to the control (data not shown here). The weights of yolk, albumen, and shells did not differ among the groups. The Haugh unit of the eggs from the groups was also found to be similar. Yolk color of the eggs from the laying hens fed diet including 0.5% sumac was found significantly lower than the control.

	Dietary levels of Sumac (%)			
Parameters	**0**	**0.25**	**0.5**	**1.0**
Egg weight (g)	11.43 ± 0.05[b]	11.70 ± 0.04[a]	11.50 ± 0.05[b]	11.51 ± 0.04[b]
Yolk weight (g)	3.57 ± 0.15	3.67 ± 0.18	3.74 ± 0.08	3.81 ± 0.08
Albumin weight(g)	6.34 ± 0.23	6.24 ± 0.23	6.43 ± 0.12	6.61 ± 0.16
Shell weight (g)	1.61 ± 0.06	1.56 ± 0.04	1.63 ± 0.06	1.52 ± 0.04
High of Albumen	4.87 ± 0.18	4.83 ± 0.20	4.40 ± 0.25	4.71 ± 0.12
Yolk Color	10.22 ± 0.28[a]	10.33 ± 0.17[a]	9.33 ± 0.24[b]	10.44 ± 0.29[a]
Haugh Unit	91.68 ± 1.05	91.45 ± 1.13	88.82 ± 1.17	90.54 ± 0.75

Table 3: *The effects of diets[1] supplemented with sumac on parameters of fresh eggs.*

[1]Basal diets contained 0, 0.25, 0.5, or 1% sumac and were fed for 48 days.

[a-b] Values are expressed as means ± SE. Those without a common superscript are significantly (P < 0.05) different within a row.

The effects of sumac on egg yolk fatty acid content were shown on table 4. Inclusion of sumac into the laying quails' diet significantly decreased the levels of fatty acids C14:0, C16:0 and C18:0 compared to the control (P < 0.05). Polyunsaturated fatty acids such as C18:2(n-6), C18:3(n-3) and C20:4(n-6) also significantly decreased in the egg yolk compared to the control (P<0.05). Eggs from the laying hens fed sumac supplemented diet had significantly greater levels of total MUFA compared to the control. Birds that consumed diets supplemented with 0.25%, 0.5% or 1% sumac deposited significantly (P < 0.05) higher level of C18:1(n-9) into their eggs compared to the control. However, eggs from the sumac supplemented groups had lower levels of C18:3(n-3) and C22:6(n-3) compared to the control. Also the level of C18:2(n-6) in the eggs from the groups fed diet containing sumac also was significantly lower than the control (P < 0.05).

	Dietary levels of Sumac (%)			
Fatty Acid	**0**	**0.25**	**0.5**	**1.0**
C14:0	0.54 ± 0.02[a]	0.38 ± 0.01[c]	0.46 ± 0.04[b]	0.37 ± 0.01[c]
C14:1(n-7)	0.08 ± 0[a]	0.05 ± 0[b]	0.05 ± 0[b]	0.05 ± 0[b]
C15:0	0.02 ± 0	0.02 ± 0.01	0.02 ± 0	0.02 ± 0
C16:0	25.69 ± 0.26[a]	24.18 ± 0.10[b]	24.46 ± 0.42[b]	24.09 ± 0.20[b]
C16:1(n-7)	4.34 ± 0.34[ab]	3.65 ± 0.28[ab]	3.53 ± 0.18[b]	4.90 ± 0.20[a]
C17:0	0.08 ± 0.01	0.08 ± 0.01	0.07 ± 0.0	0.07 ± 0.01
C18:0	8.34 ± 0.17[a]	7.81 ± 0.53[a]	7.34 ± 0.21[a]	5.88 ± 0.49[b]
C18:1(n-9)	50.82 ± 0.20[c]	55.70 ± 0.06[b]	57.98 ± 0.91[a]	58.31 ± 0.10[a]
C18:2(n-6)	8.18 ± 0.12[a]	6.09 ± 0.37[b]	4.01 ± 0.41[d]	5.16 ± 0.10[c]
C18:3(n-3)	0.13 ± 0.01[a]	0.08 ± 0.01[b]	0.06 ± 0.01[b]	0.08 ± 0.01[b]
C18:3(n-6)	0.16 ± 0.02[a]	0.10 ± 0.01[b]	0.07 ± 0.01[b]	0.09 ± 0.01[b]
C20:1(n-9)	0.09 ± 0.01	0.07 ± 0.01	0.10 ± 0.01	0.08 ± 0.01
C20:3(n-6)	0.09 ± 0.01	0.07 ± 0.01	0.10 ± 0.01	0.08 ± 0.01
C20:4(n-6)	0.04 ± 0.01[a]	0.04 ± 0b	0.02 ± 0[c]	0.02 ± 0c
C22:6(n-3)	0.84 ± 0.17[a]	1.06 ± 0.15[a]	0.31 ± 0.03[b]	0.42 ± 0.04[b]
C24:1(n-9)	0.07 ± 0.01[a]	0.05 ± 0[b]	0.03 ± 0[c]	0.03 ± 0[c]
Σ SFA	34.74 ± 0.18[a]	32.46 ± 0.56[b]	32.46 ± 0.56[b]	30.43 ± 0.80[c]
Σ MUFA	55.39 ± 0.29[c]	59.52 ± 0.30[b]	61.69 ± 0.74[a]	62.87 ± 0.90[a]
Σ PUFA	9.51 ± 0.35[a]	7.56 ± 0.20[b]	4.59 ± 0.47[d]	5.79 ± 0.16[c]
Total	99.64 ± 0.11[a]	99.53 ± 0.06[a]	98.52 ± 0.43[b]	99.09 ± 0.16[ab]

Table 4: *The effects of sumac on the fatty acid composition of the egg yolks.*

[abc]Means with different superscripts within the same row are significantly different (P < 0.05).

ΣSFA*: Total Saturated Fatty Acids; ΣMUFA: Total Monounsaturated Fatty Acids; ΣPUFA: Total Polyunsaturated Fatty Acids.*

Discussion

There is no known study conducted in the literature about fatty acid composition of eggs in the quails. Only limited number of studies associated with the effects of diets supplemented with sumac on the fatty acid composition and egg cholesterol was conducted in laying chickens. Therefore, the result of the present study will be compared with data reported in those studies using laying chicken as an experimetal material. A study was conducted about the effect of sumac supplementation on egg fatty acid composition in Hy-Line Brown laying hens [16]. It was shown that diet containing 1% sumac increased the levels of C16:0 and C16:1(n-7) and decreased level of C18:1(n-9) in the egg yolks [16]. Conversely, in the present study, the levels of SFA, mainly C16:0 and C18:0, in the egg yolk from the groups fed sumac supplemented diets decreased significantly compared to the control. Also, in contrast to the study by Galik., *et al*. [16], in the present study, the level of C18:1(n-9) significantly increased in the eggs from the quails fed sumac supplemented diets compared to the control. A recent study conducted in laying hens showed that inclusion of sumac into the laying hens' diet did not have any effect on the levels of C16:0 and C18:0, but decreased the level of C16:1(n-7) and C18:1(n-9) [18]. In the present study, inclusion of sumac did not have any effect on the level of C16:1(n-7), except the group fed 0.5% sumac. Also, eggs from the groups fed sumac supplemented diets had significantly greater levels of C18:1(n-9).

Broilers fed a diet supplemented with 1% sumac had higher FCR than the control [19]. Similar to the study conducted by Golzadeh., *et al.* [19], in the present study, body weight of the birds fed sumac supplemented diets were found to be similar to the control. However, the same study showed that broilers fed sumac supplemented diet had the highest feed consumption ratio and suggested that the deteriorated feed consumption and FCR might be related to polyphenolic compounds in the sumac such as tannins [19]. Similar to the present study, it was reported that there were no significant differences observed for FCR or body weight gain in the broiler chickens fed 0.25, 0.5 or 1% sumac supplemented diet [20]. Similar to the study by Alishah., *et al*. [20] FCR in the groups fed a diet at the levels of 0, 0.25, 0.5, 1% sumac was found to be similar. However, inclusion of sumac into the diets increased the body weights of the quails compared to the control. Similarly, a recent study showed that diet including 1% sumac significantly ($P = 0.0501$) increased the body weight of the laying chickens [21]. The values of FCR were found to be similar among the groups [21]. Egg production and egg weight of the laying chickens fed sumac was found to be similar [21]. In the present study, inclusion of dietary sumac did not influence egg yolk cholesterol content in the dietary groups compared to the control group. However, in the study conducted in laying chickens, it was shown that sumac inclusion of the sumac at he levels of 1 or 3%, but not 2% decreased the levels of cholestrol in the egg yolk [18]. In the present study, eggs from quails fed diets including 0.25 or 1% sumac were significantly greater than the control and inclusion of dietary sumac did not have any effect on the egg production and yolk cholesterol content compared to the control.

Conclusion

In conclusion, diets supplemented with 0.25 or 1% sumac significantly increased body weight of the quails compared to the control. Inclusion of sumac into the diets increased the egg weight in Japanese quail. Finally, adding sumac at the levels of 0.25, 0.5 or 1% decreased total SFA and increased total MUFA gradually in the egg. Further research is needed to assess the role of sumac in the increase of egg weight and change in the yolk fatty acid composition.

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