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Fatty acid and microbiological profile of the meat (longissimus dorsi muscle) of wild boar (*Sus scropha scropha*) hunted in Tuscany

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ABSTRACT

The aim of this work is to study the influence of gender, age and hunting period on the fatty acid composition of the longissimus dorsi muscle excised from 42 wild boars hunted on a farm located in Tuscany. A sub-sample of 22 muscles was used for the study of the microbiological profile of wild boar meat. The results show that gender had an effect only on C16:1 n7, which was higher in females ($p \leq .05$). Slaughtering age influenced more parameters, thus resulting in a higher content of C6:0, C18:2, C20:1 and n6/n3 ratio in meat from adults ($p \leq .05$) and in a higher percentage of C16:0 ($p \leq .05$) in meat from young animals. The hunting month greatly influenced the meat quality because, in addition to the single fatty acids, it significantly modified the MUFA, PUFA, PUFA/SFA and n6/n3 ratio, underlining the great difference between meat of wild boar shot in October – November vs December – January. Ether extract was higher in sub-adults than in young animals ($p \leq .01$) but was not influenced by gender and hunting month. Regarding the microbiological analyses, *Salmonella* spp. was only detected in one sample, while *Yersinia enterocolitica* was not detected at all. Data on the presence of pathogenic bacteria confirmed health risk for the consumer comparable to that associated with meat obtained from farm animals, while data on microbial loads (total aerobic mesophilic and psychrotrophic counts, Enterobacteriaceae, *Escherichia coli*) did not highlight any specific criticality.

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Wild boar; meat quality; fatty acids composition; microbiological profile

Introduction

Game meat, and particularly wild boar meat, is traditionally consumed in central Italy. In the last few years, the consumption of this meat has significantly increased, throughout Italy. In fact, the excessive growth of the wild ungulate population has led to the application of management strategies to limit their expansion and decrease their economic impact on agriculture, such as specific culling programmes, thus leading to the increased availability of this meat (Ramanzin et al. 2010; Avagnina et al. 2012). Game meat is characterised by a high nutritional value and particular sensory properties, which are desired by consumers, and it is considered as a significant source of healthy food (Strazdina et al. 2014).

As regards fatty acids composition, little is known both on the average value and the effect of age (slaughtering or hunting age), gender and hunting period (Ramanzin et al. 2010): as told in that review most of data are obtained from animals raised in farming conditions, so without considering the seasonal variation in nutritional status and available vegetation.

On the contrary, fatty acid composition of meat from domestic animals has been extensively studied due to its implications for human health. Due to the relationship between high-fat diets and heart disease, consumer interest in the fat content and fatty acid profile of foods has grown (Scollan et al. 2006). Generally, a reduction in total fat intake is recommended, particularly of saturated fatty acids (SFA), which are associated with an increased risk of obesity, hypercholesterolaemia and some cancers (Wood et al. 2003). A higher intake of polyunsaturated fatty acids (PUFA) is also recommended, especially *n*-3 PUFA at the expense of *n*-6 PUFA (British Department of Health 1994). Moreover, the low PUFA/SFA and high *n*-6/*n*-3 ratios of some meats contribute to the

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imbalance in the fatty acid intake of today's consumers (Wood et al. 2008).

With regard to game, meat safety, zoonotic agents, including various pathogenic microorganisms, and toxic elements can be harboured by this meat (Hensel 2009; Amici et al. 2012). In addition, shooting/slaughtering and the subsequent handling phases are critical for its hygienic production (Casoli et al. 2005). Although various studies have investigated both the fat quality and hygienic quality of wild boar meat in Europe (Dimatteo et al. 2003; Paulsen & Winkelmayer 2004; Hoffman & Wiklund 2006; Gill 2007; Marsico et al. 2007; Atanassova et al. 2008; Skewes et al. 2009; Ramanzin et al. 2010; Quaresma et al. 2011; Avagnina et al. 2012; Dannenberger et al. 2013) there is a lack of studies regarding wild boar in central Italy. Thus, to fill this gap, the present study analyses the meat quality (fat content, fatty acid profile and hygienic quality) of wild boar hunted in Tuscany, taking into account gender, slaughtering age and hunting period in order to verify the possible effects of these parameters.

Materials and methods

Animals and sampling

Longissimus dorsi samples were collected from 42 wild boars hunted on a farm situated in a hilly 600 hectares wide area, located in the province of Florence (Tuscany). In this area, only 300 ha are used for game hunting and rearing. The wild boar population number is difficult to estimate, since wild boar damage the herd fences allowing the escape and the entrance of neighbouring animals, which makes the populations variable during the year. It is possible only to speculate a number fluctuating between 100–150 animals. Wild boars are free ranging, so they eat a great variety of indigenous plants, grains, seeds, fruits, roots, insects, slugs, heartworms, small mammals and carrion; only during winter, sometimes, they received feed supplementation (maize, feed, fruit, vegetables and so on) on the basis of the lowest price on the market. The animals were shot between October 2014 and February 2015. Muscle samples of all animals were collected in the farm's slaughterhouse after the evisceration. The samples were chosen from higher number of animals in order to have the right numerousness; particularly, the average age range for young is comprised from 6 to 8 months (mean 6.9 ± 0.23) and the average age range for sub-adults is comprised from 10 and 14 months (mean 12.3 ± 0.24). The distribution of animal during the hunting period is as follows: Young animals: five in October, eight in November, five in December and four in January; Sub-adult animals: five in October, six in November, five in December and four in January.

All the samples were transported in a refrigerated container to the laboratory: a sub-sample of 22 muscles (13 young subjects and 9 sub-adults) were excised, kept at 0–4 °C and used within 24 h from slaughtering for the microbiological analyses.

After taking these sub-samples, all the 42 samples were frozen at −20 °C for the chemical analysis.

Chemical analysis

Fat content and fatty acid analysis

Fat content was determined in 5 g of meat with a gravimetric method after extraction following Folch et al. (1957) method using chloroform/methanol solution. The ether extract was resuspended in 2 mL of chloroform and stored at −20 °C until the preparation of fatty acid methyl esters using methanolic sodium methoxide solution (0.5 N) according to the method described by Christie (1982). One microlitre of fatty acid methyl esters for each sample was injected by split injection mode into a Perkin Elmer Auto System (Norwalk, CT). The instrument was equipped with an automatic injector, a flame ionisation detector (FID), and a capillary column (Factor Four Varian, Middelburg, Netherlands; 30 m × 0.25 mm; film thickness 0.25 mm Middelburg, Netherlands). Helium was used as the carrier gas with a flow of 1 mL min^{-1}. The initial oven temperature was set at 50 °C, after 2 min the temperature was increased at a rate of 2 °C min^{-1} to 180 °C and held for 2 min; then increased by 1 °C min^{-1} to 200 °C and held for 15 min. After increasing by 1 °C every minute, the temperature reached 220 °C. Injector and detector temperatures were 270 °C and 300 °C, respectively. The peak areas of individual fatty acids (FAs) were identified by comparison with fatty acid standard injection (Sigma Aldrich Chemical Co., St. Louis, MO) and quantified as a percentage of the total FAs. The relative proportion of each fatty acid was expressed as the relative percentage of the sum of the total fatty acids. To evaluate the nutritional properties of the meat polyunsaturated/saturated ratio (P/S), monounsaturated + saturated)/saturated ratio (M + P)/S, *n*-6/*n*-3 ratio, atherogenic (AI) and thrombogenic (TI) indices were calculated as suggested by Ulbricht and Southgate (1991) while hypocholesterolaemic/Hypercholesterolaemic ratio (h/H) was calculated following the method described by Fernàndez et al. (2007).

Microbiological analysis

Microbiological analysis was carried out on a subset of 22 samples comprising 13 young wild boars (seven males, six females) and nine sub-adults (four males, five females). Twenty-five grams of each sample were aseptically removed and blended with 225 mL of sterile peptone saline solution using a 400 Circulator stomacher (PBI International, Milan, Italy). Dilutions were prepared in the same diluent and used for standard plate enumeration counts. Total aerobic mesophilic and psychrotrophic counts were determined on Plate Count Agar (1 mL on pour plates) after incubation at 30 °C for 3 days and at 4 °C for 10 days, respectively. *Enterobacteriaceae* were enumerated on Violet Red Bile Glucose Agar (0.1 mL on spread plates) after incubation at 37 °C for 24 h. *Escherichia coli* was determined on Tryptone Bile X-Glucuronide Medium (0.1 mL on spread plates) after incubation at 44 °C for 24 h. The presence of *Salmonella* spp. was evaluated following the UNI EN ISO 6579: 2004 standard. For the evaluation of *Yersinia enterocolitica,* 10 g of each sample were aseptically removed, blended with 90 mL of Peptone Sorbitol Bile broth (PSB) and incubated at 4 °C for 21 days. A loopful of the enriched broth was streaked onto CIN (Cefsulodin, Irgasan and Novobiocin) Agar plates and incubated at 30 °C for 48 h and colonies suspected as being *Y. enterocolitica* were confirmed by inoculation in TSI Agar slants (24 h of incubation at 30 °C) and the urease test. All culture media and supplements were purchased from Oxoid (Basingstoke, UK).

Statistical analysis

To compare meat quality characteristics on the basis of sex, age and hunting period, all data were subdivided into groups: female ($n = 22$) and male ($n = 20$); young ($n = 22$) and sub-adult ($n = 20$); October ($n = 10$), November ($n = 14$), December ($n = 10$) and January ($n = 8$). Data were subjected to analysis of variance following a linear model, followed by Tukey's HSD for *post hoc* comparisons (SAS 2002):

$$Y_{ijkl} = \mu + a_i + b_j + \gamma_k + (\alpha\beta)_{ij} + \varepsilon_{ijkl}$$

where: Y_{ijkl} = dependent variable; μ = overall mean; α_i = gender effect; β_j = age effect; γ_k = hunting period; $(\alpha\beta)_{ij}$ = effect of the interaction (gender × age); ε_{ijkl} = residual error

Results from microbial counts were converted into log CFU/g. Differences in bacterial viable counts were then tested with a one-way ANOVA test using age, gender and hunting period as factors, followed by Tukey's HSD for *post hoc* comparisons.

Results and discussion

Fatty acid profile and fat content

Although the statistical analyses showed little differences due to variability parameters, it is worth reporting all the data, in order to have full information regarding fat content and fatty acid profile of the analysed meat.

Gender, contrary to expectations, has effect only on one fatty acid: so we did not present any table but only this result in the text: the meat of the females only had a statistically higher value of C16-1 *n*7. This value is lower than the findings of Quaresma et al. (2011) on *psoas major* muscle, who reported that gender had no influence on this fatty acid (2.2% and 2.3% for females and males respectively); Razmaite et al. (2012) recorded a higher level for this acid, 3.01% in females and 3.31% in males.

Hunting age had a great influence on *longissimus dorsi* fat content (Table 1). The sub-adult fat content is in agreement with the value observed by Quaresma et al. (2011) who found values ranging from 4.75% to 4.55%. Conversely, Zomborszky et al. (1996) found that wild boar had the fattest meat (5.3%). Analysing the chemical composition of *longissimus* muscle in wild boar, Dannenberger et al. (2013) also showed higher percentage values in adults than in young animals.

Fatty acid composition is enough influenced by age (Table 1). The C6:0 percentage was higher in the sub-adults meat than in the young ($p \leq .01$), which may be related to the higher fat content registered (Dannenberger et al. 2013). On the other hand, the palmitic acid content (C16:0) was higher in the young than in sub-adults, with a trend not revealed before in the literature. The total C18:2 was statistically higher in adults than in the young animals and similar to the findings of Dannenberger et al. (2013). However, Skewes et al. (2009) reported lower values than ours (4.95%), probably due to the different feeds. C20:1 was also higher in the sub-adults than in the young animals.

How the hunting month interacts with species, gender, age and habitat conditions in influencing the fat content of carcases and meat is, to our knowledge, scarcely known but worth further exploration (Stevenson et al. 1992; Hofbauer et al. 2006). As regards our data, Table 2 highlights the great difference in the *longissimus dorsi* fat content, although without reaching statistical significance. The December and January values are very high and different from

Table 1. Effect of hunting age on fat content and fatty acid concentrations (% of total FA) of wild boar *longissimus dorsi* muscles.

	Intramuscular fat		
	Young	Sub-adult	*p*
N	22	20	
IMF, %	1.50[b] ± 0.816	4.90[a] ± 0.853	.01
C4:0	0.03 ± 0.011	0.03 ± 0.010	ns
C6:0	0.01[b] ± 0.014	0.08[a] ± 0.012	.01
C8:0	0.02 ± 0.010	0.02 ± 0.008	ns
C10:0	0.07 ± 0.016	0.05 ± 0.014	ns
C11:0	0.08 ± 0.030	0.12 ± 0.027	ns
C12:0	0.14 ± 0.042	0.12 ± 0.037	ns
C13:0	0.03 ± 0.017	0.01 ± 0.015	ns
C14:0	1.42 ± 0.558	0.73 ± 0.493	ns
C14:1	0.03 ± 0.013	0.05 ± 0.011	ns
C15:0	0.15 ± 0.031	0.17 ± 0.027	ns
C15:1	0.03 ± 0.015	0.07 ± 0.013	ns
C16:0	26.35[a] ± 1.101	22.29[b] ± 0.972	.04
C16:1 *n-7*	1.84 ± 0.278	1.52 ± 0.245	ns
C17:0	0.47 ± 0.074	0.51 ± 0.065	ns
C17:1	0.42 ± 0.155	0.21 ± 0.137	ns
C18:0	14.96 ± 1.387	15.21 ± 1.225	ns
C18:1 total	35.13 ± 2.791	30.33 ± 2.465	ns
C18:2 total	11.79[b] ± 2.069	20.89[a] ± 1.827	.02
C18:3 *n*-6	0.06 ± 0.017	0.04 ± 0.015	ns
C18:3 *n*-3	0.90 ± 0.327	0.82 ± 0.289	ns
C20:0	0.23 ± 0.038	0.24 ± 0.034	ns
CLA	0.02 ± 0.008	0.01 ± 0.007	ns
C20:1	0.08 ± 0.306	1.14 ± 0.270	.05
C21:0	0.08 ± 0.031	0.08 ± 0.027	ns
C20:2 *n*-6	0.45 ± 0.082	0.61 ± 0.072	ns
C20:3 *n*-6	0.27 ± 0.100	0.27 ± 0.089	ns
C20:4 *n*-6	3.04 ± 1.359	2.59 ± 1.200	ns
C20:3 *n*-3	0.13 ± 0.041	0.14 ± 0.036	ns
C22:0	0.07 ± 0.013	0.04 ± 0.012	ns
C22:1	0.05 ± 0.028	0.06 ± 0.025	ns
C20:5 *n*-3	0.08 ± 0.037	0.08 ± 0.032	ns
C23:0	0.27 ± 0.132	0.14 ± 0.117	ns
C22:2 *n*-6	0.17 ± 0.072	0.33 ± 0.063	ns
C24:0	0,32 ± 0,085	0.25 ± 0.075	ns
C24:1	0.14 ± 0.040	0.09 ± 0.035	ns
C22:5 *n*-3	0.50 ± 0.250	0.45 ± 0.22	ns
C22:6 *n*-3	0.14 ± 0.049	0.16 ± 0.044	ns
SFA (S)	44.72 ± 2.174	40.10 ± 1.919	ns
MUFA (M)	37.72 ± 2.974	33.48 ± 2.626	ns
PUFA (P)	17.37 ± 3.570	26.07 ± 3.160	ns
PUFA/SFA	0.38 ± 0.130	0.68 ± 0.110	ns
n-6/*n*-3	9.29 ± 1.875	16.82 ± 1.655	.03
(M + P)/S	1.23 ± 0.143	1.53 ± 0.127	ns
AI	0.58 ± 0.060	0.43 ± 0.053	ns
TI	0.22 ± 0.024	0.22 ± 0.022	ns
h/H	1.70 ± 0.203	2.32 ± 0.179	ns

LDF: *longissimus dorsi* fat; CLA is considered as 18:2 cis 9, trans-11; SFA, MUFA, PUFA, sum of all saturated, monounsaturated and polyunsaturated fatty acids, respectively; AI: atherogenic index; TI: thrombogenic index; h/H: hypocholesterolaemic/Hypercholesteraemic ratio. Values are presented as least square mean ± standard error.
[a,b]Means with a different superscript letter within a row differ significantly ($p \leq .05$).

data in the literature. This is probably due to the fact that, during winter and in the period near to shooting, some breeders or hunters usually give food supplements to compensate for the restricted diet in the wild. Moreover in these months, the mating period has finished, and depot fat is easily deposed.

Caproic acid (C6:0) was higher in October and November than December and January ($p = .01$). There were also statistical differences ($p = .02$) for palmitic acid (C16:0), with a similar average value to the findings of Razmaite et al. (2012). A higher value of C16:1 *n*-7 ($p = .01$) was found in December than in other months in disagreement with Razmaite et al. (2012) who reported values that were similar throughout the winter season. C18:1 ($p = .01$) was higher in December and January compared with October and November. Conversely, total C18:2 was higher in October and November than in December and January ($p = .01$). C20:1 had a higher value in November than in other months with higher values in comparison to Razmaite et al. (2012) who found similar values in all the hunting months. C22:2 *n*-6 ($p = .01$) was higher in November than in the other months, with a generally higher average value than the findings of Sales and Kotrba (2013). Therefore, higher levels of monounsaturated fatty acids, were found in meat from animals hunted in December and January vs October and November ($p = .02$), in disagreement with Razmaite et al. (2012) who reported similar values in all hunting period; December and January values were similar to those of Sales and Kotrba (2013). The polyunsaturated fatty acids, however, were lower in December and January than October and November ($p = .01$) again in disagreement with Razmaite et al. (2012) who showed lower PUFA levels without any differences in all hunting periods.

As regards the meat quality indices, few statistical differences were found, reflecting the results for single fatty acids, and in agreement with the findings of other authors (Quaresma et al. 2011, Razmaite et al. 2012; Sales & Kotrba 2013). Gender did not influence any ratio, thus it is possible to affirm that meat from males and females has a similar quality. Slaughtering age only affected *n*-6/*n*-3 ratio, which was significantly higher in sub-adults ($p = .03$). This value is very different from the recommended value (max 4 as suggested by Simopoulos 2004) and higher than the findings of Dannenberger et al. (2013) and Skewes et al. (2009). The hunting month had a great influence on the P/S ratio ($p = .05$) with a higher value in October and November than in December and January, but generally different from the recommended value (about 0.4, Wood et al. 2003). In addition, *n*-6/*n*-3 was highest in October and in November than in December and in January ($p = .01$) with very different average value from the recommended one (max 4). The (M + P)/S, AI, TI and h/H ratios did not show any differences on the basis of the variability factors considered. For these parameters, it is only possible to make some general comments. The (M + P)/S ratio showed a lower value

Table 2. Effect of hunting month on fat content and fatty acid concentrations (% total fatty acids) of wild boar *longissimus dorsi* muscles.

	Intramuscular fat				
Fatty acid	October	November	December	January	*p*
N	10	14	10	8	
IMF, %	1.65 ± 1.814	1.64 ± 1.385	3.27 ± 1.795	7.38 ± 1.883	ns
C4:0	0.04 ± 0.012	0.02 ± 0.010	0.03 ± 0.012	0.03 ± 0.012	ns
C6:0	0.10^{a} ± 0.016	0.08^{a} ± 0.012	0.01^{b} ± 0.015	0.02^{b} ± 0.016	.01
C8:0	0.02 ± 0.011	0.03 ± 0.008	0.02 ± 0.011	0.02 ± 0.011	ns
C10:0	0.04 ± 0.019	0.04 ± 0.014	0.08 ± 0.018	0.07 ± 0.019	ns
C11:0	0.17 ± 0.034	0.08 ± 0.026	0.07 ± 0.034	0.07 ± 0.036	ns
C12:0	0.12 ± 0.048	0.13 ± 0.037	0.13 ± 0.047	0.15 ± 0.050	ns
C13:0	0.01 ± 0.020	0.04 ± 0.015	0.02 ± 0.020	0.02 ± 0.020	ns
C14:0	0.33 ± 0.636	0.96 ± 0.486	1.52 ± 0.630	1.49 ± 0.661	ns
C14:1	0.05 ± 0.015	0.05 ± 0.011	0.03 ± 0.015	0.03 ± 0.016	ns
C15:0	0.21 ± 0.035	0.23 ± 0.027	0.08 ± 0.021	0.11 ± 0.036	ns
C15:1	0.09 ± 0.017	0.07 ± 0.013	0.02 ± 0.017	0.02 ± 0.018	ns
C16:0	21.46^{b} ± 1.255	21.47^{b} ± 0.958	27.83^{a} ± 1.242	26.52^{a} ± 1.303	.02
C16:1 *n*-7	0.83^{b} ± 0.317	1.07^{b} ± 0.242	2.90^{a} ± 0.313	1.91^{b} ± 0.329	.01
C17:0	0.63 ± 0.084	0.66 ± 0.064	0.29 ± 0.083	0.39 ± 0.087	ns
C17:1	0.20 ± 0.177	0.39 ± 0.135	0.37 ± 0.175	0.30 ± 0.184	ns
C18:0	16.37 ± 1.582	14.85 ± 1.208	14.20 ± 1.565	14.90 ± 1.642	ns
C18:1 total	23.79^{b} ± 3.183	24.82^{b} ± 2.431	41.04^{a} ± 3.150	41.27^{a} ± 3.305	.01
C18:2 total	25.49^{a} ± 2.359	24.92^{a} ± 1.801	6.90^{b} ± 2.334	8.06^{b} ± 2.449	.01
C18:3 *n*-6	0.06 ± 0.019	0.06 ± 0.015	0.05 ± 0.019	0.03 ± 0.020	ns
C18:3 *n*-3	0.58 ± 0.373	0.45 ± 0.285	0.84 ± 0.370	1.57 ± 0.388	ns
C20:0	0.25 ± 0.043	0.19 ± 0.033	0.23 ± 0.043	0.27 ± 0.045	ns
CLA	0.02 ± 0.009	0.02 ± 0.007	0.01 ± 0.009	0.02 ± 0.009	ns
C20:1	0.97^{a} ± 0.349	1.41^{a} ± 0.267	0.18^{b} ± 0.345	0.23^{b} ± 0.362	.02
C21:0	0.10 ± 0.035	0.10 ± 0.027	0.10 ± 0.035	0.03 ± 0.037	ns
C20:2 *n*-6	0.73 ± 0.093	0.70 ± 0.071	0.31 ± 0.092	0.37 ± 0.097	ns
C20:3 *n*-6	0.43 ± 0.115	0.36 ± 0.087	0.17 ± 0.113	0.12 ± 0.119	ns
C20:4 *n*-6	4.32 ± 1.550	4.29 ± 1.184	1.68 ± 1.534	0.98 ± 1.609	ns
C20:3 *n*-3	0.17 ± 0.046	0.16 ± 0.035	0.09 ± 0.046	0.11 ± 0.048	ns
C22:0	0.06 ± 0.015	0.04 ± 0.011	0.05 ± 0.015	0.05 ± 0.016	ns
C22:1	0.06 ± 0.032	0.05 ± 0.025	0.03 ± 0.032	0.08 ± 0.033	ns
C20:5 *n*-3	0.07 ± 0.044	0.12 ± 0.032	0.11 ± 0.042	0.02 ± 0.044	ns
C23:0	0.25 ± 0.151	0.31 ± 0.115	0.13 ± 0.149	0.12 ± 0.157	ns
C22:2	0.39^{ab} ± 0.082	0.43^{a} ± 0.063	0.16^{bc} ± 0.081	0.02^{c} ± 0.085	.02
C24:0	0.40 ± 0.097	0.35 ± 0.074	0.22 ± 0.096	0.16 ± 0.101	ns
C24:1	0.09 ± 0.045	0.14 ± 0.035	0.12 ± 0.045	0.12 ± 0.045	ns
C22:5 *n*-3	0.81 ± 0.285	0.67 ± 0.218	0.21 ± 0.282	0.20 ± 0.297	ns
C22:6 *n*-3	0.22 ± 0.056	0.21 ± 0.042	0.08 ± 0.055	0.09 ± 0.058	ns
SFA (S)	40.60 ± 2.478	39.61 ± 1.893	45.01 ± 2.453	44.42 ± 2.574	ns
MUFA (M)	26.10^{a} ± 3.391	28.00^{a} ± 2.590	44.33^{b} ± 3.356	43.98^{b} ± 3.521	.02
PUFA (P)	32.90^{a} ± 4.080	31.94^{a} ± 3.110	10.46^{b} ± 4.030	11.56^{b} ± 4.230	.01
P/S	0.80^{a} ± 0.140	0.85^{a} ± 0.110	0.20^{b} ± 0.140	0.23^{b} ± 0.150	.05
n-6/*n*-3	19.05^{a} ± 2.138	20.23^{a} ± 1.632	7.15^{b} ± 2.115	5.80^{b} ± 2.220	.01
(M + P)/S	1.51 ± 0.164	1.58 ± 0.125	1.19 ± 0.162	1.23 ± 0.170	ns
AI	0.39 ± 0.068	0.43 ± 0.052	0.61 ± 0.068	0.58 ± 0.071	ns
TI	0.27 ± 0.030	0.24 ± 0.021	0.19 ± 0.027	0.18 ± 0.030	ns
h/H	2.46 ± 0.231	2.37 ± 0.176	1.52 ± 0.228	1.69 ± 0.240	ns

LDF: *longissimus dorsi* fat; CLA is considered as 18:2 cis 9, trans-11; SFA, MUFA, PUFA, sum of all saturated, monounsaturated and polyunsaturated fatty acids, respectively; AI: atherogenic index; TI: thrombogenic index; h/H: hypocholesterolaemic/Hypercholesteraemic ratio. Values are presented as least square mean ± standard error.
[a,b]Means with a different superscript letter within a row differ significantly ($p \leq .05$).

than the recommended one (1.25 – British Department of Health 1994) only for young animals and for meat derived from wild boar slaughtered in December and January. Atherogenic and trombogenic indices were always lower than 1.00, and TI, in particular, was lower than the value reported by Ulbricht and Southgate (1991) in pork, beef and lamb (1.66, 1.39, 1.58, respectively).

Another approach is the use of the hypocholesterolaemic/Hypercholesterolaemic (h/H) ratio, based on the functional effects of some fatty acids on the cholesterol metabolism (Santos-Silva et al. 2002). In the present study all the value were lower than the recommended ones (>2.5) (Fernàndez et al. 2007).

Microbiological profile

No statistically significant difference was found for microbiological analyses on the basis of age and gender. Table 3 reports the viable bacterial counts for each hunting month. Overall, total mesophilic bacteria loads were on average 5.36 log CFU/g, while total

Table 3. Viable counts (logCFU/g) of selected bacterial groups in samples of wild boar *longissimus dorsi* muscles.

Microbiological analysis	October	November	January	*p*
N	5	10	7	
Total aerobic mesophilic count	$6.1^{a} \pm 0.27$	$4.74^{b} \pm 0.18$	$5.71^{a} \pm 0.28$	.01
Total aerobic psychotrophic count	5.36 ± 0.41	4.41 ± 0.18	4.94 ± 0.59	ns
Enterobacteriaceae	$5.13^{a} \pm 0.59$	$3.74^{b} \pm 0.31$	$4.58^{a,b} \pm 0.25$	.04
E. coli	4.75 ± 0.72	3.91 ± 0.25	3.96 ± 1.04	ns

Values are presented as mean ± standard error.
[a,b]Means with a different superscript letter within a row differ significantly ($p \leq .05$).

psychrotrophic loads were 4.80 log CFU/g. Average *Enterobacteriaceae* and *E. coli* counts were 4.32 log CFU/g and 4.12 log CFU/g, respectively. Meat from the muscular tissue of healthy animals is considered sterile and contamination of deep tissues during slaughtering under controlled conditions is very unlikely, however, it can occur when animals are shot in the field, and possibly wounded with damage to the internal organs (Gill 2007). Our data on microbial loads are thus not unexpected. In fact, the total mesophilic bacteria count in our study is comparable to those reported by Decastelli et al. (1995) for meat samples of wild boars shot in the north of Italy, and collected at a carcase dressing facility, which ranged from 4 to 8 log CFU/g. For swabs from the muscle surface of 72 wild boars shot in the Western Alps Avagnina et al. (2012) reported total aerobic counts with a median value of 4.61 log CFU/cm^2 and *Enterobacteriaceae* counts with a median value of 3.00 log CFU/cm^2. For freshly shot wild boar samples from Germany, Atanassova et al. (2008) reported total mesophilic bacteria and *Enterobacteriaceae* counts with a geometrical mean of 3.2 and 2.1 log CFU/cm^2, respectively. These values, however, are generally lower than those reported in the literature and could have been the result of well-organised hunt and rapid evisceration of the animals (Atanassova et al. 2008). *Escherichia coli* loads in our study had similar values to those reported by Decastelli et al. (1995), which ranged from 1 to 5 log CFU/g. Our data, however, are higher than those reported for frozen or chilled wild boar meat sampled in game meat trading facilities in France (2.66 log CFU/g) (Membré et al. 2011), although the refrigeration and freezing could be partly responsible for the lower bacterial counts. Various factors affect the hygienic conditions of game meat, such as whether an animal was expertly shot, the rapid evisceration, and the conditions in which the carcase is dressed (Decastelli et al. 1995; Atanassova et al. 2008; Avagnina et al. 2012; Sales & Kotrba 2013). All these factors likely played a role in our study, and could account for the diversity of *Enterobacteriaceae* counts in the different samples, ranging from 2.00 to 6.7 log CFU/g, and for the differences in microbial loads among different hunts. In our study, *Salmonella* spp. was detected in only one sample (4.5%), coming from an adult male. These results are in agreement with previous data on wild boar where Salmonella spp. was either not detected (Atanassova et al. 2008; Avagnina et al. 2012) or detected in a limited number of samples (Decastelli et al. 1995; Paulsen et al. 2012). Gill (2007) suggested that *Salmonella* may vary among different populations of wild boars, frequent in some populations and not very common in others. Generally, it is assumed that the risk associated with Salmonella in large wild game is small, due to its sporadic finding (Atanassova et al. 2008). In our study, *Yersinia enterocolitica* was never detected although its presence has been previously reported for wild boar meat. Avagnina et al. (2012) detected *Yersinia enterocolitica* in 4.61% (3/65) and Ercolini et al. (2007) in 6% (3/50) of wild boar meat samples. Finally, as reported by other researchers, the low frequency of bacterial pathogens indicated that the wild boar meat shows mainly spoilage and shelf-life problems, rather than safety issues (Avagnina et al. 2012; Sales & Kotrba 2013). No specific microbiological criteria exist yet for game meat within European Union legislation, and the microbiological quality of wild boar meat is generally considered to be similar to that of domestic pigs (Membré et al. 2011). Since a low microbiological quality of wild boar meat is mainly due to the evisceration and skinning under poorly controlled conditions, only appropriate handling in all phases of game production, from hunting to fork, guarantees the quality and safety standards for this type of meat.

Conclusions

The hunting month mostly influences the fatty acid profile of meat, which is probably due to the fact that, in the wild, there is no environmental control, particularly on the diet. Only small differences were detected for gender and hunting age. Except for AI and TI

indices, which were in agreement with the recommended values, all the other ratios seemed to indicate a fatty acid content that is not well-balanced for human diet, as often happens for individual foods that should only be one of many components in a well-balanced diet. Given that wild boar is a monogastric animal, it may be advisable to provide, during the autumn–winter period, a supplementary food diet in order to improve the fat content and fatty acid composition. Wild boar meat seems to be of good microbiological quality, with health risks for the consumer comparable to those associated with meat obtained from farm animals. In addition, only appropriate handling at all stages of the processing and marketing chain ensures high quality.

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

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