RESEARCH ARTICLE

QUALITY PROPERTIES AND FATTY ACIDS COMPOSITION OF BREAST MEAT FROM JAPANESE QUAILS WITH DIFFERENT VARIETIES GROWN UNDER WARM CLIMATE

Alper Güngören[1], Gülşah Güngören[2*], Ü. Gülcihan Şimşek[3], Ökkeş Yilmaz[4], Muammer Bahşi[5], Sultan Aslan[6]

[1]Department of Food Hygiene and Technology, Faculty of Veterinary Medicine, Kastamonu University, Kastamonu, Türkiye
[2]Department of Animal Science, Faculty of Veterinary Medicine, Kastamonu University, Kastamonu, Türkiye
[3]Department of Animal Science, Faculty of Veterinary Medicine, Firat University, Elazıg, Turkiye
[4]Department of Biology, Faculty of Science, Firat University, Elazıg, Türkiye
[5]Department of Primary Education, Faculty of Education, Firat University, Elazıg, Türkiye
[6]Department of Genetics, Faculty of Veterinary Medicine, Dokuz Eylül University, Izmir, Türkiye

***Corresponding author:**
Dr. Gülşah Güngören
Department of Animal Science, Faculty of Veterinary Medicine, Kastamonu University, Kastamonu, Türkiye

Adress:Kastamonu Üniversitesi Veteriner Fakültesi Kuzeykent Kampüs, Merkez/ Kastamonu, Türkiye

Phone: +90 554 900 24 72
ORCID:0000-0002-0360-7735
E-mail:ggungoren@kastamonu.edu.tr

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ABSTRACT

As climate change is expected to worsen in the future, raising livestock animals used in meat production with maximum efficiency in warm climate conditions may become a necessity to meet food needs. To this end, the experiment was carried out to determine the quality properties of breast meat from different colored Japanese quails (*Coturnix coturnix Japonica*) grown under the warm climate conditions. A total of 100 quails were used, with 25 each of black, white, golden, and gray. After the quails were grown under the warm climate conditions from the 15th-42nd Day, they were slaughtered, and the chemical-physicochemical properties, along with the fatty acid composition of the breast muscles, were determined. The values of b* (yellowness) were significantly lower in the black quails (P<0.01). The lowest fat content of meat was determined in black and gray quails, and the highest fat content was determined in white quails (P<0.001). The proportion of total saturated fatty acids was the highest in the gray quails, and total monounsaturated fatty acids were found to be the highest in the golden and the lowest in the gray quails (P<0.05). The highest proportion of n-3 polyunsaturated fatty acids was detected in gray quails and the lowest in golden and white quails (P<0.01). The white and golden quails had the highest n-6: n-3 proportions, while the gray quails had the lowest (P<0.01). This study concluded that quail varieties had distinct traits that arise due to varying environmental circumstances. Quail varieties growing in warm climates may have different meat quality parameters.

Keywords: Fatty acids, meat quality characteristics, quail varieties, warm climate

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INTRODUCTION

Climate change is a global menace to the food and nutritional safety of the world. Every year, the seasons change because of global warming, and the average temperature keeps going up. The average global temperature has increased at an approximate rate of 0.15-0.20 °C per decade since 1975 and is expected to increase by 1.4-5.8 °C over the next few years (Malhi et al., 2021). Raising species, breeds, and even varieties that are resistant to warm weather will have great importance in the near future. Publications that have come out recently show that rising temperatures can affect many populations of species across large areas of land (Lehikoinen et al, 2021). Various studies report that it is more difficult for bird communities to adapt to high exposure to warming caused by climate change than for mammals (Riddell et al., 2021).

The Japanese quail is a small avian species in the Coturnix genus, and its consumption as food has increased. Its main advantages are that the time between generations of quails is short, they yield more products per unit area, their raising is cost-effective, and they are resistant to many diseases (Lukanov, 2019; Tarhyel et al., 2012). However, exposing poultry to warm climate conditions has a negative impact on their performance and causes economic losses (Kumar et al., 2021).

Quails are homeothermic animals that conserve a stable internal body temperature without considering environmental effects. When the environmental temperature exceeds the thermoneutral distance, respiratory activity increases, since panting for air is a necessity for birds in order to increase the heat loss by evaporation. This allows quails to maintain body temperature. This situation may suffer from extreme physiological disorders, such as decreased efficiency of feeding or low specific gravity (Nawab et al., 2018; Batol et al., 2021). There have been many ideas for how to make birds more tolerant of heat, such as creating new hybrids.

Most of the color changes in the plumage within and between species have a powerful genetic component. The plumage color phenotype is considered the principal aspect of the complex genetic composition of Japanese quails (Sayed and El Shoukary, 2021). Also, it can be considered an economically important trait that is attributed to multiple genes, gene-gene interactions, and environmental factors. Furthermore, latent relationships might exist between plumage color and body weight (Davoodi, 2021). Also, Sezer and Tarhan (2012) tried to find a link between the color of Japanese quails' feathers and how they grew. They concluded that morphological characteristics, especially feather color, played a big role in both the identification process and the choice of quail varieties.

Quail meat is one of the best alternative animal protein sources due to its low fat and cholesterol content (Nasar et al., 2016). Although quail meat has less fat content compared to other poultry meats, it has a high amount of unsaturated fatty acids. It is also rich in terms of conjugated linoleic acid (anti-inflammatory, antithrombotic, and anti-atherosclerotic), which has many beneficial effects on human physiology (Genchev et al. 2008; Nasr et al., 2017). Besides the composition of the meat, color, texture, and taste are among the other quality traits affecting the acceptability of the product by consumers before and after the sale. The appearance of meat depends on the skin and meat color, and it mostly affects the choice of consumers. In terms of storage and processing, meat quality is affected by factors such as pH value, water holding capacity, and cooking loss. It has been determined that there are varieties of Japanese quail based on plumage color (Mir et al., 2017). In terms of yield characteristics, different Japanese quail varieties have varying growth rates, feed conversion efficiency, and egg-laying capacity. Some varieties may be more resilient to climate change-induced stress and have better productivity under suboptimal environmental conditions. However, this may also depend on other factors such as genetic makeup, nutrition, and management practices.Changes in climate can also affect the yield quality of Japanese quail. Heat stress can cause oxidative stress and lipid peroxidation, leading to decreased meat quality (Gonzalez-Rivas et al., 2020).

The studies to date have focused on demonstrating that different varieties of Japanese quail have comparable meat quality (Inci et al., 2015; Nasr et al., 2016; Sabow, 2020). Climate change is expected to worsen in the near future (Malhi et al., 2021). Raising the livestock animals used in meat production with maximum efficiency in warm climate conditions may be a necessity shortly to meet the food need. In this context, the quality parameters of quail strains under warm climate conditions have been a matter of curiosity. So, the goal of this study was to compare the meat quality of black, white, golden, and gray Japanese quails that were raised in warm climates.

MATERIAL AND METHODS

Ethical statement

This study was approved by the Elazığ Veterinary Control Institute Poultry Unit. Approval was received from Elazığ Veterinary Control Institute Local Ethics Committee (EVKEM: 2020/01).

Experimental design

In the study, a total of 100 Japanese quails (*Coturnix coturnix Japonica*), with 25 from each plumage color (black, white, golden, and gray), were included in the test period by being matched with their initial live weights (Aslan et al., 2022). The study was planned with 5 replications, with 5 quails in each repetition. Throughout the test period (15th-42nd Days), the quails were housed in special broiler quail cages. A control group was not formed in this study because it was desired to examine the differences between the variances in only warm climatic conditions. An environmentally-controlled room, including the cages, was arranged, and the temperature and humidity values in the room were monitored with a digital gauge. The warm climate condition was set to be 34ºC for 8 h a day (from 9:00 a.m. to 05:00 p.m.) and 22 ºC for the remaining 16 h throughout the experiment (Aslan et al., 2022). Water cans were placed in front of the heaters, and the ambient relative humidity (RH) was maintained at 55-60%. The light/dark period was set up as a 23/1 h feed, and water was given to the quail ad libitum, as shown in Table 1 (NRC, 1994). At the end of the experiment, all the quails were weighed and taken to be slaughtered. For slaughter, a total of 10 quails (5 females and 5 males), reflecting the average of each group (1 female and 1 male from

Table 1 Composition and nutritional properties of the feed used in quail nutrition

Feed Materials	%	Chemical Composition	%
Corn, Yellow	51.50	KM, %	89.9
Soybean meal, 48%	28.00	HP, %	24.0
Corn Gluten, 43% HP	12.00	HY, %	2.48
Wheat Bran, Coarse	5.00	HK, %	5.52
Vegetable Oil	0.51	HS, %	3.32
Dicalcium Phosphate	0.70	ME, kcal/kg	2900
Dl-Methionine	0.01		
Limestone	1.35		
L-Lysine Hydrochloride	0.27		
L-Threonine	0.16		
Salt	0.25		
Vitamin-Mineral Mix*	0.25		

* Vitamin-mineral premix (For each 1 kg): Vitamin A, 12.000 IU; Vitamin D3, 3.300 IU; vitamin E, 20 mg; Vitamin K3, 4 mg; Vitamin B1, 3.0 mg; Vitamin B2, 7.0 mg; Vitamin B6, 5.0 mg; Vitamin B12, 0.015 mg; Niacin, 25.0 mg; D-calcium pantothenate, 10.0 mg; folic acid, 1.0 mg; D-biotin, 0.05 mg; choline chloride, 175 mg; manganese, 100 mg; iron, 60 mg; zinc 60 mg; copper, 5 mg; cobalt, 0.5 mg; iodine, 2 mg; selenium, 0.15 mg; phytase, 300.

each replication), were selected. The slaughter, carcass, and breast weights of the quails were measured using a balance with g precision. Half of the breasts were separated, and M. pectoralis major was kept at -20 ºC for fatty acid and basic nutrient analyses. The rest of the breast was kept at +4 ºC for 24 h, and then the color, ultimate pH (pHu), water holding capacity, and cooking loss analyses were performed.

Chemical and physicochemical analysis

The crude protein content of the samples was determined using the Dumatherm protein analyzer and the Dumas method (Gerhardt, Germany). Crude fat, dry matter, and crude ash analyses were performed based on the Association of Official Agricultural Chemists (AOAC) guidelines (AOAC, 2000). In determining the pHu value of the M. pectoralis major muscle 24 hours after the slaughter, the probe of the standardized pH meter was stuck to three different points of the breast meat, and the pHu value was recorded by taking the average of every three measurements. Water holding capacity (WHC) was determined as reported previously (Hamm, 1961). Cooking loss (CL) analysis was performed at the 24th hour after the slaughter based on the method reported by Honikel (1998). The color of the meat was analyzed with a colorimeter device (Chen et al., 2021). Instrument calibration was performed on the white plate and black hole provided by the producer. The average of the measurements performed in three different parts of the breast meat was recorded.

Determination of fatty acid profile by gas chromatography

Briefly, a 0.5-1 g tissue sample was homogenized in a 5 ml hexane–isopropanol mixture at a rate of 3:2 (v/v) for 30 sec. The homogenization vessel was washed with 2 ml of lysis solvent and taken to the centrifuge tubes. Then, the upper supernatant parts were taken from the tissue samples and centrifuged at 4500 rpm for 10 min, and they were put into covered test tubes (Hara and Radin, 1978). The collected lipid extract from the hexane/isopropanol phase was taken to the 30 ml test tubes. Subsequently, 5 ml of 2% methanolic sulfuric acid was added to them, and they were vortexed. This mixture was left for methylation for 15 h in a drying oven at 50 ºC. Then, they were cooled to ambient temperature and mixed thoroughly by adding 5% (5 ml) sodium chloride. The produced fatty acid methyl esters were extracted with 5 ml of hexane, and the hexane phase was taken by pipette, treated with 5 ml of 2% KHCO3, and kept for 4 h for the phases to separate. Then, the mixture, including the methyl esters, was dissolved with 1 ml hexane, the solvent of which was evaporated at 45 ºC and under a nitrogen stream, and they were taken into 2 ml covered autosampler vials and analyzed in gas chromatography. After the fatty acids in the lipid extract were converted into methyl esters and analyzed with Macherey-Nagel capillary columns in Shimadzu GC-17 Ver. 3 gas chromatography (GC-17 series, Shimadzu, Japan). During the analysis, the colon temperature was kept at 120-220 ºC, the injection temperature was kept at 240 ºC and the detector temperature was kept at 280 ºC. The colon temperature was set from 120 ºC to 220 ºC. The temperature increase was determined as 5 ºC/ min until 200 ºC and 4 ºC/ min from 200 ºC to 220 ºC. It was kept at 220 ºC for 8 min, and the total period was determined to be 35 min. Nitrogen gas was used as the carrier gas. During the analysis, the mixtures of the standard fatty acid methyl esters were injected, and the retention time of each fatty acid was determined before the analysis of the fatty acid methyl esters of the samples. After this process, the required scheduling was performed, and the fatty acid methyl ester mixtures of the samples were analyzed. The results were determined as a percentage for each fatty acid among the total fatty acids. The calculations were made using the GC Solution 2.3 software.

Statistical analyses

After the normality and homogeneity tests were performed, all data were subjected to a one-way ANOVA using analysis of variance.Significant differences have also been subjected to Tukey HSD testing. All analyses were performed using SPSS 22 for Windows. The results were considered significant when P values were less than 0.05.

RESULTS

Performance

Slaughter weights, carcass weights, and breast weights of black, white, golden, and gray-colored Japanese quails raised in warm climate conditions are given in Figure 1. The different varieties of Japanese quails were found to be similar in terms of the characteristics examined (P>0.05).

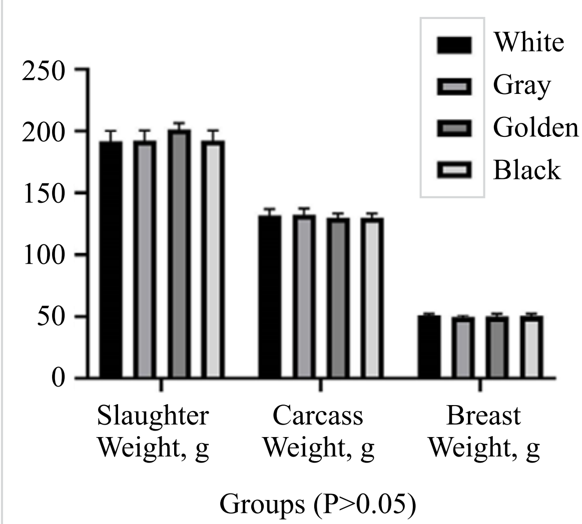

Figure 1 Slaughter, carcass, and breast weights of Japanese quails with different varieties grown under warm climate conditions (Mean±SE)

Chemical and physicochemical characteristics of breast meat

The composition of the breast meat of different colored quail varieties is given in Table 2. In terms of protein and ash content, there was no significant difference between the groups in the chemical analysis of breast meat (P>0.05). The effect of varieties on intramuscular fat content was significant (P<0.001), and the meat of white quails had a higher fat content than the black ones. The dry matter content of white quail meat was lower than that of golden quail meat (P<0.05).

Table 2 Basic breast meat compositions and meat quality characteristics of Japanese quails with different varieties grown under warm climate conditions

Variables	Quails with Different Varieties (Mean±Std Error)				P
	White	Gray	Golden	Black	
Protein,%	19.96±0.86	21.97±1.51	22.60±0.85	20.64±0.88	0.293
Fat, %	3.20±0.49[a]	1.87±0.19[ab]	2.21±0.76[ab]	1.13±0.51[b]	0.000
Dry matter,%	29.09±0.34[b]	31.73±1.29[ab]	33.61±2.46[a]	30.87±1.24[ab]	0.023
Ash, %	1.66±0.12	1.60±0.15	2.10±0.15	1.77±0.13	0.069
Ultimate pH (pH_u)	6.22±0.02	6.19±0.03	6.29±0.03	6.16±0.05	0.169
WHC* (%)	21.05±1.38	21.87±0.82	22.16±0.72	21.53±1.04	0.886
Cooking loss (%)	18.57±0.78	21.52±1.45	18.35±0.38	20.43±1.13	0.102
Lightness (L*)	44.17±0.57	42.61±1.41	42.92±1.62	42.85±0.86	0.792
Redness (a*)	8.66±0.89	10.46±1.88	8.85±1.23	9.08±0.97	0.768
Yellowness (b*)	12.88±0.51[a]	12.91±0.66[a]	13.19±0.64[a]	10.29±0.45[b]	0.003

[a,b] Values within a row with different superscripts differ significantly at P<0.05.

* WHC: Water Holding Capacity

When Table 2 was viewed, there was no significant difference among the groups in terms of pHu, water holding capacity, and cooking loss (P>0.05). Among the color parameters, the L* (lightness) and a* (redness) values of the groups were found to be similar (P>0.05), and the difference between the groups in the b* (yellowness) value was found to be significant (P<0.01). While the b* value was similar in white, golden, and gray varieties, this value was significantly lower in black quails (P<0.01).

Breast meat fatty acid compositions

When the results of fatty acids are examined (Table 3), cis-10 pentadecenoic acid (C15:1) (P<0.01), heptadecenoic acid (C17:0) (P<0.001), cis-10 heptadecenoic acid (C17:1) (P<0.01), stearic acid (C18:0) (P<0.05), eicosatrienoic acid (C20:3) (P<0.05), eicosapentaenoic acid (C20:5 n-3) (P<0.001), docosahexaenoic acid (C22:6 n-3) (P<0.05), nervonic acid (C24:1) (P<0.05) values were found to be higher in gray quails. The total monounsaturated fatty acid (∑MUFA) proportion was the highest in golden and significantly lowest in gray quails (P<0.05). Total polyunsaturated fatty acids (∑PUFA) were similar among the groups. The highest proportion of n-3 polyunsaturated fatty acids was detected in gray quails and the lowest in white quails and golden quails (P<0.01). The proportion of n-6 unsaturated fatty acids was similar among the groups (P>0.05). The n-6:n-3 proportion was calculated as the highest in the golden group and the lowest in the gray group (P<0.01).

Table 3 Fatty acids profiles of breast meat in Japanese quails with different varieties grown under warm climate conditions (g/100 g fatty acids)

Variables	Quails with Different Varieties (Mean±Std. Error)				P
	White	Gray	Golden	Black	
Myristic acid (C14:0)	0.66±0.03	0.55±0.03	0.51±0.05	0.57±0.02	0.150
cis-10 Pentadecenoic acid (C15:1)	0.84±0.10[b]	1.50±0.18[a]	0.87±0.14[b]	1.21±0.13[ab]	0.008
Palmitic acid (C16:0)	20.45±0.24	20.23±0.43	19.20±0.73	20.40±0.53	0.303
Palmitoleic acid (C16:1 n-7)	6.40±0.65	4.82±0.34	5.30±0.51	6.05±0.30	0.106
Heptadecenoic acid (C17:0)	0.49±0.08[ab]	0.87±0.17[a]	0.25±0.06[b]	0.12±0.01[b]	0.000
cis-10 Heptadecenoic acid (C17:1)	0.40±0.05[ab]	0.59±0.07[a]	0.30±0.06[b]	0.47±0.03[ab]	0.006
Stearic acid (C18:0)	7.34±0.65[ab]	9.37±0.56[a]	6.90±0.53[b]	8.10±0.37[ab]	0.016
Oleic acid (C18:1 n-9)	27.15±3.25	26.06±1.11	32.90±2.67	26.33±1.39	0.139
Linoleic acid (C18:2 n-6)	24.76±1.79	22.49±0.39	22.22±1.21	22.55±0.40	0.370
α-Linolenic acid (C18:3 n-3)	1.09±0.11	0.90±0.05	1.00±0.08	0.94±0.03	0.356
Eicosatrienoic acid (C20:3)	0.41±0.06[b]	0.67±0.06[a]	0.44±0.07[b]	0.62±0.06[ab]	0.024
Arachidonic acid (C20:4 n-6)	4.84±0.77	7.02±0.70	4.54±0.73	6.56±0.78	0.057
Eicosapentaenoic acid (C20:5 n-3)	0.21±0.03[b]	0.42±0.03[a]	0.10±0.02[c]	0.13±0.01[bc]	0.000
Docosahexaenoic acid (C22:6 n-3)	1.14±0.18[ab]	1.81±0.17[a]	1.06±0.18[b]	1.62±0.20[ab]	0.016
Lignoceric acid(C24)	0.33±0.05	0.44±0.05	0.28±0.04	0.36±0.05	0.170
Nervonic acid (C24:1)	0.37±0.07[b]	0.60±0.09[a]	0.32±0.05[b]	0.55±0.04[ab]	0.033
Others[1]	3.10±0.21[ab]	1.66±0.14[b]	3.80±0.46[a]	3.42±0.35[a]	0.000
∑SFA[2]	27.28±1.64[b]	31.48±0.51[a]	27.20±0.98[b]	29.61±0.56[ab]	0.017
∑MUFA[3]	39.80±1.73[ab]	34.66±1.23[b]	43.00±2.46[a]	37.45±1.31[ab]	0.014
∑PUFA[4]	32.90±2.19	33.85±0.90	29.79±1.57	32.93±1.08	0.276
∑PUFA n-3	2.87±0.24[b]	3.91±0.24[a]	2.68±0.23[b]	3.54±0.28[ab]	0.004

Variables	Quails with Different Varieties (Mean±Std. Error)				P
	White	Gray	Golden	Black	
∑PUFA n-6	29.96±1.99	29.94±0.71	27.06±1.41	29.33±0.85	0.390
n-6:n-3 proportion	10.84±0.74[a]	7.88±0.43[b]	10.44±0.67[a]	8.63±0.58[ab]	0.004

[1]Others = (C12:0, C14:1, C15:0, C18:1 n-7, C18:3 n-6, C20:0, C20:1, C20:2, C22:2, C22:4 n-6, C22:5 n-6, C22:5 n-3)

[2]∑SFA (saturated fatty acids) = sum of C14:0 + C16:0 + C17:0 + C18:0 + C24:0

[3]∑MUFA (monounsaturated fatty acids) = sum of C15:1 + C16:1 n-7 + C17:1 + C18:1 n-9 + C18:1 n-7 + C24:1

[4]∑PUFA (polyunsaturated fatty acids) = sum of C18:2 n-6 + C18:3 n-3 + C20:3 n-6 + C20:3 n-3 + C20:4 n-6 + C20:5 n-3 + C22:5 n-3 + C22:6 n-3

[a,b,c] Values within a row with different superscripts differ significantly at P<0.05

DISCUSSION AND CONCLUSION

Performance

The carcass yield in Japanese quail is managed by the slaughter age, breed, line, sex, raising conditions, and feeding programs (Alkan et al., 2013). Furthermore, heat stress has been shown in many studies to reduce feed intake and weight gain in quails (Orhan et al., 2020; Orhan et al., 2021). Quails exposed to heat stress try to maintain body temperature by reducing metabolism (Alagawany et al., 2017). Quail carcass weight was found to be similar in different varieties in current research. In other studies, without heat stress, Nasr et al. (2017) reported carcass weight to be high in the white, golden, gray, and brown varieties, respectively. Inci et al. (2015) have reported carcass weight to be high in wild-type dark brown, white, and golden quail, respectively. Sabow (2020) reported that the carcass weight of black and brown quails was similar, and the white quails had the lowest carcass weight. The superiority of different varieties based on the examined trait may be an indicator that these varieties have different adaptations for different environmental conditions, as postulated by Jeke et al. (2018).

Chemical and physicochemical characteristics of breast meat

The protein and ash values between groups were found to be similar. Likewise, Nasr et al. (2017) and Sabow (2020) reported that the protein content of the quails with different plumage colors was similar. In this study, the fat content was the lowest in black quails and the highest in white quails, and the dry matter content was the highest in golden quails (Table 2). It is known that the meat composition is significantly affected by the adaptation process of genotypes under heat stress (Al-Sagan et al., 2020). It has been reported that the ash value decreased due to mineral loss (Xing et al., 2019), and therefore, the dry matter level may be affected. In this study, the breast-meat fat content of the quails was found to be lower compared to the studies by Sabow (2020). High temperatures reduce fat metabolism in poultry during the growing stage (Kumar et al., 2021). Also, it was considered that this difference was associated with different feeding programs or slaughter ages.

Genetic factors are effective on meat quality, and the variation between the breeds or varieties of poultry used in global breeding is important. Meat pH is obtained as the most important factor that affects poultry meat's physical and chemical properties, including water-holding capacity, color, and storage life (Nasr et al., 2017; Sabow, 2020).

The average ultimate pH for quails was reported as 5.30-6.58 by various researchers (Genchev et al., 2008; Narinc et al. 2013; Zerehdaran et al., 2012). In the study, the pH of the pectoral major muscle in Japanese quail varieties had similar values to the varieties examined in other studies (Genchev et al., 2008; Nasr et al., 2017). Also, Sabow (2020) reported that, similarly, there was no difference between the quails with white, black, and brown plumage colors in the pHu. The meat of Japanese quail possessed the highest ultimate pH levels when compared with other poultry meats (Karakaya et al., 2005). The difference in ultimate pH might be based on a difference in intramuscular glycogen content, amount of anaerobic glycolysis after slaughtering, and breed factors (genetic difference between breeds) (Nasr et al., 2017; Ribarski and Genchev, 2013). As Walasik et al. (2006) reported, the quail muscles were characterized by a slower progression of rigor due to higher mitochondrial levels and, consequently, higher pH levels than other poultry muscles.

Studies have shown that low pH levels in meat reduce the WHC and tenderness quality (pale, soft, and exudative) of the meat and enhance the cooking loss percentage (Barbut, 1997). No significant difference was found in water holding capacity or cooking loss among the experimental groups of the present study (Table 2). It was considered that this similarity was caused by the pHu similarity among the groups. Besides, the detected levels of WHC and cooking loss in the four different plumage colors are nearly similar to the results of other studies (Genchev et al., 2008; Nasr et al., 2017; Ribarski and Genchev, 2013; Zerehdaran et al. 2012).

Meat color is an organoleptic parameter that directly expresses the freshness of meat. Meat color is affected by many factors, such as myoglobin amount, intramuscular fat content, genotype, sex, age, the diet of animals, the pre-slaughter applications, and boiling temperature (Fletcher, 2002). There are different findings on the effect of plumage color on L*, a*, and b* values. Some researchers have reported an interval between L*: 48.00–61.54, a*: 13.1–19.20, and b*: >19.81 (Boni et al., 2010; Ponnampalam et al., 2017), and some researchers determined some lower values: L*: 35.89–52.34, a*: 5.1–14.4, and b*: 3.32–13.4. The values found in this study are similar to those found by other researchers who found low values (Narinc et al., 2013; Nasr et al., 2017, Ribarski and Genchev, 2013). Also, L* and a* values were similar between the groups, and the b* value, demonstrating yellowness, was the lowest in black quails. The reason for this state may be the concentration of pigments, the antioxidant potential of meat, and the level of intramuscular fat in the meat (Ponnampalam et al. 2017). Indeed, in this study, the lowest fat content was determined for this variety.

Breast meat fatty acid compositions: The lipids of the muscle involve phospholipids, triacylglycerol, and cholesterol. While triacylglycerol is made up mainly of saturated fatty acids (SFA) and monounsaturated fatty acids (MUFA), a part of phospholipid has a great proportion of polyunsaturated fatty acids (PUFA) (Abdulla et al., 2018). The major FA that was detected in breast meat was oleic acid in all varieties, as expected. In addition, palmitic acid was the main fatty acid in total SFA in all varieties, followed by stearic acid. Similarly, Sabow (2020) and Kürekci (2021) observed quail meat and other poultry species such as broiler chicken (Ölmez et al., 2021) or duck meat (Huo et al., 2021). In this study, while there was no difference in palmitic acid between quail varieties, the highest amount of stearic acid was found in gray quails. Sabow (2020), stated the amounts of stearic acid in white, black, and brown quails grown under normal conditions as 9.57, 9.55, and 9.66, respectively. Also, the amount of stearic acid in quail varietals reared in warm climate conditions was lower than the amount indicated by Sabow (2020), and only 9.37 percent of gray quails had the same amount. As known, compared with palmitic acid, stearic acid lowers levels of total cholesterol, LDL cholesterol, as well as HDL cholesterol (van Rooijen et al., 2021). Furthermore, stearic acid in saturated fatty acids has anti-thrombogenic and anti-atherosclerotic properties and is biocompatible with the human body (Attia et al., 2017). According to current research, MUFA and n-6 are important, but the n-3 proportion was highest in golden quails and lowest in gray quails. On the contrary side, the highest proportion of n-3 polyunsaturated fatty acids, EPA, and DPA levels were detected in gray quails. In another study, the fatty acid composition of quail varieties under normal conditions was found to be similar (Sabow, 2020). It seems that warm climate conditions may affect the fatty acid composition of golden and gray quail varieties. The fact that n-3 ∑PUFA proportions were high in gray and black quails may be associated with the fact that these varieties had more powerful antioxidant systems, since the relationship of the melanin pigment with the antioxidant defense system has been previously determined in another study (Galvan et al., 2010). Erişir (2018) determined a higher level of kidney and liver malondialdehyde in the golden genotype, among the golden and gray quails, which were kept under heat stress. The low malondialdehyde level in the gray genotype was associated with the fact that this genotype had a better adaptation to heat stress, which supported this thesis. Similarly, Vitousek (2013) demonstrated that dark-colored swallows were more resistant to oxidative damage.

The results of the current study indicate that most meat quality parameters obtained from the four quail strains were comparable. Some researchers suggest that white quails possess the best carcass traits and meat quality (Inci et al., 2015, Sabow, 2020). Some of them recommend that brown quail could be preferred for meat production purposes (Nasr et al., 2017). These recommendations are valid for normal conditions. However, it is important to know the traits of quail strains under adverse conditions before making any other recommendations. The current study discovered that the meat quality parameters of different quail varieties growing in warm climate conditions were changeable. On the other hand, the highest n-3 PUFA ratio was obtained from dark-colored quails, especially gray-colored quails. Overall, the adaptation ability, yield characteristics, and yield quality changes of different Japanese quail varieties in the face of climate change depend on various factors, including genetic makeup, environmental conditions, and management practices. Further research is needed to better understand the effects of climate change on Japanese quail and to develop effective adaptation strategies to mitigate the negative impacts on their productivity and welfare.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

CONTRIBUTIONS

Concept –AG, GG, ÜGS, SA.; Design – AG, GG, ÜGS, SA; Supervision – ÜGS; Resources –ÜGS, SA; Materials – AG, GG, ÖY, MB; Data Collection and/or Processing – AG, GG, ÖY, MB; Analysis and/or Interpretation – AG, GG, ÜGS; Literature Search – AG, GG; Writing Manuscript – AG, GG, ÜGS; Critical Review – ÜGS.

REFERENCES

Abdulla NR, Sabow AB, Foo HL, Loh TC, Zamri AM. 2018. Growth performance, fatty acid profile and lipid oxidative stability of breast muscle in chickens fed probiotics and antibiotics or their mixture. S Afr J Anim Sci, 6, 48.

Alagawany M, Farag MR, Abd El-Hack ME, Patra A. 2017. Heat stress: effects on productive and reproductive performance of quail. World's Poult Sci J, 73, 747-56.

Alkan S, Karsli T, Karabağ K, Galiç A. 2013. Farklı hatlardaki Japon bıldırcınlarında (Coturnix coturnix Japonica) farklı kesim yaşı ve cinsiyetin karkas özelliklerine etkisi. Ziraat Fakültesi Dergisi, 8, 12-8.

Al-Sagan AA, Khalil S, Hussein EO, Attia YA. 2020. Effects of fennel seed powder supplementation on growth performance, carcass characteristics, meat quality, and economic efficiency of broilers under thermoneutral and chronic heat stress conditions. Animals, 10, 206.

AOAC. 2000. Official Methods of Analysis Association of Official Analytical Chemists. 17th Ed., AOAC international, Maryland, USA.

Aslan S, Baykalir Y, Simsek U G, Gul B. 2022. Effects of heat stress on fattening performance, carcass traits, oxidant/antioxidant status, and hepatic heat shock protein 70 levels in different plumage colors of Japanese quail (Coturnix coturnix japonica). Pol J Vet Sci, 25, 599-605.

Attia YA, Al-Harthi MA, Korish MA, Shiboob MM. 2017. Fatty acid and cholesterol profiles, hypocholesterolemic, atherogenic, and thrombogenic indices of broiler meat in the retail market. Lipids Health Dis, 16, 1-11.

Barbut S.1997. Problem of pale soft exudative meat in broiler chickens. Br Poult Sci, 38, 355-8.

Batool F, Bilal RM, Hassan FU, Nasir TA, Rafeeque M,Elnesr SS, et al. 2021. An updated review on behavior of domestic quail with reference to the negative effect of heat stress. Anim Biotechnol, 1-14.

Boni I, Nurul H, Noryati I. 2010. Comparison of meat quality characteristics between young and spent quails. Int Food Res J, 17, 661-7.

Chen Q, Zhang J, Zhang Y, Meng S, Wang Q. 2021. Rheological properties of pea protein isolate-amylose/amylopectin mixtures and the application in the high-moisture extruded meat substitutes. Food Hydrocolloids, 117, 106732.

Davoodi P, Ehsani A, Vaez Torshizi R, Masoudi AA. 2021. New insights into genetics underlying of plumage color. Anim Genet, 53, 80-93.

Erişir Z, Şimşek ÜG, Özçelik M, Baykalır Y, İflazoğlu Mutlu S, Çiftçi M. 2018. Effects of dietary grape seed on performance and some metabolic assessments in Japanese quail with different plumage colors exposed to heat stress. Rev Bras de Zootec, 47, e20170172.

Fletcher D. 2002. Poultry meat quality. World's Poult Sci J, 58, 131-45.

Galván I, Gangoso L, Grande JM, Negro JJ, Rodríguez A, Figuerola J, et al. 2010. Antioxidant machinery differs between melanic and light nestlings of two polymorphic raptors. PLoS One, 5, e13369.

Genchev A, Mihaylova G, Ribarski S, Pavlov A, Kabakchiev M. 2008. Meat quality and composition in Japanese quails. Trakia J Sci, 6, 72-82.

Gonzalez-Rivas P A, Chauhan S S, Ha M, Fegan N, Dunshea, F R, Warner R D. 2020. Effects of heat stress on animal physiology, metabolism, and meat quality: A review. Meat Sci, 162, 108025.

Hamm R. 1961. Biochemistry of meat hydration. In Chichester CO, Advances in food research (pp. 355-463). Washington DC, USA: Academic Press.

Hara A, Radin NS. 1978. Lipid extraction of tissues with a low-toxicity solvent. Anal Biochem, 90, 420-6.

Honikel KO. 1998. Reference methods for the assessment of physical characteristics of meat. Meat Sci, 49, 447-57.

Huo W, Weng K, Gu T, Luo X, Zhang Y, Zhang Y, et al., 2021. Effects of integrated rice-duck farming system on duck carcass traits, meat quality, amino acid, and fatty acid composition. Poult Sci, 100, 101-7.

Inci H, Sogut B, Sengul T, Sengul AY, Taysi MR. 2015. Comparison of fattening performance, carcass characteristics, and egg quality characteristics of Japanese quails with different feather colors. Rev Bras de Zootec, 44, 390-6.

Jeke A, Phiri C, Chitiindingu K, Taru P. 2018. Nutritional compositions of Japanese quail (Coturnix coturnix japonica) breed lines raised on a basal poultry ration under farm conditions in Ruwa, Zimbabwe. Cogent Food Agric, 4, 1473009.

Karakaya M, Saricoban C,Yilmaz MT. 2005. The effect of various types of poultry pre-and post-rigor meats on emulsification capacity, water-holding capacity and cooking loss. Eur Food Res Technol, 220, 283-6.

Kumar M, Ratwan P, Dahiya SP, Nehra AK. 2021. Climate change and heat stress: Impact on production, reproduction and growth performance of poultry and its mitigation using genetic strategies. J Therm Biol, 102867.

Kürekci C, Özsoy B, Hassan E, Özkan H, Gundoğdu A, Yurdagül Özsoy Ş, et al. 2021. Effect of essential oil supplementation to diet on meat quality, fatty acid composition, performance parameters and intestinal microbiota of Japanese quails. J Anim Physiol Anim, 105, 927-37.

Lehikoinen A, Lindström Å, Santangeli A, Sirkia PM, Brotons L, Devictor V, et al. 2021. Wintering bird communities are tracking climate change faster than breeding communities. J Anim Ecol, 90, 1085-95.

Lukanov H. 2019. Domestic quail (Coturnix japonica domestica), is there such farm animal?. World's Poult Sci J, 75, 547-58.

Malhi GS, Kaur M, Kaushik P. 2021. Impact of climate change on agriculture and its mitigation strategies: A review. Sustainability, 13, 1318.

Mir NA, Rafiq A, Kumar F, Singh V, Shukla V. 2017. Determinants of broiler chicken meat quality and factors affecting them: a review. J Food Sci Technol, 54, 2997-3009.

Narinc D, Aksoy T, Karaman E, Aygun A, Firat MZ, Uslu MK. 2013. Japanese quail meat quality: Characteristics, heritabilities, and genetic correlations with some slaughter traits. Poult Sci, 92, 1735-44.

Nasar A, Rahman A, Hoque N, Talukder AK, Das ZC. 2016. A survey of Japanese quail (Coturnix coturnix japonica) farming in selected areas of Bangladesh. Vet World, 9, 940.

Nasr MA, Ali E.-SM, Hussein MA. 2017. Performance, carcass traits, meat quality and amino acid profile of different Japanese quails strains. J Food Sci Technol, 54, 4189-96.

National Research Council. 1994. Nutrient requirements of poultry. Washington DC, USA: National Academies Press.

Nawab A, Ibtisham F, Li G, Kieser B, Wu J, Liu W,et al. 2018. Heat stress in poultry production: Mitigation strategies to overcome the future challenges facing the global poultry industry. J Therm Biol, 78, 131-9.

Ölmez M, Şahin T, Karadağoğlu Ö, Yörük MA, Kara K, Dalga S. 2021. Growth performance, carcass characteristics, and fatty acid composition of breast and thigh meat of broiler chickens fed gradually increasing levels of supplemental blueberry extract. Trop Anim Health Prod, 53, 1-8.

Orhan C, Kucuk O, Sahin N, Tuzcu M, Sahin K. 2020. Effects of taurine supplementation on productive performance, nutrient digestibility and gene expression of nutrient transporters in quails reared under heat stress. J Therm Biol, 92, 102668.

Orhan C, Sahin N, Sahin K, Kucuk O. 2021. Influence of dietary genistein and polyunsaturated fatty acids on lipid peroxidation and fatty acid composition of meat in quail exposed to heat stress. Trop Anim Health Prod, 53, 1-11.

Ponnampalam EN, Hopkins DL, Bruce H, Li D, Baldi G, Bekhit AE. 2017. Causes and contributing factors to "dark cutting" meat: Current trends and future directions: A review. Compr Rev Food Sci Food Saf, 16, 400-30.

Ribarski S, Genchev A. 2013. Effect of breed on meat quality in Japanese quails (Coturnix coturnix japonica). Trakia J Sci, 11, 181-8.

Riddell EA, Iknayan KJ, Hargrove L, Tremor S, Patton JL, Ramireze R, et al. 2021 Exposure to climate change drives stability or collapse of desert mammal and bird communities. Science, 371, 633-6.

Sabow AB. 2020. Carcass characteristics, physicochemical attributes, and fatty acid and amino acid compositions of meat obtained from different Japanese quail strains. Trop Anim Health Prod, 52, 131-40.

Sayed RK, El Shoukary RD. 2021. Recessive white plumage color mutation of Japanese quail (Coturnix coturnix japonica) revealed morphological variations in the oropharyngeal roof structures, accompanied by behavioral differences. Microsc Res Tech, 84, 3044-58.

Sezer M, Tarhan S. 2005. Model parameters of growth curves of three meat-type lines of Japanese quail. Czech J Anim Sci, 50, 22-30.

Tarhyel R, Tanimomo B, Hena S (2012): Organ weight: As influenced by color, sex and weight group in Japanese quail. Sci J Anim, 1, 46-9.

van Rooijen MA, Plat J, Blom WA, Zock PL. 2021. Dietary stearic acid and palmitic acid do not differently affect ABCA1-mediated cholesterol efflux capacity in healthy men and postmenopausal women: A randomized controlled trial. Clin Nutr ESPEN, 40, 804-11.

Vitousek MN, Stewart RA, Safran RJ.2013. Female plumage colour influences seasonal oxidative damage and testosterone profiles in a songbird. Biol Lett, 9, 20130539.

Walasik K, Adamski M, Bogucka J, Kubicki J. 2006. Some characteristisc of musculus pectoralis superficialis microstructure in quails. Anim Sci, 1, 140-1.

Xing T, Gao F, Tume RK, Zhou G, Xu X. 2019. Stress effects on meat quality: a mechanistic perspective. Compr Rev Food Sci Food Saf, 18, 380-401.

Zerehdaran S, Lotfi E, Rasouli Z. 2012. Genetic evaluation of meat quality traits and their correlation with growth and carcase composition in Japanese quail. Br Poult Sci, 53, 756-62.

SVOJSTVA KVALITETE I SASTAV MASNIH KISELINA MESA PRSA RAZLIČITIH VRSTA JAPANSKIH PREPELICA UZGOJENIH U UVJETIMA TOPLE KLIME

SAŽETAK

S obzirom na očekivano pogoršanje klime u budućnosti, maksimalno učinkovit uzgoj životinja za proizvodnju mesa u uslovima tople klime će postati neophodan kako bi se zadovoljile potrebe za mesom. Iz ovog razloga smo izveli eksperiment kako bismo odredili svojstva kvalitete mesa prsa različitih obojenih japanskih prepelica (*Coturnix coturnix Japonica)* uzgojenih u uslovima tople klime. Uključeno je ukupno 100 prepelica, po 25 od svake vrste, crnih, bijelih, zlatnih i sivih. Nakon što su prepelice uzgojene u uvjetima tople klime od 15. do 42. dana i zaklane, određena su hemijsko-fizikohemijska svojstva, zajedno sa sastavom masnih kiselina u prsnim mišićima. Vrijednosti *b (žutilo) su bile znatno niže kod crnih prepelica (P<0.01). Najniži sadržaj masti u mesu je pronađen kod crnih i sivih prepelica, a najviši sadržaj masti kod bijelih (P<0.01). Omjer ukupnih zasićenih masnih kiselina je najviši kod sivih prepelica, a najviše ukupnih mononezasićenih masnih kiselina je pronađeno kod zlatnih, a najmanje kod sivih prepelica (P<0.05). Najviši omjer n-3 polinezasićenih masnih kiselina je pronađen kod sivih prepelica, a najniži kod zlatnih i bijelih prepelica (P<0.01). U ovom istraživanju je zaključeno da različite vrste prepelica imaju različita svojstva zahvaljujući različitim uvjetima koji vladaju u okolišu. Vrste prepelica koje se uzgajaju u uslovima tople klime mogu imati različite parametre kvaliteta mesa.

Ključne riječi: Masne kiseline, svojstva kvaliteta mesa, topla klima, vrste prepelica