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THE CARCASS AND MEAT QUALITY CHARACTERISTICS OF JAPANESE QUAIL FED A DIET SUPPLEMENTED WITH POWDERED *LACTUCA SERIOLA* LEAVES

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ABSTRACT
The present study was aimed to evaluate the effect of dietary supplementation with *Lactuca serriola* leaves on growth performance, carcass characteristics, meat quality, and its antioxidant stability of Japanese quails. A total of eighty growing quails (1-week old) were distributed into 2 equal groups consisting of 40 birds (5 replicates of 8 birds each). The first group was fed a basal diet without *Lactuca serriola* leaves (0 g.kg^{-1} diet) and the second group received diets containing 20 g.kg^{-1} *Lactuca serriola* leaves. At age of 6 weeks, quails were slaughtered for meat and carcass examinations. The growth performance for the quails fed with *Lactuca serriola* leaves diet was similar to that of a control group. Carcass measurements, physical properties, and chemical composition of quail breast meat did not differ between the control and experimental group. However, the inclusion of *Lactuca serriola* leaves significantly increased the omega-3 polyunsaturated fatty acid content and improved breast meat lipid stability during postmortem refrigerated storage compared to the control diet. In conclusion, dietary supplementation of *Lactuca serriola* leaves can improve the performance of Japanese quail enrich its meat with an omega-3 polyunsaturated fatty acid, and reduce lipid oxidation during storage.

Keywords: growth; *Lactuca serriola*; meat traits; polyunsaturated fatty acid; quail

INTRODUCTION
In recent years, products of different species of poultry are marketed including quail products. Japanese quail is the main species of poultry whose meat is commonly demanded everywhere in the world, especially in America, Europe, and Asian nations **(Partovi and Seifi, 2018)**. Nowadays, a major concern of poultry producers is to optimize the produced meat both qualitatively and quantitatively **(Abdulla et al., 2017)**. Consequently, many recent studies have been represented herbs and spices as efficient and safe feed additives to improve poultry health as well as the rate of growth **(Adegoke et al., 2018; Rasul, 2020; Reda et al., 2020)**. Additionally, the active molecules in herbs and spices or their oils can prevent meat oxidation that negatively affects the meat's organoleptic properties and also abates its nutritional value **(Reda et al., 2020)**. Lipid oxidation is a limiting factor, which determines the safety and shelf-life of meat. It is considered a major cause of non-microbial meat spoilage, specifically under pro-oxidative conditions such as storage during refrigeration and frozen **(Sabow et al., 2016)**.

Lactuca serriola L. (Compositae) is an herbaceous species widely grown in Europe, India, Pakistan, India, and Middle Eastern countries. The plant is used in a medicinal application that is the old practice of human history **(Vargas-Sánchez et al., 2019)**. Research has demonstrated that *Lactuca serriola* contains lactic acids and β- carotene. It is also a rich source of almost all vitamins and contains a high amount of calcium, zinc, and iron **(Janbaz et al., 2013)**. *Lactuca serriola* contains phenolic compounds that help to enhance its antioxidants capacity. The antioxidant effect of *Lactuca serriola* is explained by its phenolic compounds including cichoric acid, alkamides, caffeic acid, and chlorogenic acid **(Nabavi et al., 2012)**.

Early investigations studied the effects of *Lactuca serriola* as pharmacological properties in humans, rabbits, and mice such as antitumor, antiviral, antimicrobial, anti-inflammatory, hypotensive, and antioxidant **(Al-Marzoqi, Hussein and Al-Khafaji, 2015; Ahangarpour, Oroojan and Radan, 2014; Janbaz et al., 2013)**. Investigations regarding the inclusion of powdered *Lactuca serriola* leave in Japanese quail diets and its effects on carcass quality were not found. It is hypothesized that the dietary addition of *Lactuca serriola* is expected to exert beneficial effects on the performance quality of carcass and meat of quail. Therefore, the present study was designed to assess the impacts of dietary inclusion of *Lactuca serriola* leaves on performances, carcass quality, and oxidative stability of Japanese quail meat.

Scientific hypothesis

The results of the current study will provide new knowledge and useful information about the *Lactuca serriola* plant and its antioxidant activity, which will give a wide range of possibilities for employing this plant as a source to improve the quality of carcass and oxidation stability of poultry meat.

MATERIAL AND METHODOLOGY

We assessed meat quality characteristics of Japanese quail fed a diet supplemented with or without *Lactuca seriola* leaves. A total of 80 male growing Japanese quails (one-week-old) with an average weight of 11.667 ±0.21 g were obtained from a commercial farm (Quail Farming, Qushtapa, Erbil-Kurdistan Region of Iraq) and randomly distributed into 2 groups, each of which included 5 replicates of 8 birds. Birds were housed in conventional type cages (90 × 40 × 40 cm) with feed and fresh water provided *ad libitum*. This study lasted until the 6th week of age. The dietary treatments were as follows: (1) basal diet without supplementation (0 g.kg^{-1} diet) and (2) basal diet + 20 g *Lactuca serriola* per 1 kg. The aerial parts of *Lactuca serriola* were collected from the botanical garden of Erbil city (Kurdistan Region, Iraq) in the year 2019. The plant was identified based on taxonomy from the College of agriculture engineering and science. The leaves were washed thoroughly in distilled water and the surface water was removed by air drying under shade. The leaves were subsequently dried in a hot air oven (CS101-beb ventilation oven, Chonping Sida instrument, China) at 40 °C for 48 h, ground into a fine powder and stored at 4 °C in dark containers until using as feed additive. On the day of manufacture, *Lactuca serriola* leaves powder was added to a 1 kg sample of basal feed-in a Univex Mixer (SRM20 Counter Mixer, USA) and mixed for 5 minutes before being remixed with the allotted feed. The chemical compositions of fresh leaves were as following: 93.7% moisture, 1.4% protein, 0.4% fat, 1.1% fiber, 2.2% carbohydrate and 1.2% ash.

The composition of the basal diet (Table 1) was formulated to meet the quails' requirements based on the guidelines provided by the **National Research Council (1994)**. Birds were exposed to 24 h of lighting with the temperature kept at 20 to 24 °C throughout the experiment.

Chemical

All the chemicals used were of analytical grade and were purchased from Sigma-Aldrich (St. Louis, MO, USA).

Growth performance

At six weeks of age, individual body weight was recorded. Also, feed intake was recorded during the experimental periods on a replicate basis to estimate feed conversion ratio (FCR = g feed per g gain).

Slaughtering procedures and carcass measurements

At the end of the experiment at 6 weeks of age, ten quails from each treatment were randomly selected, weighed, and slaughtered following the halal slaughter procedure. The halal slaughtering method was carried out by cutting the neck, severing both carotid arteries and jugular veins without decapitating the head during the process. Upon slaughter, carcasses were immediately taken to the laboratory for carcass examinations. Dressed carcasses were chilled at 4 °C for 24 h and reweighed (cold carcass weight; CCW). The dressing out the percentage of the carcass was determined as the proportion of CCW to the slaughter weight.

Physical analyses of quail breast meat

For meat quality characteristics, the breast muscle was separated into two parts. The first part was properly labeled, vacuum packaged, and stored at 4 °C for determination of drip loss. The second breast portion was used for other meat quality measures including pH, cooking loss, and tenderness. The pH of meat was recorded immediately after 24 h postmortem on the breast muscle using a portable pH meter (HANNA® instruments, Woonsocket, USA) after calibration using two buffers of pH 4.0 and 7.0. Cooking loss and tenderness of the breast samples were measured using the procedure described by **Sabow (2020)**. To measure cooking loss, the meat samples were cooked at 80 °C in a pre-heated water bath (HAAKE ® instruments, Woonsocket, USA) for another 10 min once the internal temperature of the samples has reached 78 °C. After cooking loss determination, the cooked meat samples were collected and used to determine tenderness using the Volodkovitch bite jaw attached to a Brookfield Texture Analyzers (CT3™, Middleborough, USA). For each sample, a block of 1 cm (height) × 1 cm (width) × 2 cm (length) was cut parallel to the direction of the muscle fibers and sheared vertically in the middle to the longitudinal direction of the muscle fibers. The sheer force values were represented as the average peak positive peak force (kg).

Chemical analysis of quail breast meat

The proximate composition of the breast meat samples was analyzed using the procedure provided by the Association of Analytical Chemists according to AOAC **(Horwitz, 2000)**. Moisture was determined by drying 1 g of meat in an oven (CS101-beb ventilation oven, Chonping Sida instrument, China) at 75 °C until a constant weight was obtained. Crude protein was measured by the Kjeldahl method (VAPODEST® 500, Gerhardt, Germany). The crude protein was obtained as 6.25 × nitrogen %. The fat content of the meat was determined by the Soxhlet extraction method (Classic Soxhlet Apparatus, Gerhardt, Germany) using petroleum ether. The Ash content of the meat was estimated by burning the sample in a muffle furnace (Heraeus KR 170E, Germany) at 550 °C for 3 h.

Oxidative stability of quail breast meat

The Thiobarbituric acid reactive substances (TBARS) value of the breast meat after 1 and 7 days of refrigerated storage was determined in duplicate according to the method described by **Aminzade Karami and Lotfi (2012)**. Briefly, 5 g of meat was homogenized with 48 mL of distilled water and 1.25 mL of 4N HCl for 2 min. The mixture was distilled until 25 mL was obtained. After filtration, 2.5 mL of the distillate was mixed with 2.5 mL of Thiobarbituric acid reagent (15% trichloroacetic acid, 0.375% thiobarbituric acid). The samples were incubated in a water bath at 100 °C for 35 min and then cooled under running tap water for 10 min. The absorbance was measured at 538 nm against a blank with a spectronic®20 GENESYSTM spectrophotometer (Spectronic Instruments, USA). The TBARS values were obtained by multiplying optical density by 7.843 and expressed as malondialdehyde (MDA) per kg meat.

Statistical Analysis

The obtained data were subjected to one-way analysis of variance (ANOVA) in the general linear model using Statistical Analysis System package (SAS) version 9.1 software (SAS Institute Inc., Cary, NC, USA). For comparison of TBARS values in day 1 and 7 postmortems, the parametric repeated measures ANOVA test were performed, and interaction between treatment groups and sampling times are calculated but were not statistically different. Differences between groups were tested with an independent sample T-test and the significance was established at a level of 0.05 ($p < 0.05$).

RESULTS AND DISCUSSION

Quail growth performance and carcass measurements

The effect of diet supplementation with *Lactuca serriola* leaves on the total final body, feed intake weight, feed conversion ratio, carcass weight, dressing percentage of Japanese quail at 6 weeks of age are given in Table 2. The inclusion of *Lactuca serriola* leaves in the quail diet led to improve final body weight, feed intake, and feed conversion ratio compared to the control treatment, although the values were not statistically significant. *Lactuca serriola* plant through its content of antioxidants plays a significant role in increase the activities of a digestive enzyme such as amylases, proteases, and lipases. Generally, stimulation of the function of pancreatic enzymes leads to promote the synthesis of bile acids in the liver and their secretion in the bile, which has a beneficial effect on digestion and absorption as well as growth stimulation. **Adegoke et al. (2018)** reported that growth performance is affected by active compounds of plant-derived supplements used in poultry nutrition. The present findings are in agreement with the findings of **Partovi and Seifi (2018)** who found no significant difference in better growth performance results ($p > 0.05$) of Japanese quail fed medicinal herb as feed additives compared with the control group.

The quail carcass traits such as carcass weight and carcass yield are an indicator of their significant efficiency and the ability for meat production **(Nasr, Ali and Hussein, 2017; Sabow, 2020)** which could be influenced by the inclusion of natural plants used in poultry nutrition **(Vargas-Sánchez et al., 2019)**. Some investigations have demonstrated the positive effect of adding natural herbs to the nutrition on poultry carcass measurements **(Ghazaghi Mehri and Bagherzadeh-Kasmani, 2014; Nosrati et al., 2017)**, while others have not emphasized such effects **(Abd El-Hack, Alagawany and Abdelnour, 2019)**. In the present study, dietary supplementation of *Lactuca serriola* leaves did not affect ($p > 0.05$) on the carcass weight and carcass yield (Table 2). In agreement with the current findings, **Reda et al. (2020)** found no significant effect of plant supplements feeding on the carcass traits of quails. In growing rabbits, **Abd El-Hack, Alagawany and Abdelnour (2019)** also reported that there was no significant difference in carcass measurements between animals fed diets containing herbal natural feed additives and those in the control animals.

Physical properties and chemical composition of quail breast meat

As shown in Table 3, the values of drip loss, cooking loss, and shear force for both experimental and control diets were not significantly different. This observation may be because of the similarity in the ultimate pH of breast meat which was 6.26 and 6.12 for quails fed control and experimental diet, respectively. The ultimate pH is a significant factor that influences the physicochemical attributes of meat **(Chan, Omana and Betti, 2011; Sabow, Haddad and Nakyinsige, 2020)**. The results of the current study agreed with **Partovi and Seifi (2018)** who detected no statistical influence of adding a natural plant to the quail diet on meat physical traits.

The inclusion of natural ingredients such as medicinal herbs and plants in the poultry diet effects on the nutritional composition of meat is unclear. The present results of proximate compositions of breast meat are not significantly different ($p > 0.05$) between the experimental and control group. This finding is consistent with that of **Partovi and Seifi (2018)** who clarified those herbal dietary supplements for Japanese quail diets had not affirmative effects in protein and fat values. Also, **Shirzadegan and Falahpour (2014)** found that meat samples of broiler chickens supplemented with dietary mixture medicinal herb has similar moisture, protein, and fat as compared to meat samples of the control group.

Polyunsaturated fatty acids of quail breast meat

Polyunsaturated fatty acids are widely taken into account to have a more beneficial biological effect **(Givens, Kliem and Gibbs, 2006; Gecgel et al., 2015)**. The effects of dietary treatments on polyunsaturated fatty acids (PUFA) of quail breast meat are given in Table 4. Although n-6 PUFA concentration did not differ between dietary treatments, feeding *Lactuca serriola* leaves diet improved significantly the total n-3 fatty acids of quail breast meat. The ratio of n-6 to n-3 PUFA was significantly lower in the breast muscles of quails fed on *Lactuca serriola* leaves as a result of their relatively high total n-3 PUFA concentrations. The n-6 to n-3 ratio is generally used as an index to assess the nutritional value of dietary fat that has particular relevance to human health **(Young, 2009; Valencak et al., 2015)**. The recent ratio of n-6 to n-3 fatty acids in the diets of North American adults should be in a range of 10:1 to 50:1, thus the ratios detected in the current study fall within this range.

Table 1 Composition of the experimental diet.

Ingredient	**g.kg^{-1} diet**
Wheat	175.0
Corn	200.0
Wheat flour	250.0
Soya bean meal	290.0
Protein concentrate (fish meal concentrate)	50.0
di – calcium phosphate	6.0
Methionine	0.9
Lysine	0.5
Choline chloride	0.5
Salt	0.9
Soya bean oil	13.0
Feed toxic	1.0
Limestone	10.0
Vitamins premix[1]	0.7
Feed sterilizes	1.0
Anticoccidial	0.5
Analyzed feed composition	
Crud protein (g.kg^{-1})	230.0
Energy metabolism (MJ.kg^{-1})	12.6

Note: [1]Multi vitamin contained retinol 2 mg, cholicalciferol 0.03 mg, α-tocopherol 0.02 mg, menadione 1.33 mg, cobalamin 0.03 mg, thiamine 0.83 mg, riboflavin 2 mg, folic acid 0.33 mg, biotin 0.03 mg, panthothenic acid 3.75 mg, niacin 23.3 mg, pyridoxine.

Table 2 Growth performance and carcass traits of growing Japanese quail as affected by graded levels *Lactuca serriola* leaves.

Items	**Lactuca serriola leaves level (g.kg^{-1} diet)**		**SEM**	***p* value**
	0	**20**		
Live body weight (g)	141.168	153.792	0.24	0.198
Total feed intake (g per day)	13.966	14.608	0.77	0.332
Feed conversion ratio (g feed per g gain)	3.463	3.325	0.15	0.851
Slaughter body weight (g)	145.801	160.798	5.96	0.063
Carcass weight (g)	91.457	100.412	3.47	0.087
Dressing (%)	62.717	62.446	1.27	0.772

Note: SEM = Standard Error of the Means.

Table 3 Physical characteristics and chemical composition of breast meat of growing Japanese quail as affected by graded levels of Lactuca serriola leaves.

Items	*Lactuca serriola* leaves level (g.kg^{-1} diet)		**SEM**	***p* value**
	0	**20**		
pH	6.260	6.120	0.07	0.288
Drip loss (%)	1.471	1.261	0.13	0.352
Cooking loss (%)	17.302	16.619	0.91	0.503
Shear force (kg)	0.916	0.872	0.07	0.604
Moisture (%)	72.453	71.712	0.71	0.476
Protein (%)	20.539	21.110	0.59	0.516
Fat (%)	5.926	6.059	0.48	0.853
Ash (%)	1.081	1.117	0.05	0.651

Note: SEM = Standard Error of the Means.

Figure 1 Lipid stability of breast meat obtained from growing Japanese quail fed dietary *Lactuca serriola* leaves supplementation.
Note: [a,b] Means with different letters are significantly different at p <0.05.

Table 4 Polyunsaturated fatty acids of breast meat of growing Japanese quail as affected by graded levels of *Lactuca serriola* leaves.

Items	*Lactuca serriola* leaves level (g.kg^{-1} diet)		SEM	*p* value
	0	20		
Total n-3 PUFA (%)	0.629^{b}	0.874^{b}	0.03	0.019
Total n-6 PUFA (%)	14.882	15.341	0.96	0.308
n6/n3 ratio	24.031^{a}	18.457^{b}	2.11	0. 028

Note: [a,b] Means within the same row with different letters are significantly different at p <0.05.
Total n-3 PUFA = Total omega-3 poly unsaturated fatty acids.
Total n-6 PUFA = Total omega-6 poly unsaturated fatty acids.
SEM = Standard Error of the Means.

Lipid oxidation of quail breast meat

Lipid oxidation is the main evidence of the quality deterioration of meat by reducing shelf life during refrigeration storage **(Estévez, 2015; Sabow, 2020)**. Therefore, the shelf-life of fresh meat is limited to a few days during storage at refrigeration temperature unless preservation methods are used. Natural ingredients such as medicinal herbs and plants which have been used in the poultry, diet have been thought to provide beneficial compounds with antioxidant activity, which might be beneficial for shelf-life extension or meat quality maintenance **(Krishnan et al., 2014; Alagawany, Ashour and Reda, 2016; Aziz and Karboune, 2018)**. The results of the lipid stability of breast meat during the first five days postmortem are given in Figure 1. At 1st day postmortem, no significant difference was observed in lipid oxidation of breast meat between experimental and control diet. However, the MDA values of groups fed with *Lactuca serriola* leaves were significantly lower than those in the control, which indicated a good antioxidant capable of removing free radicals. Furthermore, the ability of *Lactuca serriola* leaves to reduce breast muscle lipid oxidation could be due to its total n-3 polyunsaturated fatty acids content as reported by **Sabow, Haddad and Nakyinsige (2020)** who attributed that lipid oxidation is significantly influenced by muscle n-3 polyunsaturated fatty acids and muscle with high n-3 polyunsaturated fatty acids gives lower malondialdehyde values than those with low n-3 polyunsaturated fatty acids. The current data are following those of **Ghazaghi Mehri and Bagherzadeh-Kasmani (2014)** who observed that dietary inclusion of medicinal herbs decreased the lipid oxidation of quail meat. Regardless of dietary groups, the MDA concentration of all breast meat samples kept at refrigerator temperature for 5 days increased (p <0.05) compared to that of refrigerated storage samples on day 1. These observations are consistent with those of **Sabow, Haddad and Nakyinsige (2020)** and **Partovi and Seifi (2018)** who observed that lipid oxidation values of quail breast meat significantly increased with storage time at refrigerator temperature.

CONCLUSION

The results of the current study indicated that dietary supplementation of *Lactuca serriola* increased the omega-3 polyunsaturated fatty acids content and improved lipid stability during postmortem aging of growing Japanese quails. Further research is required to investigate the impact of dietary *Lactuca serriola* leaves on performance, some blood parameters, and morphology with microbial populations of the small intestine in quail (*Coturnix coturnix japonica*).

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The authors declare no conflict of interest.

Ethical Statement:
All birds received humane care according to the standard local guidelines. The experimental protocol was approved by the local animal care and use committee of the college of agriculture engineering and science, Salahaddin University-Erbil, Kurdistan Region, Iraq.

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