Relationship between Meat Quality Measurements in Pigs Fed Different Dietary Fat Sources

Alonso V. [1], Provincial L. [1], Najes, L.M. [1], Guillén, E. [1], Gil, M. [1], Campo, M.M. [1], Roncalés, P. [1] and Beltrán, J.A. [1]

[1] University of Zaragoza/Department of Animal Production and Food Science, Miguel Servet 177, Zaragoza, Spain

Abstract— **The aim of this study was to examine the relationship between meat quality parameters, intramuscular fatty acid composition, instrumental texture and sensory attributes on pork. The animals were fed a basal diet (control diet) supplemented with different fats: animal fat (1%; 3%), soyabean oil (1%) and calcium soaps of palm oil fatty acids (1%). A principal component analysis (PCA) was performed with the variables measured in *Longissimus thoracis et lumborum* muscle. The PCA explained 76.33 % of the variability of the results within the first two axes. The first PC (58.43 %) was characterized by the major saturated (SFA) and monounsaturated (MUFA) fatty acids, tenderness and fat flavour. These variables were negatively correlated with the polyunsaturated acids (PUFA) and PUFA/SFA ratio, lying near the first PC on the opposite side. IMF content and juiciness were negatively correlated with WBSF values. Each quadrant in the biplot discriminated against one of the type of added fat. Control and animal fat diets were on the left side of the graph, close to the variables SFA, MUFA and IMF, whereas soyabean oil diet was situated on the right side of the graph, where the PUFA were grouped.**

Keywords— **Dietary fat, Fatty acid composition, Pork.**

I. INTRODUCTION

The use of fat in animal feeding has several physical and nutritional advantages, so that these fats are nearly irreplaceable in the swine feed industry [1]. Animal fats have been added to commercial swine feed in Spain for many years. The dietary fat source is changing from primarily animal fat (more saturated fat) towards more vegetable fat (more unsaturated fat) and this change may affect the quality of pork fat [2]. Therefore, the feed industry has prompted the search for alternative sources of dietary fat supplements. Diets enriched with vegetable oils (such as sunflower oil, soybean oil or corn oil) that contain an elevated unsaturated percentage should result in healthier products for consumers [3]. Soyabean oil is one of the most availability vegetal oil in Spain and is rich in linoleic acid. On the other hand, palm oil has high content of palmitic and oleic acids and low-medium content of linoleic acid. The majority of available calcium soaps are manufactured from fatty acids distillated of palm.

The relationships between physical and biochemical parameters and sensory quality are important to understand how the dietary fats impact in the eating quality. [4] proposed the use of principal component analysis for evaluating meat quality when several correlated measurements are used.

The aim of this study was to examine the relationship between meat quality parameters, intramuscular fatty acid composition, instrumental texture and sensory attributes in pigs fed different dietary sources of fat.

II. MATERIALS AND METHODS

A. Animals and sampling

Forty three entire males pigs, Pietrain x (Landrace x Large White), were randomly assigned to one of five dietary fat treatments with the individual animal as the experimental unit. All the diets contained the same proportions of raw materials (barley grain, wheat grain and soybean meal 44 % CP), except the proportion of corn grain that was different depending on the percentage of added fat. The five diets differed in their fat sources: 1) Control diet (without added fat); 2) Animal fat (tallow-lard mix) at 1% (AF1); 3) Animal fat at 3% (AF3); 4) Soyabean oil at 1% (SBO1); and 5) Calcium soaps of palm oil fatty acids at 1% (CaSPO1). All the concentrates were isoproteic (17 % crude protein). The pigs were stunned using carbon dioxide and slaughtered at an abattoir at approximately 83.8 ± 6.3 kg carcass weight.

The *Longissimus thoracis et lumborum* (LTL) muscle was removed from each carcass 48 h after slaughter. After 24 h at 4 ± 1 °C, the LTL muscle was sectioned into 2 cm-thick steaks (7 chops) and a 6 cm-thick section. All samples (except those for colour and drip loss) were placed in vacuum bags and frozen at -20 °C until meat quality analysis.

B. pH measurement

Ultimate pH (pHu) of the LTL was measured using a portable pH meter at 72 h postmortem (p.m.). Each value was the mean of four random measurements.

C. Instrumental measurement of colour

A Minolta CM-2002 spectrophotometer was used to measure colour at the surface of a 2 cm-thick LTL chop at 72 h p.m. exposed to air for 2 h. The parameters registered were CIE L^* (lightness), a^* (redness), and b^* (yellowness). Each value was the mean of 10 observations on the same chop.

D. Drip loss

A 2-cm-thick chop was weighed and placed on a supporting mesh in a sealed plastic container. After a storage period of 24 and 48 hours at 4 ± 1°C, the samples were taken out of the container, dabbed lightly on filter paper and weighed again. Drip loss was expressed as a percentage of the initial weight, based on [5].

E. Cooking loss

The cooking loss was determined in LTL chops that were weighed before and after grilling for Warner-Bratzler shear force determinations.

F. Lipid oxidation

Lipid oxidation was measured by the 2-thiobarbituric acid method of [6]. The TBA-reactive substances (TBARS) values were calculated from a standard curve of malondialdehyde, and expressed as mg malondialdehyde/kg sample.

G. Intramuscular fat and fatty acid analysis

Intramuscular fat (IMF) was extracted from the muscle according to the [7] method and quantified as the weight percentage of wet muscle tissue. The samples were extracted according to [7] to determinate composition in fatty acids from intramuscular fat and the methyl esters from fatty acids (FAMES) were analysed in a gas chromatograph HP-6890 II, with a capillary column SP-2380 (100 m x 0.25 mm x 0.20 μm), using nitrogen as the carrier gas.

H. Warner-Bratzler shear force (WBSF) determinations

Samples were fast-thawed in tap water for 4 hours before the vacuum was broken, and the samples were wrapped in aluminium foil and cooked at 200°C in a double-plate grill to an internal temperature of 72°C. After cooking, chops were placed in a vacuum bag and immediately immersed in an ice bath. Twelve, 5-cm-long rectangles (1×1-cm^2 cross-section) were cut parallel to the direction of the muscle fibres, and subsequently sheared perpendicular to the muscle fibre direction with a Warner-Bratzler shear blade attached to a TA-XT2 Texture Analyser (Stable Micro Systems) equipped with a 250-N load cell and a crosshead speed of 2 mm/s. The Texture Expert computer software (version 1.20; Stable Micro Systems) was used for data collection and WBSF values were recorded as the maximum peak force of shearing (expressed in N).

I. Sensory analysis

The steaks used for sensory panel evaluations were cooked as previously described for WBSF, removed from the grill and immediately sub-sampled by cutting cubes. Four sessions of sensory tests were performed to evaluate the effects of the five dietary fat treatments in a standardised tasting room. Panellists used line scales to quantify pork, fat, urine and acid odour intensity (1=no odour to 10=very intense odour), tenderness (1=very tough to 10=very tender), juiciness (1=very dry to 10=very juicy), fibrousness (1=low fibrous to 10=very fibrous), pork, fat and acid flavour intensity (1=no flavour to 10=very intense flavour)

and overall acceptance (1=unpleasant to 10=very pleasant).

J. Statistical analysis

Relationships among parameters of meat quality parameters, intramuscular fatty acid composition, instrumental texture and sensory attributes were performed by Principal Component Analysis (PCA) and were evaluated by calculating Pearson's correlation coefficients. PCA was applied using the statistical software XLSTAT Pro 7.5 and the Pearson's method using the statistical software SPSS 15.0.

III. RESULTS AND DISCUSSION

The results of the principal component analysis (PCA) are shown in Fig. 1 and 2. Fig. 1 shows a plot of the traits on the two first principal components. The PCA explained 76.33% of the variability of the results within the first two axes. The first PC was able to predict 58.43% of the variation of the whole study.

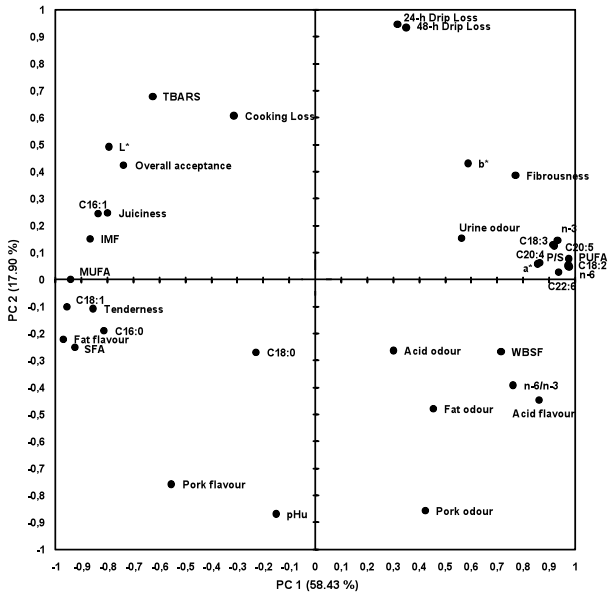

Fig. 1. Projection of parameters of meat quality, IMF fatty acid composition, WBSF and sensory attributes in the plane defined by two principal components.

This component is mainly characterised by C16:0 and C18:1*n*-9 fatty acids, SFA and MUFA proportions and fat flavour and tenderness attributes on the left side, and C18:2*n*-6, C18:3*n*-3, C20:4*n*-6, C20:5*n*-3 and C22:6*n*-3 fatty acids, PUFA, *n*-6 and *n*-3 proportions, P/S ratio and a* colour parameter on the right side.

There was a correlation ($P \leq 0.05$) of C18:1*n*-9 (0.98), SFA (0.93) and MUFA (0.95) with fat flavour attribute. However, the majority of PUFA, *n*-6 and *n*-3 proportions and P/S ratio were related positively ($P<0.10$) with acid flavour. The fatty acid composition of the LTL muscle has been suggested to influence the eating quality of pork, with SFA and MUFA being positively correlated and PUFA negatively correlated with pork flavour [8]. In our study, fat flavour is more related with SFA and MUFA than pork flavour.

IMF content, C16:1 and L* value, as well as sensory juiciness and overall acceptance reached a high negative loading on CP 1, whereas WBSF value had a high positive loading on CP 1, close to *n*-6/*n*-3 and acid flavour. WBSF were negatively correlated with IMF content (0.95; $P=0.015$) and positively correlated with long chain fatty acid proportions ($P<0.10$), which agrees with [9] who reported that WBSF had a negative correlation with the proportion of MUFA and positive correlation with the proportion of PUFA.

The *n*-6/*n*-3 ratio was positively correlated ($P<0.10$) with sensory evaluation of acid (0.81), fat (0.88) and pork (0.81) odour. Pork odour was correlated (-0.95; P=0.015) with TBARS values. The increase of amount of oxidation products could hide pork odour.

IMF content was correlated (0.92) ($P=0.029$) with *L** values which agrees with [10] who reported that a higher level of fatness has been associated with paler meat.

The proportion of SFA was correlated with tenderness (0.94; $P=0.018$), juiciness (0.82; $P=0.091$) and fibrousness (-0.95; $P=0.012$). We found in previous studies [9] that tenderness and juiciness were correlated positively ($P \leq 0.05$) with the proportion of MUFA and negatively with PUFA.

The TBARS values was correlated (-0.93) ($P=0.024$) with the *n*-6/*n*-3 ratio and is in the same quadrant that animal fat diets. We have found that if *n*-6/*n*-3 relation is lower, more lipid oxidation is expected. In our study, the greatest values of oxidation were found in control and animal fat diets. However,

no differences were found with SBO1 diet which is noteworthy, and this fact was somewhat unexpected because several studies have found that dietary fat sources rich in PUFA enhance susceptibility to oxidation. It could be due to the antioxidant compounds from the soyabean oil may have prevented lipid oxidation increased.

The second PC, although only explained 17.90% of the variability, was characterized by the percentage of drip loss, which was negatively correlated (P<0.10) with pH and pork flavour.

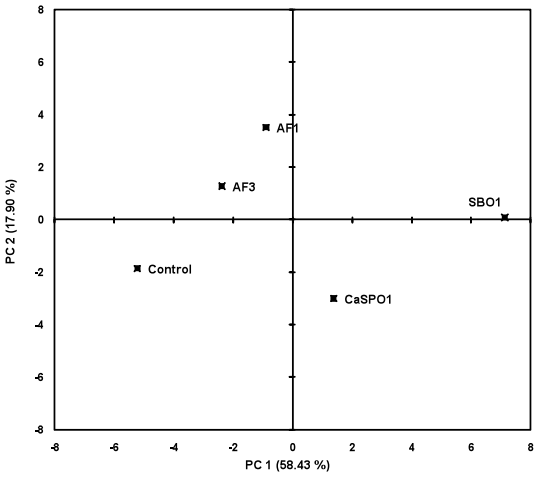

Fig. 2. Projection of the observations of the five diets studied in the plane defined by two principal components.

The projection of the observations of the five diets studied in the plane defined by the first two PCs is shown in Fig. 2. Each quadrant in the biplot discriminated against one of the sources of added fat. Control diet was located on the lower left quadrant of the figure, where the proportion of SFA and MUFA and tenderness and fat flavour attributes lay. SBO1 diet was clearly differentiated from the rest of diets and was positively placed in the right quadrant of the figure together with the proportion of PUFA and close to WBSF, fibrousness, acid flavour and *n*-6/*n*-3 ratio. CaSPO1 diet was located on the lower right quadrant of the figure, with fat, acid and pork odour and near to WBSF and *n*-6/*n*-3 ratio. Animal fat diets were placed on the upper left-hand quadrant, close to IMF, TBARS values and overall acceptance and juiciness attributes.

IV. CONCLUSIONS

The fat sources used in this study can be recommended for inclusion, at these levels, in diets with no detrimental effects on meat quality.

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