ISPEC Tarım Bilimleri Dergisi
6(4): 657-666, 2022

Araştırma Makalesi

E-ISSN:2717-7238
www.ispecjournal.com

ISPEC Journal of Agr. Sciences
6(4): 657-666, 2022

Research Article

The Effect of Sumac Supplementation on Egg Yield and Egg Quality in Layer Quails

Besime DOGAN DAS[1a*]
Nurcan KIRAR[1b]
Osman BILAL[1c]
Aydın DAS[2a]
Mehmet AVCI[1d]
Faruk BOZKAYA[2b]
Tuncay TUFAN[3a]

[1]Harran Universitiy, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Sanlıurfa

[2]Harran Universitiy, Faculty of Veterinary Medicine, Department of Animal Husbandry, Şanlıurfa

[3]Siirt Universitiy, Faculty of Veterinary Medicine, Department of Animal Nutrition and Nutritional Diseases, Siirt

[1a]**ORCID**: 0000-0003-2163-2632
[1b]**ORCID**: 0000-0002-2778-1789
[1c]**ORCID**: 0000-0002-4404-6516
[2a]**ORCID**: 0000-0003-0371-5434
[1d]**ORCID**: 0000-0002-2523-2137
[2b]**ORCID**: 0000-0001-6423-8067
[3a]**ORCID**: 0000-0001-8420-4235

[*]Sorumlu yazar (Corresponding author): bdas@harran.edu.tr

DOI: https://doi.org/10.5281/zenodo.7302595

Alınış (Received): 25/05/2022
Kabul Tarihi (Accepted): 30/06/2022

Keywords
Coturnix coturnix japonica, diet, egg production, *Rhus coriaria* L., yolk colour

Abstract
This study was carried out to determine the effect of adding different amounts of sumac to layer quail diets on egg production and some egg quality characteristics. In the study, 60 days aged 76 female quail were used. Quails were randomly distributed in individual cages, with 4 groups and each group has 19 quails. Thus, this study was carried out in a total of 4 groups; 1 control and 3 experimental groups. The mixed feeds of the experimental groups were prepared by adding sumac at the amount of, 0% (Control Group), 1% (Group I), 2% (Group II) and 3% (Group III). The trial was completed in 8 weeks. Sumac supplementation did not affect egg weight and feed efficiency in layer quails. Addition of 3% sumac 1-4, 4-8, 1-8 increased feed consumption between weeks. Egg production between 1-4 and 1-8 weeks increased significantly in the group with 2% sumac. It was determined that the addition of sumac significantly improved egg yolk weight, albumin weight, egg yolk color and Haugh unit; It was observed that it did not affect egg shell weight, shell thickness, albumen index, yolk index, shape index and egg specific gravity. As a result, it was concluded that the addition of sumac to the laying quail diets did not have any negative effects on performance and some egg quality, but resulted in positivly in terms of egg quality parameters.

INTRODUCTION

In recent years, quail breeding has become widespread in Turkey. The importance of quail meat and egg, which is a source of animal protein in human nutrition, is gradually increasing. Therefore, the determination of the external and internal quality of quail eggs and the effects of feed additives on these properties are investigated (Erisir et al., 2015). There are many criteria that consumers pay attention to when buying eggs. One of these criteria is the color of egg yolk. Egg laying animals cannot synthesize the pigments in the egg yolk (Englmaierová et al. 2014). Egg yolk color is largely dependent on the fat-soluble pigments in the compound feed. Egg yolk color is associated with oil-like compounds called xanthophylls (Rose, 2005). Different feed additives are used to balance the xanthophyll amount while preparing compound feed (Rose, 2005). Some researchers reported that feed additives affect egg production and egg quality parameters in poultry (Ipek et al. 2003; Lokaewmanee et al. 2009; Erisir et al. 2015; Sengul 2021). Sumac is the common name for the genus Rhus, and Rhus coriaria belongs to the Nacardiaceae family in the order of Sapindales. Sumac (*Rhus coriaria L.*), one of the feed additives, is a plant that belongs to the Anacardiaceous family and is widely grown in Asian countries (Shidfar et al., 2014). Sumac is rich in B vitamins, as well as gallic acid, vanillic acid. Sumac seeds are a very good source of gallotannis, essential oil and anthocyanin, the compound responsible for the red color (Ghasemi et al., 2014). Sumac is rich in many minerals such as potassium, calcium, magnesium and phosphorus (Gumus et al., 2018). It has been stated that regularly consumed sumac has a protective effect on atherosclerosis, oxidative stress and liver enzymes caused by foods high in fat (Setorki et al., 2012). In a study on the pericarp of sumac contains important minerals such as calcium, phosphorus, magnesium and iron. While there is a high amount of calcium in the sumac seed, copper, aluminum and iron are also found in very small amounts (Ozcan et al., 2007). In addition, studies have determined that there are more than 200 phenolic compounds in sumac (Abu Reidah et al., 2015). Sumac has been used as a medicinal plant in humans and to preserve food (Fazeli et al., 2007). However, the literature on sumac usage in animal feed, especially with respect to quail, is very limited. In this study, the effect of adding different amounts of sumac to the diet (0%, 1%, 2% and 3%) on egg production and egg quality in quails (*Coturnix coturnix japonica*) was investigated.

MATERIAL and METHODS

The study was carried out according to the animal axperiments manual of the Siirt University Animal Experiments Local Ethics Committee (Decision no:2020/05/03). In this study, 76 female quails (Coturnix coturnix japonica) aged 60 days were used. The experiment was carried out in cages with 5 floors, each floor with independent rails and light bulbs for lighting. Quails were randomly distributed in individual cage compartments in 4 groups and 19 quails in each group. The mixed feeds of the experiment groups were prepared as isocaloric and isonitrogenous by adding 0% (Group I), 1% (Group II), 2% (Group III) and 3% (Group IV) sumac for the control group. While preparing the experiment group diets, the sumac to be added to the feed was mixed thoroughly with the feed ten times its own amount, then a homogeneous mixture was obtained by adding feed little by little in a large bucket. The raw nutrient contents of the feed materials and compound feeds used in the study were made according to NRC (1994). Dry matter (DM), crude protein (CP), crude cellulose (CC), Crude Oil (CO), crude ash (CA) contents of the feeds were analyzed (AOAC 1990). The chemical composition of sumac is given in Table 1. Total phenolic content of sumac were analyzed (Singleton et al. 1999). Results are given as gallic acid equivalents (GAE).

Table 1. The chemical composition of sumac

DM %	CA %	CP %	CO %	Tannin (mg/100g)	Phenolic compounds (Mg GAE/kg oil)
95.29	18.79	3.87	11.72	1417.6	1540.0

DM: Dry matter, CA: Crude ash, CP: Crude protein, CO: Crude oil

The raw material composition and nutrient content of the mixed diets used in the experiment are given in Table 2. In the study, sumac used as an additive was determined as DM 98%, CP 3%, CO 12%, CA 2.8%, Metabolic Energy (ME) 2000 kcal/kg. ME content was calculated according to TSE (1991). At the beginning and end of the experiment, quails were weighed one by one and their live weights were recorded. Eggs were collected by counting at the same time each day and weighed to determine egg weight. The research lasted 8 weeks. Egg weights were recorded daily from the beginning of the study to the end of the study. All eggs were collected for 2 months, once a week, and used to determine the internal and external quality characteristics of the eggs. The feed efficiency ratio was calculated as the kilogram of feed consumed per kilogram of egg produced. Determination of the egg shape index was made with the help of caliper from the place where the long and short axes were the longest. Eggs whose weights and shape indices were determined were broken on a glass table and their yolk and albumen heights were determined by micrometer. The yellow diameter, albumen length and albumen width values were measured with a caliper sensitive to 0.01 mm. The egg was washed in water and the egg white residues were removed. It was then dried for 24 hours. The dried shells were weighed and the shell weights were determined. After weighing the shells, the shell thickness was measured with a micrometer. Shell thickness was measured from three different parts of the shell, blunt, pointed and lateral, and the average shell thickness was calculated by taking the arithmetic average of these values. Saturated saline solution, which is widely used in calculating the egg specific gravity, was used. For this, the solution density was frequently checked (Kahraman, 2008). As egg internal and external quality criteria; length, fresh shell and dry shell weight, shell thickness (pointed-medium-blunt), white and yolk weight, yellow color scale (Roche Yellow Color Range, 1-15), white and yolk height, white and yolk diameter, shape index, yolk index, white index and haugh unit were calculated using the following formulas and methods (Senkoylu, 2001). Shape index (%) = (egg width [cm] / egg length[cm]) × 100

Albumin index (%) = (average of albumin height [mm] / albumin length [mm] and albumin width [mm]) × 100;

Egg yolk index (%) = (yolk height [mm] / yolk diameter [mm]) × 100

The color of the egg yolk was evaluated using the Roche Color Index (RCI).

Haugh Unit: 100 Log ((White height, mm)+7.57-1.7x(Egg Weight)x0.37); where AH = albumin height (mm) and EW = egg weight (g).

Table 2. The composition and nutrient values (%) and metabolic energy contents (kcal/kg) of the mixed feeds used in the experiment

Raw Materials	Control	Sumac 1%	Sumac 2%	Sumac3%
Vegetable oil	02.65	02.80	02.79	02.91
Red Wheat	14.95	14.75	11.41	10.51
Corn	45.15	44.00	45.70	45.13
Soybean Meal, 51%	28.20	28.40	29.05	29.40
Sumac	0.00	1.00	2.00	3.00
Dicalcium Phosphate	1.71	1.71	1.71	1.71
Dl-Methionine	0.10	0.10	0.10	0.10
Lime Stone	6.56	6.56	6.56	6.56
L-Lysine Hydrochloride	0.01	0.01	0.01	0.01
Sodium Bikarbonate	0.12	0.12	0.12	0.12
Salt	0.25	0.25	0.25	0.25
Vitamin-Mineral Mixture	0.30	0.30	0.30	0.30
Total	100	100	100	100
Analiz Değerleri (%)	**Control**	**Sumac 1%**	**Sumac 2%**	**Sumac 3%**
Dry Matter	87.09	87.21	87.11	87.18
Crude protein	20.01	20.00	20.03	20.00
Crude Oil	4.65	4.77	4.73	4.82
Crude celluloze	2.40	2.51	2.60	2.71
Crude Ash	11.26	11.28	11.31	11.34
Calculated Value (%)				
ME	2901	2900	2903	2901
Ca	3.00	3.00	3.00	3.00
Available Phosphorus	0.30	0.30	0.30	0.30
Met+Sistin	0.74	0.74	0.74	0.74
Lizin	1.05	1.05	1.05	1.05

Vitamin-mineral values in a kg of mixed feed; Vitamin A 12,000. IU; Vitamin D3 5,000. IU; Vitamin E 50mg; Vitamin K3 4.mg; Vitamin B1 3mg; 6 mg of vitamin B2; niacin 40mg; Calcium D-pantothenate 15mg; Vitamin B6 5mg; Vitamin B12 0.0 3mg; Folic Acid 1mg; Biotin 0.075mg; Choline Chloride 400mg. Vitamin C 50 mg and antioxidant 10 mg. Manganese 120mg Iron 40mg; Zinc 110mg; Copper 16mg; Cobalt 0.005mg; Iodine 0.125 mg; Selenium 0.003mg

Statistical analysis

Statistical calculations of the groups in terms of egg quality values were applied by variance analysis method, and Duncan test was applied to control the significance of the difference between groups. Statistical analyzes were performed in SPSS 17.0 (1999) program.

RESULTS and DISCUSSION

The data on the live weights, feed consumption, feed efficiency ratio, egg production and egg weight of the laying Japanese quails at the beginning and end of the trial are given in Table 3. When the performance data table of sumac addition was examined in the study, the live weight values of the groups per trial were determined as 215.29 g, 223.82 g, 218.11 g and 222.32 g in the control (0%), 1% sumac, 2% sumac and 3% sumac groups, respectively. The body weight values at the end of the experiment were determined as 236.03 g, 238.02 g, 224.37 g and 238.13 g in the groups, respectively. The addition of sumac supplementation to laying quail feeds did not affect egg increase ($p>0.05$). However 1-4 and 1-8. It was determined that egg production increased significantly in the sumac 2% level group between weeks ($P<0.05$). The effect of sumac supplementation on feed conversion rate is insignificant, but feed consumption 1-4, 4-8, 1-8. It was determined that it increased in the group to which 3% sumac was added between weeks ($P<0.05$). Thanks to its antimicrobial components, sumac is used to combat microbial organisms (Irmak 2019). The addition of sumac increases the taste of the feed (Alloui et al., 2014). Sumac inhibits harmful bacterial colonies in the intestines of pathogenic bacteria. It has been determined that it affects the fattening performance positively by increasing the number of beneficial bacteria population (Kheiri et al., 2015; Cakmak, 2018). Gumus et al. (2018) conducted a study in which they investigated the fattening performance, egg quality characteristics and blood parameters with the additives of 0.5% Sumac, 0.5% Turmeric and 0.25% Sumac + 0.25% Turmeric to layer hen diets. In the study; reported that there was no statistical difference between the groups on body weight, feed consumption, feed efficiancy ratio, egg production, egg weight at the end of the trial (P>0.05). Similarly, Kırar et al. (2020) determined that the addition of 1%, 2% and 3% sumac powder to quail feeds had no effect on weekly live weight gain, feed consumption and feed conversion ratio of quails. Ghasemi et al. (2014) evaluated the effect of broiler chicks on performance and determined that the addition of 0.1%, 0.2% and 0.3% sumac to the diet significantly increased feed consumption compared to the control group. Mansoob (2011), different in broiler ration feed consumption of sumac use at significant in weight gain and feed efficiency showed that it has an effect. Live weight gain and feed conversion rate healing from the active substance found in sumac (cinnamaldehyde and eugenol) (Mansoob, 2011). Salih (2015) stated that when 1%, 2% and 3% sumac powder is used as a feed additive in ATAK-S layer hen diets, it does not affect live weight gain, feed consumption and egg production, but improves feed efficiency and egg weight. Sabır (2014) determined that adding 1% sumac powder to layer Japanese quail diets decreased the live weight at the end of the trial compared to the control group and the group with 0.5% sumac addition, and the feed consumption was insignificant. Mansoub (2011) determined that the use of different sumac levels of 0.75, 1, 1.5 and 2 in broilers has no effect on the feed conversion ratio. Golzadeh et al. (2012) reported that the use of 1% sumac improved the rate of feed conversion in broilers, but the use of 0.25% and 0.5% sumac did not have a significant effect on the feed conversion rate. Ahmadian et al. (2020), they stated that the feed consumption of broilers fed with diets containing 1%, 2%, 3% sumac fruit decreased. When compared with the studies done, the results on the fattening performance are in agreement with our current study. In the study, the values related to the effect of Japanese quails on egg quality characteristics are given in Table 4. As seen in Table 4, it was determined that the addition of sumac significantly improved egg yolk weight, albumin weight, egg yolk color, haugh unit, and egg specific gravity in laying quails (P<0.05). It is thought that the phenolic compounds in sumac have a positive effect. Consumers want the egg yolk color to be dark. For this reason, some phytogenic additives are widely used in order to improve egg yolk color in laying hen diets (Englmaierova et al., 2014). It is thought that an anthocyanin compound, which is responsible for the red color of the sumac fruit, has an effect on the change in egg yolk color, which is an important parameter for consumer satisfaction. There was no statistically significant difference between the groups in terms of eggshell weight, shell thickness, white index, yolk index, shape index and specific gravity, which are considered as criteria for determining eggshell quality.

Table 3. Productive performance of Japanese quail layers

Performance trait	Control	Sumac 1%	Sumac 2%	Sumac 3%	SEM	P
Initial body weight (g)	215.299	223.829	218.113	222.324	2.196	0.508
Final body weight (g)	236.030	238.025	224.371	238.139	2.410	0.132
Feed intake (g/day)						
1-4 weeks	18.478[b]	19.589 [ab]	18.800[b]	20.863[a]	0.288	**0.015**
4-8 weeks	30.805[b]	32.341 [a]	32.048[a]	32.260 [a]	0.138	**0.000**
1-8 weeks	30.143[c]	31.454 [ab]	31.046[b]	31.912[a]	0.155	**0.000**
Egg production (%)						
1-4 weeks	86.276[b]	88.158 [ab]	90.227 [a]	88.723 [ab]	0.484	**0.033**
4-8 weeks	87.915	89.668	90.254	89.864	0.408	0.186
1-8 weeks	87.031 [b]	89.005 [a]	90.226 [a]	89.192 [a]	0.364	**0.015**
Egg weight (g)						
1-4 weeks	11.905	12.072	11.785	12.251	0.119	0.550
4-8 weeks	11.777	11.941	11.774	12.071	0.107	0.731
1-8 weeks	11.844	12.007	11.781	12.158	0.112	0.641
Feed conversion ratio (kg feed/kg egg)						
1-4 weeks	1.806	1.842	1,775	1.927	0.023	0.125
4-8 weeks	2.991	3.039	3,035	3.000	0.028	0.916
1-8 weeks	2.937	2.956	2,936	2.966	0.024	0.967

SEM: Standard error of mean; **[a, c, d, e]:** Values followed by different letters within a row differ significantly at P<0.05

In another study; Salih (2015) found that when 1%, 2% and 3% sumac powder was used as a feed additive in laying hen diets, egg shape index, albumin length, yolk weight and yolk height increased significantly compared to the control group, but shell weight, shell thickness, albumin reported that it did not affect height and haugh unit. Sabir (2015) found that the addition of 0.25%, 0.5% and 1% sumac had no effect of different sumac levels on egg parameters such as egg shell weight, yolk weight, albumin weight, albumin height and Haugh unit in layer quails. reported that the addition of control and 1% sumac did not change the color of egg yolk. Arpasova et al. (2014) reported that the addition of essential thyme oil and sumac powder to layer hen diets did not cause significant effects on feed consumption, live weight gain and feed efficiency ratio, egg production and egg weight. Gumus et al. (2018) reported that the addition of 0.5% sumac to the diet did not affect egg production and egg weight. The difference between the results of the research and some literature data may be caused some factors. These factors are such as the animal material used, the dose of sumac, the environment in which the animals are housed, the health status of the animals, the structure of the diet and the feed additives used in the diet 1.

Table 4. The effect of dietary sumac addition into the diet on egg quality traits

Egg quality trait	Control	Sumac 1%	Sumac 2%	Sumac 3%	SEM	P
Shape index (%)						
1-4 weeks	76.577	78.096	76.750	77.666	0,324	0.288
4-8 weeks	76.617	77.628	76.662	76.665	0.297	0.572
1-8 weeks	76.374	77.805	76.821	77.340	0.316	0.419
Shell weight %						
1-4 weeks	9.561	9.643	9.408	9.143	0.083	0.154
4-8 weeks	8.770	8.928	8.917	8.787	0.064	0.743
1-8 weeks	9.145	8.972	9.199	8.755	0.115	0.533
Yolk weight %						
1-4 weeks	28.103^{b}	29.893^{ab}	31.648^{a}	30.528^{a}	0.378	**0.007**
4-8 weeks	29.588^{b}	31.416^{a}	29.492^{b}	30.410^{ab}	0.258	**0.027**
1-8 weeks	28.826	30.649	29.654	29.654	0.406	0.485
Albumin weight %						
1-4 weeks	62.334^{a}	60.464^{ab}	58.942^{ab}	60.329^{b}	0.390	**0.020**
4-8 weeks	61.641^{a}	59.655^{b}	61.590^{a}	60.801^{ab}	0.281	**0.040**
1-8 weeks	62.028	60.377	61.145	61.590	0.452	0.625
Yolk index (%)						
1-4 weeks	36.292	38.146	37.327	38.702	0.440	0.238
4-8 weeks	41.059	41.674	41.143	40.731	0.320	0.780
1-8 weeks	38.501	40.175	39.016	39.785	0.355	0.348
Albumin index (%)						
1-4 weeks	2.534	2.597	2.726	2.747	0.120	0.536
4-8 weeks	2.804	2.559	2.797	2.654	0.041	0.106
1-8 weeks	2.669	2.575	2.761	2.732	0.046	0.510
Shell thickness (mm)						
1-4 weeks	0.223	0.223	0.222	0.218	0.001	0.549
4-8 weeks	0.233	0.239	0.237	0.235	0,001	0.703
1-8 weeks	0.232	0.237	0.233	0.229	0,001	0.318
Yolk color						
1-4 weeks	5.937^{d}	7.062^{c}	9.444^{b}	10.3889^{a}	0.238	**0.000**
4-8 weeks	6.000^{d}	8.000^{c}	10.187^{b}	10.687^{a}	0,242	**0.000**
1-8 weeks	5.105^{c}	7.000^{b}	8.894^{ab}	10.055^{a}	0,320	**0.000**
Haugh unit						
1-4 weeks	87.363^{b}	88.405^{ab}	90.321^{a}	90.052^{a}	0.425	**0.040**
4-8 weeks	91.363	90.226	91.247	90.178	0.252	0.188
1-8 weeks	89.383	89.373	90.694	90.383	0.310	0.306
Specific gravity						
1-4 weeks	101.578	104.210	103.684	103.157	0.395	0.100
4-8 weeks	103.125	103.055	103.750	102.500	0.319	0.611
1-8 weeks	102.222	103.472	103.611	102.368	0.323	0.294

SEM: Standard error of mean; ^{a,c,d,e} **:**Values followed by different letters within a row differ significantly at P<0.05

In conclusion, the use of antibiotics as performance enhancers in poultry diets has been banned in the European Union and our country since 2006. Thus, the use of alternative additives that can replace antibiotics has increased. In recent years, the use of feed additives such as prebiotics, probiotics and phytobiotics, which are thought to replace antibiotics, has increased in poultry farming. Since there are not many studies on the use of sumac in layer quail diets, the research findings were generally compared with the results of the studies conducted with laying hens. The results of the research differed from some literature data. These differences may be due to factors such as the animal material used, the environment in which the animals are housed, the health status of the animals, the structure of the diet and the feed additives used in the diet. When the study data were evaluated, the addition of sumac had no effect on the feed conversion rate in layer quails. However, in quails, it was determined that 3% sumac supplementation increased feed consumption between 1-4, 4-8, 1-8 weeks. It was observed that the addition of sumac significantly increased egg yolk weight, albumin weight, egg yolk color, Haugh unit, egg specific gravity, and did not affect eggshell weight, shell thickness, white index, yolk index, shape index in laying quails. As a result, it was concluded that the addition of sumac to layer quail diets did not have any negative effects on performance and some egg quality. It gave positive results in terms of egg quality parameters, and it has the potential to be an alternative feed additive in terms of the active ingredients it contains.

REFERENCES

Abu-Reıdah, I.M., Alı-Shtayeh, M.S, Jamous, R.M., Arraez-Román D., Segura-Carretero, A. 2015. HPLC–DAD–ESI-MS/MS screening of bioactive components from *Rhus coriaria L.* (Sumac) fruits. Food chemistry, 166:179-191.

Ahmadıan, A., Seıdavı, A., Phıllıps, C.J. 2020. Growth, carcasscomposition, haematolog yandimmunity of broiler supplemented with sumac berries (*Rhuscoriaria L*) and Thyme(*Thymusvulgaris*) Animals, 10(3): 513.

Allouı, M.N., Agabou, A., Andallouı, N. 2014. Application of herbs and phytogenic feed additives in poultry production-a review. Global Journal of Animal Scientific Research, 2:234-243.

AOAC.1990. Official methods of analysis (15th ed.). Arlington, VA: Association of Official Agricultural Chemists.

Arpasova, H., Kacanıova, M., Galık, B., Čuboň, J., Mellen, M. 2014. The effect of oregano essential oil and *Rhus coriaria L.* on selected performance parameters of laying hens. Scientific Papers Animal Science and Biotechnologies, 47(1): 12-16.

Cakmak, M. 2018. Effects of the addıtıon of sumac extract on growth performance, serum bıochemıstry and ıntestınal mıcrobıoata ın broılers at dıfferent stockıng densıtıes. Dicle University Graduate School of Natural and Applied Sciences, 1-39.

Englmaıerova, M., Bubancova, I., Skrıvan, M. 2014. Carotenoids and egg quality. Acta Fytotechnica et Zootechnica, 17: 55–57.

Erısır, Z., Gulcıhan S. U., Cıftcı, M., Yıldız, N., Dalkılıc, B. 2015. The effects of orange peel oil and sex ratio on egg production and egg characteristics in laying quails (*Coturnix coturnix japonica*). Fırat University Veterinary Journal of Health Sciences, 29 (1): 23 – 30.

Fazeli, M. R., G. Amin, M. M. A. Attari, H. Ashtiani, H. Jamalifar, and N. Samadi. 2007. Antimicrobial activities of ıranian sumac and avishan-e shirazi (*Zataria Multiflora*) against some food-borne bacteria. Food Control, 18: 646–649.

Ghasemı, R., Faghanı, M., Reza, J., P., Khonmırzaıe, N., Rahımıan, Y. 2014. Using sumac (*Rhus coriaria L.*) extract affect performance and intestinal characteristics of broiler chicks. Journal Agricultural Science, 4 (8): 442-445.

Golzadeh, M. P., Farhoomandand, M., Daneshyar. 2012. Dietary rhus coriaria l. powder reducesthe blood cholesterol, VLDL-c and Glucose, but ıncreases abdominal fat in broilers. South African Journal of Animal Science, 42(4): 398-405.

Gumus, H., Oguz, M. N., Bugdayci, K. E., Oguz, F. K. 2018. Effects of sumac and turmeric as feed additives on performance, egg quality traits, and blood parameters of laying hens. Revista Brasileira de Zootecnia, 47.

Ipek, H., I. Yerturk, M., Avcı, M. 2003. The effect of different amounts of zinc and copper supplementation on egg production and some blood parameters in laying period quail diets. Van Veterinary Journal, 14 (1): 65-68.

Irmak, E. 2019. Investıgatıon of antıoxıdant capacıty of mulberry and sumac products from dıfferent regıons. Master's Thesis, 1-91.

Kahraman, A. 2008. Effects of supplemental methıonıne and magnesıum on egg productıon and egg qualıty ın layıng hens. Master's Thesis, 1-38.

Kheırı, F., Rahıman, Y., Nasr, J. 2015. Application of sumac and dried whey in female broiler feed. Archives Animal Breeding, 58(1): 205-210.

Kırar, N., Bılal, O., Das, A., Koyuncu, I., Avcı, M. Bozkaya, F., and Tufan, T. 2020. Effects of dietary addition of different rates sumac (*Rhus Coriaria L.*) powder on growth performance, meat quality, carcass composition and oxidative stress markers of japanese quail. Journal of the Faculty of Veterinary Medicine of the University of Harran 9(2): 177-182.

Lokaewmanee, K., Mompanuon, S., Khumpeerawat, P., Yamauchı, K. 2009. Effects of dietary mulberry leaves on egg yolk color. The journal of poultry science, 46: 112-115.

Mansoub, N. H. 2011. Effect of different levels of sumac powder (*Rhus Coriaria L.*) on performance, carcassand blood parameters of broiler chickens. Annals of Biological Research, 2(5): 647-652.

NRC, U. 1994. Science and judgment in risk assessment. Washington: National Academy of Sciences, Whashington, USA.

Ozcan, M., M., Unver, A., Arslan, D., Kosar M. 2007. Research on the detailed biology, composition and use of sumac (*Rhuscoriaria L.*) fruit from different regions in the production of oleoresin. TUBITAK Project, Konya.

Rose, S. P. 2005. Principles of poultry science. CAB İnternational. UK. 135p.

Sabır, S.P. 2014. The use of sumac (*Rhuscoriaria L.*) as a feed additive in Japanese quail diet. Master's Thesis. 1-45.

Salıh, Y.G. 2015. Effect of dıfferentlevels of sumac (*Rhus coriaria*) and gınger (*Zingiber officinale*) powders on egg qualıty, yolk cholesterol, and yolk fatty acıd composıtıonın layıng hens. Kahramanmaras Sutcu Imam Unıversıty, Master Thesıs.1-84.

Sengul, A. 2021. Effect of supplementation of red beetroot powder in quail diets. The Indian Journal of Animal Sciences, *91:*1.

Senkoylu, N., 2001. Modern chicken production. 3rd Edition, Istanbul, 538 p.

Setorki, M., Rafieian, M., Heidarian, E., Ghatreh, K., Shahinfard, N., Ansari, R., Forouzandeh, Z. 2012. Effect of *Rhus coriaria* consumption with high cholesterol food on some atherosclerosis risk factors in rabbit. J Babol University of Medical Sci., 14:38- 45.

Shıdfar, F., Rahıdeh, S.T., Rajab, A. 2014. The effect of sumac (*Rhus coriaria L.*) Powder on serum glycemic status. ApoB. ApoA-I and total antioxidant capacity in type 2 diabetic Patients. Iranian Journal of Pharmaceutical Research, 13(4):1249-1255.

Singleton, V.L., Orthofer, R. & Lamuela-Raventos, M. 1999. Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. Methods in Enzymology, 299:152-178.

SPSS I. 1999. SPSS for Windows. Chicago, Illinois.

TSE 1991. Animal Feed-Metabolic (Reversible) Energy Determination (Chemical Method). TSE No: 9610, Turkish Standards Institute, Ankara.