Slaughtering of entire male pigs seen from the slaughterhouse perspective

M D Aaslyng¹, S Støier¹, B W Lund¹ and D B Nielsen¹

¹ Danish Technological Institute, Gregersensvej 9, DK_2630 Taastrup, Denmark

E-mail: mdag@teknologisk.dk

Abstract. Several challenges need to be taken into account before a full transition to slaughtering entire male pigs. To optimize welfare, entire male pigs should spend as short a time as possible in the pick-up facilities at the farm. At the slaughterhouse, there is no need to control the ratio between genders in the pens, as this has only minor effects on welfare. Boar taint detection must be performed, and an analytical on-line method is being developed. Rejection limits for skatole and androstenone must be set as a balance between the risk of consumers getting a negative experience on consuming the meat and the number of carcasses discarded. Smoking is a promising strategy for use of the discarded carcasses, and as much smoke as possible is recommended. Using spices and serving the meat in complex meals can also be a strategy to utilize boar tainted meat. In addition to boar taint, meat from entire male pigs is less tender and the protein content is lower than meat from castrates. In addition, the weight distribution of the carcass is different, with entire males having approximately 500g more weight at the fore-end and less at the ham. However, the meat percentages are higher in the entire males, and this can somewhat counteract the weight distribution.

1. Introduction
The number of entire male pigs raised and slaughtered in Europe is increasing, and the pressure from customers interested in animal welfare is further accelerating this development. However, seen from a slaughterhouse perspective, there are several challenges that need to be taken into account before a transition towards slaughtering of entire male pigs can be initiated. This review will discuss these challenges from the point when the pigs arrive at the slaughterhouse and until the meat is consumed. This includes aspects of handling the live animal to optimize animal welfare, analysis for boar taint components and how to set rejection limits, how the carcass of entire male pigs differs from castrates, and how the tainted meat can be utilized. Last, the monetary cost of slaughtering entire male pigs is calculated under different scenarios.

2. Animal welfare at the slaughterhouse
Entire male pigs are known to be more aggressive than castrates [1], and this must be taken into account when handling the pigs on the day of slaughter. It is recommended entire male pigs spend as short a time as possible in the pick-up facilities at the farms to reduce the frequency of skin damage before they arrive at the slaughterhouse. Keeping pigs in smaller groups during lairage at the slaughterhouse is a well-known method to reduce fighting. Despite having the pigs in smaller groups, pigs in pens with entire male pigs have more aggression instances and a lower rest index than pens
without entire male pigs. However, the observed difference in rest index between pens with and without entire male pigs is limited. Therefore, from an animal welfare point of view, it will be more important to avoid excessive handling of the animals, which would be needed if genders are kept at specified ratios in the pens. Consequently, the ratio between genders in the pens during lairage should not be controlled [2]. To increase welfare and reduce the amount of skin damage, slaughter of the unrestful pens at lairage in as fast a time as possible is recommended.

Another item incurring public attention concerning animal welfare is the need for tail docking in pigs. In production of entire male pigs, the risk of tail bites must be addressed. The incidence of tail bites in a production unit could be continuously monitored using a vision based system to assess the degree of tail bites on all carcasses at the slaughterhouse [3]. Farmers can also use this feed-back as a management tool to monitor smaller incidences of tail bites and act if the level increases.

3. Analysis of boar taint compounds and rejection limits
To avoid the risk of selling boar tainted meat to the consumers, boar taint detection must be performed on all entire male carcasses. In countries like the Netherlands and Germany, this is done by using a human nose methodology in which a person smells a heated sample of fat from each entire male carcass and classifies it into acceptable/not acceptable. However, this is a rather unspecific method [4], and it is difficult to set reliable rejection limits. The quantitative, chemical analysis of the boar taint compounds skatole and androstenone is, therefore, an optimal approach to detect boar taint on the slaughter line. An analytical method based on the extraction of relevant boar taint compounds from pig backfat, followed by measurement by laser diode thermal desorption-tandem mass spectrometry is expected to be introduced at the end of 2019. This method will be able to selectively quantify the boar taint compounds, skatole and androstenone, at the pace of the slaughter line. Regardless, even if the concentrations of skatole and androstenone are known, a decision of where to set the rejection limits must be made. Several papers have been published, including consumer studies as reviewed by Font-i-Furnols [5], to help in setting sorting limits.

However, a precise acceptability level of boar taint is difficult to set and depends on several factors. A recent European study showed that consumers always preferred meat from castrates irrespective of the level of skatole and androstenone in the backfat of entire male pigs [6], and it seems unrealistic to establish a rejection limit ensuring that all consumers will like meat from entire male pigs as well as meat from castrates. This was confirmed in a Danish study estimating the risk of disliking the meat, which showed that almost 80% of the carcasses would be discarded if the risk was set at similar levels for castrates and entire male pigs [7]. Instead, a recommended approach can be to consider the acceptable risk for a negative consumer experience balanced with the percentage of discarded carcasses that would be acceptable to the slaughterhouse.

4. Carcass composition
Entire male pigs have a higher meat percentage than castrates, and in most cases, this can be regarded as a positive trait. However, at the same time, the weight distribution of the three-parts (fore-end, middle and ham) of the carcass is different. Entire male pigs have approximately 500g more weight in the fore-end and 500g less weight in the ham compared with castrates. This difference in weight and lean meat percentage between the genders and three-parts was evaluated by computed tomography, using the same method as described by Olsen et al. [8]. If the carcasses are sold as three-parts, the higher meat percentage for entire males will be lost due to the higher value of the hams compared to the value of the fore-end.

Furthermore, the meat quality differs between genders. In one study, drip loss was higher in entire male pigs than in castrates [9], indicating a lower water holding capacity. Also the protein content differs between genders, being lower in entire male pigs than in females and castrates [10], which is important if the meat is used for further processing. For fresh meat consumption, not only is boar taint of importance, but tenderness is also, and a study has shown that tenderness is very important for consumer response even towards boar tainted meat [11]. Several studies have demonstrated a lower
tenderness in meat from entire male pigs compared with castrates [10-12]. However, even though these meat quality differences exist, they are difficult to value.

5. Processing of tainted meat

If rejection limits for boar taint are established, a certain number of the carcasses will be discarded and cannot be used for fresh meat consumption. The number depends on several factors: How restrictive are the sorting limits? How efficient is the primary production in reducing the concentration of skatole? How heavy are the pigs? Still, a considerable amount of the discarded meat must be used for other purposes to avoid food waste and consolidate the economics of production. Strategies for masking boar taint are, therefore, intensively investigated.

5.1. Smoking

Smoking is one of the most promising strategies for masking boar taint, and it has been widely discussed in the literature [13-17]. When discussing the masking effect of smoke, it is important to include a description of how intensive the smoked flavour is, and also how boar tainted the meat is. We have shown that smoking at 45°C for up to 60 min cannot fully mask boar taint in bacon from animals having a high concentration of skatole (0.6 µg/g in back fat) and androstenone (5.8 µg/g in back fat), while boar taint in sausages with the same level of skatole but lower in androstenone (2.4 µg/g in back fat) was fully masked after 60 minutes of smoking [13]. In contrast, another study showed that increased smoking time did not reduce boar taint, but in that study, the change in smoking time was only from 15 to 19 min, which might explain the lack of an effect [17]. Smoking can be regarded as an art, and using the same time/temperature/relative humidity in two different smoking chambers might result in a different intensity of smoked flavour. So even though smoking is a promising strategy for masking boar taint, both the smoking processing parameters and the intensity of boar taint must be taken into account. In practice, the strategy must be adapted to the individual product and smoking chamber.

5.2. Masking with herbs and spices

Several pork products and dishes are made using different spices, and the masking effects of these are of interest. Relatively few studies have looked into the masking effect of spices in a systematic way, although some studies exist using e.g. coriander and mace [17], oregano [18] and a spice mix for sausages [16]. We screened several different herbs and spices added to meat balls, to set up some general guidelines for choice of masking agent. The most important factor seems to be that the spice or herb must have a low odour threshold (and thereby a strong flavour) such as cinnamon, thyme and rosemary. On this basis, a spice mix was developed for pulled pork including cinnamon and paprika. This spice mix was effective in masking androstenone while only limited masking was seen for skatole. Therefore, if spices and herbs are going to be used to mask boar taint, it is important to include meat samples high in both skatole and androstenone in the investigations.

5.3. Serving meals not meat

In most consumer studies related to boar taint, the meat or meat products are served to the consumers in a neutral way. However, in practice, most meat and meat products are eaten in a meal context. Even when served in a tomato sauce, minced pork from entire male pigs (2.0 µg/g androstenone and 0.3 µg/g skatole in melted backfat) was more disliked than pork from female and castrate pigs [19]. Serving pork chops with potatoes, beans and gravy did not alter the acceptability score of boar tainted meat [20]. In contrast, we have seen a clear reduction of boar taint detection, when meat products were served in a meal context, both with consumers and with a trained panel (unpublished data). Serving ham in a ham and cheese toasted sandwich was especially effective, as no significant linear effect was seen of skatole or androstenone on boar taint, even though high levels of the compounds were evaluated (up to 9.0 µg/g androstenone and 0.54 µg/g skatole). The consumers did not differentiate between the ham from castrates or entire male pigs in ham and cheese sandwiches (Hall test) or toast
(HUT). A similar result was seen when the pulled pork described in section 5.2 was served in a pulled pork slider. Therefore, using meat from tainted carcasses as meat products in a complex serving in which the taint can be masked by the meal is recommended.

6. Monetary value for the slaughterhouse of entire male pig production
Calculating the monetary value of entire male pig production is difficult as several factors – specific for the individual slaughterhouse – must be taken into account. It is necessary to analyse scenarios when estimating the monetary value of pig production. In the following sections, the value of three different scenarios is calculated (Table 1). In all scenarios, market access and the logistics in handling the discarded carcasses are not taken into account. All pigs are analysed for skatole and androstenone using the method described in Section 3. This cost is set to €1.20 per sample. Danish average meat prices are used as well as the estimated value for degradation of the tainted meat, reduced tenderness and reduced protein content.

6.1. A few discarded carcasses sold as bulk production
In this scenario, only 2% of the carcasses are discarded. Taken from a Danish random sample of pigs, this would equate to a sorting limit of 0.25 µg/g skatole and no sorting on androstenone. No value is set for the lower tenderness or the change in protein content. The approved carcasses are sold as three parts without further cutting or processing. In this scenario, the extra cost per entire male carcass has been estimated as €3.36 per carcass.

6.2. Sorting on both skatole and androstenone
In this scenario, the carcasses are sorted on a combination of skatole and androstenone. The rejection level for androstenone is high (5 µg/g), while it is 0.25 µg/g for skatole, resulting in 4.5% of carcasses being discarded. The carcasses are divided into four, splitting the middle into belly and loin, and in addition, the bones are sold as spareribs. This means that the high meat percentage in the entire male pigs gives a positive monetary value while the high number of discarded carcasses has a negative monetary value. A small amount (the loin from 40% of the carcasses) is sold as fresh meat in which the low tenderness has a negative value, while another small part (the loin of the ham from 60% of the carcasses) is sold for further processing in which the low protein content has a negative value. In this scenario, the cost has been estimated as €3.96 per carcass.

6.3. Low sorting limits on skatole and androstenone
In this scenario, the sorting limits are set to 0.25 µg/g skatole and 2 µg/g androstenone to reduce the risk of a negative experience by the consumer. This would amount to 18% of carcasses being discarded. In addition, 5% of carcasses are sold as fresh meat having a negative value due to reduced tenderness, while 24% are sold for meat products with a negative value of protein. The carcasses are split as in scenario 6.2. Due to the very high number of discarded carcasses, this scenario is very expensive, being approximately €9.80 per carcass.

Table 1. Three different scenarios for estimating the monetary value for the slaughterhouse of entire male production. The examples are calculated using Danish average cost and with estimated value degradation for the tainted meat as well as the value of tenderness and protein content. For further details, please contact the author.

| Rejection limits | Scenario 1 | Scenario 2 | Scenario 3 |
|------------------|------------|------------|------------|
| skatole          | 0.25 µg/g  | 0.25 µg/g  | 0.25 µg/g  |
| androstenone     | no         | 5 µg/g     | 2 µg/g     |
% discarded carcasses because of boar taint

|                | 2%                      | 4.5%                    | 18%                     |
|----------------|-------------------------|-------------------------|-------------------------|
| Carcass        | Sold as fore-end, middle and ham | Sold as fore-end and ham while the middle is loin with 8 mm fat and belly | Sold as fore-end and ham while the middle is loin with 8 mm fat and belly |
| Eating quality | Tenderness has no value | The loin from 40% of the carcasses is sold as fresh meat. Low tenderness gives a low price | The loin from 40% of the carcasses is sold as fresh meat. Low tenderness gives a low price |
| Protein content| Protein content has no value | From 60% of the carcasses, the loin or the ham will be sold to products in which the protein content has a value | From 60% of the carcasses, the loin or the ham will be sold to products in which the protein content has a value |
| Boar taint analysis | All samples from entire male pigs | All samples from entire male pigs | All samples from entire male pigs |
| Monetary value per entire male carcass | €3.36 | €3.96 | €9.80 |

7. General discussion
Changing to produce entire male pigs will have consequences for the slaughterhouse, not only related to boar taint and sorting of the carcasses. Some factors, such as a high meat percentage, can have a positive monetary value, while other factors, such as the percentage of discarded carcasses, a lower protein content and less tender meat can have a negative monetary value. The three examples given to estimate the monetary cost of production show how difficult it is to set a given value on entire male pig production. Each slaughterhouse must calculate the effect using their own prices, not only for the meat from approved carcasses (i.e. boar taint acceptable carcasses), but also according to how they expect the cost to be formed for the discarded carcasses. Results from this research should help the industry in such decision making.

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