CONTRIBUTION OF QUALITY AND COMPOSITIONAL TRAITS TO THE CHARACTERIZATION OF *LONGISSIMUS THORACIS, MASSETER,* AND *SEMITENDINOSUS* PORCINE MUSCLES

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Abstract – The contribution of quality and compositional traits to the characterization of *Longissimus thoracis* (LT), *Masseter* (MS), and *Semitendinosus* (ST) porcine muscles was evaluated to establish categories of samples representing the major differences in muscle structure and composition within the *DREAM* (Design and development of REAlistic food Models with well-characterised micro- and macro-structure and composition) EU project. Physico-chemical characteristics were determined and selected variables were used to characterize the three muscles. A Principal Component Analysis (PCA) was carried out to study the relationships between the physico-chemical variables and to discriminate between samples from the three muscles. The glycolitic LT muscle showed higher lightness, expressible juice, total carbohydrates, protein, and omega-6:omega-3 fatty acid ratio; and lower redness, yellowness, pH, moisture, collagen, fat, polyunsaturated:saturated fatty acid ratio and vitamin E content compared with the oxidative MS muscle. The ST muscle showed intermediate values for most variables except for fat composition, vitamin E and carbohydrates which were similar to MS, and for fat percentage which was the highest. Samples from the three muscles can be clearly discriminated in the space generated with the first two components of the PCA, especially between samples from LT and MS.

Key Words – composition, pork, technological quality.

I. INTRODUCTION

An integrating collaborative project from the 7th Framework Programme is supported by the European Commision to work on the Desing and development of REAlistic food Models with well-characterised micro- and macro-structure and composition (*DREAM*). The *DREAM* project is developing realistic, physical and mathematical food models for use as standards to facilitate development of common approaches to risk/benefit assessment and nutritional quality in food research and industry. One objective within the proteinous cellular network model (meat) is to establish categories of samples representing the major differences in muscle structure and composition. Thus, a group of physical and compositional properties were selected to characterize distinct muscle groups. The objective of this short paper is to present results from the physico-chemical characterization of three pork muscles (*Longissimus thoracis*, *Semitendinosus*, and *Masseter*) using selected muscle properties.

II. MATERIALS AND METHODS

Muscle sampling

Heads, loins and hams from ten entire male carcasses (89±7 kg carcass weight, 56±3% of lean), coming from the cross-breed (25% Duroc x 25% Landrace) x 50% Pietrain, were obtained at 24 hours post-mortem from a commercial abattoir. Right *Longissimus thoracis* (LT), right and left *Masseter* (MS), and right *Semitendinosus* (ST) muscles were excised from the ribs, head and ham, respectively, at 48h post-mortem. *Longissimus thoracis* and *Semitendinosus* muscles from the right-side carcass were cut into slices of different thickness: 4 cm were cut to evaluate pH and color, 3 cm for composition, 1.5 cm for expressible juice, and 1 cm for vitamin E content. *Masseter* samples from the right and left-side carcasses were cut for pH, color and composition evaluation, while samples for vitamin E and expressible juice analyses were removed from the right-side carcass only.

Technological quality

The ultimate pH was measured in triplicate using a penetration Crison PH25 DL pH-meter (Crison Instruments S.A., Alella, Barcelona, Spain). Slices from each muscle were cut and allowed to bloom during 15 minutes before lightness (L*, black - white), redness (a*, red - green), and yellowness (b*, yellow - blue) were measured in triplicate using a Minolta CR-400 colorimeter (AQUATEKNICA S.A., Valencia, Spain). Instrumental color was measured in two areas of the ST muscle, the dark (STR: *Semitendinosus Red*) and the light (STW: *Semitendinosus White*) colored zone. Expressible juice was determined following the procedure described by Hamm [1] and reported as a percentage of moisture released after applying pressure on 5 g of meat samples in duplicate.

Meat composition

Collagen, fat, moisture and protein percentage were determined using a Food Scan™ Lab Analyzer (Type 78800, Foss Iberia S.A, Barcelona, Spain). Lipids were extracted using chloroform-methanol procedure of Folch et al. [2] converted to fatty acid methyl esters (FAME) following the method ISO 5509-1978 (E) and analyzed by gas chromatography (Hewlett–Packard 5890 Series II GC, S.A, Barcelona, Spain) in duplicate using tripentadecanoin (T4257, Sigma–Aldrich, Madrid, Spain) as internal standard. Muscle vitamin E content was determined following the method described by Casademont et al. [3]. Total carbohydrates were determined following the method of AOAC 958.06 [4], using a spectrophotometer Shimadzu UV-1603 (Shimadzu Europa GmbH, Duisburg, Germany) at 630 nm, and results were expressed as % of total glucose.

Data analysis

Data were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC) with animal and muscle as fixed effects in the model and means separated by the Tukey's Studentized range test. A principal component analysis (PCA) was carried out with the physico-chemical data from the three pork muscles by the PRIN-COMP procedure of SAS. Instrumental color data for the ST muscle were averaged across the light and dark colored areas for PCA analysis.

III. RESULTS AND DISCUSSION

LT and STW showed similar L* values, which were higher than MS, followed by STR which was the darkest muscle (Table 1). MS and STR were more red than STW and specially LT which was the least red. Muscle yellowness was highest for STR, followed by STW and MS and finally LT muscle showing lowest b* values.

Table 1. Instrumental color (L*: lightness, a*: redness, b*: yellowness) of *Longissimus thoracis* (LT), *Masseter* (MS), *Semitendinosus Red* (STR, dark area), and *Semitendinosus White* (STW, light area) pork muscles. Mean±SD.

	Muscles			
	LT	MS	STR	STW
L*	46.05^{a}±1.41	38.74^{b}±1.64	36.74^{c}±1.75	45.67^{a}±2.59
a*	7.53^{c}±0.77	16.58^{a}±0.93	16.68^{a}±1.09	9.32^{b}±1.40
b*	1.57^{c}±0.63	2.10^{bc}±0.61	3.40^{a}±0.91	2.65^{b}±0.60

Means within columns with the same superscript letter are not significantly different (P>0.05)

Muscle pH, expressible juice and composition are shown in Table 2. Muscle pH was highest and expressible juice lowest for MS, while LT showed the lowest pH and highest expressible juice with ST muscle showing intermediate values for the two variables. The MS had the highest percentage of moisture and collagen, the lowest of protein and intermediate fat percentage compared with the other two muscles. On the other hand, the LT muscle had the highest percentage of protein and the lowest percentage of moisture, collagen, and fat, while the ST muscle had the highest fat percentage. The n-6:n-3 fatty acid ratio was lower (P<0.05) for MS than LT and intermediate for ST which did not differ (P>0.05) from either muscle. The PUFA:SFA fatty acid ratio and vitamin E content were lower and total carbohydrates higher (P<0.05) for LT than MS and ST which did not differ (P>0.05).

Table 2. Meat quality and composition of *Longissimus thoracis* (LT), *Masseter* (MS), and *Semitendinosus* (ST) pork muscles. Mean±SD.

	Muscles		
	LT	MS	ST
pH	5.42^{c}±0.06	5.96^{a}±0.19	5.79^{b}±0.12
Juice*, %	39.32^{a}±2.01	22.04^{c}±4.06	34.25^{b}±1.75
Collagen, %	1.22^{c}±0.11	2.26^{a}±0.25	1.70^{b}±0.17
Moist*, %	74.11^{c}±0.49	77.02^{a}±0.45	76.02^{b}±0.90
Protein, %	24.38^{a}±0.35	19.60^{c}±0.31	21.01^{b}±0.47
Fat, %	0.95^{c}±0.63	1.73^{b}±0.49	2.34^{a}±0.99
n-6:n-3*	16.30^{a}±0.62	15.77^{ab}±0.97	15.01^{b}±1.22
PUFA:SFA*	0.85^{b}±0.14	1.29^{a}±0.09	1.19^{a}±0.15
VitE*, ug/g	3.02^{b}±0.94	4.16^{a}±1.21	4.29^{a}±1.23
CHO*, %	0.43^{a}±0.13	0.19^{b}±0.13	0.13^{b}±0.04

Means within rows with the same superscript letter are not significantly different (P>0.05). *Juice: expressible juice, Moist: moisture, n-6:n-3: omega-6 (18:2, 18:3, 20:2, 20:3, and 20:4):omega-3 (18:3, 20:3, 20:5 and 22:6) fatty acid ratio, PUFA:SFA: polyunsaturated (18:2n6, 18:3n6, 18:3n3, 20:2n6, 20:3n6, 20:4n6, 20:3n3, 20:5n3 and 22:6n3):saturated (14:0, 16:0, 17:0, 18:0, 20:0 and 21:0) fatty acid ratio, VitE: vitamin E, CHO: total carbohydrates.

Principal component analysis was carried out to examine the relationships among the different traits studied in each muscle. Figure 1A shows a plot of the different variables for the first two principal components accounting for 76% of the total variation in the data (PC1: 61%, PC2: 15%). Groups of variables can be distinguished in the plot with pH, redness, moisture, collagen and fat percentage, vitamin E and the PUFA:SFA fatty acid ratio located in the positive axis of PC1. Lightness, protein percentage, and to a lower extent expressible juice and total carbohydrates are situated in the negative axis of PC1. Samples from the three muscles can be clearly discriminated in the space generated by the first two principal components of the PCA (Figure 1B). PC1 is associated with variables related to the muscle type (leaner and glycolitic vs. fatter and oxidative). PC1 is separating the glycolitic muscle LT in the plot area corresponding to high values of L*, protein %, expressible juice % and % of total carbohydrates from the oxidative muscle MS with high values of pH, redness, moisture, collagen, vitamin E, fat percentage and PUFA:SFA fatty acid ratio. Samples from the ST muscle are located closer to samples from the MS than samples from the LT muscle. PC2 is associated with variables related with fat percentage and its composition, separating samples of the ST with higher fat percentage and lower n-6:n-3 fatty acid ratio from samples of the MS.

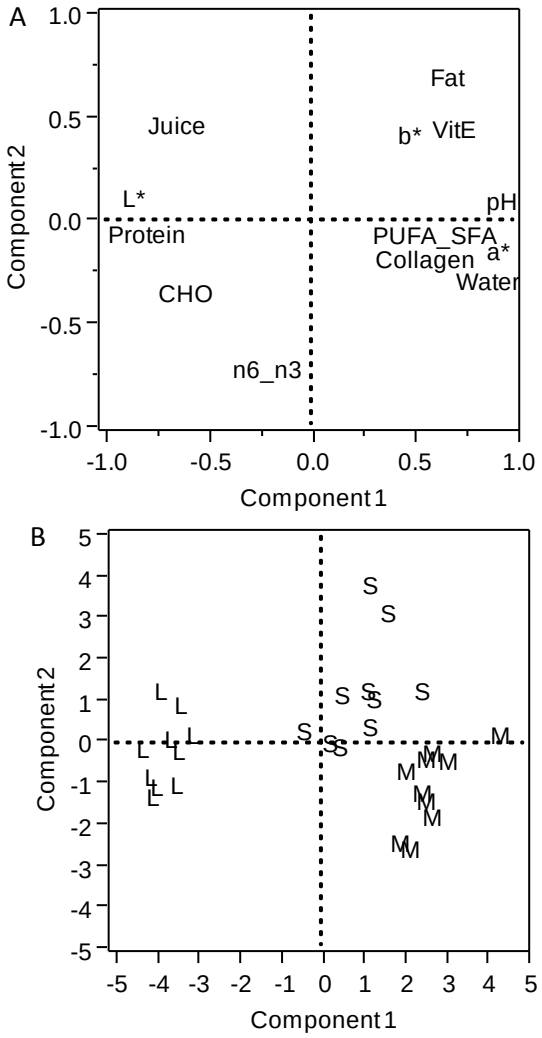

Figure 1. Projection of the physico-chemical variables (A) and the samples (B) onto the space defined by the principal components (PC1: 61%, PC2: 15%). Variables: total carbohydrates (CHO), vitamin E (VitE), omega-6:omega-3 fatty acid ratio (n6_n3), polyunsaturad:saturated fatty acid ratio (PUFA_SFA). Sample groups: *Longissimus thoracis* (L), *Semitendinosus* (S), *Masseter* (M).

IV. CONCLUSION

The glycolitic LT muscle showed higher lightness, expressible juice, total carbohydrates, protein, n-6:n-3, and lower redness, yellowness, pH, moisture, collagen, fat, PUFA:SFA and vitamin E content compared with the oxidative MS muscle. The ST muscle showed intermediate values for most variables except for fat composition, vitamin E and carbohydrates which were similar to MS, and for fat percentage which was the highest. Samples from the three muscles can be clearly discriminated in the space generated by the first two components of the PCA, especially between samples from LT and MS.

ACKNOWLEDGEMENTS

We acknowledge the 7th EU framework large-scale integrating collaborative project *DREAM* (2009-222654-2) that has been the major source of information for this short paper.

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