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Breast meat quality characteristics and its oxidative status during storage at refrigerator temperature and growth capabilities of Japanese quail fed by *Echinacea purpurea* extract

[1*]Partovi, R. and [2]Seifi, S.

[1]Department of Food Hygiene, Faculty of Veterinary Medicine, Amol University of Special Modern Technologies, Amol, Iran; Address: Emam Khomeini Street, Aftab 24, Amol, Iran
[2]Department of Clinical Sciences, Faculty of Veterinary Medicine, Amol University of Special Modern Technologies, Amol, Iran; Address: Emam Khomeini Street, Aftab 24, Amol, Iran

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Abstract

Japanese quail production performance and its breast meat characteristics and oxidative stability affected by dietary supplementation of *E. purpurea* extract, were illustrated in this study. There was no difference between treatments in relation to FBW, FCR, CW, breast and thighs yield, and also pH 24 h, drip loss, cooking loss, fat and protein content of breast meat. However, diet supplementation with *E. purpurea* extract decreased TFI. *E. purpurea* extract decreased dressing percentage and the difference was significant between control group with 0.025 and 0.05% groups. Experimental groups had higher dry matter and ash content. *E. purpurea* extract had no effect on TBARS value of breast meat at 1 and 7 days of storage at 4°C, however TBARS value showed significant increase at 7th day. In conclusion, dietary *E. purpurea* extract supplementation had both no effect on Japanese quail growth performance and its meat characteristics or affected them adversely.

Introduction

The poultry industry is one of the most advanced in the field offood industry and the increase in the production of poultry products has been remarkable. Today, products of different species of poultry are marketed including quail products (Genchev *et al.*, 2008). Japanese quail *(Coturnixcoturnix japonica)* is one of the most important species of poultry whose meat and eggs are consumed especially in Asia, Europe, and America (Minvielle, 2004). Currently a concern of priority in food industry is to improve the produced meat both qualitatively and quantitatively. As a consequence, a good amount of research work has been dedicated to discovering natural, efficient, and safe additives such as plants, extracts and essential oils instead of antibiotics in order to improve the appetite and growth rate of poultry (Brenes and Roura, 2010). Among the most significant objectives of using natural additives is to prevent meat oxidation that negatively affects the meat organoleptic properties and also abates its nutritional value. Fat oxidation and microbial spoilage are the key elements to determine the shelf life of meat (Rossi *et al.*, 2013). Administering natural additives in poultry feed is superior to adding them to the poultry meat. Among the advantages of this method is the ease with which this addition is performed. In addition, it precludes the need for processing and also leads to an even distribution of additives in meat (botsoglou *et al.*, 2002).

Purple Coneflower *(Echinacea purpurea)* of the family Asteraceae is the most common medicinal plant in Europe.This plant has been administered to treat common cold and also its use as a food additive is increasing (Thygesen *et al.*, 2007). Pellati *et al.* (2004) demonstrated that the *Echinacea* extracts contain phenolic compounds and function as antioxidants. Antioxidant effects of *Echinacea* extract are explained by its phenolic compounds including cichoric acid, alkamides, caffeic acid, and chlorogenic acid (Thygesen *et al.*, 2007; Soleimani *et al.*, 2011).

The objectives of this study were to demonstratetheeffectof *E. purpurea* extract on characteristics and oxidative stability of Japanese quail breast meat and evaluate its ability to stimulate Japanese quail production performance when used as a feed supplement. Most of the relevant studies have been conducted on chicken and turkey while data regarding addition of *Echinacea* extract to Japanese quail feed and its effects on meat quality are lacking.

Materials and Methods

Animals and experimental design

Two hundred one-day-old male Japanese quailswere divided into five treatments each of which

*Corresponding author.
Email: *r.partovi@ausmt.ac.ir*

containing four replicates with 10 quails in each replicate and kept for a period of 42 days. The dietary supplementations were dissolved in the quail's drinking water and were fed ad libitum. The diet fed to the quails was designed to meet the requirements dictated by the NRC (1994). The diet included a starter (1-22 days) and a finisher (23-42 days). The composition of the diet fed to the birds waschemically evaluated based on the guidelines provided by the Association of Official Analytical Chemists (AOAC, 2004). The diet composition is illustrated in Table 1.The ethanolic extract of *E. purpurea* plant was purchased from Zardband Pharmaceuticals Co. [Tehran, Iran] and it was added to drinking water. *E. purpurea* extract has caffeic acid in the concentration of 2.99mg/ml. This is how the experimental diets were designed: JQ-C: the basal diet; JQ-1: the basal diet supplemented with 0.025% *E. purpurea* extract; JQ-2: the basal diet supplemented with 0.05% *E. purpurea* extract; JQ-3: the basal diet supplemented with 0.1% *E. purpurea* extract; JQ-4: the basal diet supplemented with 0.2% *E. purpurea* extract. Their health status was controlled daily.At the end of the experiment the total feed intake (TFI) was measured.

Table 1. Nutrient composition of diets

Item	Diet	
Ingredients (%)	**Starter (1-22 d)**	**Finisher (23-42 d)**
Corn	47.00	60.00
Soybean meal	43.5	33.40
Corn gluten germ	3.00	1.00
Vegetable oil	2.7	2.00
Oyster shell	1.2	1.10
Dicalcium phosphate	1.5	1.45
Common salt	0.30	0.32
L-Threonine	0.05	0.04
DL-Methionine	0.25	0.20
Vitamin and mineral premix [1]	0.50	0.50
Chemical composition (%)		
Crude protein	24	20.20
Calcium	0.95	0.86
Available phosphorus	0.44	0.41
Sodium	0.19	0.18
Lysine	1.31	1.06
Methionine+Cystine	0.68	0.60
Metabolizable energy (kcal/kg)	2925	3020

1vitamin and mineral premix supplied per kilogram of diet: Vit A, 10000 IU; Vit D3, 9800 IU; Vit E, 121 IU; Vit B_{12}, 20 µg; Riboflavin, 4.4 mg; Calcium pantothenate, 40 mg; Niacin, 22 mg; Choline, 840 mg; Biotin, 30 µg; Thiamin, 4 mg; Zinc sulfate, 60 mg; Manganese oxide, 60 mg.

Slaughtering procedures

At slaughtering age (42 days) one bird per pen (4 birds in each experimental group) was slaughtered. Live weight at the time of slaughter and also hot carcass weight were recorded and feed conversion ratio (FCR) and dressing percentage were calculated. Also, breast and thigh muscles (% of final BW) were determined. Carcasses were kept in a cool chamber, at 0 to 4°C, for day after which the breast muscles of all quails were harvested from the carcasses, packed in vacuum packages, and were frozen (−20°C) for chemical composition and oxidative stability. Fresh breast meat samples were used for the physical analyses.

Physical analyses of quail breast meat

pH was measured on breast muscle using a pH-meter (Jenway 3505, Staffordshire, UK) at 24hr postmortem. Using two buffers of pH 4.0 and 7.0, the pH probe was calibrated, and calibration was repeated between samples. Drip and cooking losses were measured using the method described by Pastorelli *et al*. (2016).In order to measure drip loss, the decrease in the weight of a previously weighed piece of meat at 4°C in a period of 24 hours is calculated in percent. Cooking loss is defined as the decrease in weight of the meat caused by cooking at 75°C in water bath for a period of one hour and then cooling the meat for 30 minutes followed by drying. Cooking loss is measured in percent.

Chemical composition of quail breast meat

Dry matter, protein, fat and ash content of all Samples of breast muscle were analyzed using the guidelines provided by the Association of Analytical Chemists (AOAC, 2004).

Measurement of oxidative stability of quail breast meat

The TBARS values were determined in duplicate using an extraction method described by Shirahigue *et al*. (2011). Briefly, 5 g of meat was homogenised in a centrifuge (SW 14R, Froilabo, Meyzieu, France) with 15 mL of homogenising solution. After filtration, 5 mL of the filtrate was mixed with 5 mL of an aqueous 0.02 M TBA solution. The samples were incubated in a water bath at 100°C for 40 mins and then cooled in cold water. The absorbance was measured at 532 nm by a spectrophotometer (T80+ UV-VIS; PG Instrumemts Ltd, Leicestershire, UK). The results were calculated from the standard curve of 1,1,3,3-tetraethoxypropane and expressed as mg of Malondialdehyde (MDA)/kg of meat. The TBARS value determination was performed after 1 and 7 days of refrigerated storage.

Statistical analyses

The obtained data were subjected to kolmogorov-smirnov test for normality and the levene test for the homogeneity of variances. Data from meat quality

Table 2. Effect of dietary supplementation with *E. purpurea* extract on production performances and carcass characteristics of Japanese quail

parameter	Treatments					SEM	P-value
	JQ-C	JQ-1	JQ-2	JQ-3	JQ-4		
TFI (g)	600.6^{a}	521^{b}	525.7^{b}	482.5^{b}	481.6^{b}	17.88	0.0017
FBW (g)	192	197.2	173.7	205.7	178.7	19.69	0.11
FCR	3.14	2.63	3.05	2.35	2.74	0.42	0.06
CW (g)	126.5	123.7	108.8	130.1	115.8	12.21	0.08
Dressing percentage	65.9^{a}	62.7^{b}	62.6^{b}	63.1^{ab}	64.7^{a}	1.67	0.02
Breast (g)	50	50.3	44	52.2	45	6.13	0.19
%Breast[1]	39.5	40.6	40.3	40	38.7	1.87	0.55
Thighs (g)	30.7	30.7	27.1	32.2	29.3	3.19	0.19
%Thighs[2]	24.2	24.7	24.9	24.7	25.3	1.24	0.74

Data are reported as mean values; n=20, JQ-C=basal diet, JQ-1= basal diet supplemented with 0.025% *E. purpurea* extract, JQ-2= basal diet supplemented with 0.05% *E. purpurea* extract, JQ-3= basal diet supplemented with 0.1% *E. purpurea* extract, JQ-4= basal diet supplemented with 0.2% *E. purpurea* extract, TFI= total feed intake, FBW= final body weight, FCR= feed conversion ratio, CW= carcass weight.1 breast meat weight percentage to carcass, 2 thighs meat weight percentage to carcass. The different superscripts ^{a,b,c,d} in the same row indicate significant differences ($P < 0.05$) between treatment groups.

parameters were subjected to one-way analysis of variance (ANOVA) in the general linear model and comparisons between treatment groups were assessed using the Tukeys post hoc tests using SPSS version 22 statistical package. For comparison of TBARS in day 1 and 7 postmortem, the parametric repeated measures ANOVA test were performed, and interaction between two factors (treatment groups and time of storage) are calculated. For all analyses, $P< 0.05$ was considered as statistically significant.

Results

Quail growth performance

The effect of diet supplementation with *E. purpurea* extract on total feed intake, final body weight, feed conversion ratio, carcass weight, dressing percentage and breast and thighs yield of Japanese quail at 42 days of age are presented in Table 2. There was no difference between treatments for FBW, FCR, CW and breast and thighs yield. However, compared with the control group, diet supplementation with *E. purpurea* extract at all concentrations decreased TFI (P=0.0017) and there wasn't significant difference between experimental groups. Diet supplementation with *E. purpurea* extract decreased dressing percentage and the difference was significant between control group with 0.025 and 0.05% groups. Diet supplementation at 0.2% caused a significant increase on dressing percentage in comparison to 0.025 and 0.05% of *E. purpurea* extract groups, yet the dressing percentage did not reach that of control group (P<0.05).

Physical characteristics and chemical composition of quail breast meat

Results of the physical characteristics and chemical composition of Japanese quail breast meat are shown in Table 3. In relation to physical characteristics of breast meat (pH 24 h, drip loss and cooking loss), there was no significant difference between groups. Feeding of *E. purpurea* extract in experimental groups had no effect on the fat and crude protein content of quail breast meat. The chemical composition of breast meat of experimental groups showed higher dry matter and ash content compared with the control group (P<0.05) and there wasn't any difference between experimental groups (P>0.05).

Lipid oxidation of quail breast meat

Figure 1 shows results of the determination of TBARS value measured in quail breast meat stored in refrigerator (4°C, 1 and 7 days). TBARS values of all samples are generally low at both intervals. Diet supplementation with *E. purpurea* extract had no effect on TBARS value of quail breast meat at 1 and 7 days of storage. TBARS value of quail breast meat in all groups except control group, showed significant increase at 7th day of storage in comparison to the first day (P=0.002). However, Control group showed lower TBARS value after 7 days of storage which wasn't significant (P=0.43).

Discussion

Some researchers have reported the positive effects of adding plant extracts to the feed consumed by poultry on their growth performance (Rahimi *et al.*, 2011).This is while others have not emphasized on such effects and even in some cases have demonstrated adverse effects of plant extracts on growth parameters of poultry (Nasir and Grashorn, 2010; Marcincakova *et al*., 2011; Marzoni *et al*., 2014). In an experiment, comparing the effects of *E. purpurea* juice on alcohol basis, applied through drinking water in

Table 3. Physical characteristics and chemical composition of breast meat in Japanese quail fed control or *E. purpurea* extract supplemented diet

Trait	Treatments					SEM	P-value
	JQ-C	JQ-1	JQ-2	JQ-3	JQ-4		
pH ^{24h}	6.32	6.33	6.16	6.34	6.35	0.15	0.3
Drip loss (%)	4.65	4.74	4.35	4.39	4.53	0.3	0.27
Cooking loss (%)	23.71	23.65	23.71	23.8	24.04	0.63	0.88
Dry matter (%)	24.19^{a}	29.05^{b}	28.68^{b}	29.52^{b}	28.8^{b}	0.35	0.0001
Crude protein (%)	22.65	22.35	21.92	22.8	22.81	0.57	0.17
Ash (%)	1.22^{a}	2.15^{b}	2.05^{b}	1.8^{b}	1.92^{b}	0.35	0.003
Fat (%)	1.93	2.2	2.59	2.19	1.99	0.37	0.1

Data are reported as mean values; n=20, JQ-C=basal diet, JQ-1= basal diet supplemented with 0.025% *E. purpurea* extract, JQ-2= basal diet supplemented with 0.05% *E. purpurea* extract, JQ-3= basal diet supplemented with 0.1% *E. purpurea* extract, JQ-4= basal diet supplemented with 0.2% *E. purpurea* extract. The different superscripts ^{a,b,c,d} in the same row indicate significant differences ($P < 0.05$) between treatment groups.

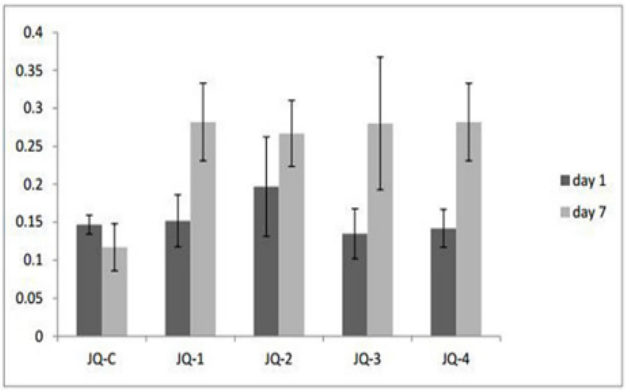

Figure 1. Effect of *E. purpurea* extract on TBARS during storage at 4°C of Japanese quail breast meat. Data are reported as mean values ± SE. JQ-C = basal diet, JQ-1 = basal diet supplemented with 0.025%. *E. purpurea* extract, JQ-2 = basal supplemented with 0.05%. *E. purpurea* extract, JQ-3 = basal diet supplemented with 0.1% *E. purpurea* extract, JQ-4 = basal diet supplemented with 0.2% *E. purpurea* extract. TBARS = thiobarbituric acid reactive substances expressed as mg malodialdehyde (MDA) kg^{-1}meat. P = 0.79 (day 1, P = 0.21 (day 7)

broilers, better feed conversion ratio was observed in *E. purpurea* treated groups as compared to control, but in our study FCR was not affected by the experimental diet (Nasir and Grashorn, 2008). In another experiment with broilers treated with 0 and 2.4% of *E. purpurea* cobs, *E. purpurea* supplemented groups showed lower total feed intake and body weight compared with control group (Rorth-Maier *et al*., 2005). Rahimi *et al.* (2011) demonstrated that feed supplementation with *Echinacea* extract significantly decreased TFI and FBW in comparison to virginiamycin group thus cannot replace antibiotics to improve growth performance. Similar to the results of the two aforementioned studies, TFI in our study was negatively affected by the *E. purpurea* supplemented diet and there was a significant difference between control and all the experimental groups but there wasn't any difference between groups on FBW. In a study conducted to assess the effects of *E. purpurea* on broilers, no significant effect was observed on weight of thighs and breast. Carcass yield in control groups was significantly ($P<0.05$) higher than in *E. purpurea* group (Nasir and Grashorn, 2010). Dressing percentage in our experiment was significantly higher in control group in comparison to groups of 0.025 and 0.05% *E. purpurea* extract. Sahin *et al*. (2012) found that there were no significant differences in terms of carcass yield due to *Echinacea* supplemented quail diets.The results of this study indicated that *E. purpurea e*xtract caused either no or negative growth-promoting effect when used in Japanese quail diets.Ineffectiveness of additives can be attributed to components of the basic diet and husbandry management. Additionally, supplementation of feed with extracts causes relative inappetence in some cases leading to adverse effects on growth performance. Some researchers believe that the favorable effects of additives can be more pronounced under conditions in which the basic feed has less digestible components and the birds are kept in an unclean environment (Lee *et al*., 2003).

The effect of plant extracts on the chemical composition of meat is vague.Genetic, environment, feed, slaughtering conditions, processing and storage of meat are among some important factors which influence meat quality (Nasir and Grashorn, 2010). A number of articles imply ineffectiveness of plant extracts on chemical characteristics of meat (Marcincakova *et al*., 2011; Marzoni *et al*., 2014). In our experiment, diet supplementation did not have any effect on physical characteristics and also crude protein and fat content of breast meat. Gardzielewska *et al.* (2003) showed that dry matter, protein and fat content of the breast meat of broilers were not affected by supplementation by *E.purpurea.* While administering 1% *Crataegus oxyacantha* and 1% *Achilleamille foliumin* poultry diet leads to

increases in dry matter and crude protein of breast meat (Marcincakova *et al*.,2011). Nasir and Grashorn (2010) found that meat samples of birds supplemented with *E. purpurea* have significantly lower crude protein and dry matter as compared to meat samples of control group. However diet supplementation with *E. purpurea* in our experiment increased dry matter in all experimental groups.Unlike the results of our study, Shirzadegan and Falahpour (2014) found that dietary mixture of Iranian green tea, cinnamon, garlic and chicory decreased the crude ash of broiler meat.

Because of containing relatively large amounts of polyunsaturated fatty acids, poultry meat isprone to oxidative destruction (Florou-Paneri *et al.*, 2005). Addition of Rosemary and Sage extracts to poultry diet leads to decreased oxidation in meat (Lopez-Bote *et al.*, 1998).The value of TBARS in breast meat of Japanese quail was not affected by dietary supplementation of Artichoke leaf powder (Abbasi and Samadi, 2014). Some studies have proved the antioxidative effect of *E. purpurea* extract *in vitro*. Sabouri *et al.* (2012) showed that different levels of *E. purpurea* extract were able to retard the oxidation rate of cake.In spite of studies indicating antioxidative effect of *E.purpurea* extract in foods, diet supplementation with this extract did not have any antioxidative effect on quail breast meat in our experiment.TBARS value of all breast meat samples kept at refrigerator temperature showed increase compared to that of non-refrigerated samples which implies an increase in fat oxidation in these samples. Such finding agrees with results of Lopez-Bote *et al.* (1998) while is contrary to results of Jensen *et al.* (1995).

Conclusion

In the present experiment, dietary *E. purpurea* extract administration negatively influence Japanese quail growth performance, increased dry matter and ash content and did not have any effect on lipid oxidation of breast meat.

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