Towards entire male pigs in Europe: a perspective from the Spanish supply chain

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ABSTRACT

Castration in pig production is mainly performed to avoid boar taint and for management purposes. The European Commission plans to end voluntarily surgical piglet castration by 2018. The aim of this study was to assess the opinions and attitudes of Spanish stakeholders from the whole pork chain regarding this plan. Two methodologies were used: focus groups with 26 participants (qualitative method) were carried out with representatives of farmers, the meat industry, government institutions, retailers (including butchers), HORECA and consumers; and 127 face-to-face surveys to butcheries (quantitative method) were carried out, including an analytical hierarchical process to assess the determining factors when purchasing fresh pig meat. Results showed that a potential end of pig castration in Europe is not considered to have an effect on conventional pig production in Spain. However, they are worried because of a negative effect on high quality production where pig castration plays an important role.

KEY WORDS:

Analytical Hierarchy Process, boar taint, butchers, focus group, pig castration.

ABBREVIATIONS:

AHP: Analytical Hierarchy Process

FG1: focus group 1 with representatives of farmers, the pig meat industry, slaughterhouses and Government

FG2: focus group 2 with representatives of restaurants and caterings, supermarkets, butcheries and consumers associations

NGO: Non-governmental organization

PGI: Protected Geographical Indication

PGO: Protected Designation of Origin

TSG: Traditional Specialities Guaranteed

INTRODUCTION

Pig production is the most important livestock activity in Spain; 40 millions of pigs are slaughtered every year which represents 16% of European production (FAOSTAT, 2012). A percentage of male pigs are castrated according to legislation (Directive 2001/93/CE) mainly for quality purposes. In 2009, castration was estimated to be performed on 79% of male pigs in Europe, 33% being in Spain (Fredriksen et al., 2009). Nowadays, although no official data is known, this percentage has been reduced to 15-20% in Spain according to the pig sector.

The practice of castration avoids the presence of boar taint produced by androstenone and skatole in meat (Bonneau, 1982; Bonneau et al., 2000). The presence of boar taint in meat may affect the acceptability of pork by consumers (Bonneau and Chevillon, 2012; Desmoulin et al., 1982; Diestre et al., 1990; Font i Furnols, 2012; Meier-Dinkel et al., 2013). Whilst skatole is perceived by 99% of consumers (Weiler et al., 1997), around 40% of consumers are anosmic for androstenone, which means that they are unable to smell this compound, therefore androstenone sensitivity also affects boar meat acceptability (Blanch et al., 2012; Font i Furnols et al., 2003; Weiler et al., 2000). A study performed in Switzerland found that part of the population experienced the presence of boar taint in meat (Huber-Eicher and Spring, 2008). Another reason for castrating piglets is meat quality; meat from castrated males has more intramuscular fat which affects its acceptability (Aluwé et al., 2013; Bañón et al., 2004; Gispert et al., 2010).

However, the practice of castration has generated a debate in the European Union due to its negative impact on animal welfare: European Declaration on alternatives to surgical castration of pigs (DG-SANCO, 2010). According to this declaration which performed by representatives of European farmers, the meat industry, retailers, scientists, veterinarians and animal welfare NGOs, under the management of the European Union, the plan is to voluntarily end the surgical castration (with or without anaesthesia) of pigs in Europe by 1 January 2018.

Several studies in different countries evaluated attitudes and opinions about alternatives to surgical castration: for Norwegian consumers castration without anaesthesia is unacceptable (Fredriksen et al., 2011), Swiss consumers did not accept immunocastration as an alternative to surgical castration, and prefer castration with anaesthesia (Huber-Eicher and Spring, 2008) and Flemish pig farmers considered entire males production as the least profitable strategy whilst sperm sexing was positively perceived (Tuyttens et al., 2012). Previous studies have assessed consumers' opinion and the relative importance of pig castration (Kallas et al., 2013; Kallas et al., 2012). In order to evaluate whether commercialization of boar meat would be a problem, it was considered useful to know if the meat industry, retailers, consumers and exportation would be able to accept the change from meat from castrated pigs to meat from entire males.

The aim of this study was to assess stakeholders' opinions of the Spanish pork supply chain, the attitudes of retailers towards the potential market of the production of entire male pigs and the impact of a potential mandatory banning of piglet castration. Another objective is to quantify the opinion of butchers, as they are one of the main retailers in the Spanish pork chain supply (MAGRAMA, 2013).

MATERIAL AND METHODS

Our methodological framework was based on two main approaches to analyse the opinions and attitudes of the main stakeholders in the pork meat supply chain (farmers, industry, government, retailers and consumers). Firstly, the focus group as a qualitative methodology was applied to analyse opinions towards the production of entire male pigs and the impact of potential banning of piglet castration in Spain. Secondly, a face-to-face survey for butchers as the main retailers for fresh pig meat in Spain was carried out as a quantitative methodology to identify the determining factors for purchasing pig meat, using the Analytical Hierarchy Process (AHP) and to assess the relative importance of pig castration within their decision.

95

96 **Focus groups**

97 Focus group methodology allows the exploration of attitudes and perceptions related to concepts,
98 products, services or programmes by interaction with other people and it is useful when there are
99 power differences between the participants (Krueger, 1994; Morgan, 1993).

100 *Study design*

101 In this study, to obtain a broad vision of the opinion of different stakeholders regarding the
102 production of entire male pigs and the potential banning of piglet castration in Spain, focus groups
103 were organized in two different Spanish regions (Barcelona and Madrid). Two kinds of focus group
104 sessions per city were organized with the following stakeholders: Focus group 1 (FG1) included
105 representatives for farmers, the pig meat industry, slaughterhouses and the government; and Focus
106 group 2 (FG2) included representatives of HORECA, supermarkets, butcheries and consumer
107 associations. They were developed on 21st November 2012 in Barcelona and 12th February 2013 in
108 Madrid with 26 participants in total, 5-8 in each session, and 1-2 participants per stakeholder and
109 session.

110 *Description of Focus groups*

111 Focus groups were conducted according to standard procedures (Morgan, 1993). The focus group
112 team consisted of a moderator and an assistant. In all the sessions a moderator led the proceedings
113 and obtained answers to the set of questions from each participant. Each focus group lasted 55-60
114 min. The Focus group sessions were recorded and field notes were taken during the session in order
115 to later analyse the data. The participants were informed that all the data obtained in the focus
116 group was only for research purposes, and that personal information would remain confidential.

Focus groups questions

Discussion questions were carefully chosen to properly reach the objective of the study regarding the opinions and attitudes of the supply chain towards the potential market of the production of entire male pigs and the impact of a potential mandatory banning of piglet castration (Table 1).

Data analyses

After each session audio files were transcribed verbatim to be sure that no important information was lost. The focus group team listened to the audio files several times in order to avoid errors of transcription that could change the meaning of the comments. Transcriptions and field notes of the focus groups were then analysed and all the data was sorted according to the set of questions.

Face-to-face butchery surveys

On the basis of the qualitative information gathered from the previous focus groups, a semi-structured questionnaire was designed with open and open-ended questions. Face-to-face questionnaires with butchers were carried out during the first semester of 2014. The final sample consisted of 127 surveys, 72 of which were carried out in Catalonia (regions of Barcelona and Girona) and 55 in Madrid. A list of all the butcheries was provided by the professional association of butchers of each region. The selection of butcheries was made randomly using the postal codes of each region as a variable of stratification.

Questionnaire design

The survey collected extensive information on butchers' characteristics, butchery physical and economic characteristics and attitudes and opinions about pig castration (Table 2). Finally, determining factors when purchasing fresh pig meat were analyzed using the AHP.

139 *The Analytical Hierarchy Process (AHP)*

140 AHP is a technique (Saaty, 1977) to support multi-criteria decision-making in discrete environments.
141 In the application of the AHP, the first step is to clearly define the main attributes that butchers take
142 into consideration when purchasing fresh pig meat. To tackle this issue, we first relied on prior
143 research performed on fresh pig meat (Font i Furnols and Guerrero, 2014; Kallas et al., 2012). The
144 attributes identified from the literature were discussed in the applied focus groups. The final set of
145 attributes included was: origin of the meat, external fat content, intramuscular fat content, pig
146 gender and colour of the meat. Each attribute in the tree was divided into three different levels to be
147 also valued (Figure 2).

148 The relative importance or weights (w_i) of attributes and levels were obtained from paired
149 comparisons determining the intensity of preference for each option with a 1 to 9 scale (Saaty,
150 1980). The relative importance of each attribute was obtained by comparing this attribute with all
151 other attributes. A matrix with the following structure was generated for each individual (k) (Saaty
152 matrix):

153 $$A_k = \begin{bmatrix} a_{11k} & a_{12k} & \dots & a_{1nk} \\ a_{21k} & a_{22k} & \dots & a_{2nk} \\ \dots & \dots & a_{iik} & \dots \\ a_{n1k} & a_{n2k} & \dots & a_{nnk} \end{bmatrix} \quad (1)$$

154 where a_{ijk} represents the value obtained from the comparison between attribute i and attribute j for
155 each individual. This square matrix has two fundamental properties: (a) all elements of its main
156 diagonal take a value of one (a_{iik}=1 $\forall i$), and (b) all other elements maintain that paired comparisons
157 are reciprocal (if $a_{ijk}=x$ then $a_{jik}=1/x$). If perfect consistency in preferences holds for each decision-
158 maker, the values given for paired comparisons will represent the weights of each attribute;
159 $a_{ijk}=w_{ik}/w_{jk}$ for all i and j. As a result, it should also hold that for any i, j and h where h represents any
160 attribute within the decision tree, $a_{ihk}\times a_{hjk}=(w_{ik}/w_{hk})\times(w_{hk}/w_{jk})=w_{ik}/w_{jk}=a_{ijk}$. Therefore, the Saaty
161 matrix can also be expressed as follows:

$$A_k = \begin{bmatrix} \frac{w_{1k}}{w_{1k}} & \frac{w_{1k}}{w_{2k}} & \cdots & \frac{w_{1k}}{w_{nk}} \\ \frac{w_{2k}}{w_{1k}} & \frac{w_{2k}}{w_{2k}} & \cdots & \frac{w_{2k}}{w_{nk}} \\ \cdots & \cdots & \frac{w_{ik}}{w_{jk}} & \cdots \\ \frac{w_{nk}}{w_{1k}} & \frac{w_{nk}}{w_{2k}} & \cdots & \frac{w_{nk}}{w_{nk}} \end{bmatrix} \quad (2)$$

Thus, if the decision-makers' property of perfect consistency is held, n weights (w_{ik}) for each attribute can be easily determined from the $n(n\text{-}1)/2$ values for a_{ijk}. However, perfect consistency is seldom present, where personal subjectivity plays an important role in doing the paired comparison. For Saaty, matrices (A_k=a_{ijk}) in which some degree of inconsistency is present, alternative approaches have been proposed to estimate the weight vector that best resembles the decision-makers' real weight vector. The geometric mean approach was used (Aguarón and Moreno-Jiménez, 2000; Kallas et al., 2007) where weights assigned by butchers to each attribute are obtained using the following expression:

$$w_{ik} = \sqrt[n]{\prod_{i=1}^{i=n} a_{ijk}} \qquad \forall i, k \qquad (3)$$

AHP was originally conceived for individual decision-making, but it was rapidly extended as a valid technique for the analysis of group decisions (Easley et al., 2000). Thus, we needed to aggregate the corresponding butcher's weights (w_{ik}) across butchers to obtain a synthesis of weights for each attribute (w_i). The aggregation process should be carried out following Forman and Peniwati (1998), who considered that the most suitable method for aggregating individual weights (w_{ik}) in a social collective decision-making context is the geometric mean:

$$w_i = \sqrt[m]{\prod_{k=1}^{k=m} w_{ik}} \qquad \forall i \qquad (4)$$

where w_i is used to summarize the results of the AHP analysis.

To mitigate the order effect in applying the AHP, we followed a design based on ordering change within the AHP attributes as advised by Chrzan (1994). The randomness was based on two types of ordering changes: (a) the order of the different pair wise comparison; and (b) the order of levels within each pair wise comparison (i.e. sometime levels are presented on the right of the pair wise comparison others on the left).

Data analyses

The FREQ and MEANS procedures of the SAS software package (version 9.2; SAS Institute Inc., Cary, NC, USA) were used to analyse the questions from the face-to face surveys to butcheries. A significance level lower than 0.05 was used. AHP was analysed by Super Decision Software (Creative Decisions Foundation, Pittsburgh, PA, USA).

RESULTS AND DISCUSSION

Focus groups

The main comments for each stakeholder are shown in Table 3 for FG1 and in Table 4 for FG2 in order summarize the main ideas from the different focus groups.

Potential impact of banning castration on pig production in Spain – Boar taint

Although no official data is known, according to the pig sector the castration rate in Spain is between 15-20%. Participants believed that in Spain there would be no important implication to pig production if castration is banned in the near future, since a large part of the market is already based on entire males. However, participants said that castration is linked to the product: farmers expressed that if the declaration ends with a prohibition of castration, it would be a problem for the Iberian pig sector. One government representative commented that there is still time to act before 2018. However, no clear actions were suggested for the present. In the same context, the

representative from a cutting plant said that they do not castrate as they have never identified that this is a serious problem for their consumers. A farmers' representative commented that the main reason for castrating is animal behaviour. Butchers feel that castration is important for them in order to produce certain high quality products.

Concerning boar taint, participants commented that it is seldom found in the fresh meat due to the fact that animals are being slaughter at an early age (approximately 6 months old) and that genetic types have changed. Participants mentioned that boar taint is more problematic in fresh meat than in processed products because it is easier to mask boar taint in these ones. Participants were uninformed with regard to the percentage of consumers able to detect boar taint (approximately 40% of population) (Blanch et al., 2012; Panella-Riera et al., 2010). Butchers commented that part of the problem is because their consumers are not familiar to this flavour, as pigs are slaughtered younger. They added that in the United Kingdom, where pigs are not castrated and they are slaughtered at heavier weights, people are used to the entire male meat flavour. Participants of the focus group stated that if consumers find meat with boar taint, they do not re-purchase at the same retailer and usually change to another supermarket or butchery (ALCASDE, 2008). As will be discussed later in the face-to-face to butchery results, they do not usually complain about abnormal odours in meat.

European Declaration on alternatives to surgical castration of pigs

Stakeholders from industry and government were aware of this declaration and they knew that it was intended to be voluntary from 2018, although they recognized that it might end up as being passed as a law. This declaration seems to be a good initiative from the pig supply chain point of view because it was written by farming representatives and other stakeholders in the European pig supply chain as well as NGOs (Non-governmental organizations).

Regarding the potential alternatives to surgical castration without anaesthesia, participants talked about castration with analgesia and anaesthesia, immunocastration and production of entire males. Participants mentioned that it would be important to know if consumers are able to distinguish between meat from a castrated animal and meat from an entire animal. In relation to the cost of castration with anaesthesia and analgesia, the general feeling is that the cost should be the responsibility of the whole chain, although in practice, participants admitted that it will be paid by farmers. They mentioned that consumers would not accept meat labelled as *meat from immunocastrated animals*.

Participants were aware that according to this declaration a list of traditional production requiring heavier pigs or pigs with a certain amount of fat would be made, to be included as exceptions to this declaration: PDO (Protected Designation of Origin), PGI (Protected Geographical Indication) or TSG (Traditional Specialities Guaranteed). The government representatives and meat processing plants were concerned about TSG -they mentioned *Jamón Serrano* as an example- because it is not linked with a territory and a similar product could be produced in a third country with TSG label. These concerns about traditional products may be due to the fact that stakeholders are unsure about what exceptions would include this declaration.

Differences in quality between castrated and entire males

Regarding productive and quality differences between castrated versus non castrated pigs participants knew that entire males have higher performance than castrated, which is why some farmers gave up castration even though pigs accumulate less fat and may have boar taint problems.

Immunocastrated animals, as an alternative to surgical castration, are raised as entire males, and immediately after the second injection they behave as castrated animals (Fàbrega et al., 2010). One butcher commented that this is not interest to industry because these animals have a higher amount of fat and therefore lower killing-out percentage. However, it is a good option for butcheries because

253 they can offer high quality products from immunocastrated pigs with more fat content. The butchers'
254 representative said that some consumers prefer lean meat to fat meat because they do not have
255 information on this subject and they think that leaner meat is healthier than fat one; but they said
256 that other customers prefer high quality products with more intramuscular fat content.

257 In line with the above, participants expressed their concern regarding the consequences of the
258 potential banning of piglet castration on high quality products; since they believe that for these
259 products it is necessary to perform surgical castration or immunocastration.

260

261 *Exportation – QS Quality Assurance*

262 Participants believed that the prohibition of castration would not be a problem for exportation
263 because most pork exportation is done for profit gain and not based for high quality. Although meat
264 quality is different between castrated and entire males, participants did not see it as a problem since
265 the rate of castration in Spain is already low and exportation rate is high. Because Spanish farms are
266 producing mostly entire males, participants commented that Spain could be at an advantage with
267 respect to other countries where only castrated pigs have been produced so far.

268 The German QS Quality Assurance scheme is a guideline for slaughtering and deboning, one of its
269 rules states that companies should have a system for classifying fresh meat according to boar taint
270 (https://www.q-s.de/qs-scheme/qs-certification-mark.html). Almost all the participants had very low
271 knowledge about this certification. The general feeling of the stakeholders is that there is a need to
272 have **a proper and fast online method available for detecting boar taint in order to avoid carcasses**
273 **with boar taint,** so industry would be able to export products according to the presence of boar taint
274 to different markets. It was mentioned that some European countries are introducing the *human*
275 *nose scoring system* in order to classify carcasses with boar taint, but participants think that more
276 research should be done, because the effectiveness of this method should be improved.

277

Quality criteria when purchasing pork meat

Participants of FG2 were asked about their purchasing decisions when buying meat. They mentioned attributes such as colour, fat content and moisture. They talked about texture and flavour although they were aware that such attributes are only appreciated after consumption. They pointed out other attributes such as origin of the meat, freshness, preservation of the meat and age of the animal; participants said that age of the animal is related to tenderness. The price was mentioned by a young consumer, and the rest of the participants agreed. It was mentioned that good hygienic conditions are always demanded, which is taken for granted. Regarding the pig gender, butchers preferred female pigs, and said that the important thing is not the sex of the pig itself but the fact that meat does not present boar taint. One of the retailers said that the sex of the animal is not important to them. Retailers added that attributes such as animal welfare and environmental aspects are incipient and up to now not relevant. A consumer organisation said that it was important to provide more information in labelling regarding quality attributes such as castrated or non-castrated, type of production and origin –although consumers are not able to process this information–. Previous studies have evaluated that the most important attributes for consumers are price, origin and taste/odour (Kallas et al., 2012; Meuwissen and Van Der Lans, 2005).

Regarding all these opinions, it seems that the main attributes that consumers look for are colour, fat content and price. As will be discussed later, this is in agreement with the results obtained in the face-to-face surveys at butcheries and is in line with attributes discussed in literature (Font i Furnols and Guerrero, 2014; Kallas et al., 2012).

Animal welfare

Participants commented that nowadays apart from good quality meat, some consumers demand products which come from animals with certain welfare standards. All participants agreed that castration is related to welfare, because animals are castrated with no anaesthesia. If pigs were

303 castrated in the same way as veterinarians castrate domestic pets it would not be any welfare
304 problem. A retailer's representative said that consumers will always say that animals should not be
305 castrated due to welfare issues, but they have no idea that one of the reasons for performing
306 castration is to avoid boar taint. Participants agreed that Spanish consumers are not ready to pay for
307 meat coming from animals raised under welfare standard conditions because animal welfare is a
308 comparatively recent issue in Spain. Regarding the whole chain (farm, transport and slaughter),
309 participants considered that during slaughtering animal welfare is correct.

310

311 *Standard market (entire males) and high quality products*

312 A representative of a meat processing plant said that butchers avoid entire males because of boar
313 taint and purchase meat from female pigs. This is in concordance with what butchers revealed about
314 attributes when buying pork meat, and also with the results from the face-to-face surveys to
315 butcheries. It was also mentioned that some retailers label pork and pork products as *meat from*
316 *female*, they explained that if you label this way consumers are sure that no boar taint will be
317 present; but as was said before, most consumers do not know the relationship of male/female meat
318 with the presence boar taint.

319 Butchers admitted that producing entire males slaughtered at an earlier age would not solve the
320 problem because the reason for raising heavier animals is to have meat with certain quality
321 characteristics required by the market. To avoid boar taint participants suggested using this meat for
322 products where it is possible to mask this smell avoiding fresh and cured meat.

323 Participants from industry in the Madrid focus group were concerned about the Iberian pig and
324 though it should be taken into consideration as an exception to this declaration.

325

Face-to-face surveys to butcheries

The socio-demographic characteristics of the survey and other butchers' features are described in Table 5 and Table 6 respectively.

Potential impact of banning castration on pig production in Spain – Boar taint

Regarding the possible impact of banning pig castration to butchers, results did not show a clear agreement: 52.4% yes, and 47.6% no (Table 7; $P>0.05$). Because there were no significant differences it can be assumed that they were unsure about what would happen if castration is banned in the near future. These results demonstrate that butchers are probably oriented to two different markets: one to standard pork, and the other to high quality products. In the focus groups, participants were quite sure that the banning of pig castration would not be a big issue for the conventional Spanish pig production, although butchers from the focus group were partly in disagreement with regard to high quality products. These results suggest that if they use meat from female pigs, they avoid boar taint. Therefore, they are selecting the meat because they cannot be sure that meat from boars is free from boar taint (Bonneau and Chevillon, 2012; Font i Furnols et al., 2000).

Differences in quality between castrated and entire males

Regarding meat quality, 62.6% of the butchers said that castration affects the meat quality (Table 7; $P<0.001$), and agreed that meat from castrated animals has better sensory quality than meat from entire males. When comparing the different types of meat (entire males, castrated males and females), 74.0% of the butchers revealed that meat from females is of better quality, 12.6% said that meat from castrated males is better, and only 4.7% of them said meat from entire males is of better quality (Table 8; $P<0.0001$). Results from a consumer study by Font i Furnols et al. (2014) confirms that consumers prefer meat from female or castrated pigs. On this line, the focus group participants agreed that meat from castrated males is of better quality than meat from entire males because of

fat infiltration and because castration avoids boar taint. The butchers unanimously agreed on this point.

Regarding complaints about meat quality, 18.9% of butchers admitted some complaints from costumers among which 27.0% were related to the presence of abnormal odours in the meat (Table 7; $P<0.0001$). Among the customers who complained about it, most of them (88.6%) asked about the origin of this odour, and the answer given by the butchers was that the meat came from entire male pigs. Regarding focus groups comments this low percentage of complaints, could be due to the fact that consumers are not used to complaining.

Quality criteria when purchasing pork meat

When purchasing meat, 79.5% of the butchers revealed that it is important to know the pig gender (Table 7, $P<0.0001$). Bearing this in mind, they were asked about the percentage of meat from different genders that they buy: 74.3% female, 18.1% castrated male and 7.6% entire male (Table 6). These results confirm the opinion expressed in the focus groups that butchers prefer meat from female pigs.

According to the purchasing decision of their customers (Table 9), butchers considered that the main attributes are: colour of the meat (77.2% of consumers paying attention to it), price (72.4%) and fat content (68.5%). Colour of the meat, fat content and price were also the main attributes mentioned in the focus groups, and other attributes such as origin or odour, although mentioned, were ranked with less importance. Previous studies showed similar results (Font i Furnols and Guerrero, 2014; Kallas et al., 2012).

AHP Results: The relative importance of the attributes when purchasing fresh pig meat

The results of the aggregation of weights for the five main attributes (w_{A1}: origin, w_{A2}: external fat, w_{A3}: intramuscular fat, w_{A4}: pig gender and w_{A5}: colour) across butchers are shown in Figure 3.

These results suggest that pig gender and intramuscular fat are the most important attributes for the butchers, with aggregate weights of 25.80% and 24.98% respectively. The colour attribute occupies third position with aggregate weight of 21.69%, the origin and the external fat attributes with an aggregated weights of 14.89% and 12.65% respectively.

The global weights represent the total preference score or the total relative importance of each level taking into consideration all attribute levels. Thus, we find that the most preferred level for butchers is the female level (17.46%), followed by the light red colour (15.35%) and an average intramuscular fat (15.25%). The lowest weight is assigned to the foreign origin (1.10%) followed by the dark red colour (1.96%). The results from AHP are in accordance with the ones from the focus group. Other questions in the survey showed that butchers prefer and buy mostly meat from female pigs, and that fat content (intramuscular fat content in particular) and colour of the meat are also important for butchers and consumers. Previous studies by Kallas et al. (2012) showed the relative importance of pig meat attributes for Spanish consumers: taste and odour (56.76%), price (20.96%), origin (16.32%) and pig gender (5.90%). Regarding these results, the relative importance of origin was similar for both, butchers and consumers, but there was a difference of criteria about pig gender, it is important for butchers whilst it seems that consumers did not take so much care about it.

Animal welfare

Butchers were asked about their knowledge on animal welfare. They answered that it was 5.3 ± 2.28 on average (9 point scale: 1=very low knowledge, 5=medium, 9=very high). Their feeling about the level of animal welfare in Spain was 5.7 ± 2.11. Table 7 shows the answers to different questions regarding animal welfare. Although they considered that the level of animal welfare is sufficient,

54.8% said that animal welfare legislation should be more restrictive in Spain. 65.9% of them answered that castration does not have any effect on animal welfare; this may be due to the fact that they do not know how castration is performed. This is in agreement with one previous study in Belgium; focus groups participants agreed that castration without anaesthesia affects animal welfare. However, 81.5% said that their consumers would not pay a plus for animal welfare. This result confirms the one obtained from the focus groups.

Standard market (entire males) and high quality products

Regarding the different types of meat the butchers sell, 64.6% were selling pork meat with different characteristics (different types of meat), 52.4% were offering meat from Duroc although they were unable to ensure that consumers would pay more for quality (Table 7; $P > 0.05$). Regarding the types of pork meat that they were offering, the butchers mentioned: meat from Duroc, Iberian, conventional crossbreeds, female and meat from organic production. On the same line as what was said in the focus groups, Iberian pig and Duroc crossbreeds seem to be one of the most important high quality products for butchers.

CONCLUSIONS

According to Spanish pig chain supply stakeholders, in conventional pig production a potential end of piglet castration in Europe by 2018 might not be considered as a problem because a high percentage of entire males are already currently being produced.

For the production of high quality products, including Iberian breed, representatives of the sector considered that the end of castration could be a problem if a list of exceptions to the declaration is not produced. This is important mainly for butchers, as one of the main retailer's stakeholders. This is because they produce high quality products that need castration in order to have some specific requirements, such as adequate intramuscular fat content and no boar taint.

According to the AHP in the face-to-face surveys to butcheries, the most important attributes of pig meat are intramuscular fat and pig gender. They are looking for an average of intramuscular fat different for conventional production and for meat from female pigs.

From the results of this trial we can conclude that policy implications about castration of piglets should be conducted in making a list of those traditional products, such as PGI, PGO and TSG. These quality schemes must be included as exceptions in the European Declaration on alternatives to surgical castration of pigs.

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REFERENCES

Aguarón, J., Moreno-Jiménez, J.M., 2000. Local stability intervals in the analytic hierarchy process. European Journal of Operational Research 125, 113-132.

ALCASDE, 2008. Report. http://www.alcasde.eu. Accessed:

Aluwé, M., Langendries, K.C.M., Bekaert, K.M., Tuyttens, F.A.M., Brabander, D.L.D., Smet, S.D., Millet, S., 2013. Effect of surgical castration, immunocastration and chicory-diet on the meat quality and palatability of boars. Meat Science 94, 402-407.

Bañón, S., Andreu, C., Laencina, J., Garrido, M.-D., 2004. Fresh and eating pork quality from entire versus castrate heavy males. Food Quality and Preference 15, 293-300.

Blanch, M., Panella-Riera, N., Chevillon, P., Font i Furnols, M., Gil, M., Gil, J.M., Kallas, Z., Oliver, M.A., 2012. Impact of consumer's sensitivity to androstenone on acceptability of meat from entire male pigs in three European countries: France, Spain and United Kingdom. Meat Science 90, 572-578.

450 Bonneau, M., 1982. Compounds responsible for boar taint, with special emphasis on androstenone:
451 A review. Livestock Production Science 9, 687-705.

452 Bonneau, M., Chevillon, P., 2012. Acceptability of entire male pork with various levels of
453 androstenone and skatole by consumers according to their sensitivity to androstenone. Meat Science
454 90, 330-337.

455 Bonneau, M., Walstra, P., Claudi-Magnussen, C., Kempster, A.J., Tornberg, E., Fischer, K., Diestre, A.,
456 Siret, F., Chevillon, P., Claus, R., Dijksterhuis, G., Punter, P., Matthews, K.R., Agerhem, H., Béague,
457 M.P., Oliver, M.A., Gispert, M., Weiler, U., von Seth, G., Leask, H., Font i Furnols, M., Homer, D.B.,
458 Cook, G.L., 2000. An international study on the importance of androstenone and skatole for boar
459 taint: IV. Simulation studies on consumer dissatisfaction with entire male pork and the effect of
460 sorting carcasses on the slaughter line, main conclusions and recommendations. Meat Science 54,
461 285-295.

462 Chrzan, K., 1994. Three kinds of order effects in choice-based conjoint analysis. Marketing Letters 5,
463 165-172.

464 Desmoulin, B., Bonneau, M., Frouin, A., Bidard, J.P., 1982. Consumer testing of pork and processed
465 meat from boars: The influence of fat androstenone level. Livestock Production Science 9, 707-715.

466 DG-SANCO, 2010. European Declaration on alternatives to surgical castration of pigs.
467 http://www.alternativepig.eu/partnership/declaration.html. Accessed: 5 August 2013

468 Diestre, A., Oliver, M.A., Gispert, M., Arpa, I., Arnau, J., 1990. Consumer responses to fresh meat and
469 meat products from barrows and boars with different levels of boar taint. Animal Science 50, 519-
470 530.

471 Easley, R.F., Valacich, J.S., Venkataramanan, M.A., 2000. Capturing group preferences in a
472 multicriteria decision. European Journal of Operational Research 125, 73-83.

473 Fàbrega, E., Velarde, A., Cros, J., Gispert, M., Suárez, P., Tibau, J., Soler, J., 2010. Effect of vaccination
474 against gonadotrophin-releasing hormone, using Improvac®, on growth performance, body
475 composition, behaviour and acute phase proteins. Livestock Science 132, 53-59.

476 Font i Furnols, M., 2012. Consumer studies on sensory acceptability of boar taint: A review. Meat
477 Science 92, 319-329.

478 Font i Furnols, M., Gispert, M., Diestre, A., Oliver, M.A., 2003. Acceptability of boar meat by
479 consumers depending on their age, gender, culinary habits, and sensitivity and appreciation of
480 androstenone odour. Meat Science 64, 433-440.

481 Font i Furnols, M., Guerrero, L., 2014. Consumer preference, behavior and perception about meat
482 and meat products: An overview. Meat Science 98, 361-371.

483 Font i Furnols, M., Guerrero, L., Serra, X., Rius, M.A., Oliver, M.A., 2000. Sensory characterization of
484 boar taint in entire male pigs. Journal of Sensory Studies 15, 393-409.

485 Forman, E., Peniwati, K., 1998. Aggregating individual judgments and priorities with the analytic
486 hierarchy process. European Journal of Operational Research 108, 165-169.

487 Fredriksen, B., Font i Furnols, M., Lundström, K., Migdal, W., Prunier, A., Tuyttens, F.A.M., Bonneau,
488 M., 2009. Practice on castration of piglets in Europe. Animal 3, 1480-1487.

489 Fredriksen, B., Johnsen, A.M.S., Skuterud, E., 2011. Consumer attitudes towards castration of piglets
490 and alternatives to surgical castration. Research in Veterinary Science 90, 352-357.

491 Gispert, M., Oliver, M.A., Velarde, A., Suarez, P., Pérez, J., Font i Furnols, M., 2010. Carcass and meat
492 quality characteristics of immunocastrated male, surgically castrated male, entire male and female
493 pigs. Meat Science 85, 664-670.

494 Huber-Eicher, B., Spring, P., 2008. Attitudes of Swiss consumers towards meat from entire or
495 immunocastrated boars: A representative survey. Research in Veterinary Science 85, 625-627.

496 Kallas, Z., Gil, J.M., Panella-Riera, N., Blanch, M., Font-i-Furnols, M., Chevillon, P., De Roest, K.,
497 Tacken, G., Oliver, M.A., 2013. Effect of tasting and information on consumer opinion about pig
498 castration. Meat Science 95, 242-249.

499 Kallas, Z., Gil, J.M., Panella-Riera, N., Blanch, M., Tacken, G., Chevillon, P., De Roest, K., Angels Oliver,
500 M., 2012. New EU Policies Towards Animal Welfare: The Relative Importance of Pig Castration.
501 EuroChoices 11, 36-43.

502 Kallas, Z., Gómez-Limón, J.A., Hurlé, J.B., 2007. Decomposing the Value of Agricultural
503 Multifunctionality: Combining Contingent Valuation and the Analytical Hierarchy Process. Journal of
504 Agricultural Economics 58, 218-241.

505 Krueger, R.A., 1994. Focus groups: a practical guide for applied research. Sage Publications, Thousand
506 Oaks, CA.

507 MAGRAMA, 2013. Base de Datos de Consumo en Hogares. Ministerio de Agricultura, Alimentación y
508 Medio Ambiente. http://www.magrama.gob.es/es/alimentacion/temas/consumo-y-
509 comercializacion-y-distribucion-alimentaria/panel-de-consumo-alimentario/base-de-datos-de-
510 consumo-en-hogares/consulta11.asp. Accessed: 10.12.14

511 Meier-Dinkel, L., Trautmann, J., Frieden, L., Tholen, E., Knorr, C., Sharifi, A.R., Bücking, M., Wicke, M.,
512 Mörlein, D., 2013. Consumer perception of boar meat as affected by labelling information,
513 malodorous compounds and sensitivity to androstenone. Meat Science 93, 248-256.

514 Meuwissen, M.P.M., Van Der Lans, I.A., 2005. Trade-offs between consumer concerns: An application
515 for pork supply chains. Acta Agriculturae Scandinavica, Section — Food Economics 2, 27-34.

516 Morgan, D.L., 1993. Successful Focus Groups: Advancing the State of the Art. SAGE Publications,
517 Newbury Park, CA.

518 Panella-Riera, N., Blanch, M., González, J., Gil, M., Gispert, M., Font i Furnols, M., Oliver, M.A., 2010.
519 Consumers' sensitivity to androstenone in Spain and UK, EAAP Working Group Meeting. Production
520 and Utilization of Meat from Entire Male Pigs, Bristol, UK.

521 Saaty, T.L., 1977. A scaling method for priorities in hierarchical structures. Journal of Mathematical
522 Psychology 15, 234-281.

523 Saaty, T.L., 1980. The Analytic Hierarchy Process. McGraw-Hill, New York.

524 Tuyttens, F.A.M., Vanhonacker, F., Verhille, B., De Brabander, D., Verbeke, W., 2012. Pig producer
525 attitude towards surgical castration of piglets without anaesthesia versus alternative strategies.
526 Research in Veterinary Science 92, 524-530.

527 Weiler, U., Fischer, K., Kemmer, H., Dobrowolski, A., Claus, R., 1997. Influence of androstenone
528 sensitivity on consumer reactions to boar meat, in: Bonneau, M., Lundström, K., Malmfors, B. (Eds.),
529 Boar taint in entire male pigs. EAAP Publication, pp. 147–151.

530 Weiler, U., Font i Furnols, M., Fischer, K., Kemmer, H., Oliver, M.A., Gispert, M., Dobrowolski, A.,
531 Claus, R., 2000. Influence of differences in sensitivity of Spanish and German consumers to perceive
532 androstenone on the acceptance of boar meat differing in skatole and androstenone concentrations.
533 Meat Science 54, 297-304.
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537 **TABLES**

538 **Table 1. Focus group topics**

Nº	Question
A	Potential impact of banning castration on pork production in Spain – Boar taint
B	European Declaration on alternatives to surgical castration of pigs
C	Differences in quality between castrated and entire males
D	Exportation – QS Quality Assurance
E	Quality criteria when purchasing pork meat
F	Animal welfare
G	Standard market (entire males) and high quality products

539

Table 2. Questions on face-to-face surveys to butcheries

Butchers' characteristics	
Age	Household members
Gender	Relation within the business
Education	Years in the butchery

Butchery characteristics
Years of business
Surface of the business
Employees
Customers
Meat format when purchasing (whole carcass, primal cuts, pieces)
SEUROP category of the meat
Percentage of meat according to pig gender

Questions regarding opinions and attitudes on pig castration
Potential impact of banning castration on pig production in Spain – Boar taint
Differences in quality between castrated and entire males
Quality criteria when purchasing pork meat
Animal welfare
Standard market (entire males) and high quality products

542 **Table 3. Main comments from the different stakeholders regarding focus group 1 questions**

	Farmers	Slaughterhouses	Industry	Government
A	*If only 30% of pigs are castrated, this demonstrates that 70% have no problem at all*	*Genetically, pigs have been selected to avoid boar taint*	*The Iberian pig is an animal with 160kg live weight, so it would be unthinkable not to castrate them*	*There is still time to react till 2018*
	The only problems for farmers are aggression and strange behaviours of entire male pigs	*Pigs are slaughtered at younger age*	*I'd rather castrate all pigs*	
B	*For farmers who have always castrated, producing entire males may be a big change in handling*	*The farmer will pay in the end*	*We are afraid that a third country starts producing Jamón Serrano*	*European Commission won't take any decision in welfare before doing the necessary studies*
	Unfortunately for farmer, slaughterhouses are able to choose other suppliers	*Commercial crossbreeds with large white and landrace have less boar taint than other breeds*	*If immunocastration is expensive they won't do it*	
C	*Originally the reason for giving up castration was productive performance*	*Non castrated animals have higher killing-out percentage because they have less fat*	*Entire males have boar taint*	*From the technological point of view, some products need castration*
D	*We are already exporting entire males to Europe*	*We are exporting for price, not for quality*	*We are castrating perhaps 20-30% and we are exporting 70-80%*	*Perhaps they will have to slaughter animals with a lower weight*
	If you have less than 2% of carcases with boar taint Human Nose could work [QS Quality Assurance]	*I feel that the real problem is that there is no online system for this [QS Quality Assurance]*	*The cost of human nose is 2-3€ per carcase [QS Quality Assurance]*	*This is a cost for slaughterhouses [QS Quality Assurance]*
F	*Intensive production have more economic resources for adapting themselves to animal welfare in a positive way*	*Being so restrictive with animal welfare in Europe may do European market less competitive*	*Entire males are more aggressive between them*	*Some slaughterhouses do not have enough adapted stable, and this problem is derived to transport*
G	*Perhaps we have reached the maximum possibility of production of entire males (70-80%)*	*You can't sell meat with boar taint because they will return it*	*The simple fact of labelling female ham it means that is not male, so it won't have any boar taint*	*Consumers don't appreciate meat from female pig because they don't know it*
	Farmers producing specific product not included as PSO need to find a way to protect their product		*We don't have any complaints about boar taint*	*We have to join this declaration, but we have some particular products to be included as exceptions*

543 A: Potential Impact of banning castration on pig production in Spain – Boar taint
544 B: European Declaration on alternatives to surgical castration of pigs
545 C: Differences in quality between castrated and entire males
546 D: Exportation – QS Quality Assurance (classification of fresh meat according to boar taint)
547 F: Animal welfare
548 G: Standard market (entire males) and high quality products
549

550 **Table 4. Main comments from the different stakeholders regarding focus group 2 questions**

	Retailers	Butchers	HORECA	Consumers
A	*There is a relationship between castration and boar taint, but percentage of carcasses with boar taint is low*	*Castration is important for us, in order to avoid boar taint*	*We will not pay to get meat with no boar taint*	*In general, consumers do not have knowledge about boar taint*
E	*Price* *Colour* *Food safety* *Quality* *Freshness* *Fat content*	*Food safety* *Quality* *Price* *Fat content* *Moisture* *Colour* *Gender*	*Price* *Quality* *Texture* *Fat content* *Age of the animal* Moisture	*Quality* *Price* *Origin* *Fat content* *Colour* Freshness
F	*There is a relationship between castration and animal welfare*	*Castration affects animal welfare*	*We have to discuss about if castration is or not an animal welfare issue*	*It will be paid by consumer, but most of them are not willing to pay more for animal welfare*
G	*Iberian pig produce meat with better quality than commercial crossbreeds*	*Our customers look for high quality products*	*We have a low profit margin, so we go for conventional products*	*I prefer to buy in butcheries, mainly because of quality*

551 A: Potential Impact of banning castration on pig production in Spain – Boar taint
552 E: Quality criteria when purchasing pork meat
553 F: Animal welfare
554 G: Standard market (entire males) and high quality products
555

Table 5. Butchers' characteristics

(*n=127*)			
Age (y; mean±SD)	48.4	±	9.14
Gender (% man:% woman)	82	:	18
Household members (n; mean±SD)	3.4	±	1.08
Education (%)			
Primary	3.9		
Secondary	50.4		
Higher degree/not university	39.4		
University	6.3		
Relation within the business (%)			
Owner	70.5		
Family employee	2.5		
Employee	20.5		
Other	6.6		
Years in the butchery (y; mean±SD)	17.7	±	13.65

SD=Standard deviation

562 **Table 6. Main features of the butcheries**

(*n=127*)			
Years of business (y; mean±SD)	30	±	20.41
Surface of the business (m^2; mean±SD)	79	±	180
Employees (n; mean±SD)			
Temporary	0.2	±	0.73
Steady	2.5	±	2.03
Customers (%; mean±SD)			
>60 years old	25	±	17.38
40-60 years old	49	±	22.62
25-40 years old	18	±	13.63
<25 years old	8.8	±	8.28
How do they buy meat? (%)[1]			
Whole carcass	28		
Primal cuts	26		
Pieces	71		
What category/ies of SEUROP do they buy? (%)			
S (≥ 60% lean)	34		
E (< 60% ≥ 55% lean)	44		
U (< 55% ≥ 50% lean)	13		
R (< 50% ≥ 45% lean)	13		
O (< 45% ≥ 40% lean)	3.1		
P (< 40% lean)	0		
What kind of meat according to gender of pig do they buy? (%)			
Entire male	7.6		
Castrated male	18		
Female	74		

563 SD=Standard deviation

564 [1] Multiple choice question, with more than one answer

565

566 **Table 7. Butchers' attitudes and opinions towards banning piglet castration and entire male**
567 **production**

Topics and questions (N=127)	Yes	No	DK	P
Impact of banning castration on pig production – Boar taint				
Banning pig castration would affect your sales?	52.4	47.6		ns
(χ^2=0.29; DF=1)				
Differences on quality between castrated and entire males				
Castration affects quality?	62.6	37.4		**
(χ^2=7.8; DF=1)				
Have you had any complain about meat quality?	18.9	81.1		***
(χ^2=49.14; DF=1)				
Have you had any complain about a strange odour in the meat?	27	73		***
(χ^2=26.70; DF=1)				
Consumers asked about the origin of this abnormal odour?	88.6	11.4		***
(χ^2=20.83; DF=1)				
Quality criteria when purchasing pork meat				
Is it important to distinguish between entire male, castrated male or female?	79.5	20.5		***
(χ^2=44.29; DF=1)				
Animal welfare				
Animal welfare legislation should be more restrictive in Spain?	54.8[a]	33.1[b]	12.1[c]	***
(χ^2=33.98; DF=2)				
Castration affects animal welfare?	34.2	65.9		**
(χ^2=12.37; DF=1)				
Customers would pay a plus for animal welfare?	18.6	81.5		***
(χ^2=49.06; DF=1)				
Standard market (entire males) and high quality products				
Do you sell different types of meat?	64.6	35.4		**
(χ^2=10.78; DF=1)				
Do you sell meat from Duroc?	52.4[a]	32.3[b]	15.3[c]	***
(χ^2=25.66; DF=2)				
Customers would pay a plus for quality?	48	52		ns
(χ^2=0.20; DF=1)				

568 DK=do not know; DF=degrees of freedom

569 ns: P > 0.1; **: P < 0.001; ***: P < 0.0001

570

571 **Table 8. Butcher's opinion about pig gender (χ^2=316.39; DF=5; P<.0001)**

Which gender has the best quality? (*n=127*)					
EM	FE	CM	FE=CM	All	DK
4.7^{c}	74.0^{a}	12.6^{b}	5.5^{bc}	1.6^{c}	1.6^{c}

572 EM=entire male; FE=female; CM=castrated male; DK=do not know

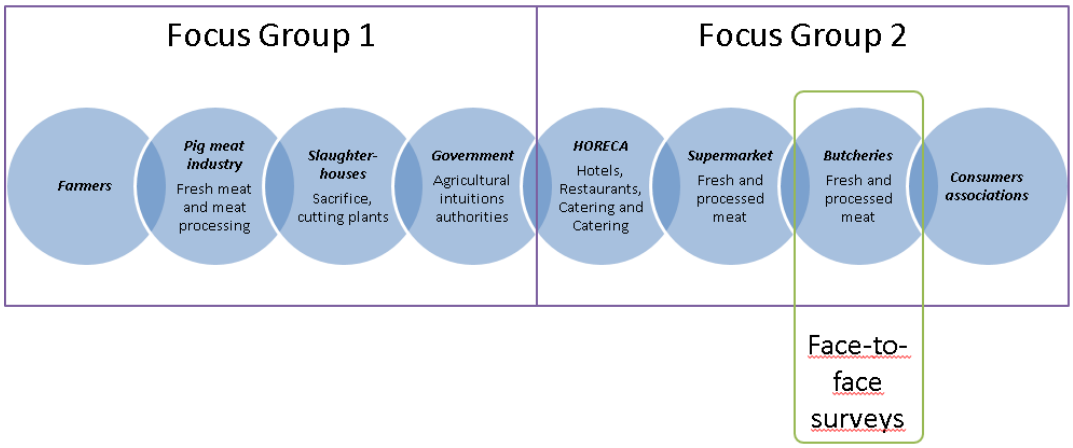
573

574 **Table 9. According to butcher's opinion, what consumers pay attention to, when buying pork**
575 **meat?**

(*n=127*)	Origin	Price	Brand	Fat content	Colour	Odour
Pay attention (%)	26.8	72.4	15	68.5	77.2	49.6
Indifferent (%)	30.7	11	32.3	15	6.3	14.2
Don't pay attention (%)	42.5	16.5	52.8	16.5	16.5	36.2
χ^2	5.12	87.98	27.28	70.74	111.8	24.39
DF	2	2	2	2	2	2
P	ns	***	***	***	***	***

576 ns: P > 0.1; **: P < 0.001; ***: P < 0.0001

577



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579 **FIGURES**

580 **Figure 1. Methodological approach to analyse the opinions and attitudes of the main stakeholders**

581 **in the pig supply chain**

582

583 **Figure 2. Hierarchical structure used to value butchers' main factors in purchasing pig meat**

584

585 **Figure 3. Relative importance of the main attributes when purchasing fresh pig meat**