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Quality and composition of meat in different productive types of domestic quail

Качество и състав на месо при различни продуктивни типове домашни пъдпъдъци

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ABSTRACT

The aim of the current work was to present the main quality characteristics and composition of the meat of the most valuable parts of the carcass - breasts and legs of 35-day-old domestic quails from meat, dual-purpose and egg-laying type. The obtained results give basis to assume that the glycogen reserve of the pectoral muscle can be associated with the productive type, which was the highest in quails of the meat type line WG (ΔpH=-0.573±0.053 compared to ΔpH=-0.299±0.059 in egg-laying line A, $P<0.001$). In the process of storing quail meat during the first 24 hours the values of the three color coordinates increased by an average of 12.5% for lightness, 16.4% for redness and 42% for yellowing of the meat. The pigment saturation of *M. pectoralis superficialis* largely depends on the productive type of birds, which determined 15.9% of the variance of the trait ($P<0.05$). It was the highest in quail eggs, and the stability of their color characteristics during the first 24 hours was the highest, which makes the visual perception of color in them closer to game meat. Higher crude protein content ($P<0.001$), lower fat ($P<0.001$) and gross energy ($P<0.05$) in *M. pectoralis superficialis* in meat type birds, compared to egg-laying quails, makes their breast meat more dietary and more in line with consumer preferences. The content of essential amino acids in quail meat fully meets the needs of the human body, and the content of saturated and unsaturated fatty acids covers approximately 2/3 of the needs.

Keywords: meat quality, Japanese quail, meat composition, productive type

РЕЗЮМЕ

Целта на настоящата работа е да представи основните качествени характеристики и състава на месото от най-ценните части на трупа - гърдите и краката на 35-дневни домашни пъдпъдъци от месодаен, комбиниран и яйценосен тип. Получените резултати дават основание да се приеме, че гликогенният запас на гръдния мускул може да се обвърже с продуктивния тип, който е най-висок при пъдпъдъците от месодайната линия WG (ΔpH=-0,573±0,053 срещу ΔpH=-0,299±0,059 при яйценосната линия А, с доказана разлика $P<0,001$). В процеса на съхранение на пъдпъдъчето месо през първите 24h стойностите при трите цветови координати се повишават средно с 12,5% за светлостта, 16,4% за червенината и с 42% за жълтеенето на месото. Пигментното насищане на *M. pectoralis superficialis* в най-висока степен зависи от продуктивния тип на птиците, който определя 15,9% от дисперсията на признака (P<0,05). Пигментната наситеност на гръдния мускул е най-висока при пъдпъдъците от яйценосен тип, а стабилността на цветовите им характеристики през първите 24h е най-устойчива, което прави зрителното възприемане на цвета при тях по-близко до дивечовите меса. По-високото съдържание на суров протеин (P<0,001), по-ниското на мазнини (P<0,001) и бруто енергия (P<0,05) в *M. pectoralis superficialis* при птиците от месодаен тип, в сравнение с тези от яйценосен, прави гръдното им месо по-диетично и в по-голяма степен отговарящо на потребителските предпочитания. Съдържанието на незаменими аминокиселини в месото от домашни пъдпъдъци напълно покрива потребностите на човешкия организъм, а съдържанието на наситени и ненаситени мастни киселини покрива приблизително 2/3 от потребностите.

Ключови думи: японски пъдпъдъци, продуктивен тип, качество на месо, състав на месо

INTRODUCTION

Over the last half century, poultry production has grown by more than 770% and egg production by approximately 445%, making it the fastest growing livestock industry. For many countries in the world, it represents a promising opportunity for food satisfaction of the population with high quality and biologically complete animal products. The choice of poultry farming is a result of the advantages it has over other branches of animal husbandry, such as lower capital costs, short generation interval, high productivity. Comparing poultry with other major industries - pigs and cattle, it has a significantly lower production of greenhouse gases (Dunkley and Dunkley, 2013). The fact that, in terms of its economic efficiency, poultry farming makes it possible to produce a sufficient amount of valuable animal protein to feed population at affordable price, has not to be overlooked.

One of the most promising poultry species, which is becoming more widespread in world production practice, is the domestic quail (Lukanov, 2019, Lukanov and Pavlova, 2020). For most countries in the world, domestic quails are raised mainly for egg production, and meat production is rather a concomitant productivity (Golubov and Krasnoyartsev, 2012). In these countries light, egg-laying quails, characterized by high egg productivity but low live weight and low egg mass are dominated (Afanasiev et al., 2015). However, for the United States and many European countries, the production of quail meat is more widespread and often a major productivity (Genchev, 2014). Thus, for the needs of egg production in these countries, heavier productive types of domestic quails are used, characterized by lower egg-laying capacity, but having a higher egg mass, better fattening abilities and meat-producing qualities (Genchev, 2012).

To date, poultry meat is one of the most sought after and consumed products of the meat industry. Compared to meat from other farm animals, it is easily digestible, and the high protein and low fat content make it a desirable dietary product used by all age and social groups (Qi et al., 2018, Gartovannaya and Ivanova, 2019). Nutritional value of the meat is determined by its chemical composition, and its quality and physicochemical properties depend on the morphological structure of muscle tissue and its ratio to connective and adipose tissue. Quail meat ranks among the lowest calorie poultry meat, along with turkey and chicken (Marangoni et al., 2015; Morar and Vaiskrobova, 2016; FoodData Central, 2019).

One of the criteria for the biological value of meat is the protein content, which in domestic quails is 21.9-23% in the breast and 18.9-20.1% in the leg (Abaeva and Demurova, 2017). The most important indicator for the evaluation of meat is the content of essential amino acids (EAA). The meat of domestic quails is rich in them, which makes it indispensable for the dietetic and especially for children's nutrition. Historically, significant progress has been made on the human body's need for essential amino acids. For the first time, a scientifically well-founded proposal in this direction was made in the report of the commission to FAO/WHO in 1973 (FAO/WHO, 1973). The same report proposes a methodology for estimating the biological value of essential amino acids by calculating the amino acid score. These needs are defined by the general term "ideal protein", which is a theoretical protein with a perfectly balanced amino acid composition, fully consistent with the physiological needs of a healthy organism. The ideal protein is composed of the amino acids lysine, methionine+cystine, isoleucine, leucine, threonine, valine and phenylalanine+tyrosine, and later histidine is added to them (FAO/WHO/UNU, 1985).

The aim of the current study is to present the main quality characteristics and composition of the meat of the most valuable parts of the carcass - the breasts and legs of 35-day-old domestic quails, belonging to three different productive types - meat, dual-purpose and egg-laying.

MATERIAL AND METHODS

Three lines of Japanese quails belonging to three different production areas: line WG - specialized meat type, line GG - heavy dual-purpose type and line A - European (light dual-purpose type) egg-laying type, created in the experimental base of Poultry unit at the Faculty of Agriculture, Trakia University - Stara Zagora, Bulgaria, were included in the study. The quails were reared in cages, observing the recommended zoohygiene parameters for the given species and age category. Feeding was three-phase with a complete compound feed (starter, grower and finisher) specially designed for quails fattening. Quail carcasses obtained under productive conditions at 35 days of age were used - a total of 54 birds, respectively 18 birds (9 male and 9 female quails) of each productive type, having close to the average for the productive type live weight. The slaughtering was made in strict compliance to requirements for protection and welfare of experimental animals (Official Gazzete, 2012). The slaughter analysis was done by using the detailed slaughter analysis protocol in experiments using Japanese quails (*Coturnix japonica*) of Genchev and Mihaylov (2008).

Meat quality analysis

Temperature and pH values of *M. pectoralis superficialis* (MPS) were determined immediately after exsanguination of the carcass and at 24 hours *post mortem* using a pre-calibrated portable pH meter Milwaukee MW 102 (Milwaukee Instruments, Inc.). The results were obtained by penetrating the electrode of the pH meter to a depth of 1 cm in the front third of the muscle.

Measurement of the color characteristics of MPS were performed on its outer (subcutaneous) surface, after exsanguination of the carcass and at 24 hours *post mortem* using a spectrophotometer PCE-CSM 2 (PCE Instruments). The coordinate values in the CIEL*a*b* system were determined in illuminant D-65. Based on the results obtained for the coordinates L*, a* and b*, the color saturation (C*), the hue (Hue angle), the color difference (ΔE*) and the meat color index (MCI) were calculated according to the formulas:

Color saturation $C^* = \mathrm{sqrt}(a^{*2}+b^{*2})$ (1);

Color difference $\Delta E^* = \mathrm{sqrt}(\Delta L^{*2}+\Delta a^{*2}+\Delta b^{*2})$ (2);

Hue (Hue angle°) $h^\circ = (\tan^{-1}(b^*/a^*)*180^\circ)/\pi$ (3)

(Petracci and Baeza, 2009);

Meat color index $MCI = L^*-C^*$ (4) (Lukanov et al., 2018), where lower values mean darker meat color.

Chemical analysis

The chemical composition of the meat from breasts and legs was determined in the Department of Accredited laboratory complex for chemical and instrumental analysis, Agricultural University, Plovdiv, Bulgaria. The contents of water, protein, fat and minerals in the meat was measured (AOAC, 2007). The energy value was determined directly on a microprocessor calorimeter KL 11 Mikado according to the method described by Atanasov et al. (2010). The total energy of the samples was recalculated on the basis of 1 kg of sample (native substance).

The content of amino acids (AA), fatty acids and mineral elements was determined in the Research Laboratory at the Faculty of Agriculture of the Trakia University, Stara Zagora, Bulgaria. The determination of AA was done by acid hydrolysis of the sample with 6N HCl solution at 110 °C for 24 h, and their separation was performed on Amino acid Analyzer T339M (Mikrotechna – Praha).

The lipid and fatty acid composition of meat was determined by lipid extraction according to the method of Bligh and Dyer (1959) with a mixture of methanol:chloroform (2:1), followed by thin layer chromatography and separation of fatty acids by gas chromatography Clarus 500 (PerkinElmer), equipped with flame ionization detector Thermo Scientific™, 60 m, ID 0.25 mm, 0.25 µm film, and H_2 as a carrier gas.

The total cholesterol content was assayed colorimetrically by the Schoenheimer-Sperry method, modified by Sperry and Webb (1950).

The mineral elements were determined after dry incineration of the sample at 550 °C and preparation of hydrochloric acid solution. The content of K^+ and Na^+ was determined on a flame photometer "Flamon B", P - spectrophotometrically by molybdate-vanadate method, and the other elements - by atomic absorption spectrophotometer (PerkinElmer).

Based on the content of AA in the meat of the breasts and legs, the amino acid score (AAS) was determined by the formula:

Amino acid score = (mg of a given EAA in 1 g of protein/ mg of the same EAA in 1 g of reference protein) ×100 (5).

The content of essential amino acids (EAA) in the "ideal protein" was used as a reference protein in the calculation of AAS (FAO/WHO/UNU, 2007) and in quail egg protein determined after averaging the EAA content of eggs published in the scientific literature (Genchev, 2012; Aletor and Famakin, 2017; Dimkov et al., 2019; Shcherbatov and Bachinina, 2021).

Determination of essential amino acid index (EAAI). To calculate the index in advance for each EAA, an Amino acid score was determined (FAO/WHO, 1973), which is the ratio of the content of the given EAA in the test product (mg/1 g protein) to its content in the reference protein:

$$EAAI = \mathrm{sqrt}^{n}\sum[(Lysine_i/Lysine_e)+(Methionine+Cystine_i/Methionine+Cystine_e)+(\ldots)+(\ldots.)+(Histidine_i/Histidine_e)] \quad (6),$$

where:

$Lysine_i$ is the content of lysine in the test product, $lysine_e$ is its content in the reference protein, and n is the number of NAAs on which the chemical number is determined. In order to determine what part of EAA can be used by the body for plastic purposes, the coefficient of excess AAS (CEAAS, %) and the biological index of the protein (BIP, %) were calculated.

Coefficient of utility and rationality of the amino acid composition (CURAAC) calculation. For this purpose in the meat of the two topographic areas (breasts and legs) was determined EAA with the lowest score (AASmin). The comparison of the score of each of the EAAs, having a higher value than AASmin gives information about the excess score of the respective EAA, which cannot be used by the body for plastic purposes:

$$CURAAC=\sum[(AAS_{Lysine}/AAS_{min})+(AAS_{Valine}/AAS_{min})+(\ldots)+(\ldots)+(AAS_{Histidine}/AAS_{min})]/n \quad (7).$$

Protein biological value (PBV) calculation. The index shows how much of the EAA in meat can be used by the body for plastic purposes (Lisitsyn et al., 2016):

$$PBV=100 - CURAAC \quad (8).$$

Statistical analysis

Statistical analysis of the obtained results was performed with the statistical software IBM® SPSS® Statistics (V26) using the generalized linear model (Univariate GLM) procedure. The statistical comparison was made by the least significant difference (LSD) test at the 95% probability level. All data are reported as mean ± standard error of the mean (x±SEM). Statistical significance was established at $P<0.05$. Dispersion analysis and calculations for elucidation of the strength of the influence of individual factors on the determination of the studied traits were made.

All figures used in the text were made using Microsoft 365 Excel software.

RESULTS AND DISCUSSION

At the time of death, body temperature of domestic quails was in the range of 40.3-40.8 °C (Table 1). At this point, the processes of glycolysis start in the muscles, and the pH values were in the range between 6.55 and 6.25 (6.39±0.03 on average). After glycolysis completion in MPS, pH values decreased between 4.8 and 8.8%. On 24-th h *post mortem* pH (pH_u) values reached 5.96±0.017 at a muscle temperature of 8.8÷10.8 °C, and no dependence was observed on the productive type of the studied birds. However, the analysis of the percentage decrease in pH values gives grounds to assume that the glycogenic stock of MPS can be linked to the productive type, which is highest in quails of the WG line and lowest in line A. The values of ΔpH, which at line WG are -0.573 ± 0.053, and at line A – 0.299±0.059 ($P<0.001$) are evidence of this. The pH values reported by us are in the range of the values published in the literature for the pectoral muscle from Mirshekar et al. (2021) (5.69-5.93) and Mazizi et al. (2020) (5.19 for female and 6.27 for male quails).

During the first 24 hours *post mortem* there were significant changes in muscle tissue that alter physicochemical and color characteristics of the pectoral muscle. Meat color is important for its quality because it is the basis of consumer perception of its appearance. With the progress of the processes leading to meat maturation, the values increased at all three color coordinates - 12.5% for lightness, 16.4% for redness, and the changes in yellowness of the meat - 42%, were the most significant (Figure 1).

The lightness of the meat (L*) mainly depends on the amount of white light absorbed and reflected, but its refraction and scattering have an effect too (Murashev et al., 2010). The results obtained by us show a tendency for the effect of productive type of quails in relation to the values of L*. The values in both studies are the highest in meat-producing type of birds. These results are expected, because the muscle fibers of MPS are formed during the embryonic period, after which in postnatal period their number remains unchanged (Velleman et

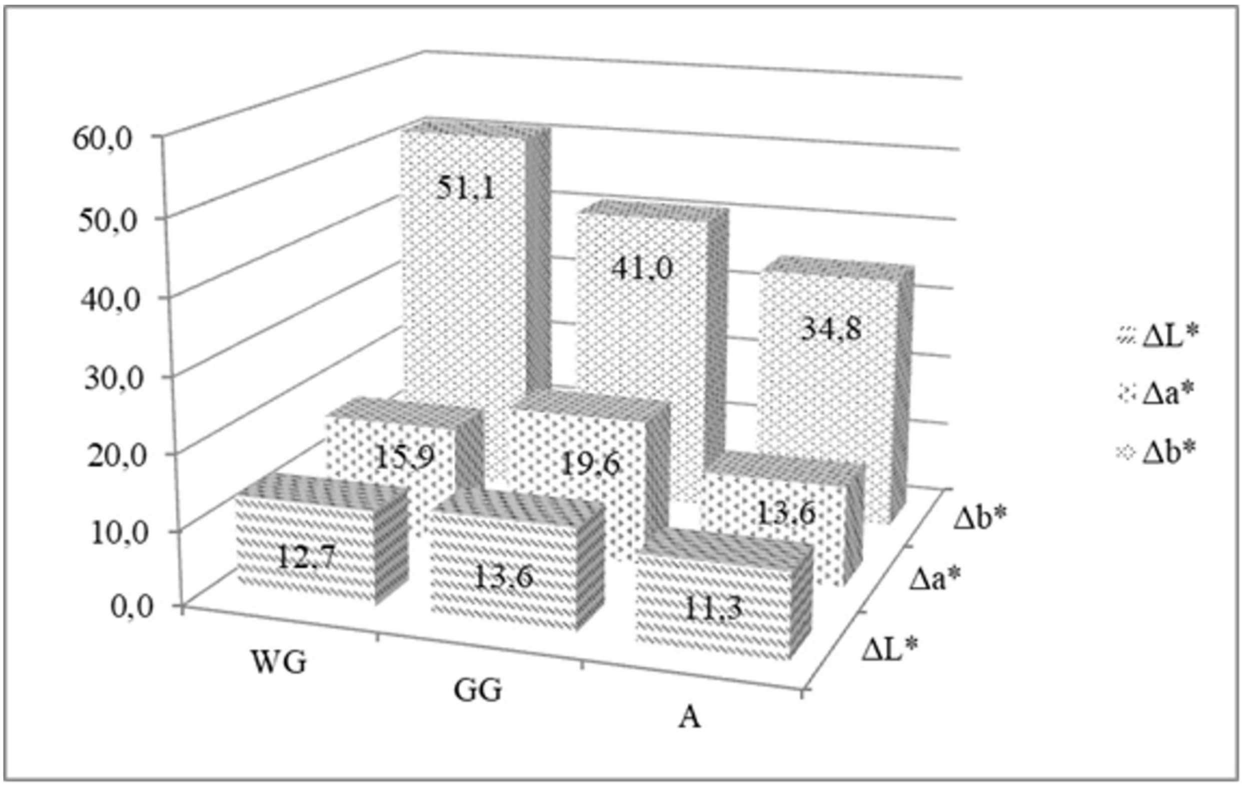

Figure 1. Increase in the values of L*, a* and b* during the first 24h *post mortem*

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Table 1. Physicochemical and color characteristics of *M. pectoralis superficialis* in domestic quails of different productive type

Parameter	Group/Gender											
	post mortem						24 h *post mortem*					
	WG		GG		A		WG		GG		A	
	M	F	M	F	M	F	M	F	M	F	M	F
T °C	40.26 ÷ 40.83						8.81 ÷ 10.83					
pH	6.6±0.06	6.5±0.05	6.4±0.06	6.4±0.09	6.3±0.09	6.3±0.07	6.0±0.05	5.9±0.05	5.9±0.03	6.0±0.03	6.0±0.03	6.0±0.05
	6.50±0.04^{af}		6.37±0.05^{b}		6.29±0.06^{g}		5.93±0.03		5.95±0.02		5.99±0.03	
L*	45.2±0.8	42.8±0.6	42.3±0.5	42.3±1.0	43.4±0.9	42.8±1.1	49.1±0.9	50.1±0.6	48.0±0.9	48.0±0.9	47.9±1.0	48.1±1.1
	44.00±0.56^{a}		42.28±0.54^{b}		43.10±0.69		49.56±0.54		48.02±0.61		47.98±0.77	
a*	7.0±0.4	7.6±0.5	8.4±0.4	5.4±0.3	8.9±0.4	8.9±0.5	8.3±0.5	8.6±0.3	10.3±0.6	9.9±0.6	9.8±0.4	10.4±0.6
	7.30±0.32^{ac}		8.42±0.36^{b}		8.90±0.32^{d}		8.46±0.29^{cf}		10.08±0.41^{g}		10.11±0.37^{d}	
b*	4.9±0.7	5.4±0.3	8.4±0.6	6.2±0.4	6.2±0.3	5.9±0.3	8.0±0.6	7.5±0.3	8.2±0.4	8.2±0.3	7.7±0.2	8.6±0.5
	5.15±0.38^{a}		5.79±0.27		6.07±0.20^{b}		7.78±0.32^{a}		8.17±0.25^{b}		8.18±0.29^{b}	
C*	8.7±0.6	9.3±0.5	10.0±0.4	10.5±0.7	10.9±0.3	10.8±0.3	11.6±0.7	11.5±0.3	13.1±0.6	12.9±0.6	12.6±0.3	13.6±0.6
	9.00±0.41^{ac}		10.24±0.42^{b}		10.83±0.23^{d}		11.52±0.39^{af}		13.01±0.42^{b}		13.06±0.36^{g}	
hue°	33.5±3.8	35.7±1.0	32.8±0.8	36.4±1.5	35.4±2.2	33.8±2.3	43.8±1.2	41.3±1.4	38.7±1.4	39.8±1.4	38.3±1.4	39.8±2.3
	34.57±1.97		34.45±0.97		34.60±1.59		42.54±0.95^{a}		39.25±1.02^{b}		39.08±1.37^{b}	
MCI	36.5±1.2	33.5±1.0	32.3±0.9	31.8±1.6	32.5±1.2	32.0±1.3	37.5±1.1	38.6±0.7	34.9±1.3	35.1±1.0	35.3±1.2	34.5±1.4
	35.00±0.86^{a}		32.03±0.91^{b}		32.26±0.89^{b}		38.04±0.66^{f}		35.02±0.84^{g}		34.91±0.91^{g}	
ΔE*							5.9±1.1	7.8±0.6	7.1±0.6	6.6±1.1	5.1±0.7	6.4±0.6
							6.84±0.68		6.88±0.63		5.74±0.49	

The differences between the mean values for males (M) + females (F), marked with different letters, were statistically proven as follows: a-b – $P<0.05$; f-g – $P<0.01$ и c-d-e – $P<0.001$

al., 2002). Thus, the increase in breast muscle does not depend on the number but on the length and thickness of muscle fibers, the size of which increases as a result of selection (Guernec et al., 2003), without affecting their metabolic profile (Le Bihan-Duval, 2004). Thicker muscle fibers have more sarcoplasm, which implies higher muscle brightness. In addition, after *rigor mortis* phase, when the hydrophilic properties of muscle tissue weaken, some of the free water passes from the sarcoplasm into the intercellular space, thus creating conditions for stronger light scattering, which increases the lightness of the meat (Wojtysiak and Poltowicz, 2006). Lighter productive type quails have thinner muscle fibers and lower values of L* respectively (Nasr et al., 2017).

Of the greatest importance for the appearance, and hence for the attractiveness of the meat, is its pigmentation, especially in the red-green spectrum (a*). Redness of the meat largely depends on the content of myoglobin in the muscle fiber, the dark muscle fibers of which are significantly richer than the light ones. Studies show that MPS in Japanese quail is made up of 96% of dark and 4% of light muscle fibers (Genchev et al., 2010).

According to Ribarski et al. (1995) with increasing quail age, part of the dark muscle fibers is transformed into light. Probably the intensity of selection may also support this transformation, as a result of which we observed an inverse relationship between the body weight of birds (productive type) and the values of a* (P<0.05). Depending on the form in which the myoglobin is at the time of the study (oxygenated, reduced or oxidized), as well as depending on the relationship between the different forms, the visual perception of color may be different. It was found that the color of the meat is best manifested 24 hours after death (Petracci and Fletcher, 2002). This is one of the main reasons why the values of a* published in the world scientific literature can differ significantly - from 2.95 (Mazizi et al., 2020) to 11.8 (Nasr et al., 2017). In our study, when meat is stored for the first 24 hours, its values increase (Δa*=1.34±0.19) from 8.21±0.21 to 9.55±0.23 (P<0.001).

The pigmentation in the yellow spectrum depends on several factors, one of which is the content of intramuscular fat. According to Genchev et al. (2010), their content in MPS in domestic quails is very low (0.3-0.6%) and could hardly have a significant effect on muscle pigmentation. However, some pigments in blood plasma and meat, such as carotenoids, xanthophylls and flavoproteins, may increase or decrease the color in the yellow-blue spectrum. For example, in carotenoids, depending on the sequence of the double bonds, pigmentation can be yellow, orange or red with different shades. When flavoproteins are oxidized, they are yellow, and when they are in repaired form, they are colorless. In this way, a mix of oxidized decomposition products is created, which has a different color (Murashev et al., 2010). This pigment mix has the potential to affect the values of b*, which in our study is the most increased compared to other coordinates (Δb*=2.37±0.23), from 5.67±0.17 to 8.04±0.16 (P<0.001). Yellowing of MPS in meat-producing birds has the lowest values (P<0.05), similar to the redness.

Pigment saturation in the two coordinates a* and b* reflects on the collective feature - color saturation (C*), which has the highest values in birds of egg-laying type and the lowest in meat-producing type (P<0.05). The values of color saturation obtained by us correspond to those published by Mazizi et al. (2020) (12.35-13.21). Dispersion analysis showed that the factors productive type and gender of birds are the basis of the manifestation of the trait color saturation (C*). These two factors determine 16.3% of the total factor variance, and the importance of the gender factor is low. However, the strength of the effect of productive type factor is much greater and it determines 15.9% of the variance of the trait (P<0.05).

The study of the point of intersection of the values of a* and b* in the coordinate system provides information about the hue of the color. The location of these points is in the central area of the quadrant, where there is a mixture of red and yellow pigments. The angle (hue°) that these intersections make with the abscissa (coordinate a* respectively) showed that in all three productive types it varies within 30.5÷51.4°. The average hue° values in the present study show that red pigments have a stronger effect on the visual expression of color than yellow ones. Analyzing the effect of the productive type, we found that the hue° angle in meat-producing quails has higher values (*P*<0.05), which shows that for the visual perception of the color of the breast meat in them the effect of the pigments from the red spectrum is weaker, compared to the other two productive types. The final touch in the analysis presented so far is provided by the results for the meat color index (MCI). As a result of the higher brightness and lower pigment saturation of the color, the breast meat of meat type birds is lighter than the other two productive types (*P*<0.01) (Table 1). The lower MCI values, especially in egg-laying birds, bring their breast meat closer to game-type meat. The study of the influence of various factors on the manifestation of MCI showed that it depends on 17.2% of the productive type and gender of quails, with the leading role of the productive type - 16.2% of the variance of the trait (*P*<0.05).

The study of color stability of MPS during the storage period of meat for the first 24 hours showed that color characteristics were the most stable in quails of the egg-laying type, where ΔE* had the lowest values. Although statistically unproven, the difference compared to the two heavier productive types is over 16% (*P*>0.05).

The study of meat composition in domestic quails showed that the dry matter in breast meat varies between 26.4 and 29.8% (Table 2). Analysis of the effect of sex showed that the dry matter in MPS in males is higher than in females (*P*<0.01). Another thing that is observed is the tendency for the effect of quail productive type on the dry matter in the breast meat. The table shows that the dry matter in MPS in meat-producing birds is lower (*P*<0.05), which confirms the comment made above that in the course of selection the increase of breast musculature in birds is achieved by thickening and lengthening of muscle fibers. As a result, the proportion of sarcoplasm increases, and this reflects not only on the lightness (L*) of the meat, but also on the water content in it. Dry matter in leg meat varies between 23.0 and 24.9%, with no proven dependence on the gender or quail productive type.

The content of protein is the most important from a dietary point of view. Its values in the breast meat in male birds are higher compared to females (*P*<0.05), which is confirmed by studies of other authors (Abaeva and Demurova, 2017). The dependence of the leg meat is exactly the opposite, but a proven difference was registered only in meat-type quails (*P*<0.001). The content of crude protein in breast and leg meat of egg-laying birds is lower compared to the two heavier lines, and the difference in breast meat has been proven (*P*<0.001). This is a logical consequence of the higher content of intramuscular fat in the meat of the two anatomical areas in the light population, with a tendency to the effect of productive type, with clearer differences in the meat of the legs (*P*<0.05). The obtained results show that the content of fat in the meat of the two studied areas (breast and legs) is significantly lower than indicated by some authors as a limit for consumer preferences, which are within 9% (Arkhipov, 2010). All this has had an impact on the content of energy in meat, which complexly concentrates in itself all its nutritional composition. Our results show that the caloric content of breast meat is between 6.64 and 7.09 MJ/kg (1586-1693 kcal). The results show a clear tendency for dependence between energy content of the breast meat and both sex (*P*<0.001) and productive type of birds. Leg meat is lower in calories than breast meat – 6.02-6.16 MJ/kg (1438-1493 kcal), as the difference between the two anatomical areas is within 9.3-13.1%. There is no clear dependence on the effect of the gender and the productive type of the birds on the meat of the legs.

A more detailed analysis of the chemical composition of the breast and leg meat, including a study of the amino acid content, confirms the overall picture outlined so far (Table 3). The content of EAA in breast meat was between 480.2 and 486.1 mg/1 g SP, with a statistically significant difference between the heavy type and the other two productive types (*P*<0.01). In the meat of the legs, the content of EAA is the lowest in line GG (heavy dual-purpose type), and the difference compared to the other two lines (meat and egg) is proven (*P*<0.001). Our results for breast meat are about 23% higher than those published by Khalifa et al. (2016) for EAA content in 6-week-old quails. The relative share of EAA in the total content of amino acids is extremely high and is between 49.2 and 50.1% for breast meat and 47.8-50.2% for legs, respectively. The results obtained in the present study exceed the values reported by Genchev et al. (2008) for the proportion of EAA of about 41% of the protein of domestic quail meat.

Table 2. Chemical composition and calorific value of meat of domestic quails of different productive types at 35 days of age

Parameter	Group/Sex					
	WG		GG		A	
	Male	Female	Male	Female	Male	Female
			Breast meat			
Dry matter, %	27.65±0.12***	26.42±0.31	29.77±0.59***	26,83±0,14	29.62±0.37***	27.97±0.22
	27.03±0.22[c]		28.30±0.76		28.80±0.44[d]	
Protein, %	22.20±0.19***	20.29±0.11	22.28±0.44***	21,01±0,14	20.40±0.26*	19.75±0.16
	21.24±0.26[c]		21.65±0.36[c]		20.08±0.20[d]	
Fat, %	2.72±0.15	3.53±0.36*	4.80±0.10***	3.29±0,02	6.53±0.08***	5.58±0.04
	3.12±0.21[ac]		4.05±0.37[bc]		6.06±0.24[d]	
Ash, %	2.33±0.03***	2.20±0.01	2.29±0.05**	2,13±0,01	2.29±0.03***	2.24±0.02
	2.27±0.02		2.21±0.04		2.26±0.02	
Energy, MJ/kg	6.80±0.03***	6.49±0.05	7.54±0.15***	6,31±0,04	7.25±0.09**	6.94±0.05
	6.64±0.05[c]		6.93±0.31		7.09±0.09[d]	
			Leg meat			
Dry matter, %	23.02±0.31	23.72±0.25	24.86±0.65	24,00±0,40	24.69±0.69	24.94±0.49
	23.37±0.21[ac]		24.43±0.37[b]		24.79±0.35[d]	
Protein, %	17.77±0.23	18.9±0.23***	18.28±0.49	18,75±0,32	17.98±0.51	17.99±0.36
	18.32±0.20		18.51±0.26		17.99±0.25	
Fat, %	3.67±0.16*	3.19±0.14	4.89±0.13***	3,63±0,06	5.05±0.14	5.26±0.10
	3.43±0.12[ac]		4.26±0.31[bf]		5.15±0.09[dg]	
Ash, %	1.23±0.02	1.32±0.03*	1.34±0.04	1,28±0,02	1.26±0.04	1.34±0.03
	1.27±0.02		1.31±0.02		1.30±0.03	
Energy, MJ/kg	5.91±0.09	6.12±0.09	6.47±0.17*	6,04±0,10	6.02±0.17	6.30±0.13
	6.02±0.06		6.25±0.13		6.16±0.11	

The differences between mean values for males + females, marked with different letters, were statistically proven as follows: a-b – *P*<0.05; f-g – *P*<0.01 и c-d-e – *P*<0.001

Proven differences between the values of the same trait between male and female birds are noted with *: * - *P*<0.05; ** - *P*<0.01 и *** – *P*<0.001

Table 3. Amino acid content (g) in 100 g of meat of domestic quails of different productive types at 35 days of age

Amino acids	Breast meat			Leg meat		
	WG	GG	A	WG	GG	A
			Essential			
Lysine	2.02±0.08[c]	2.05±0.04[c]	1.76±0.02[d]	1.71±0.05[c]	1.73±0.05[c]	1.52±0.02[d]
Methionine	0.52±0.03	0.57±0.03[f]	0.49±0.01[g]	0.49±0.02[f]	0.47±0.01[c]	0.41±0.01[gd]
Isoleucine	1.11±0.05	1.15±0.03[f]	1.06±0.01[g]	0.91±0.02	0.94±0.02	0.93±0.01
Leucine	1.92±0.07[a]	1.99±0.04[c]	1.77±0.02[bd]	1.63±0.04	1.67±0.04[f]	1.55±0.01[g]
Phenylalanine	0.93±0.02[c]	0.95±0.03[c]	0.80±0.01[d]	0.83±0.02[c]	0.83±0.01[c]	0.70±0.02[d]
Threonine	0.84±0.06[a]	0.69±0.02[bc]	0.94±0.02[d]	0.72±0.06[a]	0.57±0.01[bc]	0.85±0.01[bd]
Valin	1.17±0.05	1.23±0.03	1.23±0.02	0.96±0.02[c]	0.97±0.02[c]	1.08±0.01[d]
Cystine	0.20±0.02	0.20±0.01	0.17±0.01	0.18±0.02	0.14±0.01[c]	0.17±0.01[d]
Tyrosine	0.67±0.05	0.57±0.02	0.57±0.02	0.57±0.05[a]	0.45±0.01[bc]	0.52±0.01[d]
Histidine	0.95±0.08	1.01±0.04	0.92±0.01	0.61±0.04[c]	0.69±0.03[c]	0.81±0.01[d]
			Nonessential			
Arginine	1.31±0.05	1.35±0.02[f]	1.24±0.02[g]	1.15±0.03[a]	1.11±0.03	1.06±0.02[b]
Glutamic acid	3.63±0.13[f]	3.80±0.06[c]	3.26±0.03[gd]	3.08±0.09	3.25±0.08[c]	2.92±0.02[d]
Glycine	0.97±0.02	1.01±0.03	0.96±0.01	0.92±0.02[ac]	0.10±0.02[bc]	0.85±0.01[d]
Serine	0.60±0.08[a]	0.39±0.02[bf]	0.49±0.03[g]	0.53±0.09[a]	0.33±0.01[bc]	0.44±0.03[d]
Alanine	1.27±0.04[a]	1.27±0.02[c]	1.16±0.02[bd]	1.09±0.03[a]	1.09±0.02[a]	0.10±0.03[b]
Proline	1.02±0.03[ac]	0.95±0.01[bc]	0.76±0.01[d]	0.89±0.02[c]	0.83±0.02[c]	0.65±0.01[d]
Aspartic acid	1.79±0.12	1.97±0.03[c]	1.80±0.02[d]	1.47±0.08	1.62±0.03	1.58±0.03
∑ Amino acids(AA), g	20.92±0.48[f]	21.14±0.34[c]	19.35±0.18[gd]	17.73±0.29	17.65±0.25	17.02±0.24
∑ Essential AA (EAA), g	10.33±0.26[a]	10.40±0.23[f]	9.69±0.09[bg]	8.61±0.15	8.43±0.13	8.54±0.10
∑ Nonessential AA (NAA), g	10.60±0.23[f]	10.74±0.14[c]	9.66±0.10[gd]	9.12±0.16[f]	9.22±0.13[c]	8.48±0.14[gd]
EAA:NAA	0.975 : 1	0.968 : 1	1.003 : 1	0.944 : 1	0.914 : 1	1.007 : 1
∑ AA, % of Crude Protein (CP)	98.50±0.49[f]	97.65±0.74	96.40±0.59[g]	96.80±0.49[f]	95.35±0.25[g]	94.650±0.449[g]
EAA, mg/1g CP	486.13±1.07[f]	480.20±1.87[g]	482.68±0.92[g]	469.94±2.60[c]	455.39±1.83[d]	474.953±1.317[c]

Note: * The amount of essential amino acids is tryptophan-free. It also includes the amino acids cystine and tyrosine.

The differences between the mean values, marked with different letters, were statistically proven as follows: a-b – $P<0.05$; f-g – $P<0.01$; и c-d-e – $P<0.001$.

One of the reasons for this difference is the fact that histidine was not defined as an essential amino acid in the cited study. Taking into account the lower content of crude protein in the meat of the egg-laying type birds and the relatively close values of EAA content in the breast and leg meat, the percentage of EAA content of their total content is higher in the egg-laying type - line A ($P<0.05$ for breast meat and $P<0.001$ for leg meat).

EAA content in meat gives reliable and accurate information about its nutritional value, but we can get a clear idea of it by comparing their content in breast and leg meat with the EAA values accepted as a standard (Table 4).

It is evident from the table that the content of EAA in domestic quail meat fully covers the needs of the human body from EAA. The EAA chemical score values in breast meat exceeded between 1.4 and 3.2 times the needs declared by FAO/WHO/UNU (2007), and in leg meat between 1.4 and 2.6 times, respectively. Many years before the FAO/WHO first announced the recommended consumption rates of EAA, known in science as the "ideal protein" (FAO/WHO, 1973), the biological value of the protein was compared to that of egg protein. If we take the EAA content of egg protein as a benchmark and make the stipulation that this is the EAA content of quail eggs, things look quite different from the above comparison with the "ideal protein". First, it must be clarified that the EAA content in domestic quail eggs exceeds more than 2 times (for the individual amino acids between 1.46 and 3.18 times) the recommended norms for the "ideal protein". Proceeding from this position, it is clear that in terms of its composition, the meat of domestic quail from both anatomotopographical areas is inferior to egg protein, and only for lysine, isoleucine, leucine and histidine, the content of EAA exceeds that of eggs. When comparing this basis, it is evident that the first limiting AA in relation to egg protein is methionine+cystine (45.1-53.6% of their content in eggs). The second limiting AA in egg protein is phenylalanine + tyrosine, followed by threonine. Taking into account the fact that the inaccuracy in determining the content of AA is within 5% (Molchanova and Suslyanok, 2013), valine in breast meat is at the limit (on average 93.5%). For leg meat, valine is the fourth limiting factor in terms of egg protein EAA. Despite the significant differences between the two approaches to protein estimation, we should not make the wrong conclusion that domestic quail meat is of low biological value, because it fully covers human needs for protein in terms of its EAA content. It should simply be noted that the second etalon baseline significantly exceeds the FAO/WHO/UNU (2007) human needs for EAA (Table 4). When evaluating the biological value of the protein from the two anatomotopographic regions, it can be seen that the EAA index in breast meat is 5.5% higher than the same in leg meat on average, and the average values are 1.87 vs. 1.76 respectively. When comparing the biological value of the protein in terms of the proportion of EAA that can be used by the body for plastic purposes, we found that the most balanced in its composition is the protein of the meat from the egg-laying line A. For the birds of this line, 54% of EAA in breast meat and 62.2% in leg meat can be used by the human body for plastic purposes.

The fatty acid profile of quail meat (Table 5) is mainly formed by four fatty acids – palmitic (C16:0), stearic (C18:0), oleic (C18:1) and linoleic (C18:2). In total, they make up 79.6% of the fat in breast meat and 79.3% in leg meat. Our results for breast meat are 1.4 and 9.3% lower than the published literature values for quail breast meat (Khalifa et al., 2016; Chudak et al., 2020). The share of oleic acid is the highest from the four fatty acids, constituting almost 1/3 of the crude fat (CF) in meat (33% in breast and 32% in leg). Its relative share varies in the publications of the other authors in a rather wide range from 25.9% (Chudak et al., 2020) to 40% (Mirshekar et al., 2021). Overall, the proportion of saturated fatty acids (SFA) in breast meat was about 3% lower than that in leg meat (0.4-9.4% for different productive types), and our average results were similar with those published by other authors (Khalifa et al., 2016; Chudak et al., 2020; Mazizi et al., 2020). From the group of SFA, the share of palmitic acid is the highest (69.5-69.9% of SFA), and no significant differences in its content were observed in the meat from the two anatomotopographic areas. The proportion of unsaturated fatty acids (UFA) in the different productive types in both anatomotopographic areas was about 2 times (from 1.9:1 to 2.19) higher than that of SFA, and the values ranged between 58.7 and 62.7% of CF. Much wider is the ratio published in the literature between UFA and SFA in breast meat, which reaches 2.57:1 (Khalifa et al., 2016) – 2.74:1 (Mazizi et al., 2020). In the UFA group, the ratio of monounsaturated (MUFA) to polyunsaturated fatty acids (PUFA) was 1.76:1 for breast meat and 1.74:1

for leg meat. The ratio of PUFA to UFA was 0.7-0.72:1, with no significant difference observed between breast and leg meat. Examining the results of other researchers we found that this ratio varies quite widely from 0.66-0.77:1 (Genchev et al., 2008; Mazizi et al., 2020; Mirshekar et al., 2021) to 1.06- 1.13:1 (Khalifa et al., 2016; Chudak et al., 2020). For PUFA, the ratio between linoleic (C18:2) and α-linolenic (C18:3) fatty acids is of interest, which is in the range of 13.3-14.2:1 in breast meat and 13.8-13.9 :1 in the leg meat. Comparing this ratio for breast meat with the results published in the literature, we found that the values obtained by us correspond to those presented by Tikk et al. (2007) - 13.1-14:1. It is slightly lower than the ratio (11.3-12.1:1) reported by Genchev et al. (2008) and Khalifa et al. (2016). A wider ratio is given by Mazizi et al. (2020), Chudak et al. (2020) and Mirshekar et al. (2021), 15.5:1, 22.3:1 and 22.8:1 respectively.

Table 4. Biological value of essential amino acids (EAA) in domestic quails of different productive types

EAA	Standard EAA in Ideal protein*, mg/1 g protein	Amino acid score, % relative to the standard					
		Breast meat			Leg meat		
		WG	GG	A	WG	GG	A
Lysine	45	211.12	227.18	194.34	207.59	213.13	187.59
Methionine + cystine	22	155.05	173.35	148.89	164.87	156.34	146.95
Isoleucine	30	173.45	191.37	176.15	165.28	173.79	172.61
Leucine	59	153.21	168.10	149.07	150.61	157.01	146.22
Phenylalanine + tyrosine	38	198.15	198.98	178.89	202.00	187.25	177.81
Threonine	23	171.06	148.39	203.05	171.67	136.83	205.99
Valin	39	141.56	156.41	156.50	134.24	138.27	154.25
Histidine	15	298.65	334.92	306.35	221.39	202.63	243.01
EAA	Standard EAA in Egg protein **, mg/1 g protein						
Lysine	81.8	116.10	124.92	106.87	114.15	117.20	103,15
Methionine + cystine	34.2	48.83	54.59	46.89	51.92	49.23	46,28
Isoleucine	49.6	104.98	115.82	106.61	100.03	105.18	104,46
Leucine	85.9	105.25	115.48	102.41	103.47	107.86	100,45
Phenylalanine + tyrosine	64.6	65.44	65.72	52.06	66.72	61.85	58,73
Threonine	58.3	67.44	58.50	80.05	67.68	53.94	81,21
Valin	63.2	87.35	96.51	96.56	82.83	85.32	95,18
Histidine	24.0	88.50	90.19	83.64	76.32	77.13	74,94
EAA Index		1,828	1.934	1.842	1.750	1.729	1.815
Biological value, %		47,18	41.20	53.98	50.89	61.54	62.19

Note: * The ideal protein is based on the recommendations about the recommended intake of EAA in mg/1 g protein (FAO/WHO/UNU, 2007);
** The content of EAA in egg protein is based on average data on their content in quail eggs (Genchev, 2012; Aletor and Famakin, 2017; Dymkov et al., 2019; Shcherbatov and Bachinina, 2021.)

Table 5. Fatty acid content (mg/100 g) in breast and leg meat of domestic quails of different productive type at 35 days of age

Amino acids	Breast meat			Leg meat		
	WG	GG	A	WG	GG	A
Myristic acid (C14:0)	26.19±3.67^{c}	28.22±2.58^{c}	51.11±2.21^{d}	35.38±2.38^{ac}	43.64±3.01^{bc}	54.39±1.07^{d}
Pentadecyl acid (C15:0)	7.12±1.02^{c}	9.57±0.80^{c}	14.40±0.45^{d}	4.51±0.43^{c}	6.12±0.83	6.96±0.22^{d}
Palmitic acid (C16:0)	676.5±94.3^{c}	796.7±73.3^{c}	1333.8±58.8^{d}	746.2±55.7^{ac}	931.0±68.6^{b}	1143.1±18.6^{ad}
Margaric acid (C17:0)	4.61±0.86^{c}	5.87±0.58^{c}	8.81±0.29^{d}	5.29±0.27^{ac}	6.77±0.56^{b}	8.15±0.23^{d}
Stearic acid (C18:0)	225.36±32.39^{c}	283.12±26.28^{c}	446.11±15.26^{d}	242.62±15.58^{ac}	304.83±22.43^{bf}	373.53±8.02^{dg}
Arachidonic acid (C20:0)	9.05±1.24^{c}	11.97±1.06^{c}	18.20±0.56^{d}	10.04±0.68^{fc}	12.66±0.73^{gc}	15.59±0.45^{d}
Behenic acid (C22:0)	19.66±3.01^{c}	23.73±2.00^{c}	38.75±1.73^{d}	22.75±2.18^{ac}	28.68±1.97^{bf}	35.16±1.27^{dg}
Myristoleic acid (C14:1)	3.44±0.67^{c}	4.40±0.39^{c}	6.64±0.27^{d}	3.59±0.18f^{c}	4.59±0.25^{gc}	5.64±0.18^{d}
Palmitoleic acid (C16:1)	162.25±22.78^{c}	205.73±18.37^{c}	324.82±14.72^{d}	182.75±10.82^{ac}	229.05±16.42^{bf}	282.10±6.96^{dg}
Margaroleic acid (C17:1)	3.11±0.45^{c}	3.95±0.35^{c}	6.18±0.21^{d}	3.50±0.21^{fc}	4.42±0.26^{gc}	5.43±0.13^{d}
Oleic acid (C18:1)	978.5±137.1^{ac}	1412.2±138.3^{bf}	1978.9±79.4^{dg}	1078.4±77.4^{ac}	1369.4±108.5^{b}	1654.5±28.8^{ad}
Eicosenoic acid (C20:1)	14.89±2.51^{c}	18.18±0.53^{c}	31.25±0.88^{d}	19.07±2.59^{a}	24.22±3.65	27.22±2.12^{b}
Linoleic acid (C18:2n6)	554.94±77.28^{c}	735.08±69.35^{c}	1110.93±46.25^{d}	613.62±43.58^{ac}	772.99±58.78^{bf}	941.63±16.82^{dg}
α-linolenic acid (C18:3n3)	41.86±6.19^{c}	51.84±5.05^{c}	82.32±2.61^{d}	44.35±2.79^{ac}	55.65±4.06^{bf}	68.33±1.52^{dg}
Arachidonic acid (C20:4n6)	57.58±9.30^{c}	76.25±7.49^{c}	113.49±3.25^{d}	58.69±3.60^{ac}	74.38±5.64^{bf}	90.50±2.11^{dg}
Docosatetraenoic acid (C22:4n6)	23.66±3.32^{c}	31.29±2.92^{c}	47.40±1.89^{d}	26.16±1.58^{ac}	32.94±2.42^{bf}	40.36±0.96^{dg}
∑ SFA	968.5±136.0^{c}	1159.1±106.4^{c}	1911.2±77.9^{d}	1066.8±76.4^{ac}	1333.7±98.1^{bf}	1636.9±28.4^{dg}
∑ UFA	1840.3±257.5^{c}	2538.95±242.2^{c}	3701.9±147.1^{d}	2030.2±141.8^{ac}	2567.6±199.7^{bf}	3115.7±57.3^{dg}
MUFA	1162.2±162.5^{ac}	1644.5±157.5b^{c}	2347.7±95.1^{d}	1287.3±90.4^{ac}	1631.7±128.9^{b}	1974.9±36.0^{ad}
PUFA	678.0±95.2^{c}	894.5±84.8^{c}	1354.2±52.4^{d}	742.8±51.5^{ac}	936.0±70.9^{bf}	1140.8±21.3^{dg}
UFA:SFA	1.90 : 1	2.19 : 1	1.94 : 1	1.90 : 1	1.92 : 1	1.90 : 1
SFA share, % from Fat	30.88±0.27^{c}	28.66±0.31^{d}	31.54±0.22^{c}	31.07±0.18^{c}	31.34±0.12^{c}	31.77±0.03^{d}
UFA share, % from Fat	58.70±0.43^{c}	62.68±0.38^{d}	61.11±0.19^{e}	59.16±0.23^{fc}	60.24±0.28^{g}	60.46±0.10^{d}
MUFA	37.09±0.30^{c}	40.59±0.33^{d}	38.75±0.21^{e}	37.51±0.16^{fc}	38.27±0.24^{g}	38.32±0.05^{d}
PUFA	21.62±0.20^{af}	22.09±0.07^{bf}	22.36±0.04^{g}	21.65±0.07^{c}	21.97±0.05^{da}	22.14±0.05^{db}

The differences between the mean values, marked with different letters, were statistically proven as follows: a-b – $P<0.05$; f-g – $P<0.01$ и c-d-e – $P<0.001$. SFA – saturated fatty acids; UFA – unsaturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids

Summarizing the results presented so far on meat composition from the studied productive types of domestic quail, we can make an estimate of what we actually get when consuming the manually deboned meat from one carcass (Table 6).

It is evident from the table that the main and most significant difference between the studied lines consists in the amount of boneless meat, with the difference between the lines WG and GG being over 14%, and that between WG and A – over 37%.

Table 6. Energy, nutrients and minerals content in hand-boned quail meat obtained

Parameter	Group					
	WG		GG		A	
	Breast	Legs	Breast	Legs	Breast	Legs
Hand boned meat, g	70.33±1.16	38.92±0.52	58.31±0.77	35.19±0.41	41.62±1.79	26.53±0.80
	109.24±1.52		93.5±0.96		68.15±2.57	
Dry matter, g	19.01±0.31	9.09±0.12	16.79±0.22	8.73±0.1	11.99±0.44	6.58±0.17
	28.1±0.04		25.52±0.26		18.56±0.6	
Caloric value, MJ	0.467±0.01	0.234±0.03	0.414±0.01	0.217±0.003	0.295±0.02	0.163±0.01
	0.701±0.01		0.630±0.006		0.459±0.022	
Protein, g	14.94±0.25	7.13±0.09	11.71±0.17	6.33±0.08	8.36±0.41	4.77±0.15
	22.07±0.31		18.04±0.20		13.13±0.55	
EAA, g	7.26±0.12	3.35±0.05	6.06±0.08	2.97±0.03	4.03±0.20	2.27±0.07
	10.61±0.15		9.03±0.09		6.3±0.27	
Lysine, g	1.42±0.02	0.67±0.009	1.2±0.02	0.61±0.01	0.73±0.04	0.40±0.02
	2.09±0.03		1.80±0.02		1.13±0.06	
Methionine + cystine, g	0.51±0.01	0.26±0.003	0.45±0.006	0.38±0.003	0.27±0.02	0.15±0.01
	0.77±0.01		0.83±0.01		0.43±0.02	
Fat, g	2.20±0.04	1.33±0.02	3.53±0.03	1.81±0.02	2.52±0.03	1.37±0.01
	3.53±0.05		5.35±0.04		3.89±0.04	
Phospholipids, mg	179.1±2.96	115.8±1.55	129.2±1.71	122.8±1.43	99.8±4.91	84.21±2.1
	294.95±4.032		252.4±2.49		184.01±6.93	
Total cholesterol, mg	40.25±0.07	26.02±0.35	29.13±0.39	27.60±0.32	22.42±1.10	18.92±0.47
	66.27±0.91		56.72±0.56		41.35±1.56	
SFA, mg	681.1±11.26	415.2±5.55	675.8±8.94	469,4±5,45	795,4±10,53	434,3±4,71
	1096.23±15.07		1145.2±11.6		1229.7±14.13	
UFA, mg	1294.2±21.4	790.1±10.6	1480.3±19.6	903,6±10,5	1540,7±22,8	826,7±9,2
	2084.2±28.6		2384.0±24.5		2367.4±28.2	
Linoleic acid, mg	390.3±6.45	238.8±3.19	428.6±5.67	272.0±3,16	462.4±6,35	249.8±2,71
	629.1±8.64		700.6±7.16		712.2±8.39	
α-linolenic acid, mg	29.44±0.49	17.26±0.23	30.22±0.40	19.59±0,23	34.26±0,45	18.14±0,2
	46.70±0.64		49.81±0.51		52.39±0.60	
Ash, g	1.59±0.03	0.50±0.01	1.32±0.02	0.46±0.01	0.94±0.04	0.35±0.01
	2.09±0.03		1.78±0.02		1.29±0.05	

Table 6. Continued

Parameter	Group					
	WG		GG		A	
	Breast	Legs	Breast	Legs	Breast	Legs
Calcium, mg	13.54±0.22	8.12±0.11	11.22±0.15	7.35±0.09	8.01±0.34	5.54±0.17
	21.66±0.30		18.57±0.19		13.55±0.51	
Phosphorus, mg	165.26±2.7	80.75±1.08	137.02±1.81	73.03±0.85	97.80±4.20	55.06±1.65
	246.015±3.450		210.05±2.19		152.86±5.82	
Potassium, mg	281.2±4.65	154.0±2.06	233.2±3.08	139.2±1.62	166.4±7.15	105.0±3.15
	435.2±6.04		372.4±3.83		271.4±10.23	
Sodium, mg	41.32±0.68	28.94±0.39	34.25±0.45	26.18±0.30	24.45±1.05	19.73±0.59
	70.26±0.95		60.43±0.61		44.18±1.63	
Magnesium, mg	12.57±0.21	6.86±0.09	10.42±0.14	6.20±0.07	7.44±0.32	4.68±0.14
	19.43±0.27		16.63±0.17		12.11±0.46	
Iron, mg	1.50±0.03	0.55±0.01	1.24±0.02	0.50±0.01	0.89±0.04	0.38±0.01
	2.05±0.03		1.74±0.02		1.27±0.05	
Cooper, mg	0.29±0.01	0.18±0.002	0.24±0.003	0.17±0.002	0.17±0.01	0.12±0.004
	0.47±0.01		0.41±0.004		0.29±0.01	
Zinc, mg	1.40±0.02	0.95±0.01	1.16±0.02	0.86±0.01	0.83±0.04	0.65±0.02
	2.35±0.03		2.02±0.02		1.48±0.06	

EAA – Essential amino acids; SFA – saturated fatty acids; UFA – unsaturated fatty acids

All other differences in the amount of energy, nutrients and mineral substances received are a logical consequence of this fact. Depending on the productive type, with the consumption of boneless meat from the most valuable parts of a quail carcass, the consumer takes between 18.5 and 28.1 g of dry matter with a caloric value between 109.5 and 167.5 kcal. This energy constitutes between 4.4 and 8.4% of the recommended daily energy intake of a healthy person with moderate physical activity between the ages of 30 and 60 (Official Gazette, 2018; Tutelyan et al., 2020).

The amount of protein received from one carcass constitutes between 38 and 55% of the recommended daily intake of protein of animal origin, and the EAAs in it cover between 25.5 and 43% of the daily needs of the human body. By its caloric value, the consumed protein provides the human body with 2.1-4.5 kcal, which represents 17.9-32.4% of the recommended caloric value, and should be provided by the daily consumed protein by one person (FAO/WHO/UNU, 2007). Nutritionally critical amino acids satisfy 27.6-51% of daily lysine needs and 17-31% of methionine+cystine needs, respectively. The relative share of lysine taken with the meat from one quail carcass is 8.6-10% of the consumed protein, and the share of methionine+cystine is 3.26-4.59%, respectively.

The fat taken with the meat obtained from one carcass provides the body with between 32.8 and 49.7 kcal of energy, which covers between 4.4 and 8.3% of the requirements for the caloric value of fat consumed by humans. The amount of phospholipids and sterols taken with the meat covers 2.6-5.9% and 13.8-22.1% of the body's daily needs respectively. Meat from a single carcass in the egg-laying type (line A) covers between 2/3 and all of the user's daily UFA and SFA requirements. In the other two productive types, these needs are satisfied between 42.5 and 66.5%. The amount of linoleic and α-linolenic fatty acids received with the meat from the breast and legs of one quail are in a ratio of 13.5-14:1 and correspond to between 3.5-6% of the calorific value of the meat for linoleic and 0.26- 0.44% for α-linolenic fatty acid. For linoleic acid this exceeds the FAO/WHO/UNU (2007) recommendations by between 1.4 and 2.4 times, and for α-linolenic acid these recommendations are met by 52-90%. When consuming hand-boned meat from 35-day-old quails from the investigated lines, the consumer takes between 1.3 and 2.1 g of minerals, in which the ratio between potassium and sodium is 2.3:1 (Table 6). With the accepted mineral substances, the human body satisfies 12-20% of its daily needs of the trace elements Fe and Zn and 30-47% of Cu.

CONCLUSION

After the completion of glycolysis in *M. pectoralis superficialis*, pH values decrease between 4.8 and 8.8%, and pH_u reaches 5.96±0.017. The obtained results give reason to assume that the pectoral muscle glycogen reserve can be associated with the productive type, which is the highest in quails of the meat-producing type - line WG (ΔpH=-0.573±0.053 vs. ΔpH=-0.299±0.059 in the egg-laying type - line A, with a statistically significant difference $P<0.001$).

In the meat storage process during the first 24h, the values for the three color coordinates increased on average by 12.5% for the lightness, 16.4% for the redness and by 42% for the yellowing of the meat. Pigment saturation of *M. pectoralis superficialis* to the highest degree depends on the productive type of the birds, which determines 15.9% of the variance of the trait ($P<0.05$). The pigment saturation of the pectoral muscle is the highest in egg-laying type quails, and the stability of their color characteristics during the first 24h is the highest, which makes the visual perception of color in them closer to game meats.

The higher protein, lower fat and energy content of breast and leg meat in the meat-type quails compared to the egg-laying ones, makes their meat more dietary and more responsive to consumer preferences.

Domestic quail meat has a very well-balanced composition and high biological value. The content of EAA in it fully covers the needs of the human organism, and the content of SFA and UFA covers approximately 2/3 of the needs. The dietary properties of the meat are enhanced by the wide ratio between K^+ and Na^+ and by the high content of iron, copper and zinc.

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