TITLE
Consumers' segmentation based on the acceptability of meat from entire male pigs with different boar taint levels, in four European countries: France, Italy, Spain and United Kingdom

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Abstract
The aim of this work was to conduct consumers' studies based on the acceptability of pork with different boar taint levels: test 1 performed in Spain (n=126) and United Kingdom (n=146), and test 2 done in France (n=139) and Italy (n=140). Each test had 3 types of pork: ‘Female meat’, ‘Low boar tainted meat’, and a third type was ‘Medium boar tainted meat’ or 'High boar tainted meat'. In the two consumer tests, 3 clusters were identified on the basis of ‘How delicious do you find this meat?’: (1) ‘pork lovers’, (2) ‘boar meat lovers’, (3) ‘Reject boar tainted meat’. Additionally, in test 2, a fourth cluster was identified: 'Reject low tainted meat'. A group of 16.2-38.2 % of consumers rejected meat from boars was identified, and a group between 12.4-21.7 % rated better the meat with medium or high levels of boar taint, suggesting that there is a niche for meat from medium and high levels of boar taint.

Highlights
- Consumer acceptability of entire male pork at eating.
- A segment of pork lovers, regardless the level of boar taint, has been identified.
- A segment of boar meat lovers has been identified.
- A segment of consumers that reject boar tainted meat has been identified.
- There is a niche for meat from medium and high levels of boar taint.
- Meat classification according to boar taint level is needed to better orientate it.

Keywords: acceptability, androstenone, boar taint, consumers, clusters, skatole
1. Introduction

Nowadays there is a growing concern about the negative effect of surgical castration of pigs without anaesthesia on animal welfare. In 2008, across Europe the majority of male piglets intended for pork production were castrated to avoid potential consumer dissatisfaction because of boar taint. At that time, castration was performed in most of the EU countries on 80-100% of the male pigs in conventional production, and surgical castration without anaesthesia was the most common technique (Fredriksen et al., 2009). The exceptions were United Kingdom and Ireland, where castration was hardly performed, and some southern countries such as Cyprus, Portugal and Spain, where a limited percentage of the male pigs were castrated in comparison to the other European countries. Since then, some countries have taken an action to avoid piglet castration without anaesthesia not only for welfare reasons, but also because the production of entire male pigs decreases production costs and results in higher meat content of the carcass (EFSA, 2004; PIGCAS, 2009). Norway and Switzerland have already banned piglet castration by law, and other countries such as The Netherlands and Germany have signed letters of intentions (Declaration of Noordwijk 2007 and Düsseldorf Declaration 2008, respectively) which aimed to avoid the need for piglet castration in the long term.

In 2010, at EU level, representatives of European farmers, meat industry, retailers, scientists, veterinarians and animal welfare NGOs, committed themselves to voluntarily end surgical castration of pigs in Europe by January 2018 by means of the European Declaration on alternatives to surgical castration of pigs (DG-SANCO, 2010). Consequently, entire male production is one of the alternatives and therefore, an increase in the production of entire males would result in a positive impact on the production efficiency and carcass composition. But as a consequence, more tainted carcasses could enter to the meat chain. A number of consumer studies have been carried out in order to ascertain the acceptability of pork from entire male pigs in different countries and using different methodologies as was reviewed in (EFSA, 2004) and more recently, by Font i Furnols (2012). The two main compounds responsible for boar taint are androstenone (Patterson, 1968) and skatole (Vold, 1970; Walstra & Maarse, 1970). The respective contributions of these two compounds vary depending on the characteristics of the meat evaluated, procedures for preparing the meat, the ability of consumers to perceive androstenone among others, as was been reviewed by Font i
Furnols (2012), and also it may vary depending on the habit of eating meat from
castrated or entire male pigs. Therefore, it would be interesting to study the impact that meat from boars could have
in the European market (Consumer satisfaction), which is traditionally used to eating
meat from castrated pigs, and identify if there is any difference comparing to other
countries where the utilization of entire male pigs is more common.
The present work had two main objectives: 1) to evaluate and update the results on
sensory acceptability of meat from entire male pigs (as an alternative to the production
of castrates), involving four European countries that produce different proportion of
castrated pigs in two consumer studies: Spain (33.2%) and United Kingdom (2.1%),
France (97.5%), and Italy (100%), and 2) to identify potential niche markets for meat
with different boar taint levels.

2. Materials and methods

2.1 Consumer studies and classification of consumers

Two consumer studies were conducted in two pair of countries where each consumer
assessed pork with various levels of androstenone and skatole. In each study, three
groups of meat samples were assessed:
• Consumer test 1. Pair of countries: Spain (ES, n=133, performed in Barcelona)
and United Kingdom (UK, n=146, performed in Reading);
• Consumer test 2. Pair of countries: France (FR, n= 139, performed in Cain &
Paris) and Italy (IT, n= 140, performed in Matelica & Reggio Emilia);
Considering the two consumer tests, a total of 558 consumers from the two different
pair of European countries participated in this project. They were stratified by age
(according to each country profile) and sex (approximately 50:50 ratio between men and
women). Consumers were required to eat pork on a regular basis.

2.2. Animals and samples

The meat and fat samples used for the consumer studies were obtained from populations
of pigs slaughtered according to commercial practice. They were collected from boars
and gilts in commercial abattoirs from Spain and France. Carcass weights and
genotypes were representative of current practice in these countries. The meat collected
in Spain was used for the consumer studies carried out in ES and UK; and the meat
collected in France was used for the consumer studies carried out in FR and IT.
For each consumer test, a minimum 20 loins from gilts, 20 loins from boars with Low Boar taint (LBT) and 20 loins from boars with Medium Boar taint (MBT) or High Boar taint (HBT) were selected. From each animal, the muscle *Longissimus lumborum* (with the subcutaneous fat) was taken from the 1st lumbar vertebra to the last rib, divided in two sections (min. 15 cm) and distributed in one of the two countries (Figure 1).

2.3. Androstenone and skatole measurements in fat

Back fat samples were collected on the day of slaughter at the level of the neck, vacuum packed and deep frozen until analyzed for androstenone (AND) and skatole (SKA). The determination of SKA levels was performed using HPLC-FLD and the determination of AND levels using GC-MS (for ES and UK samples, Ampuero et al., (2011)) or by HPLC-FLD (for FR and IT samples; Pauly, Spring, O'Doherty, Ampuero, & Bee (2008). Results were expressed as µg/g, on pure fat basis. Meat samples were classified as FE (meat from gilts), Low boar taint (LBT), Medium boar taint (MBT) or High boar taint (HBT) depending on the sex and the levels of boar taint compounds (Blanch et al., 2012; Table 1). Each consumer test and each session was carried out with 3 samples: samples from gilts (FE) as a reference, and two more samples with different levels of boar taint: in consumer test 1 (ES & UK) meat from LBT and MTB was used; and in consumer test 2 (FR & IT), meat from LBT and HBT.

2.4. Preparation of samples

In each location, loins were defrosted at 2-4 °C during 24h, and cut into 0.5 cm thick slices with 5 mm of subcutaneous fat (when it was possible). Each slice was cut in two pieces, and cooked using a cooking plate at 180°C (which was greased with maize oil). A different cooking plate was used for each type of meat presented within a session. The meat was turned upside down regularly until a core temperature of 80°C and the meat was salted after cooking, reproducing home preparation. Samples were then immediately served to the consumers for evaluation.

2.5. Sensory evaluation of samples

Sessions of 10-12 consumers were organised for meat evaluation. Each consumer assessed 3 pieces of meat, one from 3 levels of boar taint (Table 1). A 10 minute interval was used between each of the three samples presented within a session. The order of presentation of samples was rotated using a partial Latin square design to avoid any first sample and carry-over effect and the identity of the samples was not given to
consumers (Macfie, Bratchell, Greenhoff, & Vallis, 1989). Consumers were asked for
hedonic questions (questions 1 to 4) and intensity evaluations (questions 5-11) as
described in Table 2, using a modified nine-point intensity scale (from 1 to 9). The
intermediate level (5) was not included to stimulate consumers to commit themselves
and not to allow a neutral assessment which is not informative (Guerrero, 1999). The
attributes ‘Delicious’, ‘Odour’ and ‘Taste’ were rated on a scale going from 1 = ‘dislike
very much’ to 9 = ‘like very much’, whereas the attributes ‘Strength of odour’,
‘Abnormal odour’, and ‘Abnormal taste’ were scored between 1 = ‘low perception’ to 9
= ‘strong perception’.

2.6. Description of EU pork consumers.

At the end of the test, consumers also answered socio-demographic questions and
frequency of consumption of different pork products, the most common purchasing
place for fresh pork meat, if they were responsible for buying fresh pork at home, if they
were responsible for cooking at home, and if they usually eat the pork with the fat.

2.7. Statistical analysis

Data analyses were conducted using SAS Statistical Package (SAS Inst., Inc., Cary, NC,
USA, version 9.2). To analyse the parameters regarding classification of consumers
(age, gender, educational level, frequency of consumption of different pork products,
the most common purchasing place for fresh pork meat, if they were responsible for
buying fresh pork at home, if they were responsible for cooking at home, and if they
usually eat the pork with the fat), FREQ and GENMOD procedures were applied. The
MIXED procedure was used to analyse the acceptability of odour and flavour by
consumers: the model included the type of animal, sensitivity to AND and their
interaction as fixed effects, session as blocking variable and consumer as random effect.
Only the significant (P<0.05) interactions were kept in the model. Differences were
declared at P<0.05 and tendencies at P<0.10.

In order to establish different clusters of consumers a hierarchical cluster analysis was
performed with the CLUSTER procedure and the Ward method. The cluster analysis
was conducted on the basis of the attribute ‘delicious’.

For each cluster, the MIXED procedure was then used to analyse the hedonic attributes
(delicious, odour, taste, and in-mouth feeling) and the intensity attributes (strength of
odour and strength of taste, abnormal odour and abnormal taste) scored by the
consumers. The model included the type of animal and country as fixed effects, session
as blocking effect and consumer as random effect. The interaction Type of animal and Country was removed from the model because it was not significant (P<0.05). Differences were also declared at P<0.05.

3. Results

3.1. Description of consumers

The description of consumers according to the gender, age and educational level is described in Table 3. A total of 558 consumers participated in the two consumer studies (consumer test 1: n=279; consumer test 2: n=279). In each one, the proportion of men and woman was around 50 % (consumer test 1: 52 %; consumer test 2: 62 %).

In consumer test 1 (ES & UK), 15, 25, 41 and 19 % of the consumers were 18-25, 26-40, 41-60 and > 60 % of age respectively; and in consumer test 2 (FR & UK), 12, 27, 51 and 10 % of the consumers were 18-25, 26-40, 41-60 and > 60 % of age respectively.

3.2. Habits of European consumers regarding pork consumption

In general, over ninety percent of consumers ate fresh pork > 2 times/week (ES 95.5 %; UK 97.3 %; IT 92.9 %) except for FR (34.8 %). The most consumed product was dry cured ham in ES and IT, cooked ham in FR, and sliced bacon in UK (Figure 2).

In general, the percentage of respondents responsible for buying fresh pork in their household was 86.4 % (Table 4). In all countries, women were more responsible for buying fresh pork than men, and they were mostly between 41-60 years old. Eighty-eight percent of respondents were partially responsible for cooking at home. Women were more responsible for cooking at home than men. France was an exception, where percentages were very similar 49.6 % women and 50.4 % men cooked at home.

Considering all respondents, 43.5 % use to eat the pork with the fat in all the countries (36.4 % of women and 53.1 % of men). Considering the place of purchasing fresh pork meat, the supermarket was the most common one, followed by the butcher and finally the traditional market.

3.3. Sensory evaluation

The hedonic evaluation of in-mouth feeling and of the intensity of salty, meaty and fatty tastes did not result in any consistent difference between meat sample groups and it is not presented.
3.3.1 Differences between meat sample groups, within experiments.

Table 5 shows significance levels within a consumer test: Consumer test 1 carried out in Spain and United Kingdom, and Consumer test 2 carried out in France and Italy. Results showed that no significant interaction between the boar taint level and the country in each consumer test.

In consumer test 1 (ES & UK), significant differences (P<0.05) were observed for the hedonic attributes assessed by the consumers (delicious, odour and taste). In all the cases, the score given to the meat from FE and MBT was significantly higher (more favourable) than the one given to the meat from LBT (Table 6). With regard to the intensity evaluations, significant differences were observed between type of meat when considering strength of odour and strength of taste (P<0.05) whereas no differences were observed when taking into account the attributes abnormal odour and abnormal taste. Results showed that the strongest odour was observed in MBT and FE meat, and the highest strength of taste was observed in MBT in comparison to LBT.

In consumer test 2 (FR & IT), significant differences (P<0.05) were observed for the hedonic delicious, odour and taste (Table 7). For all of them, HBT meat was rated worst (lower scores) than FE meat. Considering the intensity scores, significant differences (P<0.05) were observed for the attributes strength of taste and abnormal taste. In both cases, HBT received the highest score (strongest taste and abnormal taste).

3.3.2 Consumer segmentation in consumer test 1: Spain and United Kingdom

Due to the fact that the interaction between Type of meat and Country was not significant, results are presented considering consumers from the two countries together. A total of three clusters were identified on the basis of 'how delicious do you find this meat'. Figure 3 shows least square means and standard error of the scores that consumers gave to each attribute (hedonic attributes: delicious, odour and taste; intensity attributes: strength of odour and strength of taste) and each type of meat (FE, LBT, MBT), for each cluster identified:

- The first cluster (n=169, 62.1 % of the sample; 57.4 % from Barcelona and 42.6 % from Reading) comprises respondents that gave high scores to all types of samples. These consumers were labelled as ‘Pork lovers’.
- The second cluster (n=59, 21.7 % of the sample; 30.5 % from Barcelona and 69.5 % from Reading) comprises respondents that liked the boar taint and therefore, the
higher the level of boar taint, the higher the score to the attribute. These consumers were considered as ‘Boar meat lovers’.

- The third cluster (n=44, 16.2 % of the sample; 25.0 % from Barcelona and 75.0 % from Reading) comprises respondents that did not liked the boar taint and therefore, the higher the level of boar taint, the lower the score to the attribute ‘Delicious’. These consumers were labelled as ‘Reject boar tainted meat’.

The three clusters did not display any relevant difference on the basis of demographic data variable (age, gender and educational level).

3.3.3. Consumer segmentation in consumer test 2: France and Italy

As observed in consumer test 1, due to the fact that the interaction between Type of meat and Country was not significant, results are presented considering consumers from the two countries together. In this consumer test, a total of four clusters were identified on the basis of ‘how delicious do you find this meat’ (Figure 4).

- The first cluster (n=136, 49.5 % of the sample; 57.4 % from France and 42.6 % from Italy) comprises respondents that gave high scores to all types of samples. These consumers were labelled as ‘Pork lovers’.

- The second cluster (n=34, 12.4 % of the sample; 23.5 % from France and 76.5 % from Italy) comprises respondents that liked the boar taint and therefore, the higher the level of boar taint, the higher the score to the attribute. These consumers were considered as ‘Boar meat lovers’.

- The third cluster (n=55, 20.0 % of the sample; 49.1 % from France and 50.9 % from Italy) comprises respondents that did not liked the HBT meat and therefore, the higher the level of boar taint, the lower the score to the attribute ‘Delicious’. These consumers were labelled as ‘Reject boar tainted meat’.

- The fourth cluster (n=50, 18.2 % of the sample; 52.0 % from France and 48.0 % from Italy) comprises respondents that gave low scores to the meat with LBT. These consumers were labelled as ‘Reject low boar tainted meat’.

4. Discussion

In the present paper, two consumer studies were carried out with the aim to ascertain consumer acceptability of boar meat with different levels of boar taint. Due to practical reasons, meat was collected in Spain and France, chemically analysed in terms of androstenone and skatole levels, and then distributed to two other countries: meat from
Spain was used for the consumer test for Spain and United Kingdom, and meat from France was used for the consumer test carried out in France and Italy. It is interesting to highlight that, consumer test 1 was planned in two countries where, as pointed out by Frederiksen et al. (2009), were used to the commercialization of meat from entire male pigs, whereas consumer test 2 was carried out in two countries where consumers were not used to this type of meat: in 2008, the percentage of production of castrated male pigs was estimated as 33.2 % in ES, 2.1 % in UK, 97.5 % in FR and 100 % in IT.

It is also interesting to point out that, in the two consumer studies, consumers were able to taste meat from entire male pigs with such low levels of boar taint comparable to the levels found in meat from gilts (Bonneau & Chevillon, 2012; type of meat LBT - low boar taint- and FE - meat from gilts). Additionally, each study had a third type of meat with medium levels (MBT in study 1) or high levels (HBT in study 2) of boar taint.

4.1. Methodology used

As reviewed by Font i Furnols (2012), the methodologies used in the already published papers are very diverse and therefore, it is difficult to compare the results among them. Issues such as type of meat (loin slices, chops, cutlets, mince meat, fat, bacon, dry cured ham...), location of the test (hall or home test), cooking procedure (including cooking device, cooking time and temperature), type of meat samples (meat from gilts, castrated pigs and/or from entire male pigs), level of boar taint in the assessed meat, and the type of attributes and scales used during the consumer test are only some examples. As stated in the methodology section, in this paper we used meat from the Longissimus lumborum muscle from the 1st lumbar vertebra to the last rib, and on the day of the consumer test, the meat was cut into 0.5 cm thick slices with a maximum of 5 mm of subcutaneous fat. The acceptance of boar meat is assumed to be dependent on the sample preparation and presentation. In this study, meat samples were cooked on a hot plate and were served uncovered to the participants to simulate a meal at home. This kind of preparation is not very common in previously published papers although it is very similar to the type of preparation that consumers usually do at home. Since AND and SKA are predominantly released during heating (Lunde et al., 2008), the intensity of these volatile compounds is expected to be higher during the preparation than at consumption. In our study, consumers were not involved in the cooking process. Therefore, due to the fact that the meat came from a very lean piece of meat, the thickness of the sample and the fact that
it was served uncovered, the methodology used in the present paper could minimize the perception of boar taint.

4.2. Overall acceptability

Taking into account that different methodologies have been used in the already published consumer tests carried out in different countries (reviewed by Font i Furnols (2012), results obtained in a given country cannot be extrapolated to another one. The present paper, however, provides the results from 4 countries using the same methodology.

In terms of hedonic assessment, in consumer test 1 (ES & UK) meat with low levels of boar taint (LBT) was worst rated than meat with medium boar taint levels (MBT). Considering consumer test 2 (FR & IT), meat with high levels of boar taint (HBT) was worst rated than meat from female (FE), and meat with low levels of boar taint (LBT) was scored in between. In the two countries were consumers are used to eating boar meat (consumer test 1) the meat with medium levels of boar taint was scored better than the meat with low levels of boar taint, whereas in the two countries were consumers were not used to eating meat from entire male pigs (consumer test 2), the higher the level of boar taint, the worst score given by the consumers. Since the results obtained were not conclusive, the need of an extra statistical analyses was identified.

To the best of our knowledge, the cluster analyses with the aim to identify consumers segmentation based on the question 'How delicious do you find this meat (with different levels of boar taint)' has not been applied yet. So far, consumer segmentation was identified on the basis of the sensitivity test described by (Weiler et al., 2000) based on smelling crystals of pure androstenone.

4.3. Consumer segmentation based on the hedonic attribute Deliciousnes

To identify the existence of market segmentation, a hierarchical cluster analysis was conducted for each consumer test. As a result, similar cluster solution was identified as best explaining data for each consumer study. Three groups or clusters were identified in consumer test 1 (ES & UK), and four in consumer test 2 (FR & IT). Interestingly, although the boar taint level of the most tainted type of meat (Table 1) was different in the two studies, clusters with similar behaviour were observed: the first three clusters identified were labelled as Pork lovers, Boar meat lovers and Reject boar tainted meat:

- Cluster 1 (Pork lovers) rated the three types of meat with relatively high scores (all of them over 5 in a 9-point scale). This cluster represents 62.1 % of the sample in
consumer test 1, and 49.5 % of the sample in consumer test 2. In both cases, compared to the other clusters identified, this one comprises the higher percentage of consumers. Despite the fact that significant differences between the type of meat have been observed in the different attributes in both studies, it is remarkable that all the scores were relatively high. This segment of consumers was found in the two consumer tests, despite the levels of boar taint in the type of meats assessed. In the case of consumer study 1 (ES & UK), scores given to the LBT meat was significantly lower (worst score, but still over 5 in the 9-point scale) than the meat from FE and MBT, which could explain the results when considering the overall acceptability.

- Cluster 2 (Boar meat lovers) rated the meat from gilt (FE) with lower scores, and the meat with MBT or HBT with higher scores. Meat with LBT was scored in-between in both cases. This cluster represents 21.7 % of the sample in consumer test 1, and 12.4 % of the sample in consumer test 2. The lower percentage of consumers that are part of this cluster in study 2 may be explained because the highest level of boar taint meat was higher in comparison to the levels in consumer study 1. In fact, it is reported that some of the sensitive consumers like the androstenone smell and it influences their scores (Blanch et al., 2012; Bonneau & Chevillon, 2012; Font i Furnols, Gispert, Diestre, & Oliver, 2003).

- In cluster 3 (Reject boar tainted meat) meat from gilt received the highest (best) score in both consumer tests, while meat with medium levels (MBT in study 1) or high levels (HBT in study 2) received the lowest (worst) score. This cluster represents 16.2 % of the sample for the consumer test 1, and 20.0 % of the sample in consumer test 2. These results are also in line to the results obtained in cluster 2. Since the levels of boar taint were higher in consumer test 2, and due to the fact that the consumers that tasted this meat were not used to boar meat, it was expected to find a higher percentage of consumers rejecting the boar tainted meat. It is interesting to highlight that the type of meat scored below 5 (in a 9-point scale) was HBT for consumer test 2, and MBT for consumer test 1. In both cases, the meat with LBT was scored in-between, but with scores around 5. Therefore, these consumers rejected meat with medium or high boar taint, but not the type of meat with low boar taint.

Additionally, in consumer test 2 (FR & IT) there was a fourth cluster identified and labelled as consumers that Reject low boar tainted meat, representing 18.2 % of the
sample. In this one, the meat with low boar taint received the lowest (worst) score in all the attributes (between 4.3 and 5.1). The identification of this cluster could be expected if we take into account that it has been found in the two countries were consumers are not used to the meat from entire male pigs.

Considering the percentage of consumers being part of each cluster (Figure 5), a percentage of 16.2 % (from cluster 3) in consumer study 1 (ES & UK) and 38.2 % (from cluster 3 plus 4) in consumer study 2 (FR & IT) could react negatively when eating meat from entire male pigs. Again, to understand these differences two facts should take into account: (i) meat with boar taint used in FR and IT had higher boar taint levels than the meat used for ES and UK, and (ii) consumers from FR and IT were not used to eat meat from entire male pigs. (Diestre, Oliver, Gispert, Arpa, & Arnau, 1990) stated that androstenone might not be a problem in countries where the production of young animals is common. Results from the present paper disagree on that statement since cluster 3 was identified in the four countries involved, which slaughter pigs at very different carcass weight (in 2009, FR: 80 kg; ES: 82kg and UK: 80kg; and in IT: 125kg, which corresponds exclusively to castrated pigs-; EUROSTAT).

4. Conclusions and implications
The present study shows that, when eating fresh pork (loin 0.5 cm thick with 5 mm back fat, cooked in a hot plate and served uncovered), different groups of consumers could be identified on the basis of 'How delicious do you find this meat'. Among them, a group of consumers that like pork meat (49.5 - 62.1% of the participants), a group of consumers that prefer meat with boar taint (12.4 - 21.7 %) and a group of consumers that reject boar tainted meat (16.2 - 20.0 %) has been identified. Results suggest that there is a group of consumers may reject meat with boar taint, but there is also a niche for meat from medium and high levels of boar taint in the cities studied. Therefore, the present research identifies a need to develop tools to select and classify carcasses on the basis of boar taint level. This situation can influence pork consumption so that it might guarantee that consumers do not purchase pork with inadequate sensory quality.

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Figure Captions

Figure 1. Sampling procedure for each consumer test.

Figure 2. Percentage of European consumers eating fresh pork more than twice per week and frequency of consumption of different pork products.

Figure 3. Least square means for hedonic traits and abnormal odour/taste given by three clusters observed in consumer test 1 (Spanish and English consumers).

Figure 4. Least square means for hedonic traits and abnormal odour/taste given by three clusters observed in consumer test 2 (French and Italian consumers).

Figure 5. Percentage of consumers representing each cluster identified in the two consumer studies.
Table Captions

Table 1. Mean and standard error of the androstenone and skatole levels on the pure fat basis, of the meat used for the consumer test.

Table 2. Questionnaire and scoring scales for the evaluation of meat samples during eating.

Table 3. Description of consumers according to gender, age and educational level.

Table 4. Frequency (%) of consumption of different pork products according to each country participant in the study.

Table 5. Significance levels within a consumer test: consumer test 1 carried out in Spain and United Kingdom, and consumer test 2 carried out in France and Italy.

Table 6. Least square means and standard error in consumer test 1 (ES & UK) of the scores given by consumers of meat from gilts (FE), from entire males with low levels of skatole and androstenone (LBT), and entire male pigs with medium boar taint (MBT).

Table 7. Least square means and standard error in consumer test 2 (FR & IT) of the scores given by consumers of meat from gilts (FE), from entire males with low levels of skatole and androstenone (LBT), and entire male pigs with high boar taint (HBT).
Figures.

Figure 1. Sampling procedure for each consumer test.
Figure 2. Percentage of European consumers eating fresh pork more than twice per week and frequency of consumption of different pork products.

**Fresh pork (times/week)**

- **ES**: 95.5% (1), 4.3% (2), 0.2% (>2)
- **UK**: 97.3% (1), 2.2% (2), 0.5% (>2)
- **FR**: 29.7% (1), 35.5% (2), 34.8% (>2)
- **IT**: 5.7% (1), 92.9% (2), 1.4% (>2)

**Consumer test 1**

- **ES**
  - Cooked ham: 71.2%
  - Ribs: 24.1%
  - Pork loin: 53.4%
  - Sausage: 47.4%
  - Dry cured ham: 82.0%
  - Minced meat: 28.6%
  - Bacon (sliced): 26.3%
  - Pork Chops: 27.8%

- **UK**
  - Cooked ham: 59.6%
  - Ribs: 5.5%
  - Pork loin: 7.5%
  - Sausage: 61.0%
  - Dry cured ham: 54.1%
  - Minced meat: 11.0%
  - Bacon (sliced): 23.3%
  - Pork Chops: 64.4%

- **FR**
  - Cooked ham: 65.4%
  - Ribs: 16.3%
  - Pork loin: 15.4%
  - Sausage: 42.6%
  - Dry cured ham: 58.2%
  - Minced meat: 13.1%
  - Bacon (sliced): 27.3%
  - Pork Chops: 46.3%

- **IT**
  - Cooked ham: 49.6%
  - Ribs: 13.2%
  - Pork loin: 22.4%
  - Sausage: 43.5%
  - Dry cured ham: 73.9%
  - Minced meat: 19.1%
  - Bacon (sliced): 9.0%
  - Pork Chops: 27.5%
Figure 3. Least square means for hedonic traits and abnormal odour/taste given by three clusters observed in consumer test 1 (Spanish and English consumers).

Cluster 1 - Pork lovers  
(n=169, 62.1 %)  
Hedonic delicious (P<0.0001)  
Strength of taste (P=0.02)  
Hedonic odour (P<0.0001)  
Hedonic taste (P<0.0001)  
Strength of odour (P<0.0001)

Cluster 2 - Boar meat lovers  
(n= 59, 21.7 %)  
Hedonic delicious (P<0.0001)  
Strength of taste (P=0.0088)  
Hedonic odour (P=0.3335)  
Hedonic taste (P=0.0088)  
Strength of odour (P<0.0001)

Cluster 3 - Reject boar tainted meat  
(n= 44, 16.2 %)  
Hedonic delicious (P<0.0001)  
Strength of taste (P=0.0004)  
Hedonic odour (P<0.0002)  
Hedonic taste (P<0.0002)  
Strength of odour (P=0.092)
Figure 4. Least square means for hedonic traits and abnormal odour/taste given by three clusters observed in consumer test 2 (French and Italian consumers).
Figure 5. Percentage of consumers representing each cluster identified in the two consumer studies.

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Consumer Study 1 (ES &amp; UK)</th>
<th>Consumer Study 2 (FR &amp; IT)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork lovers</td>
<td>62.1%</td>
<td>49.5%</td>
</tr>
<tr>
<td>Boar meat lovers</td>
<td>21.7%</td>
<td>12.4%</td>
</tr>
<tr>
<td>Reject boar tainted meat</td>
<td>16.2%</td>
<td>18.2%</td>
</tr>
<tr>
<td>Reject low boar tainted meat</td>
<td></td>
<td>20.0%</td>
</tr>
</tbody>
</table>
Table 1. Mean and standard error of the androstenone and skatole levels on the pure fat basis, of the meat used for the consumer test.

<table>
<thead>
<tr>
<th></th>
<th>androstenone (ppm pure fat)</th>
<th>skatole (ppm pure fat)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[range]</td>
<td>[range]</td>
</tr>
<tr>
<td><strong>Consumer test 1: ES &amp; UK</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gilt (FE)</td>
<td>&lt; 0.04</td>
<td>0.04 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>[0.02-0.07]</td>
<td></td>
</tr>
<tr>
<td>Low Boar Taint (LBT)</td>
<td>0.20 ± 0.07</td>
<td>0.06 ± 0.02</td>
</tr>
<tr>
<td></td>
<td>[0.04-0.29]</td>
<td>[0.02-0.08]</td>
</tr>
<tr>
<td>Medium Boar Taint (MBT)</td>
<td>1.07 ± 0.40</td>
<td>0.18 ± 0.07</td>
</tr>
<tr>
<td></td>
<td>[0.58-2.28]</td>
<td>[0.11-0.39]</td>
</tr>
<tr>
<td><strong>Consumer test 2: FR &amp; IT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gilt (FE)</td>
<td>&lt;0.2</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>Low Boar Taint (LBT)</td>
<td>&lt;0.2</td>
<td>&lt;0.03</td>
</tr>
<tr>
<td>High Boar Taint (HBT)</td>
<td>2.39 ± 1.07</td>
<td>0.11± 0.07</td>
</tr>
<tr>
<td></td>
<td>[0.59-5.18]</td>
<td>[0.02-0.28]</td>
</tr>
</tbody>
</table>

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.
Table 2. Questionnaire and scoring scales for the evaluation of meat samples during eating.

<table>
<thead>
<tr>
<th>Questions</th>
<th>Scoring scales&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hedonic evaluations</strong></td>
<td></td>
</tr>
<tr>
<td>1. How delicious do you find this product?</td>
<td>1. Not good at all</td>
</tr>
<tr>
<td></td>
<td>9. Really delicious</td>
</tr>
<tr>
<td>2. What do you think of the odour?</td>
<td>1. Not pleasant at all</td>
</tr>
<tr>
<td>4. What do you think of the in-mouth feeling?</td>
<td></td>
</tr>
<tr>
<td><strong>Intensity evaluations</strong></td>
<td></td>
</tr>
<tr>
<td>5. Strength of odour</td>
<td>1. Barely perceptible</td>
</tr>
<tr>
<td>6. Abnormal odour</td>
<td>9. Very strong</td>
</tr>
<tr>
<td>7. Strength of taste</td>
<td></td>
</tr>
<tr>
<td>8. Salty taste</td>
<td></td>
</tr>
<tr>
<td>9. Meaty taste</td>
<td></td>
</tr>
<tr>
<td>10. Fatty taste</td>
<td></td>
</tr>
<tr>
<td>11. Abnormal taste</td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> All scoring scales were from 1 to 9, without 5.
Table 3. Description of consumers according to gender, age and educational level.

<table>
<thead>
<tr>
<th></th>
<th>Consumer test 1</th>
<th></th>
<th>Consumer test 2</th>
<th></th>
<th></th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ES</td>
<td>UK</td>
<td>FR</td>
<td>IT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>133</td>
<td>146</td>
<td>139</td>
<td>140</td>
<td>558</td>
<td></td>
</tr>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>54.9</td>
<td>50.0</td>
<td>49.6</td>
<td>74.3</td>
<td>42.8</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>45.1</td>
<td>50.0</td>
<td>50.4</td>
<td>25.7</td>
<td>57.2</td>
<td></td>
</tr>
<tr>
<td>Age (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-25</td>
<td>10.5</td>
<td>19.9</td>
<td>15.1</td>
<td>10.0</td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td>26-40</td>
<td>30.8</td>
<td>19.2</td>
<td>28.8</td>
<td>25.7</td>
<td>26.0</td>
<td></td>
</tr>
<tr>
<td>41-60</td>
<td>43.6</td>
<td>39.0</td>
<td>41.0</td>
<td>60.0</td>
<td>45.9</td>
<td></td>
</tr>
<tr>
<td>&gt;60</td>
<td>15.0</td>
<td>21.9</td>
<td>15.1</td>
<td>4.3</td>
<td>14.2</td>
<td></td>
</tr>
<tr>
<td>Educational level (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary studies not completed</td>
<td>3.0</td>
<td>0.0</td>
<td>11.7</td>
<td>2.9</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>Primary studies</td>
<td>12.1</td>
<td>4.8</td>
<td>3.6</td>
<td>25.0</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>Secondary studies</td>
<td>53.8</td>
<td>61.6</td>
<td>46.0</td>
<td>29.4</td>
<td>47.9</td>
<td></td>
</tr>
<tr>
<td>University studies</td>
<td>31.1</td>
<td>33.6</td>
<td>38.7</td>
<td>42.6</td>
<td>36.5</td>
<td></td>
</tr>
</tbody>
</table>

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.
Table 4. Frequency (%) of consumption of different pork products according to each country participant in the study.

<table>
<thead>
<tr>
<th>Consumer test 1</th>
<th>Consumer test 2</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ES 133</td>
<td>UK 146</td>
</tr>
<tr>
<td>n</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are you partially responsible of doing the shopping of fresh pork eaten in your household?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>78.9</td>
<td>81.5</td>
</tr>
<tr>
<td>Are you partially responsible for cooking in your household?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>80.5</td>
<td>82.9</td>
</tr>
<tr>
<td>When you eat the pork meat, do you eat it…</td>
<td></td>
<td></td>
</tr>
<tr>
<td>without the fat</td>
<td>58.6</td>
<td>43.8</td>
</tr>
<tr>
<td>with the fat</td>
<td>41.4</td>
<td>56.2</td>
</tr>
<tr>
<td>Where do you buy fresh pork meat?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>At the butcher</td>
<td>58.6</td>
<td>21.9</td>
</tr>
<tr>
<td>At the supermarket</td>
<td>72.2</td>
<td>95.9</td>
</tr>
<tr>
<td>At the traditional market</td>
<td>42.1</td>
<td>4.8</td>
</tr>
</tbody>
</table>

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.
Table 5. Significance levels within a consumer test: consumer test 1 carried out in Spain and United Kingdom, and consumer test 2 carried out in France and Italy.

<table>
<thead>
<tr>
<th></th>
<th>Consumer test 1 (ES &amp; UK)</th>
<th></th>
<th>Consumer test 2 (FR &amp; IT)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n= 279</td>
<td></td>
<td>n= 279</td>
<td></td>
</tr>
<tr>
<td>BT</td>
<td>C</td>
<td>BTxC</td>
<td>S</td>
<td>BT</td>
</tr>
<tr>
<td>Hedonic evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>delicious</td>
<td>**</td>
<td>***</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>odour</td>
<td>***</td>
<td>***</td>
<td>ns</td>
<td>*</td>
</tr>
<tr>
<td>taste</td>
<td>***</td>
<td>**</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Intensity evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>strength of odour</td>
<td>***</td>
<td>***</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>abnormal odour</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>strength of taste</td>
<td>*</td>
<td>†</td>
<td>ns</td>
<td>†</td>
</tr>
<tr>
<td>abnormal taste</td>
<td>ns</td>
<td>**</td>
<td>ns</td>
<td>†</td>
</tr>
</tbody>
</table>

BT: boar taint level; C: country; BTxC: interaction Boar taint level x Country; S: Session of the sensory evaluation.
ns: P>0.10; †: P ≤ 0.10; *: P ≤ 0.05; **: P ≤ 0.01; ***: P ≤ 0.001
Table 6. Least square means and standard error in consumer test 1 (ES & UK) of the scores given by consumers of meat from gilts (FE), from entire males with low levels of skatole and androstenone (LBT), and entire male pigs with medium boar taint (MBT).

<table>
<thead>
<tr>
<th></th>
<th>FE</th>
<th>LBT</th>
<th>MBT</th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSM</td>
<td>S.E.</td>
<td>LSM</td>
<td>S.E.</td>
</tr>
<tr>
<td>Hedonic evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delicious</td>
<td>6.4a</td>
<td>0.11</td>
<td>5.9b</td>
<td>0.12</td>
</tr>
<tr>
<td>Odour</td>
<td>6.5a</td>
<td>0.10</td>
<td>6.0b</td>
<td>0.10</td>
</tr>
<tr>
<td>Taste</td>
<td>6.5a</td>
<td>0.11</td>
<td>6.0b</td>
<td>0.11</td>
</tr>
<tr>
<td>Intensity evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength of odour</td>
<td>4.8a</td>
<td>0.12</td>
<td>4.3b</td>
<td>0.12</td>
</tr>
<tr>
<td>Abnormal odour</td>
<td>2.6</td>
<td>0.11</td>
<td>2.7</td>
<td>0.11</td>
</tr>
<tr>
<td>Strength of taste</td>
<td>5.7ab</td>
<td>0.10</td>
<td>5.5b</td>
<td>0.10</td>
</tr>
<tr>
<td>Abnormal taste</td>
<td>2.6</td>
<td>0.11</td>
<td>2.7</td>
<td>0.11</td>
</tr>
</tbody>
</table>

FE: meat from gilt; LBT: meat from entire male pigs with low levels of boar taint; MBT: meat from entire male pigs with medium levels of boar taint.
Table 7. Least square means and standard error in consumer test 2 (FR & IT) of the scores given by consumers of meat from gilts (FE), from entire males with low levels of skatole and androstenone (LBT), and entire male pigs with high boar taint (HBT).

<table>
<thead>
<tr>
<th></th>
<th>FE</th>
<th></th>
<th>LBT</th>
<th></th>
<th>HBT</th>
<th></th>
<th>Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LSM</td>
<td>S.E.</td>
<td>LSM</td>
<td>S.E.</td>
<td>LSM</td>
<td>S.E.</td>
<td></td>
</tr>
<tr>
<td>Hedonic evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delicious</td>
<td>5.7a</td>
<td>0.11</td>
<td>5.6ab</td>
<td>0.11</td>
<td>5.4b</td>
<td>0.11</td>
<td>0.0518</td>
</tr>
<tr>
<td>Odour</td>
<td>5.9a</td>
<td>0.11</td>
<td>5.9a</td>
<td>0.11</td>
<td>5.4b</td>
<td>0.11</td>
<td>0.0002</td>
</tr>
<tr>
<td>Taste</td>
<td>5.8a</td>
<td>0.11</td>
<td>5.7ab</td>
<td>0.11</td>
<td>5.4b</td>
<td>0.11</td>
<td>0.0153</td>
</tr>
<tr>
<td>Intensity evaluations</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength of odour</td>
<td>4.4</td>
<td>0.12</td>
<td>4.5</td>
<td>0.12</td>
<td>4.5</td>
<td>0.12</td>
<td>0.3047</td>
</tr>
<tr>
<td>Abnormal odour</td>
<td>2.3</td>
<td>0.11</td>
<td>2.4</td>
<td>0.11</td>
<td>2.5</td>
<td>0.11</td>
<td>0.1537</td>
</tr>
<tr>
<td>Strength of taste</td>
<td>4.8ab</td>
<td>0.11</td>
<td>4.7b</td>
<td>0.11</td>
<td>5.1a</td>
<td>0.11</td>
<td>0.0102</td>
</tr>
<tr>
<td>Abnormal taste</td>
<td>2.2b</td>
<td>0.12</td>
<td>2.5ab</td>
<td>0.12</td>
<td>2.6a</td>
<td>0.12</td>
<td>0.0309</td>
</tr>
</tbody>
</table>

FE: meat from gilt; LBT: meat from entire male pigs with low levels of boar taint; HBT: meat from entire male pigs with high levels of boar taint.