Scientific Research

Effect of Breed and Sex on Pork Meat Sensory Evaluation

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Abstract

This work had an objective to evaluate the sensory quality of two categories of pork meat from a commercial pork meat and a selected meat from the Portuguese black pork (Preto Alentejano breed). Sixteen animals were used, 8 females and 8 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. Sensory analysis was performed by a trained taste panel of 10 elements, in 5 sessions. All evaluation conditions were standardized, and the attributes studied were odor intensity, toughness, juiciness and flavor intensity. The taste panel found differences mainly between breeds. The panellists scored Preto Alentejano meat as being juicier, tenderer, and with richer taste than Commercial meat. The higher juiciness score of Preto Alentejano meat was probably attributable to the higher intramuscular fat content compared with Commercial meat. The Commercial pork was characterized mainly by high toughness.

Keywords

Pork Meat; Sensory Evaluation; Generalized Procrustes Analysis

1. Introduction

Pork is one of the most traditional meats consumed by Portuguese people. From the 800 thousand tons of meat and meat products produced in Portugal, pork represents about 43% of total value. In Portugal, two native pig breeds are reared (Bisara and Alentejano), according to the FAO database. Recently, there has been a development of pig's breeds in Portugal, with many changes in production, processing and marketing taking place [1].

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The Preto Alentejano is a local non-improved swine breed which has survived during the last years owing to a demand increasing of Iberian products and the protection of origin designation products. Commercial pig breeds have great prolificacy and precocity which are raised purely in an intensive way, using a more advanced technology that translates into a possible improvement in terms of carcass yield.

Consumer accepts or rejects meat according to the feelings experimented when observing or ingesting it, thus evaluating food sensory quality. These sensory characteristics are perceived by senses resulting from food/consumer interaction. These perceptions will influence consumer decisions. Nevertheless, despite meat organoleptic characteristics, cooking methods can be important factors [2].

It is well known that there is variation among panelists when evaluating a sample [3]. To reduce variation it becomes necessary to develop a common language for the panelists to agree with the meaning of each term used in the evaluation of a samples set. Although it can take long time, training and discussion inside the panel are very useful to help all panelists evaluate each attribute similarly. However, no training can eliminate all variations [4]. Generalized Procrustes Analysis (GPA) [5] is a statistical method that adjusts some of the variation found. GPA is based on profiles standardization respecting to rotation/reflection, isotropic scaling and translation, in order to provide a better average which is the so called consensus configuration [3].

As referred by Dahl and Naes [6] (2004), Procrustes methods were first introduced in psychometrics, an important branch of multivariate statistical analysis. Since mid 80s, GPA has been used as a sensorial analysis standard tool, given the important contributions of Qannari et al. [7] and Wu et al. [8], among others. GPA is a multivariate technique to analyze data from various individuals, and is developed to allow food sensory analysis, where numerous judges give a score to diverse attributes of food samples. The interest is to know how individuals differ and how much they agree in their perceptions of the same object (food sample).

So the objective of this work is to study the effects of gender and breed in the sensory characterization of pork meat from a commercial and a local breed (Preto Alentejano).

2. Materials and Methods

The study was performed in the Laboratory of technology and quality of the carcass and meat of the Agricultural school of Bragança, using 8 females and 8 males from each of a commercial breed and the local breed Black pork (Preto Alentejano).

All animals weighted between 80 and 100 kg live weight. They came from two factories working in pig meat sector, one in the north and the other on the south of Portugal, both selling fresh meat and transformed products. Commercial animals were raised intensively, and fed based on commercial feed manufactured on their own factory. Alentejano animals were reared extensively, fed, almost exclusively, with acorns, complemented with fresh herbs, roots and aromatic herbs.

All animals were slaughtered at the abattoir of the factory where they came from, after 24 hours fasting, and carcasses were refrigerated at 4˚C for 24 hours. Carcasses were carefully halved, and from the right half, the *longissimus thoracis et lumborum* muscle was removed between the 5th thoracic vertebra and the 10th lumbar vertebra. The muscle was then vacuum packed and frozen at −21˚C until analysis. Samples were, then, properly transported to the laboratory of technology and quality of the carcass and meat in the Agriculture School of Bragança.

To evaluate the meat quality atrained taste panel of 10 experts, in five sessions, performed a sensory analysis.

The taste panel was constituted by a group of professors and other staff of the Polytechnic Institute of Bragança, already recruited for other research studies with meat and trained specifically to taste pork meat. Training consisted in two phases. The 1st, based in an individual evaluation of muscle *longissimus thoracis et lumborum* samples from five different species, and the second to adapt the panel elements to scales and sensory descriptors. All training and evaluation processes obeyed the Portuguese standards [9].

Sensory evaluations were conducted in a specific tasting room of the Agriculture School of Polytechnic Institute of Bragança. During evaluations, room temperature and moisture were maintained in 20˚C - 22˚C and 60% - 70%, respectively. Room light was white and in each booth the red light was used to mask the samples color.

Samples were taken from the muscle from the *longissimus thoracis et lumborum* on right side of the carcass between 10th and 12th lumbar vertebras. The day before the tasting session samples were thawed in a refrigerator at 4˚C. Then samples were wrapped in aluminum sheets and cooked in a conventional oven until internal temperature of 75˚C, measured by a penetration thermometer inserted in the sample center. After reaching the de-

sired temperature, samples were cut into small pieces of $2 \times 2 \times 0.5$ cm, perpendicularly to muscular fibers, involved again in aluminum sheets and put in small heaters to maintain their temperature. Samples were presented to sensory analysis panelists in the same conditions, blind, in a random and balanced distribution order, coded with 3 digits numbers. Each panelist had enough time to evaluate each sample and between samples clean the residues left by the previous sample in their mouths with water and Golden apples or toasts.

The tasting parameters evaluated were odor intensity, toughness, and juiciness and flavor intensity.

In each session panelists evaluated 8 samples using a 10-cm non-structured scale with intervals but not numbered, representing at the extremes the minimum (sensation absence) and the maximum (extremely intense sensation). Panelists were asked to indicate a point on the scale corresponding to the intensity of their different feelings for each attribute.

The experimental design consisted of a factorial plan with 2 sexes and 2 breeds as fixed factors, comprising 4 treatments: commercial females (FC), commercial males (MC), Preto Alentejano females (FP), and Preto Alentejano males (MP). An ANOVA was performed to study the differences between treatments, and when differences were significant a Tukey test was used to evaluate those differences. Generalized Procrustes Analysis was used to minimize differences between assessors of the sensory analysis. The data matrices of 4 (meat samples) by 4 (sensory parameters) for the 10 assessors (configurations) were matched to find a consensus using the XLSTAT, an add in of Excel software.

3. Results

Means and standard error of the mean for all sensory traits obtained from each treatment, and the significance of the differences between means after an ANOVA are shown in **Table 1**. The ANOVA showed significant differences on meat hardness and juiciness. However, means are very close to each other and this can justify the use of multivariate analysis as GPA. Also in the ANOVA, no differences were found on flavor and odor, and GPA could discriminate their relation with meat samples.

Table 2 shows the PANOVA that resumes the efficiency of each GPA transformation in terms of total variation reduction. Translation was the most efficient with p-value inferior to 0.0001.

Residuals by meat sample after transformation are identical and low (**Table 3**). Nevertheless, black females presented the lower residual, and for that were the most consensual among experts. On the other hand, Expert 9 had the highest residual (**Table 4**), and her/his evaluation did not match consensus. Two groups of experts could be grouped. The first group by experts 2, 3, 4, 7, 9 and 10 used a wider part of the scale while the second group by experts 1, 5, 6 and 8 used a narrower part of the scale, once their scaling factors were higher and lower than 1, respectively.

Table 1. Sensory scores (means ± SEM) for pork sensory analysis.

Sensory traits	FC	FP	MC	MP	p-value
Odor intensity	4.53 ± 0.266	5.07 ± 0.244	5.08 ± 0.269	4.52 ± 0.273	0.219
Hardness	4.99 ± 0.275[a]	3.60 ± 0.267[b]	4.47 ± 0.323[ab]	3.50 ± 0.274[b]	<0.0001
Juiciness	2.63 ± 0.221[b]	4.00 ± 0.233[a]	2.49 ± 0.211[b]	4.28 ± 0.251[a]	<0.0001
Flavor intensity	4.09 ± 0.255	4.45 ± 0.226	4.24 ± 0.238	4.49 ± 0.199	0.570

FC: Commercial female, FP: Black female, MC: Commercial male, MP: Black male. a, b: means in same row with different superscripts are significantly different.

Table 2. PANOVA for pork sensory analysis.

Source	DF	SS	MS	F	Pr > F
Residuals after scaling transformation	45	23.777	0.528		
Scaling transformation	9	10.713	1.190	2.253	0.035
Residuals after rotation	54	34.490	0.639		
Rotation	54	29.089	0.539	1.020	0.477
Residuals after translation	108	63.579	0.589		
Translation	36	196.884	5.469	10.351	<0.0001
Corrected total	144	260.463	1.809		

DF: Degrees of freedom, SS: Sum of squares, MS: Mean squares.

Table 3. Residual variance for each meat group for pork sensory analysis.

Meat sample[1]	Residual
FC	7.713
FP	4.461
MC	6.208
MP	5.395

[1]FC: Commercial female, FP: Black female, MC: Commercial male, MP: Black male.

Table 4. Residual variance, scaling factors and percentage variation explained by the first two principal components for each assessor for pork sensory analysis.

Assessor	Residual	Scaling factor	F1	F2	F3
1	2.549	0.800	94.642	3.623	1.734
2	2.357	1.609	33.400	55.642	10.958
3	1.582	1.040	60.601	32.062	7.337
4	1.298	2.977	36.549	34.258	29.193
5	2.671	0.682	86.209	5.775	8.016
6	2.812	0.784	60.204	3.770	36.026
7	3.061	2.464	15.309	41.314	43.376
8	1.501	0.789	74.107	22.240	3.653
9	4.368	1.042	24.333	28.500	47.167
10	1.578	1.229	59.620	35.807	4.574

F1, F2, F3: Factors obtained by performing the GPA.

Three axes were sufficient to explain 100% of total variability. The first represents 59.13%, the second 24.42%, and the third the remaining16.44% of the total variability.
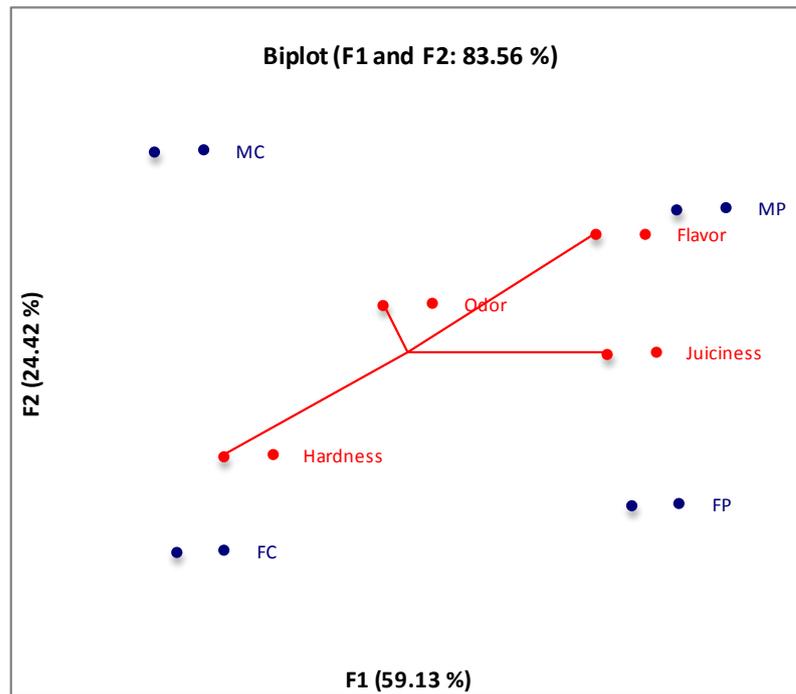
Figure 1 represents the correlation between meat samples and Factors 1 and 2. Factor 1 (F1) has high correlations with all attributes except odor intensity. Hardness is highly and negatively correlated with F1, while juiciness, and flavor intensity are highly and positively correlated with the same factor. F1 can be called Texture. Factor 2 (F2) has low correlations with all sensory attributes, but the highest were hardness and flavor intensity.

The coordinates of meat samples show that meat from Commercial breed is placed in the negative part of F1, and meat from Black pork are placed in the positive part of the same factor. This indicates that meat from animals of different breeds is separated by texture, both hardness and juiciness, but also by flavor. On the other hand, females are in the positive part of F2, and males in the negative part. So, sexes differ in hardness and flavor intensity.

Figure 2 represents the correlation between meat samples and Factors 1 and 3. Factor 1 (F1) has high correlations with all attributes except odor intensity, as mentioned before. Factor 3 correlated highly with odor intensity and can be called Odor. Taking into account the direction of the vector representing odor, which deviates from the coordinates of meat samples, it can be said that all meat samples presented low odor intensity. However, it would be commercial males and black females' meat the ones presenting higher values of that sensory attribute.

4. Discussion

Sensory analysis performed by trained panelists is the most appropriate tool to explain differences between treatments as perceived by humans. However, several times the sensory evaluation of meat has been misused and preference variables are included in descriptive studies and discussed only in terms of overall acceptability. Generalized Procrustes Analysis (GPA) is a powerful multivariate technique extensively used in sensory evaluation minimizing differences between assessors, identifying agreement between them and summarizing the sets of 3-dimensional data (objects, characteristics and assessors [10]. In the present study GPA produced a consensus configuration for sensory evaluation of pork meat by the taste panel, which is more significant respecting the samples than the original non transformed mean configuration. In the analysis mean by session, by expert and by meat sample was used. Only three axes were sufficient to explain 100% of total variability. The first two axes

F1 first principal component of GPA; F2 second principal component of GPA.

Figure 1. Consensus configuration: joint representation of correlation between sensory traits and F1 and F2; and groups of animal's meat coordinates for pork sensory analysis.
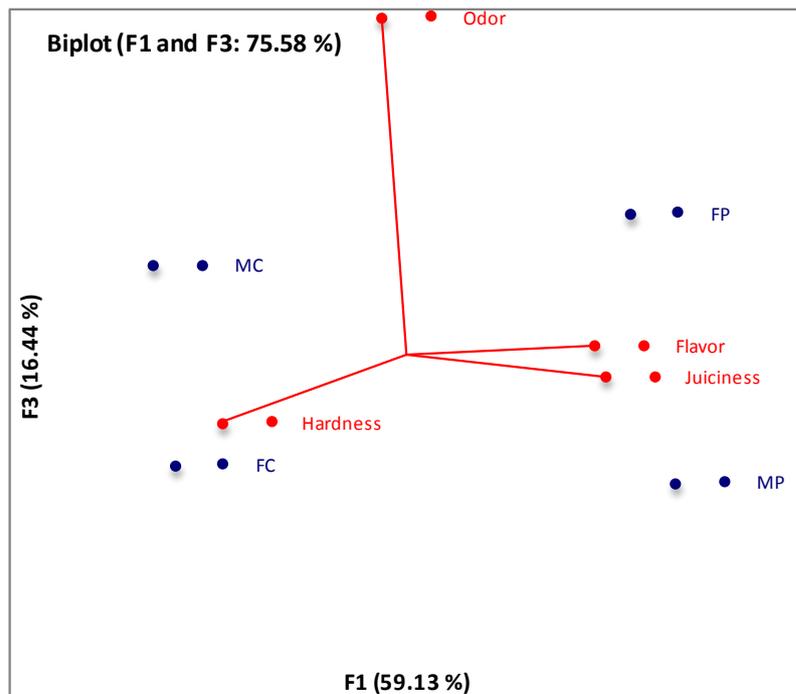
F1 first principal component of GPA; F3 third principal component of GPA.

Figure 2. Consensus configuration: joint representation of correlation between sensory traits and F1 and F3; and groups of animal's meat coordinates for pork sensory analysis.

accounted for by 83.6% of the variability. This is an accurate result though Jonsäll *et al*. [11] had explained 92% of the variability in sensory analysis of pork from different genotypes, by the first two factors in a Principal Components Analysis.

As found in the ANOVA and GPA, breed had a big effect on meat texture and Commercial breed was tougher than Black breed. Breed also had big effect on juiciness and flavor intensity, which attributes were higher in Black pork. These results are in agreement with Cameron *et al*. [12], comparing Duroc and British Landrace breeds; Wood *et al*. [13] and Edwards *et al*. [14] also found breed differences when evaluated texture by consumers panels, in Duroc, Landrace and Large White breeds. Lloveras *et al*. [15] also found breed differences on texture by a sensory panel; they verified Duroc meat was tougher than Yorkshire and Landrace meat. These findings were already reported by Persson *et al*. [16].

Black pork, raised outdoors, showed meat with higher juiciness and tenderness in relation to Commercial breed which contradicting the results obtained by some authors in studies also performing ANOVA and PCA (principal components analysis) by Enfaält *et al*. [17], working with loins from pigs reared outdoors that were less juicy and less tender than loins from pigs reared indoors; also Jonsäll *et al*. [18] showed that loins from pigs reared outdoors were less juicy than loins from pigs reared indoors; and as well as Jonsäll *et al*. [19] that found that loins of pigs from organic farm were less juicy than ones pigs reared conventionally while there was no difference in tenderness.

Results show in agreement with Cameron *et al*. [12] and against the popular belief that sex had lower effect on sensory attributes than breed as can be seen in **Figure 2** from the high correlation of Factor 3 with odor intensity suggesting the low odor intensity in all meat samples. These results was also in accordance with Wood *et al*. [20], who found low level of odor intensity, and no significant differences on pork meat odor of different breeds of animals fed on different diets. Globally according Rodrigues and Teixeira [21] results confirmed that GPA analysis may be an important tool for studying relationships between products and their sensory attributes and could assist producers and retailers in finding the best products to satisfy consumer requirements.

5. Conclusion

Assessors were able to distinguish the different meat samples and were generally very consensual in all sensory attributes. Black pork meat had higher juiciness and flavor intensity, while commercial pork was harder and presented a little higher odor intensity. Differences found between genders were low, but males presented higher odor and flavor, and females, particularly commercial females, were harder than males.

References

[1] Matos, C.A.P. (2000) Recursos Genéticos Animais e Sistemas de Exploração Tradicionais em Portugal. *Archivos de Zootecnia*, **49**, 363-383.

[2] Ibañez, F.C. and Barcina, Y. (2001) Análisis Sensorial de Alimentos. Métodos y Aplicaciones. *Journal of Animal Science*, **63**, 102-113.

[3] Arnold, G.M. and Williams, A.A. (1986) The Use of Generalised Procrustes Techniques in Sensory Analysis. In: Piggot, J.R., Ed., *Statistical Procedures in Food Research*, Elsevier, London, 233-253.

[4] Stone, H. and Sidel, J.L. (2004) Sensory Evaluation Practices. Academic Press Inc., Tragon Corporation, Redwood City, 408 p.

[5] Gower, J.C. (1975) Generalized Procrustes Analysis. *Psychometrika*, **40**, 33-51. http://dx.doi.org/10.1007/BF02291478

[6] Dahl, T. and Naes, T. (2004) Outlier and Group Detection in Sensory Panels Using Hierarchical Cluster Analysis with the Procrustes Distance. *Food Quality and Preference*, **15**, 195-208. http://dx.doi.org/10.1016/S0950-3293(03)00058-2

[7] Qannari, E.M., MacFie, H.J.H. and Courcoux, P. (1999) Performance Indices and Isotropic Scaling Factors in Sensory Profiling. *Food Quality and Preference*, **10**, 17-21. http://dx.doi.org/10.1016/S0950-3293(98)00033-0

[8] Wu, W., Guo, Q., de Jong, S. and Massart, D.L. (2002) Randomisation Test for the Number of Dimensions of the Group Average Space in Generalised Procrustes Analysis. *Food Quality and Preference*, **13**, 191-200. http://dx.doi.org/10.1016/S0950-3293(02)00024-1

[9] NP-ISO-8586-1 (2001) Norma Portuguesa ISO 8586-1. Análise Sensorial. Guia Geral para a Selecção, Treino e Controlo dos Provadores. Parte 1: Provadores Qualificados.

[10] Rodrigues, S. and Teixeira, A. (2009) Effect of Sex and Carcass Weight on Sensory Qaulity of Goat Meat of Cabrito Trnasmontano. *Journal of Animal Science*, **87**, 711-715. http://dx.doi.org/10.2527/jas.2007-0792

[11] Jonsäll, A., Johansson, L., Lundström, K., Andersson, K.H., Nilsen, A.N. and Risvik, E. (2002) Effects of Genotype and Rearing System on Sensory Characteristics and Preference for Pork (M. Longissimusdorsi). *Food Quality and Preference*, **13**, 73-80. http://dx.doi.org/10.1016/S0950-3293(01)00060-X

[12] Cameron, N.D., Warris, P.D., Porter, S.J. and Enser, M.B. (1990) Comparison of Duroc and British Landrace Pigs for Meat and Eating Quality. *Meat Science*, **27**, 227-247. http://dx.doi.org/10.1016/0309-1740(90)90053-9

[13] Wood, J.D., Jones, R.C.D., Francombe, M.A. and Wheleham, O.P. (1986) The Effects of Fat Thickness and Sex on Pig Meat Quality with Special Reference to the Problems Associated with Over-Leanness. 2. Laboratory and Trained Taste Panel Results. *Animal Production*, **43**, 535-544. http://dx.doi.org/10.1017/S0003356100002749

[14] Edwards, S.A. (2005) Product Quality Attributes Associated with Outdoor Pig Production. *Livestock Production Science*, **94**, 5-14. http://dx.doi.org/10.1016/j.livprodsci.2004.11.028

[15] Lloveras, M.R., Goenaga, P.R., Irureta, M., Carduza, F., Grigione, G., Garcia, P.T. and Amendola, A. (2008) Meat Quality Traits of Comercial Hybrid Pigs in Argentina. *Meat Science*, **79**, 458-462. http://dx.doi.org/10.1016/j.meatsci.2007.10.033

[16] Persson, J. and Stina, F.M. (1986) Carcass Properties as Related to Sensory Properties of Pork. Springer-Verlag Ibérica, Barcelona, 180 p.

[17] Enfält, A.C., Lundström, K., Hansson, I., Johansson, S. and Nyström, P.E. (1997) Comparison of Non-Carriers and Heterozygous Carriers of the RN Allele for Carcass Composition, Muscle Distribution and Technological Meat Quality in Hampshire-Sired Pigs. *Livestock Production Science*, **47**, 221-229. http://dx.doi.org/10.1016/S0301-6226(96)01409-1

[18] Jonsäll, A., Johansson, L. and Lundström, K. (2001) Effects of Red Clover Silage and RN Genotype on Sensory Quality of Prolonged Frozen Stored Pork (M. Longissimusdorsi). *Food Quality and Preference*, **11**, 371-376. http://dx.doi.org/10.1016/S0950-3293(00)00010-0

[19] Jonsäll, A., Johansson, L., Lundström, K., Andersson, K.H., Nilsen, A.N. and Risvik, E. (2002) Effects of Genotype and Rearing System on Sensory Characteristics and Preference for Pork (M. Longissimusdorsi). *Food Quality and Preference*, **13**, 73-80.

[20] Wood, J.D., Nute, G.R., Richardson, R.I., Whittington, F.M., Southwood, O., Plastow, G., Mansbridge, R., da Costa, N. and Chang, K.C. (2004) Effects of Breed, Diet and Muscle on Fat Deposition and Eating Quality in Pigs. *Meat Science*, **67**, 651-667.

[21] Rodrigues, S. and Teixeira, A. (2013) Use of Generalized Procrustes Analysis (GPA) to Test the Effects of Sex and Carcass Weight on Sensory Quality Evaluations of Terrincho Lamb Meat. *Meat Science*, **93**, 485-488. http://dx.doi.org/10.1016/j.meatsci.2012.10.011

Abbreviations

GPA: Generalized Procrustes Analysis
PCA: Principal Components Analysis
PANOVA: Procrustes analysis of variance
F1: First principal component of GPA
F2: Second principal component of GPA
FC: Commercial females
FP: Black females
MC: Commercial males
MP: Black males
SEM: Standard error of mean
DF: Degrees of freedom
SS: Sum of squares
MS: Mean squares