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Effect of different fattening period duration on meat productivity of domestic quails

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Abstract. *The study was conducted with 224 domestic quails from the specialized meat-type WG line. The duration of fattening period and sex on productive traits, slaughter traits and meat quality of quails was evaluated. The study has shown that the longer duration of the fattening period in quails from the meat-type line WG was associated with lower production efficiency, with more reduction after the 35th day of life. The production efficiency in male quails was lower compared to that in females. The dispersion analysis demonstrated that the determination of 72.2% and 69.6% of dressed carcass weight and deboned meat weight, respectively, depended on fattening period duration (p<0.001). When fattening increased from 28 to 42 days, the amount of feed necessary for one bird increased by 73% and 87%, corresponding to increased costs by 64.5% and 77%. For production of 1 kg dressed quail carcasses, the necessary feed increased by 42.3-45.8% on a weight basis and by 35-37.7% on a cost basis. For production of 1 kg deboned quail meat, corresponding increases are by 42.1-49.5% and 34.8-41.2%, respectively. The period between 28 and 35 days of age was the most appropriate for planning slaughter of WG quails. During that period, the economic efficiency, although already declining, was still within acceptable limits and the increase in quantitative traits in both sexes – still relevant, making the produce more attractive for consumers. With age, the changes in colour characteristics of M. pectoralis superficialis result in darkening of meat (p<0.001). Thus, it assumes nuances specific rather for game meat. This effect is desirable, as it improves the commercial presentation of domestic quail meat in line with consumers' attitudes.*

Keywords: age, Japanese quails, meat type, meat quality, sex

Introduction

The efficiency of stock domestic quail meat production depends mainly on the selection of a breed/line. Depending on the sexual maturity onset and growth performance of the selected population, fattening period of birds may become the key factor for slaughter scheduling in males or females. At a global scale, the meat from domestic quails offered in retail stores does not always originate from special meat-type populations. For many years, the production of quail meat was based on the American meat-type Pharaoh breed (Afanasyev et al., 2015), whose meat production traits are already unsatisfactory for the modern consumers. Today, consumers' preferences are increasingly focused on quails with larger and more muscled carcasses. These attitudes have stimulated the selection work in the desired direction. Thus, in many countries around the world, heavy meat-type populations of domestic quails were created and currently used for stock production of quail meat (Afanasyev et al., 2013). Such a specialized meat-type line was created in the Poultry breeding unit at the Faculty of Agriculture, Trakia University – Stara Zagora, Bulgaria. The line is acknowledged in the specialized literature as WG line (Lukanov et al., 2018a) and is characterized with significantly early onset of sexual maturity and exceptionally intensive growth performance at a young age (Genchev and Lukanov, 2019). A lot of results have been reported in scientific literature regarding the productivity of meat-type quails, yet the relatively great variations in live body weight for the same or very close ages in reports should be noted. In Pharaoh quails fattened until 28-30 days of age, live weights from 110-120 (Tarasewicz et al., 2007) to 156-159 g (Naumova and Donets, 2013) were reported. Weights published for birds at 33-35 days of age ranged between 139.4 (Wilkanowska and Kokoszynski, 2011) and 196.8 g (Afanasyev et al., 2015), and for 40-42 days old quails – between 169.1 (Wilkanowska and Kokoszynski, 2011) and 242-252 g (Naumova and Donets, 2013). These live weight differences are associated with substantial variations in slaughter traits. Most researchers affirm that as the age of quails advanced, slaughter yields increased. However, peak values reported in different studies were obtained at various ages: 5 weeks (Bughio et al., 2020), 6 weeks (Naumova and Donets, 2013; Afanasyev et al., 2015; Abou-Kassem et al., 2019), 7 weeks (Afanasyev et al., 2013). According to Alkan et al. (2013) the age of maximum slaughter yields depends on the aim of selection with a specific population. The analysis of slaughter yield with respect to the sex of birds also demonstrated contradictory results. Slaughter yield of male quails was reported to decrease between 5 and 7 weeks of age (Seker et al., 2007), whereas more recent investigations have proved increased yields during the same age period (Abou-Kassem et al., 2019).

The presented variable data have determined the aim of the

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present study – evaluation of slaughter age on productive traits, slaughter traits and meat quality of quails from the specialized meat-type WG line.

Material and methods

Experimental design

The trials were conducted at the Training and experimental base of the Poultry Breeding unit, Faculty of Agriculture, Trakia University – Stara Zagora, Bulgaria. The experimental design included 224 domestic quails from the specialized meat-type WG line. The birds were fed compound feeds during three phases. The ingredients and nutritional content of the respective feeds are presented in Table 1. Day-old quails were housed in battery cages, 56 per cage, divided into 4 groups. The rearing conditions in all cages were the same, strictly according to species' requirements. During the study period, the following traits were monitored: livability (%), live body weight (g), weight gain (g), feed intake (g), feed conversion ratio (kg/kg weight gain). The birds were sexed at 14 days of age on the basis of differences in feathering colour patterns. Male and female quails were housed in separate cages and from that time onward, registration of traits was done in relation to sex. Five subgroups from each sex were formed, with 20 birds each.

Table 1. Component (%) and nutritional composition of the compound feed mixtures used

Components	Starter (1-14 days of age)	Grower (15-21 days of age)	Finisher (22-42 days of age)
Corn	29.2	35.5	38.8
Wheat	21	23.8	27
Soybean meal, 44% CP	34.6	25.8	20
Sunflower meal, 34% CP	8	8.5	9
Fish meal, 72% CP	2	1	0
Sunflower oil	0.615	0.905	1
Dicalcium phosphate	1.92	1.82	1.71
Chalk	1.52	1.48	1.43
Vitamin premix	0.6	0.6	0.5
NaCl	0.2	0.2	0.2
$NaHCO_3$	0.1	0.1	0.1
Lysine, 98%	0.11	0.175	0.15
DL-methionine	0.135	0.12	0.11
Nutritional composition			
ME, MJ/kg	11.06	11.51	11.79
CP, %	24.00	20.51	18.04
CF, %	5.28	5.02	4.90
Ca, %	1.20	1.10	1.00
Available P, %	0.50	0.45	0.40
Lysine, %	1.30	1.10	0.91
Methionine %	0.52	0.45	0.40
M+C, %	0.92	0.81	0.73
Linoleic acid, %	1.30	1.62	1.75
Feed price, BGN/t*	764.08	672.13	591.48

CP- Crude Protein; ME- Metabolizable Energy; CF- Crude Fibre; Ca- Calcium; P- Phosphorus; M+C- methionine+cysteine; *1BGN=0.51 EUR.

Health status and mortality were monitored on a daily basis. Live body weight was measured weekly on a CB 2000 balance with precision of 0.1 g. The amounts of offered feed and remnants from non-consumed feed from the previous day were measured every day with precision of 0.1 g. On the basis of feed intake over one week and the weight gain, feed conversion ratio was calculated for each sex. Data by groups up to 14 days of age were taken into account in the calculation of productive traits by gender. Production efficiency indices were calculated using the European production efficiency factor (EPEF) and European broiler index (EBI) used in broiler chicken production according to the formulas (Marcu et al., 2013):

EPEF = [livability (%) x live weight (kg)/age (days) x FCR (kg/kg weight gain)]x100 (1)

EBI = livability (%) x daily weight gain (g/day/bird)/ FCR (kg/kg weight gain)x10 (2)

Slaughter analysis

At 28, 35 and 42 days of age, after 4-hour fasting and 3-hour water withdrawal, 15 male and 15 female birds with weight close to the group average were selected for slaughter analysis. Procedures relating to euthanasia of birds, processing, parcelling and deboning of quails were performed according to the protocol described by Genchev and Mihaylov (2008). To avoid any possible effect of scalding on meat colour analysis, the feathers were removed from the carcass by skinning. The weight of skinless carcasses, of visceral organs, and different cuts were determined on Kern EMB 200-3 analytical balance

(KERN & SOHN GmbH) with precision of 0.001 g.

The temperature (°C) and pH of *M. pectoralis superficialis* were determined at post slaughter hour 24 (pH_u) with a portable Milwaukee MW 102 pH meter (Milwaukee Instruments, Inc.). Before use, the device was calibrated in standard solutions with pH 4.0 and pH 7.0.

The colour of *M. pectoralis superficialis* was determined on *post mortem* hour 24 by means of PCE-CSM 2 spectrophotometer (PCE Instruments). Colour coordinates in the CIEL*a*b* system in CIE illuminant D-65 on the lateral muscle surface was used. On the basis of values of a^* and b^* coordinates, chroma (C*), hue angle (Hue^o) and the meat colour index (MCI) were calculated by the following equations:

Chroma (C*) = $(a^{*2} + b^2)^{0.5}$ (3)

Hue angle^o (h^o) = $[\tan^{-1} (b^*/a^*).180^o]/\pi$

(Petracci and Baeza, 2009) (4)

Meat colour index (MCI) = L* - C*

(Lukanov et al., 2018b), (5)

where lower values corresponded to darker meat.

Statistical analysis

Data were analyzed with IBM® SPSS® Statistics (V26) software. Calculations aimed at evaluation of the type of relationship between different traits and effect strength of the different factors on trait determination were performed according to models described in detail by Merkurieva (1970).

Results and discussion

The live weight and weight gain were very strongly influenced by both sex and fattening period duration (Table 2). All sex-related differences were statistically significant ($p<0.05$), with increased level of significance after 28th day of age. It was found out that in male quails, both live weight and weight gain were influenced by fattening duration only up to the 35th day of age ($p<0.001$). After that age, the body weight of male quails remained practically the same, which does not justify their further rearing under real production conditions. In females, live weight and thus, weight gain increased at a stable rate until 42 days of age, with statistically significant ($p<0.001$) differences at different ages.

Table 2. Average live body weight and weight gain of quails at the end of the fattening period, g

Age, days	Male	Difference	Female
	Live body weight		
28	232.03±1.40^c	**	238.45±1.57^c
35	259.79±2.20^d	***	280.82±1.90^d
42	262.36±2.23^d	***	314.93±2.86^e
	Weight gain		
1-28	219.43±2.46^c	*	227.30±2.77^c
1-35	250.10±1.70^d	***	270.39±1.61^d
1-42	251.89±2.23^d	***	304.46±2.86^e

*Differences between values marked with different letters were demonstrated at $p<0.001$.

The more detailed analysis of production parameters showed that in this experiment, quails from the WG line demonstrated excellent livability, ranging within 97.3-98.4% without sex- or age-related effects (Table 3). In relation to fattening period duration, the amount of feed per bird and the intake of metabolizable energy (ME) and nutrients increased by more than 73% in males and by more than 87% in females (by 38- 41% for the period 28-35 days of age and by 25.7-32.9% for the period 35-42 days of age). For the same fattening period, Inci et al. (2015) have reported very close results to ours in quails from different colour varieties. For all three age periods, the amount of consumed feed, respectively metabolizable energy and nutrients by female quails was higher, and as fattening period became longer, the sex-related difference increased from 2.3 to 10.6%. Consequently, the cost of feed necessary for fattening of one bird increased from 0.38-0.39 BGN over a 28-day period to 0.63-0.69 BGN for 42-day period, which corresponds to price increase by 64.5% in male sex and by 77% - in females. The values of the two production efficiency indices - EPEF and EBI, confirm these facts. They showed unquestionably that the efficiency of producing male quails was lower than that of females, with particular decline of efficiency after 35 days of age.

Table 3. Feed and nutrients necessary per bird at different durations of the fattening period

Parameters	Fattening period, days					
	1-28		1-35		1-42	
	♂	♀	♂	♀	♂	♀
Livability, %	98.37	98.32	97.63	97.51	97.39	97.27
Feed, g/bird	576.90	590.13	795.60	832.45	1000.38	1106.11
ME, MJ/bird	6.62	6.77	9.19	9.63	11.61	12.85
CP, g/bird	119.52	122.00	158.94	165.69	195.86	215.02
Lysine, g/bird	6.31	6.44	8.30	8.64	10.15	11.12
M+C, g/bird	4.71	4.81	6.31	6.58	7.81	8.59
FCR, kg/kg	2.941	2.888	3.545	3.369	4.381	3.944
Consumed feed value, BGN*/bird	0.38	0.39	0.51	0.53	0.63	0.69
EPEF	27.33	28.90	20.50	23.22	13.89	18.49
EBI	26.22	27.64	19.68	22.36	13.33	17.88

CP- Crude Protein; ME- Metabolizable Energy; M+C - methionine + cysteine; FCR- Feed Conversion Ratio; EPEF- European production efficiency factor; EBI- European broiler index; *1BGN=0.51 EUR.

The fattening period of quails from the WG line had a considerable influence on slaughter traits (Table 4). The strongest effect was observed on absolute values of weights of cleaned carcass without offal (dressed carcass weight), deboned breast and thigh meat and abdominal fat. As a result of changes in live weight and weight gain occurring with age, dressed carcass weight also increased significantly ($p<0.001$). A similar conclusion was drawn also by other research teams in line with our data (Wilkanowska and Kokoszynski, 2011), reporting a more obvious effect until 35 days of age (Bughio et al., 2020). During the subsequent period (35-42 days), live weight increased only in female birds ($p<0.05$). The evaluation of sex effect on live weight showed that for all three studied ages, dressed carcass weight was higher in female quails, which followed from their higher live weight ($p<0.01$). Deboned meat weights of valuable carcass cuts (breast and thighs) followed a pattern similar to that of dressed carcass weight changes. Our results and interpretation agree with conclusions of Vali et al. (2005) and Kumar et al. (2011) but were not fully in line with those of El-Full (2000) about sex influence on slaughter traits of quails.

Table 4. Slaughter characteristics of quails depending on the length of the fattening period

Parameters	♂	Difference	♀
		Slaughter at 28 days of age	
Live body weight, g	227.70±1.39^{c}	***	238.08±2.20^{c}
Carcass weight, g#	132.53±1.18^{c}	***	140.27±1.07^{c}
Carcass yield, %*#	58.23±0.57^{c}		58.96±0.47^{ab}
Meat in breast and legs, g	87.87±0.75^{c}	***	92.97±1.03^{c}
Meat in breast and legs, %	66.33±0.46		66.26±0.29^{c}
Abdominal fat, g	0.81±0.14^{c}		0.96±0.17^{c}
Abdominal fat, %	0.62±0.11^{e}		0.68±0.12^{c}
		Slaughter at 35 days of age	
Live body weight, g	261.2±3.70^{d}	***	281.4±2.21^{d}
Carcass weight, g#	162.77±2.03^{d}	**	171.01±2.29^{da}
Carcass yield, %*#	62.39±0.69^{d}		60.84±1.02^{a}
Meat in breast and legs, g	107.59±1.78^{d}		108.98±1.47^{de}
Meat in breast and legs, %	66.07±0.45	***	63.73±0.21^{ad}
Abdominal fat, g	1.07±0.23^{a}	**	2.51±0.38^{de}
Abdominal fat, %	0.66±0.15^{a}	**	1.49±0.23^{ad}
		Slaughter at 42 days of age	
Live body weight, g	261.47±2.59^{d}	***	314.00±3.43^{e}
Carcass weight, g#	161.54±2.43^{d}	***	180.37±2.51^{b}
Carcass yield, %*#	61.77±0.63^{d}	***	57.52±0.98^{b}
Meat in breast and legs, g	107.24±1.32^{d}	***	116.55±2.23^{df}
Meat in breast and legs, %	66.46±0.59	*	64.59±0.69^{b}
Abdominal fat, g	1.97±0.32^{bd}	***	3.90±0.26^{df}
Abdominal fat, %	1.22±0.19^{bf}	***	2.16±0.14^{bd}

Note: # The parameters presented are for skinless carcasses; Differences between the weight of male and female birds are noted with *: *$p<0.05$; **$p<0.01$; ***$p<0.001$; Differences between values of different ages within the same sex, marked with different letters, have been demonstrated in: a-b - at $p<0.05$; f-g - at $p<0.01$; c-d-e - at $p<0.001$.

The relationship between slaughter weight and dressed carcass weight, as well as between slaughter weight and weights of valuable cuts showed that in both cases the relationship of traits was almost linear (curvilinearity coefficient between 0.040 and 0.115). This fact allowed performing correlation analysis that showed correlation coefficients between slaughter and dressed carcass weights of $r=0.900$ in male and $r=0.866$ in female quails. The correlation coefficient of valuable carcass cuts *vs* slaughter weight were $r=0.889$ and $r=0.823$ in male and female birds, respectively. For both studied traits, their association with slaughter weight was slightly less strong in females. This is attributed to physiological changes in the reproductive tract of female birds occurring with age. For both traits, their correlation with slaughter weight in females was the strongest at 28 days of age, when sexual maturity intensity was still low. After that age, the relationship between both traits declined at a very intensive rate. The calculations demonstrated that the strength of slaughter weight effect on coefficients of determination of dressed carcass weight and manually deboned meat weight was weaker at 35 days of age than at either 28 or 42 days of age (Figure 1).

This weakening of the relationship is a direct consequence of the end of intensive growth in male WG quails about the 35th day of age and the increasing disproportion between the slaughter and dressed carcass weights of female birds after 28 days of age. This was confirmed by slaughter yield, which increased up to 35 days of age in both sexes ($p<0.05$), and afterwards decreased. A similar tendency for slaughter age effect on quail slaughter yield was reported by other authors (Alkan et al., 2013; Afanasyev et al., 2015; Abou-Kassem et al., 2019; Bughio et al., 2020). The dependency of the trait on slaughter age was significant ($\eta=0.548$), and slaughter yield

values after 28 days of age were higher in male birds. Only at 42 days of age, however, the differences were statistically significant ($p<0.001$). A comparable tendency for sex effect on slaughter yields as age increased was also reported by Kumar et al. (2011) and Afanasyev et al. (2013). On the contrary, Kosshak et al. (2014), Afanasyev et al. (2015), and Hamad et al. (2019) reported facts for higher slaughter yield in females compared to males. The study of Naumova and Donets (2013) provided evidence that slaughter yield of females from the investigated Pharaoh population was higher until 6 weeks of age, and thereafter, the opposite tendency was observed. Abou-Kassem et al. (2019) found out that as slaughter age increased from 5 to 7 weeks, the slaughter yield of males increased, whereas in females it was reduced.

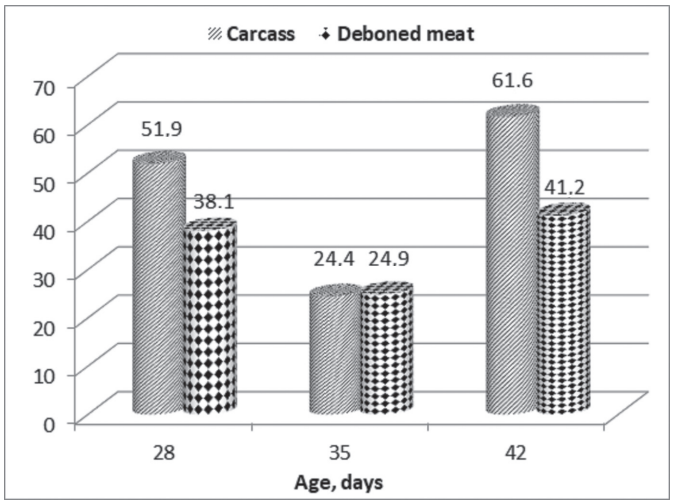

Figure 1. Strength of influence of the carcass weight on the manifestation of the carcass weight and the weight of the meat from the valuable carcass parts (%)

Reported results for slaughter yield vary within a rather large range – from 54.6-60.2% (Bughio et al., 2020) to 77.0-83.2% (Abou-Kassem et al., 2019). The most frequently reported data are for carcasses with skin, whereas the results presented in this study refer to skinless carcasses. Taking into consideration that fact, skin weight was calculated and it was concluded that recalculated slaughter yields (between 62.05 and 66.59%) were the closest to those reported by Wilkanowska and Kokoszynski (2011) (63.7% at 33 days of age and 66.1% at 42 days of age) and Tarasewicz et al. (2007) (64.53-66.31% for male quails at 42 days of age).

Dispersion analysis showed that the two production traits exceptionally important for evaluation of meat productivity (dressed carcass weight and deboned meat weight) were influenced by both fattening period duration and the sex of quails ($p<0.001$). The analysis confirmed that fattening period had a predominant effect (72.2% of the total variation for dressed carcass weight and 69.59% - for deboned meat). The sex effect on these two traits was significantly weaker - 8.74% for dressed carcass weight and 4.50% for deboned meat weight. According to the analysis, the determination of slaughter yield, similarly to dressed carcass and deboned meat weights, was more strongly influenced by slaughter age (14.75%; $p<0.001$) and less strongly by quail sex (5.69%; $p<0.05$). The relationships for the other important trait – deboned meat – was the opposite; this trait was determined more strongly by quail sex (11.75%; $p<0.001$) than by slaughter age (8.27%; $p<0.05$).

On the basis of production costs and slaughter results, the necessary feed, metabolizable energy and nutrients for production of 1 kg dressed quail carcasses and 1 kg deboned breast and thigh meat were calculated according to slaughter age and sex of quails (Table 5). In relation to fattening period, the necessary feed for production of 1 kg dressed carcasses from WG quails increased from 4.21-4.35 kg for 28-day period to 6.13-6.19 kg for 42-day period. This constituted an increase of 42.3-45.8% of quails' needs for feed, whose share in production costs is more than 60% as acknowledged by agricultural science. Accounting for the increase in feed necessary for production of 1 kg dressed quail carcasses, its cost also increased yet not proportionally to feed increase (35-37.7%). Calculations for production of 1 kg deboned breast and thigh meat showed that the necessary amount of feed increased by 42.1 and 49.5% (from 6.35-6.57 for 28-day fattening to 9.33-9.49 kg for 42-day fattening), forming an increase in costs by 34.8-41.2%. When making an estimate about the amount of produce obtained from 1 BGN production cost, it could be observed that as fattening age increased, the efficiency of invested capital was reduced, with slower reduction between 28 and 35 days of age. During that period, except for live body weight, the reduction in dressed carcass and deboned meat weights was more pronounced for female quails. During the period 35-42 days of age, the reduction of all traits was greater *vs* the previous period, with more pronounced decline in male birds. Summarizing the results for the reduction in produce from 1 BGN investment (by 8-14% for the period 28-35 days of age) and the increase (by 17-23% for the same period) in the amount of produce per bird (see Table 4), it could be convincingly affirmed that the period between the 28th and 35th day was the most appropriate for scheduling slaughter in WG quails. During that age period, the economic efficiency began to decline, but it still remained within acceptable limits in both sexes, which makes the produce more attractive for consumers.

For meat production, not only quantitative and economic parameters, but also the quality is of particular significance. Meat quality is what attracts the consumer and in fact, sells the product. Among meat quality traits, meat pH and colour are important. pH_u values of *M. pectoralis superficialis* varied between 5.74 and 6.26 and were influenced neither by slaughter age, nor by bird sex (Table 6). Similar to our average meat pH results were reported by Genchev et al. (2010) (5.88-6.0 in males and 5.8-5.99 in females), Wilkanowska and Kokoszynski (2011) (5.92 at 33 days of age and 5.96 at 42 days of age) and Narinc et al. (2013) (5.94 ranging from 5.3 and 6.78). Higher data were published by Zerehdaran et al. (2012) (6.36, range 5.3-7.4) and Hamad et al. (2019) (6.11 in males and 6.18 in females); the latter results corresponded to those from a previous study by Genchev et al. (2008) and Genchev (2010) using the same quail genotype.

Table 5. Productive characteristics of quails from the WG line depending on the fattening period duration

Parameters		Fattening period, days					
		1-28		1-35		1-42	
		♂	♀	♂	♀	♂	♀
Consumption to form 1 kg cleaned carcass							
Compound feed, kg		4.353	4.207	4.888	4.868	6.193	6.132
ME, MJ		49.9	48.3	56.5	56.3	71.9	71.3
CP, kg		0.902	0.870	0.977	0.969	1.213	1.192
Lysine, g		47.6	45.9	51.0	50.5	62.8	61.6
M+C, g		35.5	34.3	38.8	38.5	48.4	47.6
Value of 1 kg, BGN*		2.90	2.80	3.15	3.12	3.91	3.85
Consumption to form 1 kg of meat from the carcass valuable parts							
Compound feed, kg		6.566	6.347	7.395	7.638	9.328	9.490
ME, MJ		75.3	72.8	85.5	88.3	108.2	110.3
CP, kg		1.360	1.312	1.477	1.520	1.826	1.845
Lysine, g		71.9	69.3	77.1	79.3	94.6	95.4
M+C, g		53.6	51.7	58.7	60.4	72.9	73.7
Value of 1 kg, BGN*		4.37	4.22	4.76	4.90	5.90	5.96
Received production against 1 BGN invested							
Live body weight, g		592.50	606.74	509.75	526.65	413.47	452.04
	Difference		♂ -14.0%; ♀ -13.2%		♂ -18.9%; ♀ -14.2%		
Cleaned carcass weight, g		344.86	357.47	317.66	320.06	255.45	259.67
	Difference		♂ -7.9%; ♀ -10.5%		♂ -19.6%; ♀ -18.9%		
Deboned meat, g		228.64	236.94	209.96	203.96	169.59	167.79
	Difference		♂ -8.2%; ♀ -13.9%		♂ -19.2%; ♀ -17.7%		

*CP- Crude Protein; ME- Metabolizable Energy; M+C- methionine + cysteine; *1BGN=0.51 EUR.

The data about meat colour characteristics showed that as slaughter age increased, the most important changes were those in the L* coordinate, expressed by lower meat lightness ($p<0.001$), whereas the most intensive changes occurred between 28 and 35 days of age (6.3%). A similar association of the trait with slaughter age was reported by Genchev et al. (2010) and Genchev (2010). In general, lightness of *M. pectoralis superficialis* in female quails was slightly higher than in males, in line with previous data (Genchev et al., 2010). Between 28th and 35th day of age, changes were observed in the values in the other two colour coordinates – a* and b*. The investigation of previous research results on this subject showed a very large range of reported average values. For a* coordinate they were between 2.7 (Zerehdaran et al., 2012) and 23.9 (Narinc et al., 2013), whereas for b* coordinate - from -1.7 (Zerehdaran et al., 2012) to +19.8 (Boni et al., 2010). In the present study, the values of a* varied between 5.77-11.6, whereas the values of b* - from 5.14 to 11.13. As age of quails advanced, the meat redness decreased by 3.8%, whereas yellowness increased by 1.6%. Interpreting the values of coordinates a* and b* in relation to sex, it could be affirmed that redness of *M. pectoralis superficialis* was more pronounced in female quails, whereas yellowness – in males (8.37±0.19 *vs* 7.87±0.16; $p<0.05$).

The colorfulness – chroma (C*) and the Hue angle provide information for the exact point of intersection of coordinates a* and b* in the coordinate system. As slaughter age advanced, C* decreased slowly (by 1.3% from 12.38 to 12.21). The analysis of the effect of pigments from the red/green and yellow/blue spectra on chroma values showed that C* of *M. pectoralis superficialis* was more substantially influenced by pigments from the red spectrum of the a* coordinate. With age, however, a tendency towards slightly lower a* influence on the account of stronger meat yellowness was found out, supported by increased Hue angle values. In general, in male quails, chroma (C*) exhibited a stable tendency towards decrease as slaughter age advanced, whereas the opposite tendency was confirmed for females. The greatest between-sex difference was found out at 28 days of age ($p<0.001$). As birds became older, pigment saturation of meat decreased, with more intensive changes between 28 and 35 days of age where differences were 8% in male and 6% in female quails. The Hue angle was between the X-axis (here, a* coordinate) and chroma. The analysis showed that in males C* was slightly deviated towards the yellow spectrum as compared to females ($p<0.01$).

The other important feature for meat quality evaluation – the meat colour index (MCI) combines the interaction of the three colour coordinates L*, a* and b*. As slaughter age increased, a marked darkening of *M. pectoralis superficialis* after the 28th day of life was noticed ($p<0.001$). This denotes that by the 35th day, the breast meat of domestic quails assumes a colour rather typical for game meat. This is in line with consumers' attitudes about domestic quail meat, and thus, improves its commercial presentation. Concerning the sex effect, this tendency was better expressed in male birds.

Table 6. Color characteristics of *M. pectoralis superficialis* depending on the age of slaughter of quails (24h *post mortem*)

Parameters	28 days of age		35 days of age		42 days of age	
	♂	♀	♂	♀	♂	♀
pH_u			♂ 5.92±0.02 ♀ 5.90±0.03			
	5.88±0.04		5.96±0.02		5.89±0.03	
	5.85±0.03	5.91±0.06	5.99±0.03	5.92±0.03	5.92±0.04	5.87±0.02
L*			♂ 50.10±0.44 ♀ 51.12±0.40			
	52.56±0.50^{c}		49.21±0.32^{d}		50.06±0.52^{d}	
	52.66±0.50	52.46±0.89	48.53±0.50^{a}	49.89±0.34^{b}	49.10±0.77	51.02±0.63
a*			♂ 9.05±0.18 ♀ 9.27±0.16			
	9.38±0.17		9.07±0.22		9.04±0.24	
	9.74±0.22^{a}	9.02±0.23^{b}	8.83±0.36	9.32±0.25	8.59±0.30	9.48±0.33
b*			♂ 8.37±0.19^{a} ♀ 7.87±0.16^{b}			
	8.04±0.21		8.14±0.23		8.17±0.25	
	8.81±0.22^{c}	7.27±0.21^{d}	8.21±0.38	8.07±0.28	8.09±0.35	8.26±0.29
Chroma			♂ 12.35±0.24 ♀ 12.19±0.19			
	12.38±0.23		12.22±0.28		12.21±0.29	
	13.15±0.28^{c}	11.61±0.24^{d}	12.09±0.45	12.34±0.34	11.81±0.45	12.61±0.35
Hue angle ^{o}			♂ 42.71±0.48^{f} ♀ 40.30±0.58^{g}			
	40.51±0.64		41.86±0.70		42.14±0.69	
	42.14±0.65^{f}	38.88±0.94^{g}	42.86±1.16	40.85±0.74	43.13±0.62	41.16±1.21
MCI			♂ 37.75±0.46 ♀ 38.94±0.44			
	40.20±0.57^{cf}		37.00±0.46^{d}		37.90±0.48^{g}	
	39.51±0.67	40.86±0.92	36.43±0.85	37.54±0.35	37.29±0.68	38.41±0.68

*Differences between values marked with different letters are statistically proven at: a-b – at p <0.05; f-g - at p <0.01; c-d-e - at p <0.001.

Conclusion

It was found that: 1) The longer duration of the fattening period in quails from the meat-type line WG was associated with lower production efficiency with more pronounced effect after the 35th day of life. The production efficiency in male quails was lower compared to that in females. 2) The dispersion analysis demonstrated that the determination of 72.2% and 69.6% of dressed carcass weight and deboned meat weight, respectively, depended on fattening period duration (p<0.001). When fattening increased from 28 to 42 days, the amount of feed necessary for one bird increased by 73% and 87%, corresponding to increased costs by 64.5% and 77%. For production of 1 kg dressed quail carcasses, the necessary feed increased by 42.3-45.8% on a weight basis and by 35-37.7% on a cost basis. For production of 1 kg deboned meat the corresponding increases are by 42.1-49.5% and 34.8-41.2%, respectively. 3) The period between 28 and 35 days of age is the most appropriate for planning slaughter of WG quails. During that period the economic efficiency, although already declining, was still within acceptable limits and the increase in quantitative traits in both sexes – still relevant, making the produce more attractive for consumers. 4) With age, the changes in colour characteristics of *M. pectoralis superficialis* result in darkening of meat (p<0.001). Thus, it assumes nuances rather specific for game meat. This effect is desirable, as it improves the commercial presentation of domestic quail meat in line with consumers' attitudes. On the basis of the present study, taking into account that slaughter yield increased up to 35 days of age and that production efficiency was strongly reduced after that time making further fattening meaningless, we could recommend scheduling of slaughter of domestic quails from the meat-type WG line between 28 and 35 days of age.

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