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Odor-Active Compounds of Iberian Hams with Different Aroma Characteristics

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The odor-active compounds of different commercial types of Iberian hams (Montanera and Pienso) were researched by gas chromatography−olfactometry based on a detection frequency method. The hams (long- and short-Montanera and Pienso Iberian hams) showed different sensory profiles, differences being significant for Montanera ham typical odor, aroma intensity and persistence, and cured and moldy aroma. Significant differences were also found for some odorants. The largest differences appeared in 2-acetyl-1-pyrroline, hexanal, (*Z*)-3-hexenal, ethyl 2-methylbutyrate, (*E*)-2-hexenal, 1-octen-3-one, 1-octen-3-ol, 2-propionyl-1-pyrroline, octanal, and an unknown odorant. Sensory characteristics and olfactometric profiles were significantly different between Montanera and Pienso hams. Significant differences also appeared between long- and short-Montanera hams, which shows great variability in this commercial type. Otherwise, the largest scores for moldy aroma in long-Montanera hams matched with the largest detection frequency of 1-octen-3-one and 1-octen-3-ol in this group.

KEYWORDS: Iberian ham; odor-active compounds; detection frequency; aroma differences; dry-cured ham

INTRODUCTION

Iberian ham is an expensive Spanish dry-cured ham produced from Iberian pigs and characterized by a prolonged dry-curing process (420−600 days for the whole process including the salting, postsalting, and ripening stages) (*1*) and excellent consumer acceptance. According to the fatty acid composition of the raw subcutaneous adipose tissue and the rearing system, Iberian hams are classified into different commercial types (*2*): "Montanera" hams, from pigs fattened outdoors (feeding based on acorns and pasture land), being the most expensive hams; "Pienso" hams, from pigs fattened indoors (feeding based on concentrate feed), being the least expensive; and "Recebo" hams, an intermediate type. Remarkable sensory differences between Montanera and Pienso hams have been reported (*3*), and several works have focused on the characterization of the several types of Iberian hams, including their volatile compound profiles (*4*, *5*). Apart from these differences, there is a large variability inside each commercial category (*1*, *6*), which contributes to hindering the characterization of Iberian ham.

The characteristic aroma of meat products greatly contributes to their overall acceptance (*7*), and it is known that it is the volatile compounds that determine the aroma attributes and contribute most to the characteristic meat aroma (*8*). However, it is well accepted that a limited number of volatile compounds actually contribute to the overall food aroma (*9*). In addition, it is known that some powerful odorants found in meat systems exist at concentrations too low to allow their identification by the usual gas chromatography−mass spectrometry (GC-MS) procedures (*10*).

Gas chromatography−olfactometry (GC-O) is a useful tool to identify and characterize the odor-active compounds. GC-O may be used to research aroma differences, because samples with different sensory profiles show differences in their odor-active compounds (*11*, *12*); in addition, odors detected during GC-O could be related to sensory attributes (*11*). Up to now the odor-active volatile compounds of dry-cured hams have been scarcely investigated (*13*−*15*), and no comparison of the odorants from different types of hams has been carried out.

Therefore, the purpose of the present work was to study the differences in the odor-active compounds among different types of Iberian ham characterized by sensory and fatty acid analyses.

MATERIALS AND METHODS

Samples. Twenty-seven Iberian hams processed according to the traditional method (*3*) were analyzed. A piece of biceps femoris muscle and 20 g of subcutaneous adipose tissue from each ham were taken, vacuum-packaged, frozen, and kept at −80 °C until required (6 months). Nine of these hams were made from Iberian pigs reared in confinement with a concentrate feed (Pienso hams). The other hams (Montanera hams) were produced from Iberian pigs reared in Montanera (free-range system based on acorns and pasture land) during the fattening period, nine of them having a long Montanera (75 days before slaughter) and nine having a short Montanera (55 days before slaughter).

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Chemicals. The reference compounds used (indicated in **Table 3**) were obtained from Sigma and Aldrich (Steinheim, Germany). Standard solutions were prepared at a concentration of 5 μL mL^{-1} of reference compounds in hexane or dichloromethane (HPLC grade).

Isolation of Volatile Compounds. Before analysis, visible fat and the surface of each sample (0.5 cm) were removed. Frozen samples were then minced and blended, and 6 g was placed into a flask for the volatile compound extraction. The isolation was carried out using an HP G1900A purge and trap concentrator (Hewlett-Packard). The sample headspace was swept onto the Tenax/silica gel/charcoal trap using a helium stream of 40 mL/min. Conditions were as follows: trap temperature during purge, −20 °C; sample temperature, 50 °C; preheat time, 5 min; purge time, 30 min. The volatile compounds were desorbed by heating the trap at 220 °C for 2 min and were injected into the gas chromatograph (GC). The transfer line to the GC was held at 210 °C.

GC-O. *GC-O Conditions.* GC-O was performed using an HP 5890 series II chromatograph (Hewlett-Packard) equipped with a flame ionization detector (FID) and a sniffing port ODO-1 (SGE, Ringwood, Australia) (without control of humidified air temperature). The effluent from the capillary column was split 1:1 (v/v) between the FID and the sniffing port using two deactivated uncoated fused silica capillaries (50 cm × 0.32 mm). Two fused capillary columns were used: an HP-5 (50 m × 0.32 mm i.d., film thickness = 1.05 μm, Hewlett-Packard) and an HP-FFAP (30 m × 0.32 mm i.d., film thickness = 0.25 μm, Hewlett-Packard). The injector and detector were maintained at 230 and 250 °C, respectively. After injection, oven conditions were as follows: 35 °C for 5 min, 10 °C min^{-1} to 150 °C, 20 °C min^{-1} to 250 °C, 250 °C for 10 min. Humidified air was added in the sniffing port at 500 mL min^{-1}.

Odor Detection Frequency (DF). The detection frequency method (*16*) was applied to identify and rank the odorants according to their odor potencies. A panel of nine assessors experienced in sensory analysis and trained in GC-O (using reference compound solutions and the volatile compounds isolated by purge and trap from Iberian ham samples) was used. During GC-O, sniffers were asked to give a description of each perceived odor, even if they did not recognize it. They were also asked about its length and its intensity to aid the odorant identifications. Two replicates of each sample (27 × 2) were performed on the nonpolar column (HP-5) to calculate detection frequency data and were randomly smelled by the assessors (six times per assessor). The assessor order was also randomized, and each assessor smelled the volatile compounds from not more than one replicate (24 min) per day. Data from the nine sniffers were analyzed, and the DF of odors having the same linear retention index (LRI) and a similar description was calculated as the number of times they were smelled. Detection frequency of an odor at the sniffing port by fewer than 5 of the 18 times for each ham group (2 replicates × 9 assessors) was considered to be noise (*12*). DF values were considered to be significantly different from the other ham groups when they differed in more than 5 of 18 times (*11, 16*).

Nine additional replicates were used to aid the confirmation of odorant identities by using the polar column (HP-FFAP).

Identification. *LRI and Odor Quality.* The identification of volatile compounds was performed by matching odor descriptions (odor quality and intensity) and LRI on the two columns with those of reference compounds under the same conditions or with odor description and LRI previously reported (*17*−*19*). Solutions of hydrocarbons (C_5−C_{18} for HP-5 and C_5−C_{25} for HP-FFAP) were analyzed in the same conditions to calculate LRI.

GC-MS. GC-MS analysis was performed on an HP 5890 series II chromatograph (Hewlett-Packard) coupled to an HP 5971A mass spectrometer (Hewlett-Packard) and equipped with one of the two capillary columns described above. Oven conditions were similar to those applied for GC-O. Mass spectra were generated by electronic impact at 70 eV, with a multiplier voltage of 1675 V. Data were collected at a rate of 1 scan s^{-1} over the *m*/*z* range 30−300. The transfer line to the mass spectrometer was maintained at 280 °C. Compounds were identified by comparison of mass spectra and LRI with those of reference compounds or with mass spectra comprised in the Wiley and the NIST/EPA/NIH mass spectral libraries and LRI previously reported (*17*−*19*).

Table 1. Fatty Acid Composition (Percent) of Subcutaneous Adipose Tissue of Montanera and Pienso Iberian Hams[a]

	Montanera			
	long	short	Pienso	*p*
14:0	1.24 ± 0.18b	1.24 ± 0.4b	1.67 ± 0.15a	0.003
16:0	19.64 ± 1.37b	20.78 ± 1.77b	25.04 ± 1.17a	<0.001
16:1	2.29 ± 0.5b	2.45 ± 0.39b	3.02 ± 0.32a	0.002
18:0	8.98 ± 0.87b	9.14 ± 0.72b	11.43 ± 0.82a	<0.001
18:1	56.86 ± 1.8a	56.18 ± 2.18a	49.14 ± 1.08b	<0.001
18:2	8.61 ± 0.31a	8.07 ± 0.53ab	7.73 ± 0.89b	0.02
18:3	0.15 ± 0.04b	0.18 ± 0.03ab	0.22 ± 0.04a	0.002
20:0	0.11 ± 0.05	0.09 ± 0.02	0.1 ± 0.02	0.544
20:1	1.56 ± 0.26a	1.4 ± 0.25ab	1.17 ± 0.14b	0.004
20:4	0.55 ± 0.06	0.48 ± 0.08	0.47 ± 0.07	0.093

[a] In the same row values followed by different letters were significantly different at a level of 5%.

Sensory Analysis. The samples (27 Iberian hams) were assessed by a panel of 18 members previously trained in sensory analysis techniques. Panelists had been selected using odor and aroma recognition thresholds and trained in descriptive analysis for 120 h (*20*). Most of them were included in a descriptive sensory panel for dry-cured hams for more than two years. A descriptive analysis method previously developed (*3*) was used. Eight traits about sensory characteristics of Iberian ham were researched: odor intensity (overall odor perceived before eating the sample), Montanera ham typical odor (odor intensity characteristic of ham from pigs reared outdoors on acorns and pasture land), aroma intensity (overall aroma when the sample is eaten), aroma persistence (intensity and time extension of aroma after the sample is swallowed), toasted aroma (intensity of the toasted aroma), cured aroma (intensity of the aroma typical from cured meats), rancid aroma (intensity of rancid aroma), and moldy aroma (intensity of moldy aroma). Sensory characteristics were assessed by using the FIZZ (version 1.01) program. An unstructured scale was used, the extremes being "very low" to "very high". Three extremely thin slices of each ham were obtained using a knife and were immediately presented on glass plates to the assessors. All sessions were done at 20−22 °C in a six-booth sensory panel room equipped with white fluorescent lighting. Three hams were evaluated in each session, and sample order was randomized.

Fatty Acid Analysis. Fatty acid composition was determined by GC of the fatty acid methyl esters synthesized by using methanolic hydrogen chloride, as described by Carrapiso et al. (*21*). Solution (0.1 μL) was injected in an HP 5890 II chromatograph (Hewlett-Packard) equipped with a cold on-column injector, a flame ionization detector, and a 30 m × 0.53 mm capillary column coated with FFAP-TPA stationary phase (1 μm thickness). Conditions were as follows: oven temperature, 220 °C isothermal for 30 min; injector and detector temperature, 230 °C; flow rate of the carrier gas (nitrogen), 2.6 mL min^{-1}.

Data Analysis. One-way analysis of variance and the Tukey test were used to compare means for sensory and fatty acid data. Factor analysis [using principal components analysis (PCA) as the method for factor extraction] (*22*) was applied to evaluate the relationships among the hams of the three groups. Discriminant analysis by stepwise procedure was used to select the most useful variables for distinguishing among groups and to classify samples (*22*). Statistical analyses were performed by the SPSS version 10.0.

RESULTS AND DISCUSSION

Three groups of hams were analyzed to research into the differences in odor-active compounds. The number of hams (nine per group) used ensures that samples and therefore olfactometric profiles are representative of each ham group. The commercial category of hams was confirmed by analyzing their fatty acids, as it is currently done for classifying raw hams by using this analytical method. Fatty acid results (**Table 1**) were

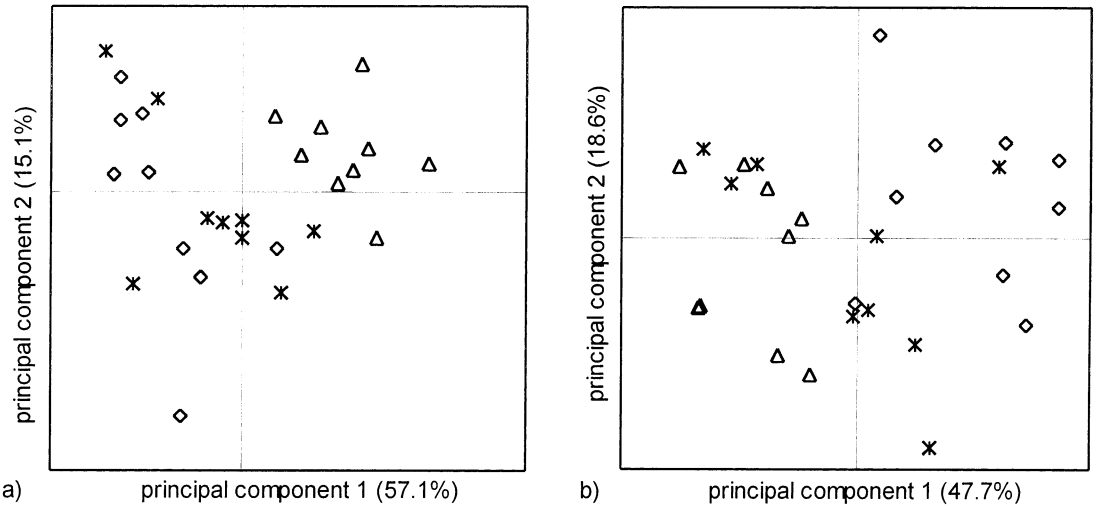

Figure 1. Principal component analyses of Montanera (long and short) and Pienso Iberian hams using fatty acid composition (percent) (variables in **Figure 1**) (a) and sensory data (variables in **Table 2**) (b): (◇) long-Montanera hams; (∗) short-Montanera hams; (△) Pienso hams.

Table 2. Descriptive Analysis of Montanera and Pienso Iberian Hams[a]

	Montanera			
	long	short	Pienso	p
odor intensity	5.4 ± 0.6	5.1 ± 0.8	4.8 ± 0.4	0.099
Montanera ham typical odor	5.4 ± 0.4a	4.8 ± 0.7ab	4.4 ± 0.5b	0.002
aroma intensity	5.6 ± 0.3a	5 ± 0.3b	4.7 ± 0.2c	<0.001
aroma persistence	5.1 ± 0.2a	4.6 ± 0.3b	4.3 ± 0.3b	<0.001
cured aroma	4.9 ± 0.4a	4.9 ± 0.3a	4.4 ± 0.4b	0.020
rancid aroma	1.7 ± 0.3	2 ± 0.5	1.8 ± 0.3	0.177
toasted aroma	1.7 ± 0.3	1.3 ± 0.3	1.3 ± 0.3	0.051
moldy aroma	0.6 ± 0.2a	0.5 ± 0.2ab	0.4 ± 0.1 b	0.031

[a] In the same row values followed by different letters were significantly different at a level of 5%.

in accordance with expected values for Montanera and Pienso hams (*2*). No significant differences were found between long- and short-Montanera hams.

The hams were characterized by performing a descriptive analysis. Significant differences were found between Montanera and Pienso hams (**Table 2**), as was previously found (*3*). Unlike fatty acid results, significant differences appeared between long- and short-Montanera Iberian hams (aroma intensity and persistence). Long-Montanera Iberian hams reached the largest scores and Pienso hams the lowest ones, except for rancid aroma (**Table 2**). Therefore, differences in odor-active compounds could be expected not only between Montanera and Pienso hams but also between long- and short-Montanera groups.

PCA data are displayed in **Figure 1**. An acceptable association among the hams of each group was found. Montanera and Pienso hams were clearly different in fatty acid data (**Figure 1a**), but odor and aroma data differences were not so marked (**Figure 1b**). In fact, sensory data showed that the hams clearly different were those included in the long-Montanera group. Long- and short-Montanera hams were not as similar in the representation of PCA sensory data as they were in the other one based on fatty acid data.

To know which were the most useful attributes to distinguish among the three Iberian ham groups, a discriminant analysis was performed. Aroma intensity and moldy aroma were selected as the most discriminating variables (the model explained 73.6% of the total variance). Therefore, volatile compounds and odorants related to these traits are especially interesting to study odor and aroma differences among the three groups.

To investigate the sensory differences, the headspace volatile compounds involved in ham odor were researched by application of the detection frequency method (*16*), which yields results similar to other olfactometry methods (*12*, *23*, *24*). Odor-active regions and detection frequency values for each group are given in order of elution on the HP-5 column in **Table 3**. Previous works on Iberian ham reported a large number of volatile compounds (*3*, *25*). However, the number of odor-active regions was reduced, as was also found in Parma hams [15 odor-active regions (*14*), although 122 volatile compounds were identified (*26*)]. These differences confirm that only a limited number of volatile compounds actually contribute to meat aroma.

Eight odor-active compounds were identified by matching their LRI on two capillary columns, MS data, and odor quality to reference compounds [2-methylpropanal, 3-methylbutanal, 1-penten-3-one, hexanal, (*E*)-2-hexenal, 2-heptanone, 1-octen-3-ol, and octanal]; tentative identifications were made for a further eight compounds [hydrogen sulfide, methanethiol, (*Z*)-3-hexenal, ethyl 2-methylbutyrate, 2-methyl-3-furanthiol, 2-acetyl-1-pyrroline, 1-octen-3-one, and 2-propionyl-1-pyrroline] (**Table 3**). Some odor-active peaks were made up of more than one compound; however, the coelutions were found only when a second column was used to identify the odorants, as was previously reported (*15*). This fact confirms that the use of a second column is advisable in order to avoid assigning odor descriptions of coelutions to abundant compounds with clear MS spectra.

Apart from one region with low detection frequencies (peak 6) (the largest value was lower than six), all of the reported odor-active regions were smelled in all of the ham groups. A single contributor to Montanera or Pienso ham odor was not found, and the two peaks defined as ham-like (peaks 9 and 10) were detected in the three groups of hams. Therefore, odor and aroma differences seem to be caused by differences in the concentration of some odor-active compounds.

For most compounds DF values were similar. However, remarkable differences were found for others, not only between Montanera and Pienso hams but also between long- and short-Montanera hams, as was also found in sensory analysis. Significant differences (a difference by at least 5 of 18) were perceived in six odor-active regions. The long-Montanera group had the largest DF for two of them [unknown (6) and 1-octen-3-one/1-octen-3-ol (11)] and the lowest DF for a further two peaks [hexanal/(*Z*)-3-hexenal (7) and ethyl 2-methylbutyrate/

Table 3. Odor-Active Compounds of Montanera and Pienso Iberian Ham Headspace

	LRI[b]				Montanera[d]		
n[a]	HP-5	HP-FFAP	odorant	descriptors[c]	long	short	Pienso
1	<500	<800	hydrogen sulfide[g]	boiled or rotten eggs, sewage	12	16	15
2	<500	<800	methanethiol[g]	rotten eggs, meat or fish, cheesy	14	16	15
3	558	834	2-methylpropanal[e]	toasted, fruity, pungent	10	8	12
4	656	931	3-methylbutanal[e]	fruity, almond-like, toasted	15	16	14
5	678	1034	1-penten-3-one[e]	rotten, sewer-like, fruity	14	12	14
6	791		unknown	cured, nutty, almond-like	5	1	0
7	803	1082/1146	hexanal[e]/(*Z*)-3-hexenal[h]	green, fruity, acorn-like	11	17	15
8	857	1053/1224	ethyl 2- methylbutyrate[f]/(*E*)-2-hexenal[e]	fruity, apple-like, strawberry-like	5	11	10
9	882	1335/1172	2-methyl-3-furanthiol[f]/2-heptanone[e]	cured ham-like, toasted, nutty	17	17	15
10	922	1348	2-acetyl-1-pyrroline[h]	overheated meat-like, cured ham-like	5	11	4
11	991	1301/1395	1-octen-3-one[f]/1-octen-3-ol[e]	mushroom-like, dirty, dust	9	7	4
12	1023	1417/1289	2-propionyl-1-pyrroline[h]/octanal[e]	stew-like, boiled meat-like, rancid	6	11	8
				total[i]	123	143	126

[a] Odors are presented in order of elution on the HP-5 column. [b] LRI values: linear retention indices (LRI) are given on two different polarity capillary columns, when applicable. [c] Odor quality perceived at the sniffing port using an HP-5 column. [d] Detection frequency (DF) determined using an HP-5 column. [e] The compound was identified by comparing it with the reference compounds on the basis of the following criteria: MS spectra, LRI on two stationary phases, and odor quality as well as odor intensity perceived at the sniffing port. [f] The MS signals were too weak; the compound was identified by comparing it with the reference compound on the basis of the remaining criteria. [g] The compound was identified by comparing it with literature data on the basis of the following criteria: MS spectra, LRI on two stationary phases, and odor quality as well as odor intensity perceived at the sniffing port. [h] The MS signals were too weak; the compound was identified by comparing it with literature data on the basis of the remaining criteria. [i] Calculated as the sum of individual DF values inside each ham type.

(*E*)-2-hexenal (8)]. Among peaks with significant differences, DF values for short-Montanera hams were only between values for long-Montanera and Pienso hams in peak 11. In peaks 6−8 DF values for short-Montanera hams were similar to those of Pienso hams. These results could be expected because most results included in **Table 2** showed that sensory differences between short-Montanera and Pienso hams were not remarkable for most characteristics (**Table 2**; **Figure 1b**). However, peak 10 and the total regions smelled were significantly larger in short-Montanera hams than in the other ham groups. A similar result was found in peak 12, although significant differences appeared only between long- and short-Montanera groups. The only sensory characteristic with a similar result was the rancid aroma, for which short-Montanera hams reached larger but not significantly different scores than the other groups (**Table 2**). The largest values of short-Montanera hams in were found for peaks 10 and 12; the total odors smelled and the rancid aroma were not expected. Although it is not possible to explain why values were not intermediate, it seems to be clear that a long Montanera fattening period is required to obtain Montanera hams with clear sensory differences and differences in peaks 6, 8, and 11 against Pienso ham. It has to be pointed out that short-Montanera hams did not reach the largest values in odor and aroma intensity and aroma persistence. In fact, the most important contributor to ham aroma was peak 9 (2-methyl-3-furanthiol/2-heptanone), which appeared almost all of the time. DF values for long- and short-Montanera hams were larger than DF for Pienso, although differences were not significant. The fact that this peak had a very large DF shows that the concentration of these odorants was probably too large to allow any comparison among their contributions to the differences in the aroma of the three types of ham. Although it is accepted that the detection frequency method generates results similar to those of other olfactometric techniques (*12*, *23*, *24*), other methods probably could provide more information about the differences in peak 9. The lack of relationship between the number of odors smelled and odor and aroma intensity could be due to the extraction method. Headspace extractions yield representative isolations because they extract the compounds that surround the food (*16*), but some works reported a superior performance of other techniques in the extract sensory characteristics (*27*). Headspace techniques mainly extract low molecular weight compounds (*28*), whereas other Iberian ham volatile compounds such as lactones, long-chain aldehydes, and fatty acids (*29*−*31*) remain unextracted (*25*). These compounds could be involved in differences in odor and aroma intensity and aroma persistence of Iberian hams, as they contribute to dry-cured ham aroma (*14*).

With regard to the Montanera ham typical odor, none of the compounds was clearly the only contributor to this attribute. Montanera ham typical odor could be defined as a special and strong meaty note, although no alternative term has been found to describe it (*1*, *3*, *6*). Meaty and ham-like peaks were identified as odor contributors in the three ham groups. However, the numbers of times the word ham or Montanera ham was used to define a peak were significantly different: 14 for long-Montanera hams, 2 for short-Montanera hams, and 7 for Pienso hams. The remarkably low number of times for short-Montanera hams was probably caused by the coelution of other odorants at larger concentrations, which increases the probability of detecting a peak but also yields a change in the perceived odor. In addition, the impact of a low concentration of ethyl 2-methylbutyrate in the largest scores found for long-Montanera hams in this typical Iberian ham characteristic could not be ruled out. In fact, a previous work reported lower concentrations of short-chain fatty acid esters for Iberian hams than for other ham types (*32*).

None of the compounds was the only contributor to cured and toasted aroma. Up to now, the compounds involved in the cured aroma of dry-cured hams have not been identified (*33*), although several attempts have been carried out and the aroma and volatile compounds of cured-fermented meats have been extensively researched. In any case, three odor-active regions were described as cured (**6**, **9**, and **10**), and all appeared in the three types of Iberian ham. The relationship between the meaty peaks 10 (2-acetyl-1-pyrroline) and 12 (2-propionyl-1-pyrroline) to cured and toasted aroma differences was not clear because the largest DF in short-Montanera hams did not match with the sensory scores. The cured, nutty-smelling unknown compound (**6**), with larger DF in long-Montanera, together with the low DF of carbonyl compounds such as hexanal/(*Z*)-3-hexenal (**7**)

and ethyl 2-methylbutyrate/(*E*)-2-hexenal (**8**) could enhance the meaty aroma and therefore the scores for cured and toasted aroma.

The lowest scores in rancid aroma for long-Montanera and largest in short-Montanera matched with the DF values for hexanal/(*Z*)-3-hexenal (**7**) (hexanal has been related to related to rancidity, *25*) and 2-propionyl-1-pyrroline/octanal (**12**), the peak most often described as rancid (**Table 3**). Other peaks were described as rancid, such as 2-methylpropanal (**3**) and 3-methylbutanal (**4**), but other words were usually preferred to define them and no significant differences were found. Other rancid peaks were smelled, but their DF values were too low to be taken into account.

Moldy aroma reached significantly lower scores in Pienso hams than in long-Montanera hams. These results agree with the lower DF value found for Pienso hams in the only mushroom-like odor-active region reported (**11**), which was made up of 1-octen-3-one and to a lesser extent 1-octen-3-ol (*15*). Both compounds are lipid oxidation products and arise, for example, from the autoxidation of arachidonic acid (*34*). This fatty acid reached the largest values in the subcutaneous adipose tissue of long-Montanera hams (**Table 1**), although no significant differences were found. Although sensory data agree with GC-O results and moldy aroma was selected as the second variable most useful to discriminate the three ham groups, it has to be taken into account that scores for moldy aroma were low, and even some assessors were not able to identify this note. Therefore, the contribution of peak 11 to ham aroma was remarkable but limited.

In conclusion, Montanera and Pienso hams showed significant differences in the sensory and olfactometric profiles. Differences were also found for long- and short-Montanera hams and, therefore, Montanera hams have a large variability that is not usually found with the current analytical method to classify the hams on the basis of fatty acid composition. Differences in odor and aroma found during the descriptive analysis matched with differences in the DF of some odorants.

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