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Original Contribution

MEAT PERFORMANCE OF DOMESTIC QUAILS AFTER PARTIAL FEED REPLACEMENT OF WHEAT WITH EXTRUDED BAKERY WASTE

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ABSTRACT
The aim of the study was to investigate the effect of the partial replacement of wheat with bakery waste in compound feed on slaughter characteristics, quality and composition of meat in a heavy population of domestic quail. A control group (n = 90), I experimental (n = 90), and II experimental groups (n = 90) quails from meat-producing population WG were formed, respectively fed with basic feed, 5% and 10% replacement of wheat in the feed with extruded baking waste. A slaughter analysis, qualitative and chemical analysis of the meat of male and female representatives of the three experimental groups was performed. The replacement of 5% and 10% of the wheat in the compound feed with extruded bakery waste does not have a negative effect on the slaughter characteristics of the studied quail population. No relationship was observed between the studied physicochemical characteristics of quail meat and the addition of 5% and 10% extruded bakery waste. A similar effect is not observed with regard to the color characteristics of the meat. An exception is the Chroma (C*), where there is a tendency to higher values on the basis of experimental groups. With an increasing proportion of wheat substitution with extruded baking waste, the fat content in breast meat increases ($P<0.001$). The study leads to the conclusion that the replacement of up to 10% of wheat in the combined feed for quails with extruded bakery waste does not adversely affect the slaughter characteristics, quality, and nutritional value of quail meat.

Key words: WG quails, slaughter characteristics, meat quality, meat composition, meat color

INTRODUCTION

The domestic quail (*Coturnix japonica domestica*), widely used worldwide for the commodity production of eggs and meat, originates from the wild Japanese quail, which can safely be said to be the latest domesticated farm bird. As a result of domestication, changes have occurred not only in the morphology but also in the behavioral reactions of domesticated quails (1, 2). Domestic quails began to be used for commercial purposes, mainly for egg production, in the 1930s, initially in Japan (3). Gradually, farm quail farming has grown and taken over new areas outside East and Southeast Asia. Between the 1970s and 1980s, quails were used predominantly as model animals in biological research (4, 5). The use of domestic quails as model animals is still relevant today, with the main emphasis shifted to the study of productivity and quality of production and their impact on the inclusion in the composition of feed mixtures of various natural or synthetic additives (6). Interest in the economic use of domesticated quails increased in the late 1980s, following the WPSA conference in Nagoya in 1988 (7). According to the author, today the world produces about 1.2-1.3 million tons of quail eggs and between 200 and 240 thousand tons of quail meat. Thus,

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the number of domestic quails ranks second among farm birds after the domestic hen. However, a large part of meat production is ancillary to egg production. Barely in the last 2-3 decades has the selection work in the field of quail breeding focused on increasing the meat-producing qualities of the breeds and lines used for commodity production. In the USA and France, specialized meat breeds with very high potential for efficient meat production were selected. In the last two decades, Trakia University, Bulgaria has also been working in this direction, creating several populations of meat quail, the heaviest of which is WG (8). In many countries around the world, specialized farms for the production of quail meat have been established and are operating (9).

The valuable taste and dietary qualities of quail meat are the basis of the growing interest of consumers in this product. Its quantity, quality and nutritional value are influenced by many factors such as genotype, diet, sex, fattening period, and others (10-13). The fattening of meat-producing quails is the most economically justified (14). Important for the reduction of production costs is the possibility to use low-value feed materials in poultry feed. Waste from the bakery industry can be cited as such to replace part of the grain component in compound poultry feed (15). Studies show that the production of quail meat is most cost-effective if the slaughter of birds takes place at 35 days of age (16-18).

The aim of the present study is to investigate the effect of the replacement of part of the wheat in the combined feed for quails with baking waste on the slaughter characteristics, quality and composition of the meat in a heavy population of domestic quail.

MATERIAL AND METHODS

Experimental design. The material in this publication is part of a large-scale study conducted in "Poultry" unit of Trakia University - Stara Zagora in January-March 2020. A total of 270 quails from the specialized meat line WG were included in the experiment and were equally divided into 3 groups, 90 each: control (standard compound feed), I experimental (5% of wheat in the feed mixture was replaced with extruded bakery waste) and II experimental groups (10% of wheat in the feed mixture was replaced with extruded bakery waste). During the experimental period, 3-phase feeding with starter, grower and finisher compound feed was applied **(Table 1).** The bakery waste was purchased by one of the largest bread producers in Bulgaria, extruded and converted into a fine-grained form in the Department of Animal Science, Faculty of Agronomy, Agricultural University, Plovdiv, Bulgaria. In this form, it was used in the preparation of the compound feed for the two experimental groups. The husbandry conditions of the birds from the three groups were the same and strictly corresponded to the requirements of the species.

Slaughter analysis. At 35 days of age, after 4 hours of feeding and 3 hours of water abstraction, the birds were weighed on a CB 2000 scale to the nearest 1 g. 6 male and 6 female birds from each group were selected by average group and gender live weight and slaughtered. The entire procedure involving the killing, processing, cutting and deboning of birds was carried out according to the protocol described in detail by Genchev and Mihaylov (19). In order to avoid any possibility that the heat treatment by scalding the birds would affect the color characteristics of the meat, the carcasses were deskinned together with the feathers. The weight of the carcass, internal organs and cuts were determined to the nearest 0.001 g on an analytical balance Kern EMB 200-3 (KERN & SOHN GmbH). Water losses (WL) after carcass cooling were determined after double weighing of cleaned and gutted carcasses at 4 and 24 hours *post mortem*. Mass loss was calculated by the formula:

$$\text{WL, \%} = \frac{\text{carcass weight on 4th } post\ mortem - \text{carcass weight on 24th } post\ mortem}{\text{carcass weight on 4th } post\ mortem} \times 100 \quad \text{(Equation 1)}$$

Qualitative analysis of meat. This part of the study was conducted in the "Poultry" unit laboratory of Trakia University - Stara Zagora, Bulgaria. The temperature and pH values of *M. pectoralis superficialis* were determined immediately after bleed-out process and at 24 hours *post mortem* using a portable pH meter Milwaukee MW 102 (Milwaukee Instruments, Inc.), calibrated in standard pH solutions - 4.0 and pH 7.0. The results were read by penetrating the electrode of the pH meter at a depth of 1 cm into the tissue of *M. pectoralis superficialis*.

***Table 1.** Component and nutritional composition of the compound feed used*

	Control group			I group			II group		
	Starter	Grower	Finisher	Starter	Grower	Finisher	Starter	Grower	Finisher
	Feed components, %								
Corn	29.2	35.5	38.8	29	35.1	38.65	28.8	35	38.4
Wheat	21	23.8	27	16	19	22	11	13.9	17
Extruded bakery waste	0	0	0	5	5	5	10	10	10
Soybean meal, 44% CP	34.6	25.8	20	34.7	25.85	20	34.75	25.93	20.1
Sunflower meal, 34% CP	8	8.5	9	8	8.5	9	8	8.5	9
Fish meal, 72% CP	2	1	0	2	1	0	2	1	0
Sunflower oil	0.615	0.905	1	0.865	1.055	1.15	0.865	1.18	1.3
Dicalcium phosphate	1.92	1.82	1.71	1.92	1.82	1.71	1.92	1.82	1.71
Calcium carbonate	1.52	1.48	1.43	1.52	1.48	1.43	1.52	1.48	1.43
Vitamin-mineral premix	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.6	0.5
NaCl	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Na_2CO_3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
L-lysine, 98%	0.11	0.175	0.15	0.11	0.175	0.15	0.11	0.17	0.15
DL-methionine, 99%	0.135	0.12	0.11	0.135	0.12	0.11	0.135	0.12	0.11
	Nutritional composition								
EPR*	110.27	134.28	156.31	110.13	134.29	156.58	110.13	134.23	156.48
ME, MJ/kg	11.06	11.51	11.79	11.05	11.51	11.79	11.05	11.50	11.79
CP, %	24.00	20.51	18.04	24.01	20.51	18.02	24.01	20.50	18.03
CF, %	5.28	5.02	4.90	5.23	4.99	4.87	5.23	4.97	4.85
Ca, %	1.20	1.10	1.00	1.20	1.10	1.00	1.20	1.10	1.00
Available P, %	0.50	0.45	0.40	0.50	0.45	0.40	0.50	0.45	0.40
Lysine, %	1.30	1.10	0.91	1.31	1.10	0.90	1.31	1.10	0.91
Methionine %	0.52	0.45	0.40	0.52	0.45	0.40	0.52	0.45	0.40
Cys+met, %	0.92	0.81	0.73	0.92	0.81	0.73	0.92	0.81	0.73
Linoleic acid, %	1.30	1.62	1.75	1.47	1.72	1.85	1.47	1.79	1.95
Feed price, EUR/t	389.68	342.78	301.65	383.87	339.93	298.64	383.87	336.98	295.94

*EPR - Energy-Protein Ratio

Examinations of the color characteristics of the breast meat were performed immediately after bleeding of the carcass and at 24 hours *post mortem* using a PCE-CSM 2 spectrophotometer (PCE Instruments). The coordinate values in the CIEL*a*b* system were determined in illuminant D-65. Studies of *M. pectoralis superficialis* were performed on the lateral surface of the muscle. Based on the obtained values for the coordinates a* and b*, the Chroma (C*) and the Meat color index (MCI) was calculated according to the formulas:

C*= $(a*^2 \quad + \quad b*^2)^{\frac{1}{2}}$ (Equation 2) (20), and

MCI= $L * - C *$ (Equation 3) (21), where lower values mean a darker color of the meat.

Chemical analysis. The chemical composition of the meat was conducted in the Department of Accredited laboratory complex for chemical and instrumental analysis, Agricultural University, Plovdiv, Bulgaria. The determined indicators were: water, crude protein, crude fats, and minerals in the cooled state of the samples (22). The determination of the potential (gross) energy in the meat was made after burning the samples in a calorimetric bomb and determining the amount of heat released. The energy value was determined directly on a microprocessor calorimeter KL

11 Mikado according to the method described by Atanasov et al. (23). The total energy of the samples was recalculated on the basis of 1 kg of sample (native substance).

Statistical analysis. The statistical processing of the obtained results was done with the statistical package IBM® SPSS® Statistics (V26).

RESULTS AND DISCUSSION

The results of the slaughter analysis are presented in **Table 2**. The table shows that the carcass weight in all three groups is higher in females than in males, but the difference is statistically insignificant (P>0.05). In the first 24 hours after slaughter, the weight losses due to the cooling of the carcass in all three groups show a clear tendency to higher values in males, but the differences are small and statistically unproven (P>0.05). There is a similar tendency for the slaughter yield indicator. Only the difference between the control and I experimental group was statistically significant (P<0.05). The dependence observed by us at 5 weeks of age does not support the conclusions of Monika et al. (2019) that the slaughter characteristics of females are better than those of males (24). Comparing the slaughter yield between the groups, we found that the differences between the sexes were in the range of 1.8-4.6% (P>0.05). Only the difference between the females from the control and I experimental group was higher (6.3%) (P<0.001). A similar trend for higher slaughter yields in male quails between 4 and 6 weeks of age has been observed by other authors (17). In contrast, in populations where targeted selection for meat-producing qualities is not done, this trend does not appear until about 7 weeks of age (25).

Abdominal fat is one of the negative signs for most consumers. **Table 2** shows the higher values of this trait in females compared to males. The gender differences in the control and experimental groups were approximately 2.5-fold (P<0.001). In experimental group II, the difference between male and female sex is the lowest, but here the percentage of abdominal fat is the highest compared to the other two groups. The difference in characteristics between the groups is approximately 60% in males and between 31 and 36% in females. Due to the large variation in the trait, the differences between the two sexes in experimental group II and versus the other two groups are insignificant (P>0.05). Results for a significantly higher proportion of abdominal fat in fattened quails up to 35 days of age have been found by other authors (17).

The total valuable parts of the carcass of birds - breasts with bones and legs in quails of the WG line vary in the range of 118-133 g, which represents between 73 and 76% of the carcass weight. Genchev (2014) published close to these results for the total share of valuable cuts of quail carcasses (3). The weight of the breasts with bone in the three groups has similar values, which vary between 71 and 84 g, which is 45-49% of the mass of the carcass. The weight of the legs is in the range between 42 and 49 g (25-30%). Our results for the portion of valuable cuts, especially breasts with bone, are higher than the data published in the literature, which are in the range of 37.3-38.7% for breasts with bone and 22.7-24.6% for the legs (26). The main reason for this difference we attribute to the purposeful long-term selection by growth intensity and meat-producing qualities along this line. This may be associated with an increase in muscle fiber size, which does not adversely affect metabolic processes in *M. pectoralis,* but increases muscle mass (27).

The best testimony for meat-producing qualities of a breed, line or hybrid combination is the pure meat obtained from the valuable parts of the carcass. Hand-deboned breast and leg meat vary between 102 and 115 g, which makes up between 63% and 68% of the carcass weight. The results obtained by us for the share of meat from the breasts and thighs exceed those published by other authors by an average of about 22% (28, 29). This difference confirms the conclusions made by Guernec et al. (2003) in a study of the postnatal development of muscle fibers in broiler chickens that as a result of selection the thickness of muscle fibers not only of *M. pectoralis* but also of leg muscles can increase up to 24% (30). Comparing the results between the sexes, we found that the share of hand-deboned meat in male quails is higher than in females (P<0.01). Regarding the differences between the groups, a significant difference was reported only between the females from the experimental groups (P<0.05).

Table 2. *Slaughter characteristics of WG quails at 35 days of age*

Parameters	Control group		I group		II group	
	male	female	male	female	male	female
Live body weight, g	273.7±2.6**	292.0±6.42	272.3±5.70*	284.0±4.04	276.7±1.8***	288.0±2.08
Carcass weight, g	168.1±2.07	175.9±3.92	163.2±1.99	170.6±6.22	165.0±3.63	166.6±5.34
min÷max	164.0÷170.9	169.1÷182.7	160.8÷167.1	163.0÷188.2	158.1÷170.4	157.6÷176.1
Carcass cooling weight loss, %	0.66±0.11	0.62±0.03	0.81±0.25	0.64±0.06	0.66±0.13	0.61±0.02
min÷max	0.52÷0.87	0.56÷0.67	0.36÷1.24	0.53÷0.71	0.51÷0.92	0.57÷0.64
Slaughter yield, %	61.0±0.28**	59.9±0.23^{c}	62.1±2.27*	56.1±0.68^{d}	59.2±0.95	57.5±1.45
min÷max	60.44÷61.38	59.59÷60.33	59.66÷66.62	55.49÷57.74	57.38÷60.54	54.95÷59.96
Edible offals, %	4.7±0.06*^{c}	5.2±0.22	4.9±0.51	5.8±0.27	5.4±0.13^{d}	5.4±0.30
min÷max	4.61÷4.82	4.97÷5.66	4.35÷5.88	5.29÷6.21	5.17÷5.59	5.03÷6.01
Abdominal fat, %	0.6±0.15***	1.5±0.13	0.6±0.18***	1.6±0.16	1.5±0.43	2.3±0.73
min÷max	0.33÷0.82	1.20÷1.60	0.23÷0.78	1.25÷1.80	0.81÷2.30	1.51÷3.73
Breast with bone, %	47.2±0.98	47.6±0.61	46.9±1.27	46.7±0.44	46.4±0.19	47.1±1.27
min÷max	45.38÷48.69	46.52÷48.63	44.96÷49.27	46.12÷47.57	46.01÷46.59	45.13÷49.49
Breast meat, %	43.0±1.21	41.7±0.63	42.9±1.26	41.5±0.40	42.5±0.25*	40.8±0.71
min÷max	40.63÷44.63	40.48÷42.54	41.23÷45.36	40.89÷42.22	42.04÷42.87	39.72÷42.17
Thigh, %	27.9±0.42**	26.3±0.41^{a}	28.8±0.59*	27.3±0.07^{b}	28.4±0.67*	26.6±0.26^{a}
min÷max	27.21÷28.67	25.43÷26.75	27.65÷29.63	27.17÷27.40	27.24÷29.55	26.35÷27.12
Thigh meat, %	23.9±0.43	22.1±0.44^{a}	24.2±0.51	23.3±0.13^{bc}	24.2±0.81*	22.1±0.11^{d}
min÷max	23.24÷24.71	21.33÷22.86	23.21÷24.87	23.13÷23.53	22.84÷25.65	22.02÷22.35
Meat (breast+ thigh), %	66.9±0.79***	63.8±0.26	67.1±0.80**	64.7±0.38^{a}	66.7±0.66***	62.8±0.63^{b}
min÷max	65.33÷67.87	63.34÷64.24	65.82÷68.57	64.04÷65.35	65.47÷67.69	62.07÷64.19

Note: The recorded carcass weight is without skin. Edible offal share is based on the live body weight. Differences between values within the same sex, marked with different letters, were statistically proven in: a-b – P<0.05; f-g – P<0.01; c-d-e – P<0.001. Differences between male and female birds of the same group are noted with: * - P<0.05; ** - P<0.01; *** – P<0.001.

Analysis of the physicochemical characteristics of meat showed that immediately after death, the pH values of *M. pectoralis superficialis* varied between 6.0 and 6.65 at a muscle depth of 39.3-42°C **(Table 3)**. After 24 h *post mortem*, the concentration of hydrogen ions decreased on average by 6.8% (P<0.001) and reached values between 5.8 and 6.17, at a temperature in the depth of the muscle between 7.4 and 10.1ºC. The average values of pH at 24 hours in all three groups are very close and do not give grounds for a relationship between the pH of the fillet and the replacement of part of the wheat with bakery waste.

During the first 24 h *post mortem*, there are significant changes in the color characteristics of *M. pectoralis superficialis*. The values of the three color coordinates L*, a* and b* increase, and in all three groups the change in the coordinate L* is the most stable. After the disappearance of *rigor mortis* and the beginning of the changes leading to meat maturation, the brightness of *M. pectoralis superficialis* in the different groups increased between 11.5% and 14% (P<0.001), and the degree of variation in this trait, as at the moment of slaughter and after 24 hours is the lowest (CV,% between 2.8% and 5.5%). In a theoretical sense, the values of L* are a function of the amount of reflected, scattered and absorbed light, but according to Murashev et al. (2010), is also influenced by the degree of refraction and scattering of light (31). After death, a number of processes take place that weakens the hydrophilic properties of proteins. After the disappearance of *rigor mortis*, part of the free water passes from the muscle fibers into the intercellular space, thus creating preconditions for stronger light scattering, which increases the brightness of the meat (32). Studies have shown that in *M. pectoralis superficialis* the changes are most intense during the first 24 hours (33, 34), but with longer storage of meat in a refrigerated state, these changes, although with a slower intensity, continue (35). However, not only the amount of scattered light but also the light absorbed by the myofibrils is important for the final result. The latter is largely a function of the contractile condition of the muscle in the study area. If there are contracted muscle fibers in the field of study, they absorb more light, and the L* values will be lower (36).

Examining the pigment saturation of *M. pectoralis superficialis* in the red-green (a*) and yellow-blue (b*) spectra, we saw that in the first 24 h *post mortem* the changes in the coordinate (a*) are the weakest. Despite the fact that after death the redness of the meat increased between 3.4% and 8.6%, the differences between the groups were small and statistically insignificant (P>0.05). The main factor influencing the redness of meat immediately after death is the concentration of heme pigments (myoglobin and hemoglobin). In the first hours *post mortem*, processes that lead to oxidation of iron in heme start, and the intensity of these changes depends on both the degree of bleeding of the carcass and the content of myoglobin in the muscle. The realization of color in the red-green spectrum largely depends on the ratio between the three forms in which myoglobin can be (oxygenated, reduced and oxidized). This is the main reason why the values of a* published in the world scientific literature differ significantly.

Similar to the a* coordinate, during the first 24 h *post mortem* the values of b* also increase, with the growth in the yellow-blue spectrum being more pronounced (between 20.4% and 39.3%). Comparing the results between the groups, it is obvious that the difference is insignificant only in the first experimental group (P>0.05).

The visual perception of the color of the meat is formed by the combination of different pigments, but the presence of water in the intercellular space also has an effect. Therefore, not only the Chroma (C*) is important, but also the meat index. Considering the color relative saturation of the three groups, a tendency for the effect of substitution of part of the wheat with bakery waste on the values of C* was observed. The lowest in both studies were the values in the control group. In the first 24 hours after slaughter, the values of C* increased between 13% and 18.9%, but only in experimental group II a significant difference was reported (P<0.05). At 24 h *post mortem*, C* values varied between 8.4 and 16.3, which is in the range of trait variation indicated by other authors (37, 38).

Comparing the results between the groups, a significant difference was reported between the control and II experimental groups, as the difference was significant both just after the slaughter of birds and at 24 h *post mortem* (P<0.05).

The Meat color index (MCI) varied between 30.1 and 37.8 immediately after slaughter and between 29.6 and 43.1 at 24 h *post mortem*. MCI values in the period after slaughter increased between 10.3 and 12.1%, and in all three groups a significant difference was reported (P<0.05). Comparing the MCI values between the groups small and statistically insignificant differences were observed (P>0.05).

The most accurate testimony for the dietary value of meat is its composition (**Table 4**). The percentage of dry matter varied between 26.1% and 28.6% in breast meat and between 22.4 and 25.7% in leg meat. These values are close to those previously published by Tarasewicz et al. (2007) - 27-27.5% results for breast meat and to the results published by Tikk et al. (2009) for leg meat - 22.2-23.8% (39, 40). Comparing the average results between the groups, we can notice an interesting phenomenon that the dry matter in the pectoral muscles in all three groups had higher values in the male sex, while in the leg muscles - vice versa, in the female sex. Although in some of the groups there were significant differences (P<0.05), the limited sample, especially in this type of research, gives us reason to be a little more reserved to the conclusions.

Table 3. *Physicochemical characteristics of breast meat in quails of the WG line at 35 days of age*

Parameters	Control group after slaughter	Control group 24 h *post-mortem*	I group after slaughter	I group 24 h *post-mortem*	II group after slaughter	II group 24 h *post-mortem*
pH	6.5±0.04***	5.9±0.06	6.4±0.09***	6.0±0.03	6.3±0.08***	6.0±0.03
min÷max	6.36÷6.60	5.80÷6.17	6.07÷6.65	5.87÷6.09	6.05÷6.47	5.90÷6.11
T^o,C	40.7±0.36***	8.9±0.25	40.4±0.14***	8.7±0.31	40.3±0.19***	9.8±0.08
min÷max	39.3÷42.0	8.0÷9.4	40.0÷40.8	7.4÷9.7	39.8÷41.0	9.5÷10.1
L*	43.1±0.90***	49.2±1.10	44.2±0.51***	49.3±0.77	43.7±0.82***	49.2±1.04
min÷max	40.49÷46.02	45.82÷52.00	42.09÷45.52	47.42÷52.46	42.01÷47.45	44.47÷52.25
a*	7.8±0.53	8.1±0.53	8.5±0.25	9.2±0.49	9.3±0.50	10.0±0.54
min÷max	5.74÷9.72	5.77÷12.23	7.44÷9.26	7.48÷10.91	8.04÷11.17	8.35÷11.33
b*	5.8±0.31**	7.9±0.64	6.3±0.35	7.5±0.57	6.4±0.27***	9.0±0.56
min÷max	4.99÷7.05	6.05÷10.76	4.74÷7.03	5.57÷9.41	5.66÷7.39	7.39÷10.85
C*	9.8±0.47	11.4±0.73	10.6±0.37	11.9±0.68	11.3±0.45*	13.4±0.69
min÷max	8.19÷11.34a	8.36÷16.29a	8.82÷11.15	9.33÷13.75	9.83÷13.02b	11.28÷15.69b
MCI	33.4±1.23*	37.8±1.59	33.6±0.74*	37.3±1.25	32.4±1.08*	35.7±1.22
min÷max	30.08÷37.83	29.58÷42.80	31.01÷35.94	33.96÷43.13	30.81÷37.62	30.37÷38.56

Note: Differences between groups marked with different letters were statistically proven in: a-b – P<0.05; f-g – P<0.01; c-d-e – P<0.001.
Differences between the values of the trait after slaughter and at 24 h *post-mortem* are marked with: * - P<0.05; ** - P<0.01; *** – P<0.001.

The nutrient content of meat is directly related to the dry matter content. Apart from the percentage of dry matter in meat, the content of crude protein is also influenced by the content of crude fat in it. The variation of the values of the crude protein in the meat of the breast is in the range between 19.7% and 22.3%, and in the meat of the legs, respectively, between 16.1% and 19%. **Table 4** shows that low crude protein values are logically associated with higher crude fat values in these groups. Comparing the results depending on the sex of the birds, we find that in all groups the crude protein in the meat from both the breast and the legs has higher values in males than in females, and in breast meat the differences are significant (P<0.001). A similar trend between the sexes has been observed in other studies with birds of the same population (41). The content of crude fat in the breast meat varied in the range of 2.14% and 4.87% and the content is higher in females (P<0.001). In the meat of the legs, despite the significant differences (P<0.001), there is no noticeable tendency for the influence of sex on the fat content.

Comparing the obtained results by groups, we found that in breast meat there is a very clear relationship between the degree of replacement of wheat with bakery waste and the content of nutrients in the meat. In both sexes the lowest was the content of crude fat, resp. highest in crude protein, in the control group. With an increase in the share of wheat substitution with bakery waste, the fat content in breast meat also increases (P<0.001).

Gross energy can be pointed out as a complex feature that focuses on the entire nutritional composition of meat. In the breast meat it varies in the range of 6.27-6.98 MJ/kg, and in the leg meat - respectively 5.58-6.41 MJ/kg. The average scores obtained in this study were almost 14% higher for breast meat and almost 10% higher for leg meat than previously published results with birds of the same population (42). One of the reasons for this result is the higher fat content in meat in the current study, which is 64% for the breast and 54.5% for the legs higher than in previous one. In general, it can be said that the gross energy in the meat of the breast in males is higher than that in females (P<0.001). The replacement of part of the wheat with bakery waste has had some effect on the gross energy content of breast meat in females (P<0.05), despite some proven differences in males, no clear trend is observed. The gross energy in the meat of the legs had less pronounced differences both between the sexes and between the groups, and a statistically significant difference was found only between the male and female birds of the first experimental group (P<0.05).

Table 4. *Chemical composition and caloric value of meat in quails of the WG line at 35 days of age*

Parameters	Control group		I group		II group	
	male	female	male	male	female	male
			Breast meat			
Dry matter, %	28.0±0.34	27.4±0.06	27.8±0.05	26.5±0.26	27.9±0.17***	26.5±0.31
min÷max					27.7÷28.1	
	27.4÷28.6	27.3÷27.5cf	27.8÷27.9	26.1÷26.8d		26.1÷26.9g
Protein, %	22.7±0.3***	20.5±0.06	22.4±0.0***	20.3±0.20	21.6±0.1***	20.0±0.23
min÷max	22.2÷23.2f	20.5÷20.6a	22.3÷22.4c	20.0÷20.5ab	21.4÷21.7gd	19.7÷20.4b
Fat, %	2.2±0.03	2.4±0.01***	2.8±0.01	3.4±0.03***	3.1±0.02	4.8±0.06***
min÷max	2.1÷2.23d	2.4÷2.45c	2.8÷2.83c	3.3÷3.4d	3.1÷3.16e	4.7÷4.87e
Ash, %	2.6±0.04***	2.0±0.01	2.3±0.004	2.5±0.02***	2.8±0.02	1.1±0.01
min÷max	2.59÷2.69d	1.99÷2.01c	2.26÷2.27c	2.45÷2.52d	2.75÷2.80e	1.12÷1.16e
Gross energy, MJ/kg	6.8±0.10	6.7±0.02	6.7±0.01***	6.4±0.06	6.8±0.04***	6.4±0.07
min÷max						
	6.69÷6.98b	6.63÷6.68cf	6.72÷6.75a	6.34÷6.51g	6.77÷6.88b	6.27÷6.48dg
			Thigh meat			
Dry matter, %	23.9±0.70	25.0±0.51*	23.0±0.47	24.7±0.65*	24.1±0.50	24.1±0.33
min÷max						
	23.0÷25.3	24.0÷25.7	22.4÷23.9	23.4÷25.5	23.6÷25.1	23.5÷24.5
Protein, %	16.7±0.60	19.7±0.49***	17.7±0.44	18.6±0.60	18.0±0.45	18.8±0.31
min÷max	16.1÷17.7	18.9÷20.3	17.2÷18.4	17.6÷19.1	17.6÷18.7	18.3÷19.1
Fat, %	4.1±0.15***	2.8±0.07	3.1±0.08	3.7±0.12***	4.0±0.10***	3.2±0.05
min÷max	3.9÷4.3c	2.7÷2.84c	3.0÷3.2d	3.46÷3.8d	3.87÷4.1c	3.07÷3.2e
Ash, %	1.1±0.04	1.2±0.03	1.2±0.03	1.6±0.05***	1.2±0.03	1.3±0.02
min÷max	1.06÷1.17f	1.13÷1.21c	1.18÷1.25fg	1.47÷1.60d	1.22÷1.29g	1.28÷1.33e
Gross energy, MJ/kg	6.0±0.21	6.2±0.16	5.7±0.14	6.2±0.20*	6.0±0.15	5.9±0.10
min÷max						
	5.75÷6.32	5.98÷6.41	5.58÷5.95	5.88÷6.40	5.90÷6.28	5.77÷6.02

Note: Differences between values within the same sex, marked with different letters, were statistically proven in: a-b – P<0.05; f-g – P<0.01; c-d-e – P<0.001. Differences between male and female birds of the same group are noted with: * - P<0.05; ** - P<0.01; *** – P<0.001.

CONCLUSION

At 35 days of age, the weight of cuts from the valuable parts of the carcass in the quails of the WG line was in the range of 71-84 g for the breast with bone and 42-49 g for the thighs. In total, the mass of manually deboned meat from these parts was 2/3 of the carcass weight, and the yield for males was higher (P<0.01). During the first 24 hours *post mortem* significant processes took place, which leads to a change in the color of the meat. The values of the three color coordinates L*, a* and b* increased, the most significant were the changes in the brightness of *M. pectoralis superficialis* (P<0.001). The Chroma (C*) of the breast meat varied within the normal range for domestic quails between 8.4 and 16.3. The color index (MCI) in the period after slaughter increased by 10-12% (P>0.05), and the most significant for this result is the share of L*. The average values of dry matter in the meat of the breast were 26.5-28%, and in the meat of the legs - 23-25%. The content of crude protein in breast meat was higher in males, as the main reason for this is the higher content of crude fat in the meat of females (P<0.001). Replacing part of the wheat with bakery waste has a direct effect on the fat content of the breast meat (P<0.001), which has to some extent affected the gross energy content.

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