Nutritional evaluation of the lipid fraction of feral wild boar (Sus scrofa scrofa) meat

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ABSTRACT

Consumer increasing demand for wild boar meat and scariness of data on its lipid fraction justified this study. The psoas major muscle collected from 25 feral wild boars was used to quantify the total lipid, total cholesterol, fatty acid (FA) profile, and vitamin E homologues. Intramuscular fat and total cholesterol contents averaged 4.64 g/100 g of meat and 56.9 mg/100 g of meat, respectively. No differences were found in FA composition between groups, except for 20:5n−3 that was higher in youngsters. All groups presented small concentrations of rumenic acid in meat (CLA; 0.24% of total FA). FA profile showed considerable resemblance with pork, while the vitamin E profile is marked by high concentrations of both alpha- (17.4±3.3 μg/g meat) and gamma-tocopherols (2.6±1.3 μg/g meat) and by the presence of other vitamin E homologues not previously reported in wild boar meat.

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1. Introduction

In Portugal, the wild boar (Sus scrofa scrofa) population has been growing since the 1980s, such increase was the consequence of several factors: 1) absence of natural predators; 2) rural depopulation, abandonment of traditional agricultural practices and agricultural lands; 3) expansion of the forest area and 4) spread of game managed areas (Lopes & Borges, 2004). These factors have promoted a widespread distribution of wild boar to an intimidating density, representing a threat not only to agricultural practices and cultures but also to the ecosystem (Herrero, García-Serrano, Couto, Ortuño, & García-González, 2006; Massei & Genov, 2004). The wild boar has an opportunistic and omnivorous feeding behavior, which includes mainly vegetable material but also small game species, eggs and nestlings of ground-nesting birds (Laurent & Timothy, 2003). Cultivated crops represent an important dietary component of wild boar and the main crops taken include maize, potatoes, oats, sugar beet, wheat and grasses (Laurent & Timothy, 2003). Therefore, in the absence of natural predators, the wild boar hunting is an ecological need, in order to decrease the wild boar density and impact on small game species and decrease its economic impact on agriculture (Geisser, Reyer, & Krausman, 2004).

The wild boar populations have been particularly successful on Montado areas. The Portuguese Montado closely resembles the Spanish Dehesa, and both represent an ancient human-modified ecosystem based on evergreen oak woodland with a scattered tree cover (60–100 trees per ha), where Cork and Holm oaks (Quercus suber and Quercus ilex rotundifolia, respectively) are the predominant trees (Correia, 1993; Pinto-Correia, 2000; Pinto-Correia & Mascarenhas, 1999). Montado lands has been managed, since ancient times, as an agro-silvo-pastoral system, being traditionally exploited for cork, and its land used for crop farming, sheep and cattle farming and Iberian pig-raising, all at low stocking densities (Pinto-Correia & Mascarenhas, 1999). Recently, significant areas of Montado are being converted into rural tourism or hunting reserves for small or big game species (Pinto-Correia, 2000).

Game hunting is an economic activity on its one, but the commerce of big game meat, a surplus of the trophy hunting activity, is of economic importance and wild boar meat has gathered enthusiastic consumers among the Portuguese population. Despite consumer's interest for wild boar meat, the information concerning its nutritional quality, particularly of the lipid fraction, is scarce. The lipid fraction is of major importance to the characterization of meat nutritional quality (Wood et al., 2004). Therefore, the objective of this study was to evaluate the nutritional quality of the Montado’s wild boar meat, determining the intramuscular fat, the fatty acid profile, cholesterol and vitamin E content.
2. Materials and methods

2.1. Animals and meat samples

The wild boars used in this study were shot, in accordance with the provision of national laws on game hunting and (Official Journal of the Republic of Portugal, law 173/99, 21st of September, and 201/2005 24th of November).

This study includes wild boars from two adjacent big game hunting reserves (Vale Feitoso and Poupa), both located in Idanha-a-Nova, a southern council of the Beira Baixa province. Both hunting reserves share a common habitat, where Montado ecosystem dominates, sharing similar feeding options (where acorn is the predominant feeding option throughout the Autumn and Winter seasons), equivalent feeding supplementation (wheat, rye and maize grains, supplemented during the summer months) and equal hunting management. The two hunting reserves possess a global area of 11,900 ha, of which 8200 ha are used for big game hunting. The wild boar population number is difficult to estimate, since wild boars damage the herd fences allowing the escape and entrance of neighboring animals, which makes the population variable during the year, however the overall wild boar adult population has been estimated to fluctuate between 400 and 600 adult wild boars.

The wild boar meat used in this study was collected from 25 wild boars (6 adult males, 10 adult females and 9 youngsters, averaging 51, 43 and 17 kg of carcass weight, respectively) shot during two battues in February of 2006 (performed one week apart from each other). The carcass weight previously presented does not correspond to overall boar population number is difficult to estimate, since wild boars damage the herd fences allowing the escape and entrance of neighboring animals, which makes the population variable during the year, however the overall wild boar adult population has been estimated to fluctuate between 400 and 600 adult wild boars.

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2.2. Analytical methods

Total meat lipids were extracted from the lyophilised meat samples (0.25 g) and measured gravimetrically, as previously described (Alfaia et al., 2006). Lipid extracts were dissolved in 1 ml of dry toluene, then fatty acid methyl esters were prepared by base-catalyzed (Alfaia et al., 2006). Lipid extracts were dissolved in 1 ml of dry toluene, then fatty acid methyl esters were prepared by base-catalyzed (Alfaia et al., 2006). Lipid extracts were dissolved in 1 ml of dry toluene, and analyzed gravimetrically, as previously described (Prates, Quaresma, Bessa, Fontes, & Alfaia, 2006).

The identity of CLA isomers found in GC analysis was confirmed using a high performance liquid chromatography system (Agilent 1100 Series, Agilent Technologies Inc., Palo Alto, CA, USA), equipped with 100 µl injection loop and diode array detector (DAD) operated at 233 nm, using as solid phase a triple silver-ion columns in series according to the procedure described previously by Alfaia et al. (2006).

The simultaneous determination of total cholesterol, tocopherols and tocotrienols was performed as previously described (Prates, Quaresma, Bessa, Fontes, & Alfaia, 2006).

2.3. Statistical analysis

Data were analyzed using GLM procedure of SAS (SAS Institute, Inc., Cary, NC) considering the sex/maturity group as single effect. Contrasts were constructed to evaluate the effect of sex (Male versus Female) and maturity (Adults versus Youngsters).

3. Results and discussion

3.1. Cholesterol

The wild boar psoas major muscle total cholesterol contents, presented in Table 1, did not differ between groups, averaging 56.9 mg/100 g of meat, with values ranging between 48.1 and 63.8 mg/100 g of meat. These values are in accordance to values of cholesterol content for pork (45.3–62.2 mg/100 g of meat) reviewed by (Chizzolini, Zanardi, Dorigoni, & Gidini, 1999), but considerably above cholesterol contents determined in wild boar longissimus dorsi and semimembranosus muscles (Skewes, Morales, Mendoza, Smulders, & Paulsen, 2009), which has solely quantified the free cholesterol.

3.2. Intramuscular fat

Intramuscular fat content in wild boar psoas major muscle, depicted in Table 1, averaged 46.4 g/kg of meat, although the values ranged between 19 and 76 g/kg. The wide amplitude of IMF values in wild boar meat, was expectable considering the wild boar feral condition, but will reflect in variable sensorial qualities.

3.3. Vitamin E homologues

Vitamin E homologues and their contents for wild boar psoas major muscle are depicted on Table 1. The α-tocopherol is the major Vitamin E homologue in wild boar psoas major muscle, representing 71% of total vitamin E homologues. The α-tocopherol content in wild boar psoas major muscle was influenced by the maturity stage (P = 0.023), with adult animals displaying a higher content than youngsters.

Table 1

<table>
<thead>
<tr>
<th>Lipids</th>
<th>Total cholesterol</th>
<th>Tocopherols</th>
<th>Tocotrienols</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>Youngster</td>
<td>RSD</td>
<td>Adults</td>
</tr>
<tr>
<td>Males</td>
<td>(n=6)</td>
<td>Females</td>
<td>(n=10)</td>
</tr>
<tr>
<td>Lipids</td>
<td>4.75</td>
<td>4.55</td>
<td>4.68</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>58.7</td>
<td>55.6</td>
<td>57.1</td>
</tr>
<tr>
<td>α</td>
<td>19.2</td>
<td>18.1</td>
<td>15.5</td>
</tr>
<tr>
<td>β</td>
<td>0.05</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>γ</td>
<td>1.75</td>
<td>1.61</td>
<td>1.14</td>
</tr>
<tr>
<td>δ</td>
<td>0.12</td>
<td>0.01</td>
<td>0.04</td>
</tr>
<tr>
<td>Total tocopherols</td>
<td>0.00</td>
<td>0.52</td>
<td>0.69</td>
</tr>
<tr>
<td>γ</td>
<td>0.42</td>
<td>0.17</td>
<td>0.77</td>
</tr>
<tr>
<td>δ</td>
<td>0.03</td>
<td>0.07</td>
<td>0.04</td>
</tr>
</tbody>
</table>

M—F: Male—Female; A—Y: Adult—Youngster.
RSD — residual standard deviation.

α g/100 g meat.
β mg/100 g.
γ µg/g of meat.
second major Vitamin E homolog in wild boar *psoas major* muscle was γ-tocopherol, representing 7.4% of total vitamin E homologues and like α-tocopherol was influenced by the maturity stage (P=0.038) with adult animals displaying a higher content than youngsters.

It was also possible to identify β- and δ-tocopherols and tocotrienols (α-, γ- and δ- tocotrienol), which were only detectable on the meat of some of the wild boars used in this experience, which may be dependent of differences in dietary habits or feeding availability through different habitats within the hunting reserves.

Maturity seems to be an important factor towards muscle deposition of vitamin E major homologues. Higher contents of both α- and γ-tocopherols were observed in adult animals. Such difference between adult and youngster animals may be consequence of several factors like different feeding habits between adults and youngsters and different metabolic rates between youngster and adults. The former suggestion is supported by the accepted nutrient requirements of swine (NRC, 1998), which disclose the higher vitamin E requirements of young domestic pig in comparison with older pigs.

Higher vitamin E contents in wild boar muscle than in muscles from pigs supplemented with high amounts of vitamin E is probably the result of combined factors, such as: 1) in monogastric animals the gastrointestinal absorption of vitamin E is positively influenced by the lipid content of the diet (Jeanes, Hall, Ellard, Lee, & Lodge, 2004), acorn has a higher lipid content than regular concentrate (Cava et al., 1997), which could promote an increased vitamin E absorption; 2) natural α-tocopherol occurs in a single stereoisomer (RRR-α-tocopherol), while synthetic α-tocopherol is a mixture of 8 different stereoisomers (all-rac, half of which are in the 2R-form and the other half in the 2S-form), the natural α-tocopherol has a superior biopotency and bioavailability than synthetic α-tocopherol, such superiority outcomes from the fact that endogenous proteins such as enzymes and receptors usually exist as one stereoisomer and react in a highly stereospecific manner (Weiser, Riss, & Korman, 1996), conditioning, for this reason, higher plasma concentrations of natural α-tocopherol than synthetic α-tocopherol (Meglia, Jensen, Lauridsen, & Waller, 2006); 3) another important fact is that the efficiency of vitamin E absorption decreases as the vitamin E intake dose increases (Jeanes et al., 2004), therefore a constant supply of vitamin E throughout the wild boar life, could contribute to an increase availability of vitamin E than the supplementation of high vitamin E dosage in a short period of time. Moreover, acorns and grass, major vitamin E source for wild boar, are assimilated by either sex or maturity.

Partial sums of fatty acids (% of total fatty acids of muscle) and nutritional ratios according to animal’s sex and maturity.

**Table 2**

<table>
<thead>
<tr>
<th>Male (n=10)</th>
<th>Female (n=9)</th>
<th>RSD</th>
<th>Contrast</th>
<th>A vs. Y</th>
<th>M vs. F</th>
</tr>
</thead>
<tbody>
<tr>
<td>14:0</td>
<td>1.0%</td>
<td>1.0%</td>
<td>0.9%</td>
<td>2.11</td>
<td>0.234</td>
</tr>
<tr>
<td>16:0</td>
<td>20.7%</td>
<td>20.7%</td>
<td>20.4%</td>
<td>15.7</td>
<td>0.648</td>
</tr>
<tr>
<td>16:1-cis-9</td>
<td>2.3%</td>
<td>2.2%</td>
<td>1.9%</td>
<td>8.78</td>
<td>0.343</td>
</tr>
<tr>
<td>17:0</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.3%</td>
<td>0.66</td>
<td>0.049</td>
</tr>
<tr>
<td>17:1-cis-9</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.1%</td>
<td>0.35</td>
<td>0.087</td>
</tr>
<tr>
<td>18:0</td>
<td>11.5%</td>
<td>10.5%</td>
<td>10.4%</td>
<td>10.5</td>
<td>0.152</td>
</tr>
<tr>
<td>18:1trans</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.97</td>
<td>0.879</td>
</tr>
<tr>
<td>18:1-cis-9</td>
<td>36.1%</td>
<td>39.7%</td>
<td>39.6%</td>
<td>42.9</td>
<td>0.369</td>
</tr>
<tr>
<td>18:2n-6</td>
<td>18.8%</td>
<td>15.9%</td>
<td>16.4%</td>
<td>34.9</td>
<td>0.551</td>
</tr>
<tr>
<td>18:3n-3</td>
<td>1.0%</td>
<td>0.9%</td>
<td>1.0%</td>
<td>1.14</td>
<td>0.544</td>
</tr>
<tr>
<td>CLA</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.658</td>
<td>0.748</td>
</tr>
<tr>
<td>20:0</td>
<td>0.1%</td>
<td>0.2%</td>
<td>0.1%</td>
<td>0.29</td>
<td>0.757</td>
</tr>
<tr>
<td>20:2n-6</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.64</td>
<td>0.437</td>
</tr>
<tr>
<td>20:3n-6</td>
<td>0.5%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>1.29</td>
<td>0.649</td>
</tr>
<tr>
<td>20:4n-6</td>
<td>4.4%</td>
<td>4.5%</td>
<td>4.9%</td>
<td>17.83</td>
<td>0.572</td>
</tr>
<tr>
<td>3-PUFA</td>
<td>0.4%</td>
<td>0.4%</td>
<td>0.4%</td>
<td>2.34</td>
<td>0.008</td>
</tr>
<tr>
<td>Other</td>
<td>2.0%</td>
<td>2.2%</td>
<td>1.9%</td>
<td>5.12</td>
<td>0.334</td>
</tr>
</tbody>
</table>

**Fatty acid partial sums:**

- **M:** Male–Female; **A:** Adult–Youngster.
- **SFA:** saturated fatty acids; **MUFA:** monounsaturated fatty acids.
- **PUFA:** polyunsaturated fatty acids; **TFA:** trans fatty acids.

Zhang et al. (2007). Differences in pork fatty acid composition are mostly explained by IMF differences between sexes and consequent neutral lipid content variations (Wood et al., 2008). In the present trial, a wide variation in the IMF content was observable, which was not explained by either sex or maturity.

Overall, the fatty acid composition observed in wild boar muscle is within the range of values reported in wild boar from Taiwan (Koizumi, Suzuki, & Kaneko, 1991), domesticated wild boar meat (Skewes et al., 2009) and pork (Wood et al., 2008). The major fatty acids in wild boar *psoas major* muscle are the oleic (18:1 cis-9), linoleic (18:2n-6), palmitic (16:0) and stearic (18:0) acids. The palmitic and the stearic acids comprise 20.6% and 10.7% of total fatty acids, with relatively small amplitude (i.e. 16:0 and 18:0 ranged from 17.2 to 23.6 and from 8.4 to 13.2, respectively).

Oleic acid midpoint was 40.1% of total fatty acids, but values ranged between 25% and 45% of total fatty acids. Linoleic acid averaged 16.1% of fatty acids but values ranged between 12% and 28%. Lowest values of 18:1 cis-9 are coupled with highest values of 18:2n-6. This dispersion was not related to IMF, suggesting that it should mainly be due to high diversity in the feeding behavior or different feed availability of wild boar individuals among different habitats within the hunting reserves. The high frequency of oleic acid in wild boar meat (36.4-43.9% of total fatty acids) might be related to abundance of acorns in autumn and winter seasons in the Montado ecosystem. Acorn fatty acid profile is dominated by oleic acid (63.8%) containing also linoleic acid (16.1%) and palmitic acid (14.6%) (Cava et al., 1997).

The wild boar tenderloin concentration of n-3 PUFA was below the values observed in feral warthog (Hoffman & Wiklund, 2006), but similar to the values observed on domestic pigs reared on pasture under organic production (Oksbjerg, Strudholm, Kimnndahl, &
and n on the nutritional indices as polyunsaturated/saturated (P/S) ratio of diet richness in linoleic acid.

Small concentrations of conjugated linoleic acid (CLA; 18:2 cis-9, trans-11 isomer) were also detected in wild boar meat (0.24% of total fatty acids). The CLA content found in wild boar meat is below the concentrations found in ruminant meats, but still above the concentrations previously reported in pork (0.06% to 0.12% (Chin, Liu, Storkson, Ha, & Nilzen et al., 2001). In wild boars, as in other monogastric animals, CLA may arise from intestinal bacterial flora biosynthesis (Chin et al., 1992), in variable concentrations dependent on diet richness in linoleic acid.

Nutritional evaluation of fat fractions of foods is frequently based on the nutritional indices as polyunsaturated/saturated (P/S) ratio of diet richness in linoleic acid.

According to recommendations of British Department of Health (1994), the P/S ratio should be above 0.40. The value obtained averaged 0.55 (0.52–0.60) and is in between the P/S ratios found in feral and reared wild boar (Marsico et al., 2007; Skews et al., 2009). On the other hand, the wild boar n–6:n–3 ratio (12.8–17 averaged 14.9 (12.8–17.0), which is 3 to 4 times above the nutritional recommendations, which state that this ratio should not exceed 4.0 (Wood et al., 2003). Our results on wild boar n–6:n–3 ratio are considerably above the ratio determined in Italian feral wild boar (Marsico et al., 2007), but similar to the ratio obtained in pork raised under organic and free range production systems (Nilzen et al., 2001; Oksbjerg et al., 2005).

The wild boar meat obtained from animals shot in late winter reproduce the acorns richness in linoleic acid (Cava et al., 1997), the prime n–6 PUFA of wild boar meat. Montado’s profusion in acorns throughout autumn and winter seasons, are probably the sole factor contributing to an increased assimilation of n–6 PUFA, while the acorn high energetic content should reduce grass intake and linoleic acid assimilation. It would be quite interesting to follow the Iberian wild boar throughout different seasons and simultaneously accessing its feeding habits.

4. Conclusion

The wild boar psoas major muscle has a fatty acid profile that is quite variable, as expected in wild animals where no environmental factors, including diet were controlled. Nevertheless, globally the fatty acid composition of meat falls within the range of values reported on pork. The vitamin E contents found in wild boar psoas major muscle were unexpectedly high, and able to provide the antioxidant protection essential to the post-mortem oxidative stability of meat. This study results stand for feral wild boars obtained in the Montado ecosystem and in late winter, different results are expected for animals slaughtered in other seasons and particularly in late spring.

Acknowledgments

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References


Marsico, G., Forcelli, M. G., Tarricone, S., Rasulo, A., Pinto, F., Celi, R., et al. (2007). Effects of duration of finishing diet on fatty acid profile of psoas major muscle has a fatty acid profile that is quite variable, as expected in wild animals where no environmental factors, including diet were controlled. Nevertheless, globally the fatty acid composition of meat falls within the range of values reported on pork. The vitamin E contents found in wild boar psoas major muscle were unexpectedly high, and able to provide the antioxidant protection essential to the post-mortem oxidative stability of meat. This study results stand for feral wild boars obtained in the Montado ecosystem and in late winter, different results are expected for animals slaughtered in other seasons and particularly in late spring. (4), 250.


