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INFLUENCE OF RAW MATTER ORIGIN AND PRODUCTION PERIOD ON FATTY-ACID COMPOSITION OF DRY-CURED HAMS

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ABSTRACT

We have here investigated the fatty acid composition in the muscle (Mm. *biceps femoris, semitendinosus and semimembranosus*) of Vipava and Vipava-style hams made from fresh pork legs that originate from Slovenia, and from Germany and Italy, respectively. Dry-cured hams are produced under technology protected according to recognized geographical indications for Vipava ham, a salt-cured ham that is air-dried rather than smoked. The fatty acid compositions of samples were determined by gas-liquid chromatography following *in-situ* transesterification. On average, hams contained 6.89% of intramuscular and intermuscular fat, with the fatty-acid composition as 50.0% monounsaturated, 11.8% polyunsaturated (PUFA) and 38.0% saturated fatty acids. The origin of the raw matter has significant influence the PUFAs in hams, which were 2.0% lower in products from pigs of Slovenian (own) rearing. The important indicators of lipid nutritive value, as P/S ratio (0.31), content of *n*-3 (0.68%) and *n*-6 (9.02%) PUFAs, and ratio of *n*-6/*n*-3 PUFAs (14.1), are similar to those cited in the literature for other types of dry-cured hams from south European regions produced from pigs reared under intensive systems.

Keywords: meat products / dry-cured ham / Vipava ham / pork legs / origin / fat / composition / fatty acids / Slovenia

VPLIV POREKLA STEGEN IN STOPNJE ZRELOSTI NA MAŠČOBNOKISLINSKO SESTAVO LIPIDOV (VIPAVSKEGA) PRŠUTA

IZVLEČEK

V članku je predstavljena maščobnokislinska sestava intra- in intermuskularne maščobe mišic (Mm. *biceps femoris, semitendinosus* in *semimembranosus)* pršutov, zaščitenih z geografsko označbo 'Vipavski pršut' in proizvedenih iz slovenske surovine, in pršutov, proizvedenih po isti tehnologiji (v tipu Vipavskega pršuta), vendar sveža stegna izvirajo iz Nemčije ali Italije. Proizvedeni so bili po tradicionalni tehnologiji, t.j. na način, ko se suho soljena prašičja stegna sušijo na zraku brez predhodnega prekajevanja. Maščobno kislinski profil intramuskularne maščobe smo določili s plinsko-tekočinsko kromatografijo po metodi *in situ* transesterifikacije. V povprečju pršuti vsebujejo 6,89 % intra- in intermuskularne maščobe, glede maščobnokislinske sestave pa 50 % pripada enkrat nenasičenim, 11,8 % večkrat nenasičenim (VNMK) in 38 % nasičenim maščobnim kislinam. Poreklo surovine značilno vpliva na delež VNMK v pršutih, ki je dva odstotka (od skupnih maščobnih kislin) manjši v pršutih izdelanih iz slovenske kot nemške in italijanske surovine. Pomembni pokazatelji prehranske vrednosti

lipidov, kot so razmerje P/S (0,31), vsebnost *n*-3 (0,68 %), vsebnost *n*-6 (9,02 %) VNMK in razmerje *n*-6/*n*-3 (14,1), so podobni podatkom, ki jih navaja literatura za druge vrste pršutov iz južnih držav evropske regije, proizvedenih iz intenzivno vzrejenih prašičev.

Ključne besede: mesni izdelki / pršut / Vipavski pršut / stegna / poreklo / maščobe / sestava / maščobne kisline / Slovenija

INTRODUCTION

Dry-cured hams are appreciated by consumers because of their sensory traits and their image as traditional products. At present, traditional technologies are used to produce high quality dry-meat products with attractive sensory qualities, such as colour, aroma and texture, and high nutritional value due to a very high proteins content. The drying and long ripening periods are processes that can form not only typical sensory traits and microbiological stability, but also change the composition and nutritional value of proteins and lipids.

Lipids in muscle and adipose tissues undergo intense degradation during processing, including lipolysis and oxidation, which generates numerous volatile compounds and consequently the typical aroma notes of dry-cured meat products (Gandemer, 1999, 2002). This degradation also has key roles for changes in the lipid composition and nutritional value of dry-cured ham. In southern European countries, the production processes include the standard steps of salting, drying and ripening. However, there are large differences in the relative times and temperature humidity cycles, mainly during drying and ripening, according to the processes used for each product in each country (Toldra and Flores, 1998). These large variations in processing conditions can affect the kinetics of lipolysis and oxidation reactions to great extents (Gandemer, 2002).

The quality of dry-cured hams is related to both the quality of the raw matter (adipose tissue and muscle) and the control of the complex biochemical reactions that take place during the ham processing. The quality of the raw matter is directly related to the rearing condition of the pigs (Lopez-Bote, 1998; Toldra and Flores, 1998). In European countries, most of the dry-cured and dry-fermented meat products are manufactured from muscle and adipose tissue of pigs reared under intensive systems. The pigs are from industrial genotypes and their crossbreeds, and they are slaughtered at 100–120 kg, at around 5–6 months of age. For dry-cured ham production, e.g. Parma and San Daniele hams, the pigs are slaughtered when they are heavier (160–180 kg) and older (9–12 months). The muscle and adipose tissue of these pigs show very similar compositional traits (Bosi *et al.*, 2000). The raw matter of dry-cured hams produced in Slovenia is mainly from European (Carso hams) or solely Slovenian pig production (Vipava hams) from middle weight pigs (120–140 kg) reared under intensive systems. Vipava ham is a Slovenian product that has protected geographical indications (IGP) (Regulations on Dry-ham of Vipava…, 2007), and it is from pigs of Slovenian production; it is processed by an original technology that uses a longer ripening. This provides a product of specific sensory quality, with a nutritional value that is most probably related to changes in the lipid fatty-acid composition.

The lipid composition of meat products is important in the context of balanced nutrition. Fresh pork leg (*m. biceps femoris*), which is also known as fresh ham, is the uncured hind leg of the hog, and shows a lipid fatty-acid composition mostly of monounsaturated fatty acids (MUFAs), such as oleic acid (18:1*c*-9), and saturated fatty acids (SFAs), such as palmitic (16:0), stearic (18:0) and myristic (14:0) acids. There are lower levels of polyunsaturated fatty acids (PUFAs), such as the *n*-6 linoleic (18:2*c*-9,12), α-linolenic (18:3*c*-9,12,15) and arachidonic (20:4*c*-5,8,11,14) PUFAs, and the long-chain *n*-3 eicosapentaenoic (EPA; 20:5*c*-5,8,11,14,17), docosapentaenoic (DPA; 22:5*c*-7,10,13,16,19) and docosahexaenoic (DHA; 22:6*c*-4,7,10,13,16,19) PUFAs (Golob *et al.,* 2006). Similar fatty-acid compositions are seen for the adipose tissue from pigs of various European areas that are used also for the production of

different protected dry-cured hams (e.g. Parma, Bayonne and Serrano), as indicated by Gandemer (2002), Fernandez *et al.* (2007) and Webb and O'Neill (2008).

The fatty-acid profile of the fresh pork leg has been changing under traditional technologies, and consequently in Carso ham some indicators of the lipid nutritional value have been improved, such as the PUFA/SFA (P/S) ratio (from 0.36 to 0.43) and the *n*-6/*n*-3 ratio (from 12.4 to 9.7) (Golob *et al.*, 2006). Spanish (Iberian, Serrano) and French (Bayonne, Corsican) dry-cured hams also show significantly lower SFA content (27.6%–37.1%) and higher MUFA content (55.9%–65.1%) (Gandemer, 2002). High amounts (10.2%) of linoleic acid have been reported for Serrano hams (Fernandez *et al.*, 2007).

However, as the components of the raw matter, the lipids in the muscle and adipose tissues can vary greatly, both quantitatively and qualitatively, according to a range of factors, including the animal species, age, sex and diet (Toldrá, 1998; Fernandez *et al.*, 2007). There is little data available on the fatty-acid composition of dry-cured hams (and none available for Vipava ham) and its nutritional value in the human diet. Likewise, the influence of the ripening duration and the origin of the raw material on fatty-acid composition has rarely been investigated. Thus, the purpose of the present study was to determine the content of intermuscular and intramuscular fat and the fatty-acid composition in the muscle (Mm. *biceps femoris, semitendinosus and semimembranosus*) of Vipava and Vipava-style hams made from fresh pork legs that originate from Slovenia, and from Germany and Italy, respectively.

MATERIALS AND METHODS

Materials

A total of 25 fresh pork legs (10 from Slovenia, 10 from Germany and five from Italy) were included in this study. The weights of the fresh legs shaped in the Vipava style were between 10 kg and 12 kg. The traditional technology that is protected according to the geographical indication as 'Vipava ham' includes the salting of the hams with sea salt, post-salting (over 11 days at temperatures of 0 °C and 5 °C), and rest ('riposo'; with or without ventilation at temperatures of 0 °C and 8 °C, with a total duration of these initial phases at a minimal 70 days. This is followed by the drying/ ripening at 12 °C to 22 °C, for a total of 12 months or 18 months.

Five experimental groups were included: V-S (Vipava hams produced from Slovenian fresh pork legs and ripened 12 months, as the standard procedure), V-L (Vipava hams produced from Slovenian fresh pork legs and ripened 18 months), Vs-GS (Vipava-style hams produced from German fresh pork legs and ripened 12 months), Vs-GL (Vipava-style hams produced from German fresh pork legs and ripened 18 months) and Vs-IS (Vipava-style hams produced from Italian fresh pork legs and ripened 12 months).

Samples for the determination of fatty acids were taken as 1-cm-thick slices of ham (intramuscular and intermuscular fat without subcutaneous fat). The slices were taken from caudal parts of each ham, and transversal on *os femoris* – the central part containing the *biceps femoris, semimembranosus* and *semitendinosus* muscles. The samples were homogenised, vacuum packed, and frozen at –20 °C until their analysis.

Intramuscular and intermuscular fat content

The intramuscular and intermuscular fat (IMF) contents were determined by the method described in AOAC Official Method 991.36. Fat (Crude) in Meat and Meat Products (AOAC, 1997). The total lipids were extracted by hot treatment with petroleum ether as the solvent.

Fatty-acid composition

The fatty-acid compositions of the samples were determined by gas-liquid chromatography (GLC), using *in-situ* transesterification (Park and Goins, 1994). The fatty acid methyl ester (FAME) contents were determined by GLC, on an Agilent Technologies 6890 gas chromatograph, with a flame ionisation detector and an Agilent Technologies HP-88 capillary column (Cat.No. 112-88A7) (100 m × 0.25 mm × 0.2 μm). The separation and detection were performed under the following conditions: temperature programme, 150 °C (held for 10 min), 2 °C/min to 180 °C (40 min), 3 °C/min to 240 °C (85 min); injector temperature, 250 °C; detector temperature 280 °C; injector: split:splitless, 1:30; volume, 1 μL; carrier gas, He 2.3 mL/min; make-up gas: N_2 45 mL/min; detector gases: H_2 40 mL/min; synthetic air (21% O_2) 450 mL/min.

The FAMEs were determined through their retention times in comparison to those of the following standard mixtures: Supelco fatty acid methyl ester mix – 37 components (Cat. No. 18919-1AMP); Supelco PUFA No.1: Animal source (Cat. No. 47015-U); Supelco Linoleic Acid Methyl Ester cis/trans Isomer Mix (Cat.No. 47791); Supelco cis-7-octadecenoic methyl ester (Cat.No. 46900-U); cis-11-octadecenoic methyl ester (Cat.No. 46904); Fluka Methyl stearidonate (Cat.No. 43959); Natural ASA CLA 10t, 12c in CLA 9c, 11t; and NuChek standards: GLC-68D, GLC-85, GLC-411 and GLC-546.

The NuChek GLC-68D and GLC-85 standards mixtures were used to determine the response factor, Rf_i, for each fatty acid. The weight portion of each fatty acid in the sample was determined using the Rf_i and the factor of transformation of fatty-acid content from FAME content. The determination of reliability and accuracy of the analytical method for the detection of fatty acids was ensured by the use of the certified reference matrix, CRM 163 (blend beef-pork fat, BCR), which was in good agreement with the certified values. The FAMEs were expressed as percentages of the total fatty-acid content.

Data analysis

The data for the fatty-acid compositions were processed by the GLM procedure (SAS, 1999). The statistical model included the main effects of fresh pork leg supplier group connected with ripening time (V-S, V-L, Vs-GS, Vs-GL, Vs-IS). The means of the experimental groups were obtained using the Duncan procedure, and were compared at the 5% probability level (SAS, 1999).

RESULTS AND DISCUSSION

Recently with human nutrition, the emphasis has shifted away from fat quantity to fat quality, as related to fatty-acid composition. SFAs have generally been labelled as the culprits for cancers and coronary heart disease, although C18:0 is considered as a neutral fatty acid. It is recommended that the total lipid intake should be 30% of the total energy intake. From 10% to 30% of the lipid energy should be from SFAs (Enser *et al.*, 1996). However, more recently, nutritionists have focused on the type of PUFA and the balance in the diet between the *n*-3 PUFAs, such as α-linolenic acid (18:3), and the *n*-6 PUFAs, such as linoleic acid (18:2). It has also been reported that the ratio of *n*-6:*n*-3 PUFAs can provide a risk factor for cancers and coronary heart disease, and especially for the formation of blood clots leading to a heart attack. The recommendation is for a ratio of less than 4.0 (Wood *et al.,* 2003). As with the P/S ratio, the meats can be manipulated to provide a more favourable *n*-6:*n*-3 ratio.

The IMF contents for the dry-cured hams produced from fresh pork legs that originated from three different countries and according to different ripening times are shown in Table 1. Across

all five groups, the IMF contents were similar, at a mean of 6.9%. These IMF contents are in agreement with findings in other studies, with levels reported of 8.8% in Parma (Fiego *et al.*, 2005), 9.3% in Iberian, 5.3% in Corsican, 3.5% in Serrano and 2.6% in Bayonne (Gandemer, 2002) hams. We also note that the chemical analyses in the present study were carried out with average samples that were obtained by mixing the *biceps femoris, semimembranosus* and *semitendinosus* muscles.

Table 1. Intramuscular and intermuscular fat (%) content (IMF) of dry-cured hams produced from fresh pork legs from three different countries and according to ripening times

Preglednica 1. Vsebnost mišične in medmišične maščobe (%) v pršutih, proizvedenih iz svežih prašičjih stegen različnega izvora in stopnje zrelosti

	Ham source (N = 5 × 10 = 50)						
	V-S	V-L	Vs-GS	Vs-GL	Vs-IS	Sign.	Overall mean
IMF ($\bar{x} \pm$ SD)	7.32 ± 2.2^a	7.27 ± 1.1^a	6.30 ± 1.06^a	6.26 ± 1.0^a	7.18 ± 0.8^a	Ns	6.89 ± 1.4

Mean values ± standard deviation for each group. N, number of observations. V-S (Vipava hams, ripened 12 months), V-L (Vipava hams, ripened 18 months), Vs-GS (Vipava-style hams, German origin, ripened 12 months), Vs-GL (Vipava-style hams, German origin, ripened 18 months) and Vs-IS (Vipava-style hams, Italian origin, ripened 12 months). Sign., statistical significance: not significant, Ns, $P > 0.05$.

The weight percentages of all of the fatty acids and some of the calculated indicators of the lipid nutritive values for the Vipava and Vipava-style hams are shown in Table 2.

The total SFA content in the hams was on average 38.0%, and the differences between all of the groups are not significant. The most prevalent SFAs were palmitic (16:0) (23.7% of total fatty acids) and stearic (18:0) (12.1%) acids. The Italian (Parma), Spanish (Serrano, Teruel) and French (Bayonne) dry-cured hams had similar contents of palmitic and stearic acids (Gandemer, 2002; Larrea *et al.*, 2007). The origins of the raw matter in our study did not affect the SFA compositions of the hams. Only two SFAs (lauric 12:0 and myristic 14:0 acids) showed low concentrations that decreased significantly with longer ripening (18 months; products V-L and Vs-GL). Both of these SFAs are known to be atherogenic (Ulbricht and Southgate, 1991).

The overall mean level of MUFAs was 50.0% of the total fatty acids, which did not differ significantly between the five groups of dry-cured hams. The most prevalent was oleic acid (18:1*n*-9; 44.6%), with no significant effects seen for the raw matter origins and ripening times of the hams. Only two MUFAs with lower proportions differed significantly ($P \leq 0.05$) between the five groups; V-L showed the lowest proportion (2.98%) of palmitoleic acid (16:1*c*-9) and the highest proportion (0.95%) of gadoleic acid (20:1*c*-9).

The PUFA content in the hams was on average 11.8% of the total fatty acids, and was significantly ($P \leq 0.05$) influenced by the raw matter origin, but not by time of ham ripening. The products of Slovenian origin (V-L and V-S) contained approximately 2% lower levels of PUFAs compared to the other groups. Of note, linoleic acid (18:2*n*-6) showed an overall high mean proportion (8.95%), which was significantly ($P \leq 0.05$) lower in products of Slovenian origin (V-S, 7.85%; V-L, 8.63%) compared to the other hams (Vs-GL, Vs-GS, Vs-IS), where it was between 9.23% and 9.86%, close to the 10.2% linoleic acid reported previously for Serrano ham (Fernandez *et al.*, 2007).

There were some long-chain *n*-3 PUFAs in the hams. The content of DPA was significantly ($P \leq 0.05$) lower in the V-L (0.13%) and V-S (0.15%) hams, compared with the samples with other origins, such as Vs-GL (0.22) and Vs-GS (0.26%). An extended ripening of hams had no significant effects on the *n*-3 PUFAs.

Table 2. Fatty acids (g/100 g fatty acids) content (means ±standard deviation) of dry-cured hams produced from fresh pork legs from three different countries and according to ripening times

Preglednica 2. Maščobnokislinska sestava (g/100 g skupnih maščobnih kislin; povprečne vrednosti ± standardni odklon) pršutov, proizvedenih iz svežih prašičjih stegen različnega izvora in stopnje zrelosti

	Ham source (N = 5 × 5 = 25)						
Fatty acids, $\bar{x} \pm SD$	V-S	V-L	Vs-GS	Vs-GL	Vs-IS	Sign.	Overall means
8:0	0.01 ±0.01^{a}	0.02^{a}	0.02^{a}	0.02^{a}	0.02^{a}	Ns	0.02
10:0	0.13 ±0.03^{a}	0.11 ±0.01^{a}	0.12 ±0.05^{a}	0.11 ±0.02^{a}	0.12 ±0.02^{a}	Ns	0.12 ±0.03
11:0	0.01 ±0.01^{a}	0.00^{a}	0.01 ±0.01^{a}	0.00 ±0.01^{a}	0.00 ±0.01^{a}	Ns	0.00 ±0.01
12:0	0.10 ±0.02^{abc}	0.08 ±0.01^{c}	0.12 ±0.02^{a}	0.10±0.04^{bc}	0.11 ±0.01^{ab}	**	0.10 ±0.02
12:1*c*-3	0.07 ±0.03^{a}	0.05 ±0.02^{b}	0.06 ±0.02^{ab}	0.06 ±0.02^{a}	0.05 ±0.01^{ab}	Ns	0.06 ±0.02
13:1*c*-3	0.04 ±0.01^{a}	0.03 ±0.01^{b}	0.04 ±0.01^{ab}	0.04 ±0.01^{a}	0.03 ±0.01^{ab}	*	0.03 ±0.01
14:0	1.43 ±0.16^{a}	1.35 ±0.19^{ab}	1.45 ±0.17^{a}	1.27 ±0.08^{b}	1.43 ±0.09^{a}	*	1.39 ±0.15
14:1*t*-5	0.02^{a}	0.02^{a}	0.03 ±0.01^{a}	0.02 ±0.01^{a}	0.03 ±0.02^{a}	Ns	0.02 ±0.01
14:1*c*-5	0.07 ±0.01^{a}	0.05 ±0.01^{b}	0.06 ±0.01^{a}	0.06 ±0.01^{a}	0.06 ±0.01^{ab}	*	0.06 ±0.01
15:0	0.05 ±0.01^{ab}	0.05 ±0.01^{a}	0.05 ±0.01^{a}	0.04 ±0.01^{b}	0.04 ±0.01^{b}	**	0.05 ±0.01
15:1*c*-5	0.25 ±0.07^{a}	0.18 ±0.07^{a}	0.25 ±0.05^{a}	0.25 ±0.06^{a}	0.21 ±0.04^{a}	Ns	0.23 ±0.06
15:1*c*-10	0.03 ±0.01^{a}	0.02 ±0.01^{a}	0.03 ±0.01^{a}	0.03 ±0.01^{a}	0.03 ±0.01^{a}	Ns	0.03 ±0.01
16:0	24.4 ±1.0^{a}	23.9 ±1.4^{a}	22.6 ±3.5^{a}	23.7 ±0.7^{a}	24.0 ±0.7^{a}	Ns	23.7 ±1.9
16:1*t*-9	0.23 ±0.03^{a}	0.22 ±0.02^{a}	0.26 ±0.05^{a}	0.23 ±0.04^{a}	0.21 ±0.02^{a}	Ns	0.23 ±0.04
16:1*c*-9	3.64 ±0.43^{a}	2.98 ±0.65^{b}	3.27 ±0.32^{ab}	3.30 ±0.65^{ab}	3.25 ±0.26^{ab}	*	3.29 ±0.51
17:0	0.27 ±0.08^{b}	0.33 ±0.05^{a}	0.28 ±0.07^{b}	0.23 ±0.06^{b}	0.22 ±0.05^{b}	***	0.27 ±0.07
17:1*t*-10	0.25 ±0.10^{a}	0.30 ±0.10^{a}	0.26 ±0.06^{a}	0.22 ±0.06^{a}	0.20 ±0.05^{a}	Ns	0.24 ±0.08
17:1*c*-10	0.04 ±0.01^{ab}	0.04 ±0.01^{b}	0.05 ±0.01^{a}	0.04 ±0.02^{b}	0.04 ±0.01^{b}	*	0.04 ±0.01
18:0	12.2 ±0.8^{a}	12.7 ±0.9^{a}	12.1 ±1.4^{a}	11.6 ±0.4^{a}	11.8 ±0.9^{a}	Ns	12.1 ±1.0
18:1*t*-9	0.11 ±0.01^{b}	0.11 ±0.01^{b}	0.11 ±0.02^{b}	0.13 ±0.02^{a}	0.11 ±0.02^{b}	*	0.11 ±0.02
18:1*c*-9	44.9 ±2.2^{a}	44.6 ±0.9^{a}	44.4 ±2.6^{a}	44.7 ±0.9^{a}	44.5 ±1.1^{a}	Ns	44.6 ±1.6
18:2*c*-9,12	7.85 ±1.56^{b}	8.63 ±0.80^{ab}	9.86 ±2.39^{a}	9.25 ±0.96^{a}	9.23 ±0.78^{a}	*	8.95 ±1.56
18:3*c*-6,9,12	0.00 ±0.01^{a}	0.01 ±0.01^{a}	0.00 ±0.01^{a}	0.01 ±0.01^{a}	0.00 ±0.01^{a}	Ns	0.01 ±0.01
20:0	0.16 ±0.03^{a}	0.17 ±0.03^{a}	0.16 ±0.02^{a}	0.16 ±0.02^{a}	0.16 ±0.03^{a}	Ns	0.16 ±0.03
18:3*c*-9,12,15	0.27 ±0.06^{c}	0.31 ±0.04^{bc}	0.62 ±0.24^{a}	0.40 ±0.18^{b}	0.32 ±0.05^{bc}	***	0.38 ±0.18
20:1*c*-11	0.72 ±0.05^{c}	0.95 ±0.05^{a}	0.81 ±0.07^{b}	0.70 ±0.15^{c}	0.87 ±0.09^{b}	***	0.81 ±0.12
21:0	0.11 ±0.12^{a}	0.07 ±0.05^{a}	0.04 ±0.04^{a}	0.08 ±0.07^{a}	0.07 ±0.09^{a}	Ns	0.07 ±0.08
20:2*c*-8,11	0.27 ±0.02^{b}	0.37 ±0.03^{a}	0.34 ±0.12^{a}	0.33 ±0.08^{a}	0.38 ±0.06^{a}	**	0.34 ±0.08
20:3*c*-8,11,14	0.06 ±0.02^{b}	0.05 ±0.01^{b}	0.06 ±0.01^{ab}	0.07 ±0.01^{a}	0.06 ±0.01^{ab}	*	0.06 ±0.01
20:3*c*-11,14,17	0.17 ±0.06^{b}	0.19 ±0.02^{ab}	0.19 ±0.02^{ab}	0.21 ±0.03^{a}	0.18 ±0.03^{b}	*	0.19 ±0.04
20:4*c*-5,8,11,14	1.52 ±0.52^{a}	1.54 ±0.22^{a}	1.68 ±0.31^{a}	1.91 ±0.37^{a}	1.57 ±0.19^{a}	Ns	1.63 ±0.36
22:1*c*-13	0.00^{a}	0.00 ±0.01^{a}	0.00^{a}	0.00^{a}	0.00^{a}	Ns	0.00
23:0	0.02 ±0.03^{a}	0.02 ±0.02^{a}	0.03 ±0.04^{a}	0.05 ±0.04^{a}	0.03 ±0.05^{a}	Ns	0.03 ±0.04
20:5*c*-5,8,11,14,17	0.04 ±0.0^{b}	0.04^{b}	0.07 ±0.01^{a}	0.07 ±0.02^{a}	0.01 ±0.02^{c}	***	0.05 ±0.03
24:0	0.00 ±0.01^{a}	0.01 ±0.01^{a}	0.01 ±0.01^{a}	0.01 ±0.02^{a}	0.02 ±0.04^{a}	Ns	0.01 ±0.02
24:1*c*-15	0.22 ±0.09^{b}	0.30 ±0.03^{a}	0.26 ±0.10^{ab}	0.31 ±0.07^{a}	0.31 ±0.05^{a}	*	0.28 ±0.08
22:5*c*-7,10,13,16,19	0.13 ±0.05^{c}	0.15 ±0.03^{c}	0.22 ±0.09^{ab}	0.26 ±0.07^{a}	0.17 ±0.04^{bc}	***	0.18 ±0.07
22:6*c*-4,7,10,13,16,19	0.07 ±0.03^{a}	0.07 ±0.01^{a}	0.07 ±0.05^{a}	0.05 ±0.01^{a}	0.08 ±0.04^{a}	Ns	0.07 ±0.03
SFAs	38.9 ±1.4^{a}	38.8 ±1.2^{a}	37.0 ±3.2^{b}	37.3 ±0.5^{ab}	38.1 ±1.5^{ab}	Ns	38.0 ±1.9
MUFAs	50.7 ±2.3^{a}	49.8 ±1.0^{a}	49.9 ±2.7^{a}	50.0 ±1.1^{a}	49.9 ±1.1^{a}	Ns	50.0 ±1.7
PUFAs	10.4 ±2.2^{c}	11.4 ±1.1^{bc}	13.1 ±2.9^{a}	12.6 ±1.3^{ab}	12.0 ±0.9^{abc}	*	11.8 ±2.0
P/S	0.27 ±0.06^{c}	0.29 ±0.03^{bc}	0.36 ±0.11^{a}	0.34±0.04^{ab}	0.32 ±0.04^{abc}	**	0.31 ±0.07
n-3	0.51 ±0.15^{c}	0.58 ±0.07^{c}	0.98 ±0.29^{a}	0.78 ±0.22^{b}	0.58 ±0.08^{c}	***	0.68 ±0.25
n-6	7.91 ±1.57^{b}	8.69 ±0.81^{ab}	9.92 ±2.38^{a}	9.33 ±0.95^{a}	9.30 ±0.78^{a}	*	9.02 ±1.56
n-6/*n*-3	16.1 ±2.6^{a}	15.1 ±1.3^{a}	10.4 ±1.5^{c}	12.7 ±3.6^{b}	16.1 ±1.5^{a}	***	14.1 ±3.1

Mean values ± standard deviation in each group. N, number of samples. V-S (Vipava hams, ripened 12 months), V-L (Vipava hams, ripened 18 months), Vs-GS (Vipava-style hams, German origin, ripened 12 months), Vs-GL (Vipava-style hams, German origin, ripened 18 months) and Vs-IS (Vipava-style hams, Italian origin, ripened 12 months). If SD < 0.01 g/100 g fatty acids, the values are not given. SFAs, saturated fatty acids. MUFAs, monounsaturated fatty acids. PUFAs, polyunsaturated fatty acids. P/S, PUFA/SFA. Sign., statistical significant: Ns, $P > 0.05$; * $P \leq 0.05$ and ** $P \leq 0.01$; *** $P \leq 0.001$.

The overall mean *n*-3 fatty-acid content in the hams was 0.68% and it was significantly influenced by the origin of the raw matter and the ripening time of the products ($P \leq 0.001$). Lower contents of *n*-3 PUFAs were seen for the V-S, V-L and Vs-IS samples (0.51% to 0.58%) than for those of Vs-GL (0.78%) and Vs-GS (0.98%). The extended ripening of hams had different influences on *n*-3 PUFA content: non-significant lower proportions in V-S *vs.* V-L sample (0.51 *vs.* 0.58%; $P > 0.05$), and significant higher proportion in Vs-GL *vs.* Vs-GS (0.98 *vs.* 0.78%; $P < 0.05$). Recommendations for the daily intake of *n*-3 PUFAs are 0.45 g for adults (FSA, 2004). Chapkin (1992) recommended 0.8 g of EPA and DHA daily for a healthy adult population, while Simopoulos (2002) recommended 0.65 g of EPA and DHA daily (calculated on an 8,400 kJ diet). All of this indicates that the hams included in our study are good sources of *n*-3 PUFAs, regardless of dry matter origin and ripening stage.

As an indicator of the lipid nutritional value, the P/S ratio did not reach the recommended minimal value of 0.4 (Wood *et al.*, 2003), with the mean value in the present study of 0.31. The German and Italian samples (Vs-GL, Vs-GS and Vs-IS) showed significantly higher P/S ratios (0.32–0.36; $P \leq 0.05$) compared with those Slovenian (V-L and V-S; 0.27–0.29). This appears to be a consequence of the different rearing conditions of the pigs (Lopez-Bote, 1998; Toldra and Flores, 1998). Similar P/S ratios have been reported for five different Spanish dry-cured hams (0.19–0.30; Fernandez *et al.*, 2007), with slightly higher, and nearer the recommended minimal value of above 0.4 reported for Carso dry-cured hams (Golob *et al.*, 2006).

The Vipava-style hams produced from fresh pork legs of German origin contained significantly higher amounts of *n*-3 PUFAs (0.78%–0.98%) compared with the Slovenian and Italian hams (0.51%–0.58%). Extended ripening significantly decreased the content of the *n*-3 PUFAs only in the case of the Vs-GS hams ($P \leq 0.05$). The amounts of *n*-6 PUFAs were significantly lower in hams of Slovenian origin (7.9%–8.7%; $P \leq 0.05$) compared with German and Italian ones (9.3%–9.9%). Ripening did not affect the *n*-6 PUFA content, regardless of the origin of raw matter.

The ratios of *n*-6/*n*-3 PUFAs varied significantly across all of the groups, ranging from 10.4 (Vs-GS) to 16.1 (V-S and Vs-IS) ($P \leq 0.001$). Shorter ripened Vs-GS hams showed a nutritionally more favourable *n*-6/*n*-3 ratio of 10.4, with a similar result previously seen for Carso dry-cured ham (9.7) (Golob *et al.*, 2006). This means that the samples were approaching the recommended values of *n*-6/*n*-3 ratio from 5 to 10 (WHO, 1994), although they did not reach the optimal ratio of 1 to 4 mentioned by Simopoulos (2002).

CONCLUSIONS

The intramuscular and intermuscular lipids of Vipava hams are composed of 38% SFAs, 50% MUFAs and 12% PUFAs. The origin of the raw matter has significant influence on the share of PUFAs in dry-cured hams, which is 2% lower in products from pigs of Slovenian (own) rearing. The extended ripening times of the hams decreased the contents of *n*-3 PUFAs in samples of German raw matter origin, differences are coincidental. The hams used in our study are relatively good sources of *n*-3 PUFAs (0.68%), regardless of the raw matter origin and ripening stage.

Important indicators of lipid nutritive values, such as the P/S ratio (0.31), the content of *n*-3 (0.68%) and *n*-6 (9.02%) PUFAs, and the ratio of *n*-6/*n*-3 PUFAs (14.1), on average did not reach recommended values for balanced (safe) nutrition, although they are similar to literature citations of other types of dry-cured hams from south European regions, produced from pigs reared under intensive systems.

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