Comparative analysis of the mineral composition in the meat of wild boar and domestic pig

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ABSTRACT
The aim of the study was to analyse the content of selected minerals in the samples of sirloin, i.e. longissimus lumborum muscle of wild boars (Sus scrofa scrofa L.) and domestic pigs (Sus scrofa f. domestica), taking the animal sex into account. Muscles were taken from 14 wild boars (ca. 13 months-old) and 165.5-month-old domestic pigs, at a sex ratio of 1:1. The sirloin mineral content was significantly (p < .01) influenced by the species. Muscle of the domestic pigs exhibited higher content of Mg than wild boar. In turn, the muscle of the wild boars was characterised by a higher content of K, Ca, Cu, Fe and Zn. The sex in both species had no impact on the mineral content in the muscle. The increase in the Na content in the muscle of the domestic pigs was accompanied by a decline in the K content. There was also negative relation between Fe and Ca in the domestic pigs and between Mg and Ca in the wild boars. There were positive associations between K and Fe in the domestic pigs and between K and Mg in the wild boars.

HIGHLIGHTS
- Effects of species on mineral concentration were estimated.
- Venison contained large amounts of minerals.
- Venison can be a competitive product to pork.

Introduction
Red meat is an important source of minerals (mainly Fe, Zn and Mn) in the human diet, as it provides highly bioavailable elements required for normal development and health (Nikolic et al. 2015; Tomović et al. 2015). Macro and microelements serve many functions in the human organism. They are the building material of bones, teeth, skin and hair and are fundamental components for metabolic processes, maintenance of acid-base equilibrium and regulation of water and electrolyte metabolism (Soetan et al. 2010; Ustymowicz-Farbiszewska et al. 2014). Minerals contained in meat, in comparison with those present in plants, are more easily absorbed and, therefore, more beneficial to the human organism (Alegría et al. 2009; de Castro Cardoso Pereira et al. 2013).

Deficiencies in macro- and micro-nutrient levels in the human diet are currently observed especially among adolescents, elderly subjects and pregnant women (Bolesławska et al. 2009; Terlikowska et al. 2013; Górna 2014). Insufficient uptake of essential metals leads to serious malnutrition, which is a worldwide problem (Skibsted 2016). Additionally, some chronic diseases (anaemia, osteoporosis, hypertension and coronary heart disease) caused by mineral deficiency in the diet are diagnosed (Woźniak et al. 2014; Nishito and Kambe 2018).

The content of nutrients in livestock meat can be influenced by many factors, e.g. animal species, age and sex as well as nutrition and environmental conditions (Kasprzyk 2015; Tomović et al. 2015; Zhao et al. 2016). The quality of game meat largely depends on the environmental conditions prevailing in animal habitats (Bodnárné-Skobraková et al. 2011). Wild boars (Sus scrofa scrofa L.) are omnivorous and feed mainly on plant food, e.g. grass, cereals, herbs, roots, fungi and forest fruits (Ballari and Barrios-García 2014; Merta et al. 2014, Crnić et al. 2015; Nasiadka and Janiszewski 2015; Albrecht et al. 2016). Furthermore, agricultural crops are currently an important component of the
Table 1. Nutritional value and chemical composition of diet.

| Items                  | Content |
|------------------------|---------|
| Ingredients, % as feed |         |
| Wheat                  | 29.0    |
| Barley                 | 20.0    |
| Pea                    | 29.7    |
| Concentrate*           | 20.0    |
| Fodder chalk           | 1.3     |

Chemical composition

- Metabolisable energy, MJ kg⁻¹: 12.5
- Protein, g per 1 kg: 155.0
- Lysine, g per 1 kg: 8.2
- Methionine, g per 1 kg: 2.5
- Fibre, g per 1 kg: 60.0
- Vitamins and minerals: 200 mg vitamin A, 280 IU vitamin D3, 300 mg vitamin E, 12 mg vitamin B12, 50 mg riboflavin, 40 mg pyridoxine, 3 mg thiamine, 2 mg niacin, 1.2 mg vitamin B6, 1 mg vitamin B2, 1 mg vitamin B1, 25 mg Ca, 150 mg Fe, 150 mg Mn, 100 mg Zn, 99 mg Cu, 1.0 mg I, 0.1 mg Se

*Content/kg: zinc (zinc oxide): 500 mg, iron (iron sulphate): 300 mg, manganese (manganese oxide): 150 mg, copper (copper pentahydrate): 99 mg, i (calcium iodate anhydrous): 2.1 mg, selenium (sodium selenate): 1.2 mg, vit. A: 20,000 IU, vit. D3: 13,000 IU, vit. E: 549.8 IU.

wild boar diet. Food of animal origin (e.g. earthworms, soil insects, molluscs, beetles, eggs and chicks from birds and larvae and caterpillars) constitutes a small portion of the wild boar diet (Merta et al. 2014; Pedrazzoli et al. 2017).

Despite the increasing consumers’ interest in the nutritional value of consumed food, the information about the level of minerals in red meat is insufficient (Guang-Zhi et al. 2008; Amici et al. 2012; Dannenberger et al. 2013; Babicz et al. 2018), especially data associated with the comparison of farm animals, e.g. domestic pigs (Sus scrofa f. domestica) with wild boars (Bozánová-Škrobáková et al. 2011). The novelty of the research is the assessment of the mineral composition of the sirloin from the PL breed, which was included in the Polish List of Traditional Products in 2018.

Pork is consumed worldwide in progressively increasing amounts (Florek et al. 2017). Pork meat is the most commonly eaten meat in Poland (Kasprzyk 2015). In 2017, its consumption per capita was 39.8 kg (Biernat 2018). Statistics prove that consumption of venison in Poland is small (0.08 kg/inhabitant kg/year), which is mainly due to high price and low accessibility (Kwiecińska et al. 2015).

The aim of the study was to carry out a comparative analysis of the content of selected elements in the sirloin of wild boars and domestic pigs.

Material and methods

Animals and meat samples

The research material was 300 g samples of sirloin, i.e. *musculus longissimus lumborum* between the first and third lumbar vertebrae, collected from the right half-carcasses of wild boars and domestic pigs in 2016. The samples were frozen at −18°C until analysis. The wild boars were culled in September and October in accordance with the hunting management scheme (Journal of Laws 1995 No. 147 item 713; Bill of October 13, 1995, Hunting law as amended). Wild boars were selected at the age of about 13 months ± 1 month. Age was determined by teeth eruption and wear according to Boitani and Mattei (1992). Body weight of 14 boars weighing 43 ± 5 kg was stored at the Food Processing Plant within 48 h after culling. The hunting grounds were located of the Lublin region covering the area of 25,155 km² (which is situated in the south-eastern Poland) on which agricultural land occupying in total 59% of the area of the country and forests 31% of the area. Plants cultivated in the fields include cereals (wheat, maize, barley and triticale), potatoes, fodder plants and vegetables. The forests are dominated by pine as well as birch, oak, spruce, beech and alder. The area is a typical lowland and upland agricultural region covered predominantly by brown soils with some admixture of rendzinas and podzolic soils. The animals lived in a rather uncontaminated areas of forests and meadows (on which small amounts of mineral fertilisers are used), far away from heavy industry. The region is characterised by a moderate continental climate. The average annual precipitation rate is 514 mm and the average annual air temperature is 9.5 °C.

The domestic pigs (PL breed) were kept on a large-scale family farm located in Lublin region, which complied with the animal welfare requirements. The 5.5-month-old fatteners weighing 100 ± 3.5 kg (16 animals, sex ratio 1:1) were slaughtered in accordance with the technological regulations valid in meat establishments. The domestic pigs were fed ad libitum with a complete mixture. Nutritional value and chemical composition of diet used are shown in Table 1. The doses were developed in accordance with pig nutrition standards (Grela and Skomial 2015).

Analyses of the minerals

The content of mineral components (Na, K, Ca, Mg, Fe, Zn, Mn and Cu) was determined using the flame atomic absorption spectrometry technique (AAS – Varian SpectrAA 280 FS) after prior microwaves mineralisation in a 5:1 mixture of HNO₃ and HCL. PTFE dishes were used. The mineralisation time was 30 min. Mars Xpress microwave mineraliser was adopted in this operation. The determination was carried out based on the calibration curve using background correction with a deuterium lamp. All elements were analysed in the air/acetylene stoichiometric flame.
Spectral Schinkel buffer solution was used for some elements like Na, K, Ca and Mg. Ultra Scientific standards with 99.999% purity and Merck Suprapur nitric (V) and hydrochloric acids were used in the analysis. Validation parameters used in the analysis are provided in Table 2. The quality control in the analysis was achieved by measurements of the blank sample, double sample and certified reference material ‘NIST-1577c Bovine Liver’. The content of elements was determined at the following wavelengths: Ca 422.7 nm, Mg 202.6 nm, Na 589 nm, Fe 248.3 nm, Mn 279.5 nm, Cu 324.8 nm, Zn 213.9 nm and K 766.5 nm. The analyses were performed in triplicate. The results were expressed in mg kg<sup>-1</sup> of meat weight. The research was conducted in the certified Central Instrumental Laboratory of the University of Life Sciences in Lublin.

**Statistical analysis**

The statistical analysis was performed by using Statistica version 13.1 software (Stat-Soft, Warsaw, Poland). Normality of data distribution was evaluated using Kolmogorov–Smirnov test and the Levene’s homogeneity of variance test was applied to examine the equality of variances. To determine the effect of the species and sex on the analysed traits, one-way analyses of variance were conducted. Additionally, Pearson’s correlation coefficients were estimated to describe the relationships between the analysed parameters. The general characteristics of the data were normal distribution, it allowed to estimate parametrical test. The calculated coefficients of correlation were strong. In the case of the muscle from the wild boars strong positive relationship (p < .01) and negative relations were noted between Fe and K and negative relations were noted between Na and K (Table 3). The positive relations were found between the concentration of Fe and the K level (p < .01) and negative relations were noted between Fe and Ca (p < .05). The calculated coefficients of correlation were strong. In the case of the muscle from the wild boars strong positive relationship (p < .01) and negative relation (p < .05) between Mg and K was found (Table 6).

**Results**

Table 3 presents the results of a comparative analysis of the content of macronutrients in the boar and pig muscles. The highest value of macronutrients in the muscle of the wild boars and domestic pigs was recorded for potassium and sodium. There was a high variation in the level of these components in the analysed muscle samples. The measured values for K and Ca in the muscle of the wild boars were higher (p < .01) than in the muscle of the domestic pigs, in contrast to Na and Mg. In the group of micronutrients (Table 4), there were statistically significant differences (p < .01). Levels of Fe, Zn and Cu in the muscle of the wild boars were higher (136, 91 and 90.8%, respectively) than in the muscle of the domestic pigs. There were no sex-differences in the mineral content in the muscle.

The investigations of the content of the elements in the muscle of the domestic pigs revealed a statistically significant (p < .01) negative association between Na and K (Table 5). The positive relations were found between the concentration of Fe and the K level (p < .01) and negative relations were noted between Fe and Ca (p < .05). The calculated coefficients of correlation were strong. In the case of the muscle from the wild boars strong positive relationship (p < .01) and negative relation (p < .05) between Mg and K was found (Table 6).

**Discussion**

Pork is an important source of nutrients, including bioavailable mineral elements. The physiological and therapeutic function of the elements consists mainly in activation of biochemical processes and enhancement of enzyme activities (Ekmeckioglu et al. 2016). Sodium and potassium are important for water and electrolyte metabolism and acid–base equilibrium in the organism. Reduction of the amount of potassium and/or an increase in the sodium level lead to calcium release exerting an adverse effect on bone mass.
Table 3. Content of macroelements in *musculus longissimus lumborum* (mg·kg⁻¹ wet weight).

| Elements | Domestic pigs | Wild boars | p | SEM |
|----------|---------------|------------|---|-----|
|          | Male n = 8    | Female n = 8 | Total n = 16 | Female n = 7 | Total n = 14 | Species total |
| Na       | 1764.00       | 1755.40    | 1759.70<sup>a</sup> | 1671.80 | 1573 | 1572.40<sup>b</sup> | <.01 | 21.60 |
| K        | 10879.00      | 10921.00   | 10900.00<sup>b</sup> | 11236.00 | 11243.00 | 11239.00<sup>a</sup> | <.01 | 47.54 |
| Mg       | 770.80        | 776.60     | 773.40<sup>b</sup> | 557.80 | 556.40 | 557.20<sup>a</sup> | <.01 | 24.85 |
| Ca       | 187.80        | 191.80     | 189.80<sup>b</sup> | 206.60 | 209.40 | 208.00<sup>a</sup> | <.01 | 2.31 |

Means in the same row with different letters are significantly different: A,B <.01.

Table 4. Content of microelements in *musculus longissimus lumborum* (mg·kg⁻¹ wet weight).

| Elements | Domestic pigs | Wild boars | p | SEM |
|----------|---------------|------------|---|-----|
|          | Male n = 8    | Female n = 8 | Total n = 16 | Female n = 7 | Total n = 14 | Species total |
| Zn       | 58.85         | 63.68      | 61.27<sup>a</sup> | 116.60 | 117.40 | 117.00<sup>a</sup> | <.01 | 6.49 |
| Fe       | 35.89         | 33.84      | 34.87<sup>a</sup> | 80.02 | 84.77 | 82.39<sup>a</sup> | <.01 | 5.59 |
| Mn       | 1.94          | 1.91       | 1.92      | 1.92 | 1.90 | 1.91 ns | 0.00 |
| Cu       | 3.05          | 3.06       | 3.05<sup>b</sup> | 5.79 | 5.84 | 5.82<sup>a</sup> | <.01 | 0.31 |

Means in the same row with different letters are significantly different: A,B <.01.

ns: Not significant.

Table 5. The values of the Pearson’s correlation coefficients for choosen metals determined in the muscle of domestic pigs (*Sus scrofa f. domestica*).

| Na | K | Mg | Ca | Zn | Fe | Mn | Cu |
|----|---|----|----|----|----|----|----|
| Na | 1.00 | -0.82<sup>**</sup> | 0.19 | 0.32 | -0.18 | -0.57 | 0.06 | -0.14 |
| K  | 1.00 | -0.25 | -0.61 | -0.23 | 0.85<sup>**</sup> | 0.22 | 0.19 |
| Mg | - | 1.00 | 0.10 | 0.54 | -0.46 | -0.50 | -0.46 |
| Ca | - | - | 1.00 | 0.26 | -0.71<sup>*</sup> | -0.23 | 0.21 |
| Zn | - | - | - | 1.00 | -0.53 | -0.57 | -0.50 |
| Fe | - | - | - | - | 1.00 | 0.49 | 0.32 |
| Mn | - | - | - | - | - | 1.00 | -0.01 |
| Cu | - | - | - | - | - | - | 1.00 |

<sup>*p ≤ .05.</sup>  
<sup>**p ≤ .01.</sup>

Table 6. The values of the Pearson’s correlation coefficients for choosen metals determined in the muscle of wild boars (*Sus scrofa scrofa L.*).

| Na | K | Mg | Ca | Zn | Fe | Mn | Cu |
|----|---|----|----|----|----|----|----|
| Na | 1.00 | 0.09 | -0.27 | -0.20 | 0.06 | -0.13 | 0.49 | -0.30 |
| K  | 1.00 | -0.80<sup>**</sup> | -0.48 | 0.20 | -0.32 | 0.28 | -0.22 |
| Mg | - | 1.00 | -0.69<sup>**</sup> | 0.45 | -0.08 | 0.18 | 0.01 |
| Ca | - | - | 1.00 | -0.63 | 0.12 | -0.44 | 0.23 |
| Zn | - | - | - | 1.00 | -0.03 | -0.10 | 0.10 |
| Fe | - | - | - | - | 1.00 | -0.06 | 0.37 |
| Mn | - | - | - | - | - | 1.00 | -0.55 |
| Cu | - | - | - | - | - | - | 1.00 |

<sup>*p ≤ .05.</sup>  
<sup>**p ≤ .01.</sup>

Teucher et al. 2008; Lanham-New et al. 2012). Sodium is the major cation in extracellular fluids. It preserves normal irritability of muscles and cell permeability, activates nerve and muscle function and involved in Na<sup>+</sup>/K<sup>+</sup>-ATPase, maintenance of membrane potentials, transmission of nerve impulses (Mohammadifard et al. 2018). Potassium (K<sup>+</sup>) is the most abundant cation in the body and nearly all (98%) of total body K is contained within tissue cells. Skeletal muscle is the most abundant tissue type, so skeletal muscle represents the largest reservoir of potassium in the body. The main functions of K are resting potential of the cell membrane and regulation of water and Na metabolism in the cell, controlling nerve impulses in muscles and the activation of a number of enzymes, especially those involved in energy production (Mohammadifard et al. 2018).

The results of this study indicate an effect of the species on the sodium and potassium contents. Generally, there were higher Na values in the muscle of the domestic pigs. These data are in agreement with the results reported by Sales and Kotrba (2013) for wild boars. A similar amount of Na in the *longissimus lumborum* muscle was observed by Cebulska (2015) in domestic pigs and by Zhao et al. (2016) in fatteners reared in organic and conventional systems. Commonly used feed mixtures do not contain sufficient quantities of sodium to meet the animal’s dietary need. This inadequacy is compensated for by including sodium chloride to the diet. Sodium is readily absorbed as the sodium ion; therefore, domestic pigs have a higher content of this element. The amount of sodium in the body is regulated by the endocrine system. The demand for sodium depends on physical activity, environmental temperature and age — growth processes (Jarosz 2017). Sodium deficiency in young animals causes growth retardation (Soetan et al. 2010). The measured values for potassium in muscle of the domestic pigs from this study are similar to values reported by Greenfield et al. (2009). The *musculus longissimus lumborum* of the domestic pigs reared in organic system exhibited higher content of K than in conventional (Zhao et al., 2016). Similar results for the potassium concentration of muscle tissue of the wild boar were obtained by Roślewska et al. (2016). Potassium is the main intercellular component of muscles and its content is increased during intensive body growth (Mieńkowska-Stepniewska et al. 2007). The recommended K intake for adults has been established at a level of 3500 mg/d (EFSA 2017).
Consumption of 321 g of wild boar meat and 311 g of pork fully meets the human requirement for K.

Another element analysed in the study was Mg, which is a basic component required for protein metabolism (Cyganszczegielniak et al. 2012). In this study, the muscle of the domestic pigs was characterised by 14% higher content of this element in comparison with the muscle from the wild boars. Significantly higher Mg values in the muscle of domestic pigs, in the range of 950–1070 mg kg⁻¹, were shown by Cebulska (2015). The lowest (265 mg kg⁻¹) Mg concentration was reported by Gali et al. (2008) in Chato Murciano fatteners. Meat of the domestic pigs is a good source of magnesium in human diet in Chato Murciano fatteners. The concentration of Mg in the muscles of wild boar than domestic pigs may result from the low content of this ingredient in the diet. The average Mg demand is 350 mg/d for males and 300 mg/d for females (EFSA 2017). Consumption of 453 g of domestic pig meat and 628 g of wild boar meat fully meets the human requirement (males) for Mg.

Ca plays an important role in the process of organism growth. Approximately 99% of calcium resources are located in bones. The other percent of the element is located in soft tissue cells (0.9%) and in blood and extracellular fluid (0.1%) (Soetan et al. 2010; Mohammadifard et al. 2018). The main function of this element is its involvement in the formation of the structure of bones and teeth (Mohammadifard et al. 2018). Therefore, a high calcium level has a positive effect on weight gain and strong bones. Calcium plays a vital role in enzyme activation. Calcium is also required for membrane permeability, involved in muscle contraction, normal transmission of nerve impulses and in neuromuscular excitability (Soetan et al. 2010). The daily requirement of the organism on calcium is dependent on age and sex and increases during the period of rapid growth and sex maturation (Jarosz 2017).

Muscle of the domestic pigs was characterised by lower Ca content (8.8%) than that in the muscles from the wild boars (Table 5). Similar values of the Ca concentration in fatteners meat were reported by Maiorano and Gambacorta (2009) for Large White pigs, whereas a substantially lower concentration (118 mg kg⁻¹) was determined by Tomović et al. (2011) for meat of pigs from Vojvodina. Cebulska (2015) reported Ca concentrations of 120, 210 and 270 mg kg⁻¹ for the Zlotnicka Spotted, hybrid and Pulawska breeds, respectively. The great variability found in concentrations of minerals can arise from multiple contributing factors, such as species, sexual maturity or the age of the animals. Net calcium absorption is as high as 60% in young, who need substantial amounts of the mineral to build bone. Absorption decreases to 15–20% in adulthood (IM 2010). Absorption of Ca varies depending upon the type of food consumed. Consumption of 100 g of domestic pig meat covers 2.8% of the demand for calcium in adults, whereas wild boar meat ensures 2.6% coverage of the daily requirement (EFSA 2017). As free-living animals, wild boars are characterised by higher activity than pig fatteners. Therefore, the muscles of wild animals are characterised by a greater number of intermediate and red fibres, i.e. fibres with predominance of aerobic metabolism and a smaller diameter than that of white fibres (Kasprzyk et al. 2010). As indicated by Gerber et al. (2009), an increased concentration of zinc is present in red and more active muscles. The results presented in this study (Table 4) confirm this finding, as the content of Zn in the muscle of the wild boars was shown to be by higher than in the muscle of the pigs. Muscle of wild boars contains two-fold higher levels of this element than domestic pigs. The present investigations indicate that the muscle of wild boars is a rich source of Fe. There was a higher (2.36 fold) Fe concentration in the muscle of the wild boars than in the muscle of the domestic pigs (Table 6), which was also reported by Roślewska et al. (2016). As reported by Dannenberger et al. (2013), wild boar meat contains around quadruple higher Fe levels than the meat of domestic pigs. Similar results of the Fe concentration in domestic pigs were obtained by Cebulska (2015) in the Pulawska and Zlotnicka Pstra breeds and by Galián et al. (2008) in Chato Murciano and Babicz et al. (2018) in hybrid (PL × PLW) fatteners. Importantly, Fe contained in meat is haem iron, which is absorbed at a several-fold higher level than the non-haem iron present in other raw materials and food products (Soetan et al. 2010; Nishito and Kambe 2018). As suggested by Krzecio-Nieczyporuk et al. (2013) and Nikolic et al. (2015), the absorption of meat-derived iron is approximately 20–30%, whereas iron contained in vegetable products is available only in approximately 5%. The average daily intake of Fe is approx. 16–18 mg/d for males and 12–16 mg/d for females (EFSA 2017; Jarosz 2017). Consumption of 100 g of wild boar meat fully meets the human requirement for Fe and provides 128% coverage of the Zn demand.

With regard to Mn, it is difficult to interpret the results, as the element occurs below the 2.2 mg kg⁻¹
limit of detection. The levels of Mn in the fattener meat and young wild boars were similar. As reported by Długaszek and Kopczyński (2013), the content of Mn in wild boar meat ranged from 0.08 to 1.39 mg·kg⁻¹. In investigations on the impact of the rearing system (conventional and organic) on the mineral content, Zhao et al. (2016) found mean Mn values of 0.473 and 0.695 mg·kg⁻¹ (respectively). Lower concentration of this element was noted in the muscle of hybrid (PL × PLW) by Babicz et al. (2018). The recommended daily intake of manganese is 3 mg/d in adults (EFSA 2017). 100 g of wild boar and domestic pig meat covers 6.4% of Mn demand.

An important role in iron absorption is played by Cu (Soetan et al. 2010; Nishito and Kambe 2018). Muscle of wild boars exhibited higher levels of this element than the muscle of the pigs. Similar results were obtained by Roślewska et al. (2016) in investigations of muscle from wild boars (males and females). Higher levels of Cu were found by Amici et al. (2012) in the muscle of the wild boars. The higher content of Zn, Fe, Mn and Cu in wild boar meat, compared with domestic pig meat, may be associated with the higher dietary content and better availability of these elements. The recommended daily intake of copper is 1.6 mg/d in males (EFSA 2017). To cover the demand for Cu, 525 g of domestic pig meat and 275 g of wild boar meat should be consumed.

Result recorded in the study show, in comparison with the domestic pig, the meat of the wild boar in terms of elements, has a higher quality due to the higher content of K, Ca, Zn, Fe and Cu. These data are consistent with the results reported by Sales and Kotrba (2013) and Kasprzyk (2015).

Mineral components in the animal organism exhibit a number of mutual synergistic or antagonistic interactions responsible for maintenance of homeostasis (Piontek et al. 2014). The correlation coefficients were analysed to estimate the association between the minerals contained in the muscle. As in the investigations conducted by Guang-Zhi et al. (2008), the K concentration was significantly correlated with the Ca. Potassium is a calcium antagonist, which increases muscle tone and permeability of cell membranes (Cygan-Szczegielnia et al. 2012). A high Ca concentration is noted at high acidity of the organism. A high calcium intake will increase the need for zinc (Soetan et al. 2010). As in the investigations conducted by Guang-Zhi et al. (2008), the K concentration had positive relation with the Fe content. As Długaszek and Kopczyński (2013) indicated, the Fe concentration correlates with the highest number of elements i.e. Zn, Cu, Mn, Cr and Ni (Długaszek and Kopczyński 2013).

In this study, negative association between Na and K in domestic pig were noted. Sodium is a potassium antagonist and together with it creates a concentration difference (gradient) on both sides of the cell membrane. The difference in these concentrations allows the membrane potential to be created and performs a number of functions: transmission of nerve impulses and contraction and relaxation of muscle cells. As suggested by Guang-Zhi et al. (2008) the balance of K and Na is essential for maintaining the water holding capacity and appropriate pH in the tissues. In the case of the wild boar muscle, the Mg concentration correlated negatively with the content of K, which was also reported by Roślewska et al. (2016) and negatively with the Ca content. Potassium ions together with magnesium are involved in maintenance of normal muscle tone. High potassium levels in the diet can reduce the availability of magnesium ions, thereby leading to development of hypomagnesaemia (Cygan-Szczezielnia et al. 2012). As suggested by Cygan-Szczezielnia et al. (2012), there is strong antagonism between Mg and Ca ions. The authors report that Mg deficiency stimulates secretion of the parathyroid hormone and hence Ca release from the bones and an increase in its concentration in the blood. The analysis of correlations between mineral elements in wild boar muscle performed by Roślewska et al. (2016) revealed a negative correlation between Fe and K, as in this study for domestic pig. Gasparik et al. (2012) showed a positive correlation (r = 0.59) between Zn and Cu in muscles from wild boars originating from western Slovakia. Game is a rich source of Ca and high calcium content improves tenderness (Guang-Zhi et al. 2008).

Conclusions

Muscle mineral content was significantly (p < .01) influenced by the species. Muscle of the domestic pigs exhibited higher level of Mg. In turn, the muscle of the wild boars was characterised by the higher content of K, Ca, Cu and a 2-fold higher concentration of Fe and Zn. Meat of wild boar is a good source of iron, zinc and potassium in human diet, covering a considerable share of daily demands for the elements. The sex of the animals of both species had no effect on the mineral content in the longissimus lumborum muscle. There were significant relations between some mineral components, which may indicate their integrated action in various functions of the organism. The data obtained in the investigations are important for consumers due to the possibility of selection of
food with an appropriate nutritional value. The animals included in the study were of different age (two times older wild boars than pigs). However, in the case of comparison of wild boar and domestic pigs, it is practically impossible to carry out this type of investigations using a similar material in terms of weight and age.

**Ethical approval**

The experimental procedures followed the requirements of the European Community Directive 2010/63/EU regarding the protection of animals used for experimental and other scientific purposes. No ethical committee permission was required as the samples were collected post-mortem.

**Disclosure statement**

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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