Seasonal variation in fatty acid composition of wild boar in Lithuania

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ABSTRACT
The aim of the present study was to investigate the fatty acid composition of wild boar meat hunted in Lithuania during different seasons of the year. Twenty four wild boars hunted during winter (January) and summer (June) hunting seasons were used in the experiment. Each sex (10 females and 10 entire males) was represented by first and second year sub-adult youngsters. Neither the hunting season nor the sex affected the intramuscular fat content in the meat of wild boar. The meat from wild boar hunted during winter season presented lower proportions of saturated (SFA) and higher proportions of polyunsaturated (PUFA) fatty acids, higher PUFA/SFA and n-6/n-3 PUFA ratios.

HIGHLIGHTS
- The fatty acid composition in the meat of wild boar was determined during the two most distinctive periods of the year (January and June).
- The effect of hunting season on the proportions of fatty acids and lipid quality indices was evaluated.

Introduction
Wild boar meat has intense organoleptic characteristics and a low-fat content (Skewes et al. 2009; Rivero et al. 2013) what makes this meat a desirable product for consumers demanding high quality and healthy food (Dannenberger et al. 2013; Rivero et al. 2013). Wild boar is an important game animal, which is distributed not only throughout Europe and Asia, but even other continents and occupies a wide variety of habitats ranging from semi-arid environments to marshes, forests, alpine grasslands, and northern latitudes (Melis et al. 2006; Belkin et al. 2012; Rivero et al. 2013; Massei et al. 2015). As in other species used for meat production (De Smet et al. 2004; Wood et al. 2008), production environment can modify the parameters of wild boar meat quality. Dannenberger et al. (2013) and Amici et al. (2015) showed the effect of region. Several results were published regarding the effects of wild boar inhabiting environment, age, sex (Quaresma et al. 2011; Dannenberger et al. 2013) and hunting month (Quaresma et al. 2011; Razmaite et al. 2012; Russo et al. 2017) on wild boar meat and lipid quality. However, most wild boar samples used in the above-mentioned studies were obtained from the animals shot in autumn and winter. Lithuania and its nature also have their own specificities. Despite different previous studies on wild boar and seasonal variation of meat quality of other wild (Valencak et al. 2003; Neethling et al. 2014) and domestic species (Pestana et al. 2012; Dalle Zotte et al. 2016), information concerning seasonal variation of fatty acid composition in wild boar is scarce. There are all four year seasons in Lithuania with the most distinctive coldest winter, when plants are dead or dormant and most often everything is covered by snow, and summer when all vegetation and soil invertebrates are growing and thrive. In Lithuania, the coldest period starts after Northern Hemisphere (about December 24) and Southern Hemisphere occurs on about June 23. Therefore, the aim of the present work was to investigate the fatty acid composition in the meat of wild boar hunted in Lithuania during the two most distinctive periods of the year (harsh January and June, before corn ripe).
Materials and methods

Animals and sampling

Twenty wild boars hunted during winter (January) and summer (June) hunting seasons were used in the experiment. Wild boars used in this study were shot in accordance with the law on hunting of the Republic of Lithuania, (law No IX-966 of 18 June 2013). Each sex (10 females and 10 entire males) was represented by first and second year sub-adult youngsters, hunted in the central part of Lithuania in the latitude of 54° 20’ to 55° 51’N and in the longitude of 23° 32’ to 24° 36’ E. Ten samples were collected in winter (January) from individuals with a mean weight of 55 kg and 10 samples were collected in summer (June) from individuals with a mean weight of 62 kg. All these samples were obtained from local hunters during 24 h period after wild boar shooting. The muscle samples for fatty acid detection were stored at -65 ± 2.5 °C until analysis.

Analytical procedures

Free fat was determined by the Soxhlet extraction method without hydrolysis (method No 960.39; AOAC 1990). The content of free fat was expressed as weight percentage of wet muscle tissue.

Fatty acid profiles

The extraction of lipids for fatty acid analysis was performed with a mixture of chloroform and methanol. Methylation of the samples was performed using sodium methoxide, 25 wt % solution in methanol (Sigma-Aldrich, St. Louis, USA). The fatty acid methyl esters (FAMEs) were analysed using a gas liquid chromatograph (GC – 2010 SHIMADZU; Kyoto, Japan). The separation of FAMEs was effected on the capillary column Rt 2560 (100 m × 0.25 mm × 0.2 μm; Restek, Bellefonte, USA). The temperatures of the injector and detector were held, respectively, at 240°C and 260°C. The rate of flow of carrier gas (nitrogen) through the column was 1.06 ml/min. The peaks were identified by comparison with the retention times of the standard fatty acids methyl esters ‘37 Component FAME Mix’ and trans FAME MIX k 110 (Supelco, Bellefonte, USA).

Lipid quality indices

Lipid quality indices, i.e. atherogenic index (AI) and thrombogenic index (TI), were calculated according to Ulbricht and Southgate (1991). The hypocholesterolemic/hypercholesterolemic (h/H) ratio was calculated according to Santos-Silva et al. (2002). The peroxidizability index (PI) was determined according to Du et al. (2003).

Data analysis

The data were subjected to the analysis of variance in general linear (GLM) procedure in SPSS 17 (Chicago, USA) with Bonferroni’s tests to determine the significance of differences of means between the groups. The differences were regarded as significant when \( p < .05 \).

Results and discussion

The overall free fat percentages in the longissimus muscle of wild boar were low (Table 1), but they were higher compared to the data reported by Pedrazzoli et al. (2017), who used the same fat determination method and found only 0.85–1.19% of fat in forest wild boars and similar or higher compared to fat (2.1% based on NIR transmission) from wild boar hunted in different regions of Germany (Dannenberger et al. 2013). In the present study, neither hunting season nor sex affected the fat content.

Fatty acid profiles

Wild boar hunting season in Lithuania affected the proportions of fatty acids. The content of total (Table 2) saturated fatty acids (SFA; \( p < .001 \)), including individual (Table 1) pentadecanoic (C15:0; \( p < .001 \)), hexadecanoic (C16:0; \( p < .05 \)), octadecanoic (C18:0; \( p < .05 \)) and docosanoic (C22:0; \( p < .05 \)) fatty acids were significantly lower from wild boar hunted in winter (January) compared with the fatty acid composition from wild boars hunted in summer (June). While the content of individual monounsaturated fatty acids such as tetradecanoic (C14:1c9; \( p < .05 \)) and trans octadecanoic (C18:1t9; \( p < .01 \)) fatty acids were lower in winter, a slight decrease of total MUFA remained insignificant. Wild boars have shown increase of PUFA (\( p < .05 \)), including individual octadecadienoic (C18:2n-6, C18:2t9, t12; \( p < .01 \)), eicosadienoic (C20:2n-6; \( p < .001 \)) and eicosatrienoic (C20:3n-6; \( p < .05 \)) fatty acids in winter (January) compared with the wild boars hunted in summer (June). Our previous study (Razmaitė et al. 2012) did not show the effect of hunting month during the winter season on SFA, MUFA and PUFA in the meat lipids of wild boar. The present and our previous (Razmaitė et al. 2012) studies showed that wild boar had PUFA/SFA ratio above the minimum (0.4)
recommended for the diet (Wood et al. 2008) throughout the year. PUFA increase relatively by 4.1% in the present study resulted in higher and more favourable PUFA/SFA (\(p < .05\)) ratio in wild boar meat during winter hunting compared to summer season (June). Melis et al. (2006) have reported that wild boar population density is primarily affected by winter harshness and secondarily by vegetation productivity. With the aim to prevent wild boar migration on a large scale and avoid an increase in the mortality rate, Lithuanian hunters practice supplemental feeding by using sugar-beet rootlets (waste product from sugar industry) and chaff or other grain refuse as additional feed for wild boars during harsh winter periods. However, it is unlikely that such supplemental feeding could increase the content of PUFA in wild boar meat. It may reflect thermoregulatory adjustments as was found for other animals in winter (Valencak et al. 2003). The increase of total PUFA was mostly influenced by n-6 PUFA increase and conversely to PUFA/SFA ratio, n-6/n-3PUFA ratio was lower in June when wild boars rely only on forest biomass resources compared to January (\(p < .05\)). This is in agreement with the results of Pedrazzoli et al. (2017), who have found

**Table 1.** Effects of hunting season and sex on fatty acid (% of total FA) composition in fat of wild boar longissimus muscle.

| Variables | Season | Sex | SED | Significance |
|-----------|--------|-----|-----|--------------|
| Free fat  | 1.66   | 2.00| 0.42| ns           |
| C10:0     | 0.04   | 0.08| 0.02| ns           |
| C12:0     | 0.04   | 0.06| 0.03| ns           |
| C14:0     | 0.89   | 0.84| 0.09| ns           |
| C15:0     | 1.73   | 0.41| 1.16| ***          |
| C16:0     | 21.83  | 20.64| 0.52| ns           |
| C17:0     | 0.25   | 0.30| 0.06| ns           |
| C18:0     | 9.73   | 9.10| 0.32| *            |
| C20:0     | 0.16   | 0.11| 0.03| ns           |
| C22:0     | 0.06   | 0.00| 0.02| ns           |
| C14:1c9   | 0.11   | 0.03| 0.05| ns           |
| C15:1     | 0.03   | 0.00| 0.01| *            |
| C16:1c    | 3.41   | 3.01| 0.24| ns           |
| C18:1t9   | 0.27   | 0.14| 0.03| ***          |
| C18:1c9   | 35.94  | 36.30| 1.83| ns           |
| C20:1n-9  | 0.50   | 0.53| 0.06| ns           |
| C18:2t9, t12 | 0.13 | 0.38| 0.08| **           |
| C18:2n-6  | 12.00  | 16.30| 1.28| **           |
| C18:3n-6  | 0.06   | 0.06| 0.01| ns           |
| C18:3n-3  | 0.58   | 0.55| 0.05| ns           |
| C20:2n-6  | 0.27   | 0.35| 0.01| ***          |
| C20:3n-6  | 0.29   | 0.41| 0.06| ns           |
| C20:4n-6  | 3.42   | 2.99| 0.54| ns           |
| C20:5n-3  | 0.33   | 0.35| 0.06| ns           |
| C22:4n-6  | 0.44   | 0.38| 0.10| ns           |
| C22:5n-3  | 0.71   | 0.59| 0.09| ns           |
| C22:6n-3  | 0.11   | 0.11| 0.03| ns           |
| UFA       | 6.66   | 6.00| 0.53| ns           |

UFA: sum of unidentified fatty acids and their isomers; SED: standard error of difference; ns: not significant; *** \(p < .001\); ** \(p < .01\); \(p < .05\).

**Table 2.** Effects of hunting season and sex on total saturated, monounsaturated and polyunsaturated fatty acids, fatty acid ratios, and lipid quality indices in the fat from wild boars.

| Variables | Season | Sex | SED | Significance |
|-----------|--------|-----|-----|--------------|
| SFA       | 34.73  | 31.55| 0.60| ***          |
| MUFA      | 45.18  | 43.56| 1.41| ns           |
| PUFA      | 18.34  | 22.45| 1.92| *            |
| PUFA/SFA  | 0.53   | 0.72 | 0.07| *            |
| n-6/n-3   | 9.68   | 13.67| 1.34| ns           |
| Al        | 0.40   | 0.37 | 0.01| *            |
| Ti        | 0.90   | 0.83 | 0.03| *            |
| h/H       | 2.58   | 2.87 | 0.10| ns           |
| Pl        | 37.95  | 40.06| 4.27| ns           |

SFA, MUFA, PUFA: sum of all detected saturated, monounsaturated and polyunsaturated fatty acids, respectively. PUFA/SFA: ratio of \(\Sigma\)PUFA to \(\Sigma\)SFA; n-6/n-3: ratio of \(\Sigma\)n-6 PUFA to \(\Sigma\)n-3 PUFA; Al: atherogenic index; Ti: thrombogenic index; h/H: hypocholesterolemic/hypercholesterolemic ratio; Pl: peroxidizability index; SED: standard error of difference; ns: not significant; *** \(p < .001\); ** \(p < .01\); \(p < .05\).
lower n-6/n-3PUFA ratio in the meat of forest wild boar compared with farmland wild boars because in Lithuania, wild boar mostly forages in forests. Sometimes, as in southern Sweden (Thurjell et al. 2009), they also use agricultural fields near forests during summer and autumn when the crops are ripe. However, with the aim to avoid the effects of ripe crops in the present study, the meat samples of wild boar were collected in June (before crop ripe). The recommendations of Bellagios report on healthy agriculture, healthy nutrition and healthy people indicated that the ratio 4:1 of n-6 PUFA to n-3 PUFA in the diet should be the goal (Simopoulos et al. 2013). Although n-6/n-3 PUFA ratio in wild boar meat is significantly higher than the recommended throughout the year, lower n-6/n-3PUFA ratio in summer (June) when wild boars use only forest biomass was more (p < .01) favourable than in winter (January) with supplemental feeding.

The sex-related differences as indicated in our previous study (Razmai et al. 2012), were minor. In the present study, higher levels (p < .05) of individual fatty acids, such as decanoic (C10:0), dodecanoic (C12:0), octadecatrienoic (C18:3n-3), were found in the lipids of females in comparison with males. Quaresma et al. (2011) have reported that sex had no influence on the fatty acid composition in wild boar psoas major muscle and this is in agreement with our results.

There was only one significant interaction between the hunting season and wild boar sex and that was for docosatetraenoic (C22:4n-6; p < .05) fatty acid. Female animals had higher percentage of this fatty acid in winter and lower percentage in summer than male animals.

In our previous study (Razmaite et al. 2012), the month of wild boar hunting period in autumn and early winter did not affect the lipid quality indices, such as atherogenic (AI) and thrombogenicity (TI) indexes and the hypcholesterolemic/hypercholesterolemic (h/H) ratio, but in the present study (Table 2), significantly lower AI (p < .05) and TI (p < .01) indices and higher more favourable h/H ratio (p < .01), respectively, were also found in the IMF of wild boar hunted in harsh winter month January compared with June.

Conclusions

Differences in fatty acid composition of wild boar presented higher proportions of PUFA, higher PUFA/SFA, n-6/n-3 PUFA and h/H ratios, and lower AI and TI indices.

Disclosure statement

No potential conflict of interest was reported by the authors.

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