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MICROSTRUCTURE AND TECHNOLOGICAL MEAT QUALITY OF GEESE FROM CONSERVATION FLOCK AND COMMERCIAL HYBRIDS

Małgorzata Gumułka[1], Dorota Wojtysiak[2], Ewa Kapkowska[1], Katarzyna Połtowicz[3], Andrzej Rabsztyn[1]

[1]Department of Poultry and Fur Animals Breeding and Animal Hygiene,
[2]Department of Reproduction and Animal Anatomy, University of Agriculture,
Al. A. Mickiewicza 24/28, 30-059 Kraków, Poland
[3]Department of Animal Genetics and Breeding, National Research Institute of Animal Production,
32-083 Balice n. Kraków, Poland

Abstract

The research was conducted on 32 Zatorska geese from poultry genetic resources in Poland and on commercial crosses of White Kołuda geese. From 14 to 17 weeks of age the birds were fattened with oats. Dissection was performed and the microstructure of *m. pectoralis superficialis* and *m. biceps femoris*, as well as the meat technological parameters: $pH_{15\ min}$, pH_{24h} postmortem, colour on the L* a* b* scale, water holding capacity, drip and thermal losses were assessed. Moreover, a phenotypic correlation was estimated between the fibre composition of *m. pectoralis superficialis* and the results of dissection and meat quality assessment. Microstructure of the muscles was similar in Zatorska and White Kołuda geese except for significantly higher content of type I muscle fibres in *m. pectoralis superficialis* in Zatorska geese. Moreover, breast and leg muscles of both groups of geese were characterized by similar technological parameters. The differences concerned only higher values of water holding capacity for leg muscles of Zatorska geese. Among the estimated relationships, only a negative phenotypic correlation for percentage of type IIB muscle fibres and a positive correlation for percentage of type I fibres and pH_{15min} value were statistically significant.

Key words: goose, oat fattening, meat quality, microstructure of *m. pectoralis superficialis* and *m. biceps femoris*

Poultry meat quality results from interrelations between the genetic potential of birds and environmental factors (Berri, 2000; Wężyk et al., 2003; Bihan-Duval et al., 2004). Moreover, physicochemical and sensory properties of meat that determine technological quality are affected by histological and biochemical features of muscle fibres (Kłosowska et al., 1998; Berri, 2000). In pigs it was found that the increase in the proportion of white fibres in *longissimus dorsi* muscle is related to increased post-mortem metabolic rate, which is further connected with poorer meat quality (Ryu and

Kim, 2005). For beef a negative phenotypic correlation was demonstrated (Crouse et al., 1991) between tenderness and diameter of meat fibres. Połtowicz et al. (2007) confirmed the same dependence for goose meat.

In poultry it has been also shown that genetic selection for rapid growth can influence changes in muscle fibre composition. An increase in muscle fibre diameter was found in breast muscles of commercial broiler chickens, turkeys and duck lines (Baeza et al., 2002; Bihan-Duval et al., 2004). However, the consequences of muscle fibre hypertrophy on the sensory and processing quality of poultry meat have not yet received much attention.

A growing interest has been observed currently in non-commercial bird breeds that were not subjected to intensive breeding. At present, the production of goose meat in Poland is based on White Kołuda goose crosses. The research conducted so far focused on the use of conservation stocks of geese such as Biłgoraj geese (Pudyszak et al., 1997) and Suwalska, Kartuska, Podkarpacka, Roman and Kuban geese for creating commercial hybrids (Mazanowski et al., 2004; Elminowska-Wenda et al., 2006). Zatorska geese were the subject of investigations on broiler and oat fattening (Szado et al., 1991). The present paper continues to characterize the meat performance of this breed and attempts to find the relationships between muscle fibre microstructure and meat quality in this poultry species.

The objective of this study was to compare the muscle fibre characteristics of *m. pectoralis superficialis* and *m. biceps femoris* and technological parameters of meat from Zatorska geese with the commercial crosses of White Kołuda geese.

Material and methods

The research was conducted on Zatorska geese from poultry genetic resources in Poland and commercial crosses of two strains of White Kołuda geese (W31). The birds were reared and fattened with oats according to the technology from the Experimental Station of the National Research Institute of Animal Production in Kołuda Wielka. Two groups of birds were kept at the Experimental Station of the Agricultural University in Kraków. At 17 weeks of age, 16 birds (8 males and 8 females) from each genetic group were slaughtered. Birds with body weight close to the mean for a group were chosen.

In order to determine the muscle microstructure, samples of *m. pectoralis superficialis* and *m. biceps femoris* were collected 15 minutes postmortem from the right side of carcasses. Samples were immediately cut into 1×1×1 cm pieces (parallel to the muscle fibres) and frozen in isopentane that was cooled using liquid nitrogen. Transverse sections (10 µm thick) were cut at –25ºC using cryostat (Slee MEV, Germany). Various types of muscle fibres were identified by histochemical reaction to determine dehydrogenase activity – NADH (Dubovitz et al., 1973). The muscle fibres were classified into types I (oxidative – red) and IIB (glycolytic – white). The microstructure traits were determined by means of percentage of both muscle fibre types and their diameter. The analyses were performed on 300 muscle fibres. Measurements were made using a Nikon E600 light microscope and computerized image analysis system Multi Scan v.14.02.

Moreover, a dissection was performed on the left side of 16 carcasses after 24-hour chilling to 4°C. Postmortem value was evaluated considering the weight of chilled eviscerated carcass with neck and the bird weight before slaughter. The percentage of breast and leg muscles in the eviscerated carcass with neck was determined.

Technological parameters of breast and leg muscles were also assessed. At 15 min postmortem pH was determined using a CyberScan 10 pH-meter equipped with a glass electrode for meat analysis. After 24-hour chilling of carcasses at 4ºC the measurement was repeated. The electrode was placed at a 45º angle, at half-thickness of the muscles. Meat colour was also determined on the L* (lightness), a* (redness), b* (yellowness) scale using a Minolta CR-310 colorimeter. Four readings per muscle were taken and an average reading was recorded. Moreover, water holding capacity was evaluated as an amount of free water according to the filter paper press method (Grau–Hamm). For measurements of drip loss samples of meat (e = 0.001 g) were placed in individual, sealed containers. After 24-hour storage at 4ºC, samples were removed from containers, wiped with absorbent paper and weighed. Thermal loss was determined after cooking of samples in a water bath at 95ºC until core temperature reached 80ºC. After cooking they were cooled and weighed for thermal loss determination.

To examine the differences between the means, the GLM procedure and Tukey's test (SAS, 2001) were used. The linear model included genetic group and sex as fixed effects. Phenotypic correlation was evaluated between the characteristics of *m. pectoralis superficialis* microstructure and technological quality of meat and percentage of breast muscles in the weight of eviscerated carcass with neck. Only this muscle was taken into consideration because in addition to *m. biceps femoris* the leg meat quality assessment comprised also other muscles.

Results

The slaughter yield of White Kołuda geese was 76.9% ± 0.67 and was significantly higher ($P \leq 0.01$) in relation to that found for Zatorska geese (73.7% ± 0.61). The percentage of breast muscles in the eviscerated carcass was similar in both breeds and reached almost 8.6%. On the other hand, the content of leg muscles was higher in Zatorska geese in comparison with White Kołuda geese, reaching 8.8% ± 0.17 and 7.7 ± 0.18%, respectively.

Irrespective of goose genetic group, muscle fibres type I formed the highest percentage in *m. pectoralis superficialis*, which was three times that of IIB fibres (Table 1). In Zatorska geese, the content of type I fibres was higher in comparison with White Kołuda geese and the differences were statistically significant ($P \leq 0.01$). On the other hand, the diameter of both muscle fibre types did not differ statistically between the analysed goose groups.

In *m. biceps femoris* a greater percentage of type IIB fibres was observed. For this muscle no significant differences were registered either for the percentage or diameter of muscle fibres between Zatorska and White Kołuda geese.

Table 1. Microstructure of *m. pectoralis superficialis* and *m. biceps femoris* in Zatorska geese and White Kołuda geese (W31) after oat fattening (n = 12)

Fibre types	Fibre content (%)				Fibre diameter (µm)			
	$\bar{x}$ ± SEM							
	Zatorska geese		White Kołuda geese – W31		Zatorska geese		White Kołuda geese – W31	
	m. pectoralis superficialis							
IIB	22.5 C	1.4	25.7 C	1.3	49.2 c	2.9	49.2	2.0
I	77.5 AC	1.4	73.1 BC	1.5	22.5 C	1.0	24.9 C	3.1
	m. biceps femoris							
IIB	53.7 D	1.9	55.0 D	1.4	56.1d	1.7	56.5	2.4
I	46.0 D	1.8	44.9 D	1.4	46.9 D	3.1	50.1D	2.6

A, B – values in lines (between genetic groups) with different letters differ significantly (P≤0.01).
c, d – values in columns (between muscles) with different letters differ significantly (P≤0.05).
C, D – as above for P≤ 0.01.

Table 2. Technological properties of breast muscles and leg muscles of Zatorska and White Kołuda (W31) geese at the age of 17 weeks (n = 16)

Trait	Zatorska geese		White Kołuda geese – W31		Zatorska geese		White Kołuda geese – W31	
	breast muscles				leg muscles			
	$\bar{x}$ ± SEM							
pH_{15min}	6.33 X	0.05	6.38 C	0.04	6.73 Y	0.05	6.70 D	0.04
pH_{24h}	6.08 X	0.04	6.12 C	0.03	6.67 Y	0.04	6.59 D	0.03
L* (Lightness)	38.52	0.67	38.55 C	0.46	39.47	0.59	40.54 D	0.57
a* (Redness)	17.00	0.26	16.72	0.28	16.33	0.41	16.36	0.35
b* (Yellowness)	3.82	0.31	3.46	0.20	3.82	0.31	4.38	0.29
Drip loss$_{24h}$ (%)	0.50 X	0.03	0.50 C	0.04	0.35 Y	0.05	0.37 D	0.04
Thermal loss (%)	32.65 x	0.92	30.35	0.79	27.31 y	0.92	27.67	0.83
Water holding capacity (%)	18.98	0.83	19.63C	0.72	18.49 A	0.85	14.00 BD	0.87

A, B – values in lines (between genetic groups) with different letters differ significantly (P≤0.01).
C, D – values in lines (for muscles of White Kołuda geese) with different letters differ significantly (P≤0.01).
x, y – values in lines (for muscles of Zatorska geese) with different letters differ significantly (P≤0.05).
X, Y – as above for P≤ 0.01.

A comparison of the analysed muscles revealed significantly (P≤0.01) higher percentage of type IIB muscle fibres in *m. biceps femoris* in comparison to *m. pectoralis superficialis* both in Zatorska and in White Kołuda geese. Moreover, *m. biceps femoris* was characterized by significantly (P≤0.01) higher diameter of type I fibres in Zatorska and White Kołuda geese and higher diameter (P≤0.05) of type IIB fibres in Zatorska geese as compared with *m. pectoralis superficialis*.

The technological parameters of breast and leg muscles of Zatorska and White Kołuda geese are presented in Table 2. Irrespective of the genetic group, breast muscles were characterized by significantly (P≤0.01) lower values of pH_{15} and pH_{24} postmortem, but higher values of drip $loss_{24h}$ in comparison with leg muscles ($P \leq 0.01$). Moreover, breast muscles were significantly ($P \leq 0.01$) lighter (L*) than leg muscles and had higher values of water holding capacity ($P \leq 0.01$), but only in White Kołuda geese. In case of Zatorska geese significantly ($P \leq 0.05$) higher values of thermal loss were recorded for breast muscles in comparison with leg muscles.

A comparison of the results between the analysed groups revealed that statistically significant differences for muscles only concerned water holding capacity. The value of this parameter was significantly ($P \leq 0.01$) higher in Zatorska geese, but only for leg muscles.

A significant ($P \leq 0.01$) negative phenotypic correlation for percentage of type IIB fibres with pH_{15min} postmortem ($r_p = -0.47$) was registered, as well as a significant ($P \leq 0.01$) positive relationship between pH_{15min} ($r_p = 0.59$) and percentage of type I red fibres. The other correlations between *m. pectoralis superficialis* fibre composition, technological quality parameters and the results of dissection were not significant.

Discussion

A growing interest in obtaining meat products with specific quality traits, has been observed lately among poultry producers. In case of goose meat a possibility to extend the offer by means of using geese from genetic reserve flocks has been suggested (Pudyszak et al., 1997; Mazanowski et al., 2004; Puchajda-Skowrońska et al., 2006).

The results for percentage and diameter of *m. pectoralis superficialis* fibres, obtained in the present study for White Kołuda geese are similar to those reported by Kłosowska et al. (1998) and Wężyk et al. (2003). On the other hand, Mindek et al. (2006) in commercial goose crosses revealed smaller percentage of muscle fibres type I in *m. pectoralis superficialis* than in the present study. In our previous research on Zatorska geese (Gumułka and Wojtysiak, 2005) we observed similar results concerning the content of muscle fibres in *m. pectoralis superficialis* and in *m. biceps femoris*, but the diameter of both types of fibres was higher.

In the literature there is little information on the effect of selection pressure on goose muscle microstructure. Wężyk et al. (2003) revealed thicker muscle fibres in *m. pectoralis superficialis* of the White Kołuda goose strain selected for reproductive traits in comparison with the strain of high meat trait values. In contrast, Połtowicz et al. (2007) observed a tendency towards higher diameter of muscle fibres in White Kołuda geese selected for meat traits. In the present experiment the difference in muscle fibre composition concerned only a significantly higher content of type I fibres in *m. pectoralis superficialis* of Zatorska geese in comparison with White Kołuda geese. This corresponds to the research conducted by Witkiewicz et al. (2004), who found a higher percentage of type I fibres in *m. pectoralis superficialis* in ducks from conservation flocks but a smaller diameter of both types of fibres in comparison with commercial lines. In our investigations only a tendency towards smaller diameter of type I muscle fibres in Zatorska geese was observed. On the other hand, Baeza et al. (2002) in sartorium muscle of Muscovy duck, selected for body weight, found an increase in the percentage of type IIB fibres but a decrease in type IIa fibres in comparison with the unselected line. Kłosowska et al. (1998) noted a considerably smaller amount of type IIB fibres in Landes geese, selected for fatty livers, than in White Kołuda geese.

The values of technological parameters of White Kołuda goose meat in our experiment differ from those obtained by other authors for the same geese or their crosses with other breeds. This mainly concerns water holding capacity, which for breast and leg muscles was more positive than that obtained by Rosiński et al. (1999) and Wężyk et al. (2003). Hovewer, Pakulska et al. (2002) found water holding capacity and drip loss similar to those in the present experiment. According to Berri (2000) physiological transformations occurring in muscles and their metabolism change as a result of keeping conditions. Moreover, processes to which the product is subjected postmortem are also important from the perspective of meat quality. Therefore it is difficult to compare the results of meat quality obtained for the same genetic material but by different authors.

Considering the parameters of meat technological quality, significant differences between Zatorska and White Kołuda geese were only found for water holding capacity in leg muscles. This partly corresponds with the results obtained by Pudyszak et al. (1997), who did not find any differences in the content of free water, the brightness of colour and pH_{48} postmortem of breast and thigh muscles between Biłgoraj geese, White Italian geese or their reciprocal hybrids. Likewise, in the paper by Wężyk et al. (2003) the results of water holding capacity and thermal drip of breast muscles were similar for both strains of White Kołuda geese. Pakulska et al. (2002), among several investigated traits of meat quality observed differences only in the thermal drip. Also in the paper by Połtowicz et al. (2007) a majority of breast meat quality parameters were similar for White Kołuda goose strains except for water holding capacity and drip loss. Contrary to the present results, Puchajda-Skowrońska et al. (2006) demonstrated significant differences in some parameters of meat quality between Biłgoraj geese and White Kołuda geese. Also Rosiński et al. (1999) and Okruszek et al. (2006) point to the effect of goose genotype on meat technological parameters.

The present paper attempts at determining the relationships between the traits of muscle microstructure and goose meat quality. On the basis of the negative phenotypic correlation obtained, it may be suggested that increased percentage of type IIB white muscle fibres in goose *m. pectoralis supereficialis* unfavourably affects meat acidity immediately after slaughter. On the other hand, high percentage of type I red muscle fibres is favourable as has been demonstrated by a positive relationship with pH_{15min} values. Ryu and Kim (2005) demonstrated that among various muscle fibre characteristics of pork, fibre type composition was mainly related to postmortem metabolic rate and meat quality traits. Similar to the present experiment, the authors revealed a negative phenotypic correlation between percentage of type IIB fibres and values of pH_{45min} and pH_{24h} postmortem for *longissimus dorsi*. Therefore for pork, increasing the percentage of type IIB fibre is related to the deterioration of meat quality. On the other hand, Ĉandek-Potokar et al. (1999) suggest that increasing percentages and cross-sectional areas of αW fibres in *longissimus dorsi* can be beneficial for water holding capacity parameters evaluated by measuring drip, thaw and cook loss of fresh meat.

In previous investigations on geese only, Połtowicz et al. (2007) point to a relationship between muscle microstructure and meat quality. However, the authors obtained a significant positive correlation for type IIB muscle fibres diameter and water holding capacity and thermal loss values. Our research did not reveal statistical confirmation of the relationships obtained by Połtowicz et al. (2007). Also Ryu and Kim (2005) emphasize that in pork relationships between muscle fibre diameter and meat quality traits were generally limited. On the other hand in broiler chickens, Berii et al. (2007) found that muscles with greater cross-sectional areas of fibres are characterized by better technological quality due to higher postmortem pH_{15} and ultimate pH.

In the present investigations, contrary to the results presented by Elminowska-Wenda et al. (2006) and Połtowicz et al. (2007), no significant relationship was observed between percentage of both types of muscle fibres or their diameters for goose *m. pectoralis superficialis* and the percentage content of breast muscles in the eviscerated carcass. In broiler chickens it was found that increased breast muscle weight due to selection, results mainly from fibre hypertrophy (Bihan-Duval, 2004). A positive correlation between fibre cross-sectional area and *major pectoralis* muscle weight in these birds was demonstrated by Berri et al. (2007).

Higher percentage of type I red fibres in *m. pectoralis superficialis* of Zatorska geese as compared to White Kołuda geese, did not significantly affect the parameters characterizing the suitability of meat for technological processing. Moreover, in these birds' leg muscles negative, higher values were noted for water holding capacity. On the basis of significant negative correlation it may be suggested that an increase in the percentage of type IIB muscle fibres in *m. pectoralis superficialis* of geese adversely affects meat acidity immediately after bird slaughtering.

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MAŁGORZATA GUMUŁKA, DOROTA WOJTYSIAK, EWA KAPKOWSKA,
KATARZYNA POŁTOWICZ, ANDRZEJ RABSZTYN

Mikrostruktura oraz cechy technologiczne mięsa gęsi ze stada rezerwy genetycznej i komercyjnych mieszańców

STRESZCZENIE

Badania wykonano na 32 gęsiach rasy zatorskiej należącej do chronionych zasobów genetycznych drobiu w Polsce i komercyjnych mieszańcach gęsi Białej Kołudzkiej.

Od 14. do 17. tygodnia życia ptaki tuczono owsem. Wykonano dysekcję, oceniono mikrostrukturę *m. pectoralis superficialis* and *m. biceps femoris* oraz parametry technologiczne mięsa: pH_{15min}, pH_{24h}, kolor według skali L* a* b*, wodochłonność mięsa (WHC), straty termiczne i wyciek swobodny. Ponadto, obliczono korelację fenotypową pomiędzy kompozycją włókien mięśniowych *m. pectoralis superficialis,* a wynikami dysekcji i oceny jakości mięsa.

Mikrostruktura mięśni była podobna u gęsi zatorskich i białych kołudzkich, z wyjątkiem istotnie większej zawartości włókien mięśniowych typu I w *m. pectoralis superficialis* u gęsi zatorskich. Również mięso z piersi i nóg obu grup gęsi cechowały podobne parametry technologiczne. Różnice dotyczyły tylko wyższych wartości wodochłonności (WHC) mięsa nóg gęsi rasy zatorskiej.

Stwierdzono ujemną, fenotypową korelację dla procentowego udziału włókien typu IIB, a wartości pH_{15min}. Dla procentowego udziału włókien typu I i wartości tej cechy jakości mięsa wykazano natomiast zależność dodatnią. Pozostałe zależności nie były statystycznie istotne.