

## **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

N.Panella-Riera<sup>1,\*</sup>, M.Blanch<sup>1</sup>, P. Chevillon<sup>2</sup>, M.Gil<sup>1</sup>, J.M. Gil<sup>3</sup>, Z. Kallas<sup>3</sup>, M. Font i Furnols<sup>1</sup>, M.A.Oliver<sup>1</sup>.

<sup>1</sup>IRTA-Monells, Finca Camps i Armet, 17121 Monells, Spain

<sup>2</sup>IFIP, La Motte au Vicomte, 35651 Le Rheu, France

<sup>3</sup>CREDA, Parc Mediterrani de la Tecnologia, 08860 Castelldefels, Spain

The first and the second authors had an equal input to the paper.

\*Corresponding author. Tel.: +34 972630052; fax: +34 972630373. *E-mail address:* [nuria.panella@irta.cat](mailto:nuria.panella@irta.cat) (Núria Panella-Riera).

2 **Abstract**

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

14

15 **Highlights**

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

22

23 **Keywords:** acceptability, androstenone, boar taint, consumers, clusters, skatole

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26 **1. Introduction**

27 Nowadays there is a growing concern about the negative effect of surgical castration of  
28 pigs without anaesthesia on animal welfare. In 2008, across Europe the majority of male  
29 piglets intended for pork production were castrated to avoid potential consumer  
30 dissatisfaction because of boar taint. At that time, castration was performed in most of  
31 the EU countries on 80-100% of the male pigs in conventional production, and surgical  
32 castration without anaesthesia was the most common technique (Fredriksen et al.,  
33 2009). The exceptions were United Kingdom and Ireland, where castration was hardly  
34 performed, and some southern countries such as Cyprus, Portugal and Spain, where a  
35 limited percentage of the male pigs were castrated in comparison to the other European  
36 countries. Since then, some countries have taken an action to avoid piglet castration  
37 without anaesthesia not only for welfare reasons, but also because the production of  
38 entire male pigs decreases production costs and results in higher meat content of the  
39 carcass (EFSA, 2004; PIGCAS, 2009). Norway and Switzerland have already banned  
40 piglet castration by law, and other countries such as The Netherlands and Germany have  
41 signed letters of intentions (Declaration of Noordwijk 2007 and Düsseldorf Declaration  
42 2008, respectively) which aimed to avoid the need for piglet castration in the long term.  
43 In 2010, at EU level, representatives of European farmers, meat industry, retailers,  
44 scientists, veterinarians and animal welfare NGOs, committed themselves to voluntarily  
45 end surgical castration of pigs in Europe by January 2018 by means of the European  
46 Declaration on alternatives to surgical castration of pigs (DG-SANCO, 2010).  
47 Consequently, entire male production is one of the alternatives and therefore, an  
48 increase in the production of entire males would result in a positive impact on the  
49 production efficiency and carcass composition. But as a consequence, more tainted  
50 carcasses could enter to the meat chain. A number of consumer studies have been  
51 carried out in order to ascertain the acceptability of pork from entire male pigs in  
52 different countries and using different methodologies as was reviewed in (EFSA, 2004)  
53 and more recently, by Font i Furnols (2012). The two main compounds responsible for  
54 boar taint are androstenone (Patterson, 1968) and skatole (Vold, 1970; Walstra &  
55 Maarse, 1970). The respective contributions of these two compounds vary depending on  
56 the characteristics of the meat evaluated, procedures for preparing the meat, the ability  
57 of consumers to perceive androstenone among others, as was been reviewed by Font i

58 Furnols (2012), and also it may vary depending on the habit of eating meat from  
59 castrated or entire male pigs.

60 Therefore, it would be interesting to study the impact that meat from boars could have  
61 in the European market (Consumer satisfaction), which is traditionally used to eating  
62 meat from castrated pigs, and identify if there is any difference comparing to other  
63 countries where the utilization of entire male pigs is more common.

64 The present work had two main objectives: 1) to evaluate and update the results on  
65 sensory acceptability of meat from entire male pigs (as an alternative to the production  
66 of castrates), involving four European countries that produce different proportion of  
67 castrated pigs in two consumer studies: Spain (33.2%) and United Kingdom (2.1%),  
68 France (97.5%), and Italy (100%), and 2) to identify potential niche markets for meat  
69 with different boar taint levels.

70

## 71 **2. Materials and methods**

### 72 *2.1 Consumer studies and classification of consumers*

73 Two consumer studies were conducted in two pair of countries where each consumer  
74 assessed pork with various levels of androstenone and skatole. In each study, three  
75 groups of meat samples were assessed:

- 76     ▪ Consumer test 1. Pair of countries: Spain (ES, n=133, performed in Barcelona)  
77         and United Kingdom (UK, n=146, performed in Reading);
- 78     ▪ Consumer test 2. Pair of countries: France (FR, n= 139, performed in Cain &  
79         Paris) and Italy (IT, n= 140, performed in Matelica & Reggio Emilia);

80 Considering the two consumer tests, a total of 558 consumers from the two different  
81 pair of European countries participated in this project. They were stratified by age  
82 (according to each country profile) and sex (approximately 50:50 ratio between men and  
83 women). Consumers were required to eat pork on a regular basis.

### 84 *2.2. Animals and samples*

85 The meat and fat samples used for the consumer studies were obtained from populations  
86 of pigs slaughtered according to commercial practice. They were collected from boars  
87 and gilts in commercial abattoirs from Spain and France. Carcass weights and  
88 genotypes were representative of current practice in these countries. The meat collected  
89 in Spain was used for the consumer studies carried out in ES and UK; and the meat  
90 collected in France was used for the consumer studies carried out in FR and IT.

91 For each consumer test, a minimum 20 loins from gilts, 20 loins from boars with Low  
92 Boar taint (LBT) and 20 loins from boars with Medium Boar taint (MBT) or High Boar  
93 taint (HBT) were selected. From each animal, the muscle *Longissimus lumborum* (with  
94 the subcutaneous fat) was taken from the 1<sup>st</sup> lumbar vertebra to the last rib, divided in  
95 two sections (min. 15 cm) and distributed in one of the two countries (Figure 1).

### 96 *2.3. Androstenone and skatole measurements in fat*

97 Back fat samples were collected on the day of slaughter at the level of the neck, vacuum  
98 packed and deep frozen until analyzed for androstenone (AND) and skatole (SKA). The  
99 determination of SKA levels was performed using HPLC-FLD and the determination of  
100 AND levels using GC-MS (for ES and UK samples, Ampuero et al., (2011)) or by  
101 HPLC-FLD (for FR and IT samples; Pauly, Spring, O'Doherty, Ampuero, & Bee  
102 (2008). Results were expressed as µg/g, on pure fat basis. Meat samples were classified  
103 as FE (meat from gilts), Low boar taint (LBT), Medium boar taint (MBT) or High boar  
104 taint (HBT) depending on the sex and the levels of boar taint compounds (Blanch et al.,  
105 (2012); Table 1). Each consumer test and each session was carried out with 3 samples:  
106 samples from gilts (FE) as a reference, and two more samples with different levels of  
107 boar taint: in consumer test 1 (ES & UK) meat from LBT and MTB was used; and in  
108 consumer test 2 (FR & IT), meat from LBT and HBT.

### 109 *2.4. Preparation of samples*

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

### 117 *2.5. Sensory evaluation of samples*

118 Sessions of 10-12 consumers were organised for meat evaluation. Each consumer  
119 assessed 3 pieces of meat, one from 3 levels of boar taint (Table 1). A 10 minute  
120 interval was used between each of the three samples presented within a session. The  
121 order of presentation of samples was rotated using a partial Latin square design to avoid  
122 any first sample and carry-over effect and the identity of the samples was not given to

123 consumers (Macfie, Bratchell, Greenhoff, & Vallis, 1989). Consumers were asked for  
124 hedonic questions (questions 1 to 4) and intensity evaluations (questions 5-11) as  
125 described in Table 2, using a modified nine-point intensity scale (from 1 to 9). The  
126 intermediate level (5) was not included to stimulate consumers to commit themselves  
127 and not to allow a neutral assessment which is not informative (Guerrero, 1999). The  
128 attributes 'Delicious', 'Odour' and 'Taste' were rated on a scale going from 1 = 'dislike  
129 very much' to 9 = 'like very much', whereas the attributes 'Strength of odour',  
130 'Abnormal odour', and 'Abnormal taste' were scored between 1 = 'low perception' to 9  
131 = 'strong perception'.

#### 132 *2.6. Description of EU pork consumers.*

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

#### 137 *2.7. Statistical analysis*

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

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

152 For each cluster, the MIXED procedure was then used to analyse the hedonic attributes  
153 (delicious, odour, taste, and in-mouth feeling) and the intensity attributes (strength of  
154 odour and strength of taste, abnormal odour and abnormal taste) scored by the  
155 consumers. The model included the type of animal and country as fixed effects, session

156 as blocking effect and consumer as random effect. The interaction Type of animal and  
157 Country was removed of the model because it was not significant ( $P < 0.05$ ). Differences  
158 were also declared at  $P < 0.05$ .

159

### 160 **3. Results**

#### 161 *3.1. Description of consumers*

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

166 In consumer test 1 (ES & UK), 15, 25, 41 and 19 % of the consumers were 18-25, 26-  
167 40, 41-60 and  $> 60$  % of age respectively; and in consumer test 2 (FR & UK), 12, 27, 51  
168 and 10 % of the consumers were 18-25, 26-40, 41-60 and  $> 60$  % of age respectively.

#### 169 *3.2. Habits of European consumers regarding pork consumption*

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

173 In general, the percentage of respondents responsible for buying fresh pork in their  
174 household was 86.4 % (Table 4). In all countries, women were more responsible for  
175 buying fresh pork than men, and they were mostly between 41-60 years old. Eighty-  
176 eight percent of respondents were partially responsible for cooking at home. Women  
177 were more responsible for cooking at home than men. France was an exception, where  
178 percentages were very similar 49.6 % women and 50.4 % men cooked at home.  
179 Considering all respondents, 43.5 % use to eat the pork with the fat in all the countries  
180 (36.4 % of women and 53.1 % of men). Considering the place of purchasing fresh pork  
181 meat, the supermarket was the most common one, followed by the butcher and finally  
182 the traditional market.

#### 183 *3.3. Sensory evaluation*

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

187 *3.3.1 Differences between meat sample groups, within experiments.*

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

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

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

206 *3.3.2. Consumer segmentation in consumer test 1: Spain and United Kingdom*

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

- 214 ■ The *first cluster* ( $n=169$ , 62.1 % of the sample; 57.4 % from Barcelona and 42.6 %  
215 from Reading) comprises respondents that gave high scores to all types of samples.  
216 These consumers were labelled as 'Pork lovers'.
- 217 ■ The *second cluster* ( $n=59$ , 21.7 % of the sample; 30.5 % from Barcelona and 69.5 %  
218 from Reading) comprises respondents that liked the boar taint and therefore, the

219 higher the level of boar taint, the higher the score to the attribute. These consumers  
220 were considered as ‘Boar meat lovers’.

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

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

### 227 3.3.3. Consumer segmentation in consumer test 2: France and Italy

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

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

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

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

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

246

## 247 4. Discussion

248 In the present paper, two consumer studies were carried out with the aim to ascertain  
249 consumer acceptability of boar meat with different levels of boar taint. Due to practical  
250 reasons, meat was collected in Spain and France, chemically analysed in terms of  
251 androstenone and skatole levels, and then distributed to two other countries: meat from

252 Spain was used for the consumer test for Spain and United Kingdom, and meat from  
253 France was used for the consumer test carried out in France and Italy. It is interesting to  
254 highlight that, consumer test 1 was planned in two countries where, as pointed out by  
255 Frederiksen et al. (2009), were used to the commercialization of meat from entire male  
256 pigs, whereas consumer test 2 was carried out in two countries where consumers were  
257 not used to this type of meat: in 2008, the percentage of production of castrated male  
258 pigs was estimated as 33.2 % in ES, 2.1 % in UK, 97.5 % in FR and 100 % in IT.  
259 It is also interesting to point out that, in the two consumer studies, consumers were able  
260 to taste meat from entire male pigs with such low levels of boar taint comparable to the  
261 levels found in meat from gilts (Bonneau & Chevillon, 2012; type of meat LBT - low  
262 boar taint- and FE - meat from gilts). Additionally, each study had a third type of meat  
263 with medium levels (MBT in study 1) or high levels (HBT in study 2) of boar taint.

#### 264 4.1. Methodology used

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

284 it was served uncovered, the methodology used in the present paper could minimize the  
285 perception of boar taint.

#### 286 4.2. Overall acceptability

287 Taking into account that different methodologies have been used in the already  
288 published consumer tests carried out in different countries (reviewed by Font i Furnols  
289 (2012), results obtained in a given country cannot be extrapolated to another one. The  
290 present paper, however, provides the results from 4 countries using the same  
291 methodology.

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

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

#### 307 4.3. Consumer segmentation based on the hedonic attribute *Deliciousness*

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

- 315 ■ Cluster 1 (*Pork lovers*) rated the three types of meat with relatively high scores (all  
316 of them over 5 in a 9-point scale). This cluster represents 62.1 % of the sample in

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

327 ■ Cluster 2 (*Boar meat lovers*) rated the meat from gilt (FE) with lower scores, and the  
328 meat with MBT or HBT with higher scores. Meat with LBT was scored in-between  
329 in both cases. This cluster represents 21.7 % of the sample in consumer test 1, and  
330 12.4 % of the sample in consumer test 2. The lower percentage of consumers that are  
331 part of this cluster in study 2 may be explained because the highest level of boar taint  
332 meat was higher in comparison to the levels in consumer study 1. In fact, it is  
333 reported that some of the sensitive consumers like the androstenone smell and it  
334 influences their scores (Blanch et al., 2012; Bonneau & Chevillon, 2012; Font i  
335 Furnols, Gispert, Diestre, & Oliver, 2003).

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

348

349 Additionally, in consumer test 2 (FR & IT) there was a fourth cluster identified and  
350 labelled as consumers that *Reject low boar tainted meat*, representing 18.2 % of the

351 sample. In this one, the meat with low boar taint received the lowest (worst) score in all  
352 the attributes (between 4.3 and 5.1). The identification of this cluster could be expected  
353 if we take into account that it has been found in the two countries where consumers are  
354 not used to the meat from entire male pigs.

355 Considering the percentage of consumers being part of each cluster (Figure 5), a  
356 percentage of 16.2 % (from cluster 3) in consumer study 1 (ES & UK) and 38.2 %  
357 (from cluster 3 plus 4) in consumer study 2 (FR & IT) could react negatively when  
358 eating meat from entire male pigs. Again, to understand these differences two facts  
359 should take into account: (i) meat with boar taint used in FR and IT had higher boar  
360 taint levels than the meat used for ES and UK, and (ii) consumers from FR and IT were  
361 not used to eat meat from entire male pigs. (Diestre, Oliver, Gispert, Arpa, & Arnau,  
362 1990) stated that androstenone might not be a problem in countries where the  
363 production of young animals is common. Results from the present paper disagree on  
364 that statement since cluster 3 was identified in the four countries involved, which  
365 slaughter pigs at very different carcass weight (in 2009, FR: 80 kg; ES: 82kg and UK:  
366 80kg; and in IT: 125kg, which corresponds exclusively to castrated pigs-;  
367 EUROSTAT).

368

#### 369 **4. Conclusions and implications**

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

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#### 382 **Acknowledgements**

383 This study was financially supported by the Health and Consumers Directorate-General,  
384 Animal Health and Welfare (DG-SANCO) of the European Commission (Contract No.

385 SANCO/2008/D5/018). Complementary financial supports were provided at the  
386 national levels by INAPORC in France and IRTA in Spain.

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451 **Figure Captions**

452 Figure 1. Sampling procedure for each consumer test.

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

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

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

459 Figure 5. Percentage of consumers representing each cluster identified in the two  
460 consumer studies.

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463 **Table Captions**

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

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

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

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

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

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

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

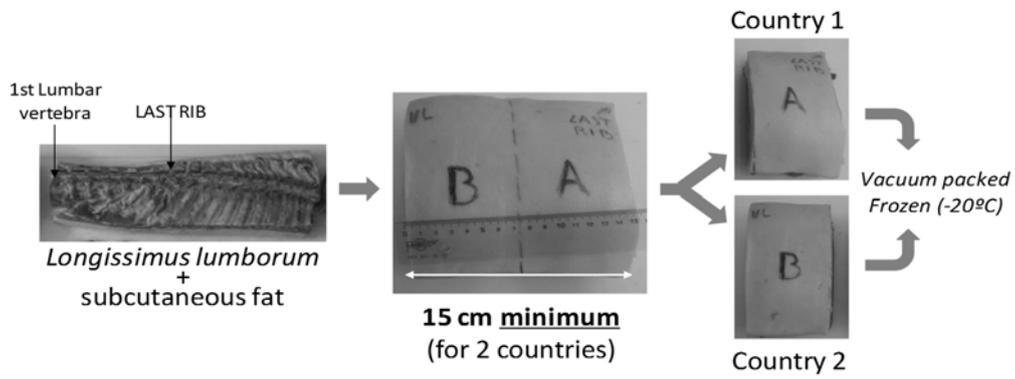
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480 **Figures.**

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482 Figure 1. Sampling procedure for each consumer test.

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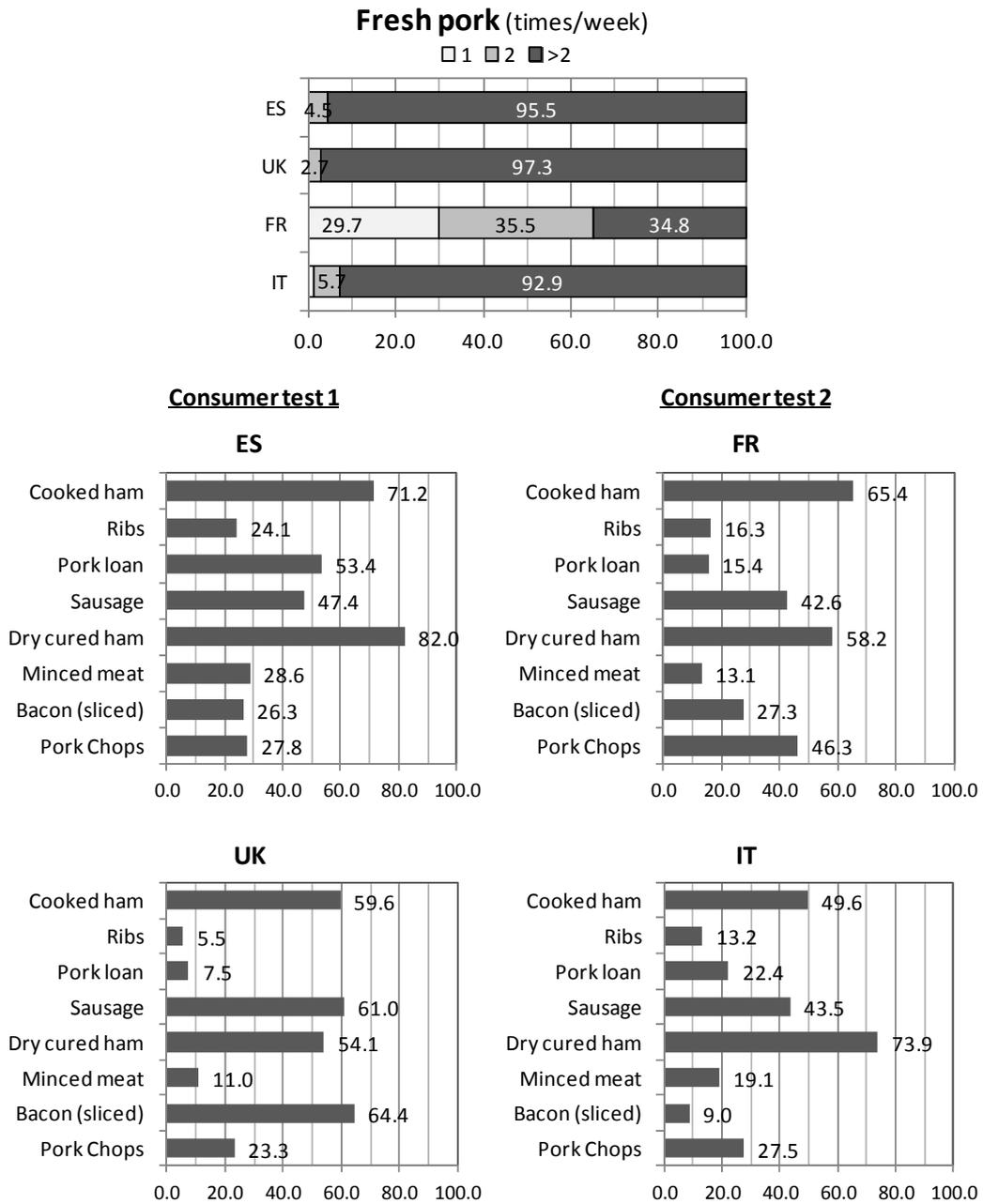


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487 Figure 2. Percentage of European consumers eating fresh pork more than twice per  
 488 week and frequency of consumption of different pork products.

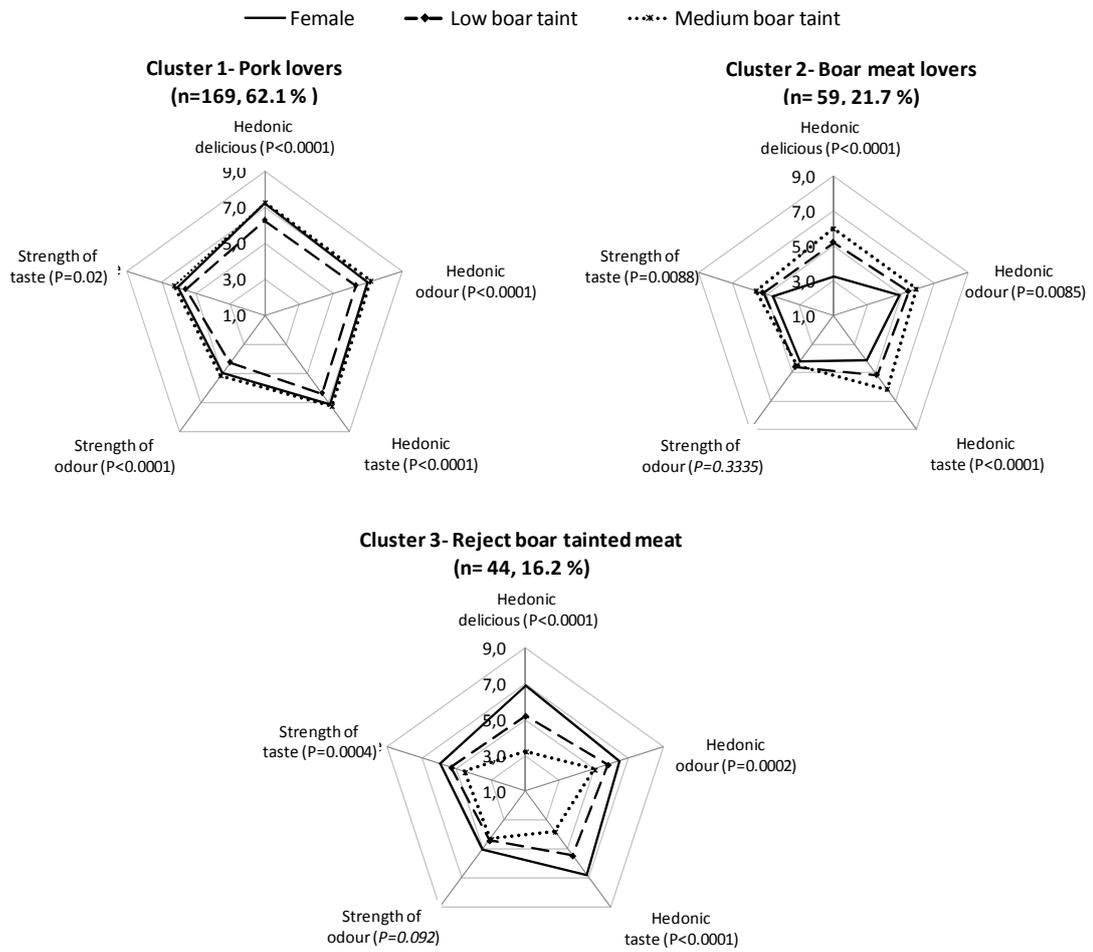


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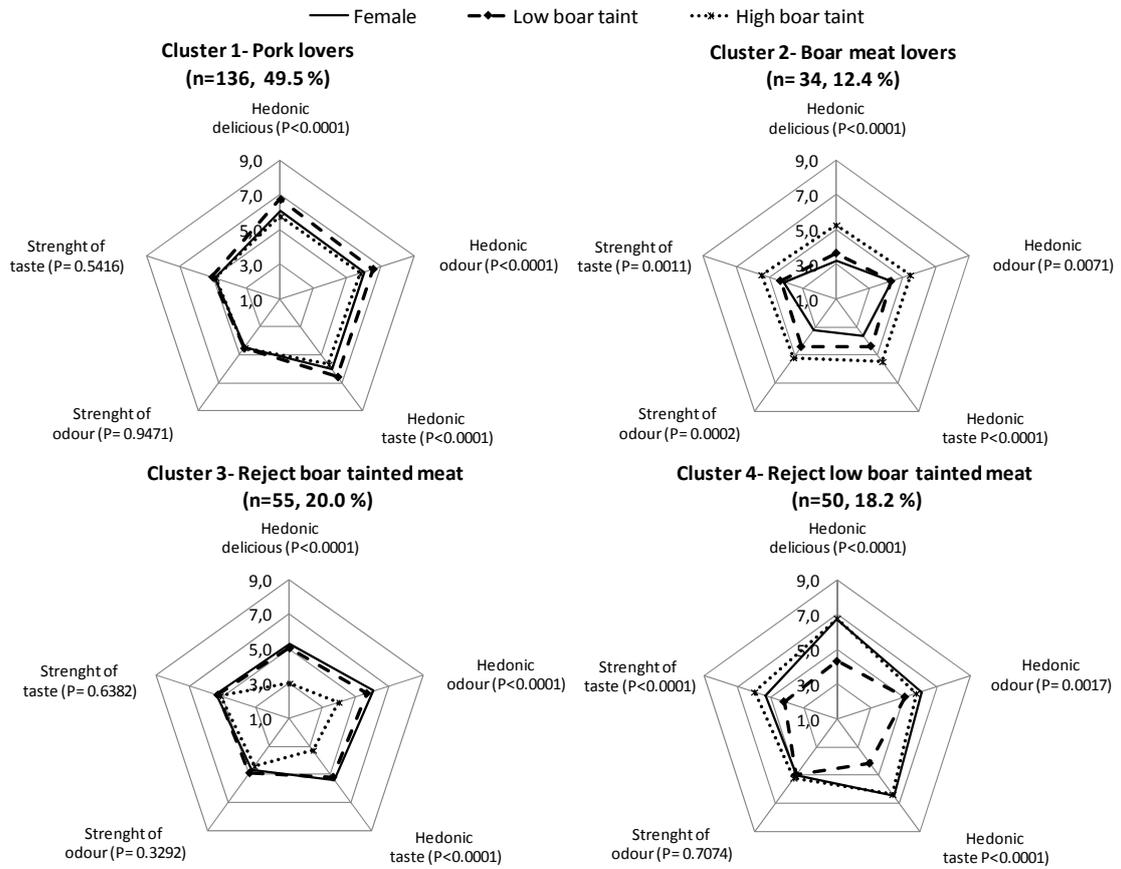
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492 Figure 3. Least square means for hedonic traits and abnormal odour/taste given by three  
 493 clusters observed in consumer test 1 (Spanish and English consumers).



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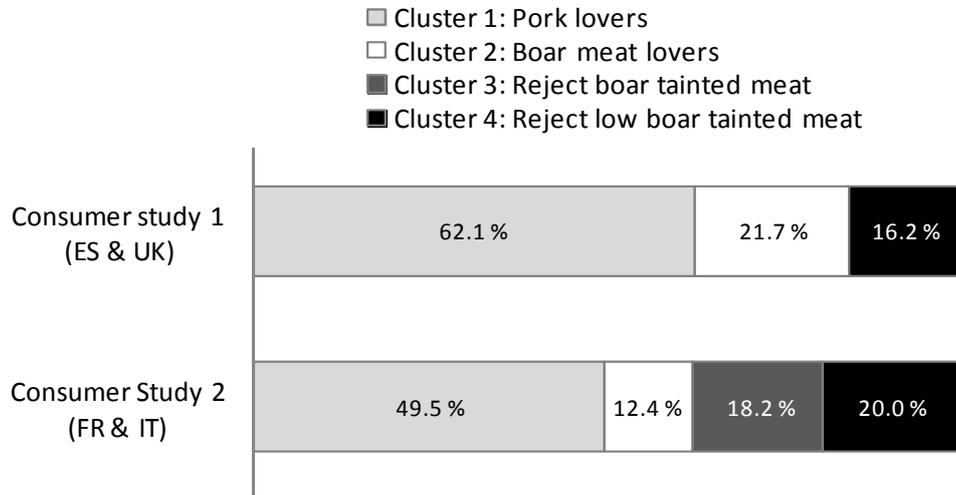
501 Figure 4. Least square means for hedonic traits and abnormal odour/taste given by three  
 502 clusters observed in consumer test 2 (French and Italian consumers).



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509 Figure 5. Percentage of consumers representing each cluster identified in the two  
510 consumer studies.



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513 **Tables.**

514

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

517

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

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.

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

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

<sup>1</sup> All scoring scales were from 1 to 9, without 5.

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

	Consumer test 1 n=279		Consumer test 2 n=279		Total
	ES	UK	FR	IT	
n	133	146	139	140	558
Gender (%)					
Male	54.9	50.0	49.6	74.3	42.8
Female	45.1	50.0	50.4	25.7	57.2
Age (%)					
18-25	10.5	19.9	15.1	10.0	14.0
26-40	30.8	19.2	28.8	25.7	26.0
41-60	43.6	39.0	41.0	60.0	45.9
>60	15.0	21.9	15.1	4.3	14.2
Educational level (%)					
Primary studies not completed	3.0	0.0	11.7	2.9	4.4
Primary studies	12.1	4.8	3.6	25.0	11.3
Secondary studies	53.8	61.6	46.0	29.4	47.9
University studies	31.1	33.6	38.7	42.6	36.5

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.

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

535

	Consumer test 1		Consumer test 2		Total
	ES	UK	FR	IT	
	n 133	146	139	140	558
Are you partially responsible of doing the shopping of fresh pork eaten in your household?					
Yes	78.9	81.5	93.5	91.4	86.4
Are you partially responsible for cooking in your household?					
Yes	80.5	82.9	97.8	91.4	88.2
When you eat the pork meat, do you eat it...					
without the fat	58.6	43.8	61.2	62.9	56.5
with the fat	41.4	56.2	38.8	37.1	43.5
Where do you buy fresh pork meat?					
At the butcher	58.6	21.9	15.8	14.3	27.2
At the supermarket	72.2	95.9	82	94.3	86.4
At the traditional market	42.1	4.8	0.7	1.4	11.8

ES: Spain; UK: United Kingdom; FR: France; IT: Italy.

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

	Consumer test 1 (ES & UK) n= 279				Consumer test 2 (FR & IT) n= 279			
	BT	C	BTxC	S	BT	C	BTxC	S
<i>Hedonic evaluations</i>								
delicious	**	***	ns	ns	†	ns	ns	***
odour	***	***	ns	*	***	ns	†	**
taste	***	**	ns	ns	*	ns	ns	**
<i>Intensity evaluations</i>								
strength of odour	***	***	ns	ns	ns	ns	ns	ns
abnormal odour	ns	ns	ns	ns	ns	ns	ns	†
strength of taste	*	†	ns	†	**	ns	ns	ns
abnormal taste	ns	**	ns	+	*	ns	ns	**

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

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

	FE		LBT		MBT		Sig
	LSM	S.E.	LSM	S.E.	LSM	S.E.	
<i>Hedonic evaluations</i>							
Delicious	6.4a	0.11	5.9b	0.12	6.4a	0.12	0.0015
Odour	6.5a	0.10	6.0b	0.10	6.5a	0.10	0.0003
Taste	6.5a	0.11	6.0b	0.11	6.5a	0.11	0.0005
<i>Intensity evaluations</i>							
Strength of odour	4.8a	0.12	4.3b	0.12	4.8a	0.12	0.0003
Abnormal odour	2.6	0.11	2.7	0.11	2.6	0.11	0.6171
Strength of taste	5.7ab	0.10	5.5b	0.10	5.9a	0.11	0.0197
Abnormal taste	2.6	0.11	2.7	0.11	2.7	0.11	0.4422

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.

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553 Table 7. Least square means and standard error in consumer test 2 (FR & IT) of the  
 554 scores given by consumers of meat from gilts (FE), from entire males with low levels of  
 555 skatole and androstenone (LBT), and entire male pigs with high boar taint (HBT).  
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	FE		LBT		HBT		Sig
	LSM	S.E.	LSM	S.E.	LSM	S.E.	
<i>Hedonic evaluations</i>							
Delicious	5.7a	0.11	5.6ab	0.11	5.4b	0.11	0.0518
Odour	5.9a	0.11	5.9a	0.11	5.4b	0.11	0.0002
Taste	5.8a	0.11	5.7ab	0.11	5.4b	0.11	0.0153
<i>Intensity evaluations</i>							
Strength of odour	4.4	0.12	4.5	0.12	4.5	0.12	0.3047
Abnormal odour	2.3	0.11	2.4	0.11	2.5	0.11	0.1537
Strength of taste	4.8ab	0.11	4.7b	0.11	5.1a	0.11	0.0102
Abnormal taste	2.2b	0.12	2.5ab	0.12	2.6a	0.12	0.0309

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.

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