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QUAIL MEAT CHARACTERISTICS: CHEMICAL CONSTITUENT AND QUALITY

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Abstract
Due to the increasing popularity of Japanese quails as a food source, the study aimed to analyze the quality and composition of the meat from these animals. The study revealed that the slaughter yield of Japanese quails ranged from 64 to 65%. The differences in the meat composition were due to the different parts of the animal. The pH level, as well as the free water percentage, of the meat were also variable within 24 hours after the animals were slaughtered. The water retention capacity of the meat was also better in female quails.

Keywords: chemical, constituent, quality, quail meat

INTRODUCTION

In the last decades, the development of poultry breeding has become the main branch of animal husbandry. As a result, various animal products such as quail and ostrich are being offered in large stores. Although quail is not an established branch, it still occupies a relevant place in the poultry breeding industry. The main producers of quail meat are the US and Europe (Tserven-Gousi and Yannakopoulos, 1986). The nutritional and taste characteristics of quail meat are some of the factors that determine the popularity of this product. The various factors that influence the quality and composition of this meat include the age at which it is slaughtered and the feeding mode (Genchev, 2003).

Quality is determined by two factors: appearance and meat consistency (Fletcher, 2002). The appearance of the meat depends on the skin and the condition of the meat. The quality of meat depends on the thickness of the muscle fibers and the ratio between the metabolic types of muscle bundles. It also depends on the water retention capacity and pH values (Riegel, Rosner, Schmidt, Schuler and Wicke, 2003). According to the Riegel, Rosner, Schmidt, Schuler and Wicke, (2003) of a study conducted in 1987, the pectoral muscle of Japanese quails had a pH value of 6.2-6.3 at the 20th minute after slaughter. The researchers concluded that the glycolysis in the muscle fibers ended up being maintained at the 45th minute post-mortem.

An analysis of the post-hatching development of Japanese quails revealed that the muscle is mainly composed of fat, muscle, and connective tissue (Afanasiev, Blohin, Genchev, Ribarski and Aleksieva, 2000). The dark muscle fibers are the ones that supply the pectoral muscle with oxygen. According to Riegel et al., (2003) the ratio of dark to light muscle fibers is about 84.5%. The ratio between the nutrients and the nutrients' composition is also important for the nutritional value of meat. One of the most important factors that a meat evaluation focuses on is the protein content and the presence of essential amino acids (Nedkov, 2004). According to dieticians, a non-trained organism needs about 8 amino acids.

In 1973, WHO and FAO stated that the ideal protein should contain concentrations of seven essential amino acids: methionine, leucine, isoleucine, valine, and phenylalanine. Genchev et al. (2004) revealed that the presence of the limiting amino acids methionine and lysine in quail meat protein accounts for approximately 11.8% of the product's total protein. Aside from being rich in PUFA-polyunsaturated fatty acids, quail meat also comes in other fatty acids. It is recommended

that the daily intake of Ω PUFA should be approximately 3% of the energy intake, and that Ω-3 fatty acids should provide not less than 0.5% of the energy (Nahm, 1999).

The PUFA from the Ω-3 and Ω-6 groups are known to reduce arterial blood pressure, to have a beneficial effect in cardiovascular disorders, asthma, oncological diseases etc. (Doncheva, 2020). According to medical specialists, the frequency of these chronic diseases is considerably increasing in the present day because of the higher Ω-6 and Ω-3 fatty acids ratio in human food. The increasing popularity of eating quality food has prompted the study to analyze the composition and quality of Japanese quails.

Method

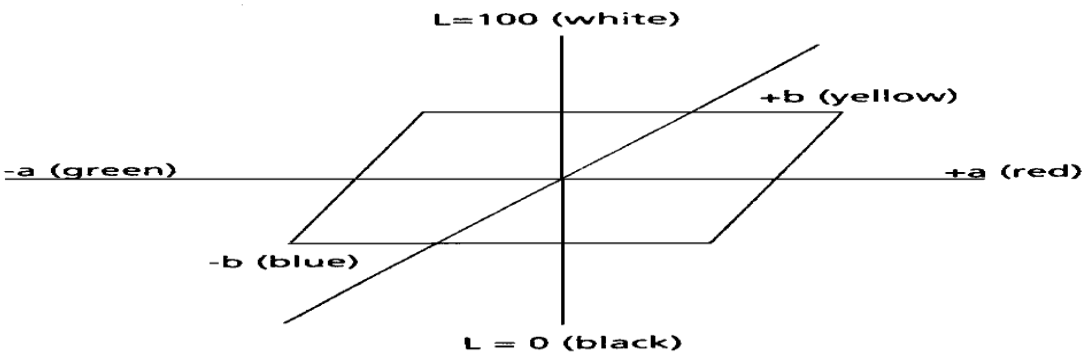
The results of two experiments were presented in this study. The experiments were performed on quails of the Pharaon breed. The experiments were performed in Animal and Poultry Production Department, Faculty of Agriculture, Damanhour University, Damanhour, Egypt in 2020 and 2021. The temperature and pH values of the studied muscles were determined using infrared thermometers. The instruments were supplied with a glass electrode and a temperature compensation. The electrodes were placed in the middle of the third muscle after the pH was determined. After 24 hours, the muscle samples were placed in a refrigerator at 4oC . The color of the muscles was then determined using a spectrophotometer that was immediately calibrated. The color of the muscle was determined using the CIELAB color system. The system was used to consider the L*, a*, and b* colorimetric coordinates.

1. L^* - a value 100 corresponded to absolute white; value) – absolute black;

Figure 1. Colour scale for determination of meat colour *(Genchev, A. Mihaylova, G. Ribarski, S. Pavlov, A. and Kabakchiev, M, 2008)*

2. a^* − a+ corresponded to red spectrum; a- corresponded to green spectrum

3. b^* − b+ corresponded to yellow spectrum; b- corresponded to blue spectrum (Fig. 1).



The water retention capacity of beef was determined using a classical method. The fat, protein, and mineral contents were also determined using samples that were subjected to chemical analysis. The mineral element concentrations were determined after ashing of beef samples at 550 degrees Celsius. The concentrations of Na+ and K+ were then measured using a flame photometer. Fat content of beef was determined by extracting fat from a mixture of methanol and chlorine. It was then separated using a gas chromatograph equipped with a flame-ionisation detector and a capillary column.

Results

Table 1. Slaughter characteristics of 35- day old Japanese quails, % of body weight

Indications	***Male***	***Difference between genders,%***	***Females***	***Males + Females***
Carcass with skin	64.97±0.30	1.5 n.s.	64.03±0.52	64.50±0.31
Carcass without skin	60.13±0.36	2.0 n.s.	58.97±0.53	59.55±0.33

Abdominal fat	0.43±0.13	25.6 n.s.	0.54±0.19	0.52±0.08
Breast with bones	25.42±0.28	0.3 n.s.	25.35±0.47	25.38±0.26
Thighs/	16.63±0.20	4.1 *	15.97±0.22	16.30±0.16
Breast meat	20.80±0.77	2.5 n.s.	20.30±1.53	20.41±0.47
Leg meat	12.62±1.41	4.6 n.s.	12.06±1.29	12.17±0.53
Total meat (breast and legs)	34.94±0.49	1.7 n.s.	34.34±0.60	34.64±0.38

*Note: n .s. – the difference is not significant; *- the difference is determined at P<0.05*

The relative grill weight of male quails was 64-65%. The proportion of breast meat in the live weight was 20.4%. Leg meat comprised 12.17% of live weight or 20.60±0.18% of grill weight. The accumulation of abdominal fat is a considerable problem in the production of poultry meat. The amount of fat that male birds consume depends on the age and sex of the animals. The table shows that the lower share of abdominal fat is due to differences in the live weight and grill weight.

Table 2. Quality characteristics of meat from breast and legs at 35 day old Japanese quails

Indications	***Male***	***Difference between genders ,%***	***Females***	***Males + Females***
pH_{24h} (breast)	6.23±0.08	1.8	6.12±0.07	6.17±0.05
WRC (breast)	22.39±0.74	3.3	21.68±1.06	22.08±0.61
pH_{24h} (legs)	6.31±0.057	1.3.	6.23±0.02	6.27±0.03
WRC (legs)	26.91±0.60	7.3.	25.08±1.02	25.51±0.80

The pH values of meat are influenced by the presence of stress factors and the muscle's glycogen stores. They can vary by up to 6.3 depending on the meat's pH content. The water retention capacity of pectoral muscle was better than that of leg muscles. It demonstrated that the muscle has a higher yielding and easier way of separation. This study supports the use of breast meat for gourmet products.

Table 3. Dynamics of quality changes in parameters of m. pectoralis in regard to preservation term at cooled condition

Indications	***30' after slaughter***	***24 h after slaughter***	***7 days after slaughter***
Temperature, ^{o}C	14.3±0.25	6.4±0.15	6.3±0.12
pH	6.42±0.07	6.17±0.05	6.47±0.08
Color of the meat			
l*	43.22±1.11	40.81±1.00	45.67±1.73
a*	8.02±0.78	10.16±0.55	11.68±0.64
b*	11.04±0.43	9.55±0.67	14.48±1.26

During the 7th post-slaughter day, the lactic acid content of pectoral muscles decreases significantly. This is due to the depletion of glycogen stores leading to lactic acid accumulation and thus, to decrease in pH from 6.42 on the 30th min after slaughter to 6.17 by the 24th hour.

Table 4. Chemical composition of whole carcass (with bones)

Indications	***Male***	***Difference between genders,%***	***Females***
Carcass with skin			
Dry matter %	32.03±0.12	2.19 n.s.	32.73±0.24
Protein,%	19.29	0.83	19.45
In this number essential amino acids	8.15	9.38	7.45
Fat, %	8.99±0.23	12.01 ***	10.07±0.22
In this number – Phospholipids	0.194	4.86	0.185
Cholesterol	0.097	3.19	0.094
NFE , %	0.49±0.09	68.97 n.s.	0.29±0.01
Ash, %	3.26±0.08	12.03 n.s.	2.91±0.20
Carcass without skin			
Dry matter,%	30.18±0.18	1.38 n.s.	29.77±0.39
Protein,%	22.7	3.61	21.91
In this number essential amino acids	9.10	6.56	8.54
Fat, %	3.45±0.15	11.01 n.s.	3.83±0.18
In this number – Phospholipids	0.158	22.48	0.129
Cholesterol	0.075	10.29	0.068
NFE , %	0.45±0.11	7.14 n.s.	0.42±0.15

Ash, %	3.58±0.06	0.84 n.s.	3.61±0.44

*Note: n .s. – the difference is not significant; ***- the difference is proved at P<0.001*

The data in Table 4 shows that the fat content of whole carcasses with bones differed among genders. In males, the fat content was higher than that of females. The comparison of the chemical analysis between male and female quails showed that the differences were not significant. However, the carbohydrate content of the carcasses was lower in females than in males. This could be explained by the higher sensitivity of the test animals to stress.

Table 5.Chemical composition of meat from 35 day old Japanese quails, %

Indications	***Male***	***Difference between genders, %***	***Females***
Br east			
Dry matter	27.51±0.302	2.19 n.s.	26.92±0.067
Protein	23.38±2.14	5.17 n.s.	22.23±3.02
Fat	2.21±0.22	24.43 n.s.	2.75±0.188
NFE	0.40±0.27	21.21 n.s.	0.33±0.10
Ash	1.51±0.10	6.62 n.s.	1.61±0.08
In this number…Ca. %	0.019±0.002	15.8 n.s.	0.022±0.002
P. %	0.222±0.005	4.5 n.s.	0.212±0.005
Na. %	0.061±0.002	12.2 n.s.	0.069±0.004
K. %	0.402±0.002	0.2 n.s.	0.401±0.003
Mg. %	0.018±0.001	0 n.s.	0.018±0.001

Fe. mg%	1.882±0.140	20.7 n.s.	1.492±0.080
Cu. mg%	0.362±0.058	2.1 n.s.	0.355±0.046
Zn. mg%	2.002±0.026	1.9 n.s.	2.040±0.082
L egs			
Dry matter	26.50±0.133	0.70 n.s.	25.86±0.107
Protein)	20.49±2.27	2.05 n.s.	20.91±0.13
Fat	3.39±0.114	3.99 n.s.	3.26±0.370
NFE	0.58±0.05	20.00 n.s.	0.40±0.02
Ash	1.64±0.06	1.23 n.s.	1.62±0. 90
In this number Ca, %	0.019±0.002	1.3 n.s.	0.020±0.001
P, %	0.227±0.006	5.5 n.s.	0.215±0.006
Na, %	0.061±0.002	10.2 n.s.	0.067±0.004
K, %	0.397±0.002	1.9 n.s.	0.390±0.007
Mg, %	0.017±0.001	0 n.s.	0.017±0.001
Fe, mg%	1.895±0.078	16.2 n.s.	1.587±0.107
Cu, mg%	0.392±0.051	8.9 n.s.	0.357±0.073
Zn, mg%	1.980±0.050	3.4 n.s.	2.047±0.011

Note*: Note: n .s. – the difference is not significant.*

Table 5 shows the dietary properties of breast and leg meat. Leg and breast meat were superior to breast meat in terms of their dietary properties. It contained higher amounts of protein and less fat. The carbohydrate content of the meat was also higher than that of breast meat.

Table 6. Amino acids content of meat from 35 days old Japanese quails, %

Amino acids	***Breast***	***Legs***
Essential amino acids lysine	2,19±0,064	2,12±0,055
Methionine	0,56±0,040	0,52±0,044
Isoleucine	1,22±0,034	1,11±0,027
Leucine	2,09±0,048	1,96±0,047
Phenylalanine	0,97±0,010	0,97±0,023
Threonine	0,74±0,038	0,69±0,020
Valine	1,29±0,035	1,15±0,036
Cysteine	0,20±0,015	0,16±0,012
Tyrosine	0,61±0,022	0,54±0,019
Non-essential amino acids Histidine	1,13±0,032	0,70±0,023
Arginine	1,40±0,036	1,31±0,048
Glutamic acids	3,96±0,094	3,81±0,226
Glycine	1,02±0,028	1,11±0,041
Serine	0,43±0,047	0,38±0,007
Alanine	1,34±0,042	1,30±0,043
Proline	0,99±0,031	0,99±0,025
Asparagine acids	2,05±0,044	1,93±0,051
Protein content	22,21±0,519	20,74±0,486

Total essential amino acids	9,07±0,208	8,52±0,216
Essential+Cystine and tyrosine**	9,88±0,211	9,22±0,235
Ratio nonessential: essential*	1,36 : 1	1,35 : 1
Ratio essential:nonessential**	1,25 : 1	1,25 : 1
Protein: essential	2,45 : 1	2,44 : 1

Note:*Amount of essential amino acids is without tryptophan; cosine and tyrosine can be essential at determined conditions*

Table 6 present the analysis of the amino acids found in quail meat revealed that it was very rich in these essential amino acids. The data also showed that the limiting amino acids for males were methionine and lysine. In general, the content of essential amino acids in breast meat was by 6.5% higher than in leg meat with significant differences for isoleucine ($P<0.05$) and valine concentrations ($P<0.01$). The sum of essential amino acids + cysteine and tyrosine was significantly different ($P<0.05$) between breast and leg quail meat.

Table 7. Fatty acids content of meat from 35 days old Japanese quails, % from total lipids

Fatty acids	***Breast/***	***Legs***
14:0	0.95±0.04	1.17±0.06
16:0	24.39±0.71	24.54±0.48
16:1	5.32±0.48	6.05±0.54
18:0	8.79±0.47	8.01±0.52
18:1	35.38±1.43	35.52±1.15
18:2 (Ω-6)	19.70±0.58	20.21±0.71
18:3 (Ω-3)	1.75±0.22	1.47±0.10

20:4 (Ω-6)	2.69±0.31	1.94±0.15
22:4 (Ω-6)	0.84±0.08	0.87±0.07
∑ Saturated fatty acids (SFA)	34.13±0.90	33.72±0.80
∑ Unsaturated fatty acids (UFA)	65.68±0.89	66.04±0.79
∑ Monounsaturated fatty acids (MUFA)	40.70±1.27	41.57±0.92
∑ Polyunsaturated fatty acids (PUFA)	24.98±0.53	24.48±0.72
Ratio: SFA/UFA	0.52:1	0.51:1
Ratio: PUFA/SFA	0.73:1	0.73:1
Ratio Ω-6 : Ω-3	15.30:1	16.65:1
Ratio C18:2 (Ω-6) : C18:3 (Ω-3)	11.26:1	13.75:1

Data on the fatty acid composition of quail meat is presented in Table 7. It shows that the fatty acids linoleic, palmitic, stearic, and oleic are responsible for almost all of the total lipid content of the meat. It was also revealed that the proportion of oleic acid in quail meat was higher than that of palmitic acid. Leg meat also contained more of this fat content than breast meat.

The proportion of linoleic acid in total lipids was higher in quail meat than in breast. The sum of PUFA was higher in both legs and breast. The content of α-linolenic acid (C18:3) was 1.75% in breast meat and 1.47% in leg meat. The ratio of Ω-6/Ω-3 PUFA was rather high– 15.3:1 in breast meat and 16.65:1 in leg meat. The ratio of linoleic (C18:2) and αlinolenic (C18:3) fatty acids was lower: 11.26:1 and 13.75:1 for breast and leg meats, respectively.

Discussion

Japanese quails are not high-slaughter species. The results of the study are similar to those of Panda & Singh (1990), which found that 60% of females and 62% of males are killed at the age of 35 days. The researchers noted that the relative share of meat for breast and legs was higher than that of other investigators. Riegel et al. (2003) reported that the higher the slaughter age, the lower the breast meat content.

The pH values of different muscles were compared to those of different topographic regions. It was concluded that the differences in these values were due to the morphological structure of the muscles. Unlike turkey and chicken, Japanese quails have dark muscle fibers that are made up of oxidative type. This type of muscle is known to contribute to the higher pH values of their meat. This is one of the main reasons for higher pH values of quail meat compared to data for broiler chickens (Drbohlav and Drbohlavova, 1987).

The enzymes of the glycolytic type are known to cause rapid depletion of glycogen stores. This impairs the ability of the muscle to resynthesis ATP. These animals also have a large reserve of creatine phosphate, which helps in the resynthesis of ATP. As a result, their muscles tend to develop a slower pace of glycolysis. Calculations performed by Drbohlav and Drbohlavova (1987) supported the notion that the pectoral muscle of broiler chickens can produce a higher level of glycolysis than that of the supracoracoideus muscle. The nutrients of meat are determined by its protein and fat content. The differences in the fat content of Japanese quails have been observed.

Due to the nature of the bird's lipids, the skin could be at risk of being destroyed during long storage. The high concentration of phospholipids that can be prone to oxidation, the membranes

of these animals are also vulnerable to this process. The pro-oxidative processes initiated by the first hours after the slaughter of Japanese quails allow us to assume that this process is more advantageous than traditional processing methods. Although not traditional in the poultry industry, pro-oxidative processing can provide advantages in terms of grill quality and meat storage. The advantages of this process are stated as reasons why consumers would prefer carcasses without skin.

Compared to other fowl meats, Japanese quails are very good sources of protein. The ratio of essential amino acids to nonessential amino acids is 1.351:1, which shows that the meat has a high biological value. The daily consumption of 2 quails is equal to the intake of 125-130 g pure meat on the average that provide a total of 2728 g protein, including 11 g essential amino acids, that is equivalent to 40% of human protein needs (Nedkov, 2004).

Following the recommendations of Hristov (2020), which limits the animal protein content of meat to 50% of daily human needs, it has been concluded that the meat of Japanese quails satisfies the requirements of animal protein. A detailed analysis of the amino acids found in the meat revealed that the total amount of essential amino acids is 43.6%. The consumption of two quails satisfies the minimal daily needs of humans for the following amino acids: lysine, leucine, phenylalanine, and valine.

By comparing the fatty acid profiles of different meat species, it was revealed that the main component of the meat is composed of four fatty acids. The data indicate that the sum of these acids provides about 81% of the total lipids in chicken meat. The same four fatty acids contribute to the total fat content of pork meat. The total fat content of different types of meat has been estimated. In contrast, the fat content of pork is reported to be about 38%.

Compared to other bird species, quail meat has higher concentrations of oleic acid. This finding shows that the fat content of the meat is richer in oleic acid than chicken meat. The concentration of this chemical is also higher in quail meat than in duck meat. Higher concentrations of oleic acid (C18:1) in quail meat are reported by Panda and Singh (1990), the result being close to oleic acid content of pork found by Doychev – 41.6-51.2% (Doichev, Yanakieva and Bachvarova, 2003).

According to the published data, the content of Ω-3 -linolenic fatty acid in the meat of different bird species is relatively high. The data also show that the linolenic acid content in different duck populations varies.he αlinolenic acid content in the meat of the different duck populations varies in a wider range – 0.8-1.62% (Wolaszyn, Ksiazkiewicz, Orkusz, Skrabka-Blotnicka, Biernat, and Kisiel, 2003). The scientific literature has focused on the importance of the various nutrients found in food and the lipid nutrition of humans. The literature also focuses on polyunsaturated fatty acids (PUFA) of the Ω-3 and Ω-6 classes. According to Doncheva, the ration of Bulgarians is mainly composed of foods rich in Ω-6 fatty acids (Doncheva, 2020) and in the view of the author, this is the main reason for the increased percentage of plasmaphospholipids of Ω-6 fatty acids and the higher Ω-6/Ω-3 PUFA ratio in the blood of Bulgarian people, estimated by now to be 7.79 vs the recommended levels of 1.5-2.3. The ratio of Ω-6/Ω-3 PUFA in meat is one of the principal criteria for evaluation of dietetic properties of food. It should however be stated that in the meat of Japanese quails this ratio is not very favourable– 15.3:1 in breast meat and 16.65:1 in leg meat. The study conducted by Rondia et al. revealed that when the amount of -linolenic acid in the diet is high, the birds can deposit more of this chemical. The investigators noted that the addition of flaxseed to the diet can increase the amount of -linoleic acid in the birds' bodies.

Conclusions

The slaughter yield of Japanese quails ranged from 64-65%. The relative proportion of breastmeat and leg meat was 33.10x0.47% and 20.60x0.18%. The meat pH level was between 6.1 and 6.3 on the 24th hour. The water retention capacity of the meat was better in female quails than in male ones. The total protein content of Breast meat contained 22.23-23.38%, whereas leg meat – 20.49-20.91%. The fat content in breast meat was 2.212.75% vs 3.26-3.39% in leg meat. The meat of Japanese quails was found to be very rich in essential amino acids. Their sum was 8.52% in leg muscles and 9.07% in breast meat, i.e. about 41% of meat proteins. The content of essential amino acids in breast meat was by 6.5% higher than that of leg meat. The limiting amino acids for men (lysine and methionine) comprised 12.36% and 12.71% of breast and leg meat protein, respectively. The composition of the fat profile of quail meat is mainly influenced by the four fatty acids: stearic, palmitic, oleic, and linoleic. The total lipids of the meat accounts for almost 90% of the total body fat.

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