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CHEMICAL COMPOSITION OF MUSCLE AFTER BEE BREAD APPLICATION IN THE NUTRITION OF JAPANESE QUAILS

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ABSTRACT

The objective of study was to evaluate the effects of a diet supplemented with bee bread powder on the chemical composition of Japanese quail meat. A total of 80 one day-old quails were assigned to 4 treatments: 1. control (C), 2. experimental diet with bee bread (2 g.kg^{-1} of feed mixture (FM); E1), 3. experimental diet with bee bread (4 g.kg^{-1} of FM; E2) and 4. experimental diet with bee bread (6 g.kg^{-1} of FM; E3). The feeding period was 56 days. The supplementation with bee bread improved the protein content of the breast muscle at a dose of 4 a 6 g.kg^{-1} FM (25.16 and 25.25 g.100 g^{-1}) versus C (24.55 g.100 g^{-1}). In the thigh muscle, a slightly increased water content in E2 and E3 (70.34 and 70.22 g.100 g^{-1}) compared to the C (69.38 g.100 g^{-1}). Bee bread had a beneficial (P≥0.05) effect on the fat in the breast muscle (1.18 g.100 g^{-1} E1, 1.08 g.100 g^{-1} E2, 1.01 g.100 g^{-1} E3) in comparison to the control (1.21 g.100 g^{-1}). The fat content in the thigh muscle increased (P≥0.05) in E1 (2.01 g.100 g^{-1}), E2 (1.76 g.100 g^{-1}), E3 (1.76 g.100 g^{-1}) when compared to the C (1.30 g.100 g^{-1}). Between male and female were observed differences only in the cholesterol content of the breast muscle of the C (female - 0.86 g.100 g^{-1}, male - 0.72 g.100 g^{-1}). Significant differences (P≤0.05) have be also found in the breast muscle in the female with respect to the water, protein, fat and cholesterol content when comparing the C and E2, E3. With respect to males we found differences (P≤0.05) in the protein content in the thigh muscle between E1:E3, E2:E3 and with respect to the fat content between the C and E2. We may state that bee bread powder at 4, respectively 6 g.kg^{-1} to the feed mixture could be a suitable supplement to the quail nutrition without a negative effect on the meat quality.

Keywords: bee bread; Japanese quail, meat; chemical composition

INTRODUCTION

During the last decade, the global consumption of poultry meat has increased. Recently, quail meat has gained popularity among consumers **(Maiorano *et al.*, 2011)**. Nowadays, quails may be found on all continents **(Genchev *et al.*, 2005)**. Generally, quails are small-to-medium sized birds, belonging to the same biological family of chicken and pheasants (*Phasianidae*), given the overall similarity in the physical characteristics and behaviour. Quails, most commonly bred for human consumption, belong to the species *Coturnix coturnix japonica* **(Boni *et al.*, 2010)**. However, quail provides more advantages than chicken, such as its resistance to numerous poultry diseases that affect chickens, its greater capacity to benefit from food, high reproduction proportions, and also low feed intake **(Santos *et al.*, 2011)**.

The quality and composition of quail meat are influenced by numerous factors such as the genotype of birds **(Genchev *et al.*, 2005; Alkan *et al.*, 2010)**, divergent selection **(Maiorano *et al.*, 2009)**, feeding **(Gardzielewska *et al.*, 2005)**, sex **(Genchev *et al.*, 2008)**, age (**Tserveni-Gousi and Yannakopoulos, 1986)**, and stress **(Mota-Rojas *et al.*, 2007)**.

Manually deboned Japanese quail meat contains 72.5–75.1% water, 20–23.4% protein, 1.0–3.4% lipids and 1.2–1.6% mineral substances **(Genchev *et al.*, 2008; Ribarski *et al.*, 2013)**. Mechanically deboned quail meat consists of 70.4% water, 17% protein, 10% fat and 2.6% minerals. The proportion of bone does not exceed 0.75%, with an average diameter of about 0.05 mm **(Antipova and Makarov, 2006)**. Comparative studies on the physicochemical properties of meat from quails, broiler chicken and ducks demonstrated that quails had the lowest-calorie meat with the highest protein content **(Lonita *et al.*, 2008)**. **Choudhary and Mahadevan (1986)** state that the protein content in breasts is 23% versus 18.7% in legs. According to the authors such difference is due to different amounts of mineral substances (1.05% versus 1.35%) and lipids (3.1% and 5%, respectively). Lipids in the breast and leg muscles are characterized by a value as high as 19.4–54% of polyunsaturated fatty acids **(Vrakin and Fomina, 1988)**.

Antibiotics had been added to poultry feed to improve the growth performance, to stabilize the intestinal microflora and to prevent infection by specific pathogenic microorganisms. However, concerns about the antimicrobial resistance have existed for nearly as long, and recent concerns regarding the prevalence of antibiotic-resistant infections in humans have raised the controversy to new heights **(Revington, 2002)**. For these reasons antibiotic growth promoters for poultry diets have been banned in the European Union and pressure from consumer groups and major poultry buyers has threatened their removal in the US. Therefore, studies on alternative products that could result in the promotion of growth, improved feed utilization, and maintenance of gut health are taking place **(Zhang *et al.*, 2005)**. For this reason, natural bee products are being widely investigated **(Babaei *et al.*, 2016; Haščík *et al.*, 2016, 2017)**.

Bee bread (BB) or ambrosia is a fermented bee product made from plant pollen, honey and bee saliva, which undergoes different chemical processes due to the action of specific enzymes, micro-organisms, moisture and temperature (35–36 °C) for 2 weeks (**Vásquez and Olofsson, 2009; Barajas *et al.*, 2012; Markiewicz-Zukowska *et al.*, 2013; Barene *et al.*, 2014; Fuenmayor *et al.*, 2014; Zuluaga *et al.*, 2015; Kieliszek *et al.*, 2018)**.

BB consists primarily of water, proteins, free amino acids, bioactive compounds, fatty acids, and carbohydrates **(Del Risco, 2012)** and it is the most nutritious food, which is used by worker bees as a source of protein for larvae and for young bees **(Urcan *et al.*, 2018)**.

BB is characterized by a higher nutritional value, better digestibility, and richer chemical composition than pollen (**Habryka, Kruczek and Drygas, 2016)**. According to the other sources **(Gilliam, 1979)**, the composition of bee bread is biochemically similar to the composition of pollen from which it is produced and like bee pollen, BB is nutritionally well balanced.

Bee bread differs from pollen by a lower pH (3.8–4.3), it contains less proteins and fats, but more carbohydrates and lactic acid. Bee bread has a better bioavailability because the walls of pollen, which cannot be destructed by gastrointestinal liquids, have been partly processed by fermentation which is why the functionally and energetically rich content of pollen can be assimilated and used easier **(Mutsaers *et al.*, 2005; Berene *et al.*, 2014)**. The chemical composition of pollen is multiform. It contains about 24% of water and a number of organic and inorganic substances such as proteins, amino acids (glutamic acid, aspartic acid, proline, arginine, valine, histidine, leucine, isoleucine, lysine, methionine, tryptophan, phenylalanine, threonine), carbohydrates (glucose, fructose, sucrose, arabinose, galactose, lactose), fats, vitamins (ascorbic acid, thiamine, riboflavin, pyridoxine, pantothenic acid, folic acid, biotin, tocopherol, menaquinones, rutin, niacin), carotenoids, flavonoids, phenolic acids, enzymes (amylase, sucrase, catalase, pectinase, phosphatase), phyto hormones, growing stimulators (auxins, gibberellins), micro and macro elements (potassium, cooper, iron, cobalt, calcium, magnesium, phosphorus, sulfur, silicon, etc.) **(Nagai *et al.*, 2004; Berene *et al.*, 2014; Bakour *et al.*, 2017; Kieliszek *et al.*, 2018; Urcan *et al.*, 2018)**.

The potential application of bee bread as a food and a nutraceutical supplement greatly depends on its chemical composition which varies directly with the flora of the region and the time of collection by the bees **(Čeksterytė *et al.*, 2008, 2016; Markiewicz-Żukowska *et al.*, 2013; Sobral *et al.*, 2017)**. In the bee bread proteins are partly cleaved to amino acids, fats are destructed, the content of carbohydrates and lactic acid increases, while changes to other components are not significant **(Berene *et al.*, 2014)**.

The activity of pollen (the amount of vitamins and enzymes) decreases after 2 or 3 months of storage. Bee bread keeps its activity longer **(Bogdanov, 2011)**. The biologically active substances present in BB are associated with several medicinal benefits. BB has hepatoprotective, immuno-modulating, antiradiation and adaptogenic properties. It stimulates the protective forces of the human body, normalizes metabolism, has a positive impact on the liver, nervous and endocrine system, and enhances tissue regeneration, physical and mental persistence of the human body **(Berene *et al.*, 2014; Bogdanov, 2015)**. BB helps to regulate lipid metabolism and has also a positive effect on the cardiovascular system (**Nagai *et al.*, 2004; Baltrušaityte *et al.*, 2007; Tomás *et al.*, 2017)**. BB has shown to possess *in vitro* antibacterial **(Baltrušaityte *et al.*, 2007; Zerdani *et al.*, 2011)**, antioxidant **(Nagai *et al.*, 2004; Zuluaga *et al.*, 2015; Tomás *et al.*, 2017)** and antitumor **(Markiewicz-Zukowska *et al.*, 2013; Sobral *et al.*, 2017)** proprieties.

We have hypothesized that meat may exhibit a better chemical composition following dietary supplementation of bee bread powder in quails when compared with quails without supplementation. The present study was therefore carried out to assess the effect of dietary bee bread powder on the chemical composition of quail meat.

MATERIAL AND METHODS

Animals and diet

The experiment was carried out in the test poultry station at the Research Institute of Animal Production in Nitra. A total of 80 Japanese quails were included in the experiment. The quails were divided into four groups (10 males and 10 females in each group) as follows: the control group received no additives (C), the experimental group E1 received bee bread powder at a dose of 2 g per 1 kg of feed mixture, experimental group E2 4 g bee bread powder per 1 kg of feed mixture and E3 group 6 g bee bread powder per 1 kg of feed mixture. Bee bread was of Slovak origin (Medula Ltd., Bratislava). The groups were kept under the same conditions.

The quails were reared using a cage technology, each cage was equipped with a feed disperser and water intake was ensured *ad libitum* through a self feed-pump up to 56 days of age.

Table 1 list the ingredients and nutrient content of the basal diets (HYD-07, HYD-11), formulated to provide the nutrient requirements of quails according to the recommended reference levels. The feed mixture was produced without any antibiotics and coccidiostats.

Table 1 Composition of basal diet and nutrient content of feed mixtures HYD-07 and HYD-11 per kg of diet.

Ingredients (%)	**Starter feed mixture (HYD-07) (1st to 21st day)**	**Finisher feed mixture (HYD-11) (22nd to 56th day)**
Wheat	13	15
Maize	34.8	32
Soybean meal (48% CP)	23	19.2
Fish meal (71% CP)	5	3
Malt flower	2	3
Rapeseed meal	5	7
Sunflower meal	5	4.5
Monocalcium phosphate	1	1
Fodder salt	0.2	0.3
Animal fat Bergafat	5	4
Calcium carbonate	5	10
Premix Euromix[1]	1	1
Analysed composition (g.kg^{-1})		
Crude protein	245	200
Fibre	50	60
Ash	14	16
Ca	8	35
P	6.5	5
Na	0.9	1.6
Lysine	14.1	11
Methionine + Cysteine	9.5	7.9
Linolic acid	10	10
ME_N (MJ.kg^{-1})	12.1	11.7

Notes: CP = crude protein; Ca = calcium; P = phosphorus; Na = natrium; ME_N = nitrogen-corrected metabolizable energy; MJ = megajoule; [1]active substances per kilogram of premix: vitamin A 15 000 IU; vitamin E 20 mg; vitamin D3 2 000 IU; riboflavin 6 mg; cobalamin 20 μg; Mn 60 mg; Zn 40 mg; Fe 40 mg; Cu 6 mg; I 1 mg; Se 0.2 mg.

Slaughter and measurements

At the end of the 56–d feeding period, twenty quails from each group (10 males, 10 females) were weighed and slaughtered at the slaughterhouse of Slovak University of Agriculture in Nitra. After evisceration, the carcasses were kept at approximately 18 °C for 1 h *post mortem*. After that, the carcasses were weighed and stored at 4 °C until 24 h *post mortem*.

To evaluate the chemical composition skinless breast muscle (*musculus pectoralis major*) and skinless thigh muscle (*musculus biceps femoris*) were taken from each group. The chemical composition of meat was rated using the INFRATEC 1265 device (Germany), analysing the water, fat and protein content as well as cholesterol (g.100 g^{-1}).

Statistical analysis

The data were analysed using the ANOVA Procedure with the help of the SAS software (version 9.3, by application Enterprise Guide 4.2). Mean values and standard deviation (*SD*) are reported in tables. Differences between treatments were tested for significance. The level of significance was established at $P \leq 0.05$.

RESULTS AND DISCUSSION

The results of experiment are presented as follows: the results of water, crude protein, fat, and cholesterol content in breast and thigh muscle disregarding sex and regarding sex which are displayed in Tables 2–5.

In the present study, the water content in the breast muscle (Table 2) of Japanese quails disregarding sex ranged from 69.86 g.100 g^{-1} (experimental group E3) to 70.76 g.100 g^{-1} (control group). The highest average value of water content measured in the fresh thigh muscle of quails disregarding sex (Table 3) after addition of the supplements was in the experimental group E2 supplemented with 4 g bee bread powder (70.34 g.100 g^{-1}) and the lowest value was detected in the control group C (69.38 g.100 g^{-1}). We have found statistically significant differences (P≤0.05) between the control group and experimental groups E2 and E3.

Table 2 Chemical composition of breast muscle of quails disregarding sex (g.100 g^{-1})

Parameter	C	E1	E2	E3	*p*-value
Water content	70.76 ± 1.27	70.69 ± 1.43	70.41 ± 0.94	69.86 ± 0.41	0.150
Crude protein	24.55 ± 0.16^{c}	24.67 ± 0.44^{c}	25.16 ± 0.26^{b}	25.25 ± 0.27^{a}	0.001
Fat	1.21 ± 0.36	1.18 ± 0.37	1.08 ± 0.20	1.01 ± 0.22	0.307
Cholesterol	0.79 ± 0.08	0.83 ± 0.17	0.69 ± 0.14	0.71 ± 0.05	0.617

Notes: Values shown as mean ± *SD* (standard deviation); C = control group; E1, E2, E3 = experimental groups; a, b = means within a line with different superscripts differ significantly at P≤0.05, one-way ANOVA.

Table 3 Chemical composition of thigh muscle of quails disregarding sex (g.100 g^{-1})

Parameter	C	E1	E2	E3	*p*-value
Water content	69.38 ± 0.81^{a}	69.94 ± 0.45^{ab}	70.34 ± 1.40^{b}	70.22 ± 0.42^{b}	0.047
Crude protein	23.32 ± 0.18	23.11 ± 0.42	23.18 ± 0.44	23.46 ± 0.30	0.135
Fat	1.30 ± 0.30	2.01 ± 0.75	1.76 ± 0.69	1.76 ± 0.36	0.056
Cholesterol	0.87 ± 0.05	0.92 ± 0.04	0.88 ± 0.18	0.91 ± 0.06	0.091

Notes: Values shown as mean ± *S.D.* (standard deviation); C = control group; E1, E2, E3 = experimental groups; a, b = means within a line with different superscripts differ significantly at P≤0.05, one-way ANOVA.

Table 4 Chemical composition of breast muscle of quails regarding sex and group (g.100 g^{-1})

Parameter	sex	C	E1	E2	E3	*p*-value
Water content	Male	69.93 ± 1.27	70.49 ± 1.19	70.89 ± 0.79	69.96 ± 0.59	0.180
	Female	71.61 ± 0.56^{a}	70.88 ±1.90^{ab}	69.93 ± 0.94^{b}	69.97 ± 0.17^{b}	0.006
	p-value	0.105	0.778	0.251	0.619	
Crude protein	Male	24.49 ± 0.04	24.60 ± 0.32	25.07 ± 0.31	25.16 ± 0.34	0.077
	Female	24.62 ± 0.23^{b}	24.75 ±0.61^{ab}	25.25 ± 0.23^{a}	25.34 ±0.20^{a}	0.015
	p-value	0.398	0.718	0.462	0.492	
Fat	Male	0.95 ± 0.37	1.22 ± 0.55	1.23 ± 0.19	0.96 ± 0.34	0.309
	Female	1.46 ± 0.06^{a}	1.15 ± 0.21^{ab}	0.94 ± 0.07^{b}	1.06 ± 0.05^{b}	0.001
	p-value	0.133	0.856	0.783	0.669	
Cholesterol	Male	0.72 ± 0.04^{A}	0.81 ± 0.09	0.75 ± 0.09	0.71 ± 0.08	0.149
	Female	0.86 ± 0.06^{aB}	0.85 ± 0.24^{a}	0.62 ± 0.17^{b}	0.70 ± 0.07^{b}	0.023
	p-value	0.033	0.073	0.684	0.315	

Notes: Values shown as mean ± *S.D.* (standard deviation); C = control group; E1, E2, E3 = experimental groups; a, b = means within a line with different superscripts differ significantly at P≤0.05; A, B = means within a column with different superscripts differ significantly at P≤0.05, one-way ANOVA, t-test.

Table 5 Chemical composition of thigh muscle of quails regarding sex and group (g.100 g^{-1})

Parameter	sex	C	E1	E2	E3	*p*-value
Water content	Male	69.23 ± 1.24	69.88 ± 0.49	70.77 ± 0.93	70.07 ± 0.27	0.159
	Female	69.53 ± 0.25	70.01 ± 0.52	69.90 ± 1.87	70.38 ± 0.55	0.729
	p-value	0.708	0.708	0.509	0.445	
Crude protein	Male	23.20±0.18^{ab}	23.19 ± 0.04^{b}	23.08 ± 0.52^{b}	23.49 ± 0.13^{a}	0.019
	Female	23.45 ± 0.04	23.04 ± 0.66	23.28 ± 0.42	23.43 ± 0.45	0.406
	p-value	0.085	0.750	0.640	0.855	
Fat	Male	1.23 ± 0.39^{b}	1.62 ± 0.19^{ab}	2.18 ± 0.40^{a}	1.65 ± 0.37^{ab}	0.041
	Female	1.38 ± 0.26	2.41 ± 0.95	1.33 ± 0.71	1.86 ± 0.40	0.144
	p-value	0.598	0.232	0.145	0.538	
Cholesterol	Male	0.86 ± 0.08	0.90 ± 0.02	0.97 ± 0.06	0.91 ± 0.03	0.410
	Female	0.88 ± 0.04	0.95 ± 0.05	0.80 ± 0.24	0.90 ± 0.09	0.085
	p-value	0.998	0.472	0.211	0.233	

Notes: Values shown as mean ± *S.D.* (standard deviation); C = control group; E1, E2, E3 = experimental groups; a, b = means within a line with different superscripts differ significantly at P≤0.05; A, B = means within a column with different superscripts differ significantly at P≤0.05, one-way ANOVA, t-test.

The water content of thigh muscle in males (Table 5) ranged from 70.77 g.100 g^{-1} (experimental group E2) to 69.23 g.100 g^{-1} (control group) and in females it ranged from 70.38 g.100 g^{-1} (experimental group E3) to 69.53 g.100 g^{-1} (control group). We have not found statistically significant differences (P≤0.05) between males and females as well as between the experimental groups. In case of the quail breast muscle of male and female, the highest measured value of the water content was in the groups E2 and C (70.89 g.100 g^{-1} and 71.61 g.100 g^{-1}, respectively) and the lowest value in control group as well as the experimental group E2, respectively (69.93 g.100 g^{-1}). We have found statistically significant differences (P≤0.05) between the control group and experimental groups E2 and E3 in the female quails.

Priti and Satish (2014) reported a higher content of water (73.93 g.100 g^{-1}) in quail meat. Similarly, **Genchev *et al.* (2008)** found a higher water content in the breast muscle of 35 day old Japanese quails in males (72.49%) and females (73.08%), as well as in case of the thigh muscle (73.5% in males and 74.14% in females).

The highest average value of crude protein content measured in the fresh breast muscle of quails after BB supplementation was found in the experimental group E3 (25.25 g.100 g^{-1}) and the lowest value was measured in the control group C (24.55 g.100 g^{-1}). We found statistically significant differences (P≤0.05) between the control group and experimental groups E2 and E3. In case of fresh thigh muscle the lowest value of crude protein content was detected in the experimental group E1 (23.11 g.100 g^{-1}) while the highest value was found in the experimental group E3 (23.46 g.100 g^{-1}). No statistically significant differences were observed (P≤0.05) between the groups.

The crude protein content of thigh muscle in males ranged from 23.08 g.100 g^{-1} (experimental group E2) to 23.49 g.100 g^{-1} (experimental group E3) while in females it varied between 23.04 g.100 g^{-1} (experimental group E1) and 23.45 g.100 g^{-1} (control group). Statistically significant differences (P≤0.05) were found between the experimental group E3 and experimental groups E1 and E2. In case of quail breast muscle of males and females, the lowest measured value of crude protein content was found in the control group C (24.49 g.100 g^{-1} and 24.62 g.100 g^{-1}, respectively) while the highest value was detected in the experimental group E3 (25.16 g.100 g^{-1} and 25.34 g.100 g^{-1}). We found statistically significant differences (P≤0.05) between the control and experimental groups E2 and E3 in female quails.

Lisunova *et al.* (2014) observed 60 days old quails and reported similar results of protein content (25.60 g.100 g^{-1}). The results of our study are comparable to

Fokolade (2015), who revealed that the protein content was significantly higher in the breast muscle (24.45 g.100 g^{-1}) in comparison to the thigh muscle (18.62 g.100 g^{-1}) of 20 weeks old quails. The protein content in male and female breast muscle (23.38 and 20.49 g.100 g^{-1}, respectively) and in male and female thigh muscle (22.23 and 20.91 g.100 g^{-1}, respectively) of 35 days old Japanese quails was presented in a study by **Genchev *et al.* (2008)**. On the other hand, the results of the present study were higher than the values (17.48 to 18.99 g.100 g^{-1}) reported by **Boni *et al.* (2010)** who compared the meat quality characteristic between young and spent quails as well as those presented by **Odunsi and Kehinde (2009)** (13.7 and 18.6 g.100 g^{-1}).

When evaluating the fat content in fresh breast muscle we found the lowest value of 1.01 g.100 g^{-1} in the experimental group E3 with the addition of BB (6 g per kg feed mixture) while the highest average value of 1.21 g.100 g^{-1} was revealed in the control group. The highest value of fat content in the thigh muscle was found in the experimental group E1 (2.01 g.100 g^{-1}) and the lowest average value (1.30 g.100 g^{-1}) the in the control group. No statistically significant differences ($P \leq 0.05$) were found in the breast and thigh muscle between groups.

The fat content in the male breast muscle ranged from 0.95 g.100 g^{-1} (control group) to 1.23 g.100 g^{-1} (experimental group E2) and with respect to the thigh muscle it ranged from 1.23 g.100 g^{-1} (control group) to 2.18 g.100 g^{-1} (experimental group E2). In the case of the female breast muscle the highest value of fat content was obtained in control group (1.46 g.100 g^{-1}) and the lowest (0.94 g.100 g^{-1}) in the experimental group E2 while in the thigh muscle, the lowest value (1.33 g.100 g^{-1}) was detected in the experimental group E2 and the highest value was observed in the experimental group E1 (2.41 g.100 g^{-1}). We have found statistically significant differences ($P \leq 0.05$) in the female breast muscle between the control group and experimental groups E2 and E3 as well as in male thigh muscle between the control group and experimental group E2.

Priti and Satish (2014) reported a higher content of fat (3.85 g.100 g^{-1}) when compared with the present results. On the other hand, similar results were published by **Genchev *et al.* (2008)** who studied the fat content in the breast muscle (male 2.21 and female 2.75 g.100 g^{-1}) and in the thigh muscle (male 3.39 and female 3.26 g.100 g^{-1}). A fat content of 1.28% in the meat of 60 day old quails was published by **Lisunova *et al.* (2014)**.

The cholesterol content in quail breast and thigh muscle of the control group was 0.79 and 0.87 g.100 g^{-1}, while it ranged from 0.69 g.100 g^{-1} (E2) to 0.83 g.100 g^{-1} (E1) in the breast muscle and in from 0.88 g.100 g^{-1} (E2) to 0.92 g.100 g^{-1} (E1) in the thigh muscle. No statistically significant differences ($P \leq 0.05$) were found.

In the case of the cholesterol content in the thigh muscle of male quails, the lowest value was observed in the control group (0.86 g.100 g^{-1}) and the highest in the experimental group E2 (0.97 g.100 g^{-1}). In the female thigh muscle, the content of cholesterol ranged from 0.80 g.100 g^{-1} (experimental group E2) to 0.95 g.100 g^{-1} (experimental group E1). No statistically significant differences ($P \leq 0.05$) were detected.

In the breast muscle of Japanese quails fed with BB the cholesterol content ranged from 0.71 g.100 g^{-1} (experimental group E3) to 0.81 g.100 g^{-1} (experimental group E1) in males and from 0.62 g.100 g^{-1} (experimental group E2) to 0.86 g.100 g^{-1} (control group) in females. We have found statistically significant differences ($P \leq 0.05$) in the breast muscle of females between control group and experimental groups E2 and E3 and we also detected statistically significant differences ($P \leq 0.05$) in the control group between the sexes.

Japanese quail meat is characterized by lower cholesterol content when compared to broiler chickens. **Maiorano *et al.* (2011)** reported a cholesterol level of *pectoralis muscle* in quail to vary from 23.57 to 37.20 mg.100 g^{-1}, which was lower than the cholesterol content found by **Maiorano *et al.* (2009)** in the breast muscle of 35 day old Japanese quail (ranging from 27.83 to 43.38 mg.100 g^{-1}). Overall low levels of cholesterol were found in the *pectoralis muscle* of English White and Manchurian Golden (26.63 and 25.33 mg.100 g^{-1}, respectively) by **Maiorano *et al.* (2011)**. **Ilavarasan *et al.* (2016)** reported a cholesterol content of Nandanam Quail-III meat in young and adult quails to be 71.50 and 74.04 mg.100 g^{-1}, respectively. **Genchev *et al.* (2008)** observed that the cholesterol content in quail carcass was 0.097 and 0.094 g.100 g^{-1} for males and females, respectively.

CONCLUSION

The present study suggests that dietary supplementation with bee bread powder in quail nutrition improved the content of protein in the breast muscle and slightly increased the water content in the thigh muscle. The feed additive in the bee bread powder form had a beneficial ($P \geq 0.05$) effect on a lower fat formation in the breast muscle, but the fat content increased in the experimental groups ($P \geq 0.05$) over the control group. In terms of sex, we found fundamental differences ($P \leq 0.05$) between the quail male and female within the experimental groups only in the breast muscle with respect to the cholesterol level in the control group. By comparing the sexes among the groups, we have found significant differences ($P \leq 0.05$) in the breast muscle only in the quail female in case of the water, protein, fat and cholesterol content between the control group and experimental groups E2 and E3. By contrast, in the thigh muscle by sex and among groups of the experiment, we found significant differences in only quail male in case of the protein content between experimental groups (E1:E3, E2:E3) and in the fat content between the control group and experimental group E2. Since bee bread powder had a clear negative impact on the chemical composition of the breast and thigh muscle of quail, we recommend its administration into the quail diet as a supplementary resource that mainly affects the function of the intestinal microflora and serves to a better utilisation of nutrients affecting the quail growth during the fattening period.

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