Acceptability of boar meat by consumers depending on their age, gender, culinary habits, and sensitivity and appreciation of androstenone odour

M. Font i Furnols*, M. Gispert, A. Diestre, M.A. Oliver

IRTA-Centre de Tecnologia de la Carn, Granja Camps i Armet, E-17121 Monells, Spain

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Abstract

Sensitivity of the consumers to androstenone, evaluated as the degree of smell (strong/weak) perceived by smelling the pure compound, is important in determining their acceptability of pork with different levels of androstenone and skatole. However, 8% (3.3% women and 16.2% men) of highly sensitive consumers like this odour, and 12.7% (9.1% women and 15.9% men) of mildly sensitive/insensitive consumers dislike it. The effect of the appreciation (like/dislike) of the smell in the acceptability of pork samples has not been reported previously. The aim of this paper is to ascertain if this liking for androstenone odour affects pork acceptability as well as the gender, age, and culinary habits of the consumers. Consumers evaluated the flavour and odour of five cooked and reheated samples, and recorded their acceptability on a 7-step scale. Results showed that acceptability of pork increases when the frequency of cooking and eating fresh pork are higher. The acceptability also differed depending on the sensitivity of the consumer within each age group. Appreciability of androstenone odour discriminates more than sensitivity in consumers’ acceptance of pork.

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Keywords: Sensitivity; Appreciation of androstenone odour; Age; Gender; Culinary habits; Consumer acceptability; Pork

1. Introduction

Boar taint is a sensory defect of pork coming mainly from entire males. It is considered to be mainly due to two compounds, skatole and androstenone. Skatole (3-methylindole) is one of the products of the microbial degradation of the Tryptophan amino acid in the gut and it is associated with naphthalene and faecal odour (Vold, 1970; Walstra & Maarse, 1970). Androstenone (3α-androst-16-en-3-one) is a male pheromone synthesized in the Leydig cells of the testis and it is associated with urine and perspiration odour (Patterson, 1968). While skatole is perceived by 99% of the consumers (Weiler, Fisher, Kemmer, Dobrowolski, & Claus, 1997), a variable percentage of consumers are anosmic to androstenone. This anosmia is genetically determined (Wysocki & Beauchamp, 1984) and depends on the sex of the consumer (Elseley, 1968; Griffiths & Patterson, 1970) and the country of assessment (Gilbert & Wysocki, 1987). Women are more sensitive to androstenone than men in all the studies carried out. The percentage of anosmic women with respect to anosmic men, is 15.8 vs. 24.1% in Europe (except United Kingdom), 10.9 vs. 30.0% in United Kingdom, 29.5 vs. 37.2% in USA and 17.2 vs. 25.5% in Asia (Gilbert & Wysocki, 1987). In Germany the percentage of insensitive people was found to be 70 of men and 66% of women and in Spain 60 and 48%, respectively (Weiler et al., 2000). These differences in the percentages between these studies could be because there were more than 10 years between both studies and the methodology to determine the sensitivity of the consumers was different. Sensitivity of consumers to androstenone has been proved to be an important factor in the acceptability of pork (Weiler et al., 2000). This sensitivity was determined by means of the score given by the consumers after smelling pure androstenone (strong/weak). Nevertheless the liking for or appreciation of this smell is also
an important factor because it has been shown that a percentage of consumers like the smell (Labows, 1988 cited by Pause, Rogalski, Sojka, & Ferstl, 1999).

The aim of this paper was (a) to determine the effects of the age, gender, culinary habits (cooking frequency and frequency of eating fresh pork) and sensitivity to androstenone smell on odour and flavour acceptability of cooked pork, (b) to see the relationship between consumers’ sensitivity and their liking for androstenone odour, and (c) to study the effect of this appreciation on the consumers’ acceptance of pork with different levels of androstenone and skatole.

2. Materials and methods

2.1. Classification of consumers

A total of 480 consumers were selected in two replicates (n=240 each) stratified by age (according to the Spanish profile) and sex (approximately the same number of men and women). In each replicate consumers from three different places in Spain were tested: Montells, Zaragoza and Madrid. Each consumer was asked to fill in a questionnaire, with questions about their frequency of cooking and of pork eating. After that, consumers were asked to give their opinion about the acceptability of the smell of five samples followed by the odour of five different samples coming from the same joints. These samples had known levels of androstenone and skatole. Consumers were checked for androstenone sensitivity by smelling pure androstenone, as described in Weiler et al. (2000), and were asked about their liking for that smell on a seven step scale (1=like very much to 7=dislike very much). Consumers that scored ‘like’ ‘like a lot’ and ‘like very much’ in their appreciation of the smell were considered to be consumers that like androstenone smell. When the score of the appreciation of the smell was “neither like nor dislike” they were considered to be consumers that indifferent to androstenone smell. Finally when the score was ‘dislike’, ‘dislike a lot’ and ‘dislike very much’ they were considered to be consumers that dislike this smell.

2.2. Selection, preparation and evaluation of meat samples

The selection and preparation of the samples are explained in Bonneau et al. (2000) and Matthews et al. (2000). In brief, samples from boars and gilts were collected from six different European countries, depending on their level of androstenone and skatole, in order to fill a grid of nine cells [three levels of androstenone: low (<0.5 g/g), medium (0.5–1.0 g/g) and high (>1.0 g/g) crossed with three levels of skatole: low (<0.11 g/g), medium (0.11–0.22 g/g) and high (>0.22 g/g)]. Gilt loins represented a 10th cell. For analytical reasons (see Bonneau et al., 2000) the number of loin samples within each cell was different (see Weiler et al., 2000 for the Spanish distribution). Samples were cooked and reheated as explained in Matthews et al. (2000) and served to the consumers according to a design that took into account the order of presentation of the samples in order to avoid any carry-over effect. Each consumer evaluated the flavour and the odour, following a hedonic 7-step scale (Matthews et al., 2000).

2.3. Statistical analysis

Statistical analysis was carried out to achieve the different objectives. Objective (a) was achieved using the GLM procedure by means of SAS software (SAS, 1988) applying the following model:

\[ y_{ijklmn} = \mu + S_i + A_j + C_k + E_l + S_{e,m} + (A^*S)e_{,jm} + e_{ijklmn} \]

where: \(y_{ijklmn}\) = flavour/odour score given by the consumer; \(S_{e,m}\) = level of skatole effect; \(A_j\) = sex effect; \(C_k\) = age effect; \(E_l\) = eat effect (l=weekly, fortnightly, 3-weekly, monthly, less often); \(S_{e,m}\) = sensitivity effect; \(e_{ijklmn}\) = residual error of the model.

Only the significant (\(P<0.05\)) interactions were kept in the model, i.e. the interaction between the sensitivity and the age of the consumers. To determine the significance between differences Bonferroni’s test was used.

Objective (b) classification of the consumers according to their gender and sensitivity (strong/weak) and appreciation (like/dislike) of androstenone smell were compared by chi-squared (\(\chi^2\)) test by means of SAS software (SAS, 1988).

Objective (c) was achieved using the GLM procedure by means of the software mentioned and applying the following model:

\[ y_{ijkl} = \mu + S_{k,1} + A_j + L_{k,e} + (S_{k,1}*L_{k,e})_{ij} + e_{ijkl} \]

where: \(y_{ijkl}\) = flavour/odour score given by the consumer; \(S_{k,1}\) = level of skatole effect; \(L_{k,e}\) = level of androstenone effect; \(e_{ijkl}\) = residual error of the model.

Only the significant (\(P<0.05\)) interactions were kept in the model, i.e. the interaction between the level of skatole and level of androstenone. To determine the
3. Results and discussion

3.1. Relation between consumers’ culinary habits, gender and age with pork acceptability

The results obtained with Model 1 are shown in Table 1. It can be seen that all the effects, as well as the interaction between age and sensitivity, are significant for the odour and flavour scores.

Acceptability of odour and flavour of pork is lower for women than men (Table 2). This is probably related to the higher percentage of androstenone sensitive women than men (Gilbert & Wysocki, 1987; Weiler et al., 2000) although differences in acceptability of pork depending on the sex of the consumers were not found by Lundström, Malmfors, Fjelkner-Modig, and Szatek (1986).

Table 3 shows the least squares mean of the odour and flavour scores given by the consumers depending on their frequency of consumption of fresh pork. It can be seen that odour scores were higher than flavour scores, indicating that pork loins were scored better for flavour than odour, as was found in other studies carried out in France (Desmoulin & Bonneau, 1981; Desmoulin, Bonneau, Frouin, & Bizard, 1982), Sweden (Lundström et al., 1982), The Netherlands (Walstra, Engel, & Matevan, 1986) and Spain (Diestre, Oliver, Gispert, Arpa, & Arnau, 1990) but not in Denmark (Steier, 1994). This is probably due to the fact that although androstenone and skatole are not highly volatile compounds (García-Regueiro, Rius, & Díaz, 1995), a proportion of these substances is evaporated during the cooking process and it is easily detected when hot cooked meat is smelled. Furthermore, boar taint sensitive consumers complain about the odour during the cooking process (Claus, Schopper, Wagner, & Weiler, 1985; Dehnhard, Claus, Herbert, & Hillenbrand, 1995) probably because temperature is also an important factor that affects the detection of boar taint (Agerhem & Tornberg, 1995; Nute, Whittington, Warris, & Wood, 1995; Wood, Nute, Fursey, & Cuthberston, 1995) and it is probably different when samples are smelled than tasted. This difference can also explain the differences in odour and flavour acceptability. There is an increase in the odour and flavour scores (worse acceptability), when frequency of consumption is less. However, only consumers that consume fresh pork weekly and fortnightly score the flavour of pork significantly better than consumers who consume fresh pork less than once a month. In addition, odour acceptability is significantly better for consumers who consume pork weekly compared with consumers that consume this meat monthly or less often. It seems logical that Spanish consumers, who regularly eat pork, record a good acceptability of rating for flavour and odour, because in Spain the consumption of pork includes meat from gilts and boars, as in the trial. However a similar result was obtained by Matthews et al. (2000) when consumers from seven European countries (including the Spanish consumers for this paper) were studied, even though they (except consumers from United Kingdom and Spain) are not used to eating boar meat. In South Africa the frequency of consumption of fresh meat had no significant effect on hedonic ratings of pork samples (Kock, Heerden, Heinze, Dijkstraeus, & Minnaar, 2001). Nevertheless, in that work consumers were also asked about their liking for pork in general (fresh and processed meat), and people with the higher liking had a significant effect on the hedonic ratings of the boar odour, this being higher.

The least squares mean of the flavour and odour acceptability of pork depending on the consumers’
frequency of cooking is given in Table 4. Although the differences are not very high (maximum difference of 0.2 points), consumers who always cook score the flavour and the odour significantly better than consumers who only cook sometimes, with consumers who never cook coming between both groups. Matthews et al. (2000) found similar results when consumers of seven European countries were studied. Consumers who always cook are more exposed to the odour of boar meat and it seems to be a contradiction in terms that ostensibly anosmic people, if they have a regular exposure to the odour, can acquire ability to perceive androstenone (Möller, Pause, & Ferstl, 1999; O’Connell, Stevens, & Zogby, 1994; Wysocki, Dorries, & Beauchamp, 1989). These inconsistencies, can be due to the fact that sensory perception of boar odour seems to have a temporal character which can be explained by differences in volatilisation (involving both odourant releasing and retention) of skatole and androstenone, odour synergism and possibly differences in the properties of the fat matrix of different samples (Kock, Heinzé, Potgieter, Dijkstra, & Minnaar, 2001b). Moreover, besides androstenone, pork loins contain other substances responsible for the odour, such as skatole, 16-androsten-3β-ol (Claus & Hoffmann, 1971; Beery & Sink, 1971; Beery, Sink, Patton, & Ziegler, 1971; Thompson, Pearson, & Banks, 1972) and short chain fatty acids, aldehydes and 4-phenyl-3-buten-2-one (Rius, 1999) that can modify the acceptability of pork taste and smell. The reheating of the samples can also introduce other flavours and odours which are or are not desirable to consumers. Finally, as Matthews et al. (2000) suggested, a lack of pork flavour can be responsible for general dissatisfaction of the consumers.

The distribution of consumers in the different classes of sensitivity and age, is shown in Table 5. The Chi-squared test has been used to test for differences between ages in the sensitivity, and these are significant. It can be seen that the percentage of sensitivity rises with age until 60 years of age is reached, when it decreases. This increase in sensitivity until 60 can partly be explained by the development of androstenone sensitivity in ostensibly anosmic people (Wysocki et al., 1989), but the increase is quite high (21.4–40.0%). The decrease of sensitivity after this age is probably due to the fact that the ageing reduces taste and odour senses, as was described by Murphy and Gilmore (1990) as well as Russell et al. (1993) and Barber (1997).

The interaction between sensitivity and age was significant when the odour and flavour acceptability of pork was tested. Least squares mean of flavour and odour scores in cooked pork loin for the consumers, depending on their age and androstenone sensitivity, after applying the GLM procedure (Model 1) is shown in Table 6. It was found (Weiler et al., 2000) that mildly sensitive/insensitive Spanish consumers perceived a lower odour score than highly sensitive consumers (when androstenone levels were higher than 0.5 μg/g). Complementary to those results, when the age of consumers is taken into account, the odour acceptability was only significantly different between these groups in the oldest (61–75 year-old) and youngest (18–25 year-old) groups. When the age of the consumers was not taken into account, the odour acceptability differences were not very high (maximum difference of 0.2 points), consumers who always cook score the odour significantly worse than the mildly sensitive/insensitive groups. From these results we can say that the age of the consumers is an important factor in their acceptability of pork, as well as in their sensitivity to the smell of androstenone.

### 3.2. Relation between gender, sensitivity and appreciation of androstenone smell

Sensitivity of the consumers was determined by their opinion (strong/weak) after smelling pure androstenone, as explained in the methodology. However, consumers were also asked to give their appreciation (like/dislike) of this odour. The distribution of the liking for pure androstenone odour by sex and sensitivity is given in Table 7. Looking at the overall consumers, 18% of them like the odour, 49% are indifferent and 33% dislike it. These percentages have a significantly ($\chi^2 = 1188$ and $P < 0.0001$) different distribution when consumers are classified according to their sensitivity to androstenone. There are 82.4% of highly sensitive consumers (31% of the total Spanish consumers tested, as found in

### Table 4
Least squares mean of odour and flavour scores* in cooked pork loin of consumers by their frequency of cooking

<table>
<thead>
<tr>
<th>Frequency of Cooking</th>
<th>n</th>
<th>Flavour</th>
<th>Odour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>977</td>
<td>3.6b</td>
<td>3.9b</td>
</tr>
<tr>
<td>Sometimes</td>
<td>1122</td>
<td>3.7a</td>
<td>4.1a</td>
</tr>
<tr>
<td>Never</td>
<td>285</td>
<td>3.7ab</td>
<td>4.0ab</td>
</tr>
</tbody>
</table>

* Odour and flavour scores from 1 (like very much) to 7 (dislike very much). Different letters within the same column indicate significant differences ($P < 0.05$).

### Table 5
Percentage of androstenone sensitive or less sensitive/insensitive consumers depending on their age

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Sensitive</th>
<th>Mildly sensitive</th>
<th>Insensitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>18–25</td>
<td>21.4</td>
<td>10.5</td>
<td>68.1</td>
</tr>
<tr>
<td>26–40</td>
<td>30.0</td>
<td>17.1</td>
<td>53.0</td>
</tr>
<tr>
<td>41–60</td>
<td>40.0</td>
<td>17.5</td>
<td>42.4</td>
</tr>
<tr>
<td>61–75</td>
<td>23.9</td>
<td>13.4</td>
<td>62.7</td>
</tr>
</tbody>
</table>

$\chi^2 = 57.54$  $P < 0.0001$
Weiler et al., 2000) who dislike the smell of androstene- none while only 12.7% of the mildly sensitive/insensitive dislike it. These percentages were 9.6 and 66.9%, respectively, when the score was “indifferent” and 20.4 and 8%, respectively, when the appreciation was “like”. Logically, sensitivity is related to the liking of the smell of androstene. However, even though the majority of more sensitive consumers dislike androstene odour there are 8% of them who like it. This percentage is significantly higher for men (16%) than women (3%) and cannot be disregarded. As suggested by Labowls (cited by Pause et al. 1999), the perceived quality of androstene varies considerably between subjects. Some find it to have a very unpleasant urinous, sweaty odour, while others describe it as having a perfumed, sandal wood odour. A possible hypothesis to explain this variation can be differences in odour appreciability depending on the concentration of this substance in the boar meat, as suggested by Wismer-Pedersen (cited by Pearson, Ngoddy, Price, & Larzelere, 1971) and can also be related to the androstene detection threshold for each consumer. This would be in accordance with the results obtained by Pearson et al. (1971) that found an acceptability or even a preference of consumers for some products made from boar meat. According to that hypothesis, 20.4% (22.4% men and 18.0% women) of the consumers less sensitive or insensitive (see Table 7), who have a higher androstene detection threshold, liked the smell. The differences in androstene appreciation can be related to the gender because androstene is a steroid that can be found in human axilla and urine, the levels of this substance in men being significantly higher than in women (Gower, Bird, Sharma, & House, 1985; Thornhill & Gangestad, 1999).

Classification of the Spanish consumers according to their sensitivity to androstene smell has been shown to influence their odour acceptability of pork, the effect on flavour acceptability being less important (Weiler et al., 2000). Due to the differences in liking for androstene smell within sensitive and insensitive consumers, it is of interest to see if the classification of the consumers according to their appreciation of androstene smell, influences their acceptability of the odour and flavour of pork in the same way as when they are classified depending on their sensitivity.

3.3. Influence of the appreciation of androstene smell in the odour and flavour acceptability of pork with different levels of androstene and skatole

The results obtained after applying GLM procedure (Model 2) are shown in Table 8. It can be seen that the appreciation of the smell of androstene, as well as the interaction between skatole and androstene level, is significant for the odour and flavour assessments.

There is a significant influence on the acceptability of pork loin (odour and flavour) depending on the consumers’ appreciation of androstene smell. Consumers who “like” the smell of pure androstene (18.1% of the whole population) score both the odour and the flavour of the cooked pork significantly better than consumers who “dislike” or “neither like nor dislike”
that smell (Table 9). Two main differences can be seen comparing these results with those obtained when the sensitivity of the Spanish consumers was taken into account (Weiler et al., 2000). Firstly, Spanish consumers' appreciation of androstenone affects both odour and flavour acceptability, while when sensitivity was studied, only the odour scores were affected. Secondly, the acceptability does not depend on the level of androstenone or skatole of the loin, while in the former work (Weiler et al., 2000) there was an interaction between androstenone content and sensitivity in the odour assessment.

This indicates a higher discrimination in the acceptability of the odour and flavour of pork when the liking for androstenone smell is considered instead of the sensitivity to that compound. Taking into account that 33.0% of the Spanish consumers evaluated do not like the androstenone smell, this characteristic cannot be omitted when the acceptability of pork is studied, because in that case, unrealistic results would be obtained. Furthermore, and as stated by Weiler et al. (2000), there may be an underestimation of consumer reaction due to the fact that samples had been heated twice before presentation to the consumers.

Fig. 1 shows the interaction between androstenone and skatole levels for odour (a) and flavour (b) scores. In both plots, the scores given to the samples with low androstenone levels are lower (better scored) or very similar to those given to the samples with high androstenone levels, independently of the skatole level of the samples. However when samples with medium androstenone levels are taken into account, the odour and flavour scores are the lowest (the best) when skatole level is low or high and the highest (the worst) when skatole level is medium. It indicates that the interaction between androstenone and skatole is in the samples with medium levels of both compounds and it suggests that both compounds are responsible for boar taint and that consumers' acceptability depends on the concentration of both of them.

### 4. Conclusions

In Spain 38% of the carcasses have high (>1.0 µg/g) androstenone levels, 26% of them have high (>0.22 µg/g) skatole levels, and 17% of them have high levels of both compounds (Font i Furnols, 2000; Walstra et al., 1999). This fact, together with the results of that paper, allows us to conclude that in Spain there is the necessity to search for a method that could reduce the levels of both compounds if high quality pork is sought. This reduction can be achieved by means of the control of feeding, rearing conditions or genetics.
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