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Characterization of dry-cured shoulders: Quality traits

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Abstract. The present study show some of the chemical and compositional characteristics of dry-cured shoulder from Iberian pigs fed with different diets and dry-cured shoulder produced with the rules of "Protected Designation of Origin Teruel ham". The existence of a quality rule makes the meat industries to follow different guidelines, from the selection of the genetic of the animal, food stuff and processing technology. As well, these rules establish different parameters that must be analyzed to avoid a possible fraud to the consumer. Not significant differences were found in the chemical parameters used by the quality standard, as fatty acids profile, in our samples. For this reason we must search other parameters to justify it. For that the use of products with characteristics very similar to the dry-cured ham which process time is shorter than that, like dry-cured shoulder, can help us to obtain good results which can be extrapolated. The aim of this study is to establish which structure and composition parameters of shoulders are more useful as quality indicators studying different dry-cured shoulders batches (white pigs *vs* Iberian pigs) depending on the genetic background of the animal and the type of feeding system during the final feeding phase.

Keywords. Shoulder – Protein – Lipid – Quality.

Une caractérisation des épaules séchées de porc : Des paramètres indicateurs de qualité

Résumé. *Dans le présent travail sont montrées certaines des caractéristiques concernant la composition des épaules séchées originaires de porcs Ibériques qui ont reçu divers types d'alimentation (aliments composés vs une alimentation naturelle) et des épaules séchées associées à l'"Appellation d'origine Teruel", qui sont élaborées conformément aux normes établies par leur appellation. La non existence de différences significatives pour quelques paramètres physiques et chimiques utilisés par la norme de qualité pour établir les caractéristiques de qualité que doivent présenter les produits, nous oblige à réaliser une nouvelle recherche de ceux-ci. Pour cela, l'utilisation de produits qui résistent à une élaboration plus rapide, tels que les épaules, peut servir à connaître le comportement d'autres produits comme le jambon d'élaboration la plus prolongée.*

Mots-clés. *Épaule – Protéine – Lipide – Qualité.*

I – Introduction

Dry-cured shoulders are products of high quality, however the most recognized product are dry-cured hams. Technological characteristics of dry-cured shoulders and sensorial qualities of the final product depend on many factors related to the production process. The effective efficiency related with shoulders production is directly connected with the genetic aptitudes and physiological characteristics (weigh, handing and genetic) where pigs raise.

The high proportion of bone and fat in the foreleg of the pig involves a lower yield and a complex consumption as consumers find it difficult to take advantage of the lean. Nevertheless, the high sensory quality, the nutritional value and the short ripening process make these products a very interesting issue of study for two main reasons. First, from a scientific point of view, the results can be useful as quality indicators of the raw material and the final product can be extrapolated to dry-cured ham which involves a longer ripening process. Secondly, an

integral study of dry-cured shoulders according to its conformation by analysis of weight, measures, muscular topography and composition in order to develop a nutrition labeling (percentage of moisture, proteins, fat …), can be useful to establish a better utilization of these pieces and for the consumers to gain a greater knowledge of the quality of this product.

II – Materials and methods

The present study was carried out with three batches of Iberian dry-cured shoulders according to the type of feeding and rearing system during the finish fattening period (90 days prior to slaughter): (i) Country Valdesequera (n=9), (ii) Montanera Salamanca (n=10) and (iii) Normal intensive feeding (n=10), and (iv) another batch of dry-cured shoulder according to the "Protected Designation of Origin Teruel Ham", Teruel shoulders (n=20). Moisture, protein and sodium chloride percentage were determined using official methods (AOAC, 2000). Myoglobin content was evaluated using the method described by Horsney (1956). It was realized a TPA (texture profile) according to the method described by Bourne (1978) for a Universal texturometer TA-XT2i (Stable Micro Systems, Godaliming, UK). Intramuscular fat content (GIM) was extracted and quantify using a mixture of chloroform:methanol (2:1) according the method described by Folch *et al.* (1957). Fatty acids methyl esters (FAMEs) were prepared by acidic-trans-esterification in the presence of sulphuric acid (5% sulphuric acid in methanol) (Sandler and Karo, 1992). FAMEs were analyzed by gas chromatography using a Hewlett-Packard HP 5890A gas chromatograph, equipped with a flame ionisation detector (FID). Volatile compounds were extracted by using the solid-phase microextraction (SPME) and subsequently analyzed by gas chromatography coupled to mass spectrometry (GC/MS) (gas chromatograph Hewlett-Packard 5890 series II coupled to a mass selective detector Hewlett-Packard HP-5791 A) according to the method described by Jurado *et al*. (2007). Volatile compounds were tentatively identified by comparing their mass spectra with those reported in the Wiley and NIST libraries.

The results from the experiments were used as variables and analyzed using a multivariant analysis (SPSS, 1997) in order to compare physic-chemical parameters between batches. Statistical significance was predetermined at 0.05.

III – Results and discussion

Table 1 show high significant differences between batches, mainly the less weight and perimeter of the pieces of Montanera batch, it might be by the less initial weight of the pieces, because the yield of the novel pieces is in pure Iberian a 20% smaller than mixed Iberian, like intensive feed batch of this study. Teruel dry-cured shoulder was smaller in longitude and width because the age and size of the animals prior to slaughter was less than the Iberian pigs. Not significant differences were found between Montanera batch and extensive feeding batch (Country Valdesequera) in perimeter and width, probably because this shoulder came from of pure Iberian pigs (that's why these were longer for the same weight than the intensive feed batch).

Chemical composition is shown in Table 2. Not significant differences were found in the fat content between the four batches of the study. It might be because the batches feeding with feed used a prescription very similar than the acorn composition, according to the analysis of the fat composition from different batches. Montanera shoulders moisture was significantly smaller regarding to the other's shoulders, possibly because its morphologic sizes are smaller in this batch so the relation between surface and volume is higher. Myoglobin content showed significant differences being higher in Montanera and Country batches opposite the others two batches. These results are expected in animals raised in extensive. In others papers it had been related with quality attributes (juiciness, intensity of flavor and persistence of flavor), (Ventanas *et al*., 2007). Higher results of sodium chloride were found, (in Iberian ham are between 3.5%, and more than 4.5% are salty) in three batches of Iberian shoulder, in comparison with Teruel

batch. This is because the three Iberian batches were processed in the same place and in the same conditions, different of Teruel shoulders. Finally, significant differences were found in protein percentage, being higher in Teruel batch.

Table 1. Morphological characteristics

	Country Valdesequera	Montanera Salamanca	Normal intensive feeding	Teruel shoulder	p
Weight (kg)	$5.4^{c} \pm 0.5$	$4.0^{a} \pm 0.5$	$5.5^{c} \pm 0.3$	$4.6^{b} \pm 0.4$	***
Lenght (cm)	$76.0^{c} \pm 3.6$	$71.4^{b} \pm 3.0$	$72.9^{b} \pm 0.5$	$62.6^{a} \pm 0.9$	***
Perimeter (cm)	$54.3^{ab} \pm 3.3$	$52.6^{a} \pm 1.4$	$56.0^{b} \pm 0.9$	$55.4^{b} \pm 1.2$	**
Width (cm)	$26.2^{a} \pm 3.6$	$26.0^{a} \pm 2.2$	$29.0^{b} \pm 3.2$	$23.9^{a} \pm 0.8$	***

Statistical significance: (***) p< 0.001; (**) p< 0.01; (*) p<0.05; (ns) not significant.

Table 2. Chemical composition

	Country Valdesequera	Montanera Salamanca	Normal intensive feeding	Teruel shoulders	p
% Moisture	$50.5^{b} \pm 3.2$	$46.8^{a} \pm 4.0$	$50.5^{b} \pm 3.5$	$50.5^{b} \pm 2.1$	*
% Chloride (NaCl) (DM)†	$11.7^{b} \pm 0.6$	$11.6^{b} \pm 1.7$	$11.6^{b} \pm 0.6$	$8.8^{a} \pm 1.1$	***
% Fat (DM)	13.6 ± 1.7	14.7 ± 3.5	14.1 ± 4.5	14.4 ± 2.2	ns
% Protein (DM)	$78.8^{ab} \pm 7.3$	$73.4^{a} \pm 7.1$	$84.1^{bc} \pm 8.9$	$87.5^{c} \pm 2.0$	***
Myoglobin (mg Mb/g m)	$6.6^{b} \pm 0.5$	$6.7^{b} \pm 0.4$	$3.9^{a} \pm 0.8$	$4.1^{a} \pm 0.6$	***

Statistical significance: (***) p< 0.001; (**) p< 0.01; (*) p<0.05; (ns) not significant.
†DM, dry matter.

Instrumental texture of Table 3 show the lower hardness of Teruel and Montanera batches in comparison with the others batches, because the higher content in fat make easier to broke the meat during the chewing, and the fewer gumminess and chewinness make higher the sensation of texture similar as "chewing gum".

Table 3. Instrumental texture

	Country Valdesequera	Montanera Salamanca	Normal intensive feeding	Teruel shoulder	p
Hardness	$3402.7^{b} \pm 724.8$	$2011.0^{a} \pm 616.6$	$3191.0^{b} \pm 1067.1$	$2037.4^{a} \pm 490.9$	***
Gumminess	$1521.6^{b} \pm 536.5$	$952.0^{a} \pm 334.1$	$1520.4^{b} \pm 532.8$	$930.1^{a} \pm 201.8$	***
Chewiness	$959.0^{b} \pm 379.1$	$523.4^{a} \pm 236.6$	$940.3^{b} \pm 368.7$	$571.0^{a} \pm 144.0$	***

Statistical significance: (***) p< 0.001; (**) p< 0.01; (*) p<0.05; (ns) not significant.

Table 4 show the total of the fatty acids presents in the intramuscular fat of the 4 batches analyzed. MUFA was significant higher in Montanera and Teruel batch. However the SFA was higher in Intensive feed batch; while in the Country batch the SFA value is similar than the Montanera and Teruel batches, not existing significant differences between them. To explain this, we need to know if the feed used is different for Country and Intensive feed batches. Other possible reasons could be because the fat content is higher in Country batch or because the genetic in this batch (pure Iberian) and the exercise make easier the desaturase activity. It is

important the higher percentage of PUFA in Teruel shoulders, being similar than the Montanera shoulders. We expected these high results in comparison with the other Iberian batches of the study.

Table 4. Fatty acids profile

	Country Valdesequera	Montanera Salamanca	Normal intensive feeding	Teruel shoulders	p
SFA	$40.35^{ab} \pm 2.01$	$39.15^{a} \pm 0.98$	$42.53^{b} \pm 1.83$	$39.74^{a} \pm 2.84$	**
MUFA	$48.42^{a} \pm 1.92$	$50.01^{b} \pm 1.23$	$49.52^{ab} \pm 2.13$	$50.72^{b} \pm 1.22$	**
PUFA	$9.49^{ab} \pm 1.91$	$10.03^{b} \pm 1.94$	$8.07^{a} \pm 2.00$	$10.07^{b} \pm 0.74$	*
n-3	$0.85^{c} \pm 0.21$	$0.58^{b} \pm 0.11$	$0.39^{a} \pm 0.10$	0.61 ± 0.11	***
n-6	$8.14^{b} \pm 1.11$	$8.30^{b} \pm 1.54$	$6.52^{a} \pm 1.70$	$8.23^{b} \pm 0.58$	**
n-6/n-3	$8.75^{a} \pm 1.67$	$14.44^{b} \pm 0.97$	$17.56^{c} \pm 2.65$	$14.03^{b} \pm 0.52$	***

Statistical significance: (***) p< 0.001; (**) p< 0.01; (*) p<0.05; (ns) not significant.

Finally, were found significant differences in the content of n-3 between the four batches of the study, being higher in Country batch follow the others three batches. We expected this for Montanera batch because these pigs were fed with grass, but not for Teruel batch. We can explain this for the used feed; it can change a lot of parameters, like fatty acids or texture profile.

Table 5 shows some of the first results of the total volatile compounds (results in $U.A.x10^{6}$).

Table 5. Volatile compounds

	Country Valdesequera	Montanera Salamanca	Normal intensive feeding	Teruel shoulders	p
3-methyl-butanal	$9.0^{a} \pm 3.8$	$18.8^{a} \pm 10.7$	$36.3^{ab} \pm 30.2$	$62.6^{b} \pm 39.0$	***
2-methyl-butanal	$4.1^{a} \pm 2.3$	$8.1^{a} \pm 4.9$	$10.8^{a} \pm 7.1$	$24.5^{b} \pm 16.3$	***
Pentanal	$13.5^{a} \pm 6.7$	$13.8^{a} \pm 8.7$	$22.6^{ab} \pm 12.7$	$31.0^{b} \pm 17.2$	**
Hexanal	$106.0^{ab} \pm 45.6$	$113.6^{ab} \pm 55.7$	$143.9^{b} \pm 84.5$	$49.0^{a} \pm 40.4$	**
Heptanal	10.9 ± 5.2	11.0 ± 4.8	9.4 ± 4.4	8.6 ± 4.7	ns
Octanal	$6.7^{a} \pm 2.9$	$6.6^{a} \pm 2.5$	$8.8^{a} \pm 3.0$	$16.4^{b} \pm 12.0$	**
Nonanal	$10.9^{ab} \pm 6.0$	$12.2^{b} \pm 4.4$	$8.8^{ab} \pm 3.0$	$6.2^{a} \pm 4.0$	**
Decanal	$0.6^{a} \pm 0.3$	$0.4^{a} \pm 0.1$	$0.4^{a} \pm 0.1$	$1.4^{b} \pm 0.7$	***
2,3-butanedione	$3.3^{a} \pm 0.3$	$0.7^{a} \pm 0.3$	$1.1^{a} \pm 0.3$	$13.7^{b} \pm 6.0$	***
2-Heptanone	$29.0^{a} \pm 14.9$	$50.0^{b} \pm 32.6$	$26.1^{a} \pm 7.3$	$15.2^{a} \pm 9.1$	***
Dihydro 2(3H)-5-methyl-furanone	$0.8^{a} \pm 0.4$	$0.8^{a} \pm 0.1$	$0.6^{a} \pm 0.2$	$2.4^{b} \pm 1.4$	***
2-pentyl-furan	$2.4^{ab} \pm 0.2$	$5.6^{b} \pm 3.0$	$1.9^{a} \pm 0.5$	$9.4^{c} \pm 3.8$	***
Dihydro 2(3H)-5-ethyl-furanone	$3.4^{ab} \pm 1.8$	$2.4^{ab} \pm 0.9$	$1.7^{a} \pm 0.3$	$3.7^{b} \pm 2.0$	**
Dihydro 2(3H)-5-butyl-furanone	$0.9^{ab} \pm 0.4$	$0.5^{a} \pm 0.1$	$0.8^{ab} \pm 0.4$	$1.2^{b} \pm 0.4$	**

Statistical significance: (***) p< 0.001; (**) p< 0.01; (*) p<0.05; (ns) not significant.

The high number of volatile compounds detected, most of them waiting for identification, make us selected some of them because its interest. Is important the higher quantities in volatile

compounds in Teruel shoulders probably because these shoulders had been under storage temperatures during the last stage of ripening, that improve the formation of this compounds like the case of the aldehydes. However, is amazing the hexanal behavior (rancid flavor), being higher in Iberian shoulders in comparison with Teruel shoulder. The high content in Iberian shoulders can be explained for its longer time of process in comparison with the Teruel shoulders, or for its higher concentration of precursors. In the case of ketones, we can emphasize the presence of 2-heptanone, presenting higher concentration in Montanera batch. One of the precursors of this ketone is linoleic acid that shows differences in content slightly higher in Montanera batch. However, this difference is not enough to explain the high difference in this compound between the Montanera batch with the rest of batches. This compound had been identified as odour-active compound showing aromatic notes like almonds or toast (Carrapiso *et al.,* 2002). At the end, 4 furans were identified and described as odour-active. These compounds were higher in Teruel shoulders and it could have an important paper in the aroma of the shoulders due to his presence in ham has related with the typical aroma to "meat" (Flores *et al.*, 1998). The fewer volatile content in the case of Iberian shoulders may be explained for the higher richness of aromatic notes for the presence of others volatile compounds which are analyzing actually.

IV –Conclusions

For the first time we provide a scientific data about shoulders quality, where the annual production is higher than 5 million of pieces, having a big economic weight in some communities in Spain.

With this study we can conclude that the fatty acids analysis can´t use only as indicator parameter about the quality of the product. In our case, we haven´t found any significant differences on the fat and the fatty acids proportion, existing the same tendency in the four batches. The same relationship had been found from the point of view of the genetic background and the animals feeding.

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