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Comparative studies on performance and meat texture traits in Pekin duck genetic resources and commercial hybrids

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ABSTRACT. The aim of the study was to determine and compare basic performance and slaughter traits, as well as meat texture in Pekin ducks from two genetic groups: Star 53 H.Y. (commercial hybrid, Grimaud Frères, France) and P-33 (Polish Pekin, domestic genetic resource), with consideration of bird sex. The experimental material consisted of 160 Pekin ducks, divided into two groups (80 birds each) according to genetic origin: A – Polish Pekin P-33 and B – Star 53 H.Y. The results showed more favourable ($P \leq 0.05$) performance trait values in the commercial group compared to the genetic resource group of Pekin ducks, including growth rate in the last (7th) week of rearing, final body weight, slaughter yield, carcass weight, proportion of breast muscle, skin with subcutaneous fat in the carcass, and remainders (neck, wings, skeleton). Analysis of meat texture indicated significant differences ($P \leq 0.05$) between the two flocks only after heat treatment: meat from the conservation group was more tender in both blade shear tests.

KEY WORDS: duck, genotype, meat quality, production traits, texture

Introduction

Ducks descended from the mallard (*Anas platyrhynchos* L.) evolved in China over the past few centuries and were introduced to the USA around 1873, and to Europe a few years later. Known as Pekin ducks, they became the dominant breeding stock in many parts of the world (Jung and Zhou, 1980; Galić et al., 2019). In Europe, their genetic potential is mainly used for duck meat production. Ducks are sexually dimorphic, although this trait is not strongly expressed in Pekin ducks (Solomon et al., 2006). It is estimated that between 1961 and 2010, duck production increased sixfold, largely due to the introduction of intensive selection programmes aimed at improving weight gain, feed conversion and reproduction (Huang et al., 2012). Currently, the wide range of strains and genetic groups subjected to different levels of selection, is used for comparative analyses of performance traits (Adamski et al., 2005; Muhlisin et al., 2013; Graczyk et al., 2016) and overall meat quality (Lacin et al., 2008; Fernandez et al., 2010; Huda et al., 2011; Lewko et al., 2024). However, reports on duck meat texture remain limited. Studies concerning meat texture parameters in various livestock species indicate that it depends on a number of ante-mortem and post-mortem factors, including species, breed, crossbreeding system, sex, age, individual variation, housing and feeding conditions, as well as anatomical location (muscle type). These factors primarily determine the texture of raw meat (Ghazali et al., 2013). Heat treatment is one of the most important technological operations in meat processing and preparation for consumption, although it is associated with changes in meat quality. As a result of protein denaturation, structural changes occur in muscle fibres and connective tissue, while fat and water become immobilised within the formed spatial network, leading to the development of a stable product structure (Wołoszyn et al., 2011; Augustyńska-Prejsnar and Sokołowicz 2014). This, in turn, determines the tenderness or toughness of heat-treated meat. Therefore, the technological assessment of meat quality should include the evaluation of both raw and heat-treated meat texture. Currently, instrumental testing is the most widely used approach, as it is faster than sensory analysis and provides higher repeatability of results (Diakun et al., 2012).

The objective of the study was to determine and compare the basic performance and slaughter traits, as well as meat texture of Pekin ducks from two genetic groups, Star 53 H.Y. and P-33. The former is a commercial hybrid (Grimaud Frères, France), while the latter (Polish Pekin) is a domestic breed maintained as part of poultry genetic resources. The effect of sex was also taken into account.

Material and methods

The ducks used in the experiment were hatched and reared for 7 weeks at the Experimental Station of the National Research Institute of Animal Production in Kołuda Wielka, Waterfowl Genetic Resources Station in Dworzyska in a semi-intensive system with access to an outdoor run. The experimental material comprised 160 Pekin ducks, divided into two groups (80 birds each) depending on their genetic origin: A – Polish Pekin P-33 and B – Star 53 H.Y. On the day of hatching, ducklings were sexed, marked with wing tags, and placed in a 1:1 sex ratio. During the first 4 weeks, they were reared in a climate-controlled room divided into boxes, each housing 8 ducks of the same sex. Room humidity was maintained at 60–70%, with temperature set at 24–26 °C in the first week and reduced by 2 °C each subsequent week. From week 5 onward, ducks were gradually acclimated to the outdoor run and, starting in week 6, kept outside until the end of the rearing period, maintaining the division into experimental groups. Outdoor temperature ranged from 12 to 26 °C with humidity between 50 and 75%. Stocking density was 7 birds per m^2 until the end of week 4 of rearing, and 3 birds m^2 thereafter. All birds received complete KB feed *ad libitum*, composed of: wheat, maize, barley, post-extraction genetically modified soybean and sunflower seed meal, wheat bran, calcium carbonate, monocalcium phosphate, soybean oil, sodium chloride and sodium bicarbonate. Ducks up to 4 weeks of age received the KB-1 mixture (20% crude protein, 12.1 MJ metabolic energy/kg, 3.0% fat, 3.2% fibre, 6.0% ash, 0.46% methionine, 1.12% lysine and 1.03% calcium) while older birds were fed KB-2 (18.5% crude protein, 11.8 MJ metabolic energy/kg, 2.3% fat, 4.5% fibre, 4.9% ash, 0.41% methionine, 0.80% lysine, and 1.59% calcium).

Birds were weighed individually at the end of each week using an Axis B15 S electronic scale (accuracy 5 g). The economic performance indicator (EPI) was calculated, and growth rate (GR) for selected growth periods of ducks was calculated using the following formula:

$$GR\% = \frac{fw - iw}{1/2(iw + fw)} \times 100,$$

where: *fw* – body weight at the end of the study period, *iw* – body weight at the beginning of the study period.

To assess carcasses composition and meat tenderness, 18 birds were selected from each group (9 males and 9 females), excluding individuals with extreme body weights. These birds were slaughtered after a 12-hour fasting period with access to drinking water. After electrical stunning and decapitation, standard post-slaughter procedures were applied. After evisceration and cleaning, carcasses were cooled by immersion in ice water for approximately 45 minutes, until the temperature in the breast muscles reached 9 °C. After draining (hanging on stands for 15 minutes), the carcasses were stored at 4 °C and 60–65% humidity. Twenty-four hours after slaughter, carcasses were individually weighed (CW), a simplified dissection was performed (Ziołecki and Doruchowski, 1989) and slaughter yield (SY) was calculated. During dissection, the following carcass components were isolated and weighed (Radwag WPT 5C): breast muscles (a total of 2 *m. pectoralis superficialis* and 2 *m. pectoralis profundus* muscles, BM), leg muscles (muscles from 2 thighs and 2 drumsticks, LM), skin with subcutaneous fat (SF), abdominal fat (AF) and remainders (CR), including neck (without skin), skeleton with back muscles and inedible parts (tendons) and wings (with skin). The proportion of each component in the eviscerated carcass with neck, excluding offal (% S), was then calculated.

Samples (10 per muscle) with a cross-section of 1 × 1 cm and a length of 1.5 cm, oriented along the muscle fibres were collected from the superficial pectoral muscle (*m. pectoralis superficialis*) and thigh muscles of each dissected bird. Six of the ten samples from each muscle were subjected to heat treatment (Honikel 1998). The samples were placed individually in hermetically sealed foil bags and heated in a water bath at 80 °C for 40 minutes. Texture parameters of raw and heat-treated muscles were determined using a TA.XT plus analyser (Stable Micro Systems). Shear force (F) was measured using a Warner-Bratzler flat blade (FB) and a Warner-Bratzler triangular blade (TB), while bite (B) force (F) was assessed using Volodkevich jaws (VJ). The initial force (F1), i.e., the force required to initiate cutting, and the final force (F2), i.e., the force required to cut through the entire sample, were measured. The blade speed was set at 1.5 mm/s, and the Volodkevich jaws operated at 2.0 mm/s.

The results were analysed using Statistica 10 (StatSoft, 2006). Mean values and the standard error of the mean (SEM) were calculated for all parameters. A two-factor analysis of variance was applied to evaluate the effects of genotype (G) and sex (S), as well as the G × S interaction. Differences between means were assessed using Duncan's test. Statistical significance was set at $P < 0.05$.

Results

After 7 weeks of rearing, ducks in group B had significantly higher ($P \leq 0.05$) body weight, EPI, carcass weight, and slaughter yield than those in group A (3.48 vs 2.50 kg, 294 vs 178, 2.34 vs 1.50 kg, and 65.89 vs 63.28%, respectively; Table 1). Considering sex, a significant difference ($P \leq 0.05$) was observed only in group A, where drakes (2.74 kg) were significantly ($P \leq 0.05$) heavier than females (2.26 kg). A highly significant ($P < 0.001$) effect of genotype and sex was found for all four performance traits and for growth rate in all analysed rearing periods. A significant interaction between genotype and sex was also observed in the period from weeks 4 to 6. During this period, drakes had a higher growth rate ($P \leq 0.05$) than females (group A: 80.5 vs 76.0%; group B: 81.4 vs 76.6%). However, when genotype was considered, a significant difference ($P \leq 0.05$) in growth rate was recorded only in the last week of rearing (group A: 17.4 vs group B: 23.7%).

The proportion of three carcass components (Table 2), namely breast muscle, skin with subcutaneous fat, and remainders, differed significantly ($P \leq 0.05$) between ducks of different genetic origin. Birds in group A were characterised by a higher proportion of breast muscle (by 5.03 p.p.) and a lower proportion of skin with subcutaneous fat (by 2.17 p.p.) and remainders content (2.54 p.p.). A significant ($P \leq 0.05$) effect of genotype on carcass tissue composition was confirmed, as well as an effect of sex on the proportion of leg muscle, skin with subcutaneous fat and abdominal fat.

The results of the raw muscle texture assessment (Table 3) obtained using both a flat and a triangular blade revealed significant ($P \leq 0.05$) sex-related differences in shear force of duck thigh muscles. These differences were consistent in both genetic groups (A and B) and in the overall mean for the entire population. The thigh muscles of females were tougher. Specifically, for the FB, the F1 force averaged 52.80 N in females and 35.18 N in drakes, while the force required for complete shearing was 68.69 N and 42.59 N, respectively. In contrast, for the TB, the corresponding values were F1 32.25 N (females) and 27.15 N (drakes), and F2

56.31 N and 35.82 N, respectively. For breast muscles in group B, meat from drakes was tougher in all F1 TB measurements.

When comparing the texture characteristics of meat after heat treatment (Table 4) in both genetic groups, the force required for cutting (F2) was lower in group A. For BM, the differences were significant ($P \leq 0.05$) for both blade types, while for LM significance was confirmed only for TB shearing. In genetic group B, significant ($P \leq 0.05$) sex-related differences were observed in F2 FB values. Specifically, BM from males were more tender than those from females (28.90 vs 31.69 N), whereas the opposite pattern was found for LM (45.74 vs 34.63 N). The biting test (both F1 and F2) also indicated significant ($P \leq 0.05$) sex-related differences in both muscle groups in group B: males had more tender BM but tougher LM. The differences for individual muscle parts were 2.86 N (F1) and 2.94 N (F2) for BM, and 2.86 N (F1) and 2.83 N (F2) for LM. In group A, a significant ($P \leq 0.05$) difference between sexes (2.92 N) was detected only for F1 BVJ BM. For BM after heat treatment, F2 values for FB and TB as well as F1 BVJ depended ($P \leq 0.05$) on genetic origin, whereas for LM, this dependence was confirmed only for F2 TB.

Discussion

During the period from 6 to 8 weeks of rearing, Pekin fattening ducks not only reach a body weight that satisfies the breeder but also develop a carcass conformation that meets consumer expectations (Witak, 2008; Pingel, 2011; Biesiada-Drzazga et al., 2012). It has been demonstrated that the main factors shaping ducks' body weight are genotype (Bernacki et al., 2008; Kokoszyński et al., 2015; Stęczny et al., 2015), sex (Wawro et al., 2004; Farhat, 2009) and nutrition (Farhat et al., 2001; Baèza, 2006; Gerzilov et al., 2011). The first two factors were confirmed by the results of the present study. After rearing, ducks from the commercial Star 53 H.Y. breeding line were heavier (Table 1) by 0.98 kg ($P \leq 0.05$). Both analysed factors, genotype and sex, as well as the genotype × sex interaction, exerted a significant ($P \leq 0.05$) effect on the final body weight of ducks. Furthermore, Kuźniacka and Adamski (2019) compared meat characteristics of two breeding lines for intensive production, P55 (Polish origin), F11 (French origin), and their hybrids, and demonstrated that genotype affected duck body weight, especially in the initial (up to 2 weeks) and final (6 to 7–8 weeks) rearing periods. Bernacki et al., (2008) also reported a significantly ($P \leq 0.05$) higher pre-slaughter body weight in Star 63 ducks (males 3113 and females 2881 g) compared to PP54 (males 2775 and females 2514 g). The authors also found significant differences ($P \leq 0.05$) in body weight between 7-week-old Star 63 males and females. Meanwhile, Biesiada-Drzazga et al., (2012) confirmed significant differences in body weight between males and females of the Star 53 H.Y line. These differences became apparent only after week 6 of life ($P \leq 0.05$) and during the following two weeks of rearing (weeks 7–8) ($P \leq 0.01$). However, in the present study, no sex-related variation in body weight was found within this genetic group. Differences in body weight related to sex were observed ($P \leq 0.05$) only in the P-33 group. Results reported by other authors also indicate such variation in this trait between P-33 drakes and ducks. For instance, Witkiewicz et al. (2006) recorded average weights of 3050 g for males and 2670 g for females after 7 weeks of rearing, while Kisiel and Książkiewicz (2004) obtained 2088 and 1986 g, respectively. In both studies, these sex-related differences in body weight were statistically significant ($P \leq 0.05$).

Star 53 H.Y. duck carcasses were significantly ($P \leq 0.05$) heavier (by 0.84 kg) than those of the P-33 group, with an average weight of 2.34 kg (Table 1). Carcass weight did not differ significantly between sexes, either within individual genetic groups or overall.

Slaughter yield is the fundamental indicator of slaughter value in livestock, including poultry. In Pekin ducks, it is significantly determined by genetic origin (Gornowicz et al., 2009; Onk et al., 2019). In the present experiment, P-33 ducks (63.28%) reached a markedly ($P \leq 0.05$) lower slaughter yield (SY). This is consistent with expectations, as these flocks are not selected for improved performance traits as they are part of a poultry genetic resources conservation programme (Kisiel and Książkiewicz, 2004). Biesiada-Drzazga et al., (2012) reported a significantly ($P \leq 0.05$) lower slaughter yield in Star 53 H.Y. males compared to females (69.9% vs. 71.2%). In the current study, the SY index for this genetic group was also lower for males, at 65.61 vs 66.16%. However, the significance of the differences was not confirmed. Similarly, Bernacki et al. (2008) observed a higher slaughter yield in females (70.3%) than in males (69.4%) after seven weeks of rearing, but without statistical significance. Slaughter yield is affected by the proportion of body components, which is generally more favourable in female ducks (Mazanowski et al., 2003), and and both the present results and data from the literature support this relationship.

The growth rate of ducks in the experimental rearing was typical for this species. In the first three weeks of life, it ranged from 178 in A males to 182% in B females and males, while in the following three weeks it was lower, and ranged from 76.0 in A males to 81.4% in B females. This was consistent with the observations of Stęczny et al. (2015), who compared the fattening performance of Pekin ducks (Star 53 H.Y.), Muscovy ducks (DROP) and Mulard ducks (STE-MULARD), and found that the growth rate index decreased significantly in all groups studied after the third week of rearing. For Star 53 H.Y. ducks, the most intensive growth was recorded between the first and second week (100%) and then decreased to 53% in the following week. Similarly, Biesiada-Drzazga et al. (2011) observed the highest growth rate in young Star 53 H.Y. birds during the first 14 days of life (164.5% on average), followed by a gradual decline, reaching 16.3% in the seventh week. In the present study, the lowest growth rate was also observed in the final rearing period, ranging from 16.2% in A males to 23.7% in B females (Table 1). Comparable results were reported in a study conducted in Egypt (Makram et al., 2017), where the growth rate of Pekin ducks was high until the end of the third week (approximately 200%), and then decreased markedly to 12.11% between weeks 7 and 8.

Here, the growth rate of ducks in both genetic groups depended on sex, with higher values observed in males, although only at a later stage of rearing. Between weeks 4 and 6, males were characterised by a significantly ($P \leq 0.05$) higher growth rate (81.0%) compared to females (76.3%). In a study on the growth of Star 53 H.Y. ducks, Biesiada-Drzazga et al. (2012) reported a higher body weight gain in males in most rearing periods; however, significant differences ($P \leq 0.05$) were confirmed only for weeks 3–4, 5–6, and 6–7. In agreement with the present results, a significantly ($P \leq 0.05$) higher growth rate in Star 53 H.Y. males was observed only after the third week of rearing.

Genotype was a key factor ($P \leq 0.05$) determining carcass formation, expressed as percentage tissue composition (Table 2). Similar results were also presented by Bernacki et al. (2006), Gornowicz et al. (2009), and Mucha et al. (2014). Meanwhile, Kokoszyński et al. (2015) compared the meat characteristics of three Pekin duck breeds used for intensive meat production (SM3 Heavy, Star 53 H.Y., and AF51), and found differences ($P \leq 0.05$) in carcass tissue composition. They reported a higher percentage of meat (especially breast muscle) and lower fat content (percentage of skin with subcutaneous fat and abdominal fat) in carcasses of 7-week-old SM3 Heavy and Star 53 H.Y. ducks. Similarly, in the present study, carcasses of Star 53 H.Y. were characterised by a significantly ($P \leq 0.05$) higher BM content (by 5.03 p.p.) and lower ST (by 2.17 p.p.) and CR (2.54 p.p.). These results indicate that selection in commercial lines has improved carcass composition in terms of meat and fat content. However, not all studies have confirmed such relationships. For example, Bernacki et al. (2006) did not find significant differences in BM, LM, or SF, when considering genetic origin (AP57, PP54, Star 63, and Dworka CaA15), sex, or rearing time.

In contrast, in the present experiment, sex affected carcass fatness (SF and AF) and leg muscle content. This was also observed in an earlier experiment (Gornowicz et al., 2009), which assessed the percentage content of basic elements in eviscerated carcasses with neck (without offal) from five conservation flocks (K-2, P-8, P-9, P-33, and LsA). Substanial ($P \leq 0.05$) differences were observed for most traits, except for the proportion of neck and skeleton. Male carcasses contained approximately 1 p.p. less BM and 1 p.p. more LM. Similar results were presented by Kisiel and Książkiewicz (2004) when comparing the quality traits of K-2 and P-33 ducks.

The results for shear forces F1 and F2 obtained with both types of blades indicated that the toughness of raw duck breast muscles was not affected by genetic origin or sex (Table 3). There are no reports in the literature investigating shear forces of raw poultry muscles. The available research results refer to standard shear force tests using the Warner-Bratzler method performed on heat-treated meat.

The results of measurements of breast muscle texture after heat treatment (Table 4) indicate that F2 values obtained with FB and TB in the Star 53 H.Y. group were significantly ($P \leq 0.05$) higher and amounted to 30.30 and 27.42 N, respectively. No significant differences in F2 force were found between sexes for either blade type. Kokoszyński et al. (2019) indicated that the *m. pectoralis superficialis* from 7-week-old Pekin P-33 ducks (66.65 N) was more tender ($P < 0.05$) than that of Star 53 H.Y. ducks (74.75 N), which was attributed to the smaller muscle fibre diameter in the lighter P-33 ducks compared to Star 53 H.Y. hybrids. As in the present study, no effect of sex or sex × genotype interaction on BM tenderness was observed. However, Omojola (2007) studied the effect of origin and sex on slaughter traits and sensory parameters of meat from Rouen, Pekin, and Muscovy ducks, and showed significant differences ($P < 0.05$) between males and females in BM shear force in all genetic groups. In Pekin ducks, the values for this trait were 25.89 and 33.44 N, respectively. The author indicated that increased breast muscle mass was associated with higher shear force. Smith et al. (2015) analysed quality traits, including WB shear force, of breast muscles in Pekin ducks from four flocks with different selection pressures and did not demonstrate an effect of origin on this parameter; values ranged from 39.23 to 43.15 N. Likewise, Onk et al. (2019) did not find any effect of genotype or sex on WB shear force in breast muscles of Pekin and native Asian ducks, with recorded shear forces of 27.56 and 25.30 N, respectively. When considering sex, the values were 26.97 N for males and 25.89 N for females.

F1 and F2 biting forces, measured using the Volodkevich test, in muscles after heat treatment, differed significantly ($P \leq 0.05$) with respect to sex in the Star 53 H.Y. group. In P-33 ducks, this effect was observed only for the F2 BVJ BM parameter. A significant ($P \leq 0.05$) influence of genotype on the force required for shearing (F2 FB and TB) and biting (F1 BVJ) was also demonstrated (Table 4).

In terms of the F2 force required to shear thigh muscles with a flat or triangular blade after heat treatment (Table 4), significant differences ($P \leq 0.05$) depending on genetic origin were found only for F2 TB (41.19 N for P-33 and 48.55 N for Star 53 H.Y.). Within genetic groups, sex-related differences in F2 were significant ($P \leq 0.05$) only in the Star 53 H.Y. group, where females required lower F2 FB force for thigh muscles (males 45.74 vs females 34.63 N). F1 and F2 biting forces measured using the Volodkevich test for thigh muscles after heat treatment also differed significantly ($P \leq 0.05$) depending on sex only in the Star 53 H.Y. birds.

The results of this research indicated that less force was required to shear BM than LM, i.e., leg muscles were tougher compared to breast muscles. In contrast, Huda et al. (2011) showed that less force was needed to shear thigh muscles than breast muscles in both Pekin and Muscovy ducks (16.77 vs 23.83 N and 31.48 vs 50.70 N, respectively). A significant effect ($P \leq 0.05$) of Pekin duck origin (P66, K2, SB, and P8) on the shear force of leg muscles was found by Wołoszyn et al. (2011), with values ranging from 34.50 (K2) to 39.10 N (P66).

Conclusions

The results of the experiment demonstrate more favourable performance traits in the commercial flock compared to the genetic resources flock of Pekin ducks. The outcomes concern the following parameters: growth rate in the last (seventh) week of rearing, final body weight, slaughter yield, carcass weight, proportion of breast muscle and skin with subcutaneous fat in the carcass, and carcass remainders (neck, wings, skeleton).

Analysis of the meat texture results revealed significant differences between the two duck flocks only in the assessment of meat after heat treatment. Namely, meat from the conservation flock was more tender in blade shearing tests for both blade types.

Conflict of interest

The Authors declare that there is no conflict of interest.

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Table 1. Performance indicators and growth rate (%) at different rearing periods of ducks according to genotype and sex

Flock	Sex	BW, kg	EPI	CW, kg	SY, %	GR in weeks of rearing			
						1–3	4–6	7	1–7
A	♂	2.74^{bc}	194^{c}	1.55^{c}	62.86^{b}	179	80.5^{a}	18.6^{b}	192
	♀	2.26^{d}	162^{d}	1.45^{c}	63.69^{b}	178	76.0^{b}	16.2^{b}	191
B	♂	3.57^{a}	298^{a}	2.45^{a}	65.61^{a}	182	81.4^{a}	23.7^{a}	194
	♀	3.38^{a}	289^{a}	2.22^{ab}	66.16^{a}	182	76.6^{b}	23.6^{a}	193
Total	♂	3.16^{ab}	246^{b}	2.00^{ab}	64.24^{ab}	181	81.0^{a}	21.2^{ab}	193
	♀	2.82^{bc}	226^{b}	1.84^{bc}	64.93^{ab}	180	76.3^{b}	19.9^{ab}	192
	A	2.50^{cd}	178^{cd}	1.50^{c}	63.28^{b}	179	78.3^{ab}	17.4^{b}	192
	B	3.48^{a}	294^{a}	2.34^{a}	65.89^{a}	182	79.0^{ab}	23.7^{a}	194
SEM		3.95	3.92	3.03	0.47	0.33	0.47	0.62	0.62
P-value									
sex (S)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
genotype (G)		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0,001	<0.001
G×S		0.006	0.006	0.844	0.049	0.465	0.006	0.234	0.469

A – Pekin ducks P-33, B – Star 53 H.Y ducks, BW – body weight before slaughter, EPI – economic performance indicator, CW – weight of the carcass with neck without offal, SY – slaughter yield, GR – growth rate, SEM – statistical error; $^{a–d}$ – means within a column with different superscripts are significantly different at $P < 0.05$

Table 2. Tissue composition (%) of eviscerated duck carcass without offal depending on genotype and sex

Flock	Sex	BM, %	LM, %	SF, %	AF, %	CR, %
A	♂	14.67^{b}	13.79	25.72^{a}	0.96	44.24^{a}
	♀	15.42^{b}	13.21	25.68^{a}	1.07	44.13^{a}
B	♂	20.22^{a}	13.42	23.06^{b}	0.93	42.01^{ab}
	♀	19.94^{a}	13.22	24.00^{ab}	1.05	41.29^{b}
Total	♂	17.45^{ab}	13.61	24.39^{ab}	0.95	43.13^{ab}
	♀	17.68^{ab}	13.22	24.82^{ab}	1.06	42.71^{ab}
	A	15.05^{b}	13.50	25.70^{a}	1.02	44.19^{a}
	B	20.08^{a}	13.32	23.53^{b}	0.99	41.65^{b}
SEM		0.14	0.11	0.25	0.04	0.16
P-value						
sex (S)		0.685	0.027	0.049	0.021	0.083
genotype (G)		<0.001	0.002	<0.001	0.024	<0.001
G×S		0.166	0.204	0.134	0.469	0.139

A – Pekin ducks P-33, B – Star 53 H.Y ducks, BM – breast muscles, LM – leg muscles, SF – skin with subcutaneous fat, AF – abdominal fat, CR – remains (skeleton, wings and neck), SEM –statistical error; ^{ab} – means within a column with different superscripts are significantly different at $P < 0.05$

Table 3. Texture characteristics of the raw breast and leg muscles of duck depending on sex and genotype

Flock	Sex	F1 FB, N		F2 FB, N		F1 TB, N		F2 TB, N	
		BM	LM	BM	LM	BM	LM	BM	LM
A	♂	35.75^{b}	39.34^{b}	43.51	47.66^{b}	21.41^{ab}	26.96^{b}	33.46	33.13^{b}
	♀	38.60^{ab}	54.52^{a}	46.41	69.30^{a}	24.32^{a}	32.93^{a}	32.40	55.56^{a}
B	♂	41.78^{a}	31.02^{b}	50.52	37.52^{b}	24.20^{a}	27.33^{b}	30.66	38.51^{b}
	♀	39.10^{ab}	51.08^{a}	47.20	68.07^{a}	19.95^{b}	31.56^{a}	30.56	57.06^{a}
Total	♂	38.77^{ab}	35.18^{b}	47.02	42.59^{b}	22.81^{ab}	27.15^{b}	32.06	35.82^{b}
	♀	38.85^{ab}	52.80^{a}	46.81	68.69^{a}	22.14^{ab}	32.25^{a}	31.48	56.31^{a}
	A	37.18^{ab}	46.93^{ab}	44.96	58.48^{ab}	22.87^{ab}	29.95^{ab}	32.93	44.35^{ab}
	B	40.44^{a}	41.05^{ab}	48.86	52.80^{ab}	22.08^{ab}	29.45^{ab}	30.61	47.79^{ab}
SEM		3,80	6.31	4.60	5.80	2.07	4.46	3.29	6.77
P-value									
sex (S)		0.733	0.006	0.402	0.045	0.645	0.008	0.225	0.038
genotype (G)		0.844	0.617	0.432	0.370	0.432	0.685	0,297	0.922
G×S		0.167	0.439	0.167	0.454	0.402	0.157	0,329	0.809

A – Pekin ducks P-33, B – Star 53 H.Y ducks, F1 – first cutting force, F2 – force necessary to completely cut the sample, FB – cutting with a flat knife, TB – cutting with a knife with a triangular cut, BM – breast muscles, LM – leg muscles, SEM – statistical error; ^{ab} – means within a column with different superscripts are significantly different at $P < 0.05$

Table 4. Characteristics of the breast and leg muscles texture after heat treatment depending on sex and genotype

Flock	Sex	F2 FB, N		F2 TB, N		F1 BVJ, N		F2 BVJ, N	
		BM	LM	BM	LM	BM	LM	BM	LM
A	♂	29.17^{ab}	38.77^{b}	25.37^{ab}	29.51^{ab}	17.16^{a}	18.69^{a}	17.17^{ab}	19.33^{a}
	♀	25.78^{b}	40.64^{b}	23.13^{b}	27.96^{b}	14.24^{b}	18.99^{a}	14.30^{b}	19.03^{a}
B	♂	28.90^{b}	45.74^{a}	28.71^{a}	35.87^{a}	14.82^{b}	18.98^{a}	14.94^{b}	19.18^{a}
	♀	31.69^{a}	34.63^{b}	26.13^{ab}	31.81^{ab}	17.68^{a}	16.12^{b}	17.88^{a}	16.35^{b}
Total	♂	29.04^{ab}	42.26^{ab}	27.04^{ab}	32.69^{ab}	15.99^{ab}	18.84^{a}	16.06^{ab}	19.26^{a}
	♀	28.74^{b}	37.64^{b}	24.63^{b}	29.89^{ab}	15.96^{ab}	17.56^{ab}	16.09^{ab}	17.69^{ab}
	A	27.48^{b}	39.71^{b}	24.25^{b}	28.74^{b}	15.70^{ab}	18.84^{a}	15.74^{ab}	19.18^{a}
	B	30.30^{a}	40.19^{b}	27.42^{a}	33.84^{a}	16.25^{ab}	17.55^{ab}	16.41^{ab}	17.77^{ab}
SEM		2.47	4.20	4.20	4.11	1.05	3.11	2.73	1.80
P-value									
sex (S)		0.826	0.653	0.249	0.362	0.141	0.454	0.126	0.677
genotype (G)		0.002	0.133	0.002	0.008	0.007	0.165	0.297	0.102
G×S		0.166	0.189	0.568	0.461	0.162	0.238	0.211	0.694

A – Pekin ducks P-33, B – Star 53 H.Y ducks, F1 – first cutting force, F2 – force necessary to completely cut the sample, FB – cutting with a flat knife, TB – cutting with a knife with a triangular cut, BVJ – biting Volodkievich's jaw BM-breast muscles, LM – leg muscles, SEM – statistical error; ^{ab} – means within a column with different superscripts are significantly different at $P < 0.05$