PE7.27 Physicochemical characteristics of muscles from free-range reared pigs 279.00

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***Abstract*— In this study we analysed the chemical composition and physical characteristics of four muscles from Alentejano (AL) pigs, *m. Biceps femoris* (BF), *m. Semimembranosus* (SM), *m. Longissimus dorsi* (LD), and *m. Psoas major* (PM). Castrated male and female AL pigs allocated to an outdoor rearing area and fed a commercial diet offered at 85% estimated ad libitum consumption, were slaughtered at ~105 kg live weight. BF, SM, LD, and PM individual samples were obtained from the left side of each chilled carcass. Significant differences were mainly found on the chemical composition and colour of the muscles. LD muscle presented the highest amount of intramuscular fat (5.9%), and SM the lowest (3.4%). These differences agree with the lower moisture content on LD (69.2%) and higher content on SM (73.1%). The myoglobin content was higher on PM (3.81 mg/g), followed by SM (2.74), BF (2.30), and LD muscle (1.21). These myoglobin contents explain the obtained physical colour measures: the PM muscle presented the higher (P<0.001) CIE a* and C* values (18.8 and 20.2, respectively), followed by SM (16.0 and 17.3), BF (15.5 and 16.4), and LD (12.0 and 13.1) muscles. The content of total collagen was higher (P<0.001) on BF and SM muscles (1.51 and 1.45 mg/g, respectively), and lower on LD and PM muscles (0.96 and 1.01). The soluble fraction of collagen did not differ among muscles, varying between 0.16 (LD) and 0.21 mg/g (SM). These results indicate that there are important differences between muscles and that these differences will have impact on the sensorial quality (e.g. colour and texture/toughness). Thus, the PM muscle was the most reddish/attractive muscle, with lower collagen content, and the LD muscle had a pale colour, the lower collagen content and the higher content of intramuscular fat. These parameters agree with the higher commercial value of the LD muscle, related with higher sensorial properties (toughness and juiciness).**

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***Index Terms*—Alentejano pig, meat quality, muscle type**

I. Introduction

The Alentejano (AL) pig is an autochthonous breed reared in the Alentejo region of Portugal. This breed is characterised by slow growth rates and is reared in a traditional production system where animals are slaughtered at 12–14 months, with 150–160 kg live weight (LW). Normally, 2 or 3 months before slaughter, AL pigs are fed in "Montanheira", with access to acorn and grass from October to February. This system produces a heavy and fat carcass, well suited for the production of dry-cured meat products, mainly dry-sausages and hams. Nowadays, the producers are increasingly using an alternative production system, to provide fresh meat for human consumption during all the year. Therefore, meat from pig production systems in which pigs are free-range reared, and fed on natural feeds with no growth promoters and antibiotics, begins to be an important field of interest [1]. However, the information about the characteristics of fresh meat obtained from free-range reared AL pigs is limited. The carcass comprises several meat cuts with different muscle composition, and muscles are comprised of different types of fibre (aW, aR, and bR) with different contractile and metabolic properties. Red muscle fibres (type 1) are rich in myoglobin content and have a high oxidative and low glycolytic metabolic capacity, whereas intermediate (type 2a) and white (type 2b) fibres are fast twitching with low oxidative and high glycolytic metabolic activity [2]. The relative proportion of the three types of fibres on each muscle largely determines its technological and sensory properties such as taste, juiciness or rate of lipid and myoglobin oxidation [3]. Depending on the types of fibre that constitute a muscle, it has a different trend to intramuscular fat deposition, a different heme pigment concentration, and its phospholipids and fatty acids composition varies [1]. Meats are more tasty and juicy, and total heme pigments and lipids oxidise faster in oxidative muscles than in glycolytic ones. This contributes to different textural properties [4] and to the formation of aromatic compounds, and thus the appearance of rancidity and warmed-over flavour during storage [5].

This study was carried out to characterise the

chemical composition and physical characteristics of four muscles, which are representative of tree meat cuts: leg (*m. Biceps femoris* and *m. Semimembranosus*) loin (*m. Longissimus dorsi*) and tender loin (*m. Psoas major*) from free-range reared AL pigs slaughtered at ~105 kg LW.

II. MATERIALS AND METHODS

Ten AL pigs were allocated to an outdoor rearing area (3 ha) and fed a commercial diet offered at 85% estimated *ad libitum* consumption. At an average LW of 105 kg, these pigs were slaughtered. The left side of each carcass was submitted to a 24h chilling, followed by commercial cuts and sample collection of the muscles BF, SM, LD, and PM. These samples were vacuum packaged and stored (-30º C) until analysis. Moisture (Portuguese Norm 1614), total protein (Portuguese Norm 1612), and neutral and polar lipids [6] were analyzed. The myoglobin content was calculated by multiplying heme pigment concentration (analyzed according to Hornsey [7]) by the factor 0.026 [1]. Total hydroxyprolin was analyzed [8] and multiplied by 7.14 [9] to obtain the total collagen content of samples. Solubility of collagen was obtained according to Hill [10]. The pH values were measured following the Portuguese Norm 3441 and the water-holding capacity (WHC) was measured as water losses after pressure during 1 min following the method described by Goutefongea [11]. Colour CIE L* (lightness), a* (redness), and b* (yellowness) were determined with a Chromameter (CR-200, Minolta Camera Co. Ltd, Japan). Hue angle and chroma values were obtained from the values a* and b*. An ANOVA was carried out and the comparison of means was made by the SNK test. The correlations between the variables studied were determined by the Pearson coefficient. SPSS statistical software was used.

III. RESULTS AND DISCUSSION

Table 1 shows the results obtained for physical and chemical composition of the four muscles studied. The chemical composition traits were significantly different among muscles, except for the polar lipids and soluble collagen contents. Significant differences were observed on moisture ($P<0.001$) and neutral lipids ($P<0.05$) between LD and SM muscles. LD presented less moisture and more neutral lipids (69.2 vs. 73.1% and 5.9 vs. 3.4%). Mayoral et al. [12] found similar differences between LD and BF on animals with the same age. On the other hand, Cava et al. [1] found ~18% less LD neutral lipids in pigs with 90 kg LW. BF and PM muscles showed intermediary and similar amounts of moisture and neutral lipids (71.9 and 72.2%, and 4.4 and 4.7%, respectively). As expected, a negative correlation (–0.88, $P<0.001$) was found between the moisture and neutral lipids content. As to the PM muscle, we observed a lower ($P<0.01$) content of protein, which is difficult to explain by the relationship with the moisture and lipid contents. Myoglobin presented different contents ($P<0.001$) among muscles, decreasing in the following order: *m. Psoas major* (2.81 mg/g) > *m. Semimembranosus* (2.74) > *m. Biceps femoris* (2.30) > *m. Longissimus dorsi* (1.21). The higher amount of myoglobin detected on PM muscle agrees with its higher content on polar lipids, confirming the metabolic oxidative type of this muscle. The lower amount of myoglobin observed on the LD muscle agrees with its metabolic type, since glycolytic muscles such as LD present lower content of myoglobin [13]. LD myoglobin values obtained on this study were similar to the ones reported by Mayoral et al. [12], but Cava et al. [1] found higher values (3 mg/g) on pigs with 90 kg LW. These values of myoglobin are well correlated with the colour measurements using the CIE L* a* b* components, as verified by correlations found between myoglobin and a* (+0.83, $P<0.001$), and myoglobin and chroma (+0.81, $P<0.001$). The amount of myoglobin is directly related with the oxidative activity and the latter affects colour stability. Therefore, muscles having higher oxidative activity are more colour labile, and according to O'Keefe and Hood [14], colour lability varies in the following order: m. *Longissimus dorsi* > m. *Semimembranosus* > m. *Psoas major*. Based on myoglobin content and chroma values, the PM muscle should have a higher oxidative activity and be more colour labile. Conversely, the LD muscle should have more stable behaviour, and BF and SM, intermediary ones. These results agree with those observed by Hood [15].

Total collagen was lower ($P=0.001$) in LD (9.6 mg/g) and PM (10.1) and higher in BF and SM muscles (15.1 and 14.5). These differences could be due to the anatomical function of the muscles. In fact, BF and SM have an important role in the coxofemoral joint and must support more tensile force due to their intervention in locomotion. The amount of soluble collagen (SC) was not significantly different among muscles, but the proportion of SC in percentage of total collagen was greater on LD and PM (17.7%) than on SM (15.2) and BF (11.8) muscles. These results agree with the different development patterns of these muscles: SM and BF are ham muscles of early development, while LD is a muscle of late development. These data also agree with the allometric coefficients obtained by Landgraf et al. [16] in cross-bred Pietrain boars (1.047 for ham,

and 1.32 for loin), and with those obtained by Lefaucheur and Vigneron [13] in Large White pigs up to 120 kg LW (1.21 for LD, and 1.08 for PM).

The amount of SC in LD and PM muscles agrees with the sensorial quality of loin and tender loin, mainly in the texture propriety toughness. Finally, the fact that SC was not significantly different among muscles, could be related to the fact that these muscle samples where obtained from animals with the same age.

The PM muscle showed a higher WHC than SM and BF, which had similar moisture contents, and higher WHC than LD, considering that this muscle lost the same weight of water but had significant lower moisture content than PM (69.2 vs. 72.1%). Melody et al. [17] found similar results when comparing PM to LD and SM muscles. These authors attributed these results to the fact that in yearly *post-mortem*, PM consistently had some autolysis of μ-calpain, whereas LD and SM did not. In fact, protein degradation is associated with differences in pork tenderness and WHC observed in different muscles.

IV. CONCLUSION

This study characterised the chemical composition and physical characteristics of four muscles, representative of three meat cuts: leg (*m. Biceps femoris* and *m. Semimembranosus*) loin (*m. Longissimus dorsi*) and tender loin (*m. Psoas major*). These three cuts clearly differ on their meat quality attributes. Among other properties, PM muscle presented greater myoglobin content and a better WHC, and LD had a greater intramuscular fat content. PM and LD revealed a lower total collagen content and a higher proportion of SC. Finally, PM muscle seems to have higher potential sensorial quality but is more prone to meat discoloration.

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Table 1. Chemical composition and physical characteristics of four muscles of AL pigs slaughtered at an average LW of 105 kg

Muscles	*Biceps femoris*	*Semimembranosus*	*Longissimus dorsi*	*Psoas major*	Sig
Moisture (g/100g)	71.9 ± 0.6 [b]	73.1 ± 0.4 [b]	69.2 ± 0.9 [a]	72.1 ± 0.5 [b]	0.000
Protein (g/100g)	21.87 ± 0.47 [b]	21.63 ± 0.23 [b]	22.02 ± 0.20 [b]	20.45 ± 0.29 [a]	0.005
Neutral lipids (g/100g)	4.37 ± 0.43 [bc]	3.38 ± 0.44 [cd]	5.91 ± 0.71 [ab]	4.75 ± 0.66 [bc]	0.030
Polar lipids (g/100g)	1.05 ± 0.09	1.05 ± 0.04	1.02 ± 0.10	1.19 ± 0.08	0.47
Myoglobin (mg/g)	2.30 ± 0.11 [b]	2.74 ± 0.11 [c]	1.21 ± 0.09 [a]	3.81 ± 0.24 [d]	0.000
Total collagen (mg/g DM)	15.1 ± 1.3 [a]	14.5 ± 0.8 [a]	9.6 ± 1.0 [b]	10.1 ± 0.5 [b]	0.000
Soluble collagen (mg/g DM)	1.8 ± 0.2	2.1 ± 0.1	1.6 ± 0.4	1.8 ± 0.2	0.70
pH	5.69 ± 0.03	5.65 ± 0.04	5.71 ± 0.05	5.76 ± 0.08	0.50
Water-holding capacity [†]	20.18 ± 1.13 [a]	25.13 ± 1.39 [b]	16.70 ± 1.28 [a]	16.83 ± 2.01 [a]	0.001
Lightness (Cie *L**)	41.85 ± 0.95 [c]	36.53 ± 1.15 [a]	46.75 ± 1.0 [b]	37.11 ± 0.48 [a]	0.000
Redness (Cie *a**)	15.45 ± 0.27 [b]	16.04 ± 0.53 [b]	12.00 ± 0.48 [a]	18.83 ± 0.52 [c]	0.000
Yellowness (Cie *b**)	5.34 ± 0.51 [a]	6.40 ± 0.42 [bc]	5.15 ± 0.42 [a]	7.11 ± 0.64 [c]	0.03
Hue angle (Hº)	18.77 ± 1.45	21.66 ± 1.06	23.01 ± 1.15	20.41 ± 1.42	0.134
Chroma (C)	16.39 ± 0.40 [b]	17.29 ± 0.60 [b]	13.08 ± 0.58 [a]	20.19± 0.66 [c]	0.000

[†] Measured as water loss after pressure during 1 min.