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Nutritional value variability of different poultry species meat in the organic production system

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Abstract: *Nutritional value variability of different poultry species meat in the organic production system.* The aim of the present study was to determine the real nutritional composition for selected quality attributes of breast muscles of different organically-farmed bird species. The study covered four species of poultry – the Broad Breasted White turkey (group T), broiler chickens (group C), Muscovy ducks (group D), and Zatorska geese (group G). The animals came from an organic farm in Sukowska Wola (Poland). The number of birds raised on the farm was 80 per each species of poultry. The birds were raised in accordance with the organic farming standard for Poland sited in the Council Regulation (EC) No 834/2007. During the course of the present experiment, the species was found to have a significant ($P \leq 0.01$; $P \leq 0.05$) effect on the dressing percentage and the muscle and giblet content of the carcasses, which was in agreement with findings of other researches. The muscle and giblet contents served as reference values. The average body weight before slaughter was, by species: turkeys (T – 11.69 kg), chickens (C – 2.45 kg), ducks (D – 2.60 kg), and geese (G – 6.85 kg). The bird species kept in the ecological farm have largely influenced the quality of the pectoral muscle of the poultry. It can be seen that the turkey and chick muscles contained slightly more protein, while less collagen, compared to the group of ducks and geese.

Key words: organic system, poultry, quality of meat

INTRODUCTION

Across developed countries, there has been a noticeably rising interest in optimal consumer nutrition with a focus on animal well-being, as well as in high animal welfare standards that result in high quality products. Rising consumer expectations are increasingly drawing attention to the issue of meat quality. Among consumers, mainly centered in large cities, there is a growing interest in organically-grown products. In Poland, the intensive farming system is the most prevalent in poultry production. Alternative systems include free-range and organic farming. This creates opportunities for increased environmental awareness, biodiversity conservation, and the development of environmentally friendly production methods. Organic farming is a system of agricultural production that utilizes natural processes occurring within a farming environment. However, this requires the introduction of regulations that control all aspects of organic production, from the economics, through production technology, to animal rearing. The Act on organic farming of 28 June 2007 forms the legal basis on this issue in Poland. The Act states that "organic stock farming should respect high animal welfare standards and meet animals' species-specific behavioral needs and animal-health management should be based on disease prevention. In this respect, particular attention should be paid to housing conditions, husbandry practices and stocking densities. Moreover, the choice of breeds should take account of their capacity to adapt to local conditions". According to the literature, meat from e.g. slow-growing chickens is characterized by higher protein content and low fat content (desirable by consumers), while prolonged rearing periods impact the concentration of chemical compounds in breast and leg muscles, which results in the more desirable odor and taste of the meat, and, as such, its better sensory attributes. Organic farming as a sector aims to ensure high animal welfare, operation devoid of negative environmental impact, and high quality products for the consumer (Vaarst and Alrøe 2002). Longer rearing periods, access to green fodder, on-farm produced feed, and high standards of animal welfare in the organic system all generate high production costs and significantly higher market prices than intensive systems (Naspetti et al. 2014). However, consumers are willing to pay the higher price for organically-grown products (Crandall et al. 2009). Prolonged rearing periods impact the concentration of chemical compounds in breast and leg muscles, which results in the more desirable odor and taste of the meat, and, as such, its better sensory attributes (Fujimura et al. 1994). In organic farming, animals are fed on-farm produced feeds or feeds purchased from other organic farms. The feed must contain no genetically-modified ingredients, synthetic amino acids or coccidiostats. It is recommended that the ratio of the open-air run area per bird should be no less than: 4 m^2 for broiler chickens, 4.5 m^2 for ducks, 10 m^2 for turkeys, and 15 m^2 for geese (Castellini et al. 2007, Pomykała 2010). At least once per year, every organic farm is subject to detailed inspection by a certification body accredited by the Polish Ministry of Agriculture and Rural Development for organic farming certification, in accordance with the PN--EN 45011 standard. These bodies are authorized to carry out inspections and issue/revoke organic farming certificates (Domagalska and Buczkowska 2015).

The aim of the present study was to determine the real nutritional composition for selected quality attributes of breast muscles of different organically--farmed bird species.

MATERIAL AND METHODS

The study covered representatives of poultry – the Broad Breasted White turkey (group T), broiler chickens (group C), Muscovy ducks (Group D), and Zatorska geese (group G). The animals came from an organic farm in Sukowska Wola (Poland). The certification body for the farm is "Ekogwarancja PTRE" PLC, whose registered office is in Lublin, conformity certificate number 434. The farm is a family business with a multi-faceted production scheme that includes poultry production. The number of birds raised on the farm was 80 per each species of poultry. The birds were raised in accordance with the organic farming standard for Poland (Council

Regulation (EC) 834/2007, Domagalska and Buczkowska 2015), which specifies that no more than 10 birds or 21 kg of live poultry can be raised per square meter of poultry house. The poultry house had a floor area of 90 m^2. The birds were fed grain-based feed from on-farm production (triticale – 35%, oats – 15%, rye – 10%, and wheat bran – 40%). In addition, birds had access to a 10,000 m^2 open-air run. The area of the open-air run conformed to the Polish regulation standard for organically reared birds. Within the open-air run area, the birds had access to green fodder which had the following botanical composition: perennial ryegrass (45%), creeping red fescue (30%), meadow grass (15%), nettle leaf (5%), and common yarrow (5%). The open-air run allowed to birds to indulge in basic instinctual behaviours such as scratching and dustbathing. The run area was dry, properly sunlit and had a permeable ground cover.

Six birds of each species (with a sex ratio of 1 : 1) were collected for the study. The age of the birds was: 18 weeks – chickens, 22 weeks – turkeys, ducks and geese. Body weights were recorded on slaughter day. The selected birds were fasted for 12 h, with constant access to water, and then slaughtered. Carcasses were chilled with the air method at a temperature of 4°C for 24 h. Then, dissection was performed following the methodology described by Ziołecki and Doruchowski (1989). Dressing percentage was calculated, i.e. content of muscles and content of giblets (gizzard, liver and heart) in respect of the body weight before slaughter. The collected breast muscles were weighed, individually marked, protected, and left for further analyses.

Chemical composition of meat

The dissected breast muscles were subjected to the chemical and physicochemical analysis. The proximate chemical composition of breast muscles were determined with standard methods: protein content – with the Kjeldahl's method using a conversion factor of 6.25 (acc. to PN-75/A-04018); and fat content – with the Soxhlet's method (acc. to AOAC, 2005).

Physical properties of meat

The pH value of meat samples was assayed according to PN-ISO 2917:2001 with a CP-411 pH-meter (Elmetron, Zabrze, Poland), using a combined glass-calomel electrode. The electrode was calibrated against buffers of pH 4.0 and 7.0.

The breast muscle was disintegrated twice in a meat grinder with a hole diameter of 3 mm and thoroughly mixed to assure homogeneity of the sample. In thus prepared sample, pH value was measured.

Water holding capacity (WHC) was determined according to Grau and Hamm (1953), three replications of muscle were tested and the average value was taken as the result.

Colour parameters (L*, a*, b*) were analysed with a Minolta CR-410 chroma meter using ground meat (wide-area illumination / 0° viewing angle). Each measurement was carried out in five replications, taking their average value as the result. Parameter L* (colour brightness) can assume values from 0 to 100. Parameters a* – redness and b* – yellowness are trichromaticity coordinates. They can assume positive and negative values; +a* corresponds to red, –a* to green, +b* to yellow, and –b* to blue.

To determine cooking loss, breast muscles were weighed to the nearest 0.01 g (m_1), and heated in a water bath at 90°C for about 30 min (until the internal temperature reached 75 ±2°C in the geometric centre). Cooked meat was cooled at room temperature for about 1 h and moved to a cold store room (4–6°C) for 24 h, after which it was weighed again (g). Cooking loss (%) was calculated using the formula:

$$\text{cooking loss} = [(m_1 - m_2) : m_1] \times 100$$

The data obtained were analyzed statistically using a one-way analysis of variance (least squares) using SPSS 23.0 software (SPSS, Chicago, IL, USA). Differences were found significant at $P \leq 0.05$ and $P < 0.01$.

RESULTS AND DISCUSSION

Dressing percentage of meat

Production performance is affected by several factors, the most significant of which are these genetic in nature, though environmental factors also do play a role (Fanatico et al. 2008). During the course of the present experiment, the genotype was found to have a significant (^{a,b} $P \leq 0.01$; ^{A,B} $P \leq .05$) effect on the dressing percentage and the muscle and giblet content of the carcasses, which was in agreement with findings of other researches. The muscle and giblet contents served as reference values. The average body weight before slaughter was, by species: turkeys (T – 11.69 kg), chickens (C – 2.45 kg), ducks (D – 2.6 kg), and geese (G – 6.85 kg). A study by Habig et al. (2017) demonstrated the body weight of 18-week-old turkeys to be lower. On the other hand, Horsted et al. (2010) reported body weight gains for New Hampshire chickens concurrent with the present study, namely 2.1–2.16 kg at 110 days of age. Finally, Castrománe et al. (2013) demonstrated the weight of organically-farmed slow-growing chickens to be 2 kg, and that of chickens from intensive farming to be 2.5 kg. Hrncar et al. (2014) found that eight-week-old ducks from caged production systems weighed 2.94 kg, and showed a different value for ducks reared in deep litter indoor housing (2.77 kg). The lower body weight of birds may be the result of their physical activity. The differences from the results of the present study may stem from the choice of genotype, nutrition and rearing method. Another research group showed that 17-week-old Zatorska geese had a body weight of 5.65 kg (Kapkowska et al. 2011).

The literature indicates a marked variance in slaughter value between different species of poultry. The analysis of the data provided in Table 1 shows that the genotype of organically-reared birds had a significant impact on dressing percentage. Group T had the highest dressing percentage, whereas group C performed the worst in this regard. Farghly and Mahrose (2017) obtained a lower dressing percentage of turkeys from an intensive farming system. This discrepancy may result from different rearing periods, as organically-reared turkeys were slaughtered six weeks later that the industrially-farmed birds. Kapkowska et al. (2011) demonstrated lower dressing percentages in younger geese as

TABLE 1. Results of slaughter analysis of poultry, least square mean values (%)

Group	Dressing percentage	Muscles		Giblets			Abdominal fat
		breast	legs	stomach	liver	heart	
T	84.22^{A}	23.75^{A}	15.13^{A}	2.85^{B}	1.08^{B}	0.34^{B}	0.78^{A}
C	70.20^{B}	14.47^{Ba}	13.46^{B}	2.61^{B}	2.26^{A}	0.39^{B}	0^{B}
D	75.54^{BAC}	17.49^{B}	8.04^{BA}	3.05^{B}	1.75^{AB}	0.87^{A}	0.52^{C}
G	78.45^{BAD}	9.49^{Bb}	8.29^{BA}	4.20^{A}	1.67^{AB}	0.60^{AB}	2.83^{BAD}
SEM	0.599	1.196	0.362	0.162	0.104	0.024	0.200

Means in a columns with different capital or lowercase letters are significantly different at ^{a,b} $P \leq 0.01$ or ^{A,B} $P \leq 0.05$, respectively.

well. However, Jankowski et al. (2017) reported a dressing percentage of 80.6% in 16-week-old turkeys. In EU Member States, the dressing percentage of broiler chickens averages 70–71%. The chickens examined under the present study showed satisfactory dressing percentage when compared to literature data. Chen et al. (2013), for instance, noted a 69.5% dressing percentage in their study, while research by Bilal et al. (2013) showed values of 64.71–66.63%, thus indicating that the farming system does have an impact on the dressing percentage of chickens. In case of geese, Boz et al. (2017) calculated lower dressing percentage and significantly higher yields of breast and leg muscles. This difference may be due to large amounts of abdominal fat having been removed along with the viscera, which could have impacted the dressing percentage and muscle yield.

For a number of years, the yield of breast meat has been noted as a factor of importance. In traditionally-reared, fast--growing chickens, the yield of breast meat may reach 30–31% and is significantly higher when compared to slow-growing chickens raised in alternative systems. In slow-growing chickens, the yield may range from 18 to 22% (Fanatico et al. 2009). Research conducted by Połtowicz and Doktor (2011) indicates that among the hybrids examined, Ross 308 rooster × Green-legged Partridge hen hybrids offered the highest yield of breast muscles (22.38% on average), whereas crossbreeding with Sussex hens produced the lowest results (17.99%). The present study indicates that geese have lower breast meat yields, while the reverse holds true for turkeys. Low leg muscle and breast muscle yields in geese carcasses results from the lack of the intensive selection for larger muscle mass that broiler chickens and turkeys were subjected to. Owens et al. (2006), Fanatico et al. (2009), Wang et al. (2009), and Połtowicz and Doktor (2011) have demonstrated that access to open-air runs has a positive effect on leg muscle yield, thus correlating this variable with physical activity of the birds. Owens et al. (2006) suggest that this may be caused by the higher levels of exercise in birds with grass-covered open-air runs. In terms of muscle yields, group D birds (ducks) from the organic farm had significantly lower leg muscle yields than those obtained by Hrncar et al. (2014). This can be attributed to the additional physical exercise provided by the open-air runs, the long bouts of walking and the conduct of natural behaviors. Similar breast and leg muscle yields were reported by Mikulski et al. (2011).

Birds from the organic system had a higher proportion of heart muscle in the carcass compared to the results obtained by other researchers (Chen et al. 2013, Hrncar et al. 2014, Farghly and Mahrose 2017, Kjærup et al. 2017). Polak (2005) also found significant ($P \leq 0.05$) increases in the heart weight of extensively-farmed birds. The author ascribed this effect to the increased cardiac activity caused by increased physical exercise taken by chickens on open-air runs.

A significantly ($P \leq 0.01$) higher liver and gizzard weight ($P \leq 0.01$) was observed in water birds. Group G was characterized by the highest gizzard weight, which results from the specificity of the digestive tract of these birds and the feed. Many researchers suggest that the higher gizzard weight may be caused by the consumption of insects, green fodder, sand from consumed green fodder may also contribute to the increased gizzard weight (Dou et al. 2009). Amerah et al. (2007) emphasize that the muscle mass of the gizzard strongly correlates with the type of feed. In turn, Lentle et al. (2013) strongly emphasize that including pellet feeds in the diet results in a reduction of the gizzard wall.

The present study showed a lower proportion of abdominal fat in the examined bird species when compared to other studies (Mikulski et al. 2011, Chen et al. 2013, Farghly and Mahrose 2017). According to Wężyk et al. (1998), the relative content of depot fat can range from 5 to 6% of the carcass weight, and its relative percentage content in the carcass varies depending on multiple factors (feeding, sex, age, farming system). A number of researchers emphasize that alternative bird farming systems result in lower levels of abdominal fat in the poultry (Castellini et al. 2002a, b, Wang et al. 2009), as confirmed in the present study (birds were found to have low fat contents, and the chicks had no detectable fat at all). According to Lewis et al. (1997), Castellini et al. (2002a), and Mahammad et al. (2017) increased exercise of poultry specimens using open-air runs contributes to the reduced fat content. In contrast, research by Gornowicz (2009) and Połtowicz and Doktor (2011) indicates that open-air run access adversely affects the fat content, increasing its relative content in the carcass.

Chemical composition of the breast muscle

The quality of meat is a product of numerous nutritional, biological and technological parameters. Quality is additionally determined by the chemical composition and physicochemical properties of the meat, as well as by the species and breed of the bird, individual traits, sex and age. The muscle tissue typically consists of about 75% water, 20% protein, 3% fat, and 2% soluble non-proteinaceous substances. The genotype of the organically-farmed birds tended to have a significant effect on their breast meat quality. As indicated, the turkey and chicken breast meat contained slightly more protein and less collagen when compared to ducks and geese (Table 2) – both beneficial qualities from a health

TABLE 2. Chemical composition of poultry meat (g/100 g), (♀ + ♂)

Group	Breast muscles			
	water	protein	fat	collagen
T	72.25^{ABa}	24.46^{Aa}	2.04^{B}	1.07^{B}
C	74.16^{A}	23.91^{Ab}	1.40^{bB}	0.95^{B}
D	71.16^{bB}	21.97^{Bd}	2.19^{aB}	1.74^{A}
G	69.68^{B}	22.77^{Bc}	5.11^{A}	1.69^{A}
SEM	0.267	0.18	0.225	0.120

Means in a columns with different capital or lowercase letters are significantly different at ^{a,b} $P \leq 0.01$ or ^{A,B} $P \leq 0.05$, respectively.

standpoint. According to Smolińska et al. (2009), meat of gallinaceous species is characterized by higher protein content than waterfowl meat. As confirmed by the present study, chicken and turkey meat were characterized by higher protein content in comparison with duck and geese meat (Table 2). There is a known correlation between protein content and fat content (Keeton and Eddy 2004). It was therefore expected that, when compared against waterfowl meat, the lower fat content of gallinaceous poultry meat (due to higher levels of exercise) would result in higher protein content.

Qiao et al. (2001) report that raw meat poultry has a water content of 75%. According to Słowiński and Mroczek (1997), the average water content of chicken breast muscle is 71.7–74.9%. In contrast, Kauffman (2001), as well as Keeton and Eddy (2004) claim that chicken meat contains 60–75% water, but this indicator varies greatly from muscle to muscle. The water content of meat is important, as it determines its storability as microorganisms grow rapidly in heavily-hydrated environments (Küçükyılmaz et al. 2012). Mean results of physical analysis of breast meat differed greatly across the groups. The present experiment showed that geese meat had the lowest (69.68%), while chicken meat had the highest water content (74.16%). Kralik and Kralik (2017) found that intensively-farmed chickens had a higher content of water in breast muscle, namely 75.28–76.01%. On the other hand, Küçükyılmaz et al. (2012) found that meat from slow-growing, organically-reared chickens had a higher water content (72.9%) compared to chickens raised in conventional systems (74.1%). Oblakova et al. (2016) analyzed the water content of turkey breast meat and showed its value to be higher for intensively-farmed turkeys (72.72 vs. 73.77%). Similarly, breast meat from ducks was found to have a higher water content compared to organically-reared birds (Wang et al. 2016). The results of the water content of goose breast meat (69.68%) obtained in our study were similar to those obtained by Boz et al. (2017) – 70.7%.

Breast meat, particularly chicken breast meat, is generally considered to be low fat (Parkhurst and Mountney 1988, Fanatico et al. 2007). Leg muscles, on the other hand, contain more fat than breast muscles (Castellini 2002a) – however, fat enhances the taste and improves the sensory attributes, juiciness and tenderness of the meat. It is important to note that lower fat content, despite being a desirable trait for consumers, diminishes the sensory attributes of meat, though it positively influences its dietary value (Łukasiewicz et al. 2009), while also improving the flavor of the meat of, for example, slow-growing chickens (Culioli et al. 1990). Fat is necessary for maintaining proper body function, protects against heat loss, and is essential for the absorption of fat-soluble vitamins. In the present experiment, the average fat content in breast muscles was: 2.04% in turkeys, 1.40% in chickens, 2.19% in ducks, and 5.11% in geese. The fat content in chickens was significantly lower than that reported by other researchers (Küçükyılmaz et al. 2012, Chen et al. 2013, Kralik and Kralik 2017). This may be due to the higher degrees of physical exercise in the examined birds and the lower content of abdominal fat, resulting in reduced adiposis around muscles and organs. This trend is also evident in turkeys (Sarica 2011, Oblakova et al. 2016). However, the breast muscle has a higher fat content in waterfowl in general and in geese in particular.

Physicochemical analysis of breast muscles

Water holding capacity (WHC), pH and the rate of cooking loss all have an effect on the technological value of meat (and, as such, also bear indirectly on the quality of the processed products). Value of pH of the meat is related to its water holding capacity. Water holding capacity decreases at lower pH values, while the water holding capacity of muscle proteins increases with pH (Połtowicz 2000). The pH of the breast meat was found to be in the 5.33–5.38 range and was not influenced by the genotype. Castromán et al. (2013) also achieved lower pH values for meat from organically-farmed birds when compared with conventional farming. This trend is corroborated by other studies (Kapkowska et al. 2011, Sarica et al. 2011, Chen et al. 2013, Oblakova et al. 2016, Wang et al. 2016). The present study has shown that the genotype has a significant effect on the cooking loss and WHC of breast muscles. The highest cooking losses were observed in group C, while the least ones in group T. Both values were statistically significant ($P < 0.01$). Group C had the highest WHC value (9.46 cm^2/g), followed by group G (8.53 cm^2/g), group T (5.79 cm^2/g), and finally group D (2.90 cm^2/g) – Table 3. The extent of muscle mass loss or cooking loss has a significant effect on the sensory attributes, particularly palatability and juiciness. According to Bielański (2004), mass loss (cooking loss) measured as the amount of weight loss after thermal processing, are significantly higher in meat with low WHC, resulting in a less juicy finished product. In addition, lower water holding capacity of meat results in a diminished processing value and lower quality of the resultant meat product. Changes in water holding capacity are closely linked to the rate of the post-slaughter processes and the rate of the pH decrease. The tenderness of meat is partly related to glycolysis and pH decrease, but it is also dependent on proteolytic enzyme activity and other factors. The tenderness and the WHC of meat are among the

TABLE 3. Physicochemical properties of poultry meat (♀ + ♂)

Group	Breast muscles		
	pH_{24}	cooking loss (g/100 g)	WHC (cm^2/g)
T	5.38	6.13^{B}	5.79^{b}
C	5.38	13.49^{A}	9.46^{aA}
D	5.37	11.60^{A}	2.90^{aB}
G	5.33	11.52^{A}	8.53^{aA}
SEM	0.034	0.700	0.900

Means in a columns with different capital or lowercase letters are significantly different at ^{a,b} $P \leq 0.01$ or ^{A,B} $P \leq 0.05$, respectively.

most important determinants of sensory quality of meat as perceived by consumers. It has also been demonstrated that a higher fat content of meat (15%) reduces the mechanical extraction of water from the muscle fibers during heating and chewing – thus improving juiciness and tenderness. While the water content itself does not always correlate with juiciness, meat with a high water holding capacity is more juicy than meat that retains water poorly. Therefore, poultry leg meat is perceived to be more juicy than poultry breast under organoleptic examination – a result of the higher fat content and water holding capacity. According to the results of the present study, chicken meat had the superior WHC values, while turkey meat performed the best in terms of cooking loss. Chen et al. (2013) demonstrated lowered cooking loss in meat from birds with access to open-air runs, i.e. 17.5% for intensively-farmed chickens and 17% for free-range chickens slaughtered at 70 days of age (Chen et al. 2013). The results obtained in our study (13.49) show lower mass loss values, a trait desirable to consumers. Hashim et al. (2013) calculated a cooking loss at 33.9%, which diverges greatly from the results of the present study. This may stem from the texture of the meat. Meat from birds reared in intensive farming systems is delicate and tends to release water more readily. Lee et al. (2013) also demonstrated a cooking loss of over 30% in duck meat (31.52 and 31.8). Kirmizibayrak et al. (2011) achieved similar results for geese. The results in regards to WHC differ slightly between the present study and other research. Lee et al. (2013) obtained insignificantly higher results in ducks. Sarica et al. (2011) found no effect of the farming system on the WHC index. WHC results from Kapkowska et al. (2011) and Kirmizibayrak et al. (2011) were higher than these obtained in the present study. A possible cause is the lower muscle water content within the examined groups, which could have contributed to lower WHC values.

Colour parameters of poultry meat (breast muscles)

Consumers assess the freshness, and even the quality of meat, by means of visual inspection. Acidic conditions (pH 5.9–6.2) stabilize favourable colour properties in meat. Less acidic conditions (pH 6.3–6.4) stimulates deoxygenation of oxymioglobin back to deoxymyoglobin, resulting the meat turning a dark red tint typical of DFD meat. The brighter colour results from the surface of open-structured meat reflecting more light as compared with the tight structure of the DFD meat. A statistical analysis of the colour measurement results showed differences in the L* values of breast muscles for the examined groups (Table 4). The colour of the meat depends on the heme pigment concentration, the pH value, and other factors. The pH value is often correlated with colour changes in poultry meat, particularly in the breast muscle. Breast muscles of ducks had the highest value of red saturation (the a* parameter), followed by geese. Both values were statistically significant. The b* parameter indicates the ratio of yellow and blue coloration. The results obtained for this parameter indicate different levels of yellow saturation of the examined poultry, at a statistically significant level. According to Kirkpinar et al. (2001), lower values of L* and higher values of a* and b* indicate more favourable colour parameters for broiler chicken meat. The colour of fresh meat carcasses is an important commercial feature and a primary mean of evaluation for consumers. The presence of heme pigments and the resulting hue of poultry meat is a product of numerous factors and depends primarily on the bird species, sex, age, feeding, muscle type, degree of exercise during life, and the degree of exsanguination (Fanatico et al. 2007). The colour is also affected by the fat content, the muscle tissue structure and active acidity (pH) of the meat (Połtowicz 2003). The colour of the meat indicates its suitability for culinary purposes (Połtowicz 2003) and derives from myoglobin content. The level of myoglobin in meat fluctuates significantly, and with it – the intensity of the red hue. Castromán et al. (2013) found that chickens from organic farming had brighter breast muscles (L* 57.7) as compared with conventionally-farmed chickens (L* 53.3). In contrast, Chen et al. (2013) found that meat from chickens with open-air run access was darker by

TABLE 4. Color parameters of poultry meat (♀ + ♂)

Group	Breast muscles		
	L*	a*	b*
T	48.33^{A}	7.29^{A}	4.58^{B}
C	48.97^{A}	4.76^{B}	3.93^{B}
D	26.06^{B}	19.25^{Ba}	4.06^{B}
G	34.26^{BA}	17.40^{BAb}	8.02^{A}
SEM	0.609	0.489	0.539

Means in a columns with different capital or lowercase letters are significantly different at ^{a,b} $P \leq 0.01$ or ^{A,B} $P \leq 0.05$, respectively.

L* – the axis of lightness L* is perpendicular to the hue plane and cuts it through at the site of crossing with axis a* and b*. The L* values range from 0 (black) to 100 (white), and between them there are all hues of grey; a *– represents colors from green (–a) to red (+a); b *– represents colors from blue (–b) to yellow (+b).

1.2 points of brightness. Küçükylmaz et al. (2012) reported brighter breast muscles (higher L* spectrum values) in birds reared in the organic system when compared to the conventional system. In case of turkeys, the results of the present study differ from these obtained by Sarica et al. (2011). The examined turkeys had darker meat than these produced in the intensive farming system. The results obtained for brightness differ from findings of other authors (Kirmizibayrak et al. 2011, Lee et at. 2013). The lower (darker) L* brightness axis values may be due to the greater concentration of myoglobin in the muscle, which results in a higher value on the a* axis and shift to higher red saturation. The results of the present analysis differ from those presented by other researchers. Castromán et al. (2013) show higher red colour saturation when compared with the present experiment. Yellow spectrum saturation (b*) was found to be lower. Numerous authors report higher values of this parameter (Kirmizibayrak et al. 2011, Castromán et al. 2013, Chen et al. 2013, Oblakova et al. 2016). This may be the result of low muscle fat content and the high concentration of myoglobin in the meat.

CONCLUSION

Summing up the results of the production and the quality of the meat, the following conclusions can be drawn: Ecoproducts are a valuable source of animal protein. In addition, slower-growing poultry characterized by the close involvement of the chest muscles and the fast-growing legs may be intended for the production of whole carcasses for consumation.

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Streszczenie: *Zmienność wartości odżywczej mięsa różnych gatunków drobiu utrzymywanych w ekologicznym systemie produkcji.* Celem badania było określenie rzeczywistego składu odżywczego dla wybranych cech jakości mięśni piersiowych różnych gatunków ptaków hodowanych w gospodarstwie ekologicznym. Badaniem objęto czterech przedstawicieli drobiu, tj.: indyk biały szerokopierśny (grupa T), kurczęta mięsne (grupa C), kaczki piżmowe (grupa D) i gęsi zatorskie (grupa G). Zwierzęta pochodziły z gospodarstwa ekologicznego w miejscowości Sukowska Wola. Liczebność każdego gatunku drobiu w gospodarstwie wynosiła 80 sztuk. Ptaki utrzymywano zgodnie z polską normą dla gospodarstw ekologicznych według Rozporządzenia Rady (WE) 834/2007. Zaobserwowano istotny wpływ ($P \leq 0,01$; $P \leq 0,05$) genotypu na wydajność rzeźną oraz udział mięśni i podrobów w tuszce ptaków. Średnia masa ciała przed ubojem poszczególnych gatunków wynosiła odpowiednio dla indyków (T – 11,69 kg), kurcząt (C – 2,45 kg), kaczek (D – 2,6 kg) i gęsi (G – 6,85 kg). Genotyp ptaków utrzymywanych w gospodarstwie ekologicznym przeważnie wpłynął w istotny sposób na jakość mięśni piersiowych drobiu. Można zauważyć, że w porównaniu z grupą kaczek i gęsi mięśnie piersiowe indyków i kurcząt zawierały nieco więcej białka, ale mniej kolagenu.

Słowa kluczowe: ekologiczny system chowu, drób, jakość mięsa

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