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Effect of sex on the meat quality of European wild boar (*Sus scrofa scrofa*)

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Abstract: *Effect of sex on the meat quality of European wild boar* (Sus scrofa scrofa). Forty carcasses (38.6–45.9 kg) from male and female (1 : 1) wild boar, which were shot in one hunting area during the 2014/2015 season, were studied. Samples of MLD were analysed for proximate chemical composition and fatty acid content of IMF as well as shear force and WHC. Values of AI and TI index were calculated. Statistical analysis confirmed a significant ($P \leq 0.05$) effect of sex on the water content of MLD, which was higher in males than in females. Protein content of MLD was high and averaged 24%. Meat was lean with IMF below 2%. The PUFA to SFA ratio was similar in both groups of sex, and the dietetically beneficial n-6 to n-3 PUFA ratio was less than 4 : 1 because the proportion of n-3 PUFA was high at 4.7–5.1 g per 100 g of fat. The effect of sex of wild boar on AI was significantly ($P \leq 0.05$) higher in males than in females. The results obtained show that the meat of wild boar of both groups of sex would be a rich source of protein in the human diet as well as a source of long-chain n-3 PUFA. The high level of long-chain n-3 PUFA is in line with dietary recommendations for the low n-6/n-3 PUFA. Due to its health-promoting benefits, wild boar meat may provide an alternative to the meat of farm animals.

Key words: wild boar, sex, meat quality

INTRODUCTION

In Poland, the size of the wild boar population has consistently increased from 173,500 in 2005 to 250,000–285,000 at present. The number of wild boar shot in the 2014/2015 season was 291,450 and encompassed all sex and age classes (GUS 2015).

The annually increasing harvesting of wild boar meat and its more availability led consumers to show greater interest in game meat and believe that animals living in their natural habitats are a source of healthy food (Popczyk 2012, Skorupski and Wierzbicka 2014, Kasprzyk 2015).

The quality of wild boar meat is an important factor as regards the consumers' choice of this type of meat. The living conditions of wild boar and the specific biodiversity of their natural feeding grounds contribute to the content of basic nutrients in their meat (including the level of protein and fat), the unsaturated

to saturated fatty acids ratio (which is particularly beneficial compared to that in pork), and the flavour and aroma of the meat (Quaresma et al. 2011, Guzek et al. 2013, Skobrák Bodnár and Bodnár 2014).

The aim of the study was to determine if the sex of wild boar has a significant effect on the quality of their meat.

MATERIAL AND METHODS

Carcasses obtained from 40 male and female (1 : 1) wild boar, which were shot in one hunting area of central Poland between December 2014 and January 2015, were investigated. Carcass weight averaged 45.9 kg for females and 38.6 kg for males. The animals were hunted at night. After shooting and bleeding out wild boar were eviscerated and transported within 48 h to a slaughterhouse, where the carcasses were weighed, removed skin and samples (300 g) of *m. longissimus dorsi* (MLD, part of *musculus lumborum*) were collected.

The samples of MLD were analysed to determine proximate chemical composition, fatty acid content of intramuscular fat (IMF), water holding capacity (WHC) and shear force. The chemical composition (water, protein, fat, collagen) was determined by near-infrared transmission (NIT) spectroscopy with calibration using artificial neural networks (ANN) and FoodScan™ meat analyser (PN-A-82109:2010).

Water holding capacity was determined in a 300 mg sample of meat, which was placed on a filter paper (Whatman 1) and held under 2 kg pressure between glass plates for a period of 5 min (Grau and Hamm 1953). An electronic planimeter was used to calculate the area of the pressed meat sample and the area of expressed water. The free water was calculated as the quotient of the difference between the areas of expressed water and pressed meat sample, and sample weight.

Shear force value was measured using a Zwick 1120 tester. Samples of MLD were boiled in water for 30 s and, after placing into an oven at 180°C, roasted to an internal temperature of 76°C. The sample was cooled at room temperature (24 h). A 20 mm cube was excised from the sample and cut with a Warner-Bratzler blade with a speed of 30 mm/min to reach a shear force of 2 N and with a speed of 50 mm/min during the test.

Lipid extraction of meat samples was performed according to the Folch procedure (AOAC 2005) at room temperature. Fatty acid methylation was performed according to the transesterification method EN ISO 5509:2000. Identification with fatty acid standards and quantitative determination of individual fatty acids in crude fat were conducted using a Agilent Technologies 7890A GC (Agilent, Waldbronn, Germany) with HP ChemStation software, a flame–ionization detector and a Varian Select FAME column (100 m length, 0.25 mm diameter, 0.25 μm film thickness; Varian/Agilent Technologies, Waldbronn, Germany). The analysis involved a programmed run with temperature ramps under the conditions and temperatures

described by Puppel (2011). Each peak was identified and quantified using pure methyl ester standards (PUFA 1, Lot LB 75066; PUFA 2, Lot LB 83491; FAME Mix RM-6, Lot LB 68242; Supelco 37 Comp. FAME Mix, Lot LB 68887; Supelco, Bellefonte, PA, USA).

Atherogenic (AI) and thrombogenic (TI) index were calculated according to the formula given by Ulbricht and Southgate (1991).

$$AI = [C12:0 + (4 \times C14:0) + C16:0] / [MUFA + PUFAn\text{-}6 + PUFAn\text{-}3]$$

$$TI = (C14:0 + C16:0 + C18:0) / [(0.5 \times MUFA) + (0.5 \times PUFAn\text{-}6) + (3 \times PUFAn\text{-}3) + (PUFAn\text{-}3 / PUFAn\text{-}6)]$$

The results were statistically elaborated. The differences between the groups were determined by the U Mann–Whitney test (IBM SPSS Statisics 23). The table contain the means of the traits together with the standard deviation.

RESULTS AND DISCUSSION

Statistical analysis confirmed a significant ($P \leq 0.05$) effect of sex on the water content of MLD (Table 1). These differences can also result from the mass of carcass. Female carcasses were heavier than male carcasses. Protein content of MLD was high and averaged 24%. Meat was lean with IMF below 2%. A similarly high protein content (23.1–24.1%) of MLD obtained from wild boar of both sexes was determined by Dannenberger et al. (2013), who also showed a significant difference in IMF level between males and females older than 1 year. In the study by Postolache et al. (2011), IMF content of *m. longissimus dorsi* exceeded 2% (2.48% in males and 2.57% in females), but the carcasses were heavier than in our study. In turn, Quaresma et al. (2011) reported IMF content to be twice as high but in *m. psoas major*. The Feder number, being the ratio of water to protein content in the meat (index of protein hydration), was similar in both groups of sex ($P > 0.05$), less than 3.5,

TABLE 1. Chemical composition, water holding capacity and shear force of MLD from wild boar

Item	Sex				*P*
	female		male		
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	
Number of animal	20		20		
Moisture (%)	71.62[a]	1.06	72.37[b]	0.76	0.042
Protein (%)	24.19	1.08	23.90	0.62	0.371
Fat (%)	1.94	0.67	1.63	0.48	0.154
Collagen (%)	1.39	0.19	1.53	0.37	0.284
Feder number	2.97	0.17	3.03	0.10	0.319
WHC (g/cm^2)	9.91	2.76	12.43	5.11	0.081
Force shear (N)	68.94[A]	17.72	51.44[B]	16.94	0.012

A, B – differences $P \leq 0.01$; a, b – differences $P \leq 0.05$.

which is characteristic for raw ham meat of pigs (Olkiewicz 2009).

Collagen is a major structural protein of muscle that largely determines meat tenderness and sensory characteristics. Sex had no effect on the collagen content of MLD and its level did not exceed 2%. That sex has no effect on collagen level in different muscles is confirmed by Postalache et al. (2011) and Lazar et al. (2014). Research results regarding the impact of gender on collagen concentrations in wild game meat are ambiguous, probably due to the combined effects of other factors including the age, diet, species and motor activity of animals (Daszkiewicz et al. 2012).

The meat from females showed a slightly higher water holding capacity compared to the meat of males ($P > 0.05$). With a slightly higher protein content and more favourable WHC, the meat from females was harder than the meat of males ($P \leq 0.01$).

Sex had no effect on SFA content and only a significantly ($P \leq 0.01$) higher C17:0 and C24:0 content of fat was found in males compared to females (Table 2). Quaresma et al. (2011) observed no significant effect of sex on the fatty acid composition of IMF. The same authors reported that the main fatty acids in *m. psoas major* are C18:1*c*9, C18:2n-6, C16:0 and C18:0. Likewise in our study, these fatty acids were most abundant in the MLD of wild boar. The most abundant acids were palmitic (C16:0) and stearic acids (C18:0) in SFA, oleic acid (C18:1*c*9) in MUFA, and linolenic acid (C18:2n-6) in PUFA, which is consistent with the findings of Quaresma et al. (2011) and Razmaite et al. (2011, 2012).

TABLE 2. Fatty acids composition (g per 100 g of total fatty acids) in MLD of wild boar

Item	Sex				*P*
	female		male		
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	
SFA	36.76	2.65	39.24	4.85	0.068
C14:0	1.39	0.28	1.64	0.44	0.076
C15:0	0.33	0.12	0.39	0.19	0.611
C16:0	23.39	3.94	25.55	3.48	0.137
C17:0	0.26^{A}	0.13	0.44^{B}	0.22	0.004
C18:0	10.79	2.63	10.08	1.93	0.481
C20:0	0.04	0.02	0.05	0.02	0.076
C24:0	0.56^{A}	0.50	1.09^{B}	0.63	0.008
MUFA	36.29	6.03	34.61	4.19	0.251
C14:1	0.66^{A}	0.30	0.91^{B}	0.25	0.002
C16:1	5.21	1.70	5.84	1.43	0.090
C17:1	0.30	0.23	0.47	0.30	0.100
C18:1 *t*9	0.22^{A}	0.10	0.50^{B}	0.21	0.000
C18:1 *c*9	29.73^{a}	6.06	26.52^{b}	5.30	0.047
C20:1	0.16^{A}	0.07	0.36^{B}	0.18	0.000
PUFA	22.23	1.93	23.21	1.67	0.050
PUFA n-6	17.54	1.99	18.00	0.68	0.297
C18:2 n-6	15.65	2.04	15.21	1.11	0.794
C18:3 n-6	0.02^{A}	0.02	0.04^{B}	0.01	0.000
C20:4 n-6	1.87^{A}	0.76	2.75^{B}	0.84	0.002
C22:2 n-6	0.17^{A}	0.17	0.43^{B}	0.24	0.262
PUFA n-3	4.69	0.67	5.21	1.31	0.151
C18:3 n-3	1.89	0.45	1.75	0.36	0.130
C18:4 n-3	0.48	0.12	0.54	0.14	0.100
C20:3 n-3	0.34^{a}	0.14	0.44^{b}	0.15	0.033
C20:5 n-3	0.22	0.06	0.22	0.07	0.938
C22:5 n-3	1.08	0.33	1.44	0.66	0.085
C22:6 n-3	0.68	0.50	0.82	0.55	0.262

A, B – differences $P \leq 0.01$; a, b – differences $P \leq 0.05$.

In our study, the proportion of n-3 PUFA in IMF was high at 4.7–5.1 g per 100 g of fat. Dannenberger et al. (2013) noted an equally high content of n-3 PUFA in the meat of female and

male wild boar from north-eastern region of Mecklenburg-Western Pomerania. A much lower n-3 PUFA was characteristic of the meat of wild boar from the north-western region of Mecklenburg-Western Pomerania, which shows that the content of these acids depends on abundance of the food base.

The PUFA to SFA ratio was similar in both sexes (Table 3). The dietetically beneficial n-6/n-3 PUFA was less than 4 : 1 (Wood et al. 2003). In the studies by Razmaite et al. (2012) and Quaresma et al. (2011), the n-6/n-3 PUFA was much greater: 10 : 1 in females and 9 : 1 in males for MLD, and 15 : 1 in females and 17 : 1 in males for *m. psoas major*.

TABLE 3. Fatty acids ratio, atherogenic index (AI) and thrombogenicity index (TI) in the MLD from wild boar

Item	Female		Male		*P*
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	
Number of animal	20		20		
PUFA/SFA	0.61	0.06	0.60	0.11	0.814
n-6/n-3	3.83	0.81	3.69	1.01	0.375
AI	0.50[a]	0.06	0.56[b]	0.09	0.027
TI	0.87	0.08	0.89	0.17	0.602

PUFA n-6 = C18:2n-6 + C18:3n-6 + C20:4n-6 + + C22:2n-6.
PUFA n-3 = C18:3n-3 + C18:4n-3 + C20:3n-3 + + C20:5n-3 + C22:5n-3 + C22:6n-3.
AI = [(4 × C14:0) + C16:0] / [n-6PUFA + + n-3PUFA + MUFA].
TI = [C14:0 + C16:0 + C18:0] / [(0.5 × MUFA) + + (0.5 × PUFA n-6) + (3 × PUFA n-3) + + PUFA n-3 / n-6].
a, b – differences $P \leq 0.05$.

Statistical analysis confirmed the effect of sex of wild boar on AI, which was significantly ($P \leq 0.05$) higher in males than in females. Similar results were obtained by Razmaite et al. (2012), who demonstrated more beneficial AI and TI values in the intramuscular fat of females (0.43 and 0.97) compared to males (0.48 and 1.09). The atherogenic and thrombogenic index inform about the dietetic value of lipids and their potential effects on the development of coronary artery disease (the lower the values, the lower the risk for the incidence of arteriosclerosis in humans).

CONCLUSION

Our results suggest that the meat from male and female wild boar is a rich source of protein in the human diet. Wild boar meat is a good source of long-chain n-3 PUFA, which are beneficial in human diets. The high level of long-chain n-3 PUFA is in line with dietary recommendations for the low n-6/n-3 PUFA. Due to its health-promoting benefits, wild boar meat may provide an alternative to the meat of farm animals.

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Streszczenie: *Wpływ płci na jakość mięsa dzika europejskiego* (Sus scrofa scrofa). Badania przeprowadzono na 40 tuszach (38,6–45,9 kg) pozyskanych od dzików obu płci (1 : 1) odstrzelonych w jednym rejonie łowieckim centralnej Polski w sezonie 2014/2015. W próbkach MLD określono podstawowy skład chemiczny i zawartość kwasów tłuszczowych w IMF oraz siłę cięcia i całkowitą pojemność wodną (WHC), a także obliczono wartość indeksów AI i TI. Analiza statystyczna potwierdziła istotny ($P \leq 0,05$) wpływ płci na zawartość wody w MLD, która była większa u samców niż u samic. Zawar-

tość białka w MLD była duża i wynosiła średnio 24%. Mięso było chude – poziom IMF wynosił poniżej 2%. Stosunek PUFA do SFA był zbliżony u obu płci. Korzystna ze względów dietetycznych relacja PUFA n-6 do PUFA n-3 wynosiła mniej niż 4 : 1, ponieważ udział kwasów PUFA n-3 w IMF był duży i wynosił 4,7–5,1 g na 100 g tłuszczu. Potwierdzono wpływ płci dzików na wartość indeksu AI, który był istotnie ($P \leq 0,05$) większy u samców niż u samic. Uzyskane wyniki wskazują, że mięso dzików obu płci może być bogatym źródłem białka w diecie człowieka, a także źródłem długołańcuchowych kwasów PUFA n-3. Wysoki poziom długołańcuchowych PUFA n-3 koresponduje z zaleceniami dietetyków odnośnie małego stosunku PUFA n-6 do PUFA n-3. Ze względu na swoje walory prozdrowotne mięso dzika może stanowić alternatywę mięsa zwierząt gospodarskich.

Słowa kluczowe: dzik, płeć, jakość mięsa

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