Sains Malaysiana 50(12)(2021): 3617-3629
http://doi.org/10.17576/jsm-2021-5012-13

The Effect of Rosehip (*Rosa canina* L.) Supplementation to Diet on the Performance, Egg and Meat Quality, Antioxidant Activity in Laying Quail

(Kesan Penambahan *Rosehip* (*Rosa canina* L.) dalam Diet kepada Prestasi, Kualiti Telur dan Daging, Aktiviti Antioksidan pada Puyuh Bertelur)

YUSUF KONCA, MAHMUT KALIBER*, HASAN HUSEYIN UZKULEKCI, BEHZAT CIMEN & HASAN YALCIN

ABSTRACT

This study was conducted to determine the effects of rosehip (RS, Rosa canina *L.) supplementation on the performance, carcass traits, meat quality, serum antioxidant activity, egg yolk pigmentation and fatty acid composition of laying quail. A total of 120 10-week-old laying quail were divided into 5 treatment groups with 8 replicates. The treatments were as follows: the first group was fed control diet (C, no rosehip addition), other groups (2, 3, 4 and 5) were fed with diets containing 2.5, 5, 10 and 15% RS, respectively. The body weight (BW), feed consumption (FC) and egg yield were not affected by the treatments. However, egg weight and egg mass increased with 5 and 10% RS supplementation (P<0.01). The breast meat's dry matter, crude protein, ash, fat, drip loss, thawing loss, cooking loss, postmortem pH1 values and the colour were not statistically influenced by RS supplementation. Rosehip supplementation caused a decrease in the L* values of egg yolk colour, however, the redness (a*) and yellowness (b*) values of the egg yolk was higher than that of the C group (P<0.01). Rosehip supplementation did not change the fatty acid composition of egg yolk. Rosehip addition at 2.5 and 5% ratio to diets decreased serum malondialdehyde (MDA), and increased serum superoxide dismutase (SOD) levels (P<0.01); while addition of 10 and 15% RS caused an increase in serum MDA and decrease in serum SOD levels compared to C group (P<0.01). In conclusion, rosehip as a feed ingredient in quail diets can be used to increase egg weight, egg mass and egg yolk pigmentation and low (2.5 and 5%) RS supplementation may decrease serum oxidant activity but not high concentrations (10 and 15%) of RS.*

Keywords: Antioxidant capacity; fatty acids; quail; rosehip; yolk pigmentation

ABSTRAK

Kajian ini dijalankan untuk mengenal pasti kesan penambahan rosehip (*RS,* Rosa canina *L.*) *kepada prestasi, trait karkas, kualiti daging, aktiviti antioksidan serum, pigmentasi kualiti telur dan komposisi asid lemak daripada puyuh bertelur. Sejumlah 120 puyuh bertelur berumur 10 minggu telah dibahagikan kepada 5 kumpulan terawat dengan 8 replikasi. Rawatan dijalankan seperti berikut: kumpulan pertama telah diberikan diet yang terkawal (C, tiada penambahan* rosehip*), kumpulan lain (2, 3, 4 dan 5) masing-masing telah diberikan diet yang mengandungi 2.5, 5, 10 dan 15% RS. Berat badan (BW), pengambilan makanan (FC) dan hasil telur adalah tidak terganggu dengan rawatan. Namun, berat telur dan jisim telur telah meningkat sehingga 5 dan 10% dengan penambahan RS (P<0.01). Bahan kering daging dada, protein kasar, debu, lemak, kehilangan air, kehilangan cecair, kehilangan selepas memasak, nilai postmortem pH 1 dan warna adalah tidak dipengaruhi secara statistik daripada penambahan RS. Penambahan* rosehip *telah menyebabkan pengurangan dalam nilai L* daripada warna kuning telur, namun, nilai warna kemerahannya (a*) dan kekuningan (b*) kuning telur adalah lebih tinggi daripada kumpulan C (P<0.01). Penambahan* rosehip *tidak mengubah komposisi lemak asid kuning telur. Penambahan* rosehip *pada nisbah 2.5 dan 5% kepada diet menunjukkan pengurangan serum malondialdehid (MDA) dan meningkatkan paras serum superoksida dismutase (SOD) (P<0.01): dengan penambahan RS 10 dan 15% telah menyebabkan peningkatan dalam serum MDA dan pengurangan dalam serum paras SOD jika dibandingkan dengan kumpulan C (P<0.01). Kesimpulannya,* rosehip *sebagai bahan makanan untuk diet puyuh boleh digunakan untuk meningkatkan berat telur, jisim telur dan pigmentasi kuning telur dan penambahan redah RS (2.5 dan 5%) mungkin menurunkan aktiviti pengoksidaan serum tetapi tidak kepada kepekatan RS yang tinggi (10 dan 15%).*

Kata kunci: Asid lemak; kapasiti antioksidan; pigmentasi kuning telur; puyuh; rosehip

INTRODUCTION

There is growing interest in herbal products grown in wild and uncontaminated areas due to their pharmacological properties, antioxidant activities and other specific functional properties in the body (Egea et al. 2010; Gao et al. 2000). New findings support some herbs have strong effect on health care and they can change gene expression in cancer cells (Valdés et al. 2013). In order to maintain a healthy and well-balanced diet (Ercisli 2007), consumers are willing to pay more for these products and there is a desire for a wide variety of choice. The Council of the European Union declared (EC No 1831/2003) that *Rosa canina* can be used as a natural feed additive for animals, with the code 403 -70/524/EEC. From a nutritive point of view, rosehip (RS) is rich in vitamin C, phenolic, carotenoids, some minerals, essential oils, and healthy fatty acids (Nowak 2005a). Moreover, rose species have important pharmacological, anti-inflammatory and antioxidant activities (Gao et al. 2000) and immunomodulatory effects (Sadigh-Eteghad et al. 2011). Nowak (2005b) showed that the essential oils of rosehips are made up of a complex mixture of about 400 compounds including a wide range of aldehydes, acids and esters. Egea et al. (2010) reported that the phenolic, carotenoid and ascorbic acid content of *Rosa canina* is much higher than that of most other fruits. Ercisli (2007) observed that *Rosa canina* is higher in total phenolic content (96 mg GAE/g DW) compared to some other Canina species. Rosa species are rich in carotenoids and it has a characteristic intense reddish colour due to its carotenoid pigments and it can be used as an alternative colorant source (Hornero-Méndez & Mínguez-Mosquera 2000).

Although rosehips are generally accepted to contain high levels of health-promoting compounds such as vitamin precursors, antioxidants, organic and fatty acids and carotenoids, but there are not enough data on their potential as a feed ingredient in poultry. In this study, we aim to investigate the effect of different RS concentrations in quail feed on laying performance and egg, carcass and meat characteristics, and egg yolk colour parameters. Furthermore, we aim to determine if RS can be used as a suitable source for egg yolk colorant.

MATERIALS AND METHODS

MATERIALS

A total of 120 10-week-old laying quail were individually weighed, and distributed into 5 treatment groups with 8 replicates and 3 chicks per cage. The cage dimensions were 25 × 20 × 25 cm. Each cage was furnished with two water nipples and feeder. The RSs were ripe and red in colour when they were harvested in autumn season in Kayseri province. The fresh rose fruits were dried in laboratory (93.17% dry matter) and finely milled. The compositions of the rosehip and experimental diets are given in Tables 1 and 2, respectively.

EXPERIMENTAL DESIGN AND ANIMAL CARE

The basal diet was based on maize-soybean and formulated on a similar level of nutrient composition to NRC (1994) recommendations. The treatments were as follows: the first group was fed only with the standard diet which contained no rosehip and was called as control group (C, no addition). The second (RS2.5), third (RS5), fourth (RS10) and fifth groups (RS15) were fed with diets containing 2.5, 5, 10 and 15% RS diets, respectively. The replicates were designated as the experimental units, and randomized with respect to the dietary treatments. At the beginning of the experiment, quail were exposed to a 14 days adaptation period for RS feeding. The quail were kept in a poultry house which provided controlled environmental conditions. The experimental diets were offered to respective quail for 8 weeks. The lighting schedule was a 16 h light and 8 h dark photoperiod. Feed and water were provided *ad-libitum*.

DETERMINATION OF PERFORMANCE TRAITS

The individual body weights of the birds were measured on the first and the last day of the experiment. The body weight changes were calculated from these data. FC for each subgroup was measured at 14, 28, 42 and 56 days of the experiment and calculated for each day. The egg production (hen-day) was recorded daily. On the last consecutive 3 days of each 14-day period all eggs were collected and for each group, 60 eggs (a total of 300 eggs) were selected randomly; then the egg weight, egg specific gravity, and eggshell weight were determined from these eggs. The egg mass for each period was calculated from the average egg weight and egg production data. Egg yield was calculated as egg number: animal number×100. The feed conversion ratio (FCR) was calculated for kg feed: kg egg mass for each 14 day. There was no mortality.

DETERMINATION OF CARCASS TRAITS

For carcass and internal organ traits evaluation, 16 quail in each group (in total 80 quail) were slaughtered by cervical dislocation on the 56 day of the experiment. The quail feathers were plucked, and the carcasses were eviscerated by hand. The carcass, liver, proventriculus, empty gizzard, heart, kidney, empty intestine (large and

small intestine) weights were recorded. Part yields of the carcass were calculated as part weight: carcass weight× 100. Cold carcass weight was recorded after the carcasses had been stored at +4 °C for 24 h. In meat samples (30 birds per group), the pH values were measured by using a pH meter (Thermo Scientific Orion Star A111) at 1 and 24 h after slaughter. To determine the pH value, the probe was inserted at a depth of 0.5 to 1 cm into the center of the breast muscle (*pectoralis major*), and then the pH value was read when the probe was stable. In breast meat samples, the colours (L* measures relative lightness, a* relative redness and b* relative yellowness) were determined by using a colorimeter (Minolta Chroma Meter, Model: CR-400) to measure the CIE Lab values.

DRIP LOSS

A cored sample, 4 cm in diameter, of the cranial section of the pectoralis muscle was collected and weighed. Subsequently, the core was suspended from a steel wire hook attached to the lid of a 1-L polymethylene pentene jar. Samples were stored at 4 °C for 48 h. After 48 h, the samples were reweighed, and drip loss was calculated (Honikel 1998).

COOKING LOSS

Cooking loss was determined in 1.5-cm-thick meat samples of similar geometry, which were individually placed inside polyethylene bags in a water bath at 80 °C for 30 min until the temperature of 72 °C or 75 °C was achieved and then cooled for 30 min. The samples were removed from the bags, dried with paper and reweighed (Honikel 1998). The weight loss, expressed as a percentage of initial weight, was determined as a cooking loss.

THAWING LOSS

To determine thawing loss, 10 g meat samples were frozen at -20 °C overnight and then hawed; the free water was discarded and the samples were reweighed, then thawing loss was calculated as the % difference between the first and last weight (Honikel 1998).

ANALYTICAL METHODS

Chemical analyses of diet and meat samples were conducted according to AOAC (2019) methods. The dry matter content of feed sample was determined by oven-drying at 105 °C for 18 h. The ether extract content of feed was obtained by Soxhlet extraction using anhydrous diethyl ether. The Kjeldahl method was used for the analysis of total nitrogen content of the feed, and crude protein was expressed as nitrogen × 6.25. Crude ash content was determined after heating in a muffle furnace at 550 °C for 4 h. The RS crude fiber (CF), acid-detergent fiber (ADF) and neutral-detergent fiber (NDF) were determined. For these analyses, an automated fiber analyzer (ANKOM Technology, New York, USA) was used (according to ANKOM Technology Method 2008).

DETERMINATION OF SERUM PROTEIN CONTENT

Protein concentrations in the serum were determined using a Lowry assay (Lowry et al. 1951) which is described in Konca et al. (2014). This method is based on the reaction of cupric ions with peptide bonds under alkaline conditions. Concentrations were calculated from a standard curve constructed using bovine serum albumin and protein levels are expressed as mg/mL.

DETERMINATION OF SERUM MALONDIALDEHYDE (MDA)

The MDA level in serum as an index of lipid peroxidation was determined by thiobarbituric acid reaction (TBAR) according to the method described by Yoshioka et al. (1979). The principle of the method depends on the measurement of the pink colour produced by the interaction of thiobarbituric acid with malondialdehyde. The pink colour absorbances are measured at 532 nm and the MDA levels are expressed as μmol/L.

DETERMINATION OF SERUM SUPEROXIDE DISMUTASE ACTIVITY (SOD)

The SOD activity was measured by the method described originally by Sun et al. (1988). This assay for superoxide dismutase (SOD, EC 1.15.1.1) activity involves the inhibition of nitro-blue tetrazolium reduction, with xanthine-xanthine oxidase used as a superoxide generator. The enzyme activity is expressed as units/mg protein.

DETERMINATION OF EGG YOLK COLOUR

The colours of egg yolk were measured (at three points of the yolk) at 14 day intervals in 60 eggs from each group (in a total of 300 samples) using a Minolta Chroma Meter (Model: CR-400) to measure the CIE Lab values (L* measures relative lightness, a* relative redness and b* relative yellowness).

DETERMINATION OF FATTY ACID (FA) COMPOSITION OF YOLK

The fatty acid (FA) compositions of the RS and egg samples were determined according to the Agilent application catalogue. For FA analyses of eggs, 120 eggs

were used (30 eggs for each group). The yolks of 3 eggs were combined to get one sample; in this way, a total of 10 samples were obtained for each group.

STATISTICAL ANALYSIS

The current data were analyzed using the General Linear Models (GLM) procedure of SPSS (1999). The models included control, 2.5, 5, 10, and 15% RS levels. The means were separated using Duncan's multiple range tests with a 5% level of probability. The results of statistical analysis are shown as mean values and standard error of the means (SEM) in the tables.

RESULTS AND DISCUSSION

In the experiment, red and ripened *Rosa canina* L. fruits were used in dried form according to the recommendations of Andersson et al. (2011). Chemical analysis showed that RS contained 93.72% dry matter, 89.16% organic matter, 9.18% crude protein, 4.56% crude ash, 8.03% crude oil, 31.83% crude cellulose, 65.32% acid detergent fiber (ADF), and 64.86% neutral detergent fiber (NDF) (Table 1). These results were similar to the findings of Esenbuga et al. (2011). They reported that *Rosa canina* seed has approximately 93.48% dry matter, 8.72% crude protein, 7.97% crude fat, 1.87% crude ash, 31.56-44.05% crude fiber, 30.87% nitrogen free extract, 64.44% acid detergent fiber, 64.78% neutral detergent fiber, and 1800 Kcal ME/kg.

As seen in Table 1, the most abundant fatty acid was found as linoleic acid (51.68%) in RS and oleic (23.25%) and alpha-linolenic acids (18.21%) were also found as major fatty acids. RS has a lower amount of saturated fatty acids, palmitic (3.5%) and stearic acids (2.15%). Ozcan (2002) reported that similar values related to fatty acid composition of the Machmudah et al. (2007) reported that RS seed is rich in linoleic acid and followed by linolenic, palmitic and stearic acid. Ercisli (2007) found that the major fatty acids in rose species are α-linolenic, palmitic and linoleic acids, consecutively.

TABLE 1. Nutrient, β-carotene, lycopene and fatty acid composition of rosehip used in this experiment

Item	Amount
Dry matter (%)	93.72
Organic matter[a] (% DM)	89.16
Crude protein (% DM)	9.18
Crude ash (% DM)	4.56
Crude cellulose (% DM)	43.49
Crude fat (% DM)	8.03
Acid detergent fiber (% DM)	65.32
Neutral detergent fiber (% DM)	64.86
Shell/seed ratio (% DM)	60.50/39.50
β-carotene (µg per 100 g sample)	1855
Lycopene (µg per 100 g sample)	9903
Fatty acids[b]	
Palmitic acid (C16:0)	3.50
Stearic acid (C18:0)	2.15
Oleic acid (C18:1)	23.25
Linoleic acid (C18:2)	51.68
a-Linolenic acid (C18:3)	18.21
Heneicosanoic acid (C21:0)	0.13
Lignoceric acid (C24:0)	0.52
Nervonic acid (C24:1)	0.18
Eicosatrienoic acid (C20:3)	0.20
Docosahexaenoic acid (C22:6)	0.18

[a]Organic matter calculated as the difference between dry matter–crude ash, [b]g fatty acid/100 g total fatty acids

BW AND FEED CONSUMPTION

The BW, body weight gain (BWG), FC and FCR of quail are given in Table 3. There were no significant differences among the groups in terms of BW on the first day. However, the BW of quail in the group fed with RS15 was lower than those of the C and RS2.5 groups at 56 days of age ($p<0.05$). As the RS ratio increased in the feed, the BW had a tendency to decrease. To the best of our knowledge, there are not enough studies to compare the effect of RS in poultry diets on performance traits. Only a few experimental results were found on RS supplementation in different animal groups. Tekeli (2014) reported that the inclusion of *Rosa canina* to diet at a level of 1 and 2% increased BW; however, a 3% RS ratio decreased BW. Also, *Rose canina* supplementation did not have an effect on the FC and FCR of broilers in cold stress condition. Loetscher et al. (2013) reported that 2.5% RS supplementation to broiler diets for two weeks increased BWG, FC, and FCR compared to the C group; however, in the overall period, these parameters did not differ significantly. In these experiments, researchers used a lower concentration in the feed than in the current experiment. Similar to present results, Esenbuga et al. (2011) reported a decrease in the final BW of lambs in response to high levels (15% RS) of dietary *Rosa canina* seed. There are a number of possible reasons for the decrease in growth performance recorded in the present study. Firstly, RS contains a high amount of cellulose (Esenbuga et al. 2011) (Table 1), and consequently low energy content. Secondly, according to our observation, when the RS percentage increased in the diet, some of the fruits' seed remained in the feeder. The seeds contained in the rosehip fruits were quite hard and remained unbroken during grinding. Birds did not prefer to eat the seeds until the feed nearly finished in the feeders.

The FC of quail was not affected by RS levels ($p>0.05$). On the other hand, the FCR was negatively influenced by RS supplementation 14th day of the experiment. RS supplementation increased the cellulose content of the feeds. However, in other periods, the FCR values were not significantly changed by RS levels. The basal feed mixture given to quail is higher in protein and energy concentration than rosehip. Therefore, there was a dilution effect in the RS supplemented diets due to RS lower nutrient composition. Loetscher et al. (2013) reported that broiler ration that contained 2.5% RS did not change the crude protein, gross energy and fat nutrient composition except for the ADF and NDF content. However, in the current experiment, the RS level was 1 to 6-fold higher than that of these studies. It is expected that a high level of cellulose in the feed would influence the FC of birds. However, there was no significant change in the FC of quail. Similarly, Esenbuga et al. (2011) reported that 15% RS supplementation to the diet of lambs did not significantly affect FC and FCR. On the other hand, Tekeli (2014) and Kılıçgün and Altıner (2010) reported that a high concentration of *Rosa canina* may cause a decrease in the BW of broilers due to high phenolic content and the negative correlation between the metal ion and free radical scavenging activity.

EGG PRODUCTION TRAITS

The egg production, yield, weight, mass, specific gravity, shell weight and egg yield of quail are given in Table 4. There were no significant differences among the groups in terms of egg production number and percentage ($P>0.05$). However, the egg weight and egg specific gravity were significant at 14, 28 and 56 days ($P<0.05$). The egg weight in the RS10 group was superior at 14, 28 and 56 day of age; in general, it was different from the C and RS15 groups ($p<0.01$). The egg mass in quail fed with RS10 was higher than those of the C, RS5 and RS15 groups on days 14 and 28 ($p<0.05$).

Egg specific gravity in the RS15 group was lower than those of the other groups and these differences were significant for the RS2.5 and RS5 groups on day 14. Also, the SG values of these groups were lower than those of the C, RS2.5 and RS10 groups on day 28 and lower than those of the C and RS5 groups on day 56.

Egg production, weight, and mass were similar to those of the C group. Only some improvements in these parameters were obtained by 10% RS supplementation to basal diet. Considering that the RS supplementation diluted the basal diet, we expected that some production parameters would be lower than those of the C group. In contrast, for all the diets, except RS15, similar results were obtained. Feed efficiency might have been increased by the phenolic substances and other ingredients of RS.

Egg shell weight and percentage to egg weight were not statistically significant among the treatment groups in all periods. RS contains high concentrations of vitamin C and carotene as a precursor of vitamin A and tocopherol as a precursor of vitamin E (Ercisli 2007). Vitamin C plays an important role in cartilage, bone, and egg shell formation (McCormack et al. 2001). Although vitamin C is normally produced by the adrenal glands of poultry (Pardue & Thaxton 1986), its synthesis is restricted under stressful conditions such as high environmental temperature (Whitehead & Keller 2003). In this experiment, the poultry house was conditioned to a mild environmental temperature. However, in spite of lack of stress, additional vitamin C from RS did not significantly improve the egg shell weight. In future studies, in hot conditions where vitamin C production is lower, the results might be significantly different.

CARCASS AND INTERNAL ORGAN TRAITS

The effects of treatments on the carcass weight, yield and internal organ incidence (%) to carcass are given in Table 5. The carcass weight of the RS15 group was lower than that of the C group. However, while the C

group had the lowest BWG, the highest carcass yield but the lowest gastrointestinal ratio was observed in the RS15 group ($p<0.05$). The gizzard ratio was found as a high value in the C group and these differences were significant between the RS2.5 and RS5 groups ($p<0.05$). The liver, heart, kidney, and proventriculus percentage did not differ among the treatment groups. Loetscher et al. (2013) reported that 2.5% RS supplementation increased carcass weight in broilers; however, it did not change carcass yield and heart, spleen, proventriculus, pancreas, and liver percentage compared to the C group. Esenbuga et al. (2011) noted that RS supplementation increased carcass weight and yield in lambs. Also, in the present experiment, the highest carcass yield was recorded in the RS15 group.

BREAST MEAT TRAITS

The effects of treatments on breast muscle composition are given in Table 6. The dry matter, crude protein, ash and fat, drip, chilling and cooking loss, pH 1 and 24 values (after slaughter, 1 and 24 h) and meat colour in breast meat were not statistically influenced by RS supplementation ($p>0.05$). RS contains a significant amount of antioxidative phenolic compound and carotenoids. Natural antioxidants may delay meat oxidation (Karakaya et al. 2011). Many plants and their extracts contain various phenolic compounds which prevent oxidative deterioration (Falowo et al. 2014). Long term exposure to oxidation can cause changes in the colour of the meat from light to dark brown (Fletcher 1999). In this experiment, the colour in meat samples was measured at 1 and 24 h after slaughter. Therefore, it measured carotenoid accumulation in meat samples. According to these data, it may not be possible to attribute the measured colour deposit in meat samples to RS supplementation diets. Similarly, Loetscher et al. (2013) determined that RS supplementation did not significantly change skin and liver colour in broilers, compared to the C group. Broiler skin colour may affect consumer preferences when they decide to buy chicken meat. Colorants are dissolved and transported via fat and they may accumulate under the skin and change skin colour. In this experiment, the meat samples were skinned and only the breast muscle colour was measured. As is well known, breast muscle contains less fat than other carcass parts. On the other hand, due to the richness of rose species in lycopene and other carotenoids, they can change skin colour effectively. It has also been demonstrated that there is a strong relationship between breast meat colour and muscle pH (Fletcher 1999). The meat pH value may also affect the water holding capacity and other physiochemical properties of meat and higher meat pH accompanied higher L* in meat samples and pale meat disappearance (Qiao et al. 2001). In this experiment, neither pH 1 nor pH 24 was affected significantly by treatments. Similarly, drip, chilling and cooking loss were not influenced by RS addition to quail diets. The incorporation of some plants to poultry diets at a high ratio may cause a negative effect on performance and product quality due to their high indigestible cellulose content or to the adverse effect on the digestive system and other vital organs of various phenolic contents. There are insufficient experimental data on the effect of RS addition to poultry diets for a better evaluation of the result of the present study.

EGG YOLK COLOUR

The effects of RS supplementation at 0, 2.5, 5, 10 and 15% ratios to quail diet on egg yolk colour are shown in Table 7. In the C group, in general, the luminosity (L*) values were higher than those in the supplemented groups ($p<0.001$). RS supplementation caused a decrease in L* values. The redness value (a*) increased with increasing RS ratios in diets ($p<0.001$), being highest for RS15. In general, the yellowness (b*) was also slightly higher in the RS supplemented groups than in the C group.

Hybrid yellow corn grain contains approximately 2 ppm of carotene and 20 ppm of xanthophyll and 3.2 ppm of other pigments (Guenthner et al. 1973). The experimental diet contained 400 kg/ton corn. This amount of corn is enough to obtain a moderate egg yolk colour in the poultry industry and there is no need for additional colorant (carotene and xanthophyll) unless a fulvous colour is desired. Razungles et al. (1989) reported that rosehip contains high concentrations of total carotenoids, which are mainly comprised of lycopene and β-carotene. Also, some rose species containing β-carotene (497.6 ppm), lycopene (391.9 ppm), rubixanthin (703.7 ppm), gazaniaxanthin (289.2 ppm), β-cryptoxanthin (183.5 ppm), zeaxanthin (266.6 ppm), and minor carotenoids (67.1 ppm) were identified by Hornero-Méndez and Mínguez-Mosquera (2000). In this experiment, quail egg yolks' redness (a*) was measured at between 0.70 and 0.96 when only the basal diet was given. RS supplementation from 2.5 to 15% caused an increase in a* values of approximately 3 to 12-fold. Lycopene, which is predominantly found in tomatoes and only in small amounts in other fruits (Bramley 2000), is also an important red colour carotenoid found in RS at about 12-35 mg/kg (Böhm et al. 2003). Along with carotene, lycopene can also be considered as a natural egg yolk colorant.

Animals are unable to synthesize carotenoids. Blount et al. (2002) reported that carotenoids are important in terms of antioxidant activity and immune function. When birds were fed with carotenoids, they showed better pigmentation, higher plasma concentrations of carotenoids, antioxidant activity and immunity, and these are responsible for egg quality. Rosehips may be used as a good source of carotenoids in the food industry, due to their highly coloured oleoresins, as natural colorants (Hornero-Méndez & Mínguez-Mosquera 2000).

THE FATTY ACID COMPOSITION OF EGG YOLK

The fatty acid compositions of eggs obtained from quail fed by regular and RS supplemented diets are presented in Table 8. No alteration was seen in fatty acid abundance sorting between regular and enriched eggs when considering egg yolk fatty acid composition. Although oleic acid was found as the most abundant fatty acid (39.6 to 50.32%) in all eggs, it was significantly high in enriched eggs ($p>0.05$). The fatty acid composition of egg yolk lipids reflects the diet composition (Yalçın & Ünal 2010). Considering that the major fatty acid of the RS is oleic acid, an increase in this is meaningful. Palmitic and linoleic acids are the second and third most abundant fatty acids in egg yolk and there were no differences among the treatment groups. Stearic acid is the other saturated fatty acid that is found in egg yolk. There was a significant decrease ($P<0.05$) in its composition in RS supplemented eggs, except in the RS15 group. There were no significant differences among the treatment groups in the other fatty acid compositions of egg yolk.

The highest ratio of RS used in the feed was 15% and it was expected that linoleic and linolenic acid levels could be affected. However, a considerable part of the oil is deposited within the RS kernel which is very hard and covered with cellulose, so there is a possibility that it may not be digested because it is not broken down in the digestive system. Poultry cannot digest cellulose, so a decrease in the digestion of the seed may have reduced the absorption of fatty acids in the seeds. It has been reported that the digestion of seed was low with the addition of 20% ration even though sheep have the ability to digest cellulose (Esenbuga et al. 2011). In the current experiment, oleic acid was increased, while stearic acid was decreased by RS supplementation compared to the control group. Other fatty acids were not affected by RS supplementation. Therefore, it is concluded that desired fatty acids which have positive effects on human health, such as omega-3, EPA, and DHA fatty acids, did not change significantly among treatments. If the seeds of RS are ground, beneficial effects may occur when the seed oils are released into the digestive system of animals. However, no significant change in fatty acid content was determined for this study. Szentmihályi et al. (2002) reported that RS seed as a waste material contains valuable oil and it can be used for medicinal purposes.

SERUM PROTEIN AND ANTIOXIDANT STATUS

The effects of RS supplementation at 0, 2.5, 5, 10, and 15% ratios in quail diet on serum protein and antioxidant status are given in Table 9. The serum protein concentrations were not affected by RS addition to quail diets. However, the serum MDA and SOD levels significantly differed among the treatment groups ($p<0.01$). In the present study, the serum MDA levels were decreased by RS addition in the RS2.5 and RS5 groups. In contrast to lower RS concentration, higher concentrations of RS (RS10 and RS15) increased MDA levels in serum. This may show that the addition of lower concentrations (2.5 and 5%) of RS to quail diets has a positive effect against lipid peroxidation in the serum lipids of Japanese quail. Here, there is a parabolic reaction between RS concentration and antioxidant activity. Similar findings were observed by Kiliçgün and Altiner (2010). These researchers reported that DPPH radical scavenging activity and metal ion chelating activity differed significantly according to the concentration of RS in broiler diet. When lower concentration levels were applied (1, 2 and 3%) the mentioned bioactivity values increased. However, at higher concentrations (4 and 8%) scavenging activity was not increased. Additionally, the highest concentration (8%) caused a serious decrease in scavenging activity and metal ion chelating activity. They also reported that *R. canina* may act not only as an antioxidant (at a 4% ratio) but also as a prooxidant in high RS concentrations (at an 8% ratio), so its effects depend on its concentrations in *in-vitro* conditions. In the current research, the data showed a similar trend for MDA and SOD concentration in the serum. While MDA concentration significantly decreased in the RS2.5 and RS5 diets and SOD increased at the same concentrations, at higher concentrations (RS10 and RS15 diets), MDA concentration increased and SOD concentration decreased compared to the control group. On the other hand, Loetscher et al. (2013) found a slight decrease in TBARS but no significant differences between the control and RS supplemented groups in broilers. Gao et al. (2000) and Yoo et al. (2008) correlated the antioxidant capacity with high contents of the total phenolic and flavonoids of the *R. canina* extracts. Daels-Rakotoarison et al. (2002) demonstrated that *R. canina* exhibited *in vivo* and *ex vivo* inhibitory effects against superoxide anion in a dose-dependent (0.5-50 mg/L) manner. Yoo et al. (2008) reported that the extracts of RS inhibited oxidative stress, have high levels of DPPH radical scavenging activity and enhanced SOD and CAT activities. The ascorbate content of RS acts as an antioxidant for lipid peroxidation (Gao et al. 2000). Böhm et al. (2003) determined that RS contains high levels of carotenoids, especially lycopene, which may cause antioxidant activity in the body. Carotenoids are active antioxidants within the lipophilic systems because of their lipidic character. Current study's findings were supported by these researchers' observations. We found that RS has a high concentration of lycopene (9903 μg/100 g) and β-carotene (1855 μg/100 g). However, the antioxidant activity of RS may be changed by phenolic and carotenoid contents which are dependent on cultivar/species, ripening period, harvesting time and year (Andersson et al. 2011).

TABLE 2. Diets feedstuff and nutrient composition

Feedstuffs	Quantity (kg)
Corn	400.0
Wheat	110.0
Soybean meal	380.0
Sunflower meal	60.0
Salt (Sodium chloride)	3.34
Limestone	13.61
Vegetable oil	21.19
DL-Methionine	1.23
L-Lysine	1.03
Dicalcium phosphate	7.10
Vitamin-mineral premix[1]	2.50
Calculated nutrient composition	
Dry matter (%)	88.29
Crude protein (% DM)	24.00
Metabolizable energy (kcal/kg)	2900
Crude fat (% DM)	4.45
Calcium (% DM)	0.80
Available phosphorus (% DM)	0.30
Lysine (% DM)	1.30
Methionine (% DM)	0.50

[1]Vitamin-mineral premix per kilogram of the diet: Vitamin A, 15000 IU; Vitamin D3, 2000 IU; Vitamin E, 40.0 mg; Vitamin K, 5.0 mg; Vitamin B1 (thiamine), 3.0 mg; Vitamin B2 (riboflavin), 6.0 mg; Vitamin B6, 5.0 mg; Vitamin B12, 0.03 mg; Niacin, 30.0 mg; Biotin, 0.1 mg; Calcium D-pantothenate, 12 mg; Folic acid, 1.0 mg, Cholinechloride, 400 mg, Manganese, 80.0 mg; Iron, 35.0 mg; Zinc, 50.0 mg; Copper, 5.0 mg; Iodine, 2.0 mg; Cobalt, 0.4 mg; Selenium, 0.15 mg assures

TABLE 3. The effects of treatments on BW, FC and FCR of quail

		Diets						
	Day	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Body weight (G)	0	213.6	219.3	219.3	221.2	218.3	4.24	NS
	56	223.4^{a}	228.6^{a}	218.6^{ab}	219.1^{ab}	207.7^{b}	4.85	*
Body weight change (g)	0 to 56	9.8	9.3	-0.7	-2.1	-10.6	5.54	NS
Feed intake (g/day)	14	27.82	29.59	28.47	28.47	27.45	1.12	NS
	28	28.63	28.21	28.25	29.93	26.39	1.25	NS
	42	26.33	28.76	30.71	28.03	28.52	1.46	NS
	56	28.86	26.50	31.65	33.50	30.10	1.74	NS
	Overall	27.91	28.26	29.77	29.11	28.97	0.71	NS
Feed conversation ratio (g feed/g egg mass)	14	2.67^{ab}	2.73^{ab}	3.13^{a}	2.63^{b}	3.10^{a}	0.15	*
	28	2.64	2.64	3.29	2.63	2.96	0.21	NS
	42	3.22	3.28	3.26	3.22	3.78	0.17	NS
	56	3.14	3.02	4.38	4.24	3.87	0.31	NS
	Overall	2.90^{b}	2.87^{b}	3.44^{a}	3.05^{ab}	3.47^{a}	0.08	**

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15%, respectively, SEM: standard error of means, P: Probability, $^{*}P<0.05$,$^{**}P<0.01$, NS: non-significant

TABLE 4. The effects of treatments on egg production, yield, weight, mass, specific gravity, shell weight and percentage of eggs

	Diets						
	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Egg production (number)							
14	39.33	39.83	35.33	38.17	34.67	1.75	NS
28	36.33	41.00	34.67	38.83	37.50	2.34	NS
42	33.33	32.83	32.17	33.5	28.67	1.76	NS
56	34.17	31.33	27.50	25.67	27.50	2.73	NS
Overall	35.79	36.25	32.42	34.04	32.09	1.41	NS
Egg yield (%)							
14	93.63	94.85	84.13	90.88	82.55	4.17	NS
28	86.51	97.62	82.54	92.46	89.29	5.57	NS
42	79.38	78.2	76.58	79.75	68.27	4.18	NS
56	81.35	79.36	75.47	71.35	79.36	6.86	NS
Overall	85.22	87.51	79.68	83.61	79.87	5.12	NS
Egg weight (g)							
14	11.12^{b}	11.21^{b}	10.90^{b}	11.65^{a}	10.88^{b}	0.11	**
28	11.20^{ab}	11.05^{b}	11.23^{ab}	11.62^{a}	10.43^{c}	0.14	**
42	11.63	11.20	11.48	11.50	11.20	0.17	NS
56	11.33^{b}	11.90^{a}	11.87^{a}	12.08^{a}	11.03^{b}	0.14	**
Overall	11.32^{ab}	11.34^{ab}	11.37^{a}	11.71^{a}	10.89^{b}	0.12	**
Egg mass (g)							
14	10.47^{b}	10.84^{a}	9.13^{b}	10.82^{a}	9.13^{b}	0.25	*
28	8.93^{b}	8.61^{b}	8.72^{b}	9.41^{a}	7.20^{b}	0.25	*
42	10.07	10.96	9.46	10.67	9.97	0.28	NS
56	9.22	8.95	7.73	7.43	7.28	0.35	NS
Overall	9.67	9.84	8.77	9.58	8.39	0.18	NS
Specific gravity							
14	1.049 ^{ab}	1.052^{a}	1.052^{a}	1.049 ^{ab}	1.047^{b}	0.001	**
28	1.048^{a}	1.049 ^{a}	1.044 ^{ab}	1.045 ^{a}	1.040^{b}	0.002	**
42	1.056	1.054	1.053	1.057	1.055	0.002	NS
56	1.051^{b}	1.054 ^{ab}	1.055 ^{a}	1.053 ^{ab}	1.048^{c}	0.001	**
Overall	1.051	1.052	1.051	1.051	1.049	0.001	NS
Egg shell weight (g)							
14	0.93	0.96	1.00	0.98	0.93	0.026	NS
28	0.98	0.92	0.85	0.97	0.90	0.027	NS
42	0.99	0.99	0.95	0.98	0.99	0.031	NS
56	0.95	0.97	1.07	1.01	0.89	0.039	NS
Overall	0.96	0.96	1.01	0.98	0.93	0.031	NS
Egg shell percentage (%)							
14	8.37	8.59	9.20	8.40	8.58	0.07	NS
28	8.73^{a}	8.30^{ab}	8.10^{b}	8.36^{ab}	8.26^{ab}	0.08	*
42	8.48	8.85	8.28	8.49	8.86	0.10	NS
56	8.40^{ab}	8.16^{b}	9.05^{a}	8.36^{ab}	8.11^{b}	0.09	*
Overall	8.50	8.48	8.53	8.40	8.45	0.08	NS

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15%, respectively, SEM: standard error of means, P: Probability, $^{*}P<0.05$,** $P<0.01$, NS: non-significant

TABLE 5. The effects of treatments on carcass, internal organ weights (g) and their relative incidence (%) to the carcass of quail

	Diets						
Traits	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Carcass weight (g)	112.11[b]	132.60[a]	124.71[a]	111.42[b]	100.53[c]	5.25	**
Carcass yield (%)	60.35[b]	62.77[ab]	60.23[b]	65.39[ab]	70.95[a]	1.93	*
Liver (%)	5.60	4.73	5.87	5.58	4.59	0.47	NS
Heart (%)	1.41	1.37	1.36	1.26	1.23	0.08	NS
Gastro intestine (%)	18.53[a]	15.95[ab]	17.36[a]	17.00[a]	12.95[b]	1.08	*
Kidney (%)	0.86	0.87	1.06	1.090	1.10	0.15	NS
Proventriculus (%)	1.05	0.84	0.96	0.91	0.76	0.07	NS
Gizzard (%)	5.50[a]	4.30[b]	4.53[b]	5.03[ab]	5.18[ab]	0.26	*

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15%, respectively, SEM: standard error of means, P: Probability, $^{*}P<0.05$,** $P<0.01$, NS: non-significant

TABLE 6. The effects of treatments on chemical composition, pH, and colour of breast muscle

	Diets						
Traits	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Dry matter (%)	26.29	26.23	27.32	27.72	27.22	0.67	NS
Crude protein (%)	27.46	26.02	27.38	26.50	26.62	0.67	NS
Crude ash (%)	7.31	9.16	8.00	9.65	8.26	0.87	NS
Organic matter (%)	18.18	17.56	19.33	19.75	18.95	1.43	NS
Drip loss (%)	2.07	2.97	2.83	3.84	3.05	0.44	NS
Chilling loss (%)	4.40	3.17	3.53	4.65	4.02	0.52	NS
Cooking loss (%)	30.78	32.57	34.09	33.18	32.91	0.79	NS
pH1	5.99	5.98	6.03	6.08	6.05	0.09	NS
pH24	6.16[a]	6.09[ab]	6.05[b]	5.93[b]	6.10[ab]	0.06	*
Meat colour							
L*	55.30	54.10	56.01	57.62	54.25	1.28	NS
a*	10.57	11.63	11.31	10.66	11.02	0.57	NS
b*	1.30	1.91	2.93	3.20	1.82	0.58	NS

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15% respectively, SEM: standard error of means, P: Probability, $^{*}P<0.05$, NS: non-significant

TABLE 7. The effects of treatments on egg yolk colour of the quails

		Diets						
Day	Trait	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
14								
	L*	59.18[a]	55.79[a]	56.21[b]	54.34[c]	55.39[ab]	0.49	**
	a*	0.801[e]	4.16[d]	5.59[c]	8.10[b]	10.09[a]	0.20	**
	b*	35.46[c]	40.32[ab]	41.78[a]	39.87[b]	40.98[ab]	0.57	**
28								
	L*	57.52[a]	55.77[b]	56.02[ab]	53.92[c]	55.48[bc]	0.58	**
	a*	0.808[e]	3.91[d]	5.26[c]	8.04[b]	9.76[a]	0.24	**
	b*	34.14[c]	42.33[a]	42.29[a]	39.58[b]	41.21[a]	0.59	**
42								
	L*	58.59[a]	57.23[b]	56.35[b]	56.23[b]	54.84[bc]	0.45	**
	a*	0.96[e]	2.71[d]	4.73[c]	6.78[b]	8.42[a]	0.16	**
	b*	35.85[c]	36.92[bc]	37.27[b]	40.15[a]	37.84[b]	0.54	**
56								
	L*	60.28[a]	57.17[b]	57.80[b]	58.01[b]	56.18[b]	0.64	**
	a*	0.77[c]	2.74[b]	3.98[b]	6.18[b]	8.11[a]	0.19	**
	b*	37.78[b]	37.71[b]	37.92[b]	40.95[a]	40.06[a]	0.46	**
Overall								
	L*	51.94	52.50	49.88	53.71	52.81	0.88	NS
	a*	1.97d	3.29c	5.07b	7.75a	7.61a	0.22	**
	b*	33.14[b]	34.59[ab]	34.39[ab]	40.23[a]	37.13[ab]	0.76	*

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15% respectively, SEM: standard error of means, P: Probability, [*]*P*<0.05,[**] *P*<0.01, NS: non-significant

TABLE 8. The effects of treatments on the fatty acid composition of quail eggs

		Diets						
Fatty acid	Week	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Palmitic acid (C16:0)	4	25.94	25.40	25.23	26.17	26.36	0.70	NS
	8	26.49	25.84	27.06	26.29	25.85	0.04	NS
Palmitoleic acid (C16:1)	4	3.77	3.68	3.81	3.51	3.64	0.32	NS
	8	3.03	3.86	4.08	3.54	3.18	0.26	NS
Stearic acid (C18:0)	4	10.13	9.59	9.54	10.04	9.77	0.39	NS
	8	12.62[a]	9.71[b]	8.94[b]	8.95[b]	11.23[a]	0.48	*
Oleic acid (C18:1)	4	44.72	43.65	44.31	45.67	45.20	0.51	NS
	8	39.62[b]	42.74[b]	50.32[a]	45.18[ab]	42.49[b]	1.44	*
Linoleic acid (C18:2)	4	11.3	10.76	12.09	10.76	11.43	0.55	NS
	8	10.75	11.67	11.58	12.90	12.92	0.38	NS
α-Linolenic acid (C18:3)	4	0.11	0.17	0.19	0.14	-	0.04	NS
	8	ND	0.12	0.16	ND	ND	0.02	NS
Eicosanoic acid (C20:0)	4	0.33	0.16	0.5	0.36	1.79	0.18	NS
	8	3.52	0.27	2.77	0.1	0.13	1.18	NS
Gondoic acid (C20:1)	4	0.21	0.20	0.23	0.17	0.21	0.08	NS
	8	0.19	0.23	0.22	0.21	0.25	0.03	NS
Docosanoic acid (C22:0)	4	0.11	0.11	0.12	0.09	0.11	0.01	NS
	8	0.14	0.11	ND	ND	ND	0.01	NS
Eicosapentaenoic acid (C20:5, n-3)	4	0.84	0.72	0.69	0.0,69	0.70	0.06	NS
	8	0.49	0.82	0.67	0.76	0.87	0.06	NS
Docosahexaenoic acid (C22:6)	4	0.46	0.47	0.48	0.38	0.47	0.04	NS
	8	0.09	0.38	0.42	0.38	0.58	0.14	NS

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15% respectively, SEM: standard error of means, P: Probability, [*]*P*<0.05, NS: non-significant, ND: not detected

TABLE 9. Blood protein, MDA and SOD levels of the quails

	Diets						
Parameter	C[1]	RS2.5[2]	RS5[2]	RS10[2]	RS15[2]	SEM	*P*
Protein	3.678	3.720	3.720	3.687	3.727	0.022	NS
MDA	2.387[c]	2.260[d]	2.265[d]	2.472[b]	2.590[a]	0.008	**
SOD	0.304[b]	0.312[a]	0.312[a]	0.301[c]	0.300[c]	0.0005	**

[a,b,c] Values with different superscript in a line differ significantly. C: control, RS:2.5, RS:5, RS:10, RS:15 rosehip ratio in diet as 0, 2.5, 5, 10 and 15% respectively, SEM: standard error of means, P: Probability, [**] $P<0.01$, NS: non-significant

CONCLUSION

In conclusion, *Rosa canina* can be used as a feed ingredient at up to 10% (RS10) in quail diets without any negative effect on production parameters. However, the inclusion of 15% RS in the diet decreased feed efficiency, egg production rate, egg mass (by increasing egg weight) and carcass weight; however, its increased carcass yield. The RS ratio in diets did not significantly influence breast meat colour. RS addition clearly increased redness (a*) and moderate level of yellowness (b*) in egg yolk colour. RS addition to diets did not significantly affect the main fatty acid components. RS supplementation may be recommended as a natural colorant in poultry diets in conventional or organic egg production.

ACKNOWLEDGEMENTS

We wish to thank Mr. Eren Sekmen Ahmet Gulunc, Abdulkadir Uzunyol and Mehmet Yilmaz for their help to animal care and technical assistance in the laboratory. We express our gratitude to Ms. Betul Sahin Guidoum and also Editorial Office of Erciyes University (Turkey) for help during the editing of this paper.

REFERENCES

Andersson, S.C., Rumpunen, K., Johansson, E. & Olsson, M.E. 2011. Carotenoid content and composition in rose hips (*Rosa* spp.) during ripening, determination of suitable maturity marker and implications for health promoting food products. *Food Chemistry* 128(3): 689-696.

AOAC. 2012. *Official Methods of Analysis of AOAC International*. Association of Official Analytical Collaboration (AOAC).

Blount, J.D., Surai, P.F., Houston, D.C. & Moller, A.P. 2002. Patterns of yolk enrichment with dietary carotenoids in gulls: The roles of pigment acquisition and utilization. *Functional Ecology* 16(4): 445-453.

Böhm, V., Fröhlich, K. & Bitsch, R. 2003. Rosehip - a 'new' source of lycopene? *Molecular Aspects of Medicine* 24(6): 385-389.

Bramley, P.M. 2000. Is lycopene beneficial to human health? *Phytochemistry* 54(3): 233-236.

Daels-Rakotoarison, D.A., Gressier, B., Trotin, F., Brunet, C., Luyckx, M., Dine, T., Bailleul, F., Cazin, M. & Cazin, J.C. 2002. Effects of *Rosa canina* fruit extract on neutrophil respiratory burst. *Phytotherapy Research* 16(2): 157-161.

Egea, I., Sánchez-Bel, P., Romojaro, F. & Pretel, M.T. 2010. Six edible wild fruits as potential antioxidant additives or nutritional supplements. *Plant Foods for Human Nutrition* 65(2): 121-129.

Ercisli, S. 2007. Chemical composition of fruits in some rose (*Rosa* spp.) species. *Food Chemistry* 104(4): 1379-1384.

Esenbuga, N., Macit, M., Karaoglu, M., Aksakal, V., Yoruk, M.A., Gül, M., Aksu, M.I. & Bilgin, Ö.C. 2011. A study on possibility of *Rosa canina* seed use as feed ingredient in diets of Morkaraman male lambs. *Tropical Animal Health and Production* 43(7): 1379-1384.

Falowo, A.B., Fayemi, P.O. & Muchenje, V. 2014. Natural antioxidants against lipid - Protein oxidative deterioration in meat and meat products: A review. *Food Research International* 64: 171-181.

Fletcher, D.L. 1999. Broiler breast meat color variation, pH, and texture. *Poultry Science* 78(9): 1323-1327.

Gao, X., Bjork, L., Trajkovski, V., Uggla, M. & Björk, L. 2000. Evaluation of antioxidant activities of rosehip ethanol extracts in different test systems. *Journal of The Science of Food and Agriculture* 80(14): 2021-2027.

Guenthner, E., Carlson, C.W., Olson, O.E., Kohler, G.O. & Livingston, A.L. 1973. Pigmentation of egg yolks by xanthophylls from corn, marigold, alfalfa and synthetic sources. *Poultry Science* 52(5): 1787-1798.

Honikel, K.O. 1998. Reference methods for the assessment of physical characteristics of meat. *Meat Science* 49(4): 447-457.

Hornero-Méndez, D. & Mínguez-Mosquera, M.I. 2000. Carotenoid pigments in *Rosa mosqueta* hips, an alternative carotenoid source for foods. *Journal of Agricultural and Food Chemistry* 48(3): 825-828.

Karakaya, M., Bayrak, E. & Ulusoy, K. 2011. Use of natural antioxidants in meat and meat products. *Journal of Food Science and Engineering* 1(1): 1-10.

Kiliçgün, H. & Altiner, D. 2010. Correlation between antioxidant effect mechanisms and polyphenol content of *Rosa canina*. *Pharmacognosy Magazine* 6(23): 238-241.

Konca, Y., Cimen, B., Yalcin, H., Kaliber, M. & Beyzi, S.B. 2014. Effect of hempseed (*Cannabis sativa* sp.) inclusion to the diet on performance, carcass and antioxidative activity in japanese quail (*Coturnix coturnix japonica*). *Korean Journal for Food Science of Animal Resources* 34(2): 141-150.

Loetscher, Y., Kreuzer, M. & Messikommer, R.E. 2013. Oxidative stability of the meat of broilers supplemented with rosemary leaves, rosehip fruits, chokeberry pomace, and entire nettle, and effects on performance and meat quality. *Poultry Science* 92(11): 2938-2948.

Lowry, O.H., Rosebrough, N.J., Farr, A.L. & Randall, R.J. 1951. Protein measurement with the Folin phenol reagent. *The Journal of Biological Chemistry* 193: 265-275.

Machmudah, S., Kawahito, Y., Sasaki, M. & Goto, M. 2007. Supercritical CO_2 extraction of rosehip seed oil: Fatty acids composition and process optimization. *Journal of Supercritical Fluids* 41(3): 421-428.

McCormack, H., Fleming, R., McTeir, L. & Whitehead, C. 2001. Bone development up to 6 weeks of age in feed-restricted broiler breeders fed on diets supplemented with different concentrations of ascorbic acid. *British Poultry* 42: 91-92.

Nowak, R. 2005a. Fatty acids composition in fruits of wild rose species. *Acta Societatis Botanicorum Poloniae* 74(3): 229-235.

Nowak, R. 2005b. Chemical composition of hips essential oils of some *Rosa* L. species. *Zeitschrift für Naturforschung C* 60(5-6): 369-378.

Özcan, M. 2002. Nutrient composition of rose (*Rosa canina* L.) seed and oils. *Journal of Medicinal Food* 5(3): 137-140.

Pardue, S.L. & Thaxton, J.P. 1986. Ascorbic acid in poultry: a review. *World's Poultry Science Journal* 42(2): 107-123.

Qiao, M., Fletcher, D.L., Smith, D.P. & Northcutt, J.K. 2001. The effect of broiler breast meat color on pH, moisture, water-holding capacity, and emulsification capacity. *Poultry Science* 80(5): 676-680.

Razungles, A., Oszmianski, J. & Sapis, J.C. 1989. Determination of carotenoids in fruits of *Rosa* sp. (*Rosa canina* and *Rosa rugosa*) and of chokeberry (*Aronia melanocarpa*). *Journal of Food Science* 54(3): 774-775.

Sadigh-Eteghad, S., Tayefi-Nasrabadi, H., Aghdam, Z., Zarredar, H., Shanehbandi, D., Khayyat, L. & Seyyed-Piran, S.H. 2011. *Rosa canina* L. fruit hydro-alcoholic extract effects on some immunological and biochemical parameters in rats. *BioImpacts: BI* 1(4): 219.

Statistical Package for the Social Sciences (SPSS). 1999. SPSS base 9.0. Application guide, SPSS, Inc. Statistical Package for the Social Sciences (SPSS).

Sun, Y.I., Oberley, L.W. & Li, Y. 1988. A simple method for clinical assay of superoxide dismutase. *Clinical Chemistry* 34(3): 497-500.

Szentmihályi, K., Vinkler, P., Lakatos, B., Illés, V. & Then, M. 2002. Rose hip (*Rosa canina* L.) oil obtained from waste hip seeds by different extraction methods. *Bioresource Technology* 82(2): 195-201.

Tekeli, A. 2014. Effect of rosehip fruit (*Rosa canina* L.) supplementation to rations of broilers grown under cold stress conditions on some performance, blood, morphological, carcass and meat quality characteristics. *European Poultry Science* 78. DOI: 10.1399/eps.2014.19.

Valdés, A., García-Cañas, V., Rocamora-Reverte, L., Gómez-Martínez, Á., Ferragut, J.A. & Cifuentes, A. 2013. Effect of rosemary polyphenols on human colon cancer cells: Transcriptomic profiling and functional enrichment analysis. *Genes and Nutrition* 8(1): 43-60.

Whitehead, C.C. & Keller, T. 2003. An update on ascorbic acid in poultry. *World's Poultry Science Journal* 59(2): 161-184.

Yalçın, H. & Ünal, M.K. 2010. The enrichment of hen eggs with omega-3 fatty acids. *Journal of Medicinal Food* 13(3): 610-614.

Yoo, K.M., Lee, C.H., Lee, H., Moon, B. & Lee, C.Y. 2008. Relative antioxidant and cytoprotective activities of common herbs. *Food Chemistry* 106(3): 929-936.

Yoshioka, T., Kawada, K., Shimada, T. & Mori, M. 1979. Lipid peroxidation in maternal and cord blood and protective mechanism against activated-oxygen toxicity in the blood. *American Journal of Obstetrics and Gynecology* 135(3): 372-376.

Yusuf Konca, Mahmut Kaliber* & Hasan Huseyin Uzkulekci
Erciyes University
Faculty of Agriculture
Department of Animal Science
38039 Kayseri
Turkey

Behzat Cimen
Erciyes University
Faculty of Pharmacy
Department of Biochemistry
38039 Kayseri
Turkey

Hasan Yalcin
Erciyes University
Faculty of Engineering
Department of Food Engineering
38039 Kayseri
Turkey

*Corresponding author; email: mkaliber@gmail.com

Received: 25 January 2021
Accepted: 8 April 2021