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Sensory traits prediction in dry-cured hams from fresh product via MRI and lipid composition

Trinidad Pérez-Palacios [a,*], Teresa Antequera [a], Rubén Molano [b], Pablo G. Rodríguez [c], Ramón Palacios [d]

[a] Tecnología de los Alimentos, Facultad Veterinaria, Universidad de Extremadura, Av. Universidad s/n, 10071 Cáceres, Spain
[b] Departamento de Matemáticas, Escuela Politécnica, Universidad de Extremadura, Av. Universidad s/n, 10071 Cáceres, Spain
[c] Departamento de Ingeniería de Sistemas Informáticos y Telemáticos, Escuela Politécnica, Universidad de Extremadura, Av. Universidad s/n, 10071 Cáceres, Spain
[d] Servicio de Radiología, Hospital Universitario Infanta Cristina, Ctra. de Portugal s/n, 06800 Badajoz, Spain

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ABSTRACT

The aim of this paper is to describe a methodology that can predict Iberian dry-cured ham sensory traits from raw material characteristics, lipid composition and Magnetic Resonance Imaging-based analysis, by using Multiple Linear Regression statistics. Thus, 18 sensory traits are tried to be defined from 10 fatty acids and 17 computational texture features. Dependence linearity within each group of independent variables is determined. Then, Multiple Linear Regression (MLR) is applied, obtaining allowable statistical coefficients (adjusted coefficient of determination, $\overline{R}^2 > 0.750$ and p-value < 0.05) for five sensory traits defined from fatty acids (fat hardness, lean hardness, flavour intensity, brightness and juiciness), and four traits from computational texture features (marbling, odour intensity, flavour intensity and redness). Finally, prediction analysis is validated with a display of statistical data ($\overline{R}^2_{LOO}$ and p-value$_{LOO}$). Therefore, some sensory traits in Iberian dry-cured hams can be predicted from fatty acids and computational texture characteristics in fresh products.

1. Introduction

The Iberian pig is an autochthonous porcine breed developed traditionally in the south-west of Spain. Hams from Iberian pigs fattened on acorn and grass in an extensive rearing system are more highly appreciate by consumers, in Spain as well as in many other countries (M.A.R.M., 2009), because of their exceptional sensory attributes (García et al., 1996). Juiciness and flavour intensity are two sensory traits that better explained the acceptability of dry-cured ham (Ruiz et al., 2002). The curing process for Iberian ham includes three major phases: a first period (salting/post-salting) in which low temperature is combined with high relative humidity to allow for salt diffusion within the hams. A second stage at moderately raised temperatures (26–28 °C) and progressively lowered relative humidity (to 40%) in order to achieve adequate drying of the hams. Finally, hams are left to mature for 12–15 months in a cellar (temperatures ranging between 10 and 22 °C with relative humidity of about 70%).

The composition of the fresh Iberian hams, especially lipid-related ones, which are characterized by high levels of intramuscular fat and monounsaturated fatty acids (MUFA) (Cava et al., 2000), has a great influence on dry-cured sensory characteristics (Andrés et al., 1999, 2004).

Several factors, including genetics, crossbreeding and rearing system influence the fatty acid profile of Iberian hams (Tejeda et al., 2002; Andrés et al., 2007), having an effect on sensory characteristics (Carrapiso et al., 2003). In fact, some studies have shown the relationship between some fatty acids of raw material and a number of sensory traits in dry-cured hams (Carrapiso et al., 2003; Ruiz-Carrascal et al., 2000). In addition, the proportions of major fatty acids (FA) (palmitic (C16:0), stearic (C18:0), oleic (C18:1 $n-9$) and linoleic (C18:2 $n-6$) acids) from subcutaneous fat have been used to classify Iberian pigs as a function of their feeding background during the fattening period (Pérez-Palacios et al., 2009).

There is an increased interest in non-destructive methods for analysing meat products, a scope where Magnetic Resonance Imaging (MRI) can be integrated as a non-destructive, non-invasive, non-radiant and innocuous technique. The combination of MRI and image analysis can present decisive capabilities for the characterisation of muscle structures. Different MRI applications have demonstrated the feasibility of this technique for studying meat and meat products. The calculation of intramuscular fat levels in the Iberian ham *Biceps femoris* and *Semimembranosus* muscles can also result from MRI applications (Ávila et al., 2005). The implementation of active contours in MRI can be used to explore

* Corresponding author. Fax: +34 927 257110.
E-mail address: triny@unex.es (T. Pérez-Palacios).

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the *Biceps femoris* and *Semimembranosus* muscles in Iberian hams (Caro et al., 2001; Antequera et al., 2007). Other studies have relied on MRI and computational texture features to classify Iberian products as a function of cross-breeding (Cernadas et al., 2001), feeding background (Pérez-Palacios et al., 2010) and in terms of intramuscular fat content and certain sensory attributes (Antequera et al., 2003). The relationship between sensory traits and some computational texture features has also been demonstrated (Pérez-Palacios et al., 2010).

Since the 1950s the sensory evaluation science has experienced big developments (Schutz, 1998). Data obtained by means of sensory analysis are as reliable as those from a physical–chemical determination (García and Carrapiso, 2001). Sensory analysis measures those features influencing consumers' acceptance, such as appearance, texture, odour, taste and flavour. Quantitative–descriptive analyses are most widely used to assess the sensory quality of Iberian dry-cured hams (Ruiz et al., 1998; Andrés et al., 2004).

Some sensory traits of meats have been predicted by using different statistical analyses. Olivares et al. (2009) carried out a regression analysis for estimating the relationships between main fatty acid proportion in subcutaneous backfat and liver and vitamin A concentration. Partial least squares regression predictive models have been used to predict colour, marbling and wavelet surface texture of beef (Jackman et al., 2008). Other studies based on image analysis have succeeded to predict lamb tenderness (Chandraratne et al., 2006) and pork marbling level (Qiao et al., 2007) by using different statistical analysis. Taking a step forward, it may be stated that the use of mathematical models for predicting sensory traits in Iberian dry-cured hams as a function of some characteristics in the raw material can turn out to be a highly significant process within this scientific and technological backdrop. Thus it may be assessed the final quality of a long process dry-cured product (around 2 years), which has high acceptability and price, before starting the processing.

The objective of the present study is to predict sensory traits in Iberian dry-cured hams from specific characteristics in the raw material, lipid composition and computational texture features, using Multiple Linear Regression (MLR).

2. Material and methods

2.1. Experimental design

This study is based on testing done with 10 castrated male Iberian pigs feeding on acorn and grass outdoors. After the fattening period, all the pigs, weighing an average of 160 kg, were slaughtered by electrical stunning and exsanguination at a local slaughterhouse. The right and left raw hams were taken from each animal. MR images were then retrieved for all the hams ($n = 20$), and the next step involved the dissection of the *Biceps femoris* muscles in the left limbs ($n_1 = 10$) to analyze the lipid composition of the raw hams, while the right hams ($n_2 = 10$) began a ripening period by following the procedure described in Antequera et al. (2007), where $n = n_1 + n_2$. Hams were rubbed with salt, containing about 1% potassium nitrate, and placed in piles of salt at 3 °C and 85% relative humidity for 1 day/kg weight (salting). After salting the hams were washed to remove salt from the surface and hung at low temperature (4 °C ± 1) and the relative humidity was progressively lowered to 75% over 80 days, to allow diffusion of salt into the hams (post-salting). The hams were then taken to a natural dryer at temperatures varying from 4 to 28 °C and 70% to 50% relative humidity during 130 days (drying). Next, the hams were left to mature for 14 months in a cellar at 10–25 °C and relative humidity of 65–80% (cellar). Once the process ended, the *Biceps femoris* muscles began to be dissected for their submission to the sensory analysis.

2.2. MRI acquisition

Magnetic resonance sequences enable the exploration of *Biceps femoris* muscles in raw Iberian hams via image analysis. MRI information, stored on a database acquired at the "Infanta Cristina" University Hospital (Badajoz, Spain), were obtained by using an MRI (Philips Gyroscan NT Intera 1.5 T) scanner. The "body" antenna was used according to sequences of T1 with the following parameters: 120 × 85 mm for field-of view (FOV), 20 ms for echo time (TE), 500 ms for repetition time (TR), 2 mm of thickness for slices, 90° for flip angle (a spin echo sequence), 0.23 × 0.20 mm for pixel resolution, and 60 as the number of slices for each ham. The MRI acquisition was done at 20 °C and it took 28 min for each ham. There were overall a total of 1800 images on the database. All the images were in DICOM format, with a 512 × 512 resolution, and were converted into GIF with the same resolution and 256 grey levels.

2.3. Computer-aided MRI analysis

A software application (Fig. 1) described in Pérez-Palacios et al. (2010) was used for the analysis of MRI. It is freely available on the page of the GIM research group, http://gim.unex.es. The *Biceps femoris* muscle was detected by using active contours (Caro et al., 2001). Then, the maximum rectangular area in the muscle, called Region of Interest (ROI) was automatically selected, and afterwards, the ROIs were analysed by applying computational texture analysis. Seventeen computational texture features were calculated: Energy, Entropy, Haralicks Correlation (HC), Inverse Difference Moment (IDM), Inertia, Cluster Shade (CS), Cluster Prominence (CP), Small Number Emphasis (SNE), Long Number Emphasis (LNE), Number Nonuniformity (NNU), Second Moment (SM), Entropy (ENT), Long Run Emphasis (LRE), Short Run Emphasis (SRE), Grey Level Nonuniforminty (GLNU), Run Length Nonuniformity (RLN) and Run Percentage (RPC).

2.4. Fatty acid methyl ester preparation and analysis

Lipids were extracted with chloroform:methanol (2:1, v/v) according to the method described in Pérez-Palacios et al. (2008). Fatty acid methyl esters (FAMEs) obtained from lipid tissues were assembled by transesterification in the presence of sodium metal (0.1 N) and sulphuric acid within methanol (Sandler and Karo, 1992). FAMEs were analysed by gas chromatography, using a Hewlett–Packard HP-5890-II gas chromatograph, equipped with an on-column injector and a flame ionization detector (FID). Separation was done on a polyethylenglycol capillary column (60 m long, 0.32 mm id, 0.25 mm film thickness) (Supelcowax-10; Supelco, Bellafonte, PA, USA) maintained at 230 °C for 60 min. The injector and detector temperatures were kept at 230 °C. The carrier gas was nitrogen, at a flow rate of 0.8 ml/min rate. The individual compounds were then identified as a result of the comparison made between their retention times and standard retentions (Sigma, St. Louis, MO, USA).

2.5. Sensory analysis

The dry-cured hams in this experiment were assessed by trained staff in a panel of 14 members. Eighteen sensory attributes were analysed in dry-cured Iberian hams (Ruiz et al., 1998), grouped in terms of subcutaneous fat appearance and texture (yellow and pink colour, hardness and oiliness), lean appearance and texture (red colour, brightness, marbling, hardness, juiciness and

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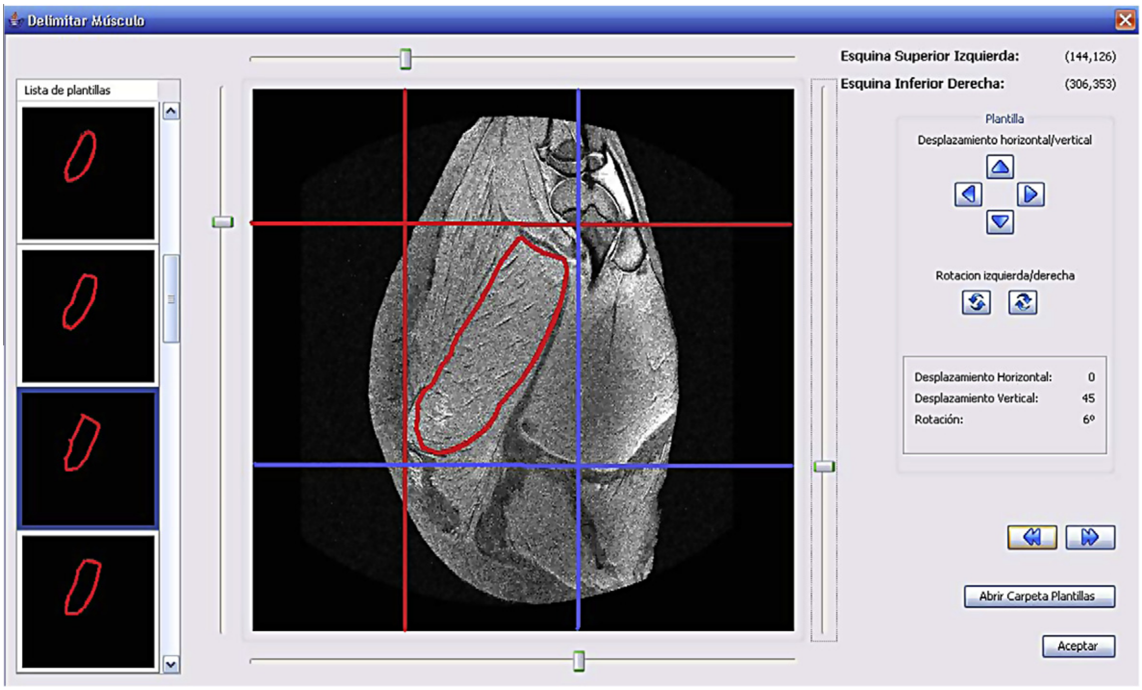

Fig. 1. Window from software application for the analysis of Magnetic Resonance Imaging.

pastiness), taste (salty, sweet and bitter), aroma (odour intensity) and flavour (intensity, cured, rancid and persistence). The analyses were conducted in tasting rooms with the conditions specified in Q3 UNE regulation, i.e., all the sessions were performed at room temperature in a sensory room equipped with white fluorescent lighting. The software used to record scores in the sensory sessions was the FIZZ Network (version 2.20: Biosystemes, France). The hams were cut into 1.5 mm thick slices, with a slicing machine. Slices were then served on plates to panellists. The panel sessions were held at mid-morning, about 4 h after breakfast. Panellists, who were also able to have about 200 ml of water at room temperature, evaluated the different sensory traits by means of a quantitative–descriptive analysis in a non-structured scale 0–10. Three samples randomly presented to the panellist were analysed in each session, where we recorded the panel average of each sample.

2.6. Statistical prediction

In order to predict the sensory traits of Iberian dry-cured hams as a function of the fatty acid composition and the computational texture features of the raw material, three sets of parameters were considered: computational texture features, fatty acids and sensory traits, containing 17, 10 and 18 variables, respectively. An individual ham was the experimental unit for analysis of all data: Q7 $n = 20$ for the ~~Magnetic Resonance Imaging~~ analysis in fresh hams, $n_1 = 10$ for the fatty acid analysis in fresh hams and $n_2 = 10$ for the sensory analysis in dry-cured hams.

A correlation matrix was used to study the linear dependence within each independent variables set (fatty acids and computational texture features), and therefore to reduce the number of them. The Pearson correlation coefficient, $r > 0.700$ serves as proof of the existence of such a linear dependence. If two variables are highly correlated, the information provided is the same (Shiranita Q5 et al., 2000). Then, Multiple Linear Regression (MLR) was applied to determine the independent variables (computational texture features or fatty acids) which define a dependent variable (sensory traits). Suitable relationships yield the adjusted coefficient of determination, $\overline{R^2} > 0.750$ and p-value < 0.05. The choice of $\overline{R^2}$ rather than the coefficient of determination (R^2), is due to the fact that R^2 is an estimation of the goodness of the model fit in the population, and any estimated model from a sample fits that sample better than a population. Thus, R^2 overestimates the goodness of fit. In turn, $\overline{R^2}$ balances this optimism by considering the sample size and number of variables (Eq. (1)).

$$\overline{R^2} = R^2 - \frac{p \cdot (1 - R^2)}{n - p - 1} = 1 - \frac{n - 1}{n - p - 1} \cdot (1 - R^2) \quad (1)$$

where p is the number of independent variables and n the number of cases. In our case, $n = 10$.

In MLR, $R^2 \geqslant 0.800$ is a good indicator of model accuracy (Jackman et al., 2009; Shiranita et al., 2000). Therefore, as $\overline{R^2} \leqslant R^2$, $\overline{R^2} \geqslant 0.750$ in our model indicates high expectations in relation to how actual precision can be obtained by this method.

p-Value contrasts the null hypothesis (denoted as H_0) that the population value is zero (contrast regression) (Eq. (2)), and allows us to decide if there is a significant linear relationship between the dependent variable and all independent variables. A result of p-value $\leqslant 0.05$, with the significance level $\alpha = 0.05$, will indicate that the hyperplane defined by the regression equation provides a good fit for the cluster of dots.

$$\begin{cases} H_0 : R^2 = 0 \\ H_1 : R^2 \neq 0 \end{cases} \quad (2)$$

where H_1 is the alternative hypothesis.

Finally, the statistical analysis was validated by using the Leave-One-Out Cross Validation method (LOOCV). It consists in applying MLR without considering the data from one of the 10 studied hams, calculating again the adjusted coefficient of determination ($\overline{R^2}_{LOO}$) and p-value$_{LOO}$. Thus, MLR was applied 10 times, without considering one ham in each MLR analysis. For validating the statistical analysis the $\overline{R^2}_{LOO}$ and p-value$_{LOO}$ should be close to the values previously established, $\overline{R^2}_{LOO} > 0.750$ and p-value$_{LOO} < 0.05$. It is thus possible to know if the model maintains the quality statistics, regardless of the presence or absence of some of the hams studied.

Analyses were done by using the SPSS package (v.15.0).

3. Results and discussion

Table 1 shows the average percentage of fatty acids in fresh Iberian hams ($n_1 = 10$) for the present study. The major fatty acids were oleic (C18:1 $n-9$), palmitic (C16:0), stearic (C18:0) and linoleic (C18:2 $n-6$) acids (56.23%, 20.60%, 8.06% and 6.41%, respectively), followed by myristic (C14:0), arachidonic (C20:4 $n-6$) and α-linolenic acid (C18:3 $n-3$) (0.97%, 0.82% and 0.46%, respectively), while the α-eicosatridecanoic (C20:3 $n-3$), γ-eicosatridecanoic (C20:3 $n-6$) and γ-linolenic (C18:3 $n-6$) acids showed smaller proportions (0.13%, 0.11% and 0.02%, respectively). The values for the computational texture features obtained after analysing the MRI from fresh Iberian hams are shown in Table 2.

In relation to the sensory analysis of dry-cured hams, Fig. 2 shows mean scores for appearance and texture in subcutaneous fat (Fig. 2A), appearance and texture in lean (Fig. 2B) and odour, taste, and flavour (Fig. 2C), with a display of high scores for fat oiliness (4.33), lean juiciness (4.64), redness (5.31), and flavour intensity (5.71). These results agree with those recorded in other works that also analyse Iberian dry-cured hams from pigs fattened with natural resources (acorn and grass) outdoors (Pérez-Palacios et al., 2009; Carrapiso et al., 2003). Q2

3.1. Independent variables selection

A correlation matrix was built for both computational texture features and fatty acids sets. After analysing the Pearson correlation coefficient and because two variables are highly correlated when $r > 0.700$, the following variables were selected: myristic (C14:0), palmitic (C16:0), stearic (C18:0), oleic (C18:1 $n-9$), linoleic (C18:2 $n-6$), γ-linolenic (C18:3 $n-6$), α-linolenic (C18:3 $n-3$) and arachidonic (C20:4 $n-6$) acids, with the only acids left

Table 1
Fatty acid composition (expressed as percentage of fatty acid methylesters ± standard error of the mean) of intramuscular lipids of *Biceps femoris* from fresh Iberian hams.

Fatty acids	
Myristic acid (C14:0)	0.97 ± 0.13
Palmitic acid (C16:0)	20.60 ± 0.89
Stearic acid (C18:0)	8.06 ± 1.80
Oleic acid (C18:1 $n-9$)	56.23 ± 1.75
Linoleic acid (C18:2 $n-6$)	6.41 ± 0.62
γ-Linolenic acid (C18:3 $n-6$)	0.02 ± 0.003
α-Linolenic acid (C18:3 $n-3$)	0.46 ± 0.19
γ-Eicostridecanoic acid (C20:3 $n-6$)	0.11 ± 0.02
α-Eicostridecanoic acid (C20:3 $n-3$)	0.13 ± 0.09
Arachidonic acid (C20:4 $n-6$)	0.82 ± 0.26

Q6 **Table 2**
Values of MRI-based texture characteristics ~~for~~ *Biceps femoris* from fresh Iberian hams.

Computational texture features	
Energy	$(9 \pm 1) \times 10^{-4}$
Entropy	3.20 ± 0.07
Haralicks Correlation	$(7 \pm 0.5) \times 10^{-4}$
Inverse Difference Moment	0.06 ± 0.003
Intertia	607.70 ± 75.28
Cluster Shade	$(-35 \pm 29) \times 10^{3}$
Cluster Prominence	$(91 \pm 46) \times 10^{5}$
SNE[a]	3.31 ± 0.81
LNE[b]	8.12 ± 2.50
NNU[c]	$(13.9 \pm 5.8) \times 10^{3}$
SM[d]	393.11 ± 197.39
ENT[e]	−7.67 ± 2.80
LRE[f]	1.10 ± 0.003
SRE[g]	0.97 ± 0.003
GLNU[h]	132.25 ± 45.46
RLNU[i]	$(4.2 \pm 1.0) \times 10^{3}$
RPC[j]	0.96 ± 0.002

[a] SNE: small number emphasis.
[b] LNE: large number emphasis.
[c] NNU: number nonuniformity.
[d] SM: second moment.
[e] ENT: entropy.
[f] LRE: long run emphasis.
[g] SRE: short run emphasis.
[h] GLNU: gray level nonuniformity.
[i] RLNU: run length nonuniformity.
[j] RPC: run percentage.

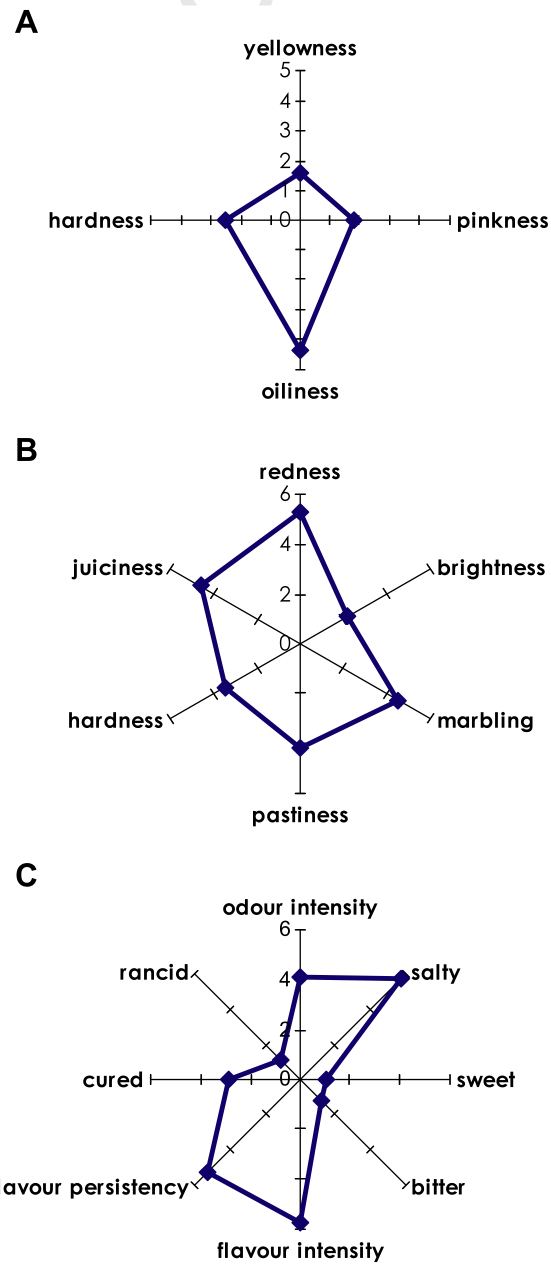

Fig. 2. Sensory analysis of Iberian dry-cured hams. (A) Appearance and texture of ham subcutaneous fat; (B) appearance and texture of lean and (C) odour, taste and flavour.

Table 3
Multiple Linear Regression statistical data between Iberian dry-cured hams sensory traits and fatty acids in raw material.

	Multiple Linear Regression	
	$\overline{R}^2$	*p*-Value
Fat hardness	0.981	0.002
Lean hardness	0.877	0.004
Flavour intensity	0.889	0.010
Brightness	0.805	0.005
Juiciness	0.787	0.016

Table 4
Multiple Linear Regression statistical data between Iberian dry-cured hams sensory traits and computational texture features in raw material.

	Multiple Linear Regression	
	$\overline{R}^2$	*p*-Value
Marbling	0.988	<0.001
Odour intensity	0.777	0.001
Flavour intensity	0.807	0.005
Redness	0.779	0.002

Table 5
Statistical data for validating fat hardness prediction as a function of fatty acids.

n[a]	$\overline{R}^2_{LOO}$	*p*-Value$_{LOO}$
Ham 1	0.978	0.0165
Ham 2	0.975	0.0184
Ham 3	0.961	0.0293
Ham 4	0.925	0.0155
Ham 5	0.978	0.0165
Ham 6	0.988	0.0091
Ham 7	0.995	0.0036
Ham 8	0.981	0.0143
Ham 9	0.982	0.0132
Ham 10	0.969	0.0233

[a] *n*: ham excluded in each analysis for calculating the statistical data considering the other nine hams.

Table 6
Statistical data for validating marbling prediction as function of computational texture features.

n[a]	$\overline{R}^2_{LOO}$	*p*-Value$_{LOO}$
Ham 1	0.987	0.0000
Ham 2	0.988	0.0001
Ham 3	0.995	0.0001
Ham 4	0.987	0.0000
Ham 5	0.988	0.0001
Ham 6	0.978	0.0001
Ham 7	0.988	0.0004
Ham 8	0.988	0.0001
Ham 9	0.989	0.0001
Ham 10	0.984	0.0002

[a] *n*: ham excluded in each analysis for calculating the statistical data considering the other nine hams.

out from the fatty acid set as follows: y-eicosatridecanoic (C20:3 *n* – 6) and α-eicosatridecanoic (C20:3 *n* – 3) acids, and Energy, HC, Inertia, CS, LNE, SRE and GLNU in the computational texture features set.

3.2. Dry-cured ham sensory traits predicted from fatty acids and computational texture features of fresh product

Tables 3 and 4 show statistical data of MLR after correlation of dry-cured ham sensory traits ($n = 17$) and fatty acids ($n = 8$) and computational texture features ($n = 7$) in fresh material. Five sensory traits (fat hardness, lean hardness, flavour intensity, brightness and juiciness) could be defined by fatty acids (Table 3), and four (marbling, odour intensity, flavour intensity and redness) could be defined by computational texture features (Table 4). For all these sensory traits, $\overline{R}^2$ and *p*-value were found within the expected range, with outstanding values in some cases, such us fat hardness ($\overline{R}^2 = 0.981$ and *p*-value = 0.002) and marbling ($\overline{R}^2 = 0.988$ and *p*-value < 0.001), and others were found close to the permitted limit in other cases, for example odour intensity ($\overline{R}^2 = 0.777$) and redness ($\overline{R}^2 = 0.779$).

The LOOCV method was determined to validate the MLR analysis. As explained above in Section 2, the method consists in applying MLR by skipping the data from one of the 10 hams. Fat hardness and marbling, defined by fatty acid and computational texture features, respectively, have been taken as examples. Tables 5 and 6 show statistical data ($\overline{R}^2_{LOO}$ and *p*-value$_{LOO}$) for validating fat hardness and marbling prediction, respectively. $\overline{R}^2_{LOO}$ values were higher than 0.750 in the 10 analyses, ranging between 0.925 and 0.995 in fat hardness, and between 0.978 and 0.995 in marbling. Results for *p*-value$_{LOO}$ were lower than 0.03 in the 10 analyses of both variables. Statistical data for validating the rest of the sensory traits were also found within the established limits. Therefore, it can be indicated that some sensory traits in Iberian dry-cured hams can be predicted from fatty acids and computational texture characteristics in fresh material with statistical accuracy.

Table 7 shows the prediction equations of the Iberian dry-cured hams sensory traits as a function of fatty acids (Eqs. A-E) and computational texture features (Eqs. F-I).

Although the prediction of sensory traits in Iberian dry-cured hams has remained an area of scientific neglect until now the influence of fatty acid composition on many sensory characteristics has been demonstrated. The most obvious correlations appear among stearic (C18:0) and oleic (C18:1 *n* – 9) acids, and brightness and oiliness. Palmitic (C16:0), stearic (C18:0) and oleic (C18:1 *n* – 9) acids were observed to be closely related to solid fat content (Davenel et al., 1999; Ruiz-Carrascal et al., 2000; Carrapiso et al., 2003). Juiciness, sweetness, fat hardness and cured aroma have also shown a relationship with fatty acid composition, whereas odour intensity, fibrousnesses, bitterness, aroma intensity, persistence and toasted aroma were not correlated to these chemical components (Carrapiso et al., 2003). The results in this paper also

Table 7
Prediction equations of dry-cured ham sensory traits from characteristics of raw material, fatty acids (A–E) and computational texture features (F–I).

Prediction equations	
A	Fat hardness: 81.568 + 10.623C14:0 + 2.028C16:0 – 0.602C18:1*n* – 9 – 2.449C18:2*n* – 6 + 1.939C18:3*n* – 3 + 2.624C20:4*n* – 6
B	Lean hardness: 5.782–5.007C14:0 + 2.028C16:0 + 1.366C18:2*n* – 6 – 7.073C18:3*n* – 3 + 180.003C18:3*n* – 6
C	Flavour intensity: 47.300–0.541C16:0–0.213C18:0 – 0.453C18:1*n* – 9 – 3.699C18:3*n* – 3 – 1.874C20:4*n* – 6
D	Brightness: –25.707 + 0.579C16:0 + 0.262C18:1*n* – 9 + 2.497C18:3*n* – 3
E	Juiciness: 10.598–0.412C18:0 – 1.300C18:2*n* – 6 – 7.197C18:3*n* – 3 – 3.096C20:4*n* – 6
F	Redness: 8.134 – 8896.878Energy + 0.006GLNU
G	Marbling: 1473.140 – 6872.589Energy + 0.028Inertia + 0.100LNE – 1506.477SRE
H	Odour intensity: 4.797 – 0.005GLNU
I	Flavour intensity: –4.041 + 3157.723HC + 0.014Inertia – 0.000012CS

demonstrated the presence of these fatty acids within the prediction equation of the sensory traits being predicted. It can also be observed that the linolenic acid (C18:3 *n* – 3) was present in the five sensory trait prediction equations from fatty acids (Eqs. A–E). This fatty acid is not a major one, with only 0.46% (Table 1), however it was considered as an important lipid component for classifying Iberian hams in terms of the pigs' feeding backgrounds (Pérez-Palacios et al., 2009).

Other studies have focused on reaching an approximate solution for the "semantic gap" existing between the computational features and some biological terms (Reyes et al., 2008; Jian et al., 2009), and yet, no significant solution has been found. MRI techniques involving T1 allow for the detection of hydrogen and other features like fat fluidity and water retention, which lengthen the T1 relaxation time (Lufkin, 1998). For this reason, samples with high water amount have a longer T1 time (Wehrli, 2002). Thus, chemical components (volatile compounds, amino acids, dipeptides and so on) related to sensory traits (odour and flavour intensity) may modify T1 sequences and lead to differing MRI. Pérez-Palacios et al. (2010) have recently shown the relationship between sensory traits and computational texture features in dry-cured hams.

Iberian dry-cured hams sensory trait prediction can therefore be achieved from fatty acids and computational textures features in fresh material, using Multiple Linear Regression. The use of computational texture features for predicting some sensory traits seems to prove to be a significant step forward, especially because Magnetic Resonance Imaging-based analysis is non-destructive.

4. Uncited references

Q3 Boletín Oficial del Estado (2004) and Norma UNE (1979).

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