Ann. Anim. Sci., Vol. 18, No. 1 (2018) 281–291 *DOI: 10.1515/aoas-2017-0033*

DE GRUYTER
OPEN

QUALITY AND DIETARY VALUE OF PORK MEAT OF THE PUŁAWSKA AND ZŁOTNICKA SPOTTED BREEDS, AND COMMERCIAL FATTENING PIGS*

Aleksandra Cebulska[1♦], Eva Václavková[2], Maria Bocian[1], Jan Dybała[1], Joanna Wiśniewska[1], Wojciech Kapelański[1]

[1]Department of Pig Breeding and Horses, UTP University of Science and Technology, Mazowiecka 28, 85-084 Bydgoszcz, Poland
[2]Institute of Animal Science, Prague-Uhříněves, Kostelec nad Orlicí, Komenského 1239, 517 41, Czech Republic
♦Corresponding author: cebulska@utp.edu.pl

Abstract

The aim of the study was to determine the quality and nutritional value of meat originating from pigs of Polish native pure breeds – the Puławska and Złotnicka Spotted as well as the commercial four-breed crossbreds F1 (Large White × Polish Landrace) × F1 (Duroc × Pietrain). Physicochemical properties of meat were evaluated, such as acidity, water holding capacity, tenderness, and color parameters. In addition, functional properties of meat were determined: nutritional value, mineral content and fatty acid profile. The dietetic indices of meat were also determined. The smallest acidity of muscle tissue was characteristic of the meat of the Puławska breed and the smallest meat drip loss was found in both native breeds (P≤0.01). This can confirm their greater technological suitability. The most tender was meat obtained from pigs of the Puławska breed (36.07 N/cm²). The darker color was characteristic of the pig meat of the Złotnicka Spotted breed (L* = 49.19) (P≤0.01). Meat of all three groups of the tested pigs had the quality characteristics related to normal meat. The highest content of protein was found in the Złotnicka Spotted meat (25.23%) at optimum fat content (2.25%). The high content of ash (1.63%) recorded in the Złotnicka Spotted meat meant higher content of macro and microelements, especially iron and zinc, as compared to meat of the four-breed crossbreds (P≤0.01). The highest amount of monounsaturated fatty acids (52.72%) was recorded in porcine meat of the Puławska breed, while content of polyunsaturated fatty acids was the highest in meat of the four-breed crossbreds (16.77% *vs.* 9.32% and 15.19%) (P≤0.01). No differences were found between the groups tested for atherogenic index. In terms of most physicochemical and functional characteristics, meat of native pig breeds was superior to the meat of commercial pigs from mass-production.

Key words: pigs, native breeds, meat quality, nutritional value

---

*This study was funded from statutory activity.

This study was co-financed by the European Social Fund and the State Budget under the Integrated Operational Programme for Regional Development, Measure 2.6 "Regional Innovation Strategies and Knowledge Transfer" own project of Kujawsko-Pomorskie "Scholarships for PhD students 2008/2009 – ZPORR".

This study was co-financed by the European Social Fund of the European Union, the state budget and the budget of the province under Measure 8.2 Transfer of knowledge, Sub-measure 8.2.2 Regional Innovation Strategies Human Capital Operational Programme (PO KL) "Step into the future – scholarships for PhD students IVth edition".

The quality of meat and its dietetic value and health-promoting properties are becoming increasingly important in conscious and rational human nutrition. Hence, especially in recent years, both in Poland and in the world, interest in native breeds has increased, which can produce high quality meat that can be used for production of products sought by food processors and consumers (Debrecéni et al., 2016; Karolyi et al., 2007; Matoušek et al., 2016). In Poland these are the Puławska, the Złotnicka Spotted and the Złotnicka White pure breeds. Their genetic diversity has been preserved since they were not included in the breeding programs and therefore retained specific characteristics of their earlier usage, preserving the specific taste and high processing value of their meat. At the same time, scientific research in this field is clearly lacking.

Evaluation of dietetic value of meat and its health-related properties is connected with a comprehensive analysis of its chemical composition, nutrient content and the contribution of components responsible for shaping its functional value (Fernandez et al., 1999; Wood et al., 2003). According to Diplock et al. (1999), the functional value of a food is associated with its positive effect on one or more vital functions of the body, as well as the ability to prevent certain diseases. Meat, including pork, has not yet been included in functional foods, but recent studies (Blicharski et al., 2013) show that some pork characteristics may indicate its nature. Content of wholesome and easily assimilable protein and vitamins, easily absorbed minerals (especially iron) among the many features that characterize meat functionality are mentioned. Attention is also paid to the occurrence of essential fatty acids and the appropriate ratio of omega-6 to omega-3 (*n-6/n-3*).

The purpose of this paper is to compare the quality of meat from two Polish native breeds remaining in the maintenance breeding – the Puławska and the Złotnicka Spotted and from highly productive four-breed crossbred pigs, commonly found in commercial production. Atherogenicity (AI) and thrombogenicity (TI) indices (Ulbricht and Southgate, 1991), which characterize the potential prone to atherosclerosis and thrombosis in humans were used to assess dietetic values of meat.

Material and methods

The study was conducted on meat obtained from 75 animals, fattened in three equal groups (25 individuals each) under the same conditions of the production farm located in the Kujawsko-Pomorskie voivodeship. The groups where the animals were fattened were as follows:

– Group I – porkers of the Puławska pure breed (I-PUL)
– Group II – porkers of the Złotnicka Spotted pure breed (II-ZLOT)
– Group III – porkers of four-breed crossbred pigs, coming from the crossing:

♀ F_1 (Polish Landrace × Polish Large White) × ♂ F_1 (Duroc × Pietrain) (III-C)

In each group the sex ratio of the tested animals was close to 1: 1.

Animals were kept in groups, in pens of 12–13 individuals, fed *ad libitum* with a complete feeding mixture at the level of 12.6 MJ metabolizable energy and 156 g of total protein. The piggery has met all the conditions of the welfare defined by Polish law (Regulation of the Minister of Agriculture and Rural Development, 2010). Once the pigs reach 100–105 kg body weight (Puławska and Złotnicka Spotted pure breed fatteners were at the age of 8 months, four-breed crossbreds were a month younger), they were transported to a meat factory where they were slaughtered under uniform standard production conditions in accordance with Polish law and standards. About 45 minutes after slaughter, the degree of acidification of *longissimus lumborum* muscle tissue (pH_1) was determined. This measurement was repeated after 48 hours from slaughter, under laboratory conditions, on the collected samples of meat (pH_u). On the next day, after carcasses cooling, carcasses were evaluated and meat samples were taken and stored for further laboratory analysis. All test samples were taken from the lumbar section of long dorsal *musculus lumborum*.

Under the conditions of the Department of Livestock Breeding Laboratory, the Department of Pig Breeding the meat drip loss was determined by the Honikel method (1987) and by the thermal leakage method developed by Walczak (1959), calculating the loss of meat juice from the difference in sample weight before and after heating. The water holding capacity of meat according to Grau and Hamm (1952) with modifications of Pohja and Niinivaara (1957) was also determined.

Meat tenderness measurement was performed using the INSTRON 3342 testing system with Warner-Bratzler attachment, according to the method provided by Szalata et al. (1999). The physico-chemical assessment also included meat color, determined with the Minolta CR 310, using the L*a*b* system (*L* * – brightness, *a** – redness and *b** – yellowness) (Itten, 2001). The amount of total pigments in the meat was determined after their conversion to hematin according to the Hornsey method (1956).

The chemical composition of meat was assessed by determining the percentage content of water, fat, total protein and ash (PN-ISO 1442:2000, PN-ISO 1444:2000, PN 75/A-04018:1975, PN-ISO 936:2000). The mineral content was determined on the previously lyophilized samples subjected to wet mineralization in the Ethos Plus Microwave Labstation. The analyses were carried out by atomic absorption spectrometry using the Solaar 969 instrument (PN-EN 14084:2004, PN-EN 15505: 2009).

The fatty acid profile was determined in the laboratory of the Institute of Animal Science in Prague (Czech Republic), performing lipid extraction according to Folch et al. (1957). The extracted fatty acids were methylated with 0.5 N sodium methoxide followed by hexane to extract the fatty acid methyl esters (Raes et al., 2001). Fatty acid analysis was performed using a gas chromatograph (6890 N Agilent Technologies) equipped with a capillary column DB-23 (60 m × 0.25 mm × 0.25 µm). The carrier gas was nitrogen (flow velocity 0.8 m/min) and the column temperature range was 120 to 230°C. The detector temperature was 260°C. The identification of methyl esters of fatty acids was done using the following standards: 37 Component FAME Mix, PUFA No. 1, PUFA No. 2, PUFA No. 3: Sigma–Aldrich) (ČSN ISO 5508) (1994).

Based on the results of fatty acid analysis, the AI and TI dietetic indices were estimated according to the formulas developed by Ulbricht and Southgate (1991):

$$AI = \frac{C12{:}0 + 4C14{:}0 + C16{:}0}{\sum PUFA\ n\text{-}6 + \sum PUFA\ n\text{-}3 + \sum MUFA},$$

$$TI = \frac{C14{:}0 + C16{:}0 + C18{:}0}{0.5 \times C18{:}1 + 0.5(MUFA - C18{:}1) + 0.5 \times PUFA\ n\text{-}6 + 3 \times PUFA\ n\text{-}3 + \frac{PUFA\ n\text{-}3}{PUFA\ n\text{-}6}}$$

These indices are expressed by the ratio of respective saturated fatty acids to unsaturated but in different proportions. The results obtained were statistically analysed by calculating the arithmetic mean (x) and the standard deviation (s). Calculations were performed using one-way analysis of variance ANOVA. Tukey's test was used to determine the significance of the differences between the study groups. Calculations were done using the STATISTICA 9.1 PL (2010) computer software.

Results

Characteristics of meat quality related to the rate and size of muscle tissue acidity, drip loss, water holding capacity, tenderness, color and muscle pigment content are presented in Table 1. More preferably, these features have developed in native porcine meat. The lowest final meat acidity pH_u ($P \leq 0.01$), the largest loss of meat weight during storage ($P \leq 0.01$) and the highest thermal leakage ($P \leq 0.01$) were observed in the meat of the commercial pigs.

Table 1. Physico-chemical traits of meat of analyzed groups of pigs ($\bar{x}$±SE)

	Group		
	I-PUL n=25	II-ZLOT n=25	III-C n=25
pH_1	6.55±0.27	6.52±0.30	6.43±0.26
pH_u	5.71 B±0.12	5.61 B±0.24	5.45 A±0.05
Drip loss (%)	2.26 A±1.67	2.95 A±2.04	4.57 B±1.61
Thermal leakage (%)	24.89 B±1.30	21.80 A±3.65	28.42 C±2.33
Water holding capacity (%)	18.07±2.87	18.59±3.80	18.63±1.95
Plasticity (cm^2)	2.58 B±0.33	2.28 A±0.20	2.64 B±0.26
Tenderness (N/cm)	36.07 a±8.81	43.27 b±11.05	38.62±6.74
*L**	52.86 B±2.67	49.19 A±2.31	53.13 B±1.97
*a**	15.97 B±0.74	17.45 C±1.29	15.02 A±1.10
*b**	3.53 Bb±1.26	2.66 a±1.23	2.40 A±1.08
Heme pigments (µg/g)	50.97±6.76	54.67±10.44	50.19±5.66

a, b – values in rows with different letters differ significantly ($P \leq 0.05$).
A, B, C – as above for ($P \leq 0.01$).

The water holding capacity of the porcine meat of all three groups was very close and high, which could have been due to a slow and steady decrease in pH in the first hour (pH_1) after slaughter. In terms of tenderness, evaluated by the cutting force (N/cm^2), the meat of the Puławska breed was significantly more tender than that of the Złotnicka Spotted pigs ($P \leq 0.05$). It reached lower values, which showed less shear force needed to cut muscle fibers.

High meat color parameters assessed by Minolta CR 310 and pigment content were the most advantageous in the meat of pigs of the Złotnicka Spotted breed. It was the darkest meat (lowest value of L *) ($P \leq 0.01$) and characterized by the highest redness ($P \leq 0.01$) and the higher content of heme pigments.

Table 2 shows the results of the determination of the basic chemical composition of the meat of the examined pig groups. Particularly noteworthy is the low content of water in native swine meat compensated by higher fat content in the Puławska porcine meat ($P \leq 0.01$) and higher protein content in meat of the Złotnicka Spotted breed ($P \leq 0.01$). Similar data were also reported by other authors (Grześkowiak et al., 2006; Szulc et al., 2012).

Table 2. The basic chemical composition of meat of analyzed groups of pigs ($\bar{x} \pm SE$)

	Group		
	I-PUL n=15	II-ZLOT n=15	III-C n=15
Water (%)	70.76 A±2.41	70.89±1.20	73.38 B±0.70
Fat (%)	4.07 B±1.54	2.25 A±0.72	1.70 A±0.61
Protein (%)	23.67 A±1.19	25.23 B±1.36	23.39 A±0.54
Ash (%)	1.50 a±0.15	1.63 b±0.11	1.53±0.11

a, b – values in rows with different letters differ significantly ($P \leq 0.05$).
A, B – as above for $P \leq 0.01$.

Table 3. Mineral content in meat of analyzed groups of pigs ($\bar{x} \pm SE$)

	Group		
	I-PUL n=15	II-ZLOT n=15	III-C n=15
Na (g/kg)	1.92 A±0.56	2.03 A±0.47	1.53 B±0.16
K (g/kg)	13.35 A±0.78	15.09 B±1.96	14.90 B±0.75
Mg (g/kg)	0.95 A±0.05	1.07 B±0.19	1.06 B±0.06
Ca (g/kg)	0.27 Bb±0.09	0.12A±0.10	0.21 Ba±0.08
Zn (mg/kg)	47.12 B±7.49	49.79 B±11.34	25.70 A±6.27
Fe (mg/kg)	30.08 Ba±6.30	40.03 Bb±16.66	13.26 A±11.84
Cu (mg/kg)	5.21 b±1.15	4.08 a±0.96	4.14 a±1.41

a, b – values in rows with different letters differ significantly ($P \leq 0.05$).
A, B – as above for $P \leq 0.01$.

Table 4. The content of fatty acids in meat of analyzed groups of pigs ($\bar{x}$±SE)

	Group		
	I-PUL n=15	II-ZLOT n=15	III-C n=15
Fatty acids profile (%)			
C14:0 – myristic	1.34±0.11	1.44±0.41	1.27±0.18
C16:0 – palmitic	24.02 b±1.06	23.68±1.02	23.03 a±0.92
C16:1 *n-7* – oleopalmitic	4.05 Bb±0.35	3.55 a±0.67	3.45 A±0.37
C18:0 – stearic	11.65±0.93	11.18±1.21	12.08±0.98
C18:1*n-9* – oleic	43.33 B±1.86	39.18 A±2.65	37.26 A±2.37
C18:1*n-7* – vaccenic	4.62 B±0.34	4.03 A±0.40	4.21 A±0.26
C18:2*n-6* – linoleic	6.18 A±1.41	10.91 B±2.39	11.09 B±1.97
C18:3*n-6* – gamma linolenic	0.10 A±0.05	0.12 a±0.05	0.17 Bb±0.05
C18:3*n-3* – alpha linolenic	0.30 A±0.04	0.49 B±0.12	0.69 C±0.11
C20:0 – arachidic	0.36±0.05	0.38±0.21	0.58±0.20
C20:1*n-9* – eicosenoic	0.72±0.06	0.60±0.09	0.63±0.07
C20:2*n-6* – eicosadienoic	0.20±0.04	0.21±0.04	0.34±0.06
C20:3*n-6* – homo-γ-linolenic	0.26 A±0.09	0.32±0.14	0.39 B±0.11
C20:4*n-6* – arachidonic	1.43 A±0.49	2.29 B±0.68	2.71 B±0.70
C20:3*n-3* – eicosatrienoic	0.06 A±0.01	0.06 A±0.02	0.14 A±0.05
C20:4*n-3* – eicosatetraenoic	0.02±0.01	0.02±0.01	0.03±0.01
C20:5*n-3* – eicosapentaenoic (EPA)	0.13±0.12	0.11±0.02	0.10±0.02
C22:4*n-6* – adrenic	0.18 A±0.04	0.28 B±0.07	0.37 C±0.09
C22:5*n-3* – docosapentaenoic (DPA)	0.43 A±0.19	0.32 A±0.07	0.70 B±0.20
C22:6*n-3* – docosahexaenoic (DHA)	0.04±0.01	0.05±0.02	0.05±0.01

a, b – values in rows with different letters differ significantly (P≤0.05).
A, B – as above for P≤001.

Ash content in meat, which characterizes the sum of all the minerals, was highest in the Złotnicka Spotted breed (P≤0.05). The content of individual minerals is shown in Table 3. Content of Na, K, Mg, Ca in g/kg and Zn, Fe, Cu in mg/kg in muscle tissue was reported. The biggest differences between compared breeds of pigs concerned the content of zinc and iron. Porcine meat of native breeds compared to commercial pigs had twice as much zinc and nearly three times more iron.

The content of individual fatty acids in the examined meat is presented in Table 4. They are classified into individual groups in Table 5. The levels of saturated and unsaturated fatty acids proved to be very evenly matched between the groups studied. Higher percentage share of monounsaturated acids, which are of great importance in meat flavor development, were found in the Puławska pig meat (P≤0.01). At the same time, it had the least polyunsaturated acids, significantly differing (P≤0.01) from the other groups of pigs. The omega-3 and omega-6 fatty acids did not show too high levels in the studied groups. The determination of the proportion of PUFA *n-6*/ PUFA *n-3* is very important from a dietary point of view. In the Puławska and four-breed crossbreds, the proportion achieved the lowest level (8.79 and 8.88) (P≤0.01). The highest content of cholesterol was characteristic of meat of the Puławska breed (P≤0.05). Low levels of thrombogenicity were reported in all groups, with the highest value reported for the Puławska pigs (P≤0.05). Atherogenicity values were similar and relatively low in all pig groups studied.

Table 5. The content of individual groups of fatty acids and dietary indices in meat of analyzed groups of pigs ($\overline{x}$±SE)

	Group		
	I-PUL n=15	II-ZLOT n=15	III-C n=15
SFA	37.79±1.89	37.20±1.54	37.49±1.58
UFA	62.05±1.89	62.56±1.59	62.32±1.57
MUFA	52.72 B±2.06	47.37 A±3.02	45.55 A±2.55
PUFA	9.32 A±2.30	15.19 B±3.11	16.77 B±3.06
UFA/SFA	1.65±0.13	1.69±0.11	1.67±0.11
PUFA *n-3*	0.97 A±0.31	1.06 A±0.17	1.71 B±0.32
PUFA *n-6*	8.35 A±2.02	14.13 B±2.98	15.06 B±2.78
PUFA *n-6*/PUFA *n-3*	8.79 A±1.26	13.39 B±1.92	8.88 A±1.02
DFA	73.70±1.12	73.74±1.37	74.40±0.10
OFA	25.36±1.15	25.13±1.39	24.30±1.08
Cholesterol (g/kg)	1.01 b±0.25	0.81 a±0.13	0.81 a±0.14
AI	0.41±0.03	0.40±0.03	0.39±0.03
TI	1.11 b±0.10	1.07±0.07	1.03 a±0.09

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

A, B – as above for P ≤ 0.01.

SFA – saturated fatty acids, UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, DFA – neutral and hypocholesterolemic acids, OFA – hypercholesterolemic acids, AI – atherogenicity index, TI – thrombogenicity index.

Discussion

Food manufacturers increasingly rely on the production of foods with elevated health and dietary value. In the case of meat and meat products, a specific source of raw material can be pigs of indigenous species previously not covered by the production improvement program, retaining their natural genetic diversity (Alfonso et al., 2005; Babicz et al., 2010; Pugliese et al., 2004).

The results of the quality studies conducted on meat of the Puławska breed and pigs of the Złotnicka Spotted breed emphasize high processing value and technological value of the meat of these animals. The meat does not lose its nutrients, which results from appropriately high pH_1 and pH_u, low meat drip loss during storage and processing of meat, its high water holding capacity and low loss after heat treatment. In addition, meat of the Puławska pigs was particularly tender, while meat of the Złotnicka Spotted breed was characterized by dark color and the highest content of muscle pigments. Similar results were obtained by other authors (Bocian et al., 2012; Florowski et al., 2006), showing the superiority of the technological properties of Złotnicka Spotted and Puławska pigs.

The high nutritional value of the tested meat of native pigs indicates the high fat content in the Puławska pig meat and above all the very high protein content in meat of the Złotnicka Spotted breed. Total valuable protein is an essential ingredient in the human diet, allowing for the continuous reconstruction and metabolism of all tissues and organs. The fat content will be discussed below with the emphasis on the role of individual fatty acids.

The sum of all the minerals was the highest in the pigs of the Złotnicka Spotted breed. The appropriate level and distribution of potassium and sodium ions forms the correct electrolyte balance of the organism (Marchello et al., 1985). The much higher content of zinc and iron in native pigs shown in this work raises the dietary and health value of this product (Giuffrida-Mendoza et al., 2007). Zinc is considered to be a microelement responsible for the secretion of certain hormones, the proper functioning of the immune system and, as having an anti-tumor effect (Matwiejuk, 2009). Heme derived iron in meat is a source of easily absorbed element essential for the production of erythrocytes and involved in the transport of oxygen in the body (Blicharski et al., 2013).

The assessment of the role of fat content in meat has changed over the years. At present, due to the great possibilities of careful analysis of the role of individual fatty acids in tissue metabolism, there are some perceived values of fat in the diet. The nature and proportion of individual fatty acids, especially saturated (SFA) to unsaturated (UFA), is important in assessing the quality and nutritional value of fats. The proportions of these fatty acid groups have been used to calculate the very important risk factors for atherogenic index (AI) and thrombogenic index (TI) (Ulbricht and Southgate, 1991). A lower AI value indicates a lower proportion of saturated to unsaturated acids, which reduces ability of endothelium of blood vessels to attach lipids and plaque formation. The thrombosis index calculated similarly from the proportion of other fatty acids, at its lower index indicates a lower risk of occurrence of disturbance of the blood coagulation process and blood clotting. These both indices in the present study were at an appropriate low level close to that observed in wild boar meat (Razmaite et al., 2012). According to the recommendations of Food and Agriculture Organization of the United Nations (FAO, 2010) the ratio of unsaturated fatty acids to saturated in the diet should be 1:1. For the meat we tested, the ratio was approximately 1.67. The World Health Organization (WHO) indicates that cholesterol intake should not exceed 300 mg/day (Jiménez-Colmenero et al., 2001). Values regarding the presence of this ingredient in meat of the tested fattening pigs indicate its low content, which should not adversely affect the health, if standard pork meat quantity is eaten. This applies to both native breeds and four-breed crossbreds.

The proportion of omega-6 to omega-3 fatty acids also deserves consideration. The reciprocal proportion of these acids shapes the healthy nature of the consumed product. Too high *n-6* fatty acids content may cause cancer and cardiovascular disease (Simopoulos, 2002). The *n-6* PUFA/*n-3* PUFA ratio should be about 4–9:1 (Simopoulos, 2002). According to Kolanowski and Świderski (1997) and Marciniak-Łukasiak and Krygier (2004) these acids should cover 1/3 of the dietary fat requirement. Results of *n-6/n-3* ratios in meat of three tested groups of pigs showed their correct level in the Puławska breed and the commercial pigs and higher than recommended in the Złotnicka Spotted breed.

In summary, the high processing and technological value of pig meat from native breeds should be emphasized. The nutritional value of the Puławska pig meat increased due to the high fat content and of the Złotnicka Spotted breed due to very high protein content. The high content of minerals, especially zinc and iron, significantly increased the dietary value of pig meat of both native breeds. Similarly, the profile of fatty acids and the proportions of individual fatty acids expressed in the form of disease risk indices (AI, TI) allow characterizing the meat of the Puławska pig – despite significant fat content – as a product with high health value.

References

Alfonso L., Mourot J., Insausti K., Mendizabal J.A., Arana A. (2005). Comparative description of growth, fat deposition, carcass and meat quality characteristics of Basque and Large White pigs. Anim. Res., 54: 33–42.

Babicz M., Kamyk P., Rejduch B., Kozubska-Sobocińska A., Stasiak A., Lechowski J. (2010). Use of Pulawska breed pig for specific-quality pork production (in Polish). Med. Weter., 66: 555–558.

Blicharski T., Książek P., Pospiech E., Migdał W., Jożwik A., Poławska E., Lisiak D. (2013). The current dietary value of pork, its importance in diet and its impact on consumers health (in Polish). Warsaw, 153 pp.

Bocian M., Wojtysiak D., Jankowiak H., Cebulska A., Kapelański W., Migdał W. (2012). Carcass, meat quality and histochemical traits of *m. longissimus lumborum* from Złotnicka Spotted pigs and commercial pigs. Folia Biol. (Kraków), 60: 181–187.

ČSN ISO 5508. (1994). Animal and vegetable fats and oils. Analysis by gas chromatography of methyl esters of fatty acids. The Czech Office for Standards, Metrology and Testing, Prague, Czech Republic.

Debrecéni O., Komová P., Bučko O. (2016). Comparison the physicochemical quality indicators of *Musculus Longissimus Dorsi* from Mangalitsa breed and their crossbreeds. J. Cent. Eur. Agri., 17: 1253–1263.

Diplock A., Aggett P., Ashwell M., Bornet F., Fern E., Roberfroid M. (1999). Scientific concepts of functional foods in Europe: consensus document. Brit. J. Nutr., 81: 1–27.

Fernandez X., Monin G., Talmant A., Mourot J., Lebret B. (1999). Influence of intramuscular fat content on the quality of pig meat – 1. Composition of the lipid fraction and sensory characteristics of *m. longissimus lumborum*. Meat Sci., 53: 59–65.

Florowski T., Pisula A., Adamczak L., Buczyński J.T., Orzechowska B. (2006). Technological parameters of meat in pigs of two Polish local breeds – Zlotnicka Spotted and Pulawska. Anim. Sci. Pap. Rep., 24: 217–224

Folch J., Lees M., Stanley S.G.H. (1957). A simple method for the isolation and purification of total lipids from animal tissues. J. Biol. Chem., 226: 497–509.

Food and Agriculture Organization at the United Nations. (2010). Fats and fatty acids in human nutrition – Report at an expert consultation. FAO Food and Nutrition Paper, 91: 1–166.

Giuffrida-Mendoza M., Arenas de Moreno L., Uzcåtegui-Bracho S., Rincón-Villalobos G., Leidenz-Huerta N. (2007). Mineral content of *longissimus dorsi thoracis* from water buffalo and Zebu-influenced cattle at four comparative ages. Meat Sci., 75: 487–493.

Grau R., Hamm R. (1952). Eine einfache Methode zur Bestimmung der Wasserbindung im Fleisch. Fleischwirtschaft, 4: 295–297.

Grześkowiak E., Borzuta K., Strzelecki J., Lisiak D. (2006). Results of assessment of meat quality in fat-meat type pigs currently fattened on small farms. Anim. Sci. Pap. Rep., 24 (Suppl.): 113–118.

Honikel K.O. (1987). The water binding of meat. Fleischwirtschaft, 67: 1098–1102.

Hornsey H.C. (1956). The colour of cooked cured pork. I. Estimation of the nitric oxide-haem pigments. J. Sci. Food Agr., 7: 534–540.

Itten J. (2001). The elements of color: a treatise on the color system of Johannes Itten, based on his book The art of color. New York, USA, John Wiley and Sons, 95 pp.

Jiménez-Colmenero F., Carballo J., Cofrades S. (2001). Healthier meat and meat products: their role as functional foods. Meat Sci., 59: 5–13.

Karolyi D., Salajpal K., Kiš G., Đikić M., Jurić I. (2007). Influence of finishing diet on fatty acid profile of longissimus muscle of Black Slavonian pigs. Poljoprivreda/Agriculture, 13: 176–179.

Kolanowski W., Świderski F. (1997). Polyunsaturated fatty acids from the n-3 group (n-3 PUFA). Beneficial health effects, recommended for consumption, food enrichment (in Polish). Żywienie Człowieka i Metabolizm, 2: 49–63.

Marchello M.J., Slanger W.D., Milne D.B. (1985). Macro and micro minerals from selected muscles of pork. J. Food Sci., 50: 1375–1378.

Marciniak-Łukasiak K., Krygier K. (2004). Characterization of omega-3 acids and their use in functional foods (in Polish). Przemysł Spożywczy, 12: 32–36.

Matoušek V., Kernerová N., Hyšplerová K., Jirotková D., Brzáková M. (2016). Carcass traits and meat quality of Prestice Black-Pied pig breed. Asian Australas. J. Anim. Sci., 29: 1181–1187.

Matwiejuk A. (2009). Minerals (macronutrients and micronutrients) and their importance in athletes nutrition (in Polish). Roczniki Naukowe Wyższej Szkoły Wychowania Fizycznego i Turystyki, pp. 97–99.

Ordinance of The Minister of Agriculture and Rural Development: On the requirements and how to proceed while maintaining livestock species for which protection standards are provisions of the European Union, Dz. U. pos. 56, no. 344, Warsaw, Poland, 2010.

Pohja M.S., Niinivaara F.P. (1957). Die Bestimmung der Wasserbindung des Fleisches mittels der Konstantdrückmethode. Fleischwirtschaft, 9: 193–195.

Pugliese C., Calagna G., Chiofalo V., Moretti V.M., Margiotta S., Franci O., Gandini G. (2004). Comparison of the performances of Nero Siciliano pigs reared indoors and outdoors: 2. Joints composition, meat and fat traits, Meat Sci., 68: 523–528.

Raes K., de Smet S., Demeyer D. (2001). Effect of double-muscling in Belgian Blue young bulls on the intramuscular fatty acid composition with emphasis on conjugated linoleic acid and polyunsaturated fatty acids. Anim. Sci., 73: 253–260.

Razmaite V., Švirmickas G.J., Šiukščius A. (2012). Effect of weight, sex and hunting period on fatty acid composition of intramuscular and subcutaneous fat from wild boar. Ital. J. Anim. Sci., 11:e32: 174–179.

Simopoulos A.P. (2002). The importance of the ratio of omega-6/omega-3 essential fatty acids. Biomed. Pharmacother., 56: 365–379.

Szalata M., Pospiech E., Łyczyński A., Urbaniak M., Frankiewicz A., Mikołajczak B., Mesyński A., Rzosińska E., Bartkowiak Z., Danyluk B. (1999). Tenderness of pig meat with differentiated meatiness (in Polish). Roczniki Instytutu Przemysłu Mięsnego i Tłuszczowego, 36: 61–76.

Szulc K., Lisiak D., Grześkowiak E., Nowaczewski S. (2012). The influence of cross–breeding Zlotnicka Spotted native breed sows with boars of Duroc (D) and Polish Large White (PLW) breeds on meat quality. Afr. J. Biotechnol., 11: 4471–4477.

The Polish Committee for Standardization (2004). PN-EN 14084:2004. Food products. Determination of trace elements. Determination of lead, cadmium, zinc, copper and iron by flame atomic absorption spectrometry (AAS) after microwave mineralization. Catalog of Polish Standards, date of publication 28.09.2004, 18 pp.

The Polish Committee for Standardization (2009). PN-EN 15505:2009. Food products. Determination of trace elements. Determination of sodium and magnesium content by flame atomic absorption spectrometry (AAS) after microwave mineralization. Catalog of Polish Standards, date of publication 13.08.2009, 17 pp.

The Polish Committee for Standardization (2000). PN-ISO 1442:2000. Meat and meat products. Determination of water content (Reference method). Catalog of Polish Standards, date of publication 14.06.2000, 9 pp.

The Polish Committee for Standardization (2000). PN-ISO 1444:2000. Meat and meat products. Determination of free fat. Catalog of Polish Standards, date of publication 14.06.2000, 7 pp.

The Polish Committee for Standardization (2000). PN-ISO 936:2000. Meat and meat products. Determination of total ash. Catalog of Polish Standards, date of publication 14.06.2000, 8 pp.

The Polish Committee for Standardization (1975). PN 75/A-04018:1975. Agricultural and food products. Determination of nitrogen by the Kjeldahl method and conversion to protein. Catalog of Polish Standards, date of publication 13.06.1975, 11pp.

Ulbricht T.L.V., Southgate D.A.T. (1991). Coronary heart disease: seven dietary factors, Lancet, 338: 985–992.

Walczak Z. (1959). Laboratory method for determining the content of jelly in canned meat (in Polish). Roczniki Nauk Rolniczych, 74-B-4: 619.

Wood J.D., Richardson R.I., Nute G.R., Fisher A.V., Campo M.M., Kasapidou E., Sheard P.R., Enser M. (2003). Effects of fatty acids on meat quality: A review. Meat Sci., 66: 21–32.

Received: 29 VI 2017
Accepted: 3 X 2017

.