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Influence of catechin (flavan-3-ol) addition to breeder quail (*Coturnix coturnix japonica*) diets on productivity, reproductive performance, egg quality and yolk oxidative stability

Kanber Kara[a], Berrin Kocaoğlu Güçlü[a], Meryem Şentürk[b] and Yusuf Konca[c]

[a]Department of Animal Nutrition and Nutritional Diseases, Faculty of Veterinary Medicine, Erciyes University, Kayseri, Turkiye; [b]Department of Biochemistry, Faculty of Veterinary Medicine, Erciyes University, Kayseri, Turkiye; [c]Department of Animal Science, Faculty of Agriculture, Erciyes University, Kayseri, Turkiye

ABSTRACT

The aim of this study was to investigate the effect of green tea (*Camellia sinensis*) catechin addition to breeder quail (*Coturnix coturnix japonica*) diet on productivity, reproductive performance, egg quality and yolk malondialdehyde (MDA) levels during storage, and some serum biochemical parameters. In this study, a total number of 180 quail, 7 weeks of age were randomly divided into 3 groups (1 control group and 2 treatment groups) with 5 replicates (9 females + 3 males). The control group was fed basal diet; the treatment groups were fed basal diet with 0.2% and 0.4% catechin supplementation for 5 weeks. The results of this study showed that 0.2% and 0.4% catechin addition had no significant effects on live weight, feed intake, egg production, feed efficiency, and egg internal quality (yolk colour, albumen index, yolk index, Haugh units, and pH) ($P > .05$). Catechin addition reduced egg weight, egg specific gravity, and egg shell thickness ($P < .001$). The catechin addition to diet significantly diminished MDA concentrations of eggs ($P < .05$). Serum glucose and triglyceride levels significantly decreased ($P < .05$) in the 0.4% catechin group, but were not significantly affected ($P > .05$) in the 0.2% catechin group compared to the control group. The addition of 0.2% catechin significantly increased fertility ($P < .05$), hatchability ($P < .01$), and the hatchability of fertile eggs ($P < .05$). In conclusion, catechin supplementation to breeder quail diet has the potential to increase egg shelf-life and reproductive performance. On the other hand, supplementation with these catechin levels decreased egg weight and egg shell quality.

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Catechins; egg quality; egg pH; malondialdehyde; productive; hatching

1. Introduction

Catechins (flavan-3-ols), which include 15 C (carbon) and comprise 2 benzene rings, and diphenyl propane heterocycle (C6–C3–C6) with a hydroxyl group on carbon 3, are flavonoid compounds. These flavanols are found in a large range of food sources, such as tea, onion, cherries, apple, broccoli, kale, tomato, berries, caraway, cumin, and buckwheat (Huang et al. 2009). Tea is a rich source of catechins, which constitute about 30% of its dry weight (Graham 1992). The catechins in green tea (*Camellia sinensis*) are the most abundant and include the following: (−) epicatechin, (−) epicatechin-3-gallate, (−) epigallocatechin, (−) epigallocatechin-3-gallate, (+) catechin, and (+) gallocatechin (Zaveri 2006). Epigallocatechin-3-gallate is the main catechin found in green tea; it accounts for about 50–60% of total catechins and is a considerably active compound in biological terms (Koo & Cho 2004; Uuganbayar et al. 2006; Zhong et al. 2009; Ariana et al. 2011). The herb or its extract, which has abundant ingredient catechins, was determined to have antioxidant, antimicrobial, antifungal, anti-carcinogenic, hypoallergic, and hypoglycemic effects by previous studies (Biswas et al. 2000; Kocyigit et al. 2000; Koo & Cho 2004; Ariana et al. 2011; Kara & Guclu 2012). In some studies, it was established that supplementation of green tea powder or extract to poultry diets decreased thiobarbituric acid reactive substances (TBARS) levels of the meat, egg, and sperm and cholesterol of the egg, increased hatchability of fertile eggs and quality of sperm (Biswas et al. 2000; Uuganbayar et al. 2005; Abdo et al. 2010; Sarker et al. 2010).

These flavonoids, with positive biological results in animal studies, should be investigated in the form of pure active compound (such as epicatechin, epicatechin-3-gallate, and epigallocatechin-3-gallate) or compounds (total catechins) instead of herbal power/extract (polypenolics-abundant) in studies. In this study, the purpose was to investigate the effect of 0.2% and 0.4% catechins (Palmaxi 500 mg, Valentis-USA) addition to breeder quail (*Coturnix coturnix japonica*) diets on productivity, reproductive performance, egg quality, MDA levels of egg yolk, and some biochemical parameters.

2. Materials and methods

2.1. *The catechins*

Catechins derived from green tea leaves (Palmaxi 500 mg) were purchased from Valentis-USA and were added to the diet in powder form. Valentis Laboratories inform that this commercial product includes min. 95% polyphenols, min. 75% catechins, min. 45% epigallocatechin-3-gallate, and max. 3% caffeine on the label.

CONTACT Kanber Kara karakanber@hotmail.com
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2.2. *Experimental design and animal management*

A total number of 180 quails, 7 weeks of age were randomly divided into 3 groups of 60 quail each and then subdivided into 5 replicates (9 females + 3 males). Each group was fed with 1 of the 3 experimental diets, basal diet (control group), and basal diet supplemented with 0.2% or 0.4% green tea catechin for 5 weeks. Ingredients and chemical composition of basal diet are given in Table 1. The quail were reared in the experimental cages of 45 × 100 cm size, with a photoperiod of 17-h daily. The temperature and humidity were recorded daily by a digital thermo-hygrometer, and the cages have average 21.7°C temperature and 40% humidity during the study. The diet and water were given *ad libitium* to animals throughout the experimental period.

2.3. *Performance parameters determination*

The breeder quail were weighed at the beginning and end of the study and their live weights were recorded. Egg production was recorded daily, egg weight and feed intake were recorded weekly, and then the feed efficiency was calculated as the amount of feed consumed for the production of 1 kg of eggs. Mortality was recorded daily of each replicate and the life force ratio (%) was calculated from the number of total animals to mortality.

2.4. *Egg internal and external quality determination*

At the 3rd and 5th weeks of study, egg specific gravity (g/cm^3) was determined in all eggs (60 eggs of each group) in sequential 2 days by the Archimedes method (Thompson and Hamilton 1982; Hempe et al. 1988), and then; eggs were stored at room temperature for 24 h and egg weights (g) were determined via an analytical balancer. At the 3rd and 5th weeks of study, the heights of albumen and yolk were measured using an electronical caliper (Mitutoyo, Height Gage) yolk diameter, albumen length and albumen width were measured using digital micrometers (Mitutoyo, Absolute Digimatic) in total 60 eggs of each group. Yolk index, a ratio of yolk height to diameter, was calculated. Haugh unit was calculated using the mathematical relationship between the egg weight and albumin height [Haugh unit = $100 \times \log\ (H - 1.7\,W^{0.37} + 7.6)$, H = thickness of the albumin (mm), W = egg weight (g)]. The egg yolk colour score was determined by *Roche Yolk Colour Fan*. Egg shell thickness, not including shell membranes, was measured using a micrometer (Mitutoyo, Dial Caliper Gage, mmx10^{-2}) (Wells 1968).

2.5. *Egg pH levels determination*

Thirty eggs per group were collected during the 5th week of the study for determined egg pH levels. Fifteen eggs per group were stored for 7 days or 14 days at + 4°C. The albumen and yolk of eggs were stirred separately with a glass rod during pH measurements. Yolk pH and albumen pH were determined using a digital pH meter (Hanna Instruments, USA) and by the direct probe thrust into the albumen and yolk, in 7-day eggs and 14-day eggs.

2.6. *Egg yolk oxidative stability determination*

The effect of different incubation time (0, 30, 60, and 90 min) on egg yolk MDA concentrations was analysed according to the modified distillation method (Kara & Guclu 2012) described by Kornbrust and Mavis (1980). After storage at + 4°C for a week 15 eggs from each group were selected for the MDA analysis. Approximately 1.0 g of egg yolk samples was diluted in 9 mL of KCl (1.15%). 0.1 mL of these diluted was homogenized in 5 mL of 80 mM Tris-maleate buffer (pH 7.4), 0.2 mL of 5 mM iron sulfate, and 0.2 mL of 2 mM ascorbic acid at 3000 rpm for 10 s in capped tubes on a vortex (Velp, Italy). Homogenates were incubated at 37°C in a shaking water bath (15 rpm) (Memmert, Germany) for an incubation duration of 0, 30, 60, and 90 min. After incubation, 2 mL of TCA–TBA–HCl mixture (150 g of trichloroacetic acid and 3.75 g of thiobarbituric acid were dissolved in 1 L of 0.25 N HCl) was added to homogenates. The tubes were incubated at 100°C and then cooled. The tubes were centrifuged at 2200 rpm (+ 4°C) for 20 min in a cooled centrifuge (Nüve NF800R, Turkey). The absorbance values of upper supernatants were measured spectrophotometrically on a spectrophotometer (Shimadzu 1208 UV/VIS, Japan) at 535 nm against a blank. The concentration of MDA in analysed samples (nmol/mg, yolk) was calculated using the following formulation: (MDA, nmol/mg = 6.4102 × 1000 × 3 × absorbance value)/(100 × mg/ml samples).

2.7. *Some biochemical parameters determination*

At the end of the study, blood samples were collected from 10 female quails and 10 male quails by cervical dislocation in each group, into tubes with silicon. The blood samples were centrifuged at 3000 rpm at room temperature for 10 min with an aim to extract serum. In serum samples, triglyceride, total cholesterol, total protein, and glucose concentrations were measured with a spectrophotometer (Shimadzu 1208 UV) using a commercial kit (Biolabo, France).

2.8. *Reproductive performance determination*

To determine the reproductive performance, hatching was observed in eggs collected in the last week of study, 32 eggs from each replicates (total 160 from each group). The eggs were numerated in separate replicates, and put in an incubator (Çimuka incubation systems, Turkey). After 17th day in incubator, the number of hatching quails was recorded, and subsequent to 20th day no hatching eggs cracked and the number of fertile eggs was determined and recorded.

The calculation of hatchability performance parameters is as follows:

$$\text{Hatchability}\,(\%) = (\text{number of hatching quail} / \text{number of all eggs in incubator}) \times 100,$$

$$\text{Fertility}\,(\%) = (\text{number of fertile eggs} / \text{number of all eggs in incubator}) \times 100,$$

$$\text{Hatchability of fertile eggs}\,(\%) = (\text{number of hatching quail} / \text{number of fertile eggs}) \times 100.$$

Table 1. Ingredients and nutrients composition of basal diet in the study.

Ingredients	% of DM
Corn	41.00
Soybean meal (with 48% CP)	24.80
Wheat	18.00
Sunflower meal (with 36% CP)	6.00
Limestone	5.00
Vegetable oil	3.00
Dicalcium phosphate	1.50
Sodium chloride	0.30
Vitamin–mineral premix[a]	0.25
DL-Methionine	0.10
L-Lysine hydrochloride	0.05
Nutrients and metabolizable energy composition	
Calculated values	
Dry matter, %	90.00
Crude protein, %	19.20
Calcium, %	2.36
Phosphorus (available), %	0.36
Lysine, %	1.05
Methionine + cystine, %	0.74
Metabolizable energy, kcal/kg	2833.00
Analysis values	
Dry matter, %	91.06
Crude protein, %	19.80
Crude fibre, %	7.15
Diethyl ether extract, %	3.25
Crude ash, %	8.48

[a]One kilogram of vitamin–mineral premix: vitamin A, 5,000,000 IU; vitamin D3, 1,000,000 IU; vitamin E, 15,000 mg; vitamin K_3, 2500 mg; vitamin B_1, 1250 mg; vitamin B_2, 2500 mg; vitamin B_6, 2000 mg; vitamin B_{12}, 20 mg; folic acid, 325 mg; choline chlorite, 150,000 mg; calcium pantothenate, 150,000 mg; D-biotin, 25 mg; Fe, 40,000 mg; Mg, 40,000mg; Zn, 40,000 mg; I, 300 mg; Cu, 5000 mg; Se, 125 mg; Co, 150 mg; antioxidant, 25 mg.

2.9. *Chemical composition of diet determination*

Dry matter (AOAC 1984, method 14.081), crude ash (AOAC 1990, method 942.05), crude protein (AOAC 1990, method 954.01), diethyl ether extract (AOAC 1990, method 920.39), and crude fibre (AOAC 1980, methods 7.066–7.070) compositions of the diet were analysed using the AOAC methods. Metabolizable energy concentration was calculated from the sum of the values of each ingredient.

2.10. *Statistical analysis*

The data were analysed statistically using SPSS 15.0 software. The significance of the differences among the groups was determined with one-way ANOVA. Differences among groups were separated by Duncan's multiple range test. Data were given as mean ± standard error mean (SEM) in the tables.

3. Results

The effects of dietary treatments on quail productive performance are given in Table 2. In this study, diets supplemented with 0.2% and 0.4% catechin had no significant effects on live weight, feed intake, egg production, feed efficiency, and life force ratio ($P > .05$).

Egg yolk colour, albumen index, yolk index, HU, and pH of egg yolk and albumen were not affected by the treatments ($P > .05$). Egg weight, egg specific gravity, and egg shell thickness were lower in catechin supplementation groups than those of the control group ($P < .001$) (Tables 3 and 4).

Table 2. Effect of catechin supplementation on productive performance parameters.

	Treatment groups			
	Control group	0.2% catechin	0.4% catechin	*P*
Parameters	Mean ± SEM	Mean ± SEM	Mean ± SEM	value
Initial body weight, g/quail	210.09 ± 3.19	209.57 ± 3.70	209.96 ± 3.38	.994
Final body weight, g/quail	215.03 ± 3.71	211.85 ± 3.84	208.18 ± 3.44	.420
Feed intake, g/day/quail	23.73 ± 0.52	22.89 ± 0.35	22.08 ± 0.71	.144
Egg production, %	75.98 ± 3.69	76.38 ± 3.83	75.86 ± 4.52	.996
Feed efficiency, g/g	2.57 ± 0.11	2.57 ± 0.07	2.54 ± 0.12	.970
Egg weight, g	12.27 ± 0.06[a]	11.71 ± 0.07[b]	11.57 ± 0.07[b]	.000
Livability, %	100.00 ± 0.00	99.67 ± 0.33	99.67 ± 0.33	.619

SEM, standard error of mean.
Note: Means on the same column differently superscripted are significantly different.

Table 3. Effect of catechin supplementation on egg quality parameters.

	Treatment groups			
	Control group	0.2% catechin	0.4% catechin	*P*
Parameters	Mean ± SEM	Mean ± SEM	Mean ± SEM	value
Egg specific gravity, g/cm^3	1.0707 ± 0.001[a]	1.0680 ± 0.001[b]	1.0665 ± 0.001[b]	.001
Egg shell thickness, mm × 10^{-2}	21.81 ± 0.16[a]	20.78 ± 0.15[b]	20.34 ± 0.20[b]	.000
Albumen index, %	10.31 ± 0.28	10.63 ± 0.31	9.75 ± 0.42	.208
Yolk index, %	44.01 ± 0.86	45.07 ± 0.53	44.36 ± 0.57	.563
Haugh unit	91.95 ± 0.53	91.83 ± 0.56	90.57 ± 0.77	.245
Yolk colour score	4.96 ± 0.09	4.75 ± 0.09	4.97 ± 0.11	.179

SEM, standard error of mean.
Note: Means on the same column differently superscripted are significantly different.

Table 4. Effect of catechin supplementation on pH of the eggs stored for 7 and 14 days.

		Treatment groups			
		Control group	0.2% catechin	0.4% catechin	*P*
Parameters		Mean ± SEM	Mean ± SEM	Mean ± SEM	value
7-day eggs	Egg yolk pH	6.22 ± 0.02	6.19 ± 0.03	6.16 ± 0.03	.266
	Egg albumen pH	9.03 ± 0.01	8.89 ± 0.01	8.87 ± 0.01	.714
14-day eggs	Egg yolk pH	6.26 ± 0.03	6.23 ± 0.02	6.19 ± 0.02	.638
	Egg albumen pH	9.17 ± 0.01	9.14 ± 0.02	9.12 ± 0.02	.143

SEM, standard error of mean.

The MDA concentrations of eggs stored for 7 days at + 4°C in 0.2% catechin group at 0, 60, and 90 ($P < .05$) minutes incubations, and also eggs in 0.4% catechin group at 0 ($P < .05$), 30 ($P < .001$), 60, and 90 ($P < .05$) minutes incubations decreased significantly (Table 5).

The serum glucose and triglyceride levels decreased significantly ($P < .05$) in 0.4% catechin group, but did not affect ($P > .05$) the 0.2% catechin group compared to the control group. Catechin supplementation did not affect serum total cholesterol and total protein levels ($P > .05$) (Table 6).

The addition of 0.2% catechin to breeder quail diet significantly increased the ratio of egg fertility, hatchability ratio ($P < .05$), and hatchability of fertile eggs ($P < .01$), but 0.4% catechin supplementation did not significantly affect these parameters ($P > .05$) compared to the control group (Table 7).

Table 5. Effect of catechin supplementation on egg yolk MDA levels (nmol/mg) of egg stored for 7 days.

	Egg yolk MDA levels (nmol/mg)			
	Incubation time			
	0th min	30th min	60th min	90th min
	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM
Control group	0.0531 ± 0.006^{a}	0.1038 ± 0.004^{a}	0.1146 ± 0.005^{a}	0.1429 ± 0.012^{a}
0.2% catechin	0.0389 ± 0.002^{b}	0.1019 ± 0.003^{a}	0.1021 ± 0.002^{b}	0.1059 ± 0.010^{b}
0.4% catechin	0.0400 ± 0.002^{b}	0.0851 ± 0.003^{b}	0.1017 ± 0.003^{b}	0.1051 ± 0.006^{b}
P value	.027	.001	.035	.018

SEM, standard error of mean.
Note: Means on the same column differently superscripted are significantly different.

Table 6. Effect of catechin supplementation on some biochemical parameters.

		Treatment groups		
	Control group	0.2% catechin	0.4% catechin	
Parameters	Mean ± SEM	Mean ± SEM	Mean ± SEM	*P* value
Glucose, mg/dL	353.61 ± 14.44^{a}	343.30 ± 8.76^{a}	308.94 ± 12.29^{b}	.027
Triglyceride mg/dL	585.36 ± 102.91^{a}	433.36 ± 72.36^{ab}	312.50 ± 74.28^{b}	.012
Total cholesterol, mg/dL	186.93 ± 11.23	194.90 ± 17.79	168.08 ± 5.64	.384
Total protein, g/dL	4.96 ± 0.36	5.04 ± 0.37	5.92 ± 0.52	.232

SEM, standard error of mean.
Note: Means on the same column differently superscripted are significantly different.

Table 7. Effect of catechin supplementation on reproductive performance parameters.

		Treatment groups		
	Control group	0.2% catechin	0.4% catechin	
Parameters	Mean ± SEM	Mean ± SEM	Mean ± SEM	*P* value
Fertility (%)	81.19 ± 3.17^{a}	91.68 ± 2.83^{b}	83.17 ± 1.15^{a}	.029
Hatchability (%)	65.79 ± 3.12^{a}	83.35 ± 3.53^{b}	65.69 ± 3.36^{a}	.004
Hatchability of fertile eggs (%)	80.91 ± 1.08^{a}	90.87 ± 2.17^{b}	78.03 ± 4.05^{a}	.015

SEM, standard error of mean.
Note: Means on the same column differently superscripted are significantly different.

4. Discussion

The catechins are present abundantly in green tea (*C. sinensis*), black tea, cocoa, berries, and grapes (Frei & Higdon 2003; Krzyzanowska et al. 2010). Current studies informed that green tea catechins, the main components of green tea leaf, have many physiological and biochemical functions, including antioxidant (radical and oxidant scavenging, metal chelating, and inhibition of pro-oxidant enzymes), antimicrobial, anti-carcinogenic, hypoallergic and blood glucose reduction in studies on different animal species (Frei & Higdon 2003; Koo & Cho 2004; Zhong et al. 2009; Ariana et al. 2011; Kara & Guclu 2012). The studies carried out on hens and quail emphasized especially the antioxidation effect on the blood and the animal products (meat and egg) and also on performance (Tang et al. 2000; Biswas et al. 2000; Abdo et al. 2010; Sahin et al. 2010; Ariana et al. 2011). The change in performance parameters such as live weight, feed intake, egg production, and feed efficiency was not observed in some studies which used green tea leaves or extracts (Biswas et al. 2000; Biswas & Wakita 2001; Ariana et al. 2011) as corresponding with results of the present study, and despite that in some studies these parameters had a negative effect (Uuganbayar et al. 2006; Kojima & Yosida 2008; Sarker et al. 2010). The egg weight decreased 4.56% and 5.70% by 0.2% and 0.4% catechins supplementation respectively, but Ariana et al. (2011) state that egg weight did not change in the 1.5% green tea powder and 0.5% green tea extract. In added catechin groups, decreased egg shell thickness and egg specific gravity were recorded, and these results were in the line with the results reported by Kojima and Yoshida (2008) and Uuganbayar et al. (2005, 2006) in different ratios (0.5%, 1%, 2%, 5%, and 10%) of green tea powder in laying hen diets. This findings may be attributed to the specialty of bonding proteins (proline-rich proteins) and/or minerals (divalent metal ions, e.g. Cu^{2+}, Zn^{2+}, Co^{2+}, Fe^{2+}, Mg^{2+}, and Ca^{2+}) and form inactive stacking of polyphenols (Crespy & Williamson 2004; Bark et al. 2012; Haifar 2012). Besides, green tea leaf catechins (especially epigallo catechin gallate) have potential effect on metabolism and assimilation of minerals in human and animal digestive channel (Crespy & Williamson 2004). In this study, albumen index, yolk index, Haugh unit, and yolk colour score were not influenced by the catechins supplementation to diet to match results of Uuganbayar et al. (2005, 2006) and Ariana et al. (2011). However, different results of studies on performance and egg quality may be due to a different form/ratio of catechins (such as catechin, epicatechin, epigallocatechin, epicatechin gallate, and epigallocatechin gallate) extracted from different plants and different avian species.

Increasing egg storage duration affects internal quality of egg, especially albumen quality by raising the pH of egg. The egg albumen includes bicarbonates and carbon dioxide, and the loss of dissolved carbon dioxide results in the increase in the pH of albumen. Prospective decreasing in egg pH, particularly in the albumen, degrades the proteins and then decreasing albumen quality (Tona 2013). In this study, the albumen pH and yolk pH of eggs which were stored for a week and two weeks at + 4°C were not affected by catechins, only decreased as numerically. Abdo et al. (2010) determined that green tea leaves (1.0%, 3.0%, and 5.0% of the diet) and green tea extracts (0.5, 1.5, and

2.5 L/100 kg of the diet) to diet (specifically green tea extracts) reduced egg pH levels of stored egg until 12 days. Moreover, other researchers stated that pH value of breast meat (*Pectoralis major*) reduced in 0.1% green tea extract (content 13.93% total catechin) supplementation to broiler diet (Erener et al. 2011). The egg pH values were not affected in our study, which could be attributed to egg storage duration and inserting catechin levels.

The egg and particularly egg yolk is rich in polyunsaturated fatty acids. For product the functional egg have been achieved increase the n-3 fatty acids include of egg via enriching poultry diets with polyunsaturated fatty acids. This may suggest that egg yolk is very susceptible to lipid oxidation. In the present study, the MDA levels in one week-stored eggs significantly decreased in catechins supplementation groups by the increase of incubation times. This result is same as that of previous studies that used green tea leaves power/extracts to reduce lipid peroxidation in the egg of poultry (Uuganbayar et al. 2005; Abdo et al. 2010) and the meat of broiler (Tang et al. 2000, 2001, 2002), stored or fresh. In addition, the MDA level in egg yolk decreased significantly in 2.0% grape pomace (include 1.1 mg/kg catechin, 5.3 mg/kg epicatechin, 0.5 mg/kg gallocatechin, and 4.3 mg/kg epigallocatechin) used in laying hen diet (Kara & Guclu 2012). This decrease in lipid peroxidation of the egg yolk may be associated with transfer to egg yolk of catechin flavonoids. Consequently, the decreased MDA in egg yolk may be connected with the scavenging activity of both superoxide and hydroxyl radicals; (i) chelating with metal ions and then form inactive complexes; (ii) and stimulating to synthesis endogenous antioxidant enzymes into cell (iii) of likely catechins in egg yolk (Rice-Evans et al. 1995; Frei & Higdon 2003; Crespy & Williamson 2004; Sutherland et al. 2006; Sahin et al. 2010). According to these results of the present study, catechin supplementation to diet may be used as an alternative and natural antioxidant for prevention of increased peroxide in long-time-stored eggs.

Supplementation of 0.2% catechins increased fertility egg ratio, hatchability ratio, and hatchability of fertile eggs, but 0.4% catechins supplementation did not significantly affect these parameters compared to the control group. Abdo et al. (2010) determinate that hatchability (%) and hatchability of fertile eggs were significantly improved 3% and 5% green tea leaves, and 1.5 and 2.5 L/100 kg green tea by extracts addition to hen diets, respectively and sperm quality parameters (sperm concentration, life sperm) improved and sperm TBARS value reduced especially by high green tea leaves and green tea extracts supplementation to cock diets. Daham and Al-Hilfi (2010) indicated that catechin addition to mice diet significant increased sperms motility, decreased dead percentage, and abnormalities of sperms. This positive effect on reproductive performance of catechin compounds may be connected with protection effect to the cell wall against lipid peroxidation.

Serum triglyceride levels decreased with catechins supplementation to diet correspond with results of previous studies (Abdo et al. 2010; Ariana et al. 2011). Biswas et al. (2000) reported that green tea powder supplementation (0.6%) to laying hen diet significantly reduced total lipid concentration of egg yolk. The absorption of fat and carbohydrate was found to be reduced by tea powder or extracts by Koo and Cho (2004). Tea has been shown to inhibit digestive lipases and interfere with lipid-micelle formation in the intestine leading to a decrease in fat absorption (Koo & Cho 2004). Besides, studies have also shown that tea lowered the uptake of sugar and reduced blood sugar level through suppression on glucose transporter activity in the intestinal epithelium (Shimizu et al. 2000). Catechin supplementation did not affect serum total cholesterol levels, but Abdo et al. (2010) determined that different levels of green tea leaves and green tea extract addition to diet decreased total cholesterol and LDL-cholesterol values.

5. Conclusion

The results of our study demonstrated that 0.2% or 0.4% green tea catechins supplementation to breeder quail diet has the potential to prevent lipid oxidation and extending the shelf-life of the egg, increasing reproductive performance without altering some performance parameters (live weight, feed intake, egg production, and feed efficiency) and internal quality of the egg. But, these levels of catechins supplementation negatively affected egg weight and shell quality. However, further studies are warranted to suitable levels of catechins, which positive effect on shelf-life of the egg and reproductive performance, but without adverse effect on performance and egg quality.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abdo ZMA, Hassan RA, El-Salam AA, Helmy SA. 2010. Effect of adding green tea and its aqueous extract as natural antioxidants to laying hen diet on productive, reproductive performance and egg quality during storage and its content of cholesterol. Egypt Poult Sci. 30:1121–1149.

AOAC, 1980. Official methods of analysis (13th ed.). Arlington, VA: Association of Official Analytical Chemists.

AOAC, 1984. Official methods of analysis (14th ed.). Arlington, VA: Association of Official Analytical Chemists.

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

Ariana M, Samie A, Edriss MA, Jahanian R. 2011. Effects of powder and extract form of green tea and marigold, and α-tocopheryl acetate on performance, egg quality and egg yolk cholesterol levels of laying hens in late phase of production. J Med Plant Res. 5:2710–2716.

Bark KM, Yeom JE, Yang IJ, Park O, Park CH, Park HR. 2012. Studies on the interaction between catechin and metal ions. Bull Korean Chem Soc. 33:4235–4238.

Biswas AH, Miyazaki Y, Nomura K, Wakita M. 2000. Influences of long-term feeding of Japanese green tea powder on laying performance and egg quality in hens. Asian-Aust J Anim Sci. 13:980–985.

Biswas MAH, Wakita M. 2001. Effect of dietary Japanese green tea powder supplementation on feed utilization and carcass profiles in broilers. J Poult Sci. 38:50–57.

Crespy V, Williamson G. 2004. A review of the health effects of green tea catechins in in vivo animal models. J Nutr. 134:3431–3440.

Daham AF, Al-Hilfi HAM. 2010. Effects of aqueous extract of catechin tea on some parameters of sperms and histopathological changes in testis of mice treated with Methotrexate (MTX). Kufa J Vet Med Sci. 1:85–96.

Erener G, Ocak N, Altop A, Cankaya S, Aksoy HM, Ozturk E. 2011. Growth performance, meat quality and caecal coliform bacteria count of broiler

chicks fed diet with green tea extract. Asian-Aust J Anim Sci. 24:1128–1135.
Frei B, Higdon JV. 2003. Antioxidant activity of tea polyphenols in vivo: evidence from animal studies. J Nutr. 133:3275–3284.
Graham HN. 1992. Green tea composition, consumption, and polyphenol chemistry. Prevent Med. 21:334–350.
Haratifar S. 2012. Nanoencapsulation of tea catechins in Casein Micelles: effects on processing and biological functionalities [A PhD Thesis]. Canada: The University of Guelph.
Hempe JM, Lauxen RC, Savage JE. 1988. Rapid determination of egg weight and specific gravity using a computerized data collection system. Poult Sci. 67:902–907.
Huang WY, Cai YZ, Zhang Y. 2009. Natural phenolic compounds from medicinal herbs and dietary plants: potential use for cancer prevention. Nutr Canc. 62:1–20.
Kara K, Guclu BK. 2012. The effects of different molting methods and supplementation of grape pomace to the diet of molted hens on postmolt performance, egg quality and peroxidation of egg lipids. J Fac Vet Med Erc Uni. 9:183–196.
Kocyigit A, Arslan SO, Erel O, Aktepe N, Avcı S, Gur S. 2000. Effects of dietary supplementation of catechin on antioxidant enzyme activities and lipid peroxidation levels in rats. Turkiye Klinik J Med Sci. 20:1–4.
Kojima S, Yoshida Y. 2008. Effects of green tea powder feed supplement on performance of hens in the late stage of laying. Int J Poult Sci. 7:491–496.
Koo MWL, Cho HC. 2004. Pharmacological effects of green tea on the gastrointestinal system. Eur J Pharmacol. 500:177–185.
Kornbrust DJ, Mavis RD. 1980. Relative susceptibility of microsomes from lung, heart, liver, kidney, brain and tettes to lipid peroxidation; correlation with vitamin E content. Lipid. 15:315–322.
Krzyzanowska J, Czubacka A, Oleszek W. 2010. Dietary phytochemicals and human health. In: MT Giardi, G Rea, B Berra, editors. Bio-farms for nutraceuticals. New York, NY: Landes Bioscience and Springer Science + Business Media LLC; p. 74–98.
Rice-Evans CA, Miller NJ, Bolwell PG, Bramley PM, Pridham JB. 1995. The relative antioxidant activities of plant-derived polyphenolic flavonoids. Free Radic Res. 22:375–383.
Sahin K, Orhan C, Tuzcu M, Ali S, Sahin N, Hayirli A. 2010. Epigallocatechin-3-gallate prevents lipid peroxidation and enhances antioxidant defence system via modulating hepatic nuclear transcription factors in heat-stressed quails. Poult Sci. 89:2251–2258.
Sarker MSK, Kim GM, Yang CJ. 2010. Effect of green tea and biotite on performance, meat quality and organ development in ross broiler. Egypt Poult Sci. 30:77–88.
Shimizu M, Kobayashi Y, Suzuki M, Satsu H, Miyamoto Y. 2000. Regulation of intestinal glucose transport by tea catechins. Biofactors. 13:61–65.
Sutherland BA, Rahman RMA, Appleton I. 2006. Mechanisms of action of green tea catechins, with a focus on ischemia-induced neurodegeneration. J Nutr Biochem. 17:291–306.
Tang SZ, Kerry JP, Sheeban D, Buckley DJ. 2002. Antioxidative mechanisms of tea catechins in chicken meat systems. Food Chem. 76:45–51.
Tang SZ, Kerry JP, Sheehan D, Buckley DJ, Morrissey PA. 2000. Dietary tea catechins and iron-induced lipid oxidation in chicken meat, liver and heart. Meat Sci. 56:285–290.
Tang SZ, Kerry JP, Sheehan D, Buckley DJ, Morrissey PA. 2001. Antioxidative effect of dietary tea catechins on lipid oxidation of long-term frozen stored chicken meat. Meat Sci. 57:331–336.
Thompson BK, Hamilton RMG. 1982. Comparison of the precision and accuracy of the specific gravity of eggs. Poult Sci. 61:1599–1605.
Tona K. 2013. Effect of egg storage conditions on eggshell resonant frequency and albumen characteristics. Int J Poult Sci. 12:130–134.
Uuganbayar D, Bae IH, Choi KS, Shin IS, Firman JD, Yang CJ. 2005. Effects of green tea powder on laying performance and egg quality in laying hens. Asian-Aust J Anim Sci. 18:1769–1774.
Uuganbayar D, Shin IS, Yang CJ. 2006. Comparative performance of hens fed diets containing Korean, Japanase and Chinese green tea. Asian-Aust J Anim Sci. 19:1190–1196.
Wells RG. 1968. Egg quality characteristics. Egg quality: A study of the hens egg. TC. Carter, ed. Edinburgh: Oliver and Boyd.
Zaveri NT. 2006. Green tea and its polyphenolic catechins: medicinal uses in cancer and noncancer applications. Life Sci. 78:2073–2080.
Zhong RZ, Tan CY, Han XF, Tang SX, Tan ZL, Zeng B. 2009. Effect of dietary tea catechins supplementation in goats on the quality of meat kept under refrigeration. Small Rum Res. 87:122–125.