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Non-ruminants

Use of water-treated black tea waste instead of wheat bran in laying hen diets

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ABSTRACT - We assessed the effects of different amounts of water-treated black tea waste (BTW) in the diets of laying hens on performance, egg quality, yolk peroxidation, and blood parameters in this study. The experiment lasted for 12 weeks, during which a total of 108 Lohman layers, of 24 weeks old, were randomly allocated to one of six dietary treatments (18 hens each); each treatment consisted of six replicate cages, each containing three hens. Experimental animals were fed a commercial diet that contained 0 (control), 20, 40, 60, 80, and 100% BTW in place of wheat bran. Providing BTW in diets for laying hens, instead of wheat bran, did not have a significant effect on egg production, egg weight, or body weight change. As the amount of BTW in the diet increased, feed intake, cracked egg rates, and feed conversion ratio linearly increased. Additionally, use of BTW in diets of laying hens did not influence some egg quality parameters, such as shape index or shell strength. Increasing proportions of BTW in the diet, however, had a quadratic effect on yolk color and shell weight, a linear effect on yolk index and shell thickness, and a cubic effect on albumen index and Haugh unit. In response to increasing BTW percentage, there were no differences in blood parameters except for albumen, triglyceride, alkaline phosphatase, and alanine aminotransferase levels. Malondialdehyde values in the egg yolks obtained from treatment groups fed diets containing BTW at different levels and stored for 14 and 28 days were lower than in those of the control group, but there were no differences at 56 days. Results of our study showed that supplementing diets of laying hens with different levels of water-treated BTW did not have adverse effects on either animal performance or egg quality parameters and resulted in strong antioxidative activity. Consequently, BTW may be used to replace up to 100% of wheat bran in the diets of laying hens, but the best outcomes are observed at 4% BTW level.

Key Words: antioxidant, egg quality, laying hens, performance

Introduction

The poultry sector has a significant role in meeting the increasing demand for animal products. Inadequacy of poultry feed resources in both quantity and quality is one problem in this sector. For this reason, nutritionists and feed manufacturers have shifted to alternative, cheap, and readily available raw materials that have not been used previously as raw feedstuffs, to reduce feed costs through studies of the evaluation, processing, and use of new feed raw materials (Scheideler et al., 2005). Many agricultural byproducts have use as animal feeds, including tea waste. Black tea waste (BTW) is the residue remaining after the processing of tea (*Camellia sinensis*) leaves for human consumption in black tea factories. Black tea waste is completely unused, is largely wasted, or is burned for energy production, causing massive pollution (Kaya et al., 2014).

Black tea waste contains the same compounds as black tea, including polyphenol, caffeine, amino acids, saponins, tannins, etc. (Pan et al., 2003). The main constituents of tea leaves are cellulose, hemicelluloses, lignin, tannins, and proteins. Functional groups in these compounds are mainly hydroxyl, oxyl, aromatic carboxylate, amino, sulfonic, and phenolic groups (Malakahmad et al., 2016). Polyphenols in tea consist of catechins, flavanols, phenolic acids, flavanonens, glycosides, and plant pigments. Catechins can be categorized into two groups based on their structure: epistructured catechins, such as epigallocatechin, epicatechin, epigallocatechin gallate, and epicatechin; and non-epistructured catechins, such as gallocatechin, catechin, gallocatechin gallate, and catechin gallate (Serdar et al., 2017). Previous works have defined the positive effects of tea and tea byproducts on performance parameters and product quality (Frei and Higdon, 2003; Kara et al., 2016a). Tea polyphenols are catechins, flavanols, phenolic acids,

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flavanonens, glycosides, and plant pigments (Serdar et al., 2017). Experimental evidence unclosed that the highest levels of catechins found in green tea led to increased antioxidant properties; furthermore, black tea contained secondary polyphenols (theaflavins and thearubigins) that are responsible for high antioxidant potential. Efficient antioxidant properties, which have a role in scavenging free radicals, inhibiting lipid peroxidation, and chelating metal ions, have been identified in black tea (Hazra et al., 2017). It is reported that factory tea waste contains 6.3% of tannic acid, which interferes in protein metabolism and water-soluble phenolic metabolites. Therefore, a suitable, easy, and cheap methodology was developed to remove this antimetabolite (Kaya et al., 2014). Wetting is a simple and economic process to destroy these anti-metabolites.

Çaykur, a government-based company in Turkey, sold 20,000 tonnes of waste material in 2014 and guarantees that they will supply 20,000 tonnes/year for the next 10 years (Serdar et al., 2017). When BTW is used correctly instead of wheat bran in the least-cost formulation diets for animal feeding, it results in a decrease in the cost of animal products (Kaya et al., 2014), but in our previous work, 6, 8, and 10% of BTW levels had deleterious effects on performance and egg quality traits, presumably due to high tannic acid content. Therefore, this research was initiated to investigate the use of BTW, after removing the tannic acid through a soaking process, to determine its effect on performance, egg quality, yolk peroxidation, and blood parameters of laying hens fed diets containing different levels of BTW in place of wheat bran.

Material and Methods

The local Research Animal Ethic Committee approved this experimental protocol (case no. 2013/4/111). This study was conducted between March and June in the city of Erzurum (39°55'18.08" N and 41°16'42.17" E) in the eastern Anatolia region, Turkey.

One hundred and eight Lohman layers, 24 weeks old, with 94% uniformity in body weight (the number of hens weighing between 0.9-1.1% of the mean body weight), were used. Layers were blocked according to the location of cages (50 × 46 × 46 cm, width × depth × height) and then assigned randomly to receive one of six isocaloric and isonitrogenous dietary treatments for 12 weeks. Each dietary treatment was replicated in six cages, each containing three hens. Laying hens were fed the basal diet without BTW (control) and the treatment diets supplemented with black tea factory waste obtained from a black tea factory in Rize (Northern Turkey). Black tea waste was soaked in water at room temperature in a ratio of 1:50 (w/v) for 24 h to reduce BTW tannic acid content, then dried at room temperature and used instead of wheat bran in the diet at 2 (T1), 4 (T2), 6 (T3), 8 (T4), and 10% (T5) based on weight. The diets were formulated to meet the nutrient requirements of laying hens (NRC, 1994) and analyzed using AOAC (1990) methods (Table 1). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined with methods developed by Goering and Van Soest (1970).

The amount of tannin in the diets was determined using the methods improved by Kondo et al. (2007). Macro and micro element contents of BTW (Table 2) were analyzed according to Güneş et al. (2011). During the experimental period, hens were fed *ad libitum* once daily at 08.30 h and water was available at all times. Hens were subjected to a 17L:7D cycle.

Body weight was recorded at the beginning and end of the study to determine the body weight changes of control and treatment groups. Daily egg production was also measured daily at the same time. Feed intake was determined bi-weekly by recording the daily feed intake of hens, and the feed conversion ratio was calculated by kg feed consumed per kg egg produced. Every 15 days, all the eggs produced in each subgroup were weighed and divided by the total number of eggs to determine the egg weights. Twelve eggs from each experimental group were stored for 24 h at room temperature before determination of egg weight.

To assess egg quality parameters, other 12 egg samples were randomly collected from each experimental group every month. Egg quality parameters, including shape index, shell strength, shell thickness, albumen index, yolk index, yolk color (Yolk Colour Fan, the CIE standard colorimetric system, F. Hoffman-La Roche Ltd., Basel, Switzerland), and Haugh unit, were calculated using the following formulas as summarized by Kaya and Macit (2012):

Shape index (%) = (egg width/egg length)×100;

Shell strength (kg/cm^2) was determined by using a machine with the spiral pressure system;

Shell thickness (mm×10^{-2}) was determined in three different parts (upper and lower ends and middle) by using a micrometer;

Albumen index (%) = (albumen height)/(average of albumen length and albumen width)×100;

Yolk index (%) = (yolk height /yolk diameter)×100,

Haugh unit = 100×log(H + 7.57-1.7×W0.37), in which H = albumen height (in mm) and W = egg weight (in g).

Table 1 - Ingredient composition and chemical analysis of the experimental diets

Ingredient (g kg^{-1})	Experimental diets (% soaked black tea waste)					
	T0 (control)	T1	T2	T3	T4	T5
Corn	350	350	350	350	350	350
Soybean meal (48% CP)	200	200	200	200	200	200
Tea waste[1]	-	20	40	60	80	100
Wheat bran	100	80	60	40	20	-
Wheat	150	150	150	150	150	150
Sunflower seed mea[l]	50	50	50	50	50	50
Fish meal	25	25	25	25	25	25
Vegetable fat	20	20	20	20	20	20
Dicalcium phosphate[1]	25	25	25	25	25	25
Marble	73	73	73	73	73	73
Vitamin-mineral premix[2]	2.2	2.2	2.2	2.2	2.2	2.2
Salt	3	3	3	3	3	3
DL-methionine	1.2	1.2	1.2	1.2	1.2	1.2
L-lysine hydrochloride	0.6	0.6	0.6	0.6	0.6	0.6
Chemical composition (analyzed on dry matter basis; g kg^{-1} of dry matter)						
Dyr matter	897	901	902	908	912	910
Crude protein	171	174	175	175	176	178
Crude fiber	25	42	48	54	62	63
Ether extract	27	27	27	26	25	25
Crude ash	116	115	112	117	111	111
Metabolizable energy (kcal kg^{-1})[3]	2640	2620	2610	2610	2600	2620

CP - crude protein.
[1] Each kilogram contained: 24% Ca and 17.5% P.
[2] The premix provided per 1 kg of diet: vitamin A, 15,000 IU; cholecalciferol, 1,500 IU; DL-α-tocopheryl acetate, 30 IU; menadione, 5.0 mg; thiamine, 3.0 mg; riboflavin, 6.0 mg; niacin, 20.0 mg; panthotenic acid, 8.0 mg; pyridoxine, 5.0 mg; folic acid, 1.0 mg; vitamin B12, 15 µg; Mn, 80.0 mg; Zn, 60.0 mg; Fe, 30.0 mg; Cu, 5.0 mg; I, 2.0 mg; and Se, 0.15 mg.
[3] This value was found with calculation from tabular values of feedstuffs reported for chickens NRC (1994).

Table 2 - Mineral composition and chemical analysis of soaked black tea waste

Item	
Chemical composition (g kg^{-1})	
Dry matter	929
Crude protein	174
Crude fiber	248
Ether extract	15
Crude ash	31
Acid detergent fiber	431
Neutral detergent fiber	558
Tannin (soaked black tea waste)	11
Tannin (untreated waste)	57
Metabolizable energy (kcal kg^{-1})[1]	2451
Mineral content (mg kg^{-1})	
Na	0.01
K	0.56
Ca	0.87
Mg	0.29
P	0.14
S	0.50
Fe	0.04
Zn	0.01
B	0.00
Al	0.17
Mn	0.15
Ni	0.00
Cr	0.00
Se	0.00

[1] This value was obtained via calculation, TSE (1991).

Blood samples taken from the subcutaneous *vena ulnaris* were collected from two hens from each cage and stored in additive-free vacutainers to determine the serum parameters (Alb = albumin; TG = triglyceride; Chol = cholesterol; HDL = high-density lipoprotein; TP = total protein; Glu = glucose; ALP = alkaline phosphatase; AST = aspartate aminotransferase; and ALT = alanine aminotransferase) at the end of the experiment. Serum was obtained following centrifugation at 3,000 rd for 10 min at 20 °C, and samples were maintained at −20 °C until laboratory analyses. Examined parameters were analyzed using commercially available kits (DDS® Spectrophotometric Kits, Diasis Diagnostic Systems Co., İstanbul, Turkey) using an autoanalyzer Vitros 5.1FS.

To determine the malondialdehyde (MDA), as an indicator of lipid peroxidation in yolk, 24 eggs were taken from each group at the end of the experiment and stored for 0, 14, 28, and 56 days at +4 °C. Six egg samples from each group were then analyzed following the method of Placer et al. (1966) using a Biotek ELISA Reader.

Data were analyzed using analysis of variance (ANOVA) in a general linear model (GLM) procedure in SPSS 20.0. Linear, quadratic, and cubic polynomial contrasts were used to evaluate the effects of different levels of BTW.

Results

Increasing supplemental BTW linearly increased feed intake (P<0.05), cracked egg rate (P<0.05), and feed conversion ratio (P<0.01) (Table 3). Egg production, egg weight, and body weight change, however, were not affected by supplementation of BTW in diets of laying hens.

Supplemental BTW had significant effects on some egg quality traits, such as shell thickness (linear; P<0.01), yolk color (quadratic; P<0.05), yolk index (linear; P<0.01), shell weight (quadratic; P<0.05), albumen index (cubic; P<0.05), and Haught unit (cubic; P<0.01), but did not influence shape index or shell strength (Table 4).

Except for Chol, HDL, TP, Glu, and AST, other blood serum parameters changed with increasing levels of BTW (Table 5). As BTW level increased, TG, ALP, and ALT linearly decreased and Alb concentration linearly increased.

The dietary treatment did not have significant effects at 56 days of storage, but MDA concentration of egg yolk linearly decreased in response to increasing supplemental BTW level at 14 and 28 days of storage (P<0.01) (Table 6).

Discussion

The BTW levels in diets of laying hens linearly increased feed intake, cracked egg rates, and feed conversion ratio. This was probably due to the high fiber ingredient of the BTW used in present study (Table 2). The intestinal system of poultry is simple and has a limited capacity to assimilate high-fiber ingredients, and, furthermore, hens lack enzymes such as cellulase and

Table 3 - The effects of experimental diets on laying performance parameters

Treatment	Response variable							
	Feed intake (g/day)	Egg production (%)	Cracked egg rate (%)	Egg weight (g)	FCR (kg feed/kg egg)[1]	Body weight (g)		
						Initial	Final	Change
T0 (control)	119.66	90.60	0.92	59.16	2.25ab	1500.7	1571.5	70.8
T1	122.33	91.49	0.15	59.69	2.24ab	1536.4	1625.0	88.6
T2	120.53	91.86	1.14	60.19	2.18b	1523.6	1668.6	145.0
T3	122.39	93.27	2.64	61.44	2.24ab	1510.1	1601.0	90.9
T4	125.91	90.82	1.58	59.09	2.43a	1506.0	1619.0	113.0
T5	126.75	90.18	2.44	58.81	2.39a	1500.3	1576.0	75.7
SEM	3.48	1.92	0.68	0.86	0.07	27.31	34.25	27.91
P-value	0.166	0.863	0.154	0.352	0.035	0.949	0.266	0.241
Polynomial analysis								
Linear	0.034	0.631	0.014	0.436	0.004	0.716	0.357	0.272
Quadratic	0.413	0.327	0.377	0.140	0.467	0.650	0.045	0.065
Cubic	0.182	0.511	0.631	0.607	0.565	0.509	0.803	0.961

SEM - standard error of the mean.
[1] FCR - feed conversion ratio (kg feed consumed per kg egg produced).
a-c - Means within columns with different letters differ significantly at P<0.05.

Table 4 - Effects of experimental diets on egg quality parameters

Treatment	Response variable							
	Shape index (%)	Shell strenght (kg/cm^2)	Shell strenght (kg/cm^2)	Shell weight (g)	Yolk color	Yolk index (%)	Albumen index (%)	Haught unit
T0 (control)	76.57	2.08	0.34a	7.19	11.73ab	45.51a	8.97	83.47b
T1	75.75	2.06	0.34a	7.34	11.22b	43.99ab	10.22	87.89a
T2	75.00	2.16	0.34a	7.33	11.33b	45.60a	10.22	88.32a
T3	75.86	2.03	0.33ab	7.31	11.72ab	44.42ab	9.97	87.56a
T4	75.47	2.09	0.32b	7.23	11.39ab	42.73b	9.43	85.25ab
T5	75.19	1.86	0.32b	7.19	11.89a	43.51b	10.10	87.66a
SEM	0.44	0.13	0.01	0.11	0.16	0.55	0.33	0.98
P-value	0.194	0.612	0.024	0.220	0.040	0.004	0.061	0.008
Polynomial analysis								
Linear	0.075	0.252	0.001	0.135	0.232	0.002	0.281	0.145
Quadratic	0.316	0.268	0.827	0.034	0.036	0.802	0.101	0.026
Cubic	0.170	0.641	0.535	0.913	0.381	0.673	0.010	0.003

SEM - standard error of the mean.
a-b - Means within columns with different letters differ significantly at P<0.05.

Table 5 - Effects of experimental diets including different levels of black tea waste on blood parameters of hens (mg/dL)

Treatment	Response variable								
	Alb (mg/dL)	TG (mg/dL)	Chol (mg/dL)	HDL (mg/dL)	TP (g/dL)	Glu (mg/dL)	ALP (Unit/L)	AST (Unit/L)	ALT (Unit/L)
T0 (control)	1.75	816.75a	130.75	30.24	4.30	202.00	205.00a	180.24	44.00a
T1	2.00	646.75abc	131.00	30.76	4.48	201.50	145.50b	153.01	14.50b
T2	1.90	717.25ab	144.25	31.52	4.23	204.25	147.25b	157.48	16.25b
T3	2.05	765.00a	134.25	30.48	4.78	203.75	118.50b	167.52	12.00b
T4	2.35	547.50bc	121.25	30.26	5.05	206.00	136.50b	195.02	9.25b
T5	2.005	504.75c	124.25	29.77	4.53	195.00	122.75b	182.56	13.00b
SEM	0.13	63.11	7.52	1.22	0.21	6.40	14.42	17.35	1.89
P-value	0.096	0.016	0.368	0.942	0.085	0.870	0.007	0.525	0.004
Polynomial analysis									
Linear	0.010	0.003	0.272	0.6021	0.067	0.686	0.001	0.325	0.001
Quadratic	0.201	0.384	0.200	0.452	0.474	0.365	0.039	0.310	0.010
Cubic	0.521	0.228	0.460	0.782	0.085	0.462	0.244	0.182	0.193

Alb - albumin; TG - triglyceride; Chol - cholesterol; HDL - high-density lipoprotein. TP - total protein; Glu - glucose; ALP - alkaline phosphatase; AST - aspartate aminotransferase; ALT - alanine aminotransferase; SEM - standard error of the mean.
a-c - Means within columns with different letters differ significantly at P<0.05.

Table 6 - Effects of black tea waste supplementation on MDA values (ng/g) of egg samples stored at 0, 14, 28, and 56 days

Treatment	Day			
	0	14	28	56
T0 (control)	0.68	2.10a	2.25a	2.60
T1	0.78	1.78b	2.13b	2.15
T2	0.78	1.85b	2.03bc	2.38
T3	0.82	1.88b	2.04b	2.45
T4	0.78	1.88b	1.94c	2.35
T5	0.75	1.48c	1.62d	2.17
SEM	0.055	0.035	0.038	0.160
P-value	0.626	0.000	0.000	0.339
Polynomial analysis				
Linear	0.431	0.000	0.000	0.267
Quadratic	0.122	0.043	0.004	0.964
Cubic	0.765	0.000	0.001	0.068

MDA - malondialdehyde; SEM - standard error of the mean.
a-c - Means within columns with different superscripts differ significantly at P<0.05.

hemicellulase needed to utilize high-fiber ingredients (Abudabos, 2011). As a result, hens increased their feed intake to compensate for deficiencies in terms of their nutrient requirements. In this study, high dietary levels of BTW in diets may have resulted in inadequate nutrient availability for the hens, which could be responsible for the observed increase in feed intake, cracked egg rate, and feed conversion ratio.

Kaya et al. (2014) reported that 0, 2, 4, 6, 8, and 10% of supplementary untreated tea waste in the basal diets of laying hens were correlated with linear decreases in feed intake, final body weight, and cracked egg rate, as well as cubic decreases in feed efficiency, egg production, and egg weight. When layers were fed diets containing 0, 2, 4, and 6% green tea byproduct, egg production was reported to increase in the groups fed 4 and 6% BTW, and feed efficiency values in these groups were lower than those of other groups (Yang et al., 2003a). Kojima and Yoshida (2008) reported that there were no differences in egg weight, egg production, or egg mass between the control and treatment groups fed diets supplemented with 1% green tea, while groups fed diets containing 5 and 10% green tea had the lowest values.

In this study, inclusion of BTW at different levels into the basal diet had variable effects on egg quality parameters (Table 3). Shell thickness and yolk index decreased linearly when laying hens were fed diets containing BTW at different levels. The decrease in shell thickness and yolk index may be related to a deficiency in hen nutrient intakes caused by BTW. The shell thickness data from this study were similar to findings of Zhang and Xu (2010), who found that tea powder (0.5, 1.5, and 2.5% of laying hen diets) decreased shell thickness. Additionally, Kojima and Yoshida (2008) reported that thinner egg shells were obtained from layers fed diets containing green tea powder at 1, 5, and 10% levels.

Increasing levels (0, 2, 4, 6, 8, and 10%) of BTW quadratically affected shell weight and yolk color in this study. Although shell weight firstly increased (8%) with increasing levels of BTW supplementation, it decreased at the highest level of BTW (10%); similarly, yolk color firstly decreased (8%) and then increased (10%). These findings agreed with those reported in most previous studies. Gradual increases in the yolk color scores in layers fed diets containing green tea leaves were reported by Abdo et al. (2010). However, Kojima and Yoshida (2008) noted that there was no difference in the yolk color among the treatment groups fed diets containing 0, 1, 5, and 10% green tea powder.

Albumen index and Haugh unit are the most two major indicators of egg quality. In this study, each parameter was affected by inclusion of BTW at 2, 4, 6, 8, and 10% levels in the basal diet. There was a cubic effect of treatment on Haugh unit and albumen index of layers fed diets containing 2, 4, and 6% BTW, and these groups had higher production than the other groups. Green tea (*Camellia sinensis*) has flavanol monomers, such as catechins, which occur at concentrations of 13.6 and 4.2 g/100 g in green tea and black tea, respectively. Catechins have pharmacologic effects because of their antioxidant properties (Yosef et al., 2012). Tea polyphenols can get over reactive oxygen radicals or chelate metals directly (Yuan et al., 2016). Black tea waste can protect albumen quality, which may be due to its direct antioxidant function whereby it scavenges reactive oxygen species or chelates transition metals. In agreement with the present results, Kaya et al. (2014) stated that Haugh unit and albumen index improved quadratically with increasing BTW proportions in the layer diet. Biswas et al. (2000) found that eggs from hens fed diet including green tea had the highest Haugh unit score. Bravo (1998) reported that the albumen tended to be higher in eggs obtained from hens fed diet including green tea powder because of the transfer of green tea powder polyphenols into β-ovomucin, which rises albumen durability. Uuganbayar et al. (2006), however, found that Haugh unit scores were not different in the eggs from layers fed diets including 1 and 2% green tea. The differences between results from previous studies and the present study may be due to different tea and varieties.

In the present study, laying hens fed diets containing increasing BTW at 2% increments in the diet, from 0 to 10%, for 12 weeks, and linear increases in Alb and linear decreases in TG, ALP, and ALT were found. In addition, Kaya et al. (2014) showed that plasma cholesterol, HDL, and AST were not influenced by supplementary BTW in layer diets. However, they reported serum albumen, TP (linearly), TG, and ALT values (quadratically) were affected by increasing BTW levels (2, 4, 6, 8, and 10%). In another study, Yang et al. (2003b) found that including green tea byproducts in broiler diets tended to decrease LDL level in blood compared with the control diet. Abdel-Azeem (2005) noted that blood lipid fractions were decreased and high-density lipoprotein was increased by the supplementation of green tea levels from 0.25% to 0.75%. Plant-origin tannins have water soluble phenolic metabolites and are known to inhibit digestive enzyme activity (Kaya et al., 2011). In this study, it was found that the tannin content of black tea waste was decreased by the wetting process. Untreated black tea waste had 5.7% tannin content, but soaked black tea waste had 1.1% tannin content (Table 2). Because of the reduction in tannin content, the results obtained in this study differ from those of most earlier studies.

Fatty acids in yolk lipids are susceptible to lipid oxidation, associated with storage time and conditions. Antioxidant supplements enhance quality criteria of animal-derived foods including the oxidative stability, storage conditions, and tenderness (Kara et al., 2016b). Therefore, antioxidants such as polyphenols, carotenoids, and tocopherols have been used in animal diets. Malondialdehyde is an indicator of lipid peroxidation. The MDA value increases during the storage period. In present study, MDA value was found to be linearly reduced in the egg of hens fed diets containing BTW compared with that from the control group at 14 and 28 days of storage. Green tea has antioxidant properties due to catechins, which have the ability scavenge reactive oxygen species (Yang, 1999). The number of antioxidants in tea depends upon the origin of the tea and its processing (Akram et al., 2012). Kaya et al. (2014) reported that MDA value of yolk from eggs stored at 14 and 28 days was linearly reduced when hens fed diets containing BTW at 2, 4, 6, 8, and 10% levels compared with that of layers fed basal diet. In agreement with findings of the present study, Uuganbayar et al. (2005) noted that egg yolk TBA value was decreased in hens fed diets supplemented with 0.5 to 2.0% green tea. Similarly, Biswas et al. (2000) stated that yolk TBA value was maintained in the eggs, stored for 10 days, from hens fed diets containing 0.6% Japanese green tea. A study on quail indicated that 200 or 400 mg of epigallocatechin-3-gallate (EGCG) exerted antioxidant effects and reduced the hepatic MDA level (Şahin et al., 2010).

Conclusions

This study focused on investigating the possibility of using black tea waste after removing tannic acid by soaking, in diets of laying hens, and results from this study showed that supplementing hen diets with different levels of water-treated black tea waste does not have an adverse effect on performance or egg quality parameters. Although group fed diet including 4% water-treated black tea waste showed the best feed conversion ratio value, the supplement may be used to replace up to 100% of wheat bran in the diets of hens.

References

Abdel-Azeem, F. A. 2005. Green tea flowers (*Camellia sinensis*) as natural anti-oxidants feed additives in growing Japanese quail diets. Egyptian Poultry Science Journal 25:569-588.

Abdo, Z. M. A.; Hassan, R. A.; El-Salam, A. A. and Helmy, S. A. 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. Egyptian Poultry Science Journal 30:1121-1149.

Abudabos, A. M. 2011. Effect of enzyme supplementation and wheat middlings as an alternative to corn on laying hens performance. Italian Journal of Animal Science 10:254-259. https://doi.org/10.4081/ijas.2011.e57

Akram, S.; Amir, R. M.; Nadeem, M.; Sattar, M. U. and Faiz, F. 2012. Antioxidant potential of black tea (*Camellia sinensis* L.) - A review. Pakistian Journal Food Science 22:128-132.

AOAC - Association of Official Analytical Chemistry. 1990. Official methods of analysis. 15th ed. AOAC International, Arlington, VA.

Biswas, Md. A. H.; Miyazaki, Y.; Nomura, K. and Wakita, M. 2000. Influences of long-term feeding of Japanese green tea powder on laying performance and egg quality in hens. Asian-Australasian Journal of Animal Sciences 13:980-985. https://doi.org/10.5713/ajas.2000.980

Bravo, L. 1998. Polyphenols: Chemistry, dietary sources, metabolism and nutritional significance. Nutrition Review 56:317-333.

Frei, B. and Higdon, J. V. 2003. Antioxidant activity of tea polyphenols in vivo: evidence from animal studies. The Journal of Nutrition 133:3275-3284. https://doi.org/10.1093/jn/133.10.3275S

Goering, H. K. and Van Soest, P. J. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agricultural Hand Book No. 379. Agricultural Research Service, United States Department of Agriculture, Washington, DC. p.12-15.

Güneş, A.; Ataoğlu, N.; Esringü, A.; Uzun, O.; Ata, S. and Turan, M. 2011. Yield and chemical composition of corn (*Zea mays* L.) as affected by boron management. International Journal of Plant, Animal and Environmental Sciences 1:42-53.

Hazra, A.; Saha, J.; Dasgupta, N.; Sengupta, C.; Kumar, P. M. and Das, S. 2017. Health-benefit assets of different Indian processed teas: A comparative approach. American Journal of Plant Sciences 8:1607-1623. https://doi.org/10.4236/ajps.2017.87111

Kara, K.; Şentürk, M.; Güçlü, B. K.; Sariözkan, S. and Eren, M. 2016a. Effect of catechins on fattening performance, meat quality, some antioxidant and blood parameters and fattening costs in Japanese quail (*Coturnix coturnix japonica*). British Poultry Science 57:522-530. https://doi.org/10.1080/00071668.2016.1174977

Kara, K.; Güçlü, B. K.; Baytok, E. and Şentürk, M. 2016b. Effects of grape pomace supplementation to laying hen diet on performance, egg quality, egg lipid peroxidation and some biochemical parameters. Journal of Applied Animal Research 44:303-310. https://doi.org/10.1080/09712119.2015.1031785

Kaya, H. and Macit, M. 2012. Effect of inclusion of garlic (*Allium sativum*) powder at different levels and copper into diets of hens on performance, egg quality traits and yolk cholesterol content. International Journal of Poultry Science 11:114-119. https://doi.org/10.3923/ijps.2012.114.119

Kaya, H.; Çelebi, Ş.; Macit, M. and Geyikoğlu, F. 2011. The effects of raw and physical processed common vetch seed *(Vicia sativa)* on laying performance, egg quality, metabolic parameters and liver histopatology of laying hens. Asian-Australasian Journal of Animal Sciences 24:1425-1434. https://doi.org/10.5713/ajas.2011.11041

Kaya, H.; Gül, M.; Çelebi, Ş.; Kaya, A.; Yıldırım, A. B. and Macit, M. 2014. The effects of black tea factory waste supplementation into laying hen diets on performance, egg quality, yolk peroxidation, and blood parameters. Journal of the Faculty of Veterinary Medicine, Kafkas University 20:375-382. https://doi.org/10.9775/kvfd.2013.10228

Kojima, S. and Yoshida, Y. 2008. Effects of green tea powder feed supplement on performance of hens in the late stage of laying. International Journal of Poultry Science 7:491-496. https://doi.org/10.3923/ijps.2008.491.496

Kondo, M.; Kita, K. and Yokota, H. 2007. Ensiled or oven-dried green tea by-product as protein feedstuffs: Effects of tannin on nutritive value in goats. Asian-Australasian Journal of Animal Sciences 20:880-886. https://doi.org/10.5713/ajas.2007.880

Malakahmad, A.; Tan, S. and Yavari, S. 2016. Valorization of wasted black tea as a low-cost adsorbent for nickel and zinc removal from aqueous solution. Journal of Chemistry 2016, Article ID 5680983, 8 pages. https://doi.org/10.1155/2016/5680983

NRC - National Research Council. 1994. Nutrient requirements of poultry. 9th rev. ed. National Academy Press, Washington, DC.

Pan, X.; Niu, G. and Liu, H. 2003. Microwave-assisted extraction of tea polyphenols and tea caffeine from green tea leaves. Chemical Engineering and Processing 42:129-133. https://doi.org/10.1016/S0255-2701(02)00037-5

Placer, Z. A.; Cushman, L. L. and Johnson, B. C. 1966. Estimation of product of lipid peroxidation (malonyldialdehyde) in biochemical systems. Analytical Biochemistry 16:359-364. https://doi.org/10.1016/0003-2697(66)90167-9

Scheideler, S. E.; Beck, M. M.; Abudabos, A. and Wyatt, C. L. 2005. Multiple-enzyme (Avizyme) supplementation of corn-soy-based layer diets. Journal of Applied Poultry Research 14:77-86. https://doi.org/10.1093/japr/14.1.77

Serdar, G.; Demir, E. and Sökmen, M. 2017. Recycling of tea waste: Simple and effective separation of caffeine and catechins by microwave assisted extraction (MAE). International Journal of Secondary Metabolite 4:78-89. https://doi.org/10.21448/ijsm.288226

Şahin, K.; Orhan, C.; Tuzcu, M.; Ali, S.; Şahin, N. and Hayirli, A. 2010. Epigallocatechin-3-gallate prevents lipid peroxidation and enhances antioxidant defense system via modulating hepatic nuclear transcription factors in heat-stressed quails. Poultry Science 89:2251-2258. https://doi.org/10.3382/ps.2010-00749

TSE - Turkish Standard Institute. 1991. Animal feeds-metabolic energy determination (chemical method). TSI Nr: 9610, Ankara, Turkey.

Uuganbayar, D.; Bae, I. H.; Choi, K. S.; Shin, I. S.; Firman, J. D. and Yang, C. J. 2005. Effects of green tea powder on laying performance and egg quality in laying hens. Asian-Australasian Journal of Animal Sciences 18:1769-1774. https://doi.org/10.5713/ajas.2005.1769

Uuganbayar, D.; Shin, I. S. and Yang, C. J. 2006. Comparative performance of hens fed diets containing Korean, Japanese and Chinese green tea. Asian-Australasian Journal of Animal Sciences 19:1190-1196. https://doi.org/10.5713/ajas.2006.1190

Yang, C. J.; Jung, Y. C. and Uuganbayar, D. 2003a. Effect of feeding diets containing green tea by-products on laying performance and egg quality in hens. Korean Journal of Poultry Science 30:183-189.

Yang, C. J.; Yang, I. Y.; Oh, D. H.; Bae, I. H.; Cho, S. G.; Kong, I. G.; Uuganbayar, D.; Nou, I. S. and Choi, K. S. 2003b. Effect of green tea by-product on performance and body composition in broiler chicks. Asian-Australasian Journal of Animal Sciences 16:867-872. https://doi.org/10.5713/ajas.2003.867

Yang, C. S. 1999. Tea and health. Nutrition 15:946-949.

Yosef, T. A.; Al-Julaifi, M. Z. and Kandeel, M. 2012. The Effects of green tea (*Camellia Sinensis*) probiotics on broilers exposed to lead-ınduced oxidative stress. Journal of American Science 8:499-506.

Yuan, Z. H.; Zhang, K. Y.; Ding, X. M.; Luo, Y. H.; Bai, S. P.; Zeng, Q. F. and Wang, J. P. 2016. Effect of tea polyphenols on production performance, egg quality, and hepatic antioxidant status of laying hens in vanadium-containing diets. Poultry Science 95:1709-1717. https://doi.org/10.3382/ps/pew097

Zhang, Z. and Xu, Y. 2010. Effects of black tea powder on performances and egg quality of laying hens. Journal of Anhui Agricultural Sciences 24:13113-13114.