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Texture Analysis of Goose Meat

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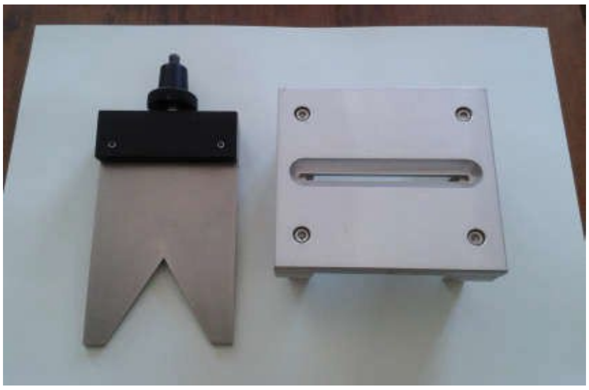
Meat and its products belongs to the group of food products for which the texture, along with the taste values, is the dominant qualitative characteristics. As a sensory feature perceived by many human senses, it determines the quality and acceptance of a consumer product. The product's texture can or even should be tested in order to best adapt it to the customers' requirements and to learn about its changes during the production process by examining the raw material, by-products and the final product (Grunert et al., 2004).

The concept of texture is difficult to define unambiguously. It is a complex feature determined, among others, through the structure, shape, chemical composition, viscosity and other physical properties of the product. In the case of meat, this characteristics is conditioned by the interaction of many constituents, including the content and quality of connective tissue, fat content, muscle fibre structure as well as enzymatic changes during meat ripening (Surmacka-Szcześniak, 2002). The texture of meat can be analysed in sensory terms or by instrumental methods. Instrumental measures have an advantage over the sensory evaluation due to the fact that they are often less labour-intensive and require less product use. Moreover, they are more repetitive and free from variability caused by, among others, psychological factors that affect the sensory reactions of human beings. However, the evaluation by instrumental measurement of the texture should be treated as a complementary to the sensory method because only the latter assessment takes into account information about the experience by the consumer while eating the product (Grunert et al., 2004; Surmacka-Szcześniak, 2002).

The instrumental measurement of meat texture is carried out by using measuring devices that enable determination of one or more mechanical characteristics of the tests (e.g. cutting or biting force) as well as obtaining full characterisation of physiochemical meat status by measuring the cutting, compressive or flexibility forces (Diakun et al., 2012; Niedźwiedź et al., 2013).

It seems that the most important among the textural features of meat is its crispness/hardness. For measurements, devices called texturometers are used, measuring the force necessary for surface incisions, complete cutting or biting of a meat sample. These measurements are taken for raw meat and heat treated meat, and the sample is a cube with a cross-section of 1x1 cm cut from the muscle along the fibres (Honikel, 1998). To measure the cutting force, among others, a set of Warner-Bratzler knives is used, i.e. a flat-cut knife and a triangular cut-out knife (photos 1, 1a and b). To determine the force of biting, anattachment is used, so-called Volodkevich bite jaws (photo 1). The values of the tested parameters are determined from the values of forces, displacement and time recorded during the measurement, and then displayed by the control software in numerical and graphic forms.

Phot. 1. Test bench – texture analyser TA.XT plus Stable Micro Systems (attachment for measuring the force of biting – Volodkevich bite jaws) (photo L. Lewko)



Phot. 1a. Object stage and knife with a triangular notch for Warner-Bratzler texture test (photo L. Lewko)

Phot. 1b. Object stage and flat knife for Warner-Bratzler texture test (photo L. Lewko)

As shown in the studies (Migdał et al., 2007, Łapa et al., 2008, Ghazali et al., 2013, Knight et al., 2014), the texture of raw livestock meat varies widely and depends on many factors. Among the determinants of the vitality, one should indicate the species, breed, sex, age, maintenance system, feeding and the anatomical position, i.e. the type of muscle. Which is also important is the post-slaughter treatment of the carcass and meat. This applies, inter alia, to the bleeding, cooling and storage processes.

On the other hand, the texture of meat after heat treatment is influenced by the type, method, process time and preparation of the product (marinating, brine injection, etc.). It has been shown that during heating, thermal denaturation of proteins occurs, which leads to specific changes in the microstructure of muscle fibres and connective tissue, and affects the ability to keep its own water and the crispness/hardness and succulence of meat (Augustinian- Prejsnar and Sokołowicz, 2014, Kozioł et al., 2016). Therefore, in the characteristics of the technological quality of meat, it is important to determine the texture of raw meat and meat subjected to thermal processing.

The production of goose meat in Poland is only 1.8% of this parameter for broiler chickens. Goose meat is perceived by consumers as a special-purpose commodity with a high culinary attractiveness. High nutritional value of goose meat was confirmed in the studies, showing a favourable chemical composition, especially in the range of unsaturated fatty acids, and the taste was evaluated favourably (Gumułka et al., 2009, Pasterka, 2012, Buzała et al., 2014). For these reasons, this type of meat is more and more appreciated by healthy food enthusiasts and connoisseurs looking for various culinary specialties. An additional impact on the increase in demand for goose meat was exerted by another two factors. The first of them is the increasing availability of goose parts (breast with the skin, leg/drumstick) in chain stores and supermarkets. Until now, only the entire carcass has been available as a commercial product. The second factor, thanks to the media, is a fashion for cooking, the original preparation of various meals according to innovative recipes and, at the same time, a comeback to old, traditional recipes (Gornowicz and Lewko, 2016). In the ways of using goose meat its texture, in particular, hardness/crispness may have a significant role. Until now this feature has been the subject of instrumental measurements only to a small extent.

Globally, in the modern technology of intensive and semi-intensive rearing of goose high-meat genetic material is used. Therefore, in the last fifty years there has been a steady increase in the number of high-performance geese/breeds, such as Eskildsen, White Koluda®, White Goslings G-35 crossbreed or Beidou White Goose LRI-1. However, extensive and semi-extensive meat production still uses throughout the world, even though in a niche range, the domestic goose breeds/regional varieties, characterised by lower performance parameters. We can observe a similar situation in our country (Calik, 2013; Gornowicz et al., 2016). The comparison of meat texture of high-yielding breeds/lines of geese and breeds/domestic varieties, currently covered by the program for the protection of genetic resources of livestock can be interesting from a consumer point of view. Such research was carried out at the National Research Institute of Animal Production, at the Experimental Station in Koluda Wielka, the Genetic Resources Station for Water Poultry (SZGDW) in Dworzyska.

The purpose of the research was to analyse the texture of raw meat and heat treated meat originating from selected breeds and varieties of domestic geese.

Materials and methods

The experimental material consisted of superficial breast muscles (*musculus pectoralis superficialis*) and thigh muscles (*musculus femoris*) of five genetic groups of geese: Lubelska (Lu), Kielecka (Ki), Subcarpathian (Pd), Pomeranian (Po) and White Koluda (BK). The four first families are included in the animal genetic resources protection program and are predisposed to extensive breeding. The goose breed of White Koluda® is a commercial breeding set whose hybrids (BK) are used for intensive fattening.

All the listed geese herds are maintained *in situ* in SZGDW in Dworzyska. After 17-week rearing, slaughter was carried out along with post-slaughter processing, maintaining the same technological conditions of 120 geese (5 groups x 24 pieces), maintained under the same environmental-nutritional conditions, in an equal sex ratio of 1:1. 24 hours after slaughter the superficial breast muscle and thigh muscle along the muscle fibres were separated from 16 chilled carcasses from each group, 5 samples each, measuring 1 x 1 cm and 1.5 cm long (Honikel, 1998). In total, 80 samples (16 carcases x 5 samples) of each muscle type were collected for each of the studied geese herds. From the collected samples, 96 were heat treated, cooked in hermetically sealed foil bags (string bags), immersed in water at 80°C for 40 minutes under cover. After cooling, the samples were chilled by placing themfor 24 hours in a refrigerator. The texture tests of goose meat, both raw and after heat treatment, were carried out on samples chilled down to +4°C. The instrumental measurement was carried using the TA.XT Plus texture analyser by Stable Micro Systems together with appropriate attachments (auxiliary table, Warner-Bratzler knife set, Volodkevich jaw holder; photos 1, 1a and b). Raw meat samples were subjected to cutting force evaluation using a flat blade knife (NP) and a knife with a triangular notch (NT) whose arms being the cutting element formed the angle of 60°. After the heat treatment, the cutting force of the knives with both blades was measured, and the force of biting was measured. The knife speed during the test was 1.5 mm/s, and for the Volodkevich bite jaws - 2.00 mm/s. The final force (F) - necessary to cut the entire meat sample was measured. For all the measurements the number of trials was 16 (n = 16) for each genetic goose group. All the results were subjected to detailed statistical analysis using the *Statistica 10* software (StatSoft, 2006). In the statistical elaboration of the results in this work, arithmetic averages were adopted $\bar{x}$). The significance of the differences between the averages was estimated using the Student's t-test.

The results and their discussion

Geese from particular genetic groups after 17 weeks of rearing had a body weight of 4119 g (Ki) to 7408 g (BK), and the weight of their carcass ranged from 2810 g (Ki) to 4790 g (BK). BK goose body and carcass mass was significantly (P≤0.05) highest for all the birds from the population covered by the program of farm animals' genetic resources protection. Among the birds of the latter group, however, the Po goose body and carcasses were significantly (P≤0.05) heavier as compared to the other ones, i.e. Ki, Lu and Pd (Fig. 1). A similar system in the formation of body and carcass mass for hybrid breeds, derived from high-yielding breeding sets, against the parameters obtained by regional goose varieties was observed by Gumułka et al. (2009), Pasternak (2012), Haraf (2014) and Solé et al. (2016).

a, b – mean values in columns with different letters differ significantly (P≤0.05).

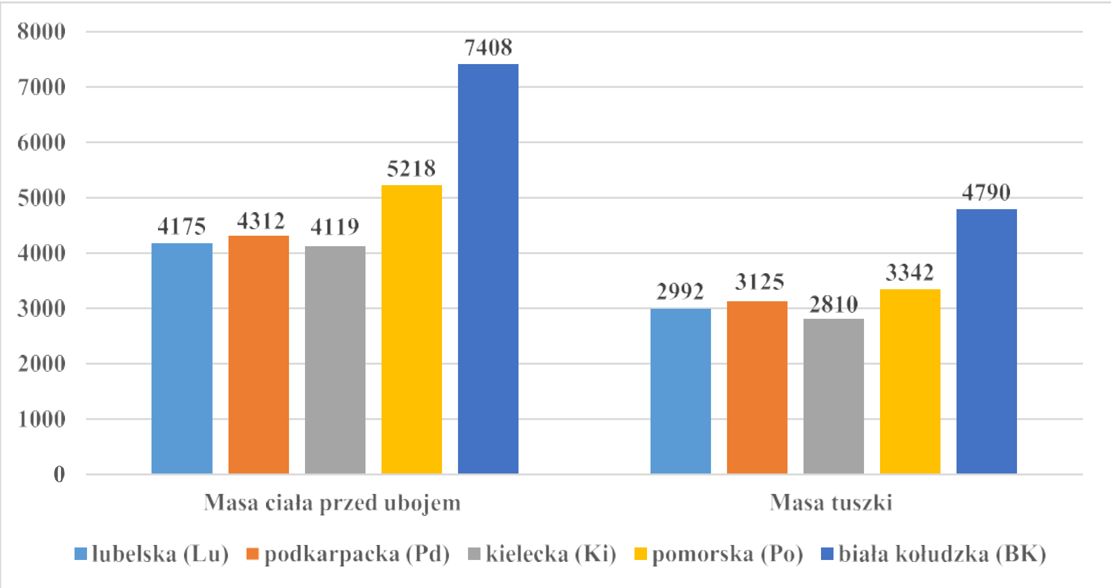
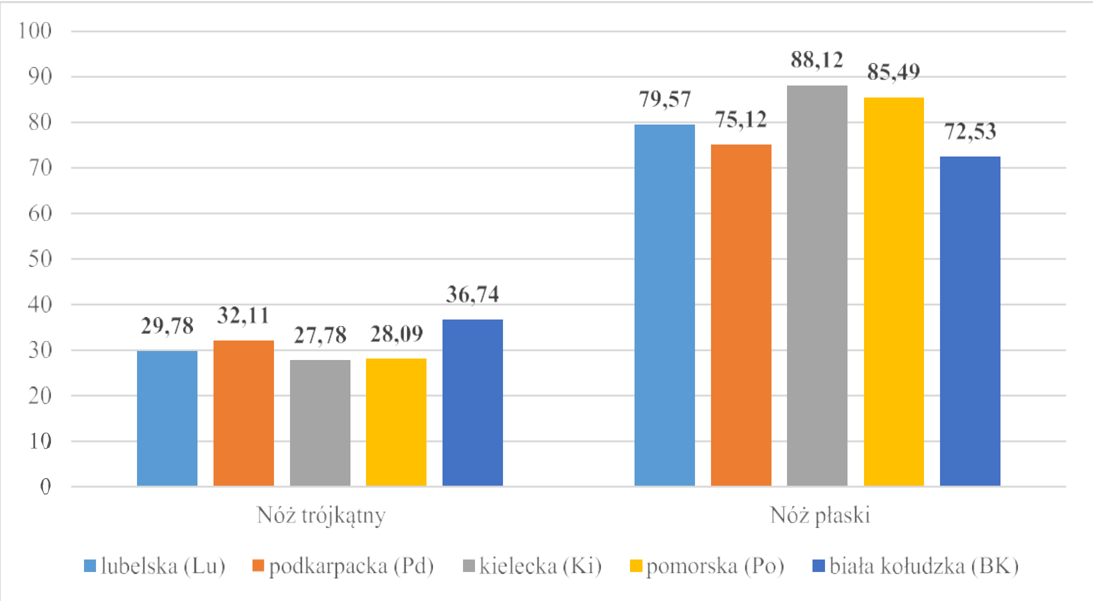


Fig. 1. Body weight before slaughter and carcass weight with neck (without giblets) from selected genetic groups of geese after 17 weeks of rearing

Raw meat

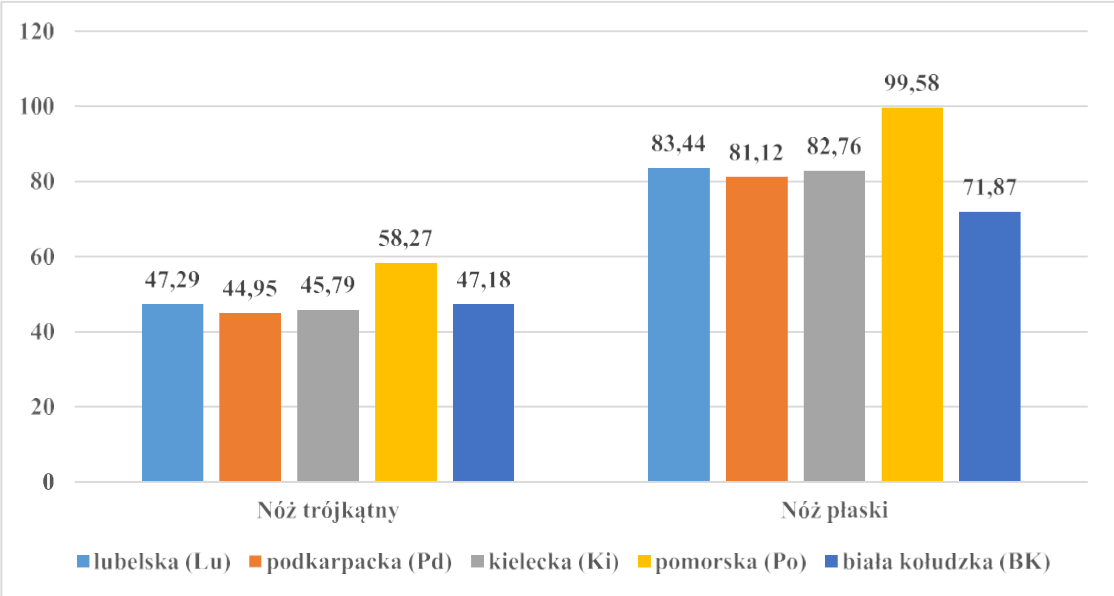
Raw breast muscles (Fig. 2) of BK geese were characterised by significantly greater force necessary to cut with a knife with a triangular cut (P <0.05) as compared to Lu, Ki and Po breeds. The difference was, respectively: 6.96 N, 8.96 N and 8.65 N. Analysing the results of the force necessary to cut the superficial breast muscles with a flat blade knife from the Warner-Bratzer set, it should be noted that significantly the lowest value of this parameter was noted for BK geese (P <0.05). The differences in values ranged from 2.59 N (Pd) to 15.59 N (Ki), and the significance of the differences was not confirmed only between BK and Pd, as was the case with the use of NT.



Explanation: see Figure 1.

Fig. 2. The force required to cut the raw breast muscles from selected genetic groups of geese after 17 weeks

Po geese were characterised by the hardest (P <0.05) raw thigh muscles (Fig. 3) for measurements with both types of knives. These values were higher from 10.98 N (Lu) to 13.32 N (Pd) using the NT knife and from 16.14 N (Lu) to 27.71 N (BK) for NP. Furthermore, it is worth Noticing that the raw thigh muscles of BK geese when cutting with a flat knife were significantly (P <0.05) the most crispy, and the force necessary to cut them was 71.87 N. This confirms the high potential for technological use of goose meat of this breed.



Explanation: see Figure 1.

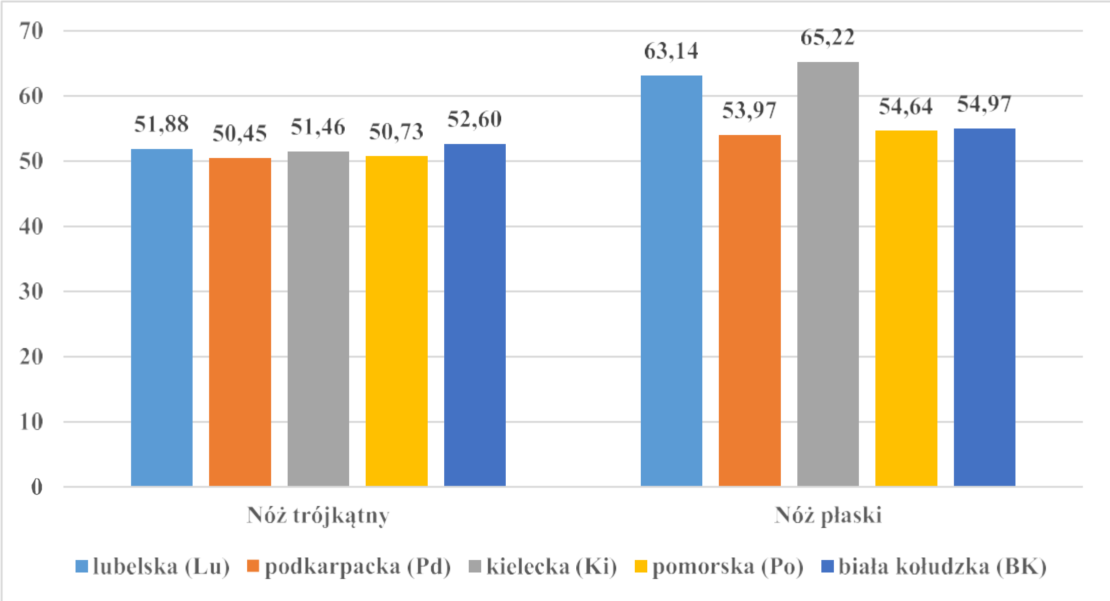
Fig. 3. The force required to cut the raw leg muscles from selected genetic groups of geese after 17 weeks of rearing

Cutting the raw goose meat with a flat knife directed perpendicularly to the fibres run required a force twice as high as using a knife with a triangle-shaped cut, thanks to which the meat was cut at an angle of 45° with respect to the direction of the fibres run.

Meat after heat treatment

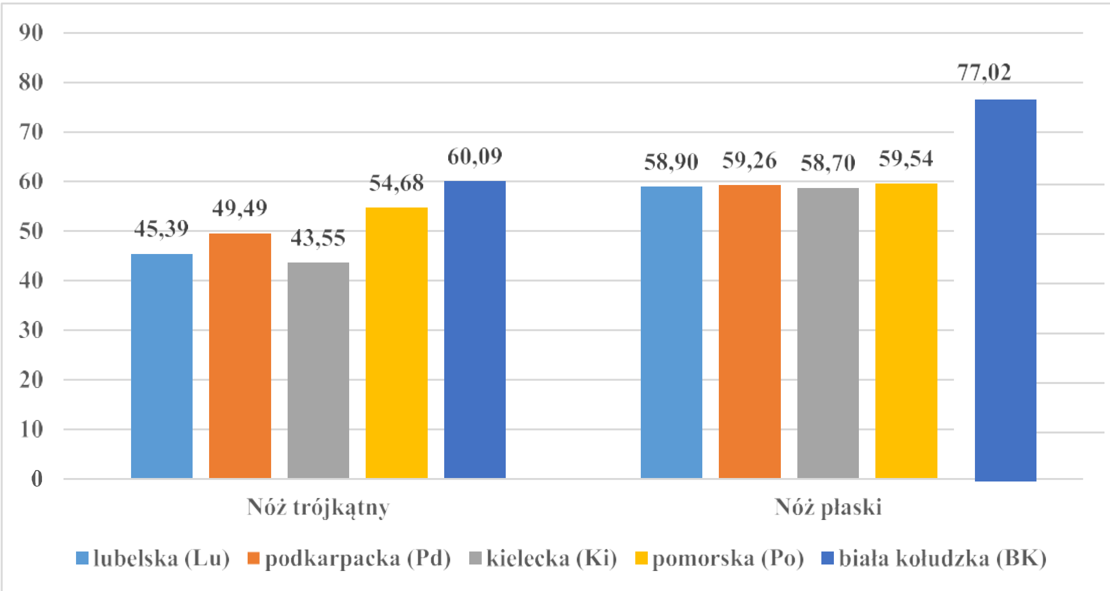
Figures 4 and 5 present the shaping of the force necessary to cut goose meat after heat treatment. It can be observed that in the superficial breast muscles after heat treatment, changes in the microstructure of fibres and connective tissue have occurred, which caused a change in the value of the force necessary to cut them. When using a triangular knife, this force increased by about 20 N and was very stable for individual goose breeds, ranging from 50.45 for Pd to 52.6 N for BK. When using a flat knife after heat treatment, significantly ($P < 0.05$) the hardest was the superficial breast muscle of Ki (65.22 N) and Lu geese (63.14 N).

After heat treatment, significantly ($P < 0.05$) the hardest were thigh muscles of BK geese, both using NT knife (60.09 N) and NP (77.02 N). Only in the case of BK geese, meat indicators after heat treatment were rated higher for raw meat (by 12.91 N NT and by 5.15 N NP). In other genetic groups of geese, the force necessary to cut thigh muscles was lower for the samples after heat treatment. The exception were Pd goose muscle samples for the NT knife.



Explanation: see Figure 1.

Fig. 4. The force required to cut the heat-treated breast muscles from selected genetic groups of geese after 17 weeks of rearing

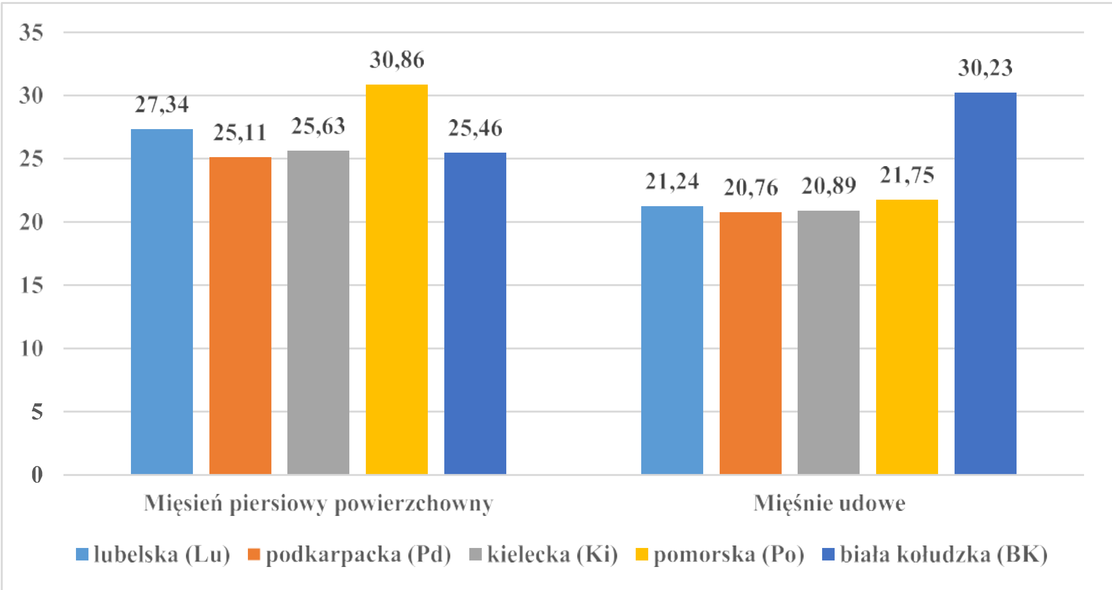


Explanation: see Figure 1.

Fig. 5. The force required to cut the heat-treated leg muscles from selected genetic groups of geese after 17 weeks of rearing

Measurement of the force required to bite breast muscle after heat treatment (Fig. 6) showed that the muscle of Po geese (30,86 N) was significantly (P <0.05) the hardest. In turn, in the case of thigh muscles, significantly (P <0.05)

higher values of this force were demonstrated for BK geese (30.23 N). It is worth noticing that only for this goose breed the force necessary to bite the thigh muscles after heat treatment was greater than for the superficial breast muscle.



Explanation: see Figure 1.

Fig. 6. The force required to chew through the breast and leg muscles from selected genetic groups of geese after 17 weeks of rearing

The cumulative analysis of the results (NT + NP) in the Warner-Bratzler test did not show significant differences between the mean values of force (F) for cutting breast muscles, both raw - from 53.62 N (Pd) to 57.95 N (Ki), as well as after heat treatment - from 52.21 N (Pd) to 58.34 N (Ki) in the studied goose genetic groups. In the case of the thigh muscle, significantly (P <0.05) the hardest muscles were in Po geese - 78.93 N as compared to 59.53 N (BK) to 65.37 N for (Lu) geese and after heat treatment - BK geese - 68.56 N as compared to 51.13 (Ki) to 57.11 N (Po). Despite numerous studies on the broadly understood quality of water poultry meat (Gumułka et al., 2009, Pasternak, 2012, Buzała et al., 2014, Lewko et al., 2017), there is still little attention paid to the assessment of the texture of goose meat.

Liu et al. (2011) made an attempt to estimate the texture quality of Yangzhou goose breast muscles (local goose breed originating from a prefecture in eastern China). The authors determined the cutting force for breast muscle depending on the maintenance system and the sex of birds. The cut force required to cut the breast muscles of females was 17.65 N. In the case of male breast muscles, it was almost 2 N higher (19.62 N). On the other hand, the values of cutting force depending on the maintenance system ranged from 17.76 N (group E) to 19.62 N (groups B and C). The authors did not prove a significant effect of the studied factors on the size of the cutting force of the estimated goose breast muscles.

The level of cutting forces depending on the sex of birds was also determined by Kirmizibayrak et al. (2011), who used for this purpose the domestic goose breed from the province of Kars (Turkey). The authors obtained a reverse dependence to that of Liu et al. (2011). They proved that the female breast muscles were harder than the male ones (30.90 N), and a greater force was needed to cut them - 0.98 N on average (31.88 N). The authors did not reveal any significant differences depending on the sex of birds. Significantly higher values of cutting force were obtained in the studies conducted by Geldenhuys et al. (2014), who used the breast muscles of the Egyptian goose as a research material (a bird closely related to geese called Egyptian goose). The authors proved that the force necessary to cut these muscles was 48.76 N. In turn, Damaziak et al. (2016) determined the maximum cutting force for White Koluda goose breast meat. The value of this parameter was in the range from 31.80 N (cooked muscles) to 55.98 N (smoked muscles). In their own studies, the cutting force required to cut raw goose breast muscles was much lower in the case of cutting with a flat knife, and amounted to the average of 30.9 N whereas in the case of cutting with a knife with a triangular cut-out as much as 80.17 N. Equally high values ($P \leq 0.05$) were obtained by Solé et al. (2016), who stated that the force necessary to cut cooked breast muscles from three genetically different groups of geese (Embden, F1 hybrids Embden x Toulouse, Toulouse) ranged from 74.75 N (Embden) up to 87.01 N (Toulouse) and it was a statistically significant difference ($P \leq 0.05$). The measurements in the Warner-Bratzler test were carried 10 days after the slaughter of geese.

High diversity of genetic groups of geese whose breast muscles were examined in terms of texture using a set of Warner-Bratzler

knives and the method of thermal treatment as well as the time of carrying measurements after the slaughter of birds caused a significant differentiation of the results obtained in the conducted research.

Summary and Results

There was no significant effect of genetic origin (Lubelska, Kielecka, Subcarpathian, Pomeranian and White Koluda geese) on the shaping of the force necessary to cut the superficial (uncooked and heat treated) breast muscle in the Warner-Bratzler test (flat knife + knife with a cut out triangle).

Among the tested genetic groups, significantly ($P \leq 0.05$) the greatest force necessary to cut thigh muscles was demonstrated for Pomeranian goose while after thermal treatment - for White Koluda. Significantly ($P \leq 0.05$) the highest force needed to bite superficial breast muscle was demonstrated for the group of Pomeranian goose, and for the thigh muscle - for White Koluda.

The meat, especially the superficial breast muscle of the geese of five studied populations, was distinguished by good texture parameters. White Koluda geese, characterised by a large weight of the body/carcass and the desired crispiness of the meat from the breast part, can be successfully used in intensive breeding and for the production of portioned items. Thighs/legs of these birds require longer thermal processing. In turn, smaller carcasses of the Pomeranian, Lubelska, Kielecka and Subcarpathian geese, characterised by similar crispiness of breast and thigh muscles after heat treatment, can be successfully used for culinary processing of the entire carcass - especially in farming at agro-touristic farms, ecological farms, etc.

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TEXTURE ANALYSIS OF GOOSE MEAT

Summary

The aim of the study was to evaluate the texture of raw and heat-treated meat (the superficial pectoral muscles and thigh muscles) from Lubelska (Lu), Kielecka (Ki), Subcarpathian (Sb), Pomeranian (Po) and White Kołuda (BK) geese. There was no significant influence of genetic origin (Lubelska, Kielecka, Subcarpathian, Pomeranian and White Kołuda goose) on shaping the force required to cut the superficial pectoral muscles in Warner-Bratzler shear test of raw and cooked meat (a flat and triangular knife). Of the studied genetic groups significantly ($p \leq 0.05$) the greatest force required to cut the raw thigh muscles has been demonstrated for Pomeranian geese while heat-treated for White Kołuda geese. However, significantly ($P \leq 0.05$) the greatest force to chew through superficial pectoral muscles has been demonstrated in the group of Pomeranian geese, and for the thigh muscles of White Kołuda. Meat, especially the superficial pectoral muscles from the five studied populations of geese were characterized by good texture parameters. White Kołuda geese that are characterized by high body/carcass weight and desired tenderness of breast meat can be successfully used in intensive farming and for the production of delicatessen food. Thigh/leg of these birds require longer heat treatment. In turn, the smaller carcasses of Pomeranian, Lubelska, Kielecka and Subcarpathian geese which are characterized by similar tenderness of breast and leg muscles after heat treatment can be successfully used for culinary processing of the whole carcasses – especially in agro-tourism farms, ecological type, etc.

Key words: geese, meat, texture analysis

Kielecka geese

Lubelska geese

Subcarpathian geese

Pomeranian geese

Photo. J. Calik