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Texture and appearance of dry cured ham as affected by fat content and fatty acid composition

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Abstract

The relationship between texture and appearance characteristics and the moisture, intramuscular fat (IMF) content and fatty acid composition of dry cured Iberian ham was studied using principal component analysis. Intramuscular fat content positively influenced the proportion of oleic acid ($R=0.5578$), and exhibited a negative relationship with linoleic and arachidonic acids ($R=-0.5215$ and -0.5770 respectively). IMF content also had a positive influence on some texture and appearance traits of ham, such as oiliness, brightness, juiciness and marbling. However, it was negatively related to dryness, fibrousness and hardness. Moisture displayed no relationship with juiciness, dryness or any other textural or appearance trait. Therefore, within the ranges of fat content and moisture found in the present study, IMF content has a stronger influence on the texture of ham than the degree of dehydration.

Keywords: Iberian ham; Texture; Fat; Moisture; Fatty acid profile

1. Introduction

Available knowledge regarding the influence of fat content and fatty acid composition on the textural characteristics of dry cured ham is scarce and contradictory. Bergonzoni, Rosi and Fabbri (1985) and Parolari, Rivaldi, Leonelli, Bellati and Bovis (1988) reported a positive relationship between tenderness of dry cured ham and lipid content. Contrarily Buscailhon, Berdagué, Bousset, Cornet, Gandemer, Touraille et al. (1994) found no relationship between textural traits and the lipid fraction.

Various reports have demonstrated a positive effect from increasing the levels of unsaturation on juiciness and tenderness of fresh meat (Cameron & Enser, 1991; Rhee, Davidson, Cross & Ziprin, 1990) and meat products (Shackelford, Miller, Haydon & Reagan, 1990; Shackelford, Reagan, Haydon, Lyon & Miller, 1991). However, some other workers have found no effect (Leszcynski, Pikul, Easter, McKeith, McLaren, Novakofski et al., 1992). The possible influence of fatty acid composition on the textural characteristics of dry cured ham remains unstudied.

It has been well documented that the proportion of liquid fat depends on its fatty acid composition (Davenel, Riaublanc, Marchal & Gandemer, 1999). The melting point of pig fat depends greatly on the proportion of saturated fatty acids (SFA), the greater the SFA content, the higher the melting point (Davenel et al., 1999; Enser, 1983). Several workers have reported an increase in oiliness and softness of the fat in fresh meat and meat products from increasing levels of polyunsaturated (Warnants, Van Oeckel & Boucque, 1996) and monounsaturated fatty acids (St. John, Young, Knabe, Thopson, Schelling, Grundy et al., 1987). However, little is known about how fatty acid composition influences sensory attributes such as brightness and oiliness of dry cured products.

The objective of the present study was to evaluate the influence of intramuscular fat content and its fatty acid composition on several textural and appearance traits of dry cured Iberian ham.

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2. Materials and methods

2.1. Sampling

Ham slices were obtained from six different anatomical locations from ten hams after either 420 or 600 days processing, which correspond to the minimum and maximum required for Iberian hams of this weight based upon the Specific Designation of Origin (SDO) "Dehesa de Extremadura" (Diario Oficial de Extremadura, 1990). The effect of processing time and slice location on sensory characteristics of Iberian ham was evaluated in a previous study (Ruiz, Ventanas, Cava, Timón, & García, 1998). Sensory analyses were performed immediately on fresh samples, while slices for chemical analysis were frozen and stored at −80°C until evaluated.

2.2. Sensory analyses

Ham slices were assessed by a trained 14 member panel, using descriptive analysis (Ruiz et al., 1998). Panelists were trained and had participated in sensory evaluation of dry cured ham for 2 years. Individual flavour and aroma recognition thresholds were used to select the subjects. Selected panelists underwent further training in evaluation of dry cured ham sensory characteristics during a 2 year period, using hams with different inherent characteristics. Panelists received a total of 120 h of training.

Two samples corresponding to two different slice locations from two hams were evaluated at each session. A total of 30 sessions were carried out (3 per week). Sample order was randomized. Panel sessions were held at 11 a.m. (3 h after breakfast). Three thin slices (0.5 mm thick) around 8 g were presented to each panelist. Slices were obtained using a knife and were served immediately on glass plates; both the slices and the plates were at room temperature (20–23°C). A glass containing about 100 ml of 12°C water was provided to each panelist between samples. All sessions were conducted in a 22°C 6-booth sensory panel room equipped with white fluorescent lighting (220–230 V 35W). Seven traits concerning texture and appearance of Iberian ham (oiliness, brightness, marbling, dryness, fibrousness, juiciness and hardness) were assessed by the panelists using an unstructured 10 cm line, ranging from less (0 cm) to more (10 cm).

2.3. Chemical analysis

Moisture was determined following the ISO recommended method (ISO/1442, 1973). Lipids of dry cured ham slices were extracted and purified with chloroform:methanol (Bligh & Dyer, 1959). Fatty acid profiles of the intramuscular lipids were determined using the procedure described by Cava, Ruiz, López-Bote, Martín, García, Ventanas et al. (1997). Results were expressed as percentages of total fatty acid methyl esters.

2.4. Statistical analyses

Principal component analysis (PCA) was carried out with the sensory and chemical data using the PRINCOMP procedure of The Statistical Analysis Systems Institute ([SAS], 1997). Correlations between sensory variables were calculated with the GLM procedure of SAS (1997).

3. Results and discussion

Levels of fat (between 4.52 and 14.66%) and moisture (19.98–49.81%) agree with levels reported in this type of product (Table 1) (Antequera, García, López, Ventanas, Asensio & Córdoba, 1994). Both the moisture and IMF

Table 1
Mean, minimun, maximum and coefficient of variation of percentages of fatty acid methyl esters, intramuscular fat content and moisture

Variable	Mean[a]	Minimun	Maximum	Coefficient of variation
Intramuscular fat (%)[b]	7.65	4.52	14.66	29.93
Moisture (%)	39.09	19.98	49.81	12.77
C12:0	0.08	0.04	0.23	25.00
C14:0	1.32	0.71	1.61	11.36
C16:0	23.32	21.14	26.06	4.37
C16:1 (n-7)	3.54	2.62	4.52	12.43
C18:0	10.43	8.62	12.93	9.49
C18:1 (n-9)	48.23	43.91	53.83	5.47
C18:2 (n-6)	10.36	6.30	14.29	17.95
C18:3 (n-3)	0.58	0.23	0.85	20.69
C20:0	0.35	0.25	0.66	20.00
C20:4 (n-6)	1.81	0.57	3.08	29.83

[a] Expressed as percentage of total fatty acid methyl esters identified.
[b] Expressed as percentage of raw matter.

content exhibited a range broad enough to study their influence on texture.

Meat from Iberian pigs has a high IMF content due to both the rearing system and the genetic features of the pig breed (Mayoral, Dorado, Guillén, Robina, Vivo, Vázquez et al., 1999). The high degree of variability observed was due to differences in fat content between muscles corresponding to the different slice locations and to the intrinsic heterogeneity attributable to the outdoors rearing system used to fatten the pigs. Differences in IMF content between ham muscles have been previously reported (Antequera et al., 1994). However, variation in moisture is probably due to different extents of dehydration within different anatomical locations of the muscles included in the slices. Muscles in the outer part of the ham are dryer than those in the centre, as has been observed when comparing *Semimembranosus* and *Biceps femoris* muscles in different studies (Antequera et al., 1994; Martin, Antequera, Ruiz, Cava, Tejeda & Córdoba, 1998). In addition, the different extent of dehydration in hams processed for long and short times may contribute to the variations observed in moisture contents.

Meat from Iberian pigs reared outdoors contains high levels of oleic acid, as a direct consequence of the high oleic acid content of acorns, which is the main food source during the fattening period (Table 1). Similar values have been previously reported in Iberian pigs both in raw meat (Ruiz, Cava, Antequera, Martin, Ventanas & López-Bote, 1998) and dry cured hams (Antequera et al., 1994).

In the first two principal components of the PCA studied, variables exhibited a positive effect of IMF content on the proportion of oleic acid (Fig. 1). However, fat content negatively influenced the proportion of linoleic and arachidonic acids. Consequently, a high, positive correlation was observed between the proportion of oleic acid and IMF content ($R=0.5578$, $P=0.0001$), and a negative correlation was detected between fat content and the proportion of linoleic ($R=-0.5214$, $P=0.0001$) and arachidonic ($R=-0.5770$, $P=0.0001$) acids. Malmforms, Lundström and Hansson (1978) and Cameron and Enser (1991) have observed similar trends in other pig breeds. Variations in the IMF content are mainly due to changes in the triglyceride content, while the phospholipid content is relatively constant. Therefore, high IMF contents imply a high level of triglycerides, and hence a decrease in the relative phospholipid contents. Cava et al. (1997) reported a higher polyunsaturated fatty acid content in muscle phospholipids of Iberian pigs, and a higher oleic acid content in triglycerides. This explains the relationship observed between IMF content and oleic, linoleic and arachidonic acids: The higher the IMF content, the higher the triglyceride content, and therefore, the higher the proportion of oleic acid, and the higher the IMF content, the lower the phospolipid content, and the lower the proportion of linoleic and arachidonic acids.

Oleic acid positively influenced the oiliness and brightness of the product, while arachidonic and linoleic acids exhibited a negative effect on both these sensory traits, as can be deduced by the loadings of such variables in the first principal component (PC) (Fig. 1). This finding is contrary to several reports where the melting point and the oiliness of pig fat were positively influenced

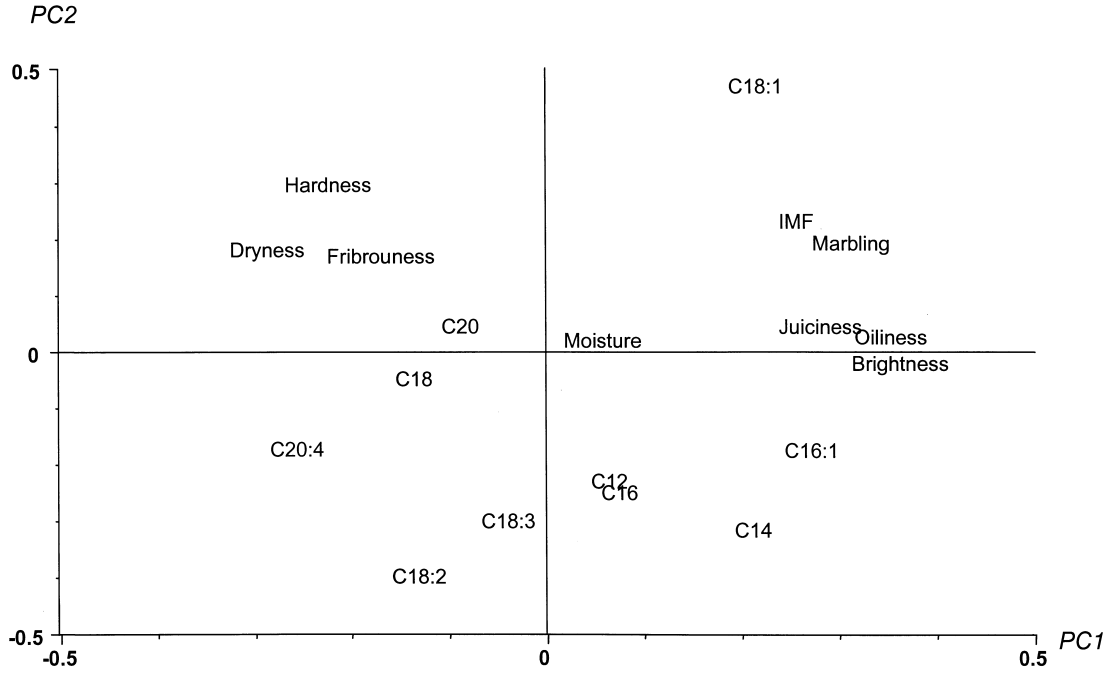

Fig. 1. Loadings of the sensory and chemical variables on the two first components in the PCA.

by polyunsaturated fatty acids (PUFA), while oleic acid had little influence (Davenel et al., 1999; Warnants et al., 1996). However, in a previous research on Iberian pigs, Flores, Biron, Izquierdo and Nieto (1988) observed that the melting point of fat had a higher correlation with oleic acid than with linoleic acid. The negative influence of PUFA on the oiliness and brightness of the ham in the present paper is probably an indirect relationship due to the negative correlation of IMF content with PUFA, rather than a direct effect on these sensory traits.

As expected, marbling was closely related to IMF content (Fig. 1). Van der Wal, Olsman, Garssen and Engel (1992) have demonstrated a significant correlation between marbling and IMF content in fresh meat. IMF content was positively related to juiciness, and negatively related to dryness, hardness and fibrousness (Fig. 1). Juiciness is an important contributor to eating quality (Hutchings & Lillford, 1988). However, the relationship between the subjective juiciness sensation and any objective measurement is not clearly understood (Winger & Hagyard, 1995). Juiciness of meat products is considered to arise from moisture released from meat products during chewing and the moisture from saliva (Winger & Hagyard, 1995). Intramuscular fat stimulates the saliva secretion and contributes directly to juiciness by coating the tongue, teeth and other parts of the mouth (Dikeman, 1987). Since processing of dry cured products involves strong dehydration, the moisture from saliva and the direct contribution of IMF should play a very important role. The present study demonstrates IMF content has a greater influence on juiciness than moisture content in dry cured hams (Fig. 1). Thus, it appears as long as the IMF content is high enough, hams can be processed for a long time without showing a problem in juiciness. However, using thighs from very lean animals could lead to dry cured hams with poor juiciness. The percentage of explained variance with the first two PC was rather low (21 and 14%) which agrees with previous reports regarding raw meat in which marbling explained only a low percentage of the variation in textural traits (reviewed by Parrish, 1974), and confirms the existence of other parameters which influence the texture and appearance of dry cured hams. In this regards, high correlations between juiciness and some flavour traits in dry cured hams have been reported (Ruiz, 1996) and the relationship between the degree of proteolysis and the texture of dry cured hams has been previously reported (Virgili, Parolari, Schivazappa, Soresi Bordini & Borri, 1995)

Hardness, dryness and fibrousness of the ham showed and inverse relationship with juiciness, oiliness, brightness, marbling, IMF content, and contents of the two monounsaturated fatty acids identified (oleic and palmitoleic acids). Surprisingly, none of these texture traits seemed to be influenced by the degree of dehydration, (Fig. 1). In previous studies of dry cured Iberian ham, higher shear force values were observed in muscles with significant lower moisture content (Córdoba, 1990). Buscailhon et al. (1994) also observed textural traits (dryness, firmness and fibrousness) were closely related to each other in dry cured hams. However, no influence of fat content on such sensory characteristics was reported, but the negative influence of IMF content on dryness, fibrousness and hardness of the ham supports similar findings reported on fresh pork (Dransfield, 1994), probably as a result of the lower resistance to shearing compared with other muscle components, since the location of the fat in the perimysial connective tissue, interrupts the bonding between fibre bundles, and allows fracture to occur more easily (Wood, 1990).

4. Conclusion

IMF content has a very remarkable effect on the texture and appearance of dry cured ham, while moisture has a very limited effect on such traits. Variations in fatty acid composition among different parts of the ham also appears to be highly influenced by IMF content. The higher the fat content, the higher the oleic acid and the lower the PUFA content.

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