Journal of Integrative Agriculture
2013, 12(11): 1961-1971

Available online at www.sciencedirect.com
ScienceDirect

November 2013

RESEARCH ARTICLE

# Pork Meat Quality of Preto Alentejano and Commercial Largewhite Landrace Cross

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## Abstract

This work aimed to evaluate the physical-chemical characteristics of pork from a local breed (Portuguese black pork called Preto Alentejano) and a commercial breed. Sixteen animals were used, 4 females and 4 males from each breed. Animals had 80-100 kg of live weight. The *longissimus* muscle between the 5th thoracic vertebra and the 10th lumbar vertebra was used in the analysis. Samples were analysed for protein, fat, pigments, ashes, dry mater, water-holding capacity, and texture. Results of fat and pigments contents indicate significant ($P$<0.05 and $P$<0.01) differences for all treatments. For protein, ashes, dry mater, water-holding capacity and texture, no significant differences were found for sex. In the analysis of fatty acids composition, ten were detected, being the main ones C16:0, C18:0, C16:1, C18:1, C18:2. There was a predominance of monounsaturated fatty acids (MUFA), followed by saturated (SFA) and polyunsaturated (PUFA). Differences were significant for sex ($P$<0.01) and breed ($P$<0.01). Preto Alentejano breed and females presented the higher percentages of SFA ($P$<0.01) and MUFA ($P$<0.001) fatty acids. Differences between breeds might be due to breed production system and feed differences.

Key words: breed, sex, pork, meat, quality

## INTRODUCTION

Pork is one of the most traditional and popular meats consumed in world despite the negative thoughts about the impact of consumption of pork in human health. The idea that pork is not recommended in hypo caloric or low cholesterol diets is not entirely true. In fact, several studies indicate that pork compared with other meats is rich in protein and poor in carbohydrates contents with similar level of cholesterol or SFA fat as chicken, beef or sheep beyond the interesting content in oleic and linoleic fat acids. That is why the knowledge of fatty acids profile in pork meat became more and more important which depends on several factors as feed (Raimondi *et al*. 1975; Asghar *et al*. 1990; Wood *et al*. 2003; Edwards 2005; Nuemberg *et al*. 2005; Teye *et al.* 2006), genotype (Rosenvold and Andersen 2003; Wood *et al.* 2003; Edwards 2005; Franci *et al.* 2005), production system and their variations as physical exercise, the exposition to natural environmental conditions and animal welfare (Lebret *et al.* 2002; Rosenvold and Andersen 2003; Edwards 2005).

In any case several authors reported that breed had a more prominent effect on meat and eating quality than sex or finish weight (Magowan *et al*. 2011; Yu *et al*. 2013). In fact, Tang *et al.* (2008) studying several breeds found that the breed-sex interaction

Received 12 October, 2012 Accepted 4 June, 2013
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doi: 10.1016/S2095-3119(13)60634-6

only impacted the average daily gain from. Kim *et al*. (2008) noted that breed of pig can have an effect on the fatty acid composition of pork. However Zhang *et al*. (2007) suggested that breed and sex are importante sources of variation for fatty acid compostion of pork *longissimus* muscle. In Portugal, two native pig breeds are reared (Bisara and Alentejano) according to the FAO database. Recently, there has been a development of pig breeds in Portugal, with many changes in production, processing and marketing taking place (Matos 2000). Preto Alentejano is Portuguese pork with more and more importance during the last years owing to a demand increasing of Iberian products and the protection of origin designation products. On the other hand, but also important for price reasons is the pork meat from commercial pig breeds. So, the objective of this work was to study the effects of breed and sex in the quality of the two most important pork meats commercialized and to study the usefulness of the fatty acid composition to discriminate the four categories of meat in terms of sex and breed.

## RESULTS

### Physicochemical composition

Table 1 shows the breed and sex effects on meat water holding capacity (WHC, expressed as percentage of cooking water loss), and texture (total applied force expressed in kgf). Cooking losses were significantly affected by breed ($P$<0.05). Commercial breed presented higher cooking losses than Preto Alentejano. There were no significant sex or interaction effects on this characteristic. No significant breed or sex differences were found on texture.

Concerning chemical composition (Table 2), obtained from *Longissimus thoracis et lumborum* muscle between the 5th thoracic vertebra and the 12th lumbar vertebra, ashes content was no significantly different between breeds or sexes. Commercial breed presented higher ($P$<0.05) protein content, but lower total fat content ($P$<0.01), pigments ($P$<0.001) and dry matter ($P$<0.01) than the Preto Alentejano breed.

**Table 1** Breed and sex effects on meat water holding capacity (WHC) and Warner-Bratzler Shear Force (WBSF)

| | | WHC (%) | Shear force (kgf) |
|---|---|---|---|
| Preto Alentejano | Males | 63.48±8.67 | 4.54±0.48 |
| | Females | 55.19±7.30 | 4.73±0.57 |
| Commercial | Males | 68.84±19.5 | 4.52±0.92 |
| | Females | 66.15±6.11 | 4.35±0.18 |
| Principal effects | Breed | * | NS |
| | Sex | NS | NS |

*, $P \leqslant 0.05$; NS, no significant.
Data are mean±standard deviation. The same as below.

Females presented higher total fat content ($P$<0.05) than males. A significant ($P$<0.05) interaction between breed and sex was observed in total fat content. While in Preto Alentejano breed males had less total fat than females, in commercial breed, males presented more total fat content than females.

In this work, significant ($P$<0.001) differences were found in pigments percentages between breed, sex and their interaction. Preto Alentejano presented higher pigments percentage than commercial breed. Males presented higher values when compared to females. In pigments it was observed that in Preto Alentejano breed males had more pigments than females, in the commercial breed females had a higher value of the same attribute.

### Fatty acid composition

Results obtained for LM intramuscular fat, grouped fatty acids profile are presented in Table 3. MUFA prevailed in both sexes, followed by SFA and then PUFA presented the lowest concentration in Preto

**Table 2** Breed and sex effects on meat chemical composition (by 100 g of sample)

| | | Ashes | Protein | Total fat | Pigments | Dry mater |
|---|---|---|---|---|---|---|
| Preto Alentejano | Males | 1.17±0.004 | 21.86±0.92 | 3.79±0.94 | 2.97±0.24 | 26.31±1.27 |
| | Females | 1.12±0.005 | 22.29±0.96 | 6.09±2.54 | 1.41±0.46 | 26.54±2.26 |
| Commercial | Males | 1.17±0.005 | 22.42±0.46 | 3.45±1.6 | 1.25±0.41 | 24.84±0.59 |
| | Females | 1.17±0.003 | 22.29±0.96 | 3.34±0.64 | 1.56±0.81 | 25.69±0.33 |
| Principal effects | Breed | NS | * | ** | *** | ** |
| | Sex | NS | NS | * | *** | NS |
| | Breed×Sex | NS | NS | * | *** | NS |

**, $P \leqslant 0.01$; ***, $P \leqslant 0.001$. The same as below.

Alentejano pork. In the commercial pork SFA prevailed, followed by MUFA and then PUFA with the lowest concentration.

Preto Alentejano breed presented higher SFA and MUFA percentage than the commercial breed. There were no significant breed differences on PUFA. Females presented higher ($P$<0.05) SFA and MUFA concentrations than males.

A total of 10 individual fatty acids were detected (Table 3), the main ones C16:0; C18:0, C16:1; C18:1, C18:2, representing almost 90% of total fatty acids.

Both Preto Alentejano and commercial breeds show an emphasis on C16:0, C18:0, C16:1 and C18:1 fatty acids. Breed had a significant effect on C16:0 ($P$<0.01), C16:1, and C18:1 ($P$<0.001). Preto Alentejano breed had higher percentage of these fatty acids than commercial breed (Table 3).

Respecting sexes differences, females showed higher ($P$<0.05) percentage of C16:0 and C18:1 fatty acids. No significant sex differences were found on the other detected fatty acids except for C18:0 with a significant ($P$<0.01) interaction between breed×sex once the Preto Alentejano females presented the highest percentage of this fatty acid (0.45 g 100 $g^{-1}$).

### Discriminant analysis

According to $F$ values of all variables considered in the analysis (Table 4), the stepwise method selected the following variables in 7 steps: C16:1, PUFA, C14, C18:1, SFA, C18, and MUFA.

Scatter plot of the first two canonical variables, of the four groups considered showed that groups were discriminated with great accuracy (Fig. 1). In fact, the first canonical variable explained 54.97% of the total variance and the second 32.98%. The model accepted the third canonical variable as significant ($P$<0.001) and 12.1% of the total variance was accounted. Total variance (100%) was accounted by the three canonical variables and all individual of each group was assigned in the correct group pre-assigned, for 100% of corrected classified. The model is significant ($P$<0.0001) for 0.045 Wilks' lambda value. Analyzing the standardized discriminant scores the most important variables were MUFA, C18:1 and SFA in the first canonical variable, and MUFA, C18:1 and C16:1 in the second canonical variable whereas the C18:1 and C16:1 were the most important in the third canonical variable.

## DISCUSSION

### Meat physic characteristics

Meat WHC and texture are objective values giving an idea about meat quality, mainly in terms of juiciness and tenderness. According to Warner *et al.* (1997) the results obtained for water loss are very high, close to pale, soft and exudative (PSE) and dark, firm and dry (DFD) meat.

These are the most important aspects at purchase and during consumption. Table 1 shows the breed and sex effects on meat WHC and texture.

Commercial breed presented higher cooking losses

**Table 3** Breed and sex effects on meat fatty acids composition (g 100 $g^{-1}$ sample)

| | Preto Alentejano | | Commercial | | Principal effects | | |
|---|---|---|---|---|---|---|---|
| | Males | Females | Males | Females | Breed | Sex | B×S |
| SFA | 1.19±0.29 | 1.90±0.75 | 1.17±0.40 | 1.07±0.23 | ** | * | ** |
| MUFA | 1.41±0.51 | 2.51±1.38 | 0.95±0.74 | 1.03±0.32 | *** | * | * |
| PUFA | 0.19±0.05 | 0.32±0.15 | 0.360±0.35 | 0.25±0.05 | NS | NS | * |
| C4 | 0.027±0.01 | 0.025±0.03 | 0.023±0.01 | 0.029±0.00 | NS | NS | NS |
| C8 | 0.117±0.01 | 0.102±0.03 | 0.103±0.01 | 0.103±0.01 | NS | NS | NS |
| C12 | 0.04±0.01 | 0.03±0.03 | 0.04±0.03 | 0.03±0.01 | NS | NS | NS |
| C14 | 0.17±0.04 | 0.22±0.05 | 0.25±0.10 | 0.13±0.05 | NS | NS | *** |
| C16 | 0.60±0.21 | 1.06±0.51 | 0.46±0.28 | 0.53±0.14 | ** | ** | * |
| C18 | 0.23±0.08 | 0.45±0.20 | 0.29±0.19 | 0.26±0.06 | NS | * | ** |
| C16:1 | 0.15±0.06 | 0.26±0.13 | 0.11±0.06 | 0.11±0.03 | *** | NS | * |
| C18:1 | 1.27±0.46 | 2.25±1.26 | 0.84±0.69 | 0.92±0.30 | *** | * | * |
| C18:2 | 0.18±0.05 | 0.31±0.14 | 0.35±0.33 | 0.25±0.05 | NS | NS | * |
| C20:4 | 0.003±0.00 | 0.008±0.016 | 0.011±0.03 | 0.004±0.00 | NS | NS | NS |

**Table 4** *F* values of all variables used in the discriminant analysis

| Variable | *F* ratio | Prob>*F* |
|---|---|---|
| Protein | 1.888 | 0.1455891 |
| Total fat | 7.837 | 0.0002681 |
| SFA | 8.556 | 0.0001376 |
| MUFA | 8.671 | 0.0001239 |
| PUFA | 2.659 | 0.0598859 |
| C4 | 0.345 | 0.7929830 |
| C8 | 2.204 | 0.1010194 |
| C10 | 3.401 | 0.0258067 |
| C12 | 0.567 | 0.6396844 |
| C14 | 8.034 | 0.0002230 |
| C16 | 8.512 | 0.0001433 |
| C18 | 5.212 | 0.0036278 |
| C16:1 | 10.555 | 0.0000237 |
| C18:1 | 8.488 | 0.0001464 |
| C18:2 | 1.954 | 0.1348247 |
| C20:4 | 0.597 | 0.6203566 |

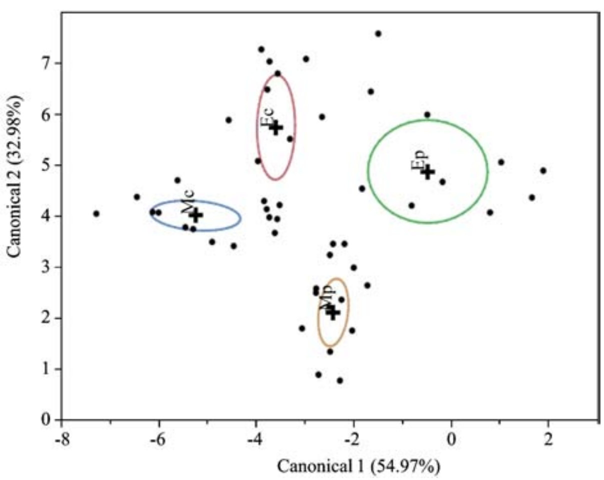


**Fig. 1** Score plots of the first *vs*. second canonical variables of Fp (female Preto Alentejano), Fc (female commercial), Mp (male Preto Alentejano), and Mc (male commercial). The color contours aggregating 50% of individuals in each group.

than Preto Alentejano. There were no significant sex or interaction effects on this characteristic. These results are similar with the results found by other authors (Enfalt *et al.* 1997; Nilzen *et al.* 2001; Jimenez 2007). In other studies, performed by Pugliese *et al.* (2004a) and Sather *et al.* (1997), working with a local breed (Cinta Senese) and a commercial breed, respectively, also found higher cooking losses in breeds raised outdoors. However Rosenvold and Andersen (2003) indicated that the outdoor production systems reduce cooking water losses. On the other hand, Lloveras *et al.* (2008), comparing 3 different pig breeds (Landrace, Duroc and Yorkshire), registered significant differences between breeds but not between sexes.

There are multiple factors affecting water cooking losses (Offer and Knight 1988; Honikel 1998). In the present work, samples were refrigerated for several days before be transported from slaughter houses to laboratory and it could be, probably a reason to explain the high cooking losses verified, maybe if this study was made with fresh samples cooking losses could diminish, as it was found and concluded by Ramirez and Cava (2007), that the refrigerating time significantly affects WHC.

Texture measurements can be made in raw and cooked meat. When samples are cooked, temperature and cooking time influence the sample deformation force. For this reason the final cooking temperature in the sample center must be precisely defined and measured, the recommended value is 75ºC. Also, samples thickness and weight must be constant (Honikel 1998). Numerous factors influence meat texture measurements: cooking temperature, sample uniformity, muscle fibers direction, conjunctive and fat tissues quantity and distribution, sample temperature and Warner–Bratzler cell speed (Jimenez 2007). In this work texture was objectively evaluated using a Warner-Bratzler cell. Results of total shear force (in kgf) of cooked meat samples showed no significantly ($P$<0.05) differences in any of the studied effects. However, Preto Alentejano breed presented relatively but not significant higher hardness.

Our results agree with Danielsen *et al*. (2000), Wood *et al.* (2004) and Edwards (2005) which consider modern meat pork breeds more tender than the traditional or ancient ones, and harder when raised in outdoor systems, explaining that is due to the fact that outdoor systems lead to lower daily gain particularly in traditional breeds, which diminishes the glycolytic potential at slaughter. Also Lloveras *et al.* (2008), in a study comparing breed and sex effect, found significant differences for both effects.

However Pugliese *et al.* (2004b) obtained no differences between exploitation systems as well as Hansen *et al.* (2006) working with commercial pork, had similar results in pigs raised in outdoor system or in an intensive system, fed *ad libitum* with a commercial concentrate feed. However, in a group of animals fed forages a harder meat was found. Even more Pugliese *et al.* (2004b) found no differences between sexes in meat texture as well as Küchenmeigter *et al.* (2005) in groups of animals submitted to different stress levels, but found an appreciable decrease of the resistance to cut taking into account the length of meat storage.

According to Bendall (1984), the total Warner-Bratzler Shear Force allows meat classification into five hardness groups: very hard (>10 kgf), lightly hard (>5 kgf), tender (>3 kgf) and very tender (<3 kgf). Using this classification, the meat of our study could be considered tender with values ranging between 4.5 and 4.7 for the Preto Alentejano breed, and 4.3 and 4.5 for the commercial breed.

## Meat chemical characteristics

The chemical composition of *Longissimus thoracis et lumborum* muscle between the 5th thoracic vertebra and the 12th lumbar vertebra (Table 2), is in accordance with the expected values to *Longissimus thoracis et lumborum* as it has been described by many authors (Moss *et al.* 1983; Seuss 1990; Warnants *et al.* 1996; Bales *et al.* 1998; Cameron *et al.* 2000; Carvalho 2003).

Ashes content was no significantly different between breeds or sexes, such as Pugliese *et al.* (2004a) results as well as in the studies by Nilzén *et al.* (2001) and Estévez *et al.* (2006), comparing Iberian and commercial. Though, the last authors found lower values than in the present work. However, Pugliese *et al.* (2004a) found some significant differences between production systems.

According with Bales *et al.* (1998), commercial breed presented higher protein content, and lower total fat content, pigments and dry matter than the Preto Alentejano breed. Serra *et al.* (1998) also found significant differences between Landrace and Iberian breeds for dry matter but. Cameron *et al.* (1990) found no significant differences between Duroc and British Landrace breeds, Muriel *et al.* (2004), in agreement with our results.

Wood *et al.* (1986), Lo *et al.* (1992) and Serra *et al.* (1998) compared Landrace with Iberian breeds and, found significant differences in total fat and the Iberian pork showed higher fat percentage. Also Cameron *et al.* (1990), Bidanel *et al.* (1991), Hovenier *et al.* (1992), Lo *et al.* (1992), and Betallé *et al.* (1995) compared Duroc with Iberian breeds, found significant differences. Persson *et al.* (1986) also found differences between Hampshire, Swedish Landrace and Swedish Yorkshire as well as Alonso *et al.* (2008) in different breeds.

Females presented higher total fat content than males and Olivares *et al.* (2008) obtained similar results in relation to total fat content. However, Latorre *et al.* (2003) and Cisneros *et al.* (1996) found higher percentage of fat content in males than females but Persson *et al.* (1986), Alonso *et al.* (2008) and Lloveras *et al.* (2008) found no significant differences between sexes in total fat content.

A significant ($P<0.05$) interaction between breed and sex was observed in total fat content. While in Preto Alentejano breed males had less total fat than females, in commercial breed males had more total fat content than females.

According to Fernandez *et al.* (1999), a high fat level positively affects meat sensory characteristics. Reixach (2004) indicates optimum fat levels of 3.5-4%, in fresh meat used for high quality cured products production, but some studies by Benito *et al.* (1998) and Solis *et al.* (2001) performed with Iberian pork for high quality production of cured products indicate fat percentages of 4.76 to 16.10% whereas Ramirez and Cava (2007) found, in three crosses of Iberian and Duroc pigs, fat percentages of 3.5-5.9%. These animals were used in cured products production. All these percentages are very superior to the usual found in commercial breeds and their crosses used in the industry, where the fat percentage must range between 1 and 2% (Serra *et al.* 1998; Wood *et al.* 2004; Mörlein 2005; Nuernberg *et al.* 2005; Fischer *et al.* 2006b).

Preto Alentejano breed is also mainly used to produce high quality cured products. According to the fat percentages found in this work and the references, this breed has the right fat values to achieve that goal.

Taking into account that the commercial breed meat is mainly used to be consumed as fresh, their fat percentages in this work can be considered adequate as found in other studies (Serra *et al.* 1998; Wood *et al.* 2004; Mörlein 2005; Nuernberg *et al.* 2005; Fisher *et al.* 2006b). Fat excess in commercial pork will produce a consumer's rejection, as fat presence influences the visual aspect and general acceptability.

## Fat and meat color

The physical appearance of fresh meat, especially the color, it is essential for consumers to make the decision to buy or not a determined product.

Fat and muscle color determination is fundamental to offer a typified product to consumers. However, in muscle, the color measure is far complex, due to the fact that its appearance varies, being conditioned by myoglobin oxidation and oxygenation processes (Alberti *et al.* 2005). Significant ($P$<0.001) differences were found in pigments percentages between breed, sex and an interaction between these factors. Preto Alentejano presented higher pigments percentage than commercial breed. Serra *et al.* (1998) also found significant differences between Landrace and Iberian breeds in pigments content, and Lloveras *et al.* (2008) confirm these results whereas Alonso *et al.* (2008) did not find breed significant differences. Preto Alentejano breed males had more pigments than females while in the commercial breed females had a higher content. Our results agree in part with Lloveras *et al.* (2008), but Alonso *et al.* (2008) found no significant differences between sexes for pigments content. Our results confirm also the evidences from several studies (Serra *et al.* 1998; Edwards 2005; Franci *et al.* 2005; Estévez *et al.* 2006) which suggested that traditional breeds having darker and redder color than commercial breeds. On the other hand some other authors as Poto *et al.* (2003, 2007) and Galián *et al.* (2005, 2007) comparing Chato Murciano with a Comercial breed, found that. Pigs raised outdoors presented darker meat than those raised indoors. The higher level of exercise of pigs can produce a higher concentration of muscle myoglobin, which can cause meat darker color in those animals. Nevertheless, some authors found no significant differences between exploitation systems (Pugliese *et al.* 2004a, b; Hansen *et al.* 2006).

## Fat and fatty acid composition

Results obtained for LM intramuscular fat grouped fatty acids profile are presented in Table 3. MUFA were most common in both sexes, followed by SFA and then PUFA presented the lowest concentration in Preto Alentejano pork while in the commercial pork SFA prevailed, followed by MUFA and then PUFA with the lowest concentration. Results are in agreement with the results of the studies by Serra *et al.* (1998), comparing Landrace with Iberian breed and Estèvez *et al.* (2006) working with Iberian pork as well as Renaudeau and Mourot (2007) in a local breed (Creole).

In relation to commercial pork, Olivares *et al.* (2008), Nilzén *et al.* (2001) and Alonso *et al.* (2008) have found similar results of the present study. Preto Alentejano breed presented higher SFA and MUFA percentage than the commercial breed, in agreement with Serra *et al.* (1998), Nilzen *et al.* (2001), Estevèz *et al.* (2006), Fischer *et al.* (2006b), Ramirez and Cava (2007), and Alonso *et al.* (2008), that observed higher SFA percentages in local breeds compared with commercial breeds. There were no significant breed differences on PUFA. Alonso *et al.* (2008) recorded similar results comparing three different pork breeds. However, Serra *et al.* (1998) found significant higher PUFA percentage in Landrace comparing with Iberian.

Females presented higher ($P$<0.05) SFA and MUFA concentrations than males. Also Zhang *et al.* (2007) found significant sex differences for individual fatty acids. Although not significant, females also had more PUFA, in agreement with Bryhni *et al.* (2002). Some authors (Carvalho 2003) found higher values in males comparing with females and others (Mitchaothai *et al.* 2007; Alonso *et al.* 2008) found no significant differences between sexes.

A total of 10 individual fatty acids were detected (Table 3), the main ones C16:0, C18:0, C16:1, C18:1, C18:2, representing about 90% of total fatty acids, which were similar to the results found by Bragagnolo and Rodriguez-Amaya (1995), Riëtte *et al.* (1999), and Alonso *et al.* (2008). Fatty acids number reported in pork studies is, generally, low. Enser *et al.* (1996) identified 20 fatty acids, Buege *et al.* (1998) identified 10 and Rhee *et al.* (1988) identified 8 with 5 as main. One exception is Bragagnolo and Rodriguez-Amaya (2002a, b) work, in which they identified 36 and 47 fatty acids, respectively.

Rosenvold and Andersen (2003) referred that fatty acids composition in animals raised outdoors, including biological production, is richer in MUFA compared to intensively raised animals meat due fundamentally to natural feed source rich in unsaturated fatty acids. According to Wood and Enser (1997), Bryhni *et al*. (2002), and Rosenvold and Andersen (2003), high percentages of PUFA can lead to soft meat affecting the product stability, increasing oxidation processes and break technological quality.

Both Preto Alentejano and commercial breeds show an emphasis on C16:0, C16:1 and C18:1 fatty acids in accordance with Estèvez *et al*. (2006), Monziols *et al*. (2007) and Ramirez and Cava (2007). Breed had a significant ($P$<0.01) effect on C16:0, C16:1 and C18:1. Preto Alentejano breed had higher percentage of these fatty acids than commercial breed (Table 3). Significant differences between breeds, on C16:0, C18:0 and C18:1, were also found by Cameron and Enser (1991), Wood *et al*. (2003) and Zhang *et al*. (2007). Commercial breed presented higher ($P$<0.05) percentage of C20:4 PUFA, in agreement with Alonso *et al*. (2008) who also found significant breed effect on C20:4 and C18:2.

In relation to sex differences, females showed higher ($P$<0.05) percentage of C16:0, C18:1 and C20:4 fatty acids than males. Carvalho (2003) reported similar results except for C20:4, which was higher in males and Alonso *et al*. (2008) obtained identical results on C16:0, C18:0 and C18:1, comparing females with castrated males but found no significant differences on C20:4. However, Cameron and Enser (1991) observed superior values of those fatty acids in males than females while Alonso *et al*. (2008) found significant sexes differences on C18:2.

In agreement with Bañon *et al*. (2003), Monin *et al*. (2003), de Smet *et al*. (2004), and Tang *et al*. (2008), no significant sex differences were found on the other detected fatty acids.

### Discriminant analysis

According to $F$ values of all variables considered in the analysis (Table 4), the stepwise method selected the following variables in 7 steps: C16:1, PUFA, C14, C18:1, SFA, C18 and MUFA.

Scatter plot of the first two canonical variables, of the four groups considered, Fig. 1 showed that groups were discriminated with great accuracy. In fact, the first canonical variable explained 54.97% of the total variance and the second 32.98%. The model accepted the third canonical variable as significant ($P$<0.001) and 12.1% of the total variance was accounted. Total variance (100%) was accounted by the three canonical variables and all individual of each group was assigned in the correct group pre-assigned, for 100% of corrected classified. The model is significant ($P$<0.0001) for 0.045 Wilks' lambda value. Analyzing the standardized discriminant scores the most important variables were MUFA, C18:1 and SFA in the first canonical variable, and MUFA, C18:1 and C16:1 in the second canonical variable whereas the C18:1 and C16:1 were the most important in the third canonical variable. The discriminant analysis confirm the usefulness to classify pork meat as has been used in several situations particularly in pork (Moss *et al*. 2000; Prieto 2007) or more recently Monroy *et al*. (2010).

## CONCLUSION

There were some differences found between the two types of breed meat studied in the present work that can be related to the exploitation system. Namely, the hardness, dark color, and fatness of Preto Alentejano meat compared to the commercial pork. Fatty acid composition, particularly the MUFA, C18:1 and C16:1, could be important variables to discriminate pork meat from Preto Alentejano breed from the other commercial pork meats and used in authentication meat products analysis.

## MATERIALS AND METHODS

### Animals and sampling

Animals had between 80 and 100 kg live weight and from two pork meat industries, one in the north working with a commercial Landrace×Largewhite cross and the other on the south of Portugal (Alentejo) working with Preto Alentejano. The Alentejano pig, is a black pig breed from this region and grazes in the "Montados" in autumn and winter, it is the so called period of "Montanheira". The "Montado" is an multifunctional system, that dominate the Alentejo landscape that have been managed by opening and selecting species of the Mediterranean Forest, grazing natural pastures and agricultural practices under and between the trees where animals as the pork Preto Alentejano are fed mainly on acorns from the cork and green oaks. In the opposite situation the commercial Landrace×Largewhite pigs were reared under intensive conditions and feeding on commercial and equilibrated concentrate.

A total of sixteen meat samples from 16 non-castrated animals were utilized. Eight meat samples per sex, and 8 per breed, in a total of 16 samples were randomly selected, in the two pork meat industries, corresponding to the *Longissimus thoracis et lumborum* muscle between the 5th thoracic vertebra and the 10th lumbar vertebra, vacuum packed and frozen at -21°C, and sent to Laboratory of Technology and Quality of the Carcass and Meat of the Agricultural School of Bragança, Portugal, for physical and chemical analysis.

## Instrumental analysis

Water holding capacity (WHC) was evaluated according to the Honikel procedure (Honikel 1998).

Shear force was evaluated, using an INSTRON 5543-J 3177 equipped with a Warner-Bratzler device. MTL muscles were cooked within plastic bags in a 70°C water bath for 90 min. Half an hour after, muscle sub-samples (1 $cm^2$ cross-section) were taken from each MTL muscle for shear force evaluation. For each animal eight shears were made. The measurement was recorded as the average yield force in kilograms, required to shear perpendicularly to the direction of the fibres.

## Chemical analysis

Protein content, total fat and fatty acids profile, ashes, pigments, and dry matter were evaluated. All analyses were made with three repetitions.

Haempigments were obtained using the reflectance of the exposed surface by spectroscopy by a Spectronic Unicam 20 Genesys e mode l4001/4 (Thermo Scientific, USA). The method is based on the muscle pigment content by Hornsey (1956).

Protein, ashes and moisture determinations were carried out following the Portuguese standard NP 1612 (2002), NP 1615 (2002) and NP 1616 (2002), respectively.

Fat determination was performed using the BÜCHI Fat Determination System (AOAC International) which consists of the Extraction Unit B-815 for simultaneous extraction/saponification of the fatty acids, and the Fat Determination B-820 which determines the fat content based on the isolated fatty acids by means of gas chromatography. The system was specifically designed for establishing total fat content as well as butyric acid determination. The Extraction Unit B-815 contains a compact heating block with four digestion positions. The samples were thoroughly mixed during digestion by magnetic stirring. The gas chromatographic separation of the extract was performed on a capillary column (DB-WAX 30 m×0.32 mm, film 0.25 mm), with hydrogen being applied as a carrier gas for the separation. Detection was done by a flame ionization detector. With the direct extraction method, the homogenized sample material was weighed into the reaction vessel together with the internal standard (tridecanoic acid) to an accuracy of 0.1 mg. In order to avoid heat-induced oxidation of the C-C double bonds of the MUFA and PUFA, approx. 50 mg ascorbic acid and 2 mL distilled or deionized water were added to the sample material. Following the addition of approx. 1.5 g potassium hydroxide and 45 mL n-butanol, boiled under reflux for 30 min while continuously stirring. The retention times were defined before the first analysis of a sample extract with the aid of a multi-component mixture consisting of six SFA. This mixture was injected in the same way as a sample and separated. The software auto-matically calculates the fat content, the content of saturated, mono- and poly-unsaturated fatty acids as well as the content of the individual fatty acids by mean of a pre-established factor. As final product, a layout with all fatty acids found, and the sums of the total SFA and unsaturated fats of the injected sample were obtained.

## Statistical analysis

The experimental design consisted of a factorial plan with 2 sexes and 2 breeds as fixed factors. Physical-chemical data were analysed using the Univariate Analysis of Variance procedure.

In order to know which meat characteristics would be more useful to classify the origin of meat (commercial or Preto Alentejano), a discriminant analysis was performed using the quadratic, different covariances and the stepwise variable selection methods. The efficiency of the discriminant power of the models selected was assessed by the test of the Wilks' lambda value. Results were analysed in terms of the absolute assignment of individuals to the pre-assigned group, the variance explained by each canonical likelihood and by the analysis of the standardized scoring coefficients.

Statistical analysis was performed using the statistical package JMP Pro 10 by Copyright© 2012 SAS Institut, Inc.

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(Managing editor ZHANG Juan)