



*Original Contribution*

## MEAT COMPOSITION AND QUALITY IN MALE JAPANESE QUAILS FROM HEAVY PHARAOH LINE

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### ABSTRACT

At 35 days of age, meat quality analysis was done as well as proximate analysis of breast and thigh muscles of 72 male quails from heavy Pharaoh line. Lightness values ( $L^*$ ) depended both on the time of *post mortem* analysis and of topographic site – lateral or medial muscle surface of the pectoral muscle. The  $L^*$  value of lateral *M. pectoralis superficialis* (MPS) was higher. Redness and yellowness of meat increased proportionally to *post mortem* ageing, with peak values on the 24th *post mortem* hour. The chroma was more expressed on the medial MPS surface. With regard to determination of a common index of meat colour based on CIE  $L^*a^*b^*$  coordinates, we propose the calculation of Meat Colour Index (MCI) according to the formula:  $MCI = (L^* - C^*)$ . The meat of Japanese quails had high protein and low fat content. Gross energy of breast meat was within 5.03 - 6.13  $MJ \cdot kg^{-1}$ , and that of thigh meat between 4.90 and 5.75  $MJ \cdot kg^{-1}$ . The processing mode of carcasses by removing the skin made quail meat an exceptionally dietetic product with fat content < 3%.

**Keywords:** Japanese quails, Pharaoh line, Meat Color Index, meat quality, meat composition.

### INTRODUCTION

During the last years, the assortment of poultry products is continuously increasing along with the amount of produce. This is particularly noted for meat production. Quail farming is not a very popular branch of poultry farming, yet it comprises a worthy niche with respect to the diversity of retail products. The wide variety of breeds, lines and crosses of Japanese quails for fattening, often from different productive types, requires using various approaches in fattening technologies. The valuable dietetic properties of quail meat are at the background of the increasing interest of consumers to this product.

One of criteria for meat evaluation is protein content, which is 23% in breast vs 18.7% in thigh meat (1). The difference is attributed by authors mainly to mineral content (1.05% vs 1.35%) and fat content (3.1% vs 5%).

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The great variety of breeds, strains and productive type implemented in the world economic practice and used in experimentation work allowed more extensive investigation on physicochemical properties and quality of meat from quails of the specialised meat-type Pharaoh breed. To this end, we aimed to evaluate meat quality and composition in a heavy Pharaoh quails line selected and reared in the Poultry unit at the Faculty of Agriculture, Trakia University, Bulgaria.

### MATERIAL AND METHODS

The study was carried out with 72 male Japanese quails on 35 days of age from the heavy Pharaoh line named WG, selected in the Poultry unit at the Faculty of Agriculture, Trakia University. The growing conditions were in compliance with the zoo-hygienic requirements for quails of the specific age category and productive type. Until the 14<sup>th</sup> day of age, they were fed a started containing 11.1 MJ/kg ME, 24% CP, 1.3% L-lysine, 0.52% methionine, 1.2% Ca and 0.5% available P. At 14 days of age, the birds were sexed. Males were weighed and divided into 6

groups with uniform weight, 12 birds in each. Each group was housed in a separate cage. Between 15 and 21 days of age, the quails were fed grower with 12.1 MJ/kg ME, 21% CP, 1.1% L-lysine, 0.5% methionine, 1.1% Ca and 0.45% available P, and from 22 to 35 days of age: finisher with 12.4 MJ/kg ME, 18% CP, 1.0% L-lysine, 0.43% methionine, 1.0% Ca and 0.4% available P.

Stunning and slaughter was done under production conditions and in compliance with European animal welfare legislation for slaughter. In order not to affect the breast meat color (*facies lateralis* of the *M. pectoralis superficialis*), the carcasses were deskinning. Drip loss was estimated by weighing on *post mortem* hours 4 and 24 and calculated according to the formula:

$$\text{Drip loss, \%} = \frac{\text{carcass weight at 4th post mortem hour} - \text{carcass weight at 24th post mortem hour}}{\text{carcass weight at 4th post mortem hour}} \times 100 \quad [1]$$

Carcass temperature and pH were determined on 45<sup>th</sup> and 90<sup>th</sup> *post mortem* minute with a portable TESTO pH-meter equipped with glass electrode previously calibrated in standard solutions with pH 4.0 and 7.0. The pH meter electrode penetration depth into the muscle tissue was 1 cm.

between two glass plates. The WHC was determined by the formula:

$$\text{WHC} = \left( \frac{A-B}{A} \right) \times 100 \quad [5],$$

where: WHC - water holding capacity of muscles, %; A - weight of muscle samples before the compression; B - weight of muscle samples after the compression. Note: lower WHC values corresponded to better WHC.

The values of coordinates in the CIE L\*a\*b\* colour space were determined on *post mortem* min 45, *post mortem* hours 4 and 24 on Konica Minolta CM-700d spectrophotometer. During meat colour analysis, CIE L\*a\*b\* coordinates were determined in D65 illuminant. The measurements of *M. pectoralis superficialis* (MPS) were done on the lateral and medial surface of the muscle. The difference between L\*, a\* and b\* values detected on min 45 and hour 24 *post mortem* was designated as ΔL\*, Δa\* and Δb\*. The spectrophotometry on the other muscles was made as follows: *M. pectoralis profundus* – in the middle third of the lateral surface (*facies lateralis*) of the muscle; *M. femorotibialis* – in the middle third of the medial surface (*facies medialis*).

Proximate analysis of meat total protein, water, fat and mineral content was done according to classic methods (5) on cooled samples. The gross energy of muscles was determined after burning in a bomb calorimetric and determination of released heat. The energy value was directly obtained from a microprocessor calorimeter KL 11 Mikado (Poland). The gross energy of samples was calculated per 1 kg sample (native substance). All data were analysed by Statistica 13.0 software (Statistica for Windows; Stat – Soft, 2015). Mean (x), standard error of mean (SEM) and coefficient of variation (CV,%) values were calculated for each group.

The chroma (C\*) and the colour difference (ΔE\*) were calculated on the basis of a\* and b\* values using the formulas (2):

$$C^* = (a^{*2} + b^{*2})^{\frac{1}{2}} \quad [2]$$

$$\Delta E^* = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{\frac{1}{2}} \quad [3]$$

Colour index (Shell Color Index) SCI:

$$\text{SCI} = L^* - a^* - b^* \quad [4],$$

where lower values corresponded to darker color (3).

The water holding capacity (WHC) of muscles was determined on *post mortem* hour 24 by the classical method of Grau and Hamm, described by Zahariev and Pinkas (4). Muscle tissue was compressed on filter paper “red band 388”

## RESULTS

The decline in meat pH showed that after *rigor mortis*, pH values changed insignificantly and after 24 h attained 5.7-5.9 for breast muscles and 6.7 in leg muscles (**Table 1**). Another important quality trait is meat hydrophilic property. The drip loss varied from 0.6 to 1.1% of carcass weight. The water holding capacity (WHC) of meat showed water loss variation within broad ranges – from 16.2 to 48.4% for breast muscles and from 12.1 to 30.2% for leg muscles (**Table 1**). Average water lost after compression of MPS was 26.5 ± 0.9%, and of *M. pectoralis profundus* (MPP) – 27.3 ± 1.2% vs 19.6 ± 0.6% for thigh meat. WHC values in standard physiological saline varied between 11.3 and 33.8% for both breast muscles and within 20.4 - 32.1% for leg muscles.

**Table 1.** Physic-chemical properties of Pharaoh quail meat at post mortem hour 24.

Traits	<i>M. pectoralis superficialis</i> (MPS)	<i>M. pectoralis profundus</i> (MPP)	Thigh muscle
	x±SEM	x±SEM	x±SEM
pH	5.72±0.02	5.94±0.02	6.75±0.02
WHC	26.5±0.9	27.3±1.2	19.6±0.6
WHC saline	19.1±1.7	22.7±2.2	26.5±1.2

The lightness of MPS ranged from 40.4 and 54.7, with influence of both the time of *post mortem* analysis and the location – lateral or medial muscle surface (**Table 2**). L\* values of the lateral MPS surface were by 1.3 and 16.7% higher than those on the medial surface, with highest differences at *post mortem* hour 4 (8.5 - 13.5%). Average L\* of the medial MPS surface increased from 41.06 ± 0.43 on the 20<sup>th</sup> min to 46.56 ± 0.51 on the 24<sup>th</sup> h *post mortem*, with ΔL\* variation of individual samples between 3.4 and 20.8%. L\* values of MPP were similar to those of MPS, and their variation was within the range established for MPS lateral surface.

Pigment saturation of breast meat in the red-green spectrum (a\*) showed variation within 5.1 - 20.1, with average values influenced both

by *post mortem* period and measurement location. Both surfaces of MPS showed a steady trend to higher muscle redness with increase of *post mortem* time.

The time course of change of MPP redness was different from that of MPS. In the deep pectoral muscle, an increase of 23.5% was noticed between *post mortem* min 20 and hour 4 and afterwards, until the 24th hour, a\* values decreased by 11.2% on the average to attain 5.2 - 9.7. The individual measurements demonstrated that after the increase in redness values on the 4th *post mortem* hour, the consequent decline until the 24th hour could overcome the previous increase so that the resultant values were lower than redness on minute 20. During our investigation, Δa\* of MPP was 5.28 ± 3.7%.

**Table 2.** Colour characteristics of breast muscles.

Coordinates	Muscles	Time <i>post mortem</i>		
		20 min x±SEM	4 h x±SEM	24 h x±SEM
L*	MPS <i>area lateralis</i>	44.05±0.40	49.26±0.55	49.65±0.56
	MPS <i>area medialis</i>	41.06±0.43	44.39±0.51	46.56±0.51
	MPP	45.05±0.57	49.30±0.56	49.59±0.31
a*	MPS <i>area lateralis</i>	8.06±0.37	9.03±0.49	11.15±0.55
	MPS <i>area medialis</i>	13.64±0.41	15.72±0.50	16.31±0.49
	MPP	7.72±0.40	9.38±0.39	8.23±0.35
b*	MPS <i>area lateralis</i>	5.14±0.20	6.92±0.19	9.86±0.39
	MPS <i>area medialis</i>	7.81±0.19	8.41±0.24	7.85±0.19
	MPP	4.59±0.18	6.34±0.27	3.77±0.27
C*	MPS <i>area lateralis</i>			14.97±0.55
	MPS <i>area medialis</i>			18.12±0.47
	MPP			9.09±0.39
ΔE*	MPS <i>area lateralis</i>			61.07±3.01
	MPS <i>area medialis</i>			23.22±1.46
	MPP			45.92±7.94
SCI	MPS <i>area lateralis</i>			28.64±1.03
	MPS <i>area medialis</i>			22.40±0.93
	MPP			37.60±0.59
MCI (modified)	MPS <i>area lateralis</i>			34.68±0.88
	MPS <i>area medialis</i>			28.44±0.86
	MPP			40.50±0.49

\*MPS – *M. pectoralis superficialis*; MPP – *M. pectoralis profundus*; L\*a\*b\* - CIE colour coordinates; C\* - chroma; ΔE\* - colour difference; SCI – Shell Colour Index (3); MCI – Meat Colour Index.

Pigment saturation of *M. pectoralis superficialis* in the yellow-blue spectrum (b\*) varied from 6.1 and 13.0. During the first 24 h *post mortem* yellowness values increased. More dynamic and with higher variation (VC –

11.3 - 16.3%) were the values obtained on the lateral MPS surface. The medial muscle surface showed variation from 6.09 to 10.1. The b\* values of MPP were lower than those of MPS, and the difference between both muscles on the 24<sup>th</sup> hour was 52%.

**Table 3.** Composition and energy value of some muscles.

Muscles	DM*, %	CP, %	CF, %	NFE, %	Ash, %	Gross energy, MJ*kg <sup>-1</sup> meat
	x±SEM min÷max	x±SEM min÷max	x±SEM min÷max	x±SEM min÷max	x±SEM min÷max	x±SEM min÷max
1	25.45±0.11	22.44±0.11	1.13±0.05	0.45±0.07	1.45±0.02	5.72±0.06
	24.64÷26.2	21.31÷23.3	0.83÷1.51	0.03÷0.80	1.29÷1.57	5.38÷6.13
2	24.94±0.21	22.34±0.15	0.83±0.03	0.42±0.11	1.35±0.01	5.36±0.05
	24.56÷25.6	22.00÷22.8	0.73÷0.94	0.01÷0.65	1.32÷1.39	5.03÷5.69
3	23.34±0.10	20.20±0.13	1.57±0.17	0.31±0.07	1.25±0.01	5.42±0.05
	22.56÷23.8	18.72÷20.9	0.82÷3.45	0.03÷0.81	1.18÷1.32	4.90÷5.75

\*DM – Dry matter; CP – Crude Protein; CF – Crude Fat; NFE - Nitrogen-free extract; 1 – *M. pectoralis superficialis*; 2 – *M. pectoralis profundus*; 3 – thigh muscle.

Colour chroma (C\*) was also more expressed on the medial MPS surface – 18.12 ± 0.47 vs the lateral (14.97 ± 0.55). Lower chroma of MPP was logical at the background of lower a\* and b\* values. Another trait characterising the stability of meat colour was the colour difference ΔE. Lower ΔE values corresponded to more stable meat colour. On the basis of ΔE\* it could be concluded that MPP colour was the least stable (VC = 71%). The values of ΔE\* did not provide information about the direction and rate of change in meat colour traits but the calculation of the colour index (CI) allowed determining also the magnitude of meat colour alteration. SCI values ranged between 19.7 and 35.3 for lateral MPS surface and between 15.4 and 27.9 for the medial surface. Higher colour index values were established for MPP – 34.2 - 41.6.

Proximate analysis results showed that dry matter of meat varied from 24.6 to 26.2% in breast meat and from 22.6 to 23.9% in thigh meat (**Table 3**). Protein content of both breast muscles was similar. Lipid content varied from 0.73 to 1.51% in breast muscles and from 0.82 to 3.45% for leg muscles. The gross energy in studied meat samples ranged between 5.03 and 6.13 MJ\*kg<sup>-1</sup> (breast) and 4.90 and 5.75 MJ\*kg<sup>-1</sup> (thigh). The differences in mineral content of studied muscles were insignificant.

## DISCUSSION

The pH of MPS during the first 24 *post mortem* hours showed a tendency to a more intensive decline compared to pH of thigh,

which is attributed to the morphological structure of muscles. The superficial pectoral muscle is from the typical glycolytic type with higher share of light muscle fibres. It is acknowledged that as the relative proportion of glycolytic fibres in muscle bundles increases, pH values reduction is more pronounced (6). Leg muscles are composed mainly of oxidative type muscle fibres (7), with substantial phosphocreatine reserve providing energy for ATP resynthesis. The high content of mitochondria in those muscles provides oxygen for slower aerobic glycolysis – the main reason for higher pH of leg muscles (8).

Apart the pH values, meat quality depends only on its hydrophilic properties. Muscle tissue contains about 75% water, and only 10 - 15% of it is chemically bound to proteins. The remaining water is retained from muscle physical structure as “free water”. That is why the ability of proteins to hold water within their structure is the highest immediately after death (9). Carcass drip loss during the cooling is one of the traits characterising meat hydrophilic properties. Our results corresponded to those from earlier studies of the same line from the Pharaoh breed (10). Higher values (1.9 - 4.8%) were reported by Zerehdaran et al. (11).

The WHC results corresponded to those of Baumgartner et al. (12) – 28 - 29% for breast meat and were higher than those reported by Genchev (10). Taking consideration of the fact that WHC variation was more considerable, both higher - 31.3% for breast muscle and

24.3% for leg muscles reported by Wilkanowska and Kokoszynski (13), as well as lower than our values - 14.2 - 15.1% for MPS (14) should be accepted. The lower WHC of breast meat could be associated with its slightly lower pH values and hence, lower WHC (15-18).

Higher WHC of leg muscles vs those of breast meat could be attributed to the metabolic profile of their muscle fibres. According to the studies, muscles with higher relative share of oxidative type fibres have a higher WHC than glycolytic type fibres (19-20).

The technological properties of meat are largely dependent on the association of pH with the morphological structure, colour and water holding capacity (16, 20, 21-22). The colour characteristics and particularly the lightness are very important for meat quality. In Pharaoh quails, variations of  $L^*$  range from 33.7 - 35.4 (23) to 53.7 - 57 (13).

The different lightness of meat on the lateral and medial surfaces of MPS is caused by the presence of Fascia pectoralis on the lateral surface that reflects and scatters the light during colour analysis. Another reason could be the contractile status of the muscle at the time of the measurement. As a rule, by the 4<sup>th</sup> *post mortem* hour, *rigor mortis* in birds is always resolved but the probability for presence of contracted muscle fibres in single parts of the muscles remains. In such areas, part of the water passes from the muscle fibre into the intercellular space and creates prerequisites for stronger light scattering and consequently, higher  $L^*$  values. Previous studies (24) concluded that the accuracy of colour analysis could be increased if it was performed on the medial surface of MPS.

The analysis of pigment saturation of breast meat in the red-green spectrum ( $a^*$ ) showed that a more real idea about meat redness could be obtained after the 24<sup>th</sup> *post mortem* hour when the interrelationships between the different muscle components: myoglobin, oxymyoglobin and metmyoglobin become more stable. In the literature,  $a^*$  values could be in general evaluated as low – 6.1 - 9.7 (25-27), intermediate – 11.7 - 12.5 (23) and high – 13.1 - 16 (13, 28). Our  $a^*$  values of medial MPS values are high whereas those on the lateral surface of the muscle – low. This allowed concluding that the medial MPS surface was more appropriate for performing meat colour analysis. The results for redness of

Pharaoh quail meat are comparable to  $a^*$  values published by Riegel et al. (7), Wilkanowska and Kokoszynski (13) and Elmali et al. (14) but were lower than values reported by Genchev (10) and Narinc et al. (29). Substantially lower  $a^*$  values of the breast muscle (6.1 - 6.9) in Japanese quails are established by Aksu et al. (27).

Meat yellowness ( $b^*$ ) is mainly influenced by the amount and colour of intramuscular fat tissue. The breast meat of Japanese quails is lean, therefore infiltrated fat did not exert any influence on  $b^*$  values although some pigments could enhance or attenuate colour in the yellow-blue spectrum. Our results agree with those in previous studies of other authors (13, 14, 27, 29).

The analysis of meat colour results through evaluation of the colour difference ( $\Delta E$ ) and colour index (SCI) allowed suggesting that the MPP colour was the least stable as found out in earlier studies (10). When the classical approach of Cavero et al. (3) for measuring of egg shell color was used, obtained values were lower, but having in mind that sometimes  $b^*$  values could be negative: from 1.2 to 2.2 in turkeys (22) and from 0.7 to 3.7 in Japanese quails (11) the final result could be compromised. Therefore, we believe that when meat colour is analysed, a more suitable formula for colour index calculation would be:

$MCI = (L^* - C^*)$ , where MCI is Meat Color Index,  $L^*$  is the value of lightness and  $C^*$  is the chroma values.

Thus, MCI values are higher by 21.9% for the lateral, by 27% for the medial MPS surfaces and by 7.8% for MPP at the same time preserving the pattern and direction of changes. Using both approaches, the darkest meat was that on the medial MPS surface and the lightest - MPP. When interpreting various data, the effect of illuminant used in the analysis should be also considered.

The obtained results for dry matter of breast and thigh meat were similar to those reported by other researchers – 21.4 - 24.5% for breast and 22.2 - 23.8% for thigh meat (30). Higher breast muscle dry matter was found out by Tarasewicz et al. (23) – 27 - 27.5%, which was most probably related to the time from sampling to analysis.

The dietetic value and properties of meat depend not only on its protein and fat content,

but also on their ratio. Earlier studies demonstrated that Japanese quail carcasses were compliant with modern consumer's attitudes – fat of 8% in carcasses with skin at 35 days of age and 11.3% at 42 days of age (10). The processing protocol by removal of skin make Japanese quail meat an exceptionally dietetic product with fat content < 3%.

## CONCLUSIONS

On the basis of results, it could be concluded that:

Lightness values ( $L^*$ ) depended both on the time of *post mortem* analysis and of topographic site – lateral or medial muscle surface. The  $L^*$  value of lateral *M. pectoralis superficialis* (MPS) was higher. Redness and yellowness of meat increased proportionally to *post mortem* ageing, with peak values on the 24<sup>th</sup> *post mortem* hour. The chroma was more expressed on the medial MPS surface. With regard to determination of a common index of meat colour based on CIE  $L^*a^*b^*$  coordinates, we propose the calculation of Meat Colour Index (MCI) according to the formula:  $MCI = (L^* - C^*)$ . The meat of Japanese quails had high protein and low fat content. Gross energy of breast meat was within 5.03 - 6.13 MJ\*kg<sup>-1</sup>, and that of thigh meat between 4.90 and 5.75 MJ\*kg<sup>-1</sup>.

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