

ESTABLISHING BEST PRACTICES

on the production,
the processing
and the marketing
of meat from
uncastrated pigs
or pigs vaccinated
against boar taint
(immunocastrated)

Final report

14 March 2019

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Establishing best practices on the production, the processing and the marketing of meat from uncastrated pigs or pigs vaccinated against boar taint (immunocastrated)

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Directorate-General for Health and Food Safety

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Executive summary

Introduction

The castration of male piglets is a routine and long-standing practice in pig husbandry, common across most countries in the European Union (EU). It is, however, considered to be poor practice from an animal welfare perspective.

Piglet castration is largely used as a method to avoid boar taint. Boar taint is an unpleasant odour or taste caused by the accumulation of two naturally occurring chemical compounds (skatole and androstenone) in the tissues of uncastrated males. These compounds contribute both individually and in combination to the perception of boar taint, which is observed during the cooking and consumption of pork. The challenge posed by boar taint to the pig meat sector complicates any move away from surgical castration, despite welfare concerns.

There are two main options available for transitioning away from surgical castration. One is to raise entire male pigs, or boars. The other is the use of a vaccine that blocks the hormone responsible for the release of gonadotropins (GnRH) and suppresses testicular function. Vaccination against boar taint requires that farmers are appropriately trained in using the vaccine and its use comes with its own costs and challenges. Supply chains in some countries have begun the transition, by raising entire males or vaccinating pigs, or both, but surgical castration is still the norm for pig farming in the majority of Member States.

This study identifies best practices used in production and across the supply chain in relation to the raising and slaughter of entire males or pigs vaccinated against boar taint, and the processing and marketing of meat from such animals. It focuses solely on practices that have been trialled and successfully used in commercial conditions rather than looking at presumed best practices, trials or future initiatives. The study builds on work previously undertaken by the European Commission looking at the economic feasibility of a transition, the challenge of detection and consumer acceptance of alternatives to surgical castration.

Best practices were identified at different points in the supply chain. At farm level, the study has considered best practices: to reduce boar taint in entire males through management techniques on farm; to vaccinate pigs against boar taint; and to provide assurance to slaughterhouses that vaccinated pigs do not present detectable boar taint. At slaughterhouse level, the project addressed best practices: to detect boar taint, quantify and manage positive carcasses; to obtain assurance from farmers that vaccinated pigs do not contain detectable boar taint; and, to deal with meat with detectable boar taint. At retail and food service, best practices were identified to increase the market value of meat from uncastrated pigs and to promote meat from vaccinated pigs.

Method

The project began with an inception phase during which the team conducted preliminary research and consulted with experts to develop a long list of best practices. This long list was then used to inform development of a data collection template. Country researchers used the template to collect information through desk and field research in seven Member States (Belgium, Denmark, France, Germany, the Netherlands, Spain and the UK) and Norway. These countries were chosen on the basis that each had some experience with either raising entire males or with vaccination against boar taint.

The purpose of the country research was not only to identify best practices within each of the topics, but also to verify that these best practices were occurring in commercial conditions. Researchers contacted a range of stakeholders during this period, including farmers, slaughterhouses, food processors, retailers and food service operators, as well as quality assurance companies, breeding companies, feed producers, laboratories that have developed techniques for boar taint detection and vaccine suppliers. Data were largely

gathered through phone interviews and email exchanges. Visits were made to slaughterhouses, a farm and a breeding company in Germany and the Netherlands.

The results of the country research were collated and reviewed by the project team to identify what could be considered best practice. A 'state of play' document was drafted that identified what practices are occurring where and what gaps remained. The results of the country research were then used in the drafting of a set of elements of best practice. These documents were prepared by a team of non-specialists with excellent writing skills and reviewed by subject matter specialists.

An online consultation platform was launched and all contributing stakeholders were invited to comment on the draft elements of best practice documents. Stakeholders could either comment directly on the platform or provide feedback to the team via email.

The feedback was collated and reviewed. In some instances, the study team followed up with stakeholders to clarify comments or gather additional information. The draft elements of practice were then revised based on these comments.

The draft documents were presented to two meetings of an advisory board consisting of stakeholders from across the supply chain. The advisory board meetings were used to discuss the feasibility of various practices and provide context on some of the outstanding comments from the online consultation. The text was revised based on feedback from the advisory board meetings and final versions of the elements of best practice were prepared for inclusion in the final report.

State of Play

Many of the challenges of switching to production of entire males or vaccination against boar taint relate to supply chain dynamics and relationships. For example, the costs and benefits of a transition to production without castration are not distributed equally between different participants in the supply chain. Switching to production of entire males results in changes to the costs incurred by the farmer, the feed producer, and the slaughterhouse. To incentivise change, these shifts in distribution of cost need to be recognised across the chain. This can be done through slaughterhouses or end-buyers offering premiums to farmers to cover the additional costs of using specific breeds of animals and specific feed to reduce the incidence of boar taint. Often, however, the additional costs are borne largely by the farmers themselves. Where supply chains are highly integrated, this is less of an issue. Where they are not, much depends on the relationship between slaughterhouses and farmers, which in many countries tends to be characterised by low trust.

A bonus-malus system¹ related directly to the presence or absence of boar taint is one way of incentivising farmers to take up more preventative practices, and pass on some part of the economic loss incurred by the slaughterhouse as a result of the presence of detectable boar taint in a carcass. Such a system, linked to boar taint detection, is used in France. There are other bonus-malus systems in which penalties are based on weight or are universal for all boars. The fact that boar taint-based financial incentives are not more widespread is ascribed largely to the subjective character of existing tests and the lack of trust between farmers and slaughterhouses.

Demand is the key driver for transition: ultimately, a transition to entire males or pigs vaccinated against boar taint can only occur where there is an end market for meat from these pigs. For most supply chains in Europe, this means that a transition can only occur where retailers and food services are willing to sell such meat.

¹ An incentive system that is designed to give positive reward for good performance, and impose a penalty for poor performance.

Practices at farm level

The prevalence of non-castration and vaccination practices varied across countries. Uncastrated pigs are commercially produced in all the countries studied in this project, with the exception of Norway. In some countries (such as Spain and the UK), production of entire males is well-established.

Vaccination against boar taint is not widely practised in Europe, meaning that the information received came from a small number of countries and sources. Belgium has the most experience with vaccination. Spain and the Netherlands also reported some use. Norway had previously trialled the use of vaccination commercially, but it is no longer being used as frequently.

A wide range of practices was found at farm level for both raising entire males and for dealing with vaccination against boar taint. Many of these practices were also already documented in the literature. Several feeding solutions were identified, and a number of them are commercially available. Although these are associated with raising entire males, feeding practices to reduce taint could also be used for pigs vaccinated against boar taint.

There are additional costs associated with many of these options but both entire males and vaccinated pigs have been shown to have more efficient feed conversion ratios than surgically castrated males. Previous research has estimated that the better feed conversion is worth €7.11 per pig for entire males and €6.10 for vaccinated pigs.

The timing of slaughter, referenced either to weight or age, is used almost universally to manage the risk of boar taint. The exact weight thresholds vary depending on country and source.

Research has looked at using breeding and genetics to reduce boar taint incidence. Breeding techniques are used at a commercial level in several countries.

The practices identified for reducing boar taint through modifying how the pigs are housed were all general practices associated with improved welfare. These practices are well documented, although it is not clear to what extent they impact boar taint prevalence.

Although vaccination against boar taint is not yet widespread in Europe, substantial information on the practice was available through the detailed guidance provided by vaccine suppliers. Practices related to vaccination were also confirmed by farmers. Information providing assurance that vaccination has worked was provided by vaccine suppliers and confirmed by farmers.

Practices at slaughtering and processing level

Some information on slaughtering and processing was available from previous research but there was less relevant literature on these practices than for farm level actions. Most slaughterhouse practices focused on detection. Some detection practices were unique to vaccination against boar taint, although many of the practices identified for detecting boar taint in entire males may also be used for vaccinated pigs.

Some examples were found of supply chains raising entire males that do not use detection methods. In the UK, boars are slaughtered at a lower weight (105-110 kg) to manage the risks of boar taint. In Spain, boar taint is addressed entirely through processing and masking.

The research located one example of a chemical testing device being used. Some examples were identified of new and promising chemical testing techniques currently under development, but none of these are currently available commercially.

The most popular detection method among slaughterhouses was some variation of the human nose method. The most common of these are on-line methods, where some type of welding equipment (including hot air devices, soldering irons with metal tips and gas-powered soldering irons) is used to heat the meat on the slaughter line and the operator

then smells it to try to detect boar taint. Two off line methods, the hot water method and the microwave method, were also found to be in use. Both involve taking a sample of fat from the carcass and taking it to a separate testing area on site. Off line methods are generally more suitable for slaughterhouses that process fewer boars and as quality control methods. Operators use several different methods to promote consistency of detection when using human nose methods. External consulting firms are frequently used to provide training and assessment of operators, and in some instances external contractors are also used for in-house testing.

Several supply chain management practices were identified. There have been some efforts to establish frameworks or protocols for human nose testing, notably a harmonised effort between quality assurance companies in Germany (QS) and in the Netherlands (IKB). Some slaughterhouses have established logistical agreements with suppliers whereby boars and gilts are provided in separate batches, which can help to make the boar taint detection process more efficient and keeps different types of carcass apart.

Some slaughterhouses provide feedback to farmers on boar taint prevalence. The protocol established by QS and IKB, for example, requires all slaughterhouses engaged in processing entire males to do so. Although some slaughterhouses had systems in place for monitoring complaints, no slaughterhouses reported having received complaints related to boar taint.

Carcasses that tested positive for boar taint were generally sold into specialist markets or used for processed meat products.

Several potential practices were identified for helping slaughterhouses to ensure that vaccinated pigs do not contain boar taint. Practices that involve measuring the size or weight of sexual organs, including the testes and the bulbourethral gland, were reported in to be in use but were felt by many stakeholders to be largely ineffective and difficult to implement. Random checks for boar taint were considered preferable, and such tests generally used similar methods to the detection tests for entire males.

Testosterone tests can be used on batches of pigs to identify at-risk carcasses. This approach was recommended by the vaccine manufacturer and has been used by some slaughterhouses.

Several options were identified for processing meat that has detectable boar taint. These practices differ between countries; their practicality ultimately depends on local processing practices and the perceived consumer sensitivity to boar taint within a Member State. In Germany stakeholders reported that dilution, fermentation and smoking of tainted meat are used to mask boar taint in the final product. Thermal treatment is used by processors in both Germany and Spain. Spices are used in Spain to mask boar taint while marinating tainted meat. Dilution is used in Denmark.

Practices at retailing and food service level

It was difficult to identify practices in retail and food service relating to management of boar taint in entire males or in pigs vaccinated against boar taint. There was little available information in the literature and companies are generally unwilling to communicate about this issue.

Practices at retailing and food service level are largely dictated by firms' understanding of the consumer acceptance of boar taint. There has been some exploration of this in the literature through cross-country or single-country studies looking for potential threshold values for androstenone and skatole.

Many consumers are not aware of piglet castration and boar taint. A few examples were identified of retailers using marketing campaigns that emphasise animal welfare and do not mention piglet castration specifically. Many of the campaigns used to promote meat from entire males use specific labels related either to a specific assurance scheme or product line. One example was found of a retailer campaign for a product line that

emphasised not only animal welfare, but also potential environmental and human health benefits related to non-castration. One example was found of a producer working in close collaboration with a retailer to conduct in-store trials of meat from entire males.

Customer complaints could help monitor the effectiveness of measures implemented to prevent boar tainted meat from reaching consumers. However, no evidence was found of retailers using this practice to address boar taint.

Elements of best practice

Best practices were identified at each stage of the supply chain.

Farmers – uncastrated pigs: management techniques

Learning to manage boars was included as a farm-level practice, as entire males have different needs and are more likely to display aggressive or sexual behaviour.

Several practices related to flooring and housing were identified. Keeping pigs clean and dry is included as a practice that can help to reduce skatole levels. Slatted floors are cited as one way to improve hygiene. Sex-separated rearing and wean-to-finish grouping are listed as housing practices that may help to reduce stress levels. Several additional practices are identified under the umbrella of “low-stress environments”. Practices to reduce competition at feeding, including wet feeding, are also included as they can help to reduce stress.

Two different options are included under breeding practices. One is choosing specific breeds, such as the Piétrain, which are less likely to test positive for boar taint. The other is selective breeding techniques: breeding companies use special techniques to select for low taint boars.

Several options are identified for reducing boar taint prevalence through the adjusting the composition of the animals’ feed. Chicory root can be used as an additive and has been shown to reduce skatole levels. Diets with adjusted amino acids are included as a way to increase the growth of entire males so that slaughter occurs at a younger age. Protein-reduced diets can be used in the few days prior to slaughter to reduce skatole levels. This is considered a low cost and highly feasible solution. Some commercially-available feeds designed to reduce boar taint were also identified.

Scheduling slaughter at a young age is also included as method for reducing the risk of boar taint.

Farmers – vaccinated pigs: vaccination process

Information is provided on the vaccination principle, which includes background information on the efficacy and cost of the vaccine. The vaccination procedure is included as a best practice, with details on the correct positioning and how to minimise stress. The use of a dosing gun and protective clothing are both listed as best practices for the implementation of the vaccine.

Information on scheduling the vaccination is provided. This includes the main protocol, describing the general timing of the first and second vaccinations and a compliance inspection. Early vaccination is included as a practice that can be used to maximise intramuscular fat and back fat. Late vaccination is included as a practice that can be used to achieve a better feed conversion and leaner carcasses. Using three doses for larger pigs is included as a practice to raise vaccinated pigs to heavier weights.

Practices for feeding vaccinated pigs are described, included details related to lysine requirements and feed conversion.

Farmers – vaccinated pigs: provide assurance to slaughterhouses that vaccinated pigs do not present detectable boar taint

Some of the farm level practices included relate to promoting trust in the vaccination process. On-farm checks of pig behaviour are described (vaccinated pigs behave noticeably differently from entire males). Supply chain assurance practices are also described, including the use of documentation to record and communicate details of vaccination procedures to other members of the supply chain.

Slaughterhouses – uncastrated pigs: detect boar taint, quantify and manage positive carcasses

The practices included at slaughterhouse level to detect, quantify and manage positive carcasses principally relate to use of the human nose method. The principle of the human nose method is described, indicating the purpose of the method and where fat should be sampled. Four main variants are included: the hot air / hot iron method and the gas-powered soldering iron (both on line methods) and the hot water method and microwave method (both off line methods).

Two scales for measuring boar taint are included. The human nose method can be used with either a binary (taint/no taint) approach or a scale with multiple levels (such as 1-5) to indicate the intensity of boar taint presence. Both methods require special training and consistent application.

Practices for selecting and training testers are discussed. Several service providers in different Member States are available to assist slaughterhouses with training and implementation.

Best practices for quality control are identified. These include using multiple testers, conducting parallel controls and using statistical analysis to investigate possible inconsistencies. As humans are prone to smell habituation, two practices to prevent this are included: taking regular breaks and using nose cleansers (such as menthol or coffee) to reset the sense of smell.

Protocols for harmonising human nose testing across supply chains are listed as a best practice and an example of a framework in use is presented.

Non-detection is identified as a best practice, where cut-off weights or masking are used to minimise the risk for boar taint.

Several practices were identified relating to supply chain management. These include keeping records and providing feedback to farmers, penalties for boar taint, conducting farm audits and accepting pigs in same-sex groups.

Two main practices were identified for classifying carcasses with boar taint. One focuses on electronic classification systems and the other on the manual classification of carcasses (use of physical markers to distinguish between tainted and non-tainted carcasses).

Slaughterhouses – vaccinated pigs: obtain assurance from farmers that vaccinated pigs do not contain detectable boar taint

Best practices for use by slaughterhouses to ensure that vaccinated pigs do not contain detectable boar taint include checks to verify that vaccination has been administered correctly. This can be important for less experienced slaughterhouses and farmers to gain confidence in the vaccination against boar taint. Three different practices are described: the human nose method, a blood test for testosterone and chemical testing of a fat sample. This section also discusses the use of bonus payments for vaccinated pigs.

Food processors – uncastrated pigs: deal with meat with detectable boar taint

The report identifies a variety of processing practices that can be used to deal with meat with detectable boar taint. Many of these practices may be suitable for use in combination with each other.

Using tainted meat for products intended to be consumed cold is a commonly used practice as boar taint is most noticeable during the cooking or heating of meat. Dilution or mixing with non-tainted meat is used for products that do not come from a single cut of meat. Dry curing, fermentation, smoking and thermal treatment are all ways of processing or cooking pig meat that can help to reduce the perception of boar taint. Using spices for sausages or for marinated meats is also included as a practice to reduce the perception of boar taint.

Retailers and food services – uncastrated pigs: promoting meat from uncastrated pigs

Several practices were identified for use by retailers and the food service industry to promote meat from uncastrated pigs. Marketing techniques include various types of campaigns. Some emphasise animal welfare benefits, others include animal welfare benefits alongside environmental or human health benefits.

Buyer specifications are included as a practice to encourage other parts of the supply chain to make the transition. During the transition, practices such as visits, information sharing and the certification of boar taint detection methods can be used to build trust within the supply chain. In-store trials are also listed as a practice that retailers can use to ensure that meat from uncastrated pigs is accepted by consumers. The use of animal welfare labels or other types of assurance schemes is included as a practice to add value to meat from entire males.

Retailers and food services – vaccinated pigs: promoting meat from vaccinated pigs

Similar practices were identified for retailers and the food service industry to promote meat from vaccinated pigs. Marketing campaigns can also be used, emphasising animal welfare, health and sustainability. Farmer management can be used, and retailers may wish to enact farm-level controls or to provide training to contracted farmers on the vaccination against boar taint.

Conclusions

While EU production of entire males and vaccinated pigs remain small by comparison with the overall production of pig meat, it involves major operators that have invested considerable resources, expertise, and effort to find solutions that work not only within individual organisations, but across whole supply chains. Evidence from these operators demonstrates that it is commercially feasible to transition from physical castration to raising entire males or vaccinating them against boar taint. While improving pigs' welfare significantly, these changes have also resulted in increased profitability for some businesses.

The practices documented in this study show that solutions require coordination and information exchange between different actors of the supply chain. Change has happened through exchange of good practices, data sharing, and agreements on how to share the costs and the benefits of changes to the mode of production. Successful transitions have occurred where initiators have demonstrated to commercial partners that a different way of working is feasible, robust, and safe. Together, these individual practices provide a compelling portfolio of options for supply chains interested in making a transition away from surgical castration.

1 Introduction

This is the final report for the “Establishing best practices on the production, the processing and the marketing of meat from uncastrated pigs or pigs vaccinated against boar taint (immunocastrated)²” as contracted by the European Commission – DG SANTE (project reference: SANTE/2018/G2/049/SI2.775309).

The purpose of this study has been to contribute to a decrease in the need for surgical castration of piglets in the EU through knowledge transfer. Specifically, it identifies and explains best practices that contribute to this objective, looking at all stages of the food chain, from farming to retail.

This report presents:

- The context for the study (section 2);
- The methodology (section 3) and workplan (section 4) for collecting data and drafting best practice documents;
- The state of play of existing practices for vaccinating pigs against boar taint and raising entire males (section 5);
- The results of the consultation process (section 6) and the final best practices (section 7); and
- The study conclusions (section 8).

This final report is the fourth report required under this contract and builds on the interim report, results of stakeholder consultations and feedback on the draft final report. This report presents updated versions of Deliverables 1 (work plan) and 2 (state of play). It also includes Deliverable 4 (consultation process and final best practices in English).

² For the purpose of this study, the terms “vaccination against boar taint” and “immunocastration” are considered to be equivalent.

2 Subject and context of the study

2.1 Strategic context of the study

The castration of male piglets is a routine and long-standing practice in pig husbandry, common across most countries in the EU. Castrating piglets is considered to be poor practice from an animal welfare perspective. This is recognised by Council Directive 2008/120/EC, which cites the need for better practices and EU-level action and states:

"Castration is likely to cause prolonged pain which is worse if there is tearing of the tissues. Those practices are therefore detrimental to the welfare of pigs, especially when carried out by incompetent and inexperienced persons."³

Piglet castration is largely used as a method to avoid boar taint. Boar taint is an unpleasant odour caused by the accumulation of skatole and androstenone in the tissues of uncastrated males. These compounds contribute both individually and in combination to the perception of boar taint, which is described as resembling urine and manure, as well as mothballs, sweat and "pig". Sensory perceptions of boar taint differ, however, and studies have shown that a sizeable proportion of consumers are not sensitive to boar taint. Boar taint is generally observed during the cooking and consumption of pork. The challenge posed by boar taint to the pig meat sector complicates any move away from surgical castration, despite welfare concerns. The observed need for action on pig castration led to the establishment of the European Declaration on alternatives to surgical castration of pigs in 2010. The declaration has been signed by industry and farmers groups, as well as animal welfare NGOs across Europe. The intention of the Declaration and subsequent partnership is to phase out the surgical castration of pigs by January 1st, 2018 and ensure the costs of this transition are shared.

There are two main options available for transitioning away from surgical castration. The first option is raising entire male pigs, or boars. Raising entire males requires changes to standard practice that can help minimise the risk of boar taint. The second option is the use of a vaccine that blocks the hormone responsible for the release of gonadotropins (GnRH) and suppresses testicular function. Vaccination requires that farmers are appropriately trained in using the vaccine and its use comes with its own costs and challenges.

Supply chains in some countries have begun the transition to raising either entire males, vaccinated pigs or both, but surgical castration is still the norm for pig farming in the majority of Member States. As such, this study highlights best practices at different stages of production and across whole supply chains that are currently used when raising, slaughtering, processing and marketing meat from entire males or vaccinated pigs. It builds on work previously undertaken by the European Commission looking at the economic feasibility of a transition, the challenge of detection and consumer acceptance of alternatives to surgical castration. However, rather than looking at presumed best practices, trials or future initiatives, this study focuses solely on practices that have been trialled and successfully used in commercial conditions.

³ Council Directive 2008/120/EC of 18 December 2008 laying down minimum standards for the protection of pigs

2.2 Topics addressed by this study

This study addresses practices at farming, slaughterhouse, processing and retail/marketing levels for both entire males and vaccinated pigs. The issues covered by the study, as listed in the terms of reference, are presented in Table 1.

Table 1. Issues to be addressed by this project, as requested by the terms of reference

Target audiences	Uncastrated pigs	Pigs vaccinated against boar taint
Farmers	Q1- Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)	Q2- Techniques and best practices to use the vaccine in various type of pigs Q3- Techniques and best practices to ensure to slaughterhouses that vaccinated pigs do no present detectable boar taint
Slaughterhouse operators	Q4- Techniques and best practices to detect boar taint, quantify and manage positive carcasses	Q5- Techniques and best practices to trust farmers that vaccinated pigs do not contain detectable boar taint
Food processors	Q6- Techniques and best practices to quantify and deal with meat with detectable boar taint	Not relevant
Retail and food services	Q7- Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served.	Q8- Techniques and best practices to increase the acceptance of meat from vaccinated pigs among consumers and to prevent meat with detectable boar taint to be on the shelves or served.

3 Methodology

This section presents the project methodology. Figure 1 presents the study workflow.

Figure 1. Overview of the work



3.1 Task 2: Collecting data and observation

3.1.1 Purpose

The aims of this task were to:

- collect information on the existing practices relevant to the study; and
- analyse the information collected and identify gaps.

This task examined the existing situation and current practices, covering all the questions identified in the terms of reference (as listed in Table 1).

The data collection task built on scoping research undertaken for Task 0 (Inception) and Task 1 (Updated methodology and work plan). The scoping research involved a targeted literature review, and brief phone discussions with members of our expert team and other chosen experts who have published relevant works on the issues presented in Table 1. Findings from scoping research resulted in an initial list of practices that might be in use commercially to address these issues, to be further investigated with data collection.

For Task 2, in-depth information was collected from selected Member States. The team also included putative best practice documents from other EU countries and third countries when they were brought to the team's attention.

The purpose of this task was not only to **identify presumptive best practices**, that is, practices that appear to have distinct advantages from an animal welfare and economic point of view, but also to **verify that presumptive best practices** identified at the inception stage **are practiced in commercial conditions**.

Existing practices and any evidence on their advantages and disadvantages were documented. Data collection and observations informed the drafting of best practice elements in Task 3.

Box 1 Member States selected for the study

As part of the terms of reference, the study team was requested to collect information from six Member States: Belgium, Denmark, France, Germany, the Netherlands and Spain. The UK and Norway were selected as additional countries for the research.

The UK has been producing entire males for a very long time and as such is a source of information on proven techniques and good practices across the whole supply chain.

Norway has a well-established supply chain for vaccinated pigs. Norway provided a useful counterpoint to Belgium, the other country in which vaccination against boar taint has been demonstrated at the proof of concept stage.

Towards the end of the study an additional enquiry was made about the production of Parma ham in Italy using vaccination.

3.1.2 Method

Stakeholder groups – farmers, slaughterhouses, food processors, retailers and food service operators – were identified through:

- Identification of relevant contacts in the personal and professional networks of members of the study team (in particular, the team's country experts);
- Expansion of the initial network through a snowballing approach (one contacted stakeholder providing the contact details of another, relevant stakeholder); and

- Additional contact details being obtained via approaches to representative associations of the different groups of stakeholders.

ICF offered confidentiality to all stakeholders to address concerns arising from the sensitivity of the topic and the potential disclosure of commercially-sensitive information.

The study team also approached some other actors who are involved in the supply chain in specific roles and were able to supply relevant information. They were:

- **Quality assurance companies;**
- **Breeding companies** that are working specifically on selecting animals based on boar taint;
- **Feed producers** manufacturing dedicated feed solutions;
- **Laboratories** that have developed techniques for boar taint detection;
- **Suppliers of vaccines against boar taint.**

The collection of evidence in each country was conducted in an official language of that country.

In task 2 the project team collected information on practices that are **observable in commercial conditions**. To ensure a consistent approach across countries, all researchers followed standard instructions and templates for data collection (see Annex 1 and Annex 3). A systematic check was applied to each presumptive best practice, with a requirement that each practice was linked to **at least one** commercial operation setting in the EU.

3.1.3 Task 2.1: Desk research

Desk research on possible best practices was conducted through the following steps:

- collection of documents already known to the project team members in their capacity as experts on the various subjects covered by the research;
- identification of other publicly available documents; and
- the despatch of email request for additional documentary evidence to key stakeholders. An accreditation letter by DG SANTE accompanied this email. The email also included a request to provide contacts of additional stakeholders.

An inventory of the relevant documents collected through desk research was produced (see Annex 7).

Table 2. Desk research protocol

Criteria	Details
Document types	The search covered the following document types: Best practice and guidance documents Standard operation procedure (SOP) documents (for slaughterhouses) Quality standards (in supply chains) National literature on existing practices (all EU sources, especially those from research projects, were reviewed as part of Task 1)
Sources	Web search: National competent authorities National industry associations National professional news Sites of individual businesses (producers, slaughterhouses, processors, retailers, food service operators, breeders, feed producers)
Language	English and the national languages of the case study Member States

3.1.4 Task 2.2: Contacts with Member State stakeholders

Selected stakeholders were contacted for this phase of the research. For individual experts and businesses, the contacts were made by telephone and face-to-face. Business organisations were also contacted by email as a supplementary measure.

Telephone enquiries were designed to:

- Verify that the information collected through desk research reflected existing practices and fill any gaps;
- Collect information on any additional practices that were not identified through desk research; and
- Discuss practices that are considered particularly beneficial with the purpose of identifying preliminary elements of best practices and potential business operators for field visits.

These enquiries were supplemented, where possible, by an email exchange, whereby the results of the desk research were shared with stakeholders for fact checking and to fill gaps.

Table 3 indicates the number of stakeholders consulted for this task. The variation in the number of stakeholders consulted by country and stakeholder group reflects the differences in production systems and practices used: for example, only a small number of operators in few countries use vaccination. The high degree of market concentration in some countries (such as Denmark) means that few companies are operating in the pig market.

The stakeholders consulted included national associations and research organisations. Some of them shared information from *ad hoc* surveys of practices associated with vaccination and non-castration. Specifically:

- In the UK, a farmer association launched a survey of its 300 members to enquire about management practices for boar taint; 31 answers were received.
- In France, an association of meat processors launched a survey directed to its 250 members, asking which type of pig meat they were sourcing and if they were dealing

with tainted meat. Only seven organisations responded to the survey (4 large companies – with more than 1,000 employees; 1 medium-sized firm – with between 100 and 1,000 employees; and 2 small firms, – with fewer than 100 employees). Five respondents indicated they were sourcing their meat only from surgically castrated or vaccinated pigs, and two indicated they were sourcing a mix of meat from both castrated and non-castrated animals. Both of the companies that accepted a mix of castrated and non-castrated pork were large firms (> 1000 employees) that control incoming and outgoing products and conduct audits of their suppliers. They also monitored customer complaints about their products. One of these manufacturers produced, among other products, bacon, which is highly sensitive to boar taint.

- A Norwegian research organisation shared the results of a survey of national pig producers about their attitude to and experience with vaccination. Of the 430 respondents, 134 of them had used vaccination against boar taint in their herd.

Table 3. Number of stakeholders who positively responded to invitations to contribute, by country and stakeholder type for Task 2.2, and complementary data collection at the end of the consultation phase (Task 4)

Stakeholder type	BE	DE	DK	ES	FR	NL	NO	UK	IT	Tot
Farmers	6	13	0	10 (1)	1 ⁴	4 (1)	1	1 (1)	1 ⁵	37 (3)
Slaughterhouses	7	10	1	7	1 ⁴	6	1	0	1 ⁵	34
Processors	1	1	2	1 (1)	4 ⁴ (1)	3	1	1	1 ⁵	15 (2)
Retailers and food service operators	3	1	1	3 (3)	0	0	1	0	0	9 (4)
Meat traders	0	0	0	1 (1)	0	0	0	0	0	1 (1)
Quality assurance companies	0	0	0	0	0	0	0	3	0	3
Breeding companies	1	1	0	1	1	0	1	0	0	5
Feed producers	1	1	0	0	1 ⁴	1	0	1	0	4
Companies providing boar taint detection services	0	1	0	0	0	0	0	0	0	1
Vaccine suppliers	0	0	0	1	0	1	0	1	0	3
Research institutes and experts	0	0	2	0	1	1	0	1	0	5
Veterinarians	0	0	1	0	1	0	0	0	0	2
Competent authorities	0	0	0	0	1	0	1	0	0	2

Note: the numbers in brackets indicate how many, out of all stakeholders consulted, were representative associations

3.1.5 Task 2.3: Preliminary visits in Member States

Field visits provided opportunities to observe some of the practices and, in particular, those that were not documented in literature review. This helped to improve the robustness and completeness of data collection findings.

Country experts and the ICF research team assessed the potential case for undertaking field visits in the countries covered by data collection. When potential field visits were identified, country experts contacted stakeholders and enquired about their availability for

⁴ In France, one consultee integrates farmers, feed producer, slaughterhouses and processors.

⁵ In Italy, a single consultee was interviewed, who represents an organisation integrating farming, slaughtering and processing.

a visit. In case of unavailability, data was gathered through phone interviews and email exchanges.

Since field visits were undertaken on the basis of intelligence received on presumptive best practices, they were unevenly distributed across the selected Member States. Some stakeholders contacted for possible field visits were not available; others agreed, but were reluctant to share additional information to what was discussed by phone; therefore, a visit was not expected to bring additional value to the research.

Field visits were conducted as described below.

Germany:

A large slaughterhouse was visited to witness the methods used to deal efficiently with large numbers of entire males.

The researcher visited a farm producing piglets in accordance with the terms of an animal welfare scheme that supports alternatives to physical castration. Feeding and breeding sizes for the production of entire males were discussed.

A breeding company was visited to discuss the latest developments in use of genetic selection for the reduction of boar taint.

The Netherlands:

A large slaughterhouse was visited to observe practices associated with the human nose method⁶ for boar taint detection. This included observing the detection tools, the implementation of the method, and how the slaughterhouse dealt with tainted meat.

3.1.6 Task 2.4: Comparative analysis, synthesis and identification of gaps

The data recording templates, once completed, were collated and reviewed by members of the project team. The project team assessed what practices were observable across countries and whether these addressed the questions listed in the terms of reference.

The practices described were then compared against the initial list of practices that was developed in Task 1 based on the broader literature (see Annex 3). This comparison enabled the identification of gaps, where some research may exist but no or few practices have been observed on the ground.

The results of this assessment are presented in section 4 (Deliverable 2).

3.2 Task 3: Drafting of elements of best practices

3.2.1 Purpose

The purpose of this task was to develop a draft set of best practices based on Deliverable 2. These were discussed and further developed through consultations with stakeholders in Task 4.

3.2.2 Method

The drafting and review of the documents was governed by a set of criteria (explained below) that were intended to ensure the quality of the end product. The drafting process was led by non-specialists with excellent writing skills. Their outputs were reviewed by subject matter experts (as detailed in section 3.2.3).

The drafting criteria were:

- Accuracy – the text should provide a good description of the practice that it addresses;

⁶ The human nose method involves the use of human operators to heat and then smell samples of pig fat to determine the presence of boar taint.

- Simplicity – the material provided should enable the end user to understand the practice without difficulty;
- Sufficiency – the material should cover all the important aspects and not assume much existing knowledge or cause users to have to look for clarification elsewhere;
- Scope – the practices should be as widely applicable as possible; highly specific best practice material should be kept to a minimum;
- Communicability – it should be transmittable and interpretable by the end users;
- Amenability to improvement – it should be in such a format that it may be improved as knowledge or techniques evolve without the need for a full redesign of the material.

The drafting process also involved characterisation of advantages and disadvantages of each option. The approach taken to this characterisation was defined by the study team and agreed with the Commission. Advantages and disadvantages were described in qualitative terms. When quantitative information was available, this was also included in the description. Advantages and disadvantages were described based on the issues relevant to each study question (for a description of each question see Table 1). These issues refer to:

- Animal welfare – this includes animal discomfort and pain, and is principally relevant for Q2
- Feasibility – this is applicable across most questions and includes consideration of:
 - The resources required (cost, competence, time)
 - The impact on the speed of process (particularly for slaughterhouses, under Q4)
 - The expected percentage of entire males' carcasses for which boar taint is detectable (Q4)
 - The expected risk of price reduction for farmers in case of detectable boar taint carcasses (Q5)
 - The percentage of detected boar taint meat compared to the quantity of meat they received, and the way such tainted meat can be used or marketed (Q6)
- Impact on boar taint prevalence (for Q1 principally)
- Reliability as a method to detect boar taint (for Q4)
- Impact on market value of meat from uncastrated pigs (for Q7)
- Impact on consumer acceptance (for Q8)
- Ability to detect boar taint in products to be served or sold (for Q7 and Q8)

3.2.3 Task 3.1 – Drafting of documents

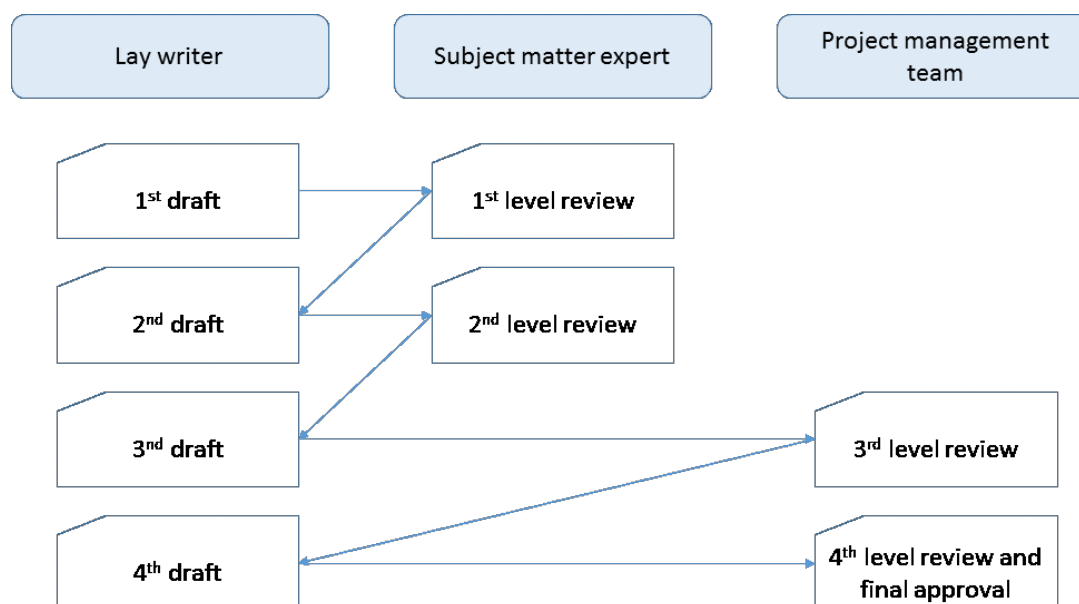
The process of drafting the documents was led by non-specialists. The lay writers used a common template that was designed by the project management team.

The eight questions within scope were divided among the lay writers. The writers used the source material gathered during Task 2.

After the completion of a first draft, the document was shared with a subject matter expert from the team. The work of the expert was guided by a checklist embedded into the draft. This identified the aspects to be addressed by the review of each section.

The draft was then sent back to the lay writer for revision, and was once more reviewed by the subject matter expert. Unless further edits were required, the draft was then reviewed by the project management team. The overall process is summarised in Table 4.

Table 4. Process for drafting elements for best practices



3.2.4 Task 3.2 – Preparation of draft illustrations

Illustrations were used to communicate information about some practices. ICF's illustrators were provided with a written request, supported by examples of the designs to be followed. The style of the illustrations was agreed with the Commission. We adopted the style previously used by ICF for the DG SANTE project "Preparation of best practices on the protection of animals at the time of killing", i.e. monochrome ink drawings of the subject matter.

The illustrator provided sketches. These sketches were finalised in the style agreed, after completion of the consultation on the drafts elements.

Images other than drawings were included in the drafts, an example being a flowchart that summarised the timeline for vaccinating pigs against boar taint.

3.2.5 Task 3.3 – Interim report (updated Deliverable 1, Deliverables 2 and 3) and meeting

The interim report provided updates to the inception report, the state of play (Deliverable 2) and draft elements of best practice addressing each of the eight study questions (Deliverable 3).

Following submission, the report was presented at a meeting held at the Commission's premises. A note summarising the points discussed and actions agreed at the meeting was produced and delivered to the Steering Group within 5 working days. Based on feedback received from the Commission, a revised final version of the interim report was submitted and then approved by the Commission. The Commission's comments on the draft elements of best practices were not addressed in the interim report since consultation with stakeholders had already been initiated. These comments are addressed in this final report. Details on the Commission's comments and on how these have been addressed are presented in Annex 5 alongside the comments received during the online consultation.

3.3 Task 4: Consulting stakeholders on elements for best practices

During Task 4, ICF consulted stakeholders on the draft elements of best practice, assessed feedback and contributions, and finalised the project outputs.

3.3.1 Purpose

The consultation phase provided an assessment of the quality of the work undertaken in Task 3 and gathered comments that were used to inform improvements. It was also an opportunity to clarify the purpose of the project with stakeholders, and a point in the process where stakeholders could express any concerns they may have about the development of the best practice documents.

3.3.2 Method

The terms of reference required that the consultation include at least the following groups:

- Stakeholders in some Member States;
- EU stakeholders;
- Member States' competent authorities;
- Scientific institutes.

The terms of reference emphasised the need to take into account the interests of small undertakings active in local markets. Some changes in pig production methods may be perceived as unaffordable by small players in Europe's pigmeat supply chains.

In addition to the groups above, ICF also consulted with a number of selected:

- Official veterinarians and veterinary practitioners;
- NGOs; and
- Thematic experts.

ICF consulted stakeholders via an interactive web platform (section 3.3.3) and a stakeholder advisory board (section 3.3.6).

3.3.3 Task 4.1 – Development of an interactive web platform

The objective of this task was to create an online platform that could be used to gather stakeholder feedback on best practice elements. The platform enabled the review of draft documents describing best practices. It was designed to provide secure access by consultees. It is an interactive tool to facilitate discussion on draft documents prepared by the study team. During the kick-off meeting, it was decided that the platform would be hosted on ICF's server.

3.3.4 Task 4.2 – Launch and moderation of interactive web platform

3.3.4.1 Stakeholder recruitment

Email invitations for participation in the online consultation were sent, followed by two reminders over the consultation period. Emails included instructions for the access and use of the platform.

The online platform was open for comments for 8 weeks, although additional time was allowed to stakeholders who requested so. When consultees suggested other relevant contacts to consult, these were added to the platform.

ICF organised and managed the consultation process. As discussed with the Commission at the kick-off meeting, the online platform was used to consult with those stakeholders who have been approached in previous phases of the work.

3.3.4.2 Platform moderation

ICF administered and moderated the online platform. Consultees were also able to provide information privately rather than through the public forum. Ultimately, many consultees chose to send feedback via email rather than commenting through the online platform. Some comments were received on the platform but the forum was ultimately not used by stakeholders to discuss the relevant issues.

3.3.5 Task 4.3 – Analysis of responses

The project team analysed and verified the consistency of information gathered via the online platform. The evaluation team carried out a rapid initial scan of comments and any additional documentation provided. The purpose of this exercise was to establish:

- Who contributed;
- What stakeholder category/ country they are representing, and whether they are individual organisations or representative associations;
- What aspects they addressed;
- What their views and concerns are.

A segmentation of the responses was carried out by:

- Stakeholder group
- Type of inputs provided by stakeholder: opinions, facts/ data, anecdotal evidence

Feedback received through comments and emails was collated into separate tables for each of the eight documents. The study team followed up with stakeholders to confirm information on any comments that were unclear or to gather more information where comments related to previously unresearched practices. Once comments had been reviewed, ICF's response to each comment and any actions taken on its basis were recorded in the table.

When specific points called for expert evaluation and response, the project management team contacted the relevant experts within the project team and asked for a review of the comments and a reasoned response for use by the person in charge of revising the drafts.

The table below indicated the number of stakeholder representatives invited to contribute through the online platform, and the number of stakeholder representatives who responded by submitting comments on the draft documents. Of those who responded, six submitted comments through the online platform, and the remaining eight submitted comments via email. The tables containing all comments received are available in Annex 5.

Table 5. Online platform - Number of stakeholders consulted by stakeholder type

Stakeholder type	Number of stakeholder representatives invited	Number of stakeholder representatives who responded
Animal welfare organisations	1	1
Breeding companies	3	1
Competent authorities	1	
Distributors	1	
Farmers	33 (7)	1
Feed producers	6	2
Processors	20 (11)	1
Quality assurance companies	6 (2)	2
Research institutes and experts	5	3
Retailers and food service operators	17 (4)	1
Slaughterhouses	16	
Slaughterhouses and processors	5 (1)	1
Vaccine supplier	4	1
Whole chain	2 (2)	1
Total	120	14

Note: the numbers in brackets indicate how many, out of all stakeholders consulted, were representative associations

3.3.6 Task 4.4 – Advisory board

The draft documents were disseminated at two meetings of an advisory board. The purpose of these meetings was: to promote awareness and dissemination of the study results; gather feedback on the elements for best practice; and support their take-up among business operators.

An important issue addressed with the advisory board was the feasibility of the best practices in the various contexts observed in the EU. A substantial share of discussion time at these meetings was reserved for consideration of this issue.

The two advisory board meetings were organised as follows:

- One meeting was held after the draft elements of best practice had been completed (Task 3). That meeting entailed a presentation of the good practice documents, including the feedback received through the online consultation. Participants were invited to provide their feedback and thus contribute to the improvement and validation of the content.
- A second meeting was organised following the completion of the draft final report. In addition to providing an update on the revision of the elements for best practices, this meeting focused on the challenges associated with the dissemination and implementation of the good practices. It provided an opportunity to discuss the best

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ways to further disseminate materials and achieve maximum impact, thus feeding insights into the second phase of the project.

The advisory board included actors with extensive practical experience of the topics covered in the study.

Board meetings were hosted in Brussels. ICF drafted an agenda for each meeting. The agenda included an introduction to the objectives of the study, an update of progress on data collection, and discussions on the different tools and solutions to market meat from uncastrated or immune-castrated pigs. All prospective participants received the final agenda and an information pack with supporting documentation in advance of the meeting.

The meetings were full day events to provide sufficient time for an in-depth discussion of the issues. They provided opportunities to present and discuss key challenges linked to the cessation of surgical castration and possible solutions. The meetings were attended by two senior representatives of the study team and one junior staff member. The meetings were conducted in English only.

After the meetings, ICF sent notes of the discussion to all participants and the Commission. A detailed note of how the comments received from the advisory board were taken into account has also been provided to the Commission.

The Advisory Board involved stakeholders from all stages of the supply chain and from all the countries involved in the data collection task. It also included representatives of animal welfare and research organisations. It included a mix of individual organisations, national-level and EU-level associations.

Table 6 presents the number of stakeholders who were contacted to be part of the Advisory Board, and the number of those who attended the first and second meetings.

Table 6. First meeting of the Advisory Board - Number of stakeholders consulted by stakeholder type

Stakeholder type	Number of stakeholders contacted	Number of stakeholders who attended the first meeting	Number of stakeholders who attended the second meeting
Breeders	1		
Farmers	11 (10)	5 (5)	3(3)
Feed producer	1		
Food processors	4 (2)		
Slaughterhouses	8 (5)	1 (1)	1
Slaughterhouses and processors	3 (1)	1 (1)	1 (1)
Veterinarians	1 (1)	1 (1)	1(1)
Vaccine suppliers	3	1	2
Animal welfare organisations	1	1	1
Quality assurance operators	2	1	
Retailers	4 (1)	1	
Research institutes and experts	2	1	2
Grand Total	41	13	11

Note: the numbers in brackets indicate how many, out of all stakeholders consulted, were representative associations

3.3.7 Task 4.5 – Finalisation of text and illustrations

Feedback from consultations and advisory board meetings were used to review and finalise the elements of best practice, as presented in this final report. These reviews followed the same process as the development of draft practices.

- The person who drafted the documents in Task 3 – a non-specialist with excellent drafting skills – revised and finalised the drafts based on the set of responses provided to all the comments reviewed through the online platform;
- The illustrator was given instructions to finalise the visuals and authorisation to reproduce existing visuals was sought from the copyright holders;
- Text and visuals were reviewed by the project management team, including an English native speaker.

4 Deliverable 1: Work plan

A detailed schedule of deliverables is provided in Table 7.

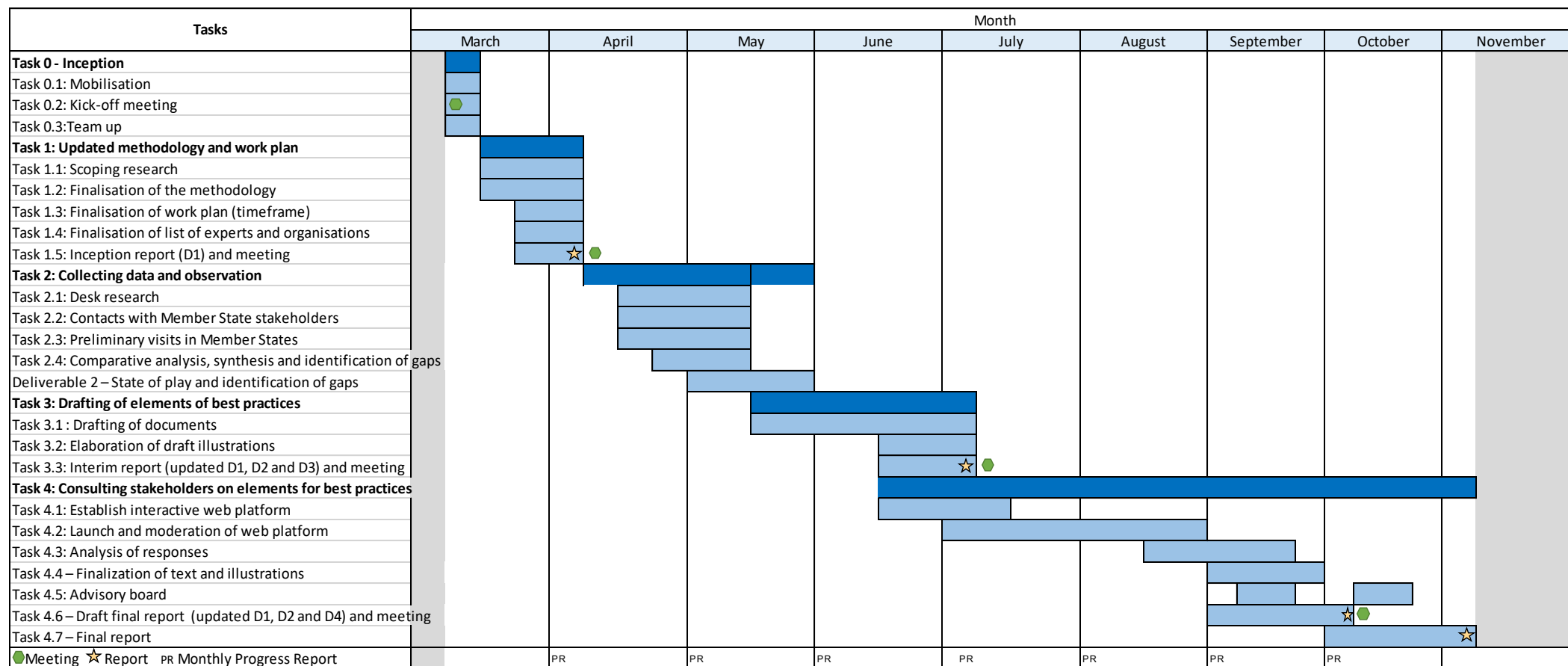
Table 7. List of deliverables

Deliverable	Scheduled delivery date
Kick off meeting and Inception Report – Deliverable 1	6 April 2018
Interim Report – Deliverables 1+2+3	6 July 2018
Draft Final Report – Deliverables 1+2+4	8 October 2018
Final Report	9 November 2018

A Gantt chart is provided at Table 8. This shows the phasing of tasks, meetings and deliverables.

Establishing best practices on the production, the processing and the marketing of meat from uncastrated pigs or pigs vaccinated against boar taint (immunocastrated) – Final report

Table 8. Gantt chart phasing of tasks, meetings and deliverables



5 Deliverable 2: State of play

This section provides:

- A summary of the options identified for all the questions listed in the terms of reference;
- A comparative analysis of the different options, with a summary of the evidence regarding advantages and disadvantages of each solution; and
- An identification of gaps.

It explains the practices currently used in different parts of the supply chain, i.e.:

- **Farming:**
 - Q1: Reducing boar taint through management techniques (such as feeding and breeding)
 - Q2: Use of the vaccine against boar taint: this includes, the number of vaccine doses to be given to pigs, the time at which the vaccine is administered, and any recommendations for administration to pigs of different weights or ages
 - Q3: Ways in which farmers provide assurance to slaughterhouses that vaccinated pigs do not present detectable boar taint.
- **Slaughtering and processing:**
 - Q4: Detecting boar taint, quantifying and managing positive carcasses
 - Q5: Checks and initiatives to obtain assurance that vaccinated pigs do not contain detectable boar taint
 - Q6: Dealing with meat with detectable boar taint
- **Retailing and food services:**
 - Q7: Increasing the market value of meat from uncastrated pigs, and preventing meat with detectable boar taint from reaching consumers
 - Q8: Increasing consumer acceptance of meat from vaccinated pigs, and preventing meat with detectable boar taint from reaching consumers

The literature sources examined for the data collection task are listed in Annex 7.

This document considers practices observable at specific points in the supply chain, and targeted at a specific type of actors within that chain. However, many of the challenges of switching to entire males or vaccinated pigs relate to relationships and communication between different members of the supply chain. In other words, supply chain dynamics play a significant role in hindering, or in contributing to transitions from pig meat production with surgical castration to pig meat production without surgical castration.

For example, the costs and benefits of a transition to production without castration are not distributed equally between different participants in the supply chain. Switching to entire males means a different set of costs incurred by the farmer, the feed producer, and the slaughterhouse to achieve meat of quality and without boar taint. To incentivise change, these costs need to be recognised across the chain. This can be done through slaughterhouses or end-buyers offering premiums to farmers to cover the additional costs of using specific breeds of animals and specific feed to reduce the incidence of boar taint. The retailer Delhaize in Belgium pays farmers participating in the 'Beter voor iedereen' label a €1 bonus per animal as well as compensation for additional feed costs. Often, however, the additional costs tend to be borne largely by the farmers themselves. Where supply chains are highly integrated, as is the case in one supply chain that has made the transition to entire males in France, this is less of an issue. However, where this is not the case, much depends on the relationship between slaughterhouses and farmers, which in many countries tends to be characterised by low trust.

A bonus-malus system⁷ related directly to the presence or absence of boar taint might incentivise farmers to take up more preventative practices. In addition to incentivising farmers, this also reflects the economic loss incurred by the slaughterhouse as a result of the presence of detectable boar taint in a carcass. Such a penalty system linked to boar taint detection is used in France. Other bonus-malus systems exist where penalties are based on weight or are universal for all boars. The absence of more widespread boar taint-based financial incentives is ascribed largely to the lack of objectivity of existing tests and the lack of trust between farmers and slaughterhouses.

Ultimately, a transition to entire males or vaccinated pigs can only occur where there is an end market for entire males or vaccinated pigs: demand is the key driver for transition. For most supply chains in Europe, this means that a transition can only occur where retailers are willing to sell such meat. Instances where a transition to entire males or vaccinated pigs has been successful all involve cooperation between different actors in the supply chain, including:

- Cooperation between retailers, breeding companies and farmers to develop and use low-taint breeds
- Cooperation between retailers, farmers, processors and feeding companies to develop feeding solutions that address boar taint and other meat quality concerns; and
- Cooperation between processors, assurance schemes and external consultants to develop harmonised boar taint detection techniques.

To the extent that these supply-chain level aspects have been documented in this study, they also appear in relevant sections of this report and in the elements of best practices. The rest of this section summarises the findings from the data collection phase.

5.1 Practices at farm level

Overall, the presence of non-castration and vaccination practices varied across countries. Uncastrated pigs are commercially produced in all the countries covered by this project, with the exception of Norway. In some countries (such as Spain and the UK), production of entire males is well-established.

Vaccination against boar taint is not widely practised in Europe, meaning that the information received came from a small number of countries and sources. Belgium has the most experience with vaccination. Spain and the Netherlands also reported some use. Norway had previously trialled the use of vaccination commercially, but it is no longer being used as frequently.

A wide range of practices was found at farm level for both raising entire males and for dealing with vaccination. Many of these practices were also already documented in the literature.

Several feeding solutions were identified, and a number of them are commercially available. Although these are associated with raising entire males, feeding practices to reduce taint could also be used for vaccinated pigs.

There are additional costs associated with many of these options, however both entire males and vaccinated pigs have been shown to have more efficient feed conversion ratios than surgically castrated males. Previous research⁸ has estimated that the better feed conversion can be valued at €7.11 per pig for entire males and €6.10 for vaccinated pigs.

⁷ An incentive system that is designed to give positive reward for good performance, and impose a penalty for poor performance.

⁸ Civic Consulting (2013). Study and economic analysis of the costs and benefits of ending surgical castration. Part 2 – Country studies. European Commission. Available at: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_civic_pt2-country-studies_20131202.pdf

The better feed conversion ratio has been cited as helping to convince many farmers in the Netherlands to switch to raising entire males when the market began to accept boar meat. In fact, so many farmers began to raise entire males that supply grew faster than demand and led to many challenges for the processing industry.

The timing of slaughter appears to be used almost universally as a means of managing the risk of boar taint, based on either weight or age, although the exact thresholds vary depending on country and source.

Recent research has looked at using breeding and genetics to reduce boar taint incidence. Breeding techniques have been found to be used at a commercial level in several countries.

The practices identified for reducing boar taint through housing were all general practices associated with improved welfare. These practices are well documented, although it is not clear to what extent they impact boar taint prevalence.

Although vaccination is not yet widespread in Europe, a good deal of information was available through the detailed guidance provided by vaccine suppliers. These practices were also confirmed by farmers. Similarly, information on providing assurance that vaccination has worked was also provided by vaccine suppliers and confirmed by farmers.

5.1.1 Q1 – Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)

5.1.1.1 State of the knowledge and comparative analysis

Several ways to reduce boar taint at farm level were identified. The solutions identified related to:

- Management of boars;
- Flooring, housing and pig management;
- Selective breeding of pigs;
- Feeding techniques;
- Early detection of pigs which may be affected by boar taint;
- Scheduling of slaughter; and
- Transport to the slaughterhouse.

Several practices were identified that relate to the **management of boars**. These practices are intended to reduce aggressive and sexual behaviour. Previous guidance produced by Wageningen University⁹ has been referred to in the main text and many of the included practices are mentioned under flooring and housing or feeding.

Many of the practices relating to **flooring and housing** seek to improve welfare and thereby reduce stress. Reductions in stress are associated with less aggressive behaviour, fewer fights between animals and consequently a reduction in boar taint. Many of the better welfare practices identified are also subject to EU regulations that guarantee minimum standards. These include keeping the density of animals low, controlling the temperature and providing enrichment. Keeping the density of animals low and keeping temperatures cool have been shown in the literature to be correlated with lower skatole levels¹⁰.

⁹ Wageningen University. 'Reducing mounting behaviour of boars – tips and recommendations'. Available at: <https://www.boarsontheway.com/wp-content/uploads/2018/08/Flyer-Berengedrag-v4-engels-2.pdf>

¹⁰ Hansen, L., Larsen, A., Jensen, B., Hansen-Møller, J., & Barton-Gade, P. (1994). Influence of stocking rate and faeces deposition in the pen at different temperatures on skatole concentration (boar taint) in subcutaneous fat. *Animal Science*, 59(1), 99-110.

Partially or fully slatted floors are used in several countries (including Belgium, Denmark, France, Germany and the UK) to eliminate urine and faeces from the pens and keep them clean. Keeping pigs clean has been associated with reductions in boar taint¹¹ and is used by most farmers. However, there are restrictions to the use of fully slatted floors in some Member States due to welfare concerns, as slatted floors can increase the risk of injury.

A variety of methods are used for grouping pigs to reduce stress. **Sex separation** was used in all countries to reduce aggression and, in some cases, to facilitate providing boars and gilts with different feed. However, farmers had mixed experiences with sex-separated rearing, with some indicating that it increased stress and led to higher levels of aggression among boars. As it appears to be common practice when raising boars, sex separation has been retained in the final documents but with a caveat added that indicates that on-farm experiences have varied. Sex separation is also considered to be vital for systems where pigs are raised to an older age/higher weight, as not separating larger/older pigs by sex can lead to a risk of sow pregnancy. **Wean-to-finish grouping**, where pigs are kept with their litter mates until slaughter, was also identified as a commercially-used practice to reduce stress. One example was given from the Netherlands of the two practices being used together: pigs being separated by sex but kept with their same-sex litter mates with little to no mixing after weaning.

Wet feeding is a technique used frequently in the industry and was reported in the UK, Denmark and Germany. It involves feeding pigs dry feed mixed with water, so that pigs drink their feed rather than chew it. Wet feeding is not explicitly done to reduce the instance of boar taint, but instead to improve the ability to control feed conversion per pen. It is seen as a way to reduce competition between pigs while feeding, which reduces aggression and could contribute to reducing the instance of boar taint. Wet feeding has been demonstrated in the literature to contribute to a reduction in skatole levels¹². Wet feeding, along with other practices to **reduce competition at feeding** have been included alongside other flooring and housing practices, rather than with other feeding practices, as they require significant changes to infrastructure.

Pietrain and Duroc **breeds** are used in some countries and these are considered to be at lower risk for boar taint. This has been tested and confirmed by several studies¹³. Several breeding companies have begun to include boar taint as a factor in their selection methods, in some instances in cooperation with retailers or processors. Topigs Norsvin has succeeded in reducing boar taint instance across their various lines (Talent, Tempo and Top Pi) and

¹¹ Aluwé et al. (2011a). Influence of soiling on boar taint in boars. *Meat Science*, 87:3, pp. 175-179. Available: [https://pure.ilvo.be/portal/en/publications/influence-of-soiling-on-boar-taint-in-boars\(c52065ec-c378-45d2-a37f-52c10eaae493\).html](https://pure.ilvo.be/portal/en/publications/influence-of-soiling-on-boar-taint-in-boars(c52065ec-c378-45d2-a37f-52c10eaae493).html)

¹² Andersson et al. (1997). The effects of feeding system, lysine level and gilt contact on performance, skatole levels and economy of entire male pigs. *Live Prod Sci*, 51:1-3, pp. 131-40.

Allen et al. (1997). Effect of nutrition and management on the incidence of boar taint. In: *Boar taint in entire male pigs*. Proceedings of a meeting of the EAAP working group "Production and Utilisation of Meat from Entire Male Pigs"; 1997 Okt 1-3; Stockholm, Sweden. Wageningen, the Netherlands: Wageningen Pers; 1997. p.88-91.

Kjeldsen, N. (1993). Practical experience with production and slaughter of entire male pigs. In *Measurement and prevention of boar taint in entire male pigs*, Roskilde, Denmark, 1992, (ed. Bonneau, M.), *Institut National de la Recherche Agronomique, les colloques no. 60*, pp. 137-144

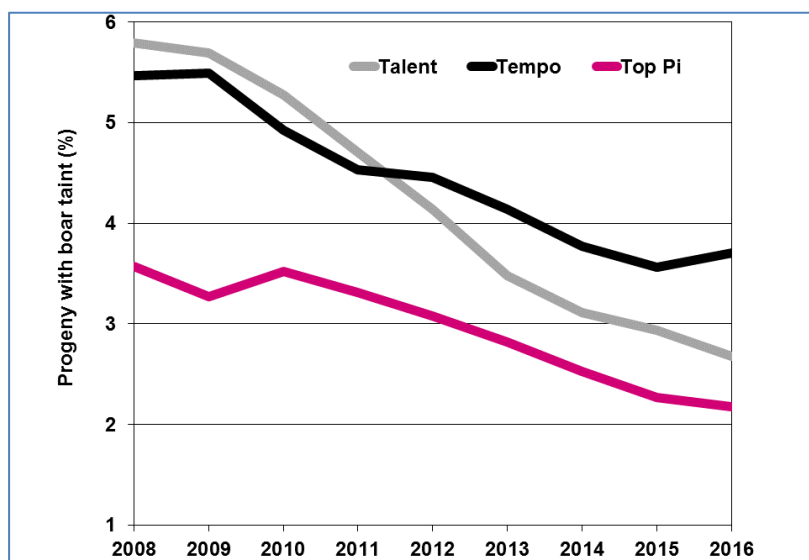
¹³ Xue et al. (1996). Breed differences in boar taint: relationship between tissue levels of boar taint compounds and sensory analysis of taint. *Journal of Animal Science*, 74. pp. 2170-2177. Available: https://www.researchgate.net/publication/14327322_Breed_Differences_in_Boar_Taint_Relationship_between_Tissue_Levels_of_Boar_Taint_Compounds_and_Sensory_Analysis_of_Taint

Aluwé et al. (2011b). Influence of breed and slaughter weight on boar taint prevalence in entire male pigs. *Animal*, 5:8, pp. 1283-1289. Available: <https://www.cambridge.org/core/journals/animal/article/influence-of-breed-and-slaughter-weight-on-boar-taint-prevalence-in-entire-male-pigs/139CA9B5D3C4A6D2477C0E3D5065DF8F>

Institute of Agriculture and Food Research and Technology (2015). *Study on how to achieve reduction of boar taint compounds by breeding, feeding and management techniques*. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_irta_20150216.pdf

has a special line, Nador, with an even smaller chance of boar taint. Nador sperm can be purchased at a premium of €1 per dose. Figure 2 shows the trend in reduced boar taint prevalence achieved for the Top Pi, Talent and Tempo terminal boar lines of Topigs.

Figure 2. Topigs' results in reducing boar taint prevalence through breeding¹⁴



In France, the breeding company Nucleus (of which the retailer Cooperl is the major shareholder) has worked to develop a line of low-taint Piétrain pigs, known as INO (from the French "inodore", without odour) pigs, for use in Cooperl's entire male supply chain. The INO sperm is available commercially and there is no premium charged as compared to other lines. In Belgium, Delhaize has worked with breeding company PIC to develop low-taint sperm for use in products with a castration-free pork label.¹⁵ PIC has indicated, however, that there have been some issues with pigs bred for low taint. Pigs bred with low-taint sperm have bellies of reduced size and quality and low-taint sperm may negatively impact sow productivity¹⁶.

Additionally, recent work has been done through a project at the University of Bonn in Germany, where genetic research helped lead to the offering of low-taint sperm. This sperm is commercially available at a premium through GFS in Germany, who are marketing the sperm under the name Inodurus 2.0. The German slaughterhouse Westfleisch has stated their intention to ask their contract suppliers to use Inodurus 2.0 sperm when finishing boars¹⁷.

Although the use of **feed additives** to reduce boar taint has been discussed in the literature and many examples described, few have been used in commercial practice. Changes to feed can impact the production of skatole, one of the main chemical compounds

¹⁴ Topigs Norsvin (2018). Less boar taint with breeding. Available at: <https://topignorsvin.com/news/less-boar-taint-breeding/>

¹⁵ Ordelman, E. (2018) Belgian retailer launches castration-free pork label. Pig Progress. Available at: <https://www.pigprogress.net/Piglets/Articles/2018/6/Belgian-retailer-launches-castration-free-pork-label-298440E/>

¹⁶ Knudsen, N. (2018) Neal Matthews, PIC: "Achieving that perfect piece of pork". Available at: https://www.pigprogress.net/Finishers/Articles/2018/11/Marbling-has-been-overrated-in-pork-352450E/?cmpid=NLC|pigprogress_focus|2018-11-09|Neal_Matthews,_PIC:_

¹⁷ van Dooren, Kees (2018) Ki-organisatie GFS introduceert stankvrije eindbeer. Boerderij. Available at: <https://www.boerderij.nl/Varkenshouderij/Nieuws/2018/11/Ki-organisatie-GFS-introduceert-stankvrije-eindbeer-357289E/>

responsible for boar taint¹⁸. Chicory root (inulin) has been used commercially by at least one producer in the Netherlands, but has been cited as being too expensive generally for commercial use. Chicory root (either whole, dried or as an extract) has been shown to reduce boar taint in several studies¹⁹. A recent study has also indicated that chicory root only needs to be provided to boars three to four days prior to slaughter (rather than two weeks prior to slaughter).²⁰ This significantly reduces the costs of using this practice commercially. One commercially-available feed, Taintstop (produced by Dumoulin), combines several different ingredients intended to address boar taint and was being tested by some of the farmers contacted in Belgium. It was also mentioned by farmers in Germany, however none were currently using it due to the higher cost. An experiment comparing Taintstop feed to a control found that it contributed to a significant reduction of tainted samples²¹. A second commercial feed solution produced by the Dutch feed company Vitelia has been trialled, and has recently become commercially available.

For farmers considering the cost of feed additives, it is relevant that evidence from the literature shows that boars have a more efficient feed conversion ration as compared to surgically castrated males: around 0.28 kg less of feed is required to produce 1 kg of pig meat when raising boars²².

Using a cereal-only or low-protein diet in the days leading up to slaughter was mentioned by a few sources as a practice which might contribute to a reduction in skatole content. However, there were divergent opinions on this practice, possibly because it was confused with the protein content of the diet. Increasing the protein content in diets intended for boars contributes to a higher growth rate, meaning that animals can be slaughtered at a younger age. Low-protein diets have been associated in the literature with higher instance of boar taint²³ and evidence suggests that results are dependent on the type of carbohydrate and protein²⁴. There was evidence of reducing protein content or providing a grain-based diet three to four days prior to slaughter being used commercially, and it was considered a cost-effective practice.

¹⁸ Jensen, B.B. (2006) Prevention of boar taint in pig production. Factors affecting the level of skatole. *Acta Veterinaria Scandinavica* 48(1): S6.

¹⁹ Hansen, L., Mejer, H., Thamsborg, S., Byrne, D., Roepstorff, A., Karlsson, A. Tuomola, M. (2006). Influence of chicory roots (*Cichorium intybus* L) on boar taint in entire male and female pigs. *Animal Science*, 82(3), 359-368.

Byrne, D.V., Thamsborg, S.M. and Hansen, L.L. (2008). A sensory description of boar taint and the effects of crude and dried chicory roots (*Cichorium intybus* L.) and inulin feeding in male and female pork. *Meat Science*, 79(2), 252-269.

Zammerini, D., Wood, J.D., Whittington, F.M., Nute, G.R., Hughes, S.I., Hazzledine, M. and Matthews, K. (2012). Effect of dietary chicory on boar taint. *Meat Science*, 91(4), 396-401.

²⁰ Maribo, H., Jensen, B.B. and Thoning, H. (2015) Fibre reducerer skatol I hangrise. Meddelelse Nr. 1055. Available at: https://svineproduktion.dk/publikationer/kilder/lu_medd/2015/1055

²¹ Boulet et al. (2017). Influence of TAINSTOP, an innovative feed concept on boar taint. *BAMST*. Available: http://www.ca-ipema.eu/download/289/documents/oieras/orals_oieras/2_N_3_Guy_Janssens.pdf

²² Civic Consulting (2013). Study and economic analysis of the costs and benefits of ending surgical castration. Part 2 – Country studies. European Commission. Available at: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_civic_pt2-country-studies_20131202.pdf

²³ Nold, R.A., Romans, J.R., Costello, W.J., Henson, J.A. and Libal, G.W. (1997). Sensory characteristics and carcass traits of boars, barrows, and gilts fed high- or adequate-protein diets and slaughtered at 100 or 110 kilograms. *Journal of Animal Science* 75(10): 2641-2651.

Lundström, K., Malmfors, B., Stern, S., Rydhmer, L., Eliasson-Selling, L., Mortensen, A.B. and Mortensen, H.P. (1994). Skatole levels in pigs selected for high lean tissue growth rate on different dietary protein levels. *Livestock Production Science* 38(2): 125-132.

²⁴ Jensen, B.B. (2006). Prevention of boar taint in pig production. Factors affecting the level of skatole. *Acta Veterinaria Scandinavica* 48(1): S6.

In addition to feeding higher protein diets at certain phases, adjusting the amino acid balance in boar feed was identified as another feasible practice for encouraging faster growth in boars, so that they are younger at slaughter.

Fasting prior to slaughter was identified as being used in Denmark, Germany and the UK but no association was made with how this might impact boar taint. Comments received during the advisory board meeting suggested that fasting prior to slaughter may help improve cleanliness during transport, which could help to reduce taint. This practice was not ultimately included as a separate best practice, but has been mentioned as a 'thing to consider' as an aspect of transport.

Organic acid feed additives were used in Denmark and Germany, but this was explicitly for the reduction of salmonella and no connection was made to boar taint.

A number of additives that were identified in the literature were not being used commercially by any of the farmers interviewed. These include: potato starch, tannin extract, pueraria lobate (kudzu root), non-nutritive adsorptive materials (active C, zeolite), rye, additional dietary fibres, readily fermentable carbohydrates, sugar beet, lupine, jerusalem artichoke, coconut palm cake and yucca extract. Although we found no evidence of commercial use, feeding rye to pigs has been subjected to a large and successful trial by farmers in Germany and may be a future option for low-taint feeding²⁵.

Farmers in Spain, the Netherlands and the UK indicated that pigs were checked regularly for signs of aggression and that it was possible to separate particularly aggressive pigs or mark them for **slaughter at an earlier age**. This was cited as being a difficult practice to implement by one farmer in Belgium, however, due to the constant state of agitation among pigs in pens. Additionally, this was felt to be a difficult and largely ineffective practice to enact for entire males by stakeholders during the consultation. As such, it was not included in the final text.

Slaughtering at a younger age or weight than would be done for other pig types is done for entire males across all farms. Age is generally considered to be a more effective measure of boar taint risk than weight, but weight cut-offs appear to be common industry practice. Most farmers seem to use weight as the defining metric, although the maximum weight for boars varies between countries. Maximum weights mentioned include 105 kg (Spain), 110 kg (the Netherlands and the UK) and 115 kg (Denmark and Belgium). One producer in the UK mentioned slaughtering by a specific age (25 weeks) and a few farmers mentioned sending particularly aggressive pigs to slaughter at a younger age. There are currently trials underway in the UK using boar taint detection to determine whether the current standard cut-off weight for boars could be raised. Using weight cut-offs to reduce boar taint risk was cited as problematic by some stakeholders, as it does not account for pigs that are 'slow growers' and may end up much older at slaughter and with a higher risk of boar taint because of this.

Farmers in the UK and the Netherlands also identified **transporting pigs** to the slaughterhouse in split sex groups as a potential best practice. This was also identified by slaughterhouses as a best practice; receiving pigs in split sex groups can help reduce stress and can facilitate the logistics of processing boars and detecting boar taint.

5.1.1.2 Data gaps

Many options for feed were identified as being uneconomic, but **little information was available on actual costs**. A commercial feeding solution, developed specifically to reduce boar taint, was identified as costing around €100 per tonne more than normal feed, but this figure was from Belgium and it is not clear whether this applies to other countries.

²⁵ Ter Beek, V. (2018) Rye: Influence on Salmonella and boar taint in finishers. Pig Progress. Available at: <https://www.pigprogress.net/Finishers/Articles/2018/2/Rye-Influence-on-Salmonella-and-boar-taint-in-finishers-245681E/>

Although wet feeding is purported to help with the reduction of boar taint, as it is not used explicitly for this purpose its **relationship to boar taint reduction is difficult to quantify**. There was also no information available on the costs of this system and how the benefits of better feed conversion might reduce overall costs in the long term.

The relationship to boar taint is even more tenuous for other feeding practices used commercially, such as fasting and the use of organic acids in feed. For this reason, these are not included in the final elements of best practice.

There is **little empirical research indicating any measurable impact from better welfare and stress reduction practices on boar taint**. Keeping pigs clean has been shown in the literature to be likely to have an effect, but the impacts of other practices do not appear to have been tested. However, there appears to be agreement among stakeholders that these practices have a positive impact on boar taint reduction and improve welfare overall.

Although behavioural indicators are used by some farmers to single out aggressive pigs, as with better welfare practices, there is limited evidence available as to how this directly relates to boar taint prevalence. No other on-farm assessments for boar taint risk were identified.

Avoiding **split marketing** (or ensuring that pigs in the same group are sent to slaughter at the same time) is considered better for welfare but no farmers confirmed that they use this practice. Even though pigs are usually kept with group mates, pigs may be sent to slaughter at different times due to differences in growth rates and in some instances, problematic behaviour.

Slaughtering pigs at a lower weight will generally lead to a lower **price per carcass**. It is not clear how much lower this price will be, and how significant this difference is for different cut-off points. For example, a generally applicable estimate of the economic impact of slaughtering at 105 kg versus 115 kg has not been found, and it is not clear how significant the difference in risk of boar taint is between these weights. These cut-off weights may also differ between breeds, but no specific information on this was available.

Keeping pigs clean and comfortable during transport is important for welfare, although it is not clear whether this can also help reduce boar taint²⁶. Transportation issues therefore have not been included in the best practices for this report.

Case study: COOPERL's transition to entire males

COOPERL is a large pig meat producer in France that integrates farmers, feed producers, slaughterhouses and processors. In 2013 COOPERL transitioned towards the production of entire males.

This transition was driven by COOPERL's earlier commitment to animal welfare. COOPERL was inspired by the example of other producers in Germany and the Netherlands having transitioned to producing meat from entire males. Several visits in those countries in 2010 helped COOPERL collect additional information and devise a plan for testing the feasibility of such a transition at COOPERL.

A first trial was run, whereby volunteer farmers were asked to stop surgical castration but not change any of their other practices. In that phase, COOPERL applied the human nose method for detecting boar taint, based on Dutch protocols. Following an evaluation of the trial, a second phase of optimisation took place.

The evaluation of the trial involved a review of all the additional savings and costs that the transition to entire male production entailed for farmers, feed producers, and

²⁶ The following source provides detailed guidance on transporting pigs: Consortium of the Animal Transport Guides Project (2017-rev1). Revision May 2018 'Guide to good practices for the transport of pigs' Available at: <http://animaltransportguides.eu/wp-content/uploads/2016/05/D3-Pigs-Revised-Final.pdf>

slaughterhouses at COOPERL. This evaluation broadly concluded that, while the feed producer was negatively impacted because of the better feed conversion of entire males and therefore reduced quantities of feed required, the farmer benefited greatly: besides doing away with the effort of surgically castrating the pigs and the costs of accompanying health checks / treatments, farmers who produce entire males have also fewer dejections and therefore can more easily manage the environmental impact of their operations. Finally, slaughterhouses incur the additional costs of boar taint detection. The overall evaluation of those costs and benefits showed that the transition would generate a net benefit to COOPERL.

The transition from trial to commercial production took place in 2013. This included the establishment of a penalty system for carcasses with detectable boar taint, linked to the human nose tests carried out on each individual carcass at the slaughterhouse, and to a systematic feedback to the farmer on the level of boar taint detected in each batch. COOPERL has also provided reports to farmers each trimester that enables each farmer to compare its performance relative to its peers.

At around that time COOPERL also invested in research in genetics through its parent company NUCLEUS. Specifically, research was conducted by NUCLEUS jointly with the French Institute for Agronomical Research (INRA) to develop a method for qualifying boars in terms of the inheritable risks of boar taint, working with the Pietrain breed. This has led to individual testing of all Pietrain boars provided by NUCLEUS, and to the elimination of those detected as presenting a high risk of boar taint. As a result, NUCLEUS has developed a label "INO" (which stands for the French *inodore*, "without smell") for these Pietrain boars.

COOPERL's transition to the production of entire males was not driven by demand by retailers and other buyers, nor by animal welfare organisations. To reassure retailers and Business-to-Business (B2B) buyers that the transition was beneficial to them and did not present risks, COOPERL ran trials with both. For example, COOPERL ran trials with store managers, whereby they were informed in advance that, for a given period, they would only receive meat from entire males. There would be close interaction between a COOPERL representative and the store manager during that trial, to monitor any variations in sales and any consumer complaints. COOPERL also organised numerous visits for retailer and B2B representatives to inspect the full process, and especially the human nose method, to convince them of its reliability for detecting boar tainted carcasses. The human nose method at COOPERL has also been audited and certified annually by the German company SGS, which provides additional reassurance to the rest of the supply chain. COOPERL highlighted for its B2B clients that carcasses of entire males are easier to process than that of castrated males, which means an economic benefit for them as well.

While these efforts have proved successful in most cases, and COOPERL has managed to take retailer and B2B clients onboard so that it successfully provides entire male meat to an estimated 13 millions consumers per year, obstacles remain, including by clients that sell premium, labelled products.

5.1.2 Q2 – Techniques and best practices to vaccinate pigs

5.1.2.1 State of the knowledge and comparative analysis

Information on the use of vaccination was mainly supplied by farmers, vaccine manufacturers, and slaughterhouses²⁷. Supporting information was also extracted from the websites of vaccine suppliers, and from training materials for farmers.

Practices were identified in the following main areas:

²⁷ In Norway, the immunocastration vaccine is administered by slaughterhouses, while in other countries this is done by farmers or staff contracted by vaccine suppliers.

- The overall vaccination process, and more specific details of when and how the vaccine against boar taint should be administered;
- The administration of an additional dose of vaccine to larger pigs.
- Feeding of vaccinated pigs; and
- Vaccination tools.

Some of the quantitative information provided on the **vaccination process** referred to practices applied in third countries that have more experience of using the vaccine against boar taint (such as Brazil)²⁸. These practices were included in the final elements of best practice when considered applicable to the EU context (based on feedback from stakeholders and our team of experts).

One dose of Improvac costs farmers between €1.40 and €1.50. If farmers vaccinate twice, this means that the total cost per pig will be between €2.80 and €3.00. This cost information was confirmed by the vaccine producer.

Farmers tend to follow the manufacturer's instructions about the vaccination process, including the **timing for administering the doses**. The first dose is administered in pigs older than eight weeks, and there is a four-week interval between the first and second doses. The farmers consulted also tended to apply a similar delay between the second dose and slaughter (i.e., four to six weeks), in line with the manufacturers' recommendations. There are documented cases of both early²⁹ and late vaccination³⁰ of pigs.

The administration of **three doses to larger pigs** and special **feeding practices** for vaccinated pigs were reported in Spain. The administration of **four doses** was documented in Italy for the production of large pigs destined for organic Parma ham only. In the latter case, the producer noted the difficulty of applying that many doses on a single animal, and the challenges of achieving a product that satisfied local certification standards. While Improvac was considered economically profitable in other markets, that was not the case there.

The stakeholders consulted appeared to use the same **tools** (i.e., a dosing gun – see section 9) to administer the vaccine.

The following additional methods cited in the literature were not reported as being used in commercial settings:

- The practice of administering the first vaccine dose to pigs younger than eight weeks.
- The use of special equipment for large-scale vaccination. The stakeholder consultation suggested that, both in small and large farms, animals are vaccinated one by one. None of the stakeholders consulted used special equipment for mass vaccination.
- Special restraining methods for larger pigs: according to consultees, both piglets and adult pigs could be vaccinated in their pens, and do not require individual restraining.

²⁸ Specifically, the consideration that, when farms are well experienced with the use of the vaccine, the proportion of pigs requiring a third dose may be as low as 0.3% of pigs.

²⁹ i.e., the first dose of the immunocastration vaccine is administered as soon as possible, once the pig has reached eight weeks of age.

³⁰ i.e., the first dose is administered as late as possible, considering the expected age of slaughter.

Case study: Vaccination protocol to produce cured hams in Spain

In Spain, farmers vaccinate Iberian pigs against boar taint to produce cured hams. Vaccination has been successful in improving profitability and animal welfare while maintaining high product quality.

The vaccine is administered as follows:

Two-doses protocol for pigs reared in intensive systems: the vaccine is administered at 26 and 30 weeks of age for pigs aimed for slaughter at 40 weeks.

Three-doses protocol for pigs reared in extensive systems: the three doses are administered respectively at 30, 34 and 44 weeks of age, with a slaughtering age of 52 weeks.

When applied correctly, these protocols ensure high levels of meat quality. Trials carried out in Spanish slaughterhouses and cutting plants since 2010 demonstrate that cured meat from vaccinated pigs is similar to that from physically castrated pigs in terms of colour, percentage of marbling, and water-holding capacity.

Several benefits from vaccination are reported. Aggressiveness is reduced, and this helps avoiding pigs getting injured. After the second dose, pigs become more feed-efficient and reach a higher weight at the time of slaughter, which result in increased profitability for the farmer. The feed conversion ratio of vaccinated pigs is close to 3% lower than castrated males. Feed expenses, which are a key component of pig farmers' costs, are therefore reduced³¹.

The transition from physical castration to vaccination did not require any changes in farms' existing infrastructures, management systems, or vaccination guidelines. The main change relates to the adaptation of pigs' diet after the administration of the second dose. A pig expert reported this is key to achieving profitability and high quality of cured products.

Prior to the second dose, vaccinated pigs are fed the same diet as entire pigs. After the second dose, pigs behave as physically castrates: on a daily basis, they voluntarily tend to eat up to 20% more feed than before the second administration of Improvac.

The diet is therefore modified. For pigs reared in intensive systems, the diet is adapted from weeks 30-32 of age. The ratio between energy and amino acids is adjusted, and the proportion of amino acids is reduced by decreasing all individual amino acids equally. The proportion of energy coming from carbohydrate is increased compared to energy from fat. Furthermore, more fibre and more trace elements are provided. Provision of E Vitamin is increased to improve meat quality. Other vitamins and minerals are kept within legal standards.

Case study: vaccination protocol applied by a Polish farm

The following case study presents the experience of a Polish producer with vaccination against boar taint. The producer has two breeding farms with a stock of about 7000 sows and four fattening farms. They produce around 180 thousand piglets per year. Of these, around 35000 will go to external farms for fattening. The rest will be fattened in their own farms. The following is a transcript from an interview with Zoetis conducted in 2014.

"We have started to test Improvac in 2009 on a group of 1100 boars. Starting end of 2010, we have begun to routinely use the Improvac vaccination technology. Our decision to start with Improvac was made based on several arguments. A first reason was to be prepared for restrictions around piglet castration in the future. The second reason was a purely

³¹ Palomo Yagüe, A. (2012). Inmunocastración en machos: resultados en cerdos ibéricos. Available at: https://www.3tres3iberico.com/articulos/inmunocastracion-en-machos-resultados-en-cerdos-ibericos_817/

economic. We think of vaccination as an investment in the production process. The benefits from using Improvac are in a lower consumption of feed, better growth and better meat quality.

Ultimately, we are a large and modern company and we are always looking for innovative solutions that can bring sustainable and economic benefits.

In our farms, we use Improvac in a slightly different way from the recommendations of the manufacturer. We extend the time to slaughter to 8-9 weeks after the second vaccination. The results of our own tests and our experience over many months have shown that this is giving us the best results. We have seen that after the second vaccination, the animals start to grow very fast with high levels of daily gain. For our production, this 8-9 week period is optimal. It maximizes our economic return and it is still completely safe in terms of boar taint. In our slaughterhouse, we don't experience any significant levels of pigs with taint after vaccination. We have introduced a control program that consists of close observation of the pigs two weeks after the second vaccination is given. One month before slaughter (4 weeks) a final compliance monitoring is performed. If we see any mating behaviour in any of the boars, we still have sufficient time to revaccinate these animals a third time. These are sporadic cases, but they do happen. The test is then completed by filling a report that is signed by the farm manager and by the veterinarian.

We are in a privileged position as almost 100% of our animals are sent to our own slaughterhouse. Thus, in the beginning it was easier to convince the slaughterhouse management. Of course, during the first deliveries, there was inevitable excitement over this new type of pigs at the line. Inspecting veterinarians examined and evaluated the carcasses with much greater commitment. Close inspection of testicles and tests including the cooking and frying of meat to evaluate the presence of boar taint were performed. After a while, everything returned to normal. In a period in which 140,000 boars were sent to the slaughter, the inspectors detected less than 30 boars suspected of having boar taint.

The inspectors continue to monitor the situation, but we see no significant [problems].

Our plan is to continue using Improvac for vaccinating our boars. We don't currently see any other alternatives, so we are not presently looking for other solutions.

I would say, do not be afraid. Try for yourself. If the product is given at the right time intervals, then it is, on one hand very safe with regards to meat quality, and on the other hand it gives an opportunity to improve the economics of the production, which is very important. Every few extra zlotys earned per pig are at least a good reason to give the product a try."

5.1.2.2 Data gaps

There were few information gaps on the use of the vaccine against boar taint. Vaccine suppliers provided detailed information from training that is delivered in EU and in third countries. It was possible to confirm this information with the farmers and experts that were consulted.

However, it was difficult to identify **quantitative information on feeding practices** (such as feedings costs) that could be considered representative of various production systems. This is due to the significant variability in standard slaughtering weights from one country to the next, which result from commercial considerations.

5.1.3 Q3 – Techniques and best practices to provide assurance to slaughterhouses that vaccinated pigs do not present detectable boar taint

5.1.3.1 State of the knowledge and comparative analysis

To provide assurance to slaughterhouses that vaccination has been performed correctly, farmers in Spain and Belgium perform **on-farm controls** prior to sending pigs to the slaughterhouse. For assurance purposes, farmers in Spain and Norway also keep records of the vaccination process and supply these documents to slaughterhouses. None of these practices were reported by Dutch farmers.

On-farm checks performed both in Spain and Belgium include the observation of pigs' behaviour, which is considered a reliable tool by many stakeholders. Measuring testes was used to select at-risk pigs by some, and appears to be common practice in Brazil, but was found to be a difficult and inconclusive practice by many stakeholders. Studies have also indicated that testes size is an unreliable indicator of the success of the vaccine.³² As such, it has not been included in the final version of the best practices. The literature reviewed for this project also referred to the use of physiological indicators³³ to verify that vaccination has been successful; however, the data collection did not find any of these indicators being used in commercial settings.

Spanish farmers supply **paper-based documentation** to slaughterhouses. This typically includes details such as the numbers of vaccinated pigs, the dates of vaccination, and the on-farm checks performed to assess the result of the vaccination. Vaccination details will also be included as part of general medical records in many countries. In third countries (such as Brazil), farmers use electronic systems to transmit this documentation. These systems have been reported within the final documents on best practices, as they may be also applicable to EU farmers.

Previous research³⁴ estimated that the costs of detection for vaccinated pigs was around €0.07 per pig.

5.2 Practices at slaughtering and processing level

Some information on slaughtering and processing was available from previous research but there was less relevant literature than for farm level practices. Most slaughterhouse practices focused on detection. Some detection practices were unique to immunocastration against boar taint (see Q5), although many of the practices identified for detecting boar taint in entire males may also be used for vaccinated pigs.

Several options were also identified for processing meat with detectable boar taint. These practices differed somewhat between countries, and their practicality will ultimately depend on local processing practices and the perceived consumer sensitivity to boar taint within a Member State.

5.2.1 Q4 – Techniques and best practices to detect boar taint, quantify and manage positive carcasses

5.2.1.1 State of the knowledge and comparative analysis

The slaughterhouse practices that were identified related to:

³² Candek-Potokar, M. et al. (2014) Testes weight is not a reliable tool for discriminating immunocastrates from entire males. Proceedings of the International Symposium on Animal Science 2014: 43-49.

³³ Such as measuring the level of certain substances in pigs' blood.

³⁴ Civic Consulting (2013). *Study and economic analysis of the costs and benefits of ending surgical castration. Part 2 – Country studies*. European Commission. Available at: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_civic_pt2-country-studies_20131202.pdf

- Separation of entire males from castrated pigs;
- Slaughter of entire males at low weight;
- Detection of taint with the human nose method;
- Instrumental detection methods;
- Scales for measuring boar taint;
- Supply chain management; and
- Classification of tainted carcasses.

Information was gathered from previous work done on the topic³⁵ and some publicly available sources on tests and services available for boar taint detection. Most of the information collected came from interviews with slaughterhouses in Belgium, the Netherlands, Denmark, France and Germany. No detection methods or subsequent practices were in use in the UK as boars are slaughtered at a low weight (105-110 kg) to manage the risks of boar taint. In Spain, no detection methods were identified as boar taint is addressed entirely through processing and masking. There was some evidence of trials of detection methods in the UK, but no evidence of this being used in commercial practice.

The most popular method among the slaughterhouses that were interviewed was some variation of the **human nose** method, using a heating tool on line (slaughterline). On line human nose methods use different types of welding equipment, which can be broadly distinguished into two categories. Gas-powered soldering irons are cordless and involve an open flame. These were used by one slaughterhouse while another stated that it had been used previously but was perceived as difficult and dangerous. Electrical tools, which are corded and do not involve an open flame, appear to be used by the majority of slaughterhouses. These include soldering irons with metal tips and hot-air hand tools.

Of the human nose off-line testing methods available, the hot water method was preferred both as a testing method for slaughterhouses that process fewer boars and as a quality control method for larger ones. The hot water method has also been used and validated in the literature³⁶. There were also some instances of the microwave method in use, also used as a testing method for slaughterhouses that process fewer boars or as a quality control method.

Case study: The human nose scoring system of a major Dutch slaughterhouse

A Dutch slaughterhouse has developed its own boar taint detection method based on the human nose. The company is an EU market leader with over 10 years of experience in producing boar meat. It operates both in the UK and in the Netherlands, slaughtering thousands of male pigs each week.

The Human Nose System has been selected as the preferred detection method because of its feasibility and its low costs: in a slaughterhouse with high throughput, staff costs to implement the method is under 1€ per test. Additionally, the human nose method helps making improvements: information is fed back to supplier, so that they can act to reduce boar taint incidence by adjusting feeding practices and genetic selection. The method also met the requirements of the slaughterhouse's clients, and of final consumers.

³⁵ Nofima (2014). *BoarCheck: a study on rapid methods for boar taint used or being developed at slaughter plants in the European Union*. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_boarcheck_20140901.pdf

³⁶ Danish Meat Research Institute (2011). Validation of "human nose" based method for boar taint detection. Available at: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_dmri_human-nose-method.pdf

The method involves:

- Checks carried out on 100% of carcasses by trained testers.
- The use of a flaming soldering iron to heat the pig's fat (Weller®, Catalog number W100PG, 100 Watt); heating is done with at 370°C with a hot iron tip, 6 mm wide and 20 mm long, for about 2-3 seconds.
- The application on the slaughter line, at slaughter speed.
- The use of a scoring system to classify carcasses based on the boar taint level detected.
- The rejection of carcasses with a deviant odour.

The scoring system for carcasses is as follows:

0 = Normal pork smell

1 = Deviant smell, but no boar taint

2 = Faint boar taint

3 = Boar taint

4 = Strong boar taint

Carcasses scored 3 or 4 are rejected.

The procedure to implement the method first involves the training of testers in laboratory (three days) and at the slaughterline (five to six weeks of experience are necessary to achieve valid results).

Once trained, each tested can check around 500 boars per hour. Testers are regularly replaced (every half an hour) to avoid fatigue.

The method is certified and quality assured. The critical elements for certification include:

- the use of a documented procedure,
- the use of validated specifications for testers, defining: sensitivity, specificity, repeatability and reproducibility, test time per individual animal, and operation time per tester.
- the training of testers;
- the provision of feedback to farmers; and
- the implementation of quality controls and audits.

There was only one mention of **chemical testing** being use on line in a slaughterhouse. This example comes from Denmark and appears to be the same example mentioned in the BoarCheck report in 2012. Chemical testing was identified in the BoarCheck report as being a preferable method for slaughterhouses processing more than 1000 boars a day (based on investment and maintenance costs). There were a few mentions of new on line chemical detection systems undergoing trials in the UK and in Denmark but no use in commercial practice as yet. Danish stakeholders indicated that a new chemical testing method would likely be ready for commercial use within the next year. Chemical testing remains limited and it is unclear whether this is due to the cost, lack of suitable technology or the still limited need due to minimal processing of boars. Chemical testing off line is not used for entire males. Chemical testing was ultimately not included as a best practice as the one example of its use was limited to a single slaughterhouse and it does not appear to be considered a feasible option by any other stakeholders.

All the interviewed slaughterhouses that deploy human nose techniques use some form of smell test assessment and training for their staff. Several identified external consulting firms that provide these training services and some used in house training and testing.

There seems to be agreement across slaughterhouses in different countries that assessors need to take regular breaks and should take a break once boar taint has been detected. In some slaughterhouses the assessors take a break every 20 to 30 minutes. There are also examples of the break frequency being calibrated to the number of pigs tested. 'Smell cleansers' such as coffee or menthol were mentioned by some sources but in the only example of commercial use identified, the assessors did not tend to use the cleansers.

Some of the larger slaughterhouses interviewed capture information on the prevalence and source of boar taint. One slaughterhouse in Belgium reported having used this information to request that a farmer with particularly high levels of boar taint in his entire males switch to vaccination against boar taint and then back to surgical castration. One slaughterhouse in France provided statistical information back to farmers to help them improve their processes. Elsewhere, statistical information appears to be collected and stored, but not necessarily analysed or fed back to farmers. Protocols for human nose testing developed by QS in Germany and IKB in the Netherlands, as well that developed by the 'Beter Leven' label in the Netherlands, require that information on boar taint prevalence is shared back with farmers.

There have been some efforts to establish frameworks or protocols for human nose testing, notably a harmonised effort between QS in Germany and IKB in the Netherlands. Such frameworks stipulate that if slaughterhouses wish to process entire males, they must use detection methods and the detection methods used must fulfil certain criteria. These criteria do not stipulate the exact methods or procedures that must be used, but instead require that the methods are well-documented, that staff are appropriately trained and that quality control procedures are in place.³⁷ Another example of a framework or protocol for human nose detection is that produced by the 'Beter Leven' label in the Netherlands, which provides a similar but slightly more detailed framework for human nose testing. Establishing such requirements for testing can help individual slaughterhouses improve the consistency and quality of their testing and can also contribute to improving the consistency of testing between slaughterhouses.

There were some reports of **on-farm audits** being used in Belgium, Germany and France. However, these tended to be conducted through a third party (as part of a research project or through a certification scheme). There was one example in France of a slaughterhouse conducting risk-based audits of farms.

There was some evidence of slaughterhouses concluding **logistical agreements** with farmers to keep sexes separate, both to make boar taint detection more efficient and to keep different categories of carcass apart. Two slaughterhouses in the Netherlands indicated that they required farmers to keep boars and gilts separate when they are brought to the slaughterhouse. Some slaughterhouses in Germany and France have boar free periods during the day, where no boars are processed, to ensure that no boar meat enters the supply chain for certain clients.

Slaughterhouses use a variety of systems to **separate tainted boars and register boar taint** once it is detected. Most slaughterhouses seem to use electronic systems to register the presence of boar taint. There was one example of a slaughterhouse in Belgium that also registered this information on paper. Large slaughterhouses in Germany use a system with electronic chipped hooks that allows tainted carcasses to be diverted. One larger slaughterhouse in the Netherlands marked tainted boars by tying a piece of string around their leg. A smaller slaughterhouse in Germany stamped tainted carcasses in addition to separating them with the electronic system.

There were several mentions of bonus and malus systems among stakeholders interviewed; this appeared to be one of the biggest areas of divergence between

³⁷ For full details of this policy, see section 3.4.21 of QS's guide to slaughter [in German], available at: <https://www.qs.de/futter-tiere-fleisch/fleisch-und-fleischwaren-schlachtung-zerlegung.html>

slaughterhouses and countries. Many slaughterhouses pay less for boar meat than they would for castrates or gilts. This reflects the additional cost and difficulty in both processing and marketing boar meat, in spite of the leaner carcasses (which are therefore more valuable) of entire males. One example was found of penalties only being applied for boars above a certain weight, as this increases the risk for boar taint. Additionally, weight frequently plays a role in payment systems for pig meat from slaughterhouses. Most slaughterhouses have an ideal weight range and penalise suppliers of pigs that are either above or below this range. Previous research (Civic Consulting 2013) found evidence of some slaughterhouses paying bonuses for boars (€1 per carcass) that were sired using particular low-taint sperm. This bonus was part of a one-year trial in Germany, but is no longer in use. In Germany, there is currently a moratorium on penalties for boar taint until 2019. In the Netherlands, all interviewed slaughterhouses used penalties for boars, although these differed in scale. They were the lowest when boars were intended for a better welfare label. One slaughterhouse in Belgium reported that it did not use penalties for boar meat as the meat would carry a better welfare label. Penalties reported by various slaughterhouses include €3, €4 or €5 per boar or €0.03 per kg of boar meat. Details of these are given in Table 9.

Table 9. Examples of penalties used for entire males

Country	Penalties used	Other notes
Belgium (slaughterhouse 1)	No penalties used	Beter leven label
Belgium (slaughterhouse 2)	Penalty on boars that are too heavy	
Netherlands (slaughterhouse 1)	Penalty of 4 EUR per boar carcass	No boar taint detection used
Netherlands (slaughterhouse 2)	Penalty of 3 EUR per boar carcass	Higher welfare label, boar taint detection used
Netherlands (slaughterhouse 3)	Penalty of 5 EUR per boar carcass	Boars not part of welfare label, boar taint detection used
Germany (slaughterhouse 1)	Penalty of 0.03 EUR per kg of boar meat	For boars imported from the Netherlands
Germany (slaughterhouse 2)	No penalty used	For boars from Germany
France	Penalty associated with the detection of boar taint in the carcass	Penalties for boar taint vary depending on the genetic profile of the animal

Slaughterhouses' use of bonus - malus systems is generally linked to the availability of markets in which they can sell that meat. Therefore, although it is a practice undertaken by slaughterhouses, the decision to use bonuses or maluses is inevitably based on the price slaughterhouses will receive for the meat from the end customer. Bonuses may also come from further up the supply chain. For example, Delhaize (a retailer) in Belgium offers farmers a €1 bonus per pig for participation in a particular pork quality label (which included a no-castration policy). This is possible for Delhaize because consumers are willing to pay more for pork carrying this label. In markets where boar meat is still considered unacceptable by the end consumer or where value has not been added through better

welfare schemes, it is impossible for slaughterhouses to change their payment system to encourage boar fattening without impacting their own economic viability. As such, the use of payment schemes and bonus-malus systems is often a function of the market. Using a penalty system that specifically penalised tainted carcasses could be used to incentivise farmers to invest in feeding, breeding or housing solutions, and for this reason could be considered a best practice. The only example of this happening was documented in one large integrated supply chain in France. A penalty system based on boar taint also reflects the reduced returns tainted carcasses receive on the market. For example, one study³⁸ estimated that tainted carcasses in the Netherlands return around €25 less than their non-tainted counterparts.

While several slaughterhouses appeared to have systems and procedures in place for **monitoring complaints** from customers, no slaughterhouses reported having received any complaints related to boar taint.

The field identified a number of methods for **dealing with tainted carcasses**. Some carcasses are sold into specific markets. For example, the UK and Scandinavian countries were mentioned by one source as being more accepting of tainted meat. Italy and Asian markets were cited as examples where boar tainted meat cannot be sold. One slaughterhouse in the Netherlands stated that they did not use or process tainted meat. Some slaughterhouses indicated that they use this meat for pet food or in certain processed products. One slaughterhouse in France indicated that they sell all tainted carcasses to a specific partner.

5.2.1.2 Data gaps

There was little evidence of commercial use of **chemical testing** of boar taint among the slaughterhouses interviewed. There was one mention of the PTR-TOF-MS³⁹ technique being under trial, but no commercial use as yet.

Little to no information was received on the **costs of the various practices**. Some have been assumed to require more investment in equipment or labour, but it is not clear how far these practices are actually feasible, in particular for slaughterhouses of different sizes or in different Member States.

The hot water method was the only technique in use off line. Other methods identified in the literature and used in studies, such as the microwave method, were not used by any of the slaughterhouses interviewed. It is not clear why this method is preferred.

The practices of using **smell cleansers and sex separation** emerged during the research and had not been previously identified in the literature review. For this reason, not all slaughterhouses interviewed were asked about these practices and there may be missing information about the extent and variation of their commercial use.

Few slaughterhouses that were interviewed did not report statistics **quantifying** the incidence of boar taint. A very large range was reported by one slaughterhouse, which claimed that the percentage of tainted boars varies between 0.5% and 6% per day and between 0% and 10% per batch. Others have reported incidence rates of 1%, 3% and between 2 and 3%. Research conducted in the Netherlands has measured an incidence rate of slightly more than 3%.

³⁸ Backus, G. (2018) Whole chain approach for moving from surgical castrate to entire male production.

³⁹ Proton-transfer-reaction time-of-flight mass spectrometry (PTR-TOF-MS) is a technique used to measure volatile organic compounds in air.

Case study: Harmonisation of standards for HNS in Europe - The case of QS and IKB

In 2012, two European quality assurance organisations, QS in Germany and IKB in the Netherlands agreed on a common framework for boar taint detection using the Human Nose Scoring (HNS) system. This additional harmonised framework represents an addition to the standards already shared by the two assurance schemes as both organisations, who adopt a supply chain approach to certification, provide standardised frameworks for different activities along the pork chain. The framework, while not going into detail regarding the specific methods and parameters that companies must follow, specifies the overall criteria needed when slaughtering entire males to ensure the reliable detection of carcasses with potential boar taint. Companies slaughtering entire males must:

- Have instructions on how the detection system is implemented and carried out test procedures;
- Specify and document the sensitivity, specificity and repeatability of the test procedure;
- Document the method used to determine the validity of the performed tests;
- Specify and document the test times per individual animal and maximum continuous testing time per test person;
- Define and implement the procedures for the monitoring of test persons and the performance of parallel controls.
- Train employees selected to detect boar taint adequately (initial training and regular further training).
- Document content and frequency of training.
- Implement and document separate logistic processes for the separation of tainted carcasses
- Implement and document correction and prevention measures in case of deviations from established procedures
- Report findings of each batch tested back to the farmer/sender.

The implementation of the framework and compliance to the criteria is carried out by regular random audits of slaughterhouses adhering to the QS/IKB certification schemes which also slaughter entire males. As part of the bilateral agreement between QS and IKB, QS is authorised to carry out random and regular audits abroad in the Netherlands. These abroad checks also have the function to review the functionality of the assurance scheme more broadly and identify further optimisation and harmonisation measures required.

5.2.2 Q5 – Techniques and best practices to obtain assurance from farmers that vaccinated pigs do not contain detectable boar taint

5.2.2.1 State of the knowledge and comparative analysis

The following types of practices were identified:

- Random checks for boar taint;
- Checks based on testes measurement;
- Checks based on bulbourethral gland measurement;
- Chemical testing of samples from a small number of pigs;
- Documented record of vaccinated pigs;
- Bonus payments to farmers who vaccinate their pigs against boar taint; and

- Testosterone tests.

Unlike entire males, not all vaccinated pigs are tested in the slaughterhouse. Checks for boar taint among vaccinated pigs tend to be risk-based or randomly sampled.

Risk-based assessment is sometimes done by observing the size of the testicles, either visually or by measuring them against a threshold. This observation can be done either on line or when the pigs first arrive at the slaughterhouse. However, although this was reported as being used by some slaughterhouses, it is not considered to be an effective method for determining whether the vaccine has been successful. This is due to the variation in testes sizes between individual pigs, even within the same breed. Studies have also confirmed that the weight of the testes is not a reliable measurement for determining the effectiveness of vaccination against boar taint.⁴⁰

The size of the bulbourethral gland can also be checked. Studies have shown that the bulbourethral gland can be a reliable indicator of the success of the vaccination⁴¹ and some evidence was found of this method being used in Norway. However, due to the relatively small size of the gland and the likelihood of it being damaged during butchering, this practice was not included in the final document.

Risk-based assessment can be done using testosterone testing, as testosterone levels tend to correlate with androstenone levels. This can be used on batches of pigs to identify potentially at-risk groups and was recommended as a practice by the vaccine manufacturer. It has been used by some slaughterhouses in Belgium and Germany.

For vaccinated pigs, **boar taint is usually detected with the same methods used for entire males**. In Norway, however, chemical testing of androstenone is used. Around one per cent of carcasses are sampled based on risk factors and fat samples are collected and sent to a laboratory in Germany. This is done because it is thought that human nose techniques are not necessarily accurate enough and there is a sense that the Norwegian public is highly sensitive to boar taint.

One vaccine manufacturer recommended that farmers provide **documentation** of when vaccines were given, records of any abscesses, abnormal behaviour and information on the transport of pigs post-farm. This is done in Norway, where all such documentation must also be signed off by a veterinarian.

Slaughterhouses differed in how they paid for vaccinated pigs. In Norway, a steep **penalty** (around €300) is applied for any vaccinated pigs that come back positive for boar taint. This has acted as a disincentive to farmers and has contributed to the reduced use of vaccination against boar taint in Norway. In the Netherlands, one slaughterhouse confirmed that vaccinated pigs were given the same standard penalty as boars (€4 per carcass). In Belgium, slaughterhouses stated that for some labels, vaccinated pigs received a **bonus payment**. One source quantified this at €0.01 per kg.

5.2.2.2 Data gaps

There are several gaps in the information on vaccination against boar taint in slaughterhouses, largely due to the fact that this is not yet widely practiced.

No detailed information was found on **slaughterhouses conducting audits of farms**, although one slaughterhouse reported that farms were audited by a third party. There is also no evidence of slaughterhouses discussing other aspects of vaccination against boar taint (such as the use of specific feeds or rearing practices) with farmers.

⁴⁰ Candek-Potokar, M. et al. (2014) Testes weight is not a reliable tool for discriminating immunocastrates from entire males. Proceedings of the International Symposium on Animal Science 2014: 43-49.

⁴¹ Ibid.

From the limited amount of information received on **payment for vaccinated pigs**, it appears there are significant differences in practice and that this may impact the economic feasibility of vaccination against boar taint for farmers. More information on how the practices compare to the payment systems used across multiple slaughterhouses would be helpful.

There were also gaps in information on **how vaccination against boar taint is documented** and how this information is transmitted between farmers and slaughterhouses. It was not clear how routine this practice is or whether any electronic systems are used to document vaccination against boar taint and pass back information on the outcomes of vaccination to farmers.

5.2.3 Q6 – Techniques and best practices to deal with meat with detectable boar taint

5.2.3.1 State of the knowledge and comparative analysis

In all the Member States in which information was collected, tainted carcasses are usually **sorted at slaughterhouse level prior to processing**. Processors do not verify the quality of the meat supplied to them. Processors do not quantify what proportion of the meat received from slaughterhouses is tainted. Typically, slaughterhouses would specify the properties of the meat to their providers, or in some instances, slaughtering and processing are integrated and the same actor is responsible for both.

Although the final document focuses solely on the management of meat with boar taint during processing, many stakeholders raised issues related to processing meat from entire males that have little to do with the presence of taint. There are many other factors related to the quality of meat that require attention when processing entire males. Examples are the ratio of fat to lean meat, pH levels, tenderness and fat quality (e.g. the degree of unsaturation, and iodine value). There are also concerns regarding the production of certain products with highly particular specifications, such as Protected Designation of Origin (PDO) products. Vaccination against boar taint has been trialled as a potential solution for producing meat that better meets the quality requirements for certain processed products, but with mixed results. As mentioned earlier, the use of vaccination against boar taint for the production of Parma ham has proven to be of limited benefit to producers, because a large proportion of carcasses end up being rejected as non-compliant with the PDO standards. These concerns, and solutions to address them, were out of scope of the study, but are important to highlight as any processor looking to transition to entire males has to address them.

The research found that processors across various Member States are using different techniques to mask boar taint in final meat products. These techniques enable the sale and consumption of tainted meat in various markets, including those where consumers are sensitive to boar taint.

Stakeholders in Germany reported that **dilution, fermentation and smoking** of tainted meat are used in their country to mask boar taint in the final product. Examples of boar tainted meat being used in pet food were reported in Germany. Stakeholders had mixed responses to the use of tainted meat in **pet food**, citing the fact that this was becoming less acceptable to the pet food industry and that the objectives of the initiative are to provide meat for human consumption and enhance the prospects of producers to sell meat from entire males or vaccinated pigs to consumers. Therefore, use of tainted meat for pet food has not been included in final version of the document. **Thermal treatment** is used by processors in both Germany and Spain. Spices are used in Spain to mask boar taint while marinating tainted meat and dilution is used in Denmark.

Tests conducted in Denmark have shown that it is not possible to remove the boar taint from meat by **dry curing**⁴². It was shown that dry curing increases the concentration of the boar taint taste in the final product. In Spain, by contrast, stakeholders have reported that boar taint can be reduced by producing **marinated meat** and chorizo through a dry-curing process. Dry curing has been included in the final version of the documents, but with the caveat that there have been mixed experiences with its effectiveness.

5.2.3.2 Data gaps

There are several gaps in the information on how processors deal with tainted meat.

The **extent to which different methods used to mask boar taint are effective** for certain levels of taint is unclear. There is a lack of quantitative information about methods reported, such as the exact proportion of tainted to non-tainted meat that needs to be used to dilute boar taint, or the optimal level of spices needed to mask a certain degree of boar taint. There is often a lack of detail on specific methods (what spices are used to mask boar taint, at what temperature the meat should be cooked to avoid boar taint, etc). As there are many factors involved in processing, and each processed product will be subject to different processes, it is not surprising that there is a lack of specific or quantifiable information. And this information is unlikely to be shared by many processors as it relates to the specific methods and recipes used in production.

The **impact** of methods used to reduce boar taint **on the market value** of products is not clearly documented either. For example, does mixing tainted meat with non-tainted meat reduce the final price of products? Do certain methods of processing result in higher-priced or premium products?

There is also a lack of information about **consumer acceptance** of products processed with tainted meat.

Finally, no examples were identified of the following techniques: **injection of brine, techniques to strip fat from meat and the use of liver**. Techniques to strip fat from the meat were mentioned by stakeholders during the consultation process, but such processes are costly and it is not clear whether this is currently occurring in commercial conditions in the EU.

5.3 Practices at retailing and food service level

For both entire males and vaccinated pigs, it was difficult to identify practices in retail and food service. There was little available information in the literature and companies are generally unwilling to communicate about this issue. Many consumers are not aware of piglet castration and boar taint.

Practices at retailing and food service level are largely dictated by firms' understanding of the consumer acceptance of boar taint. There has been some exploration of this in the literature through cross-country or single-country studies looking for potential threshold values for androstenone and skatole.

⁴² Claudi-Magnussen, C., Kristensen, L., and Tørngren, M. *Use of tainted boar meat for processed meat products*. Danish Meat Research Institute. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_emp_use-of-tainted-boar-meat.pdf

5.3.1 Q7 - Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served

5.3.1.1 State of the knowledge and comparative analysis

The use of an **agreed set of specifications** for suppliers was the main technique used by retailers to avoid boar tainted meat reaching their customers. Specifications prohibit castration, impose specific breeding or feeding techniques, or require certain housing conditions. Auditing or farm inspections may be used to ensure compliance. The use of buyer specifications related to castration policies was found in Germany, Denmark, the Netherlands, the UK and Belgium. These specifications are sometimes linked to certain animal welfare standards and product labels, some of which set specific requirements on non-castration. Examples include:

- Red Tractor Assured Food Standards⁴³ and 'RSPCA'⁴⁴ assurance labels are based on schemes that do not allow castration in the pork supply chain. These labels are widely recognised and used by consumers in the UK.
- The BMA's British Quality Assured Pork⁴⁵ (BQAP) label does not allow for the slaughter of males over 100 kg. This is specifically aimed at avoiding boar taint.
- The Beter leven – Een ster⁴⁶ (Live better – One star) assurance scheme in the Netherlands forbids surgical castration. This standard is applied to pig meat products sold in retail markets. The "Beter leven" label also includes a requirement for slaughterhouses to use boar taint detection.
- The QS assurance scheme in Germany and the IKB assurance scheme in the Netherlands do not forbid castration but allow for the inclusion of meat from entire males so long as detection techniques are used. For this purpose, QS and IKB have also developed a framework for human nose boar taint detection (for further details on this, see Q4).
- In addition to specifying standards, standard owners or retailers may provide guidance to parts of the supply chain looking to transition to producing boar meat. For example, QS in Germany has developed a guide for farmers that includes a checklist to help determine whether farming conditions are already suitable for raising boars or whether any alterations need to be made.⁴⁷

In France one producer (integrating farmers, feed vendors, slaughterhouses and processors) has provided assurance to retailers and business-to-business (B2B) buyers by organising **visits and demonstrations** of the human nose detection method, sharing information about annual third party audits of its human nose detection protocol, and running pilots in close collaboration with store managers at retail shops.

Existing techniques used by retailers to increase the value of meat from uncastrated pigs include **marketing campaigns and export to specific markets**.

Retailers in the UK and the Netherlands have indicated that **marketing messages** addressed to consumers generally do not mention castration issues. These messages generally mention broader better animal welfare standards; more specific references to non-castration are only available to consumers interested enough to read their animal

⁴³ <https://assurance.redtractor.org.uk/>

⁴⁴ <https://www.rspcaassured.org.uk/about-us/>

⁴⁵ <http://britishmeatindustry.org/our-work/bmpa-pork-scheme/>

⁴⁶ <https://beterleven.dierenbescherming.nl/varken-2sterren>

⁴⁷ This guide is available through the QS website [in German]: https://www.qs.de/services/files/mediencenter/publikationen/QS_Jungebermast_A5_web_RZ.pdf

welfare purchasing policies.⁴⁸ Retailers are generally very reluctant to communicate about non-castration practices to consumers and so meat from uncastrated pigs is not specifically differentiated.

This is not universally the case, however. In Belgium Delhaize has recently included and publicised a 'castration free' policy for one of its pork labels.⁴⁹ The marketing for this label highlights the absence of castration, but also mentions several other aspects of this label:

- The meat has been carefully selected for taste, and comes from a specific low-taint breed
- Pigs are fed a balanced diet which also contributes to human health (through the inclusion of omega-3 fatty acids)
- The production is entirely Belgian and farmers receive an incentive per animal and reimbursement for additional feed costs; and
- There is a lower need for antibiotic use and therefore reduced use of antibiotics in the rearing of the pigs.
- Rather than referencing it as part of a broader animal welfare policy, this example includes non-castration and better welfare alongside taste, quality, human health, an appeal to supporting local farmers and environmental concerns.

Another way to increase the value of meat from uncastrated pigs with detectable boar taint is to sell it in markets where the acceptance of boar taint is higher than in the producers' domestic market. The UK is often cited as an example where tainted meat may have a market. However, this was disputed as a best practice by stakeholders who felt that there is no such thing as a market with higher acceptance of boar taint and that this should not be considered a solution for the problem of tainted meat. Denmark is a special case, as a lot of pork meat from the country is exported, including to Asian countries where consumers are very sensitive to boar taint. This complicates any potential transition to the production of entire males.

Retailers deal with **customer complaints** which may or may not be linked with boar taint. In some cases, complaints may help monitor the effectiveness of measures implemented to prevent boar tainted meat from reaching consumers. This may help retailers take informed decisions about problems arising within the value chain. However, no evidence was found of this information being used effectively by retailers to deal with boar taint on a routine basis. Although all retailers will have a system for managing complaints, it may be difficult to determine whether complaints are related to boar taint or to other issues with the meat, and no evidence was found of retailers passing this information on further down the supply chain. For this reason, this practice was not included in the final version of the documents.

5.3.1.2 Data gaps

The data needed to determine whether meat labelled according to animal welfare standards is sold at higher **prices** in countries where these standards have been reported were not available. It is also not clear whether exporting meat to different market places creates challenges (e.g. increased costs for transport) or provides opportunities (e.g. higher pricing). More quantitative information is needed to address this gap.

There was little evidence of retailers using **complaint management** to monitor the effectiveness of the measures put in place to avoid boar tainted meat ending on shelves.

There was no information on **checks made by buyers** on behalf of supermarket chains that could be used to prevent tainted meat from reaching consumers. The converse was

⁴⁸ See, for example, the national animal welfare purchasing policy of Aldi in Germany, available at: <https://www.aldi-nord.de/unternehmen/verantwortung/lieferkette-food/tierwohl-bei-aldi-nord/tierwohl-einkaufspolitik.html>

⁴⁹ Delhaize. (2018) Delhaize kiest voor exclusief varkensras met nog meer smaak en nog meer oog voor dierenwelzijn. Available at: https://www.delhaize.be/press_overview:exclusief-varkensras

observed, whereby suppliers invited retailers to demonstrations of their protocols for detecting boar taint, largely to convince the latter to accept meat from entire males on their shelves.

Case study: Delhaize's successful marketing of meat from non-castrated pigs

In June 2018, Belgian retailer Delhaize launched its new castration-free pork products under its "Better for Everyone" (Mieux pour Tous / Beter voor Iedereen) label, a label established in 2014 with a focus on nutritional quality and sustainability. The label is based on four pillars, namely: 100% Belgian production, better taste, better animal and human nutrition, and better animal welfare. The non-castration clause was introduced as a new element of the label, with the first meat products from non-castrated pigs available for purchase in selected stores in March 2018. Since then the availability of non-castrated pig meat has expanded and at present all pork meat sold in Delhaize supermarkets is sold under the "Better for Everyone" labels and is therefore non-castrated.

To make the transition to non-castrated pig meat, Delhaize implemented various changes within its supply chain. First of all, in order to work closely with all actors along the chain and achieve these changes, all pig producers, feed companies and slaughterhouses who follow the "Better for Everyone" label standard must join the Healthy Farming Association established by Delhaize. This network of supply chain actors was created to improve the sustainability of the food chain with a specific focus on animal feed. To date this network includes 208 Belgian pig producers. Furthermore, Delhaize created a double incentive for farmers to produce according to Delhaize's standards: they guarantee the purchase of a certain volume of the farmer's production, and they also pay a higher price for the carcasses compared to the market average. More specifically, farmers receive an extra €3.59 per produced pig, of which €2.59 will be full compensation for higher costs associated to the special feed formula rich in omega-3 that farmers are required to use, and €1 will be the bonus.

To minimise the presence of boar taint in its meat Delhaize implemented a number of technical changes in the breeding, rearing and slaughtering stages of its pork supply chain. The first technical solution was the use of selective breeding. Delhaize selected a specific "bouquet" variant of the Piétrain breed from Flemish company DANIS and its artificial insemination centre KI Lichtervelde, which benefits from the expertise of big breeding company PIC. This Belgian pig breed was selected because it does not develop boar taint as much as other breeds, while also fitting with the focus on Belgian products and production of Delhaize's "Better for Everyone" label. The specific bouquet variant is only exclusive to Delhaize and pig producers can only use this breed with the retailer.

Delhaize also established clear guidelines that pig producers need to follow when rearing the pigs for slaughter. Implementation of the guidelines are monitored via regular inspections and the use of Tracy from Belpork, a digital registration and traceability system that allows all members along the chain to track and input information, including inspection outcomes. Nutritional quality of the meat is regularly checked and samples are analyzed in the independent laboratory of UGent. According to the guidelines, male and female pigs must be reared separately as the sight or smell of gilts might increase the level of hormones linked to boar taint in males. Moreover, pigs must be fed the specific feed formula provided by AVEVE-Dumolin, made up of local cereals and flaxseed rich in omega-3. While this special feed is used specifically to reduce boar taint, this is not mentioned by Delhaize as a benefit of the special diet fed to pigs. Instead Delhaize states that this specific feed composition improves the taste of the meat and improves pigs' health and welfare by reducing the need for medication and antibiotics. Delhaize also states that this special diet increases omega-3 in the meat, offering additional health benefits to consumers. No changes were implemented for the slaughter weight of entire males, which remained at 110kg.

Finally, Delhaize also implemented technical changes during slaughter. The retailer introduced detection measures on the slaughter line by requiring the use of trained assessors to identify tainted carcasses. To do this, the assessors heat up a sample of pig fat with a gas-powered soldering iron and smell it to detect boar taint. If boar taint is detected, the carcass is removed from the slaughter line and is redirected to another value chain for pork meat not sold as fresh meat for cooking. Of the pig meat produced according to the "Better for Everyone" standards, 45% is sold as fresh meat and 55% as processed meat. Delhaize states that by implementing the above-mentioned changes in breeding, rearing and slaughtering in its pork supply chain, boar taint affects approximately 2% of the 6000 to 8000 pigs slaughtered weekly for its supermarkets.

Overall, the changes made by Delhaize have been welcomed by politicians, NGOs, and supply chain actors who perceive the use of entire males as an improvement of the retailer's commitment to increased animal welfare. Moreover, Delhaize has been able to market non-castrated meat successfully to customers by focusing on provenance, taste, health benefits and animal welfare. In promoting the improved "Better for Everyone" label, Delhaize highlighted the benefits of using meat from the 100% Belgian Piétrain breed, describing its meat as tender, flavoursome, juicy and of superior quality. These claims were backed by taste panels conducted prior to the launch which showed that customers found the meat tastier than before. Secondly, the "Better for Everyone" label present on the meat packaging predominantly promotes the health benefits of consuming meat rich in omega-3 resulting from the flaxseed-rich diet fed to pigs. The focus on the additional animal welfare benefits resulting from non-castration, while mentioned on its site and in the media, do not seem to be the main focus of its product marketing to consumers. Lastly, Delhaize does not sell its "Better for Everyone" products at a premium, making the new improved pork meat accessible to all its customers.

Case study: Lidl Belgium's move to entire males

In 2012, Lidl Belgium decided to move fully to the sale of meat from entire, non-vaccinated pigs. This was a decision that applied only to Lidl Belgium rather than the broader Lidl group. This change was due to Lidl's focus on animal welfare standards, and to the broader political context in Belgium – characterised by increased media attention to the matter of animal welfare. Lidl Belgium was also interacting regularly with the Non-Governmental Organisation GAIA, which raised the question of pig castration.

The transition took place within a short period of three months. Lidl Belgium engaged with its suppliers to ask them to move to the production of entire males. A number of farmers providing meat to Lidl Belgium were already working with entire males at the time, therefore this facilitated the transition for the whole supply chain.

There was a feeling among farmers that the production of entire males presented various disadvantages, such as increased fragility and propensity to suffer from cold temperatures, greater aggressiveness, and more frequent injuries. However, farmers have embraced the transition on the basis of the benefits it has brought them: abandoning the act of castrating piglets, not having to manage the risks of wound infection in castrated piglets, and seeing non-castrated pigs grow with less food than is required in castrated pigs. There were no monetary incentives offered to farmers to help them transition towards the production of entire males.

Slaughterhouses hired additional staff to perform smell tests on the carcasses so as to detect boar taint. Boar tainted carcasses are stored separately, and the meat undergoes further processing. It is not sold as fresh meat to consumers.

Lidl Belgium has never communicated specifically on the issue of non-castration on labels of products sold to consumers. It has been reported elsewhere, such as on Lidl Belgium's

website. Nowadays, Lidl Belgium has also included a new label on its products, the 'Beter Leven' label. This includes also non-castration as one of several other aspects / benefits.

5.3.2 Q8 - Techniques and best practices to increase the acceptance of meat from vaccinated pigs among consumers and to prevent meat with detectable boar taint to end on the shelves or served

5.3.2.1 State of the knowledge and comparative analysis

The reliance on an **agreed set of specifications** (among which the obligation to use vaccination with Improvac for all piglets) was the only documented technique used by retailers to avoid boar tainted meat ending on shelves at retail stores. Belgium is the only country where a retail company (ColruytGroup) has reported sourcing its meat from vaccinated pigs. The company has embraced immune-castration in 2010 and has deployed this across all its brands (Okay, Bio Planet, Spar, Cru, etc.).

Farmers are typically visited by an independent organisation once a year to control that they respect the specifications agreed upon. Additional **audits** are also conducted every year on a random basis by ColruytGroup. The company is supported by technical experts that offer training to animal handlers on the use of Improvac, the treatment of piglets, livestock keeping, and animal welfare issues.

ColruytGroup communicates about vaccination against boar taint in combination with other messages on other benefits to positively position itself as caring for animal welfare, pig health and sustainability. While the retailer is very reluctant to use the term "immunocastration", it uses the word "vaccination" in all its **communications to consumers** (website⁵⁰, short videos at the butcher shelves, bi-weekly customer folders, consumer complaint service, etc.).

Like for non-castration, retailers sourcing their meat from vaccinated pigs deal with consumer **complaints** which may or may not be linked with boar taint. In some cases, consumer management methods may help monitor the effectiveness of measures put in place to prevent boar tainted meat from reaching shelves. Although consumer management can only be used ex-post, it may help retailers take informed decisions about problems arising within the value chain.

Case study: Colruyt's successful transition to vaccination against boar taint

In 2010, Colruyt conducted a trial to improve pigs' welfare by using vaccination against boar taint. It used Improvac on approximately 2,600 boars and monitored all production steps from vaccination to meat consumption. The trial involved the gathering of information on various implications from transitioning to vaccinated pigs, such as profitability for pig producers, meat taste and fat content, and consumer reactions. The study was done in cooperation with the Flemish Research Institute for Agriculture, Fisheries and Food (ILVO).

Colruyt's trial revealed several advantages of vaccination compared to physical castration: better animal welfare, better feed efficiency and reduced manure production. Additionally, no surgery is required with vaccination. This technology therefore reduces the risk of infection, and antibiotics are needed less often. Meat from vaccinated pigs is also leaner than pork from castrates. Panels involved in tasting tests were not able to distinguish between meat from castrates and meat from Improvac-vaccinated animals. There was a small preference for the pork from vaccinated pigs.

Based on these results, Colruyt discussed the plan to implement vaccination with its suppliers, and addressed any suppliers' concerns. Following these discussions, Colruyt

⁵⁰ <https://www.colruytgroup.com/wps/portal/cg/en/home/stories/Welfare-pigs>

decided to include vaccination against boar taint as a mandatory requirement for its suppliers.

Based on Colruyt's requirements, it is the responsibility of slaughterhouses to recruit farmers that use vaccination. When slaughterhouses detect boar taint, Colruyt encourages them to contact the farmer and assess whether vaccination has been done correctly. Zoetis can help farmers address problems.

Colruyt conducts targeted and random checks for boar taint, including taste checks and laboratory analyses. The transition to vaccination did not increase Colruyt's costs for supply chain controls: checks for boar taint are integrated into existing meat quality controls. The use of vaccination did not result in any negative impacts on pork sales.

Colruyt does not mention vaccination on its products' packaging: its policy is to avoid unnecessary messages on packaging, as these may confuse the consumer. It rather communicates the use of vaccination by other means, such as press releases, in-store videos, and its webpage. The use of vaccination is accompanied by messages on improved animal welfare. In its communications to consumers, Colruyt does not use technical words such as "immuno-castration", but rather uses "vaccination", which is more understandable to consumers. Consumers' reactions to these campaigns were limited and mainly positive because of the improved animal welfare implications from vaccination.

When transitioning to vaccination, Colruyt's biggest challenge was to convince farmers to change their practices. To address this, Colruyt developed a communication plan in cooperation with Zoetis to inform farmers of the vaccination technology, its application and its advantages. Zoetis offers technical support and training to farmers.

5.3.2.2 Data gaps

There were only few examples found in Europe of retailers having opted for meat from vaccinated pigs. This issue is not targeted specifically by retailers in their communication to consumers. It is therefore difficult to see if there is any **consumer acceptance** of products processed with meat from vaccinated pigs and what potential impact higher consumer awareness on this issue would have on prices.

There was little evidence found of retailers having used **complaint management** to monitor the effectiveness of the measures put in place to avoid boar tainted meat ending on shelves. Only one retail company (ColruytGroup) has reported that client complaints may lead the company to block the whole production line if the company suspects that a specific delivery contains boar tainted meat. This is part of ColruytGroup's strict quality procedure and was said to be extremely rare for boar taint.

5.4 Summary of initial findings and results of the data gathering

Although certain practices seem to be widespread (for example, slaughtering boars at a lower weight), there seems to be significant heterogeneity in the approaches to raising boars or vaccinated pigs used across Europe. Much of the variation seems to stem from the attitude toward the problem of boar taint itself and retailers' views on how acceptable boar taint is perceived to be to the end consumer.

The extent to which these assumptions about sensitivity or lack thereof are grounded in evidence remains unclear. There was no evidence of consumer complaints about boar taint and many consumers are not aware of the issue of boar taint or castration in the first place. Indeed, when complaints regarding off-smelling meat are received, it is difficult for suppliers to determine whether the presence of boar taint is the cause of the odour.

There must be agreement in the supply chain for many of these practices to work. The production of boars or vaccinated pigs is not possible unless there is an ultimate market into which such meat can be sold. This is especially true for those countries where suspicion

towards production without castration is high, and additional effort must be made at the farm, slaughterhouse and processing levels to ensure that no tainted meat enters the supply chain.

In France, the Netherlands, Denmark, Belgium, Germany and Norway, additional investments have had to be made at slaughterhouse level where boars are slaughtered. These investments are practical only where there is a guaranteed market for meat from boars or vaccinated pigs. A number of them are practical when a sufficient volume of boars are to be processed through the slaughterhouse.

The practices are all used to different degrees by slaughterhouses that process boars, and all require some degree of investment, either in hiring or training personnel or investing in additional equipment or infrastructure. Incentives to supply boar meat must be enough to allow for additional investment in such processes.

Investment in such processes is also only practical if farmers are raising boars or vaccinated pigs. Many practices at farm and at slaughterhouse level benefit from coordination between farm and slaughterhouse. For example, split sex rearing easily allows farmers to provide animals to the slaughterhouse in split sex groups or participate in 'boar free' times on the slaughterline.

5.5 Description of problems encountered and solutions found

Several challenges were encountered while researching the elements of best practice. The amount of information available varied greatly depending on the point in the supply chain under consideration. Information on practices at farm and slaughterhouse level was available through both interviews, documentation and field visits. Information from retail and food service was not as accessible and the study team encountered challenges in identifying practices. Various sources of information were consulted in an effort to address these issues (such as different supply chain actors and their representative associations, websites of retailers and assurance schemes, and our team of experts).

The number of field visits was comparatively small. This was due to several factors: in some instances, field visits were not deemed likely to provide information beyond what was available from telephone interviews. In other instances, stakeholders were reluctant to participate in field visits.

There was a lack of information on costs and feasibility. This is a common problem with this kind of study. Experts within the study team, and particularly participants to the Advisory Board, were able to offer advice on the feasibility of certain practices. Previous studies provided some insight on costs. To address this challenge, all data gaps were mapped systematically and this mapping informed the stakeholder consultation. Feedback received during the consultation provided additional information on how practical the draft elements are from stakeholders' perspectives.

6 Deliverable 4 (1) – Consultation process

A wide range of feedback was received from stakeholders during the course of the consultation process. Some of the feedback received focused on the overall format and structure of the documents, finding that the existing presentation did not provide the necessary detail and did not appropriately address the links between different parts of the supply chain.

On some issues, there were clearly contradictory opinions between stakeholders, some of which reflect broader debates on pig welfare. For example, the inclusion of slatted floors was contentious for some stakeholders and there were very different views on sex-separated rearing and its effectiveness at reducing aggression among boars. More generally, the document on farming practices for entire males generated the most feedback.

Opinions also seemed to be divided on the efficacy of existing instrumental methods versus human nose techniques. For a few stakeholders, human nose techniques are not reliable enough for commercial use and there is too great a risk that tainted meat will enter the supply chain. For most stakeholders, however, existing instrumental methods are not sufficient and are too costly for commercial use. Indeed, the method currently established in Denmark has not been implemented anywhere else in spite of many years of use in commercial conditions. Rather, most users of the human nose method saw it as a reliable solution for detecting boar taint, until an affordable chemical detection method is found.

Some comments came from stakeholders who recommended related studies that pointed to new or alternative practices. In these instances, no action was taken as only practices found in commercial conditions were included in the documents. In some instances, the study team followed up with stakeholders to confirm whether the practices described were also used commercially.

Finally, the consultation process highlighted gaps that were then filled by complementary research, including additional desk research and interviews.

A record of all comments received through the online consultation is provided in Annex 5. For each comment, this includes ICF's response and any actions taken to address these comments.

7 Deliverable 4 (2) - Final best practices

This section presents the elements of best practice identified through data collection and revised on the basis of the stakeholder consultation and advisory board meeting. Each sub-section focusses on one of the eight issues listed in the terms of reference for this project (see Table 1).

Boar taint is caused by the **skatole** and **androstenone** accumulation in tissues of pigs, usually uncastrated males. These compounds contribute both individually and in combination to the perception of boar taint. Some of the measures believed to impact boar taint specifically impact androstenone levels, others specifically impact skatole levels. Practices in this document therefore generally refer to one or the other.

This section considers practices observable at specific points in the supply chain and targeted at a specific type of actor within that chain. However, many of the challenges of switching to entire males or vaccinated pigs relate to relationships and communication between different members of the supply chain. Case studies are presented in this report in Section 5 providing examples of transitions that have occurred in three different Member States with involvement from different types of actors.

7.1 Q1. Farmers – uncastrated pigs: management techniques

This document lists good practice examples for reducing the risks of boar taint in entire males at farms. These practices are all currently used in commercial operations in the EU.

Making the transition to raising entire males requires careful consideration and planning on the part of the farmer. The following guide refers to practices that may be of interest to farmers making such a transition. In addition to the practices described, it is important for all farmers to **communicate with their supply chain and customers** before and during any transition to raising entire males. Understanding the costs and benefits to other parts of the supply chain will also help farmers advocate for and lead the transition away from surgical castration.

Things to consider

- ➔ Producing entire males without boar taint can mean reduced costs and efforts on some aspects, and additional expenses on others. In some markets, financial incentives exist for entire male production. The farmer should assess and compare those costs and benefits.
- ➔ Not all customers will accept boar meat. The farmer should make sure they have customers for boar meat before moving to the production of entire males.

Case study: COOPERL's transition to entire males

COOPERL is a large pig meat producer in France that integrates farmers, feed producers, slaughterhouses and processors. In 2013 COOPERL transitioned towards the production of entire males and convinced partners further down the supply chain to transition with them. This transition involved several changes to farm level practices. Further details on this case study are provided in Section 5.1.1.

7.1.1 Managing boars - principle

Farmers aiming to raise entire males need to learn how to manage boars and their behaviour. Some farmers report increased physical and sexual aggressiveness among boars. Keeping these behaviours to a minimum improves welfare and keeps stress levels low.

Many of the practices included in this document, including practices to reduce competition at feeding and keeping good housing conditions, can help minimise aggressive behaviour among boars.

Boars require consistent handling as well. They are particularly sensitive to changes in management. A regular routine, including their feeding, climate and housing situation, can help reduce stress in boars.

Further reading

For additional information on handling boars, see existing guidance produced by Wageningen University. 'Reducing mounting behaviour of boars – tips and recommendations'. Available at: <https://www.boarsontheway.com/wp-content/uploads/2018/08/Flyer-Berengedrag-v4-engels-2.pdf>

7.1.2 Flooring and Housing

By improving the overall quality of flooring, housing and pig management, stress and fighting may be reduced. This is good for welfare and reducing boar taint, as increased stress has been associated with higher levels of taint. Clean and dry environments are also important to prevent boar taint.

7.1.2.1 Keeping pigs clean and dry

Keeping pigs clean may help reduce skatole levels.

Pens should be cleaned regularly.

Where straw is used for bedding, it should be kept as clean as possible and topped up or refreshed regularly.

Fully or partially slatted floors are also used to help keep pig environments clean and dry. They help to eliminate urine and faeces from pens. Fully slatted floors may lead to increased lameness and injuries, however. Some Member States (including the Netherlands, Denmark, Finland and Sweden) have prohibited or restricted the use of fully slatted floors.

Advantages

- ➔ Dry floors keep pigs clean and improve overall hygiene.

Disadvantages

- ➔ Fully slatted floors may lead to other welfare issues.

Things to consider

- ➔ Floors should be well-maintained. For example, if slatted floors are used, the edges can become sharp and this can increase the risk of injuries.
- ➔ Keeping floors dry is dependent on good ventilation.

7.1.2.2 Sex-separated rearing

Separating boars and gilts means they will not smell or hear one another. The sight or smell of gilts may increase the levels of hormones linked with boar taint. Raising boars in sex-separated groups may also help reduce aggression, although the evidence on this is not clear. For pigs raised to heavier weights and older ages, separating by sex is necessary to prevent the risk of sow pregnancy.

Separation makes some of the feed options for reducing boar taint more practical and economical. When boars and gilts are separated, the more expensive feeds (with taint-reducing additives) can be provided to boars only.

Separating pigs by sex is done at weaning, the start of the finishing phase or when the pigs reach a certain weight. Boars and gilts may be separated either by pen, in different areas of a shed or in different sheds altogether.

Many slaughterhouses require farmers to provide pigs in sex-separated groups. Sex-separated rearing allows farmers to do this without separating groups when they are taken to slaughter.

Advantages

- ➔ Separation at rearing stage reduces logistical requirements when slaughterhouses request sex-separated groups.

Disadvantages

- ➔ Separation may lead to increased aggression among boars.

Things to consider

Sex-separated rearing may require additional infrastructure. Separate pens need to be available. If separate feed will be provided to boars and gilts, farmers will need separate feed silos.

7.1.2.3 Wean to finish grouping

Pigs are kept together in their litter groups (which means with their siblings). There is no or minimal mixing after weaning. These groups are also sent to the slaughterhouse together. This reduces stress and may therefore contribute to a reduced instance of boar taint.

Wean to finish grouping might also be combined with sex-separated rearing. This would, however, require smaller finisher pens for groups of around 4-5 animals.

Advantages

- ➔ This reduces stress in pigs throughout life.
- ➔ This may contribute to increased weight gain.
- ➔ This can also help prevent the spread of disease and contribute to animal health.

Things to consider

- ➔ This implies additional logistics to separate animals before slaughter, if slaughterhouses request sex-separated groups.
- ➔ Smaller pens may lead to additional housing costs. Separate pens need to be available to ensure groups can stay together.

7.1.2.4 Low stress environments

Some good practices for reducing stress are:

- Make sure pigs have enough space. Legal requirements differ depending on pig weight: for example, at least 0.65 m² per pig for pigs between 85 and 110 kg; at least 1 m² for pigs above 110 kg. Pig pens should enable pigs to comfortably rest, eat and eliminate.
- Keep group sizes small. Keeping groups to around 30 pigs or less can reduce stress, competition and improve welfare.

- Remove ill or injured pigs from the pen.
- Use partly open pen walls. This allows pigs to have contact with neighbouring pens and can help reduce aggressive behaviour.
- Ensure temperature control and proper ventilation. Keep temperatures as consistent as possible. Make sure housing is properly insulated and avoid draughts.
- Ensure suitable lighting, including a consistent day and night rhythm. Avoid overly bright lights.
- Keep pigs supplied with sufficient fresh water.
- Provide enrichment, such as: wood and branches, straw in racks or as bedding, alfalfa and hemp rope. Enrichment objects that are destructible, edible and encourage rooting are most effective. Enough enrichment materials should be provided so that pigs do not need to compete with one other. This helps keep boars calm and occupied.

Advantages

- ➔ Low stress environments improve overall pig welfare.
- ➔ They also reduce adverse behaviours such as aggression, ear- and tail biting.

Disadvantages

- ➔ Implementing these practices may increase costs.
- ➔ If straw is used, it must be kept dry.

Things to consider

There is existing guidance on improving the welfare of pigs. Many assurance schemes and certification programmes have their own welfare standards and requirements. These can help farmers decide how to change their practices.

Further reading

Previous European Commission work on better welfare conditions to reduce tail biting contains good guidance on reducing stress in pig environments. See: *European Commission (2016) Cutting the need for tail-docking*. Available at: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_practice_farm_pigs_tail-docking_eng.pdf

7.1.3 Reducing competition at feeding

Reducing competition at feeding can reduce stress, improve welfare and can help reduce the risk of boar taint.

Feed for boars should not be restricted and instead, boars should be fed **on demand**. Feeding systems with multiple feeding spaces help to reduce competition. For example, offering feed in long troughs can help to reduce competition. Troughs should be at least 17 centimetres (cm) long per piglet, and at least 22 cm long per growing pig.

One option for reducing competition at feeding is "wet feeding", or "liquid feeding". Wet feed consists of a mix of dry feed and water (or other liquids). With this system, pigs drink their feed rather than chewing it. Wet feeding is used largely for controlling consumption. A long trough is used, allowing all pigs to eat at the same time. Alternatively, a sensor-managed system is used with smaller troughs. This schedules feedings and avoids "rush hour" effects. Wet feeding systems allow for better control over feed conversion. They make it easier to calculate correct feeding amounts.

Farmers who use wet feeding should ensure that pigs also have access to sufficient fresh water.

Advantages

- In addition to reducing boar taint, this practice has positive effects on animal welfare and pigs' growth.

Disadvantages

- The need to install feeding equipment means that a transition to this practice has a high upfront cost.

Things to consider

- Pens should be large enough to accommodate additional feeders or feeding equipment. Pigs should still have enough space to keep separate areas for resting, activity and elimination.
- Additional feeders may disrupt the air flow through a pen. Check that ventilation systems are functioning when making any changes to infrastructure.

7.1.4 Breeding

Selective breeding can be used to help reduce androstenone levels. There are two main breeding techniques used.

The first method is to select on breed. Certain breeds of boars, such as the Piétrain, are less likely to have boar taint.

The second method selects within a breed. Several breeding companies have developed techniques and practices that allow them to offer 'low-taint' sperm. Topigs Norsvin has developed a method to select low-taint boars. Their low-taint sperm is available for purchase. Similarly, Nucleus in France offers Piétrain selected low-taint reproducers, labelled "INO". A low-taint line has also been developed by the University of Bonn in Germany, in partnership with the breeding company GFS and the slaughterhouse Westfleisch. The retailer Delhaize in Belgium has worked with breeding company PIC to develop a low-taint line for a castration-free pork label.

Advantages

- Selective breeding reduces boar taint risk from the outset.

Disadvantages

- Dosages of low-risk sperm are sometimes priced higher than normal dosages. One dosage of Nador sperm from Topigs Norsvin costs an additional €1 more per dosage. By contrast, Nucleus' INO boars are available at no premium cost compared to other boars.
- Availability of these products varies per country.

Things to consider

- Switching to a different breed of pig depends on the customers or market involved and should be discussed within the supply chain. Switching breeds may also require changes to farm management practices.
- Using 'low-taint' sperm only addresses one half of the genetic material of pigs. The potential contribution of the genetic material of sows should also be considered.

7.1.5 Feed composition

A range of additives can be used in pig feed to lower skatole levels. Changes to feed can also be used to improve growth rates, lowering the age at slaughter and reducing the risk for boar taint.

Things to consider

- ➔ Farmers who invest efforts in feed composition to reduce boar taint tend to feed boars and gilts separately. Feed composition solutions are therefore best suited for **sex-separated rearing**.
- ➔ Farmers need separate feed bins or silos to store different types of feed for different categories of animals.
- ➔ Farmers may wish to make other changes to feed composition when raising entire males. For example, boars tend to be leaner than gilts and castrates. This can cause problems for processors and they may request or incentivise changes to feed composition that increase the fat content in boars.
- ➔ Farmers considering any changes to the composition of feed should also ensure that pigs continue to enjoy their food and that it meets their taste expectations.

7.1.5.1 Chicory root (*cichorium intybus*)

Inulin, a dietary fibre most commonly extracted from chicory root, significantly reduces the level of skatole – responsible for boar taint – in boars. Most animal feed suppliers sell dried chicory root. It is included in feed (at 7% - 15%) two to three weeks before slaughter. There is evidence that *3 to 4 days* before slaughter may be sufficient to produce the desired effects, however. Jerusalem artichoke is another source of inulin.

For example, a Dutch farmer found that among pigs fed with inulin, 52% fewer presented boar taint compared to pigs fed a standard diet. The diet decreased skatole levels in pig carcasses by 80% on average. Inulin made up 7% of the animal's diet and was given for three weeks before slaughter.

Advantages

- ➔ This method has been proven to successfully reduce skatole and boar taint.
- ➔ Pigs fed with this diet may grow faster than other pigs.
- ➔ This diet has positive effects on pig behaviour, as it results in reduced biting and jumping. This may in turn reduce the risk of injuries.

Disadvantages

- ➔ This feeding practice has a high cost. 100kg of inulin costs around €200. A cheaper option using beet pulp as an additional ingredient is also available.

Things to consider

- ➔ Chicory may not be available from all feed suppliers and may need to be sought out separately.
- ➔ Silo management is important for farmers who wish to use feed additives such as chicory root.
- ➔ For some farmers, it may also be possible to plant chicory on farm.

7.1.5.2 Diet with adjusted amino acids

Boars can be fed a diet with increased lysine. Lysine is an essential amino acid and important for pig nutrition. It accelerates growth in the finishing phase. This reduces the number of slow-growing pigs and can help slow-growing pigs reach their slaughter weight at a younger age. This helps reduce the risk of boar taint.

Adjusting amino acids can be discussed with feed suppliers or alternatively, lysine can be purchased as a supplement.

Advantages

- ➔ This diet increases growth rate at finishing stage.
- ➔ A diet high in amino acids may help reduce sexual and aggressive behaviour.
- ➔ Supplementing with amino acids can help reduce variation in slaughter weights.

Disadvantages

- ➔ This diet may add cost compared to conventional diets.

Things to consider

Farmers may wish to find a feed supplier that provides custom-made nutrition, so that amino acids can be adjusted to fit the farm's needs.

7.1.5.3 Protein reduced diet prior to slaughter

Some feeds that are typically given to pigs, such as soybean-based feeds, have a higher protein content than other feeds, such as cereals. Switching to a low-protein, grain-based diet prior to slaughter reduces skatole levels and the risk of boar taint.

A protein-reduced diet may contain, for example, 48% wheat and 48% barley. These diets must also contain the correct level of essential amino acids.

Boars should be given a protein reduced diet at least **four days before slaughter** for this to take effect.

Advantages

- ➔ This diet has a low cost.

Things to consider

Providing a grain-based diet prior to slaughter can be done alongside other feeding practices, including providing diets with adjusted amino acids. Diets with adjusted amino acids are provided throughout the finishing phase to improve growth. The switch to a low-protein diet only needs to occur four days before slaughter.

7.1.5.4 Commercial feed designed to reduce boar taint

There are currently two examples of feed products on the market that are specifically intended to reduce boar taint. These feeds are given to boars in the last few weeks before slaughter. They combine fibres and feed additives to reduce skatole levels.

These feeds are available from Dumoulin in Belgium (Taintstop) and Vitelia in the Netherlands.

Advantages

- ➔ This feed combines several evidence-based feeding techniques.

Things to consider

These feeds cost significantly more than standard feed but only need to be provided between one to two weeks before slaughter to take effect. In Belgium, for example, Taintstop costs around 100 EUR per tonne more than normal feed and should be given to pigs two weeks before slaughter.

7.1.6 Scheduling slaughter at a young age

Farmers may decide to slaughter entire males when they reach a certain age or weight, which usually differs from the slaughter weights of other pigs (such as castrated pigs).

Although slaughtering at a low weight is often cited as a way to reduce the risk of boar taint, age is the more important factor. Younger pigs may not have developed the characteristics related to boar taint, such as sexual behaviour and aggressiveness. Besides, using weight as a proxy for age means slaughtering slow-growers at a later age, which entails a high risk for boar taint. For this reason, farmers may choose to slaughter pigs before a certain age.

In some cases, good farming practices make it possible to increase weight while reducing the proportion of tainted carcasses.

In a German slaughterhouse, slaughter weight has been increased from 90-92 kg to 95 kg dead weight as a result of improvements in feeding schedules, genetics and pig management. Following these changes, the proportion of tainted carcasses decreased from 5-8% to 2-2.5%.

Farmers can therefore use feedback from slaughterhouses to identify trends related to boar taint and choose the appropriate age of slaughter. For example, farmers may decrease the age threshold if slaughterhouses report a high number of tainted carcasses for pigs slaughtered after a certain age.

Age can be monitored through markers on the pigs, such as **ear tags**. Wean-to-finish grouping can also be used to keep pigs of the same age together. Reducing competition at feeding could be used to help reduce the discrepancy between growth rates.

Advantages

- ➔ This practice is easy to implement.

Disadvantages

- ➔ Farmers may receive a lower price per pig, as younger pigs tend to weigh less than older ones. In the absence of a financial incentive, farmers may decide not to implement this practice
- ➔ This practice may not be feasible in countries where pigs are slaughtered at high weights.

Things to consider

There may be specific customer requirements around the weight ranges of pigs that make selection for slaughter at a certain age difficult. As with other changes, it is therefore important to discuss this possibility with customers before and during the transition.

7.2 Q2. Farmers – vaccinated pigs: vaccination process

This document provides good practice examples that can be used by business operators to successfully use vaccination against boar taint. These practices are used in commercial

operations. This document also discusses some of the advantages and disadvantages of these practices. This will help you to choose what practice suits you best.

Making the transition to raising vaccinated pigs requires careful consideration and planning on the part of the farmer. The following guide refers to practices that may be of interest to farmers making such a transition. In addition to the practices described, it is important for all farmers to **communicate with their supply chain and customers** before and during any transition to vaccination against boar taint. Understanding the costs and benefits to other parts of the supply chain will also help farmers advocate for and lead the transition away from surgical castration.

7.2.1 Vaccination principle

Vaccination against boar taint is as an alternative to physical castration to control boar taint. Pigs are injected with a vaccine that stimulates their immune system and blocks the production of the substance responsible for the onset of boar taint (called Gonadotropin-Releasing Factor - GnRF). Vaccination against boar taint is performed using Improvac®, a vaccine marketed by Zoetis Animal Health. A similar vaccine, Ceva Valora®, is marketed by Ceva Animal Health, but this vaccine is not yet commercially available in Europe.

Meat from vaccinated pigs can be safely eaten at any time after the vaccination.

Farmers have used vaccination against boar taint in Belgium and Poland to produce fresh meat since 2010.

Belgian farmers are paid 0.01€/kg more for vaccinated pigs than for castrated pigs.

One dose of Improvac costs between €1.40 and €1.50⁵¹.

Things to consider

- ➔ It is important that farmers inform slaughterhouses about their use of vaccination, the characteristics of the vaccine and its effects on pigs and meat. Providing information about what controls are performed to ensure that the vaccine is administered correctly helps build trust in the supply chain.
- ➔ The costs of vaccination is compensated by the improved feed efficiency of pigs. Additionally, pork buyers may pay a premium for meat from vaccinated pigs.

7.2.2 Vaccination procedure

The vaccine may be administered by farmers, or by others (such as external vaccinators trained and certified by vaccine suppliers, depending on the preferences and commercial arrangements of each farm). European authorities require vaccine administrators to be trained and certified.

The same procedure, as prescribed by the manufacturer, should be applied for both injections. The vaccine is injected under the skin **behind the pig's ear** (see picture below: the red mark indicates the correct site where the vaccine should be injected). As for other injections given to pigs, it is important that the vaccination site is clean and dry. Any drippers and sprays should therefore be turned off well before vaccination.

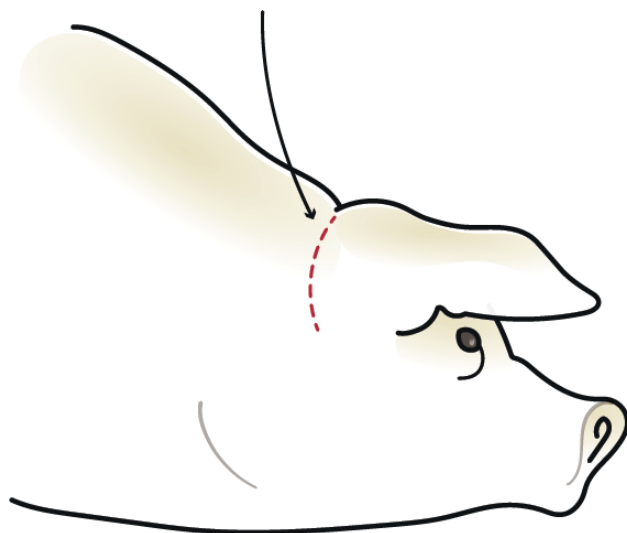
The person administering the vaccine should calmly enter the animal's pen. There is no need to restrain pigs individually, and they can be vaccinated in their pens. Tools such as handling boards can be used to gently move animals and bring them close to each other, so that they can be easily vaccinated. Vaccination should only start when pigs are calm

⁵¹ This is the standard price paid by farmers. This price may decrease when the vaccine is sold in high volumes. In addition to purchasing the vaccine, farmers may also decide to pay for additional veterinary services offered by vaccine suppliers.

and grouped together on one side of the pen so that they can easily be reached by the vaccinator. It is important that all doses of the vaccine are administered correctly by trained staff to avoid risks of stress and abscesses.

Each pig should be marked immediately after vaccination (for example, with a coloured marker), to distinguish it from pigs which still have to receive their dose. To avoid possible mistakes, pigs should never be marked before they are vaccinated. In case of doubt as to whether a pig has successfully received its dose, the pig should be revaccinated immediately.

Figure 3. Recommended site for the injection of the vaccine⁵²



The person administering the vaccine should have been trained on all aspects of the vaccination process:

- The preparation, maintenance and cleaning of the vaccination syringe;
- The administration of the vaccine and the handling of pigs; and
- The preparation of control documents⁵³.

This training is usually delivered by Zoetis free of charge. It may take half a day to one day for a farmer to be trained and evaluated on all aspects of the vaccination process.

Advantages

- ➔ The process of administering the vaccine is similar to that for other vaccines.
- ➔ Vaccination has a very high success rate when applied correctly.

Disadvantages

- ➔ The vaccination requires additional effort from the farmer. However, if a farmer switches from physical castration to vaccination, this additional effort is offset by the reduced workload from not having to physically castrate the pigs.

⁵² Image drawn from original material provided by Zoetis Inc. Source: Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished). Produced with permission from Zoetis Inc. (July 2018).

⁵³ See also document titled: "Farmers - immunocastrated pigs: provide assurance to slaughterhouses that immunocastrated pigs do not present detectable boar taint".

- ➔ The vaccination procedure is harder to perform on pigs housed outdoor than on those raised indoor. Outdoor-raised pigs need to be herded into a shoot or pen before the vaccine is administered.

Things to consider

The staff administering the vaccine needs to be properly trained to ensure that the vaccine is administered correctly. Staff also need sufficient time to become familiar with the vaccination tools (see section 2 of this document).

7.2.3 Dosing gun

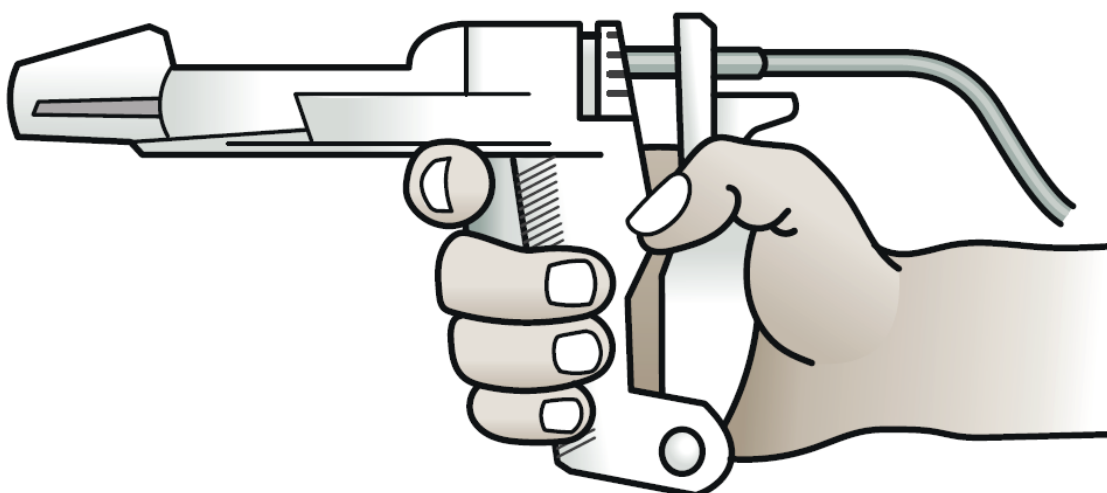
The vaccine can have the same effects in humans as in pigs. For this reason, it is necessary to avoid the risk of accidental self-injection. People who accidentally self-inject the vaccine should not use the vaccine anymore.

A special syringe (also called dosing gun – see picture below) should be used to administer the vaccine. This tool has several safety mechanisms: the needle is protected, and it is only activated once the gun is pressed against the pig's body and the trigger is pulled.

The dosing guns recommended by vaccine suppliers are Secure Plus by NJ Phillips and Sekurus by Simcro. Zoetis provides dosing guns to farmers for free.

To avoid the risk of self-injection, the person administering the vaccine should always make sure to point the gun away from his/her body. If the gun is not pointed away, there is a risk that the person can inject his/her own leg if the pig moves during the vaccination process.

Figure 4. Example of a dosing gun for the injection of the vaccine⁵⁴



Advantages

- ➔ The gun has a safety mechanism to avoid self-injection of the vaccine
- ➔ The gun is easy to use and is frequently supplied for free by vaccine distributors
- ➔ It is appropriate for use with both small and large pigs

⁵⁴ Image drawn from original material provided by Zoetis Inc. Source: Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished). Produced with permission from Zoetis Inc. (July 2018).

Disadvantages

- ➔ Staff need to be trained to use the dosing gun and keep it clean

Things to consider

- ➔ The correct handling of the injection gun requires training to ensure safety.
- ➔ The dosing gun and needles require cleaning and maintenance, consistently with the requirements specified by manufacturers of these tools.

7.2.4 Protective clothing

Leather protective leggings or chaps may be used to protect the lower leg and create a barrier to prevent self-injection.

Advantages

- ➔ This is relatively low cost

Disadvantages

- ➔ Protective clothing may cause discomfort in hot weather

7.2.5 Vaccination schedule

The vaccination schedule is set as per the recommendations of the manufacturer. However, within the recommendations provided by suppliers, vaccination schedules are flexible and can be adjusted according to the desired outcome parameters of carcass weight, feed conversion ratio, and fat content.

Things to consider

- ➔ Implementing the recommended schedule requires thorough record-keeping of the age of each pig on farm and additional planning.
- ➔ Adjustments to the normal schedule require trials ran jointly with slaughterhouses and processors.

7.2.6 Main protocol

The main protocol for vaccination requires the injection of two doses. The first injection is done at **no earlier than eight weeks** of age and has no physiological effects. The second should be given **at least four weeks after the first** and **within four to six weeks before slaughter**. This is based on recommendations from the manufacturer. The European licence, however, allows pigs to be sent to slaughter without risk for boar taint up to the tenth week after the second vaccination.

The effects of the vaccine are temporary and reversible. The substances responsible for boar taint (mostly androstenone and skatole) decrease significantly two to three weeks after the second dose and these effects last until approximately 10 weeks after the second dose.

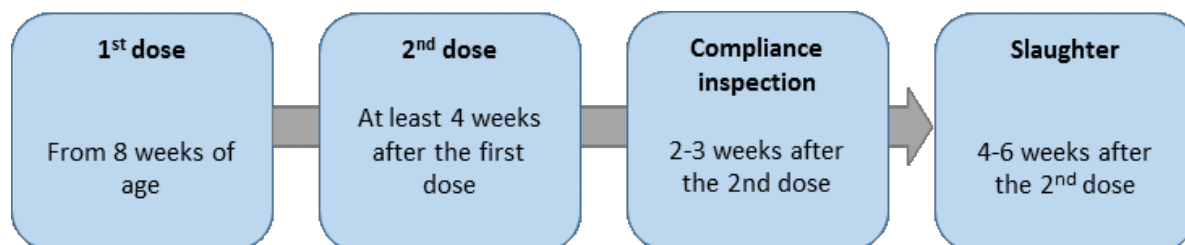
An additional injection might be applied if the intended effect is not observed (for example, if the pig behaves as an entire male⁵⁵). This situation is relatively rare. When farmers are

⁵⁵ For additional information on the checks to verify if vaccination has been successful, see document titled: "Techniques and best practices to provide assurance to slaughterhouses that immunocastrated pigs do no present detectable boar taint").

well experienced with the use of the vaccine and receive regular training on vaccination, the proportion of pigs requiring a third dose may be as low as 0.3% of pigs.

A generic vaccination timeline, as recommended by the manufacturer, is presented below.

Figure 5. *Generic timeline to administer the vaccine*⁵⁶



Farmers may adapt the timeline according to their needs (for example, based on specific characteristics of their production process, or according to slaughterhouses' requirements on market weights).

If piglets have to be transported long distances between the nursery house and the fattening site, it is better to let them rest for a week and reduce their stress levels before administering the first dose.

Farmers may align vaccination timings across different pig batches. For example, they can ensure that the second vaccination of an older batch is made on the same day of the first vaccination of a younger batch. This can make the vaccination process more efficient.

Pigs need to be slaughtered at the latest 10 weeks after the second vaccination; a third dose may be given to heavy or older pigs (see also section titled "Use of three injections for larger pigs").

7.2.7 Early vaccination

Some farmers choose to apply the second vaccination as early as possible. That is to reduce aggressiveness towards other pigs. Reduced aggressive behaviour is observed from one to two weeks after the administration of the second dose. Pigs reach puberty on average around 16-18 weeks of age and will increasingly show aggressive behaviour when growing older. For example, if the vaccination timeline is set to apply the second vaccination at 19 weeks, with slaughter at 24-25 weeks age, but the pigs show excessive sexual behaviour around 19 weeks, then the second vaccination could be given one to two weeks earlier (that is, at week 17) without a need to change the slaughter time.

The commercially available vaccine is not licensed for use in pigs younger than 8 weeks, and the second dose should be administered at least four weeks after the first one. So there is a limit on the recommended minimum age of vaccination.

Advantages

- ➔ Early vaccination minimises undesirable pig behaviour, such as aggressiveness. This is beneficial to animal welfare and may also improve carcass quality (for example, by reducing the risk of skin lesions and leg damages).
- ➔ Another reason to vaccinate pigs early is to maximize the amount of intramuscular fat and backfat. Some markets require pork products with higher fat levels.

⁵⁶ Image drawn from original material provided by Zoetis Inc. Source: Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished). Produced with permission from Zoetis Inc. (July 2018).

Disadvantages

- ➔ The time between the second dose of the vaccine and the slaughter should not exceed 10 weeks; if this happens, a third dose of the vaccine should be applied 4 to 10 weeks before slaughter to ensure absence of boar taint in carcasses. Early vaccination may therefore require the administration of a third injection. For example: first vaccination at week 8; second vaccination at week 12; third vaccination at week 18 to 20; slaughter at week 24.

Things to consider

The correct vaccination schedule needs to be aligned with husbandry practices on the farm. It needs to be adjusted to the market requirements set by the slaughterhouse as well.

Case study: vaccination protocol applied by a Polish farm

A Polish farm using Improvac has had success slaughtering animals at a later point, around 8-9 weeks after the second vaccination. They have found that this maximises their economic returns. Further details on this case study are provided in Section 5.1.2.

7.2.8 Late vaccination

Some farmers choose to administer the second dose as late as possible.

Advantages

- ➔ Farmers choose to vaccinate late to maximise the 'boar-like' performance of pigs, and therefore achieve better feed conversion and leaner carcasses.

Disadvantages

- ➔ Due to late vaccination, pigs may become aggressive because of increased testosterone levels. This can be avoided by giving pigs more space or through other management techniques. Alternatively, earlier second vaccination should be considered.

7.2.9 Use of three injections for larger pigs

A third dose may be administered to heavy or older pigs before slaughter. The third dose can be given 10 weeks after the second dose. For example, if the pig is scheduled to be slaughtered at 28 to 32 weeks of age, then the third dose can be given at 24 weeks of age.

Pigs tend to be slaughtered at heavy weights for commercial reasons (such as market requirements by slaughterhouses and processors), rather than due to considerations associated with the use of the vaccine.

A protocol with 3 injections has been used in Spain and Italy to produce both fresh meat and meat destined for dry curing.

Case study: Vaccination protocol to produce cured hams in Spain

In Spain, farmers vaccinate Iberian pigs against boar taint to produce cured hams. Vaccination has been successful in improving profitability and animal welfare while maintaining high product quality. Further details on the Spanish experience are provided in Section 5.1.2.

Advantages

- ➔ This practice helps avoid boar taint in pigs which are slaughtered at heavy weights

Disadvantages

- ➔ If the vaccination is not properly executed, there may be additional stress and risk of abscesses associated with the additional vaccination

Things to consider

The correct vaccination schedule needs to be aligned with the husbandry practices on the specific farms and the market requirements set by the slaughterhouse, processor, or other standards.

7.2.10 Feeding of vaccinated pigs

Before the second dose of the vaccine, pigs are fed the same way as entire males. After the second dose, pigs tend to eat more feed and gain weight faster than entire males. Following the second dose, vaccinated pigs also have lower lysine requirements than entire males. For this reason, their diet should be adapted and the daily amount of feed should be increased.

For example, the average quantity of feed eaten daily by common breeds of pigs may be increased by 20% after the second dose. On a daily basis, this results in a weight gain approximately 5% higher than entire males.

Farmers in Belgium, Poland and Spain have had positive experiences with the better feed conversion ratios of vaccinated pigs. The improvement in feed conversion reduces costs. This helps compensate for the additional costs of vaccination.

Advantages

- ➔ Vaccinated pigs grow faster and reach their slaughtering weight earlier than entire males. Overall, feed efficiency therefore remains unchanged and due to reduced lysine requirements, feed costs may be lower.

Things to consider

This practice may require split sex rearing to offer optimized feed formulations to both genders.

7.3 Q3. Farmers – vaccinated pigs: provide assurance to slaughterhouses that vaccinated pigs do not present detectable boar taint

This document provides good practice examples that can be used by farmers to reassure slaughterhouses that vaccinated pigs do not present detectable boar taint. The practices mentioned are all currently used in commercial operations in the EU.

Making the transition to raising vaccinated pigs requires careful consideration and planning on the part of the farmer. The following guide refers to practices that may be of interest to farmers making such a transition. In addition to the practices described, it is important for all farmers to **communicate with their supply chain and customers** before and during any transition to vaccination against boar taint. Understanding the costs and benefits to other parts of the supply chain will also help farmers advocate for and lead the transition away from surgical castration.

7.3.1 On-farm checks of pig behaviour

On-farm checks are one of the ways that farmers have collected information they then sent to slaughterhouses for quality assurance purposes.

To verify if pigs have been successfully vaccinated, farmers may check their behaviour.

These checks are done **2 to 3 weeks after the second vaccination**. Checks can be done at any time of the day. However, feeding time or the hottest times of the day should be avoided. Since pigs' activity is reduced during these times, it is more difficult to make pigs stand to observe them and assess their behaviour.

Farmers can check pigs' behaviour to verify whether they have been successfully vaccinated. Absence of sexual behaviour suggests that vaccination has been done correctly. The following characteristics should be absent:

- ➔ Frequently repeated attempts to mount or penetrate other pigs in the pen;
- ➔ Enlarged and reddened testicles; and
- ➔ Repeated aggressive behaviour.

Presence of one or more of these signs indicates that the pig may have missed a dose.

Checks for behavioural indicators involve two main steps.

Firstly, the person performing the checks should enter the farm and inspect all pens from the outside, by calmly walking through the building several times. For a building with 500 pigs, this takes approximately 15-20 minutes.

Secondly, it is important to have a stop at each pen and check possible signs of repeated sexual behaviour. Pens may be observed from the outside, by slowly walking through the corridors between pens and spending a few minutes observing each pen. Alternatively, farmers may calmly enter the pens and spend 10-15 minutes in each pen to observe animals. After 10-15 minutes, pigs get used to the presence of the farmer and most of them have a calm and normal behaviour. At this point, it will be easy to identify pigs which show repeated aggressive or sexual behaviour.

Based on these checks, suspect animals are marked and vaccinated again. After this additional dose, some animals may still present signs that suggest a risk of boar taint, such as sexual behaviour. In these cases, the slaughterhouse should be made aware that the carcass needs to be assessed for possible presence of boar taint.

Zoetis trains farmers to conduct these checks in all countries where they market the vaccine. Zoetis may also arrange for trained vaccinators to conduct these checks based on contractual agreements with farmers.

Case study: vaccination protocol applied by a Polish farm

A Polish farm using Improvac has had success slaughtering animals at a later point, around 8-9 weeks after the second vaccination. They use behavioural checks as part of their protocol for ensuring that all pigs are properly vaccinated. Further details on this case study are provided in Section 5.1.2.

Advantages

- ➔ It takes relatively little time to perform checks. In most situations, behavioural indicators are clear: when one or more animals have missed a dose, there is much more agitation in the pen. Once farmers gain enough experience to understand these signals, checks become part of their daily routine.

Disadvantages

- ➔ This requires trained personnel to perform checks. Training on conducting on-farm checks is delivered by vaccine suppliers together with training on other aspects of the vaccination process⁵⁷.

⁵⁷ See also document titled: "Farmers – immunocastrated pigs: vaccination".

- ➔ Sexual behaviour may sometimes be confused with dominance behaviour: to establish a hierarchy in a group, for example, some pigs may try to mount other pigs. Dominance mounting is shorter and less frequent than sexual mounting. Dominance behaviour does not necessarily indicate that the pig has not been correctly vaccinated. If trained to recognise these behaviours, the person performing the checks will be able to easily differentiate between sexual behaviour and dominance behaviour.

7.3.2 Supply chain assurance

Farmers may provide information to slaughterhouses to demonstrate that they apply the correct vaccination procedures and checks. This helps reassuring slaughterhouses that farmers are committed to providing high quality animals, and that the risk of tainted carcasses is low.

7.3.2.1 Documentation

Farmers may include information on the quality assurance of the vaccination process⁵⁸ in their standard pig transport documentation, to share with slaughterhouses. Standard information would include, for example, the name of the producer, the number of pigs sent to the slaughterhouse, their sex, the loading time and vehicle number. Farmers may add the following details on vaccination:

- ➔ The number of vaccinated males; and
- ➔ A confirmation that vaccinated pigs have been checked prior to slaughter, and that farmers have identified pigs which are suspected to present boar taint (if any).

⁵⁸ Information on the medicinal products used on a farm is also documented in official medical records. These records, however, would not contain information about the results of the on-farm checks carried out to assess the correct administration of the vaccine.

Establishing best practices on the production, the processing and the marketing of meat from uncastrated pigs or pigs vaccinated against boar taint (immunocastrated) – Final report

Figure 6. Example of a template for sharing information on vaccination with slaughterhouses⁵⁹

PIGS LOT RECORD				
Producers Name:		BRAND		
Address:		Lot No.		
Transporter: Vehicle Registration Number: Loading time:am/pm				
<i>OWNER TO COMPLETE</i>				
Type	Number	Comments		
Vaccination against gonadotropin-releasing factor (GnRF)				
Gilts				
Culled boars				
Others				
Total				
DECLARATION (✓)		YES	NO	REASON (If answer is NO)
All males vaccinated against GnRF have been observed for sexual behavior within the last 24 hours and any suspect pigs have been clearly identified.				
[Other declarations]				
PRESALE CHECK				
Pigs in this consignment were taken off feed at:		Time:	Date:	
Pigs for special attention have been identified as follows:		Reason:	Identification:	
Truck in clean condition:			Comments:	
Approximate temperature at loading:				
[Other comments: ...]				
Name of Person conducting the Presale Check (print):				
Producer's Signature:		Date		
Agent/Driver:		Date		
Abattoir:		Date		

⁵⁹ Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished)

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Farmers may wish to share with slaughterhouses an additional document (vaccination declaration), with details on the vaccination process:

- ➔ The name of the person who administered the vaccine.
- ➔ The dates of vaccination and the number of animals vaccinated.
- ➔ The dates of on-farm checks.
- ➔ The presence of abscesses on the pigs' skin, which may be due to vaccination or other injections.
- ➔ The identification of animals who required an additional dose of the vaccine, after on-farm checks.
- ➔ The number of vaccinated animals sent for slaughter.

A sample template for the vaccination declaration is presented below.

Figure 7. Example of a template for the vaccination declaration⁶⁰

Vaccination declaration																					
This is to confirm that [name of the person who administered the vaccine, and his/her organisation] has administered the vaccine [name of vaccine] to pigs of [lot number] located in [name of the farm and address]. The vaccination process is described in the table below. Table 1: Vaccination process <table border="1" style="width: 100%; border-collapse: collapse; margin: 10px 0;"><thead><tr><th rowspan="2" style="width: 15%;">Number of animals in the lot</th><th colspan="4" style="width: 70%;">Dates</th><th rowspan="2" style="width: 15%;">Number of animals sent for slaughter</th></tr><tr><th style="width: 17.5%;">Administration of the first dose</th><th style="width: 17.5%;">Administration of the second dose</th><th style="width: 17.5%;">Pre-slaughter inspection</th><th style="width: 17.5%;">Loading for slaughter</th></tr></thead><tbody><tr><td style="text-align: center;">[number]</td><td style="text-align: center;">[date]</td><td style="text-align: center;">[date]</td><td style="text-align: center;">[date]</td><td style="text-align: center;">[date]</td><td style="text-align: center;">[number]</td></tr></tbody></table> Additional details: [for example, presence of abscesses] [Date and signature]						Number of animals in the lot	Dates				Number of animals sent for slaughter	Administration of the first dose	Administration of the second dose	Pre-slaughter inspection	Loading for slaughter	[number]	[date]	[date]	[date]	[date]	[number]
Number of animals in the lot	Dates				Number of animals sent for slaughter																
	Administration of the first dose	Administration of the second dose	Pre-slaughter inspection	Loading for slaughter																	
[number]	[date]	[date]	[date]	[date]	[number]																

Documentation on vaccination is generally paper-based. Documents are completed manually by the farmer and the person administering the vaccine (there may be cases where the farmer is also the person administering the vaccine). These documents accompany each group of pigs when they are sent for slaughter. The driver of the transport vehicle delivers the documentation manually to slaughterhouses.

It is also possible to transmit data on vaccination procedures with an electronic system⁶¹. This system can be accessed in real time by several people, including those responsible for

⁶⁰ Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished)

⁶¹ For example, the Endorsis platform developed by Zoetis is used in some countries outside the EU and is being implemented in Germany: <https://www.endorsis.com/Login/Login.aspx?ReturnUrl=%2f>. Other examples of platforms include TrazaImprovac, used in Spain: <https://www.trazaimprovac.com/>, and Global Vet Link, used in the US: <https://user.globalvetlink.com/gvl2/login/auth>.

the administration of the vaccine, the farmer, the vaccine supplier, and the slaughterhouse staff. This system simplifies the tracking and verification of vaccination data.

In Spain, documentation accompanies vaccinated pigs and is delivered manually.

Advantages

- ➔ This supports a trustful and transparent relationship between farms and slaughterhouses
- ➔ Documentation can be used to inform statistical records at slaughterhouses; specifically, they can be used to identify and address vaccination issues, and therefore improve the whole vaccination process. The vaccination declaration enables to identify the person who administered the vaccine. Therefore, in case of boar taint issues it is possible to target potential interventions (such as re-training on the vaccination process) to the right person. This helps reassuring slaughterhouses that farmers are committed to resolving problems if and when they appear.

Disadvantages

- ➔ The preparation of documents may be time consuming depending on format and level of detail. The time needed to prepare the documentation may be reduced by providing farmers with standardised templates that are easy to fill in.

7.4 Q4. Slaughterhouses – uncastrated pigs: detect boar taint, quantify and manage positive carcasses

This document lists good practice examples of dealing with boar taint at slaughterhouses. The document includes information on (i) detecting boar taint and (ii) quantifying and managing positive carcasses. The practices mentioned are all currently used in commercial operations in the EU. Other relevant practices at slaughterhouses, such as transport and handling, are not discussed in this document, but they are important since they can have an impact on the prevalence of boar taint.

It is necessary to systematically detect boar taint in carcasses of entire males, in order to:

- Separate out carcasses with boar taint and those without
- Inform farmers, breeders, and feed producers of the level of boar taint so they can improve their practices accordingly
- Reassure buyers (processors and retailers) that no boar tainted meat will be unknowingly sold to consumers
- Market meat from entire males with no detectable boar taint as a high value product

The most widely used method for detecting boar taint is the **human nose** method. Although no detection method is fool-proof, this method delivers robust results when implemented correctly. It is considered best practice by many slaughterhouses and their suppliers and clients within entire male supply chains. This document presents numerous good practices for using the human nose method.

Several chemical testing methods are also under development. They have yet to be used in commercial conditions and are therefore not discussed in this document.

Making the transition to slaughtering entire males requires careful consideration and planning on the part of the slaughterhouse. The following guide refers to practices that may be of interest to slaughterhouses making such a transition. In addition to the practices described, it is important for all slaughterhouses to **communicate with their supply chain and customers** before and during any transition to slaughtering entire males.

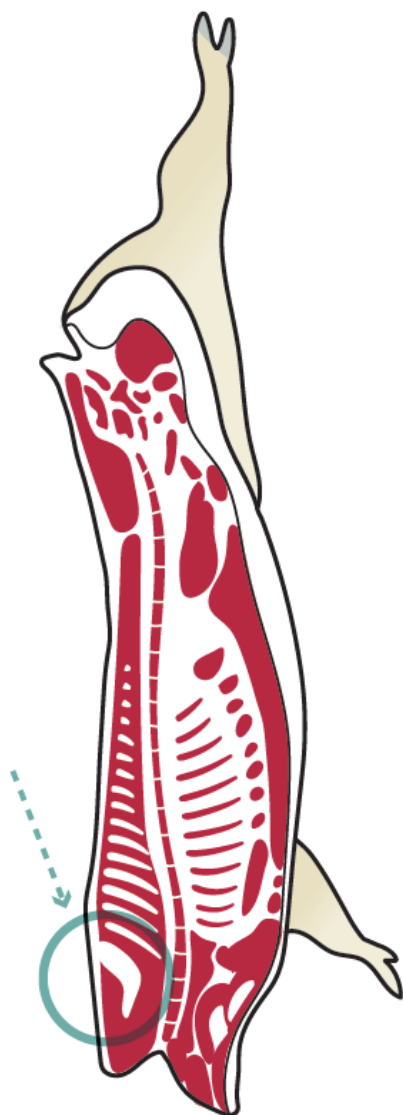
Understanding the costs and benefits to other parts of the supply chain will also help slaughterhouses advocate for and lead the transition away from surgical castration.

Things to consider

Whatever method a slaughterhouse chooses for detecting or dealing with boar taint, this information should be provided to clients and suppliers. This can help to build trust along the supply chain and can help slaughterhouses address concerns regarding boar taint.

7.4.1 Human nose - principle

Figure 8. Location of the neck fat



All human nose techniques rely on trained testers **heating** and then **smelling** a sample of fat on each carcass. This occurs *after* the carcasses have been cut in half and *before* the carcasses are cooled.

DO use neck fat. The neck is easy to reach. The fat in this area is easily accessible. It can be heated without damaging the meat around it. Some techniques also heat some of the muscle around the fat, so that both types of tissue are tested.

DO NOT use abdominal fat for sampling boar taint. Testing carcasses on abdominal fat is more likely to lead to errors in the detection of boar taint.

Things to consider

Switching to the human nose method means having **enough staff** trained and available to carry out the tests.

→ This needs to take into account the **speed of the slaughter line** and the **number of boars** anticipated. The human nose method is sustainable only if there is a continuous flow of boars at the slaughterhouse.

→ The role of tester may be unpleasant, therefore the need and benefits of the practice need to be **communicated well to operators** to make it accepted.

→ One must take into account the need for the assessors to **take regular breaks**.

→ Processing boars does not only require more staff time for conducting smell tests. Additional staff time is also required to cut out male parts from the carcass.

For example, one slaughterhouse has used 1 tester per slaughter line at 500 boars/hour, regularly replaced every 30 minutes.

Many slaughterhouses that use the human nose method rely on **their own staff**, hired and trained to assess boar taint. One Dutch slaughterhouse estimated that this costs less than €1 per test.

Others **borrow trained operators** from other slaughterhouses. External contractors will generally charge for their staff by the hour. For example, one contractor charges €65 per hour for a minimum of four hours. In the Netherlands, the costs of using external contractors for human nose testing was calculated to be equivalent to €2.10 per carcass.

Others **hire external contractors**.

Case study: The human nose scoring system of a major Dutch slaughterhouse

A Dutch slaughterhouse has developed its own boar taint detection method based on the human nose. The company is an EU market leader with over 10 years of experience in producing boar meat. It operates both in the UK and in the Netherlands, slaughtering thousands of male pigs each week. Further details on this case study are provided in Section 5.2.1.

7.4.2 Human nose method - variants

Variants of the human nose methods exist:

- *on line*: the detection of boar taint occurs as carcasses move through the slaughterhouse. Slaughterhouses use the hot air/hot iron technique, or gas-powered soldering irons for on line testing.
- *off line*: fat samples are collected on the carcasses and then taken elsewhere (such as a laboratory) for analysis. Slaughterhouses use the hot water or microwave technique for off line testing.

7.4.2.1 Hot air/hot iron method (on line)

A tester places a welding device against the neck of the pig carcass for 2-3 seconds. Immediately afterwards, a tester smells the carcass and judges whether boar taint is present. This is then recorded.

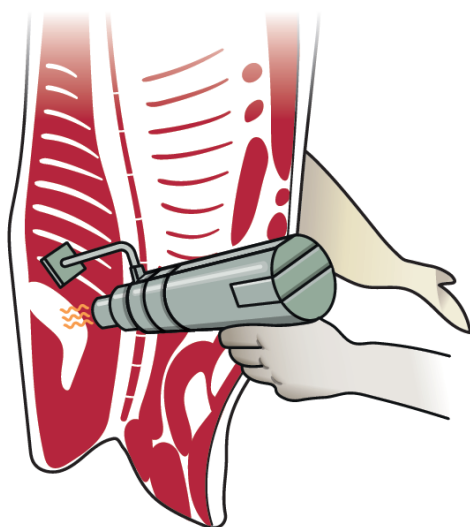
The number of testers depends on the speed of the slaughter line: in faster operations two testers to work together. Slower lines may only require one.

Slaughterhouses use hand-held **hot air welding devices**. These may be modified to include a guide bar (as in Figure 2). That helps orient and stabilise the operator's hand and standardises the distance between the heating device and the carcass.

Alternatively, a hand-held **soldering iron** with a hot iron tip may be used. Where a metal tip is used, it should be cleaned regularly.

Suppliers of welding equipment used by slaughterhouses include Leister and Weller. Such equipment can be purchased at DIY or hardware stores.

Figure 9. The hot air method



Advantages

- This allows for rapid testing on line and therefore does not have any impact on the speed of the slaughter line.
- The equipment is low cost.

Disadvantages

- The equipment tends to be cabled, and an electrical connection is therefore needed.
- Operators using hot air devices can risk being burnt.

Things to consider

Soldering equipment comes with different wattages and settings. The appropriate wattage or temperature setting may differ depending on slaughterhouse conditions or the type of equipment used. It may be necessary to experiment with different options before deciding on what equipment is most appropriate within a certain setting.

7.4.2.2 Gas-powered soldering iron (on line)

This method is largely similar to the hot air/hot iron method but differs in the source of heat used. Here, a gas flame is used to torch the neck of the pig carcass or to heat a metal plate used to heat the fat on the carcass.

Gas powered soldering irons are small, portable and cordless. Suppliers include Weller. This equipment can be purchased at DIY or hardware stores.

Advantages

- This allows for rapid testing on line and therefore does not have any impact on the speed of the slaughter line.
- The equipment used is cordless and can be moved easily.
- The equipment is low cost.

Disadvantages

- The use of open flame can lead to a risk of burning and fire.

Things to consider

Gas canisters need to be replaced frequently. This cost should be considered for slaughterhouses processing larger numbers of entire males.

7.4.2.3 Hot water method (off line)

A 5-gram sample of lard is collected from the neck of the carcass. It is taken to a testing room or laboratory. The sample is placed in a test tube, beaker or conical flask. Boiling water is poured over the sample and it is covered.

The tester waits until the sample has cooled slightly, to approximately 80 degrees. The covering is then removed and the vapours are sniffed by the tester to determine whether boar taint is present. The result is then recorded.

7.4.2.4 Microwave method (off line)

A 5 to 20-gram sample of fat is collected from the neck of the carcass. It is taken to a testing room or laboratory. The sample is placed in a container, covered with a lid and then heated using a microwave.

The covering is then removed and the sample is smelled by the tester to determine whether boar taint is present.

Advantages

- ➔ These methods are low cost.
- ➔ These methods are suitable for smaller operations, where fewer boars are processed.
- ➔ These are reliable methods for re-testing carcasses as part of quality control procedures of on line testing.

Disadvantages

- ➔ Off line methods are inefficient as compared to the hot iron or open flame and only suitable for off line testing.

Things to consider

For off-line methods, slaughterhouses need a robust numbering system for samples and carcasses to ensure that samples and carcasses are matched correctly.

7.4.3 Human nose method - Alternative taint scales

Slaughterhouses that use the human nose method have used scales to record the tester's assessment. These scales are one of the tools that enable **differentiating** between different levels of boar taint, which can provide more **options for marketing** tainted meat on the markets the meat is intended for. Scales are also one of various tools that can be used to ensure **consistency** in boar taint detection.

7.4.3.1 Binary scales (Tainted/untainted)

Some slaughterhouses use a simple yes/no system: testers only need to establish whether boar taint is detectable or not.

Advantages

- ➔ This is a simple distinction, which makes it easier to train testers.

Disadvantages

- ➔ This limits options for the classification of boar tainted meat, its processing and commercialisation on different markets.

Things to consider

This method requires that operators share a consistent and common understanding of boar taint threshold.

7.4.3.2 Scales with multiple levels

Some slaughterhouses allow operators to assess the presence of taint on a scale (such as from 0 to 4, where 0 means "normal pork smell" and 4 "strong boar taint"). This provides more nuance and detail.

Advantages

- ➔ This allows for several options for the classification of meat, its processing and commercialisation on different markets.
- ➔ This enables more detailed feedback to farmers, breeders, and feeding producers, than when using a binary (yes/no) scale.
- ➔ Granular scales enable better identification of “borderline” carcasses that may require re-testing before classification.

Things to consider

Testers need to have a good understanding of how to use the scale. This method therefore requires thorough training and enhanced quality assurance checks.

7.4.4 Human nose method – Selection and training of testers

Particular care needs to be devoted to the selection and training of testers.

Selection of testers is important because:

- Some people are unable to detect androstenone
- Some people are hyper-sensitive to androstenone

Testers **should not** be selected from either of these groups. To evaluate the ability of individuals to act as testers, some slaughterhouses use smell kits. These can be purchased from an external contractor.

Testers need to be **trained**. It is important that assessors are not only able to detect boar taint, but also that they are able to distinguish it from other similar smells. Boars might present other odours that will not impact the quality of the meat but could be confused for boar taint.

Training is sometimes carried out in-house. External contractors can be relied on if there is no capacity or expertise in house.

External contractors offering training and services in the human nose method include ELFI Analytik GbR, SGS and DLG e.V. in Germany, the Danish Technological Institute in Denmark, ILVO in Belgium and Kiwa CMR in the Netherlands.

Initial training can take between **4 to 6 weeks**, including a first phase of a few days in the laboratory, followed by several weeks on the slaughter line alongside a trainer.

Training includes also other aspects than detecting boar taint, such as procedures for the classification of carcasses.

Assessors are trained at hiring and then periodically retrained.

7.4.5 Human nose method – procedures to prevent habituation

Testers are **at risk of becoming habituated** to the smell of boar taint over time. As a result, their ability to detect boar taint may decrease. Slaughterhouses have used various solutions to prevent habituation.

7.4.5.1 Taking breaks

Many slaughterhouses use different testers. They rotate testers every 20 or 30 minutes, or after a certain number of carcasses (100 in one example). This also means that once a tester has detected boar taint, they must take a break before continuing. A tester that is relieved from their ‘human nose’ role may take on another task on the line, until they are called back.

Advantages

- Taking breaks helps keep testers consistent in their judgments.
- Operators can be testers and perform other roles on the line throughout the day.

Disadvantages

- For staff to take breaks, several trained testers must be available at any given time the line is operating.

7.4.5.2 Nose cleansers

To avoid smell habituation some slaughterhouses use a 'nose cleanser', such as coffee grounds or menthol. A cleanser can be sniffed between samples, allowing the tester to 'reset' before moving on. If clothing is clean, smelling the inner arm may also be used as a 'reset' method.

Advantages

- A cleanser can be provided to assessors at low cost.

Disadvantages

- The use of a cleanser may not be easily integrated into rapid on line testing.

Things to consider

Some slaughterhouses have found that although cleansers are offered to smell assessors, they are used very little. Some experimentation may be needed to determine how cleansers can best be incorporated in on line detection.

7.4.6 Human nose method – Quality control

Quality control checks help maintain a robust detection process at the slaughterhouse.

7.4.6.1 Using multiple testers

When one tester detects boar taint and the animal is identified as such, a sample is taken and a second tester confirms whether boar taint is present. The second opinion allows the slaughterhouse to avoid false positives and confirm the presence of boar taint. If doubt remains after a second test or if there have been a high number of tainted carcasses within a particular batch of animals, it may go to another tester for a third opinion.

Advantages

- The use of multiple testers minimises the risk of error.

Disadvantages

- For multiple testers to be available, additional trained staff must be available.
- This requires a combination of both on line and off line techniques and infrastructure.

7.4.6.2 Parallel controls

Slaughterhouses can establish protocols for parallel controls. These should occur regularly, such as by re-testing a sample of tainted carcasses on a weekly basis.

Testing can be checked against laboratory results that detect the presence of chemicals responsible for boar taint. Testing can also be verified through an additional round of human nose testing.

This information can be used to compare individual assessors and ensure detection is consistent and reliable.

Where external contractors are used for training, they may also provide regular re-training and assessment services, to ensure that detection remains reliable.

Advantages

- The use of parallel controls can reinforce trust in the detection system.

Disadvantages

- Laboratory testing may take additional time to process and cause a delay in feedback.

Things to consider

Parallel controls are required by some assurance schemes. These schemes, including QS in Germany and IKB in the Netherlands, may be able to provide additional guidance on what quality control system best suits a particular slaughterhouse and detection procedure.

7.4.6.3 Statistical analysis

Slaughterhouses analyse boar taint detection data from one day to another, and from one tester to another. This enables them to investigate possible inconsistencies, which can then be addressed by, for example, re-training a tester.

7.4.7 Human nose method - Protocols for harmonising human nose testing across supply chains

Some assurance schemes have begun developing standards for boar taint detection. These standards are a tool for the harmonisation of human nose testing across supply chains.

Human nose testing protocols can be established as a framework, stipulating certain conditions that the human nose testing procedure in place needs to fulfil. Such frameworks do not define the specific methods that should be used for human nose testing, but instead set out criteria required for a robust and verifiable detection system.

For example, the framework established by QS includes the following:

- Procedures and instructions must be in place defining how detection is performed, including how long each operator can continuously detect, how operators are monitored and how parallel controls occur.
- Operators should be given initial training and regular additional training.
- There must be practices in place to ensure that tainted carcasses can be easily separated.
- The slaughterhouse must provide feedback to their farmers and suppliers on the instance of boar taint within each batch.

The 'Beter Leven' label in the Netherlands has also developed a similar, but more detailed framework.

Establishing protocols for human nose testing also offers the opportunity to further harmonise methods between certifiers and countries.

Case study: Harmonisation of standards for HNS in Europe - The case of QS and IKB

In 2012, two European quality assurance organisations, QS in Germany and IKB in the Netherlands agreed on a common framework for boar taint detection using the Human

Nose Scoring (HNS) system. Further details on this case study are provided in Section 5.2.1.

Advantages

- ➔ These standards offer a framework for slaughterhouses to develop and manage human nose testing on entire male carcasses.
- ➔ Standards embedded into assurance schemes support mutual recognition and trade of meat from entire males across EU countries

Disadvantages

- ➔ Some requirements may be difficult for some slaughterhouses to implement.

7.4.8 Non-detection

In some countries, the issue of boar taint is addressed entirely through on-farm practices and by slaughtering animals at a lower weight. In other countries, no detection is used and boar taint is addressed entirely through processing and masking.

Weight cut-offs differ depending on the source but are generally between 100 kg and 115 kg, although there are also some instances where entire males are being slaughtered at up to 130 kg. Processing techniques to address boar taint are described in Q6 (Section 7.6).

Entire males slaughtered at lower weights are considered to be low-risk for boar taint, therefore no detection is used at the slaughterhouse and the meat is not processed separately. It is assumed that the risk for boar taint is low enough that no further steps are required to address it.

However, age is a better indicator for boar taint than weight, so it is likely that some pigs slaughtered at a low weight (slow growers) will still be at risk for boar taint.

Advantages

- ➔ There are no costs of detection involved.

Disadvantages

- ➔ Slaughtering at a low weight requires herd management to ensure that all entire males are slaughtered before reaching the cut-off weight.
- ➔ This could limit revenue per pig that farmers may achieve by rearing bigger animals.
- ➔ Tainted meat may enter the supply chain.

Things to consider

- ➔ Weight cut offs are a helpful proxy for age but are not fool-proof. It may be helpful to have discussions with farmers or suppliers about age and growth rates.
- ➔ Upper and lower weight limits are stipulated by the processor and are often influenced by the market or set by quality assurance schemes. Slaughtering at lower weights might therefore require discussions within the supply chain.

7.4.9 Supply chain management

7.4.9.1 Keeping records and providing feedback

Some slaughterhouses keep records of all carcasses that present boar taint and their origin. This information can then be used to provide feedback to farmers if there is a high

occurrence of boar taint among their animals. Where supply chains are more integrated, feedback may also be provided to feed suppliers or breeding companies.

QS in Germany and IKB in the Netherlands require slaughterhouses that deal with entire males to provide feedback on the testing results to farmers, alongside feedback on other factors related to the health of the pig and quality of the meat.

Advantages

- ➔ Providing feedback to farmers can help reduce instances of boar taint in the supply chain
- ➔ Providing feedback to breeders or feed providers can help improve existing breeding/feeding solutions

Disadvantages

- ➔ The use of negative feedback may lead to farmers re-adopting castration unless coupled with guidance or economic incentives.
- ➔ This requires additional controls and systems to be in place, including data capture, database storage and analysis of data

7.4.10 Penalties for boar taint

Slaughterhouses may penalise farmers that supply entire males with high levels of boar taint.

The return for slaughterhouses on tainted carcasses is significantly lower than for non-tainted carcasses. In the Netherlands, for example, tainted carcasses return around €25 less than non-tainted carcasses. Penalties can therefore help slaughterhouses reduce this risk.

Advantages

- ➔ This provides an incentive for farmers to adopt better farm-level practices.
- ➔ This helps balance the risks for the slaughterhouse since boar tainted meat has less value.

Things to consider

Using penalties may impact the relationship between the slaughterhouse and farmer and could lead to a loss of trust. The use of penalties should therefore be considered alongside other measures that offer positive incentives to encourage farmers to raise entire males.

7.4.11 Farm audits

For special markets or for certain certification programmes, some slaughterhouses (or contracted auditors) may undertake physical farm visits and inspections to ensure that no animals are undergoing castration and that other animal welfare practices are compliant with the relevant standard. Such inspections can take place once a year with additional random audits to ensure adequate controls. Some slaughterhouses may choose to target farms based on past performance. For certification programmes, the costs of such audits may be covered by other actors in the supply chain.

Advantages

- ➔ Audits can help increase confidence in farm welfare standards.
- ➔ Certification can add value to meat, increasing profitability for farmers.

Disadvantages

- ➔ Audit programmes come with additional costs.
- ➔ Audit programmes cannot guarantee compliance between visits.

7.4.12 Same-sex groups

Some slaughterhouses require farmers to supply pigs to the slaughterhouse in same-sex groups only. This can help slaughterhouses with the logistical issues of having mixed carcass types on line.

Some slaughterhouses choose to have certain times where no boars are allowed on the slaughter line. All the meat produced at this time is intended for customers or product categories that will not or cannot use boar meat. This requires scheduling arrivals and good coordination with farmers / suppliers / transporters.

Advantages

- ➔ This may contribute to a reduction in boar taint instance due to more reliable matching of samples to carcasses.
- ➔ This ensures all boars are dealt with at once, making testing more efficient.

Disadvantages

- ➔ This may be challenging for farmers who raise their pigs in mixed groups.

Things to consider

Some farmers may already raise pigs in same-sex groups and will find it easy to transport boars and gilts separately. Some farmers may have concerns, however, that sex separation leads to increased aggression among boars and will prefer other grouping arrangements. As farmers' experiences differ on this subject, it may be helpful to have a conversation on these issues before transitioning.

7.4.13 Classification of carcasses

Classification of carcasses allows slaughterhouses to deal with groups of tainted and non-tainted carcasses after detection. The tainted carcasses can then be processed in a way that minimises the issue of boar taint. For slaughterhouses that are also involved in processing, this may mean using the meat for appropriately processed products. Processing may not be feasible for some operations, and tainted carcasses are instead sold to other special markets. Slaughterhouses report different instances of tainted carcasses, but most appear to range between 1% and 3%.

Things to consider

There must be sufficient space in the cold store to separate carcasses on the basis of boar taint.

7.4.14 Electronic classification of carcasses

When an operator detects boar taint using on-line testing technology, they may be able to indicate to an electronic system (such as by pressing a button) that the carcass is tainted. Carcasses are hung on hooks embedded with electronic chips, and once a signal indicates the presence of boar taint, the carcass is derailed to be dealt with separately.

Advantages

- This offers an efficient and streamlined system to both record instances of taint and separate tainted carcasses.
- Electronic classification systems can be used to streamline other slaughterhouse processes.

Disadvantages

- The infrastructure required is likely to be costly if existing electronic systems are not already in use.

7.4.15 Manual classification of carcasses

In some slaughterhouses, when boar taint is judged to be present, operators use a physical indicator to mark the carcass. Physical indicators might be a piece of string tied to the pig's leg or a stamp displayed visibly on the carcass. Operators may also keep a written (or electronic) record for statistical purposes.

Advantages

- There is a lower investment cost compared to electronic classification.

Disadvantages

- This does not automatically include classification information in electronic records.

7.5 Q5. Slaughterhouses – vaccinated pigs: obtain assurance from farmers that vaccinated pigs do not contain detectable boar taint

This document provides good practice examples that can be used by business operators to build trust in vaccination against boar taint. This document presents practices which are used in commercial operations.

Many slaughterhouse operators, and their customers, remain sceptical of the proposition that vaccination is an effective means of preventing boar taint. Lack of trust in vaccination as a means of preventing boar taint is an issue across the supply chain. This is particularly the case where supply chains are not well integrated and slaughterhouses lack confidence that assurance procedures have been fully carried out on-farm. Consequently, building trust in vaccination against boar taint requires engagement with many different actors, from farmers to retailers and consumers. The following practices are used to increase confidence in vaccination against boar taint and its effectiveness. Understanding the costs and benefits to other parts of the supply chain will also help slaughterhouses advocate for and lead the transition away from surgical castration.

7.5.1 Checks to verify that vaccination has been administered correctly

Some slaughterhouses choose to conduct checks for boar taint in vaccinated pigs on the slaughter line or off-line. These checks may involve on-line sensory testing of boar taint, or off-line chemical testing for substances associated with boar taint.

Checks can be done randomly or can be based on risk factors. Risk-based checks are likely to be more efficient than random checks. For risk-based checks, the frequency of checks may be adjusted to the slaughterhouse and farmer and their experience with vaccination against boar taint. More frequent checks may be conducted for less-experienced slaughterhouses and/or farmers. The person responsible for receiving the animals in the lairage may also check for the physical signs of the effectiveness of vaccination on arrival. Targeted checks may therefore be conducted on batches of pigs which show signs that the vaccine may have not been administered correctly.

Using these checks, slaughterhouses can then communicate results to farmers and to the next stage of the supply chain.

Advantages

- Checks enhance industry-wide confidence in vaccination against boar taint.
- The results of checks can be used to set priorities for future risk-based checks.
- The results of checks can also be reported back to farmers, so that they can take the measures necessary to address the incorrect administration of the vaccine.

Disadvantages

- If checks are not based on any specific risk factors, they may not be efficient.

Things to consider

Checks performed by the slaughterhouse should be thoroughly documented, and then shared with the farmers. This is crucial to avoid fuelling distrust in the relationship. Slaughterhouses therefore need an efficient process for collecting data on checks, which may be for example an electronic system.

7.5.1.1 Human nose method

Some slaughterhouses may use the same checks and boar taint detection techniques that are used for entire males. Integrating checks for vaccinated pigs with checks used for entire males can improve efficiency and reduce costs of checks.

For details on the human nose method, including advantages and disadvantages please read the document titled "Slaughterhouses – uncastrated pigs: detect boar taint, quantify and manage positive carcasses"

7.5.1.2 Blood test for testosterone

One method for assessing whether vaccination has been successful is testing groups of pigs for testosterone levels. Testosterone levels can be checked through a simple blood test. Many human healthcare providers offer these tests and results can be received within 24 hours. The results of this test can then be used to determine whether animals have been properly vaccinated and therefore whether they are at risk for boar taint.

Vaccinated pigs generally have testosterone levels between 5 to 100 ng/dl. Entire males, by contrast, generally have testosterone levels between 500 to 1500 ng/dl. However, testosterone levels are cyclical and there is no definitive cut off. This test is therefore best used for assessing batches of pigs. If testing shows that a batch of pigs contains several males with high testosterone levels, it is likely that vaccination has not been done properly on this group of pigs. These pigs can then be subjected to additional sensory testing and feedback can be provided to the farmer.

Advantages

- This identifies groups of pigs most at risk for boar taint.
- This allows the slaughterhouse to provide feedback to farmers on the success of vaccination.
- This method is faster and cheaper than chemical testing (see below).

Disadvantages

- Requires slaughterhouses have additional capabilities to perform blood tests.
- The tests incur additional costs

- Without a validated cut-off value for testosterone levels, false-negative results may occur.

Things to consider

- The optimal number of pigs to be tested depends on the level of confidence required by slaughterhouses and their partners.
- Tests cost between €8 and €10 per test.

7.5.1.3 Chemical testing of a fat sample

The slaughterhouse can take a fat sample from a small number of vaccinated pigs and send these to an external laboratory for chemical testing. This analysis is used to detect the levels of androstenone in the fat. Samples that contain above 1 µg/g of androstenone are considered to be positive for boar taint. This provides a quantifiable indicator of the level of boar taint present in the tested carcass.

Advantages

- This type of testing does not require slaughterhouses to have any boar taint testing capabilities on-site.
- Chemical testing offers quantifiable feedback on the presence of boar taint.

Disadvantages

- This is not a rapid testing method so does not allow for tainted carcasses to be quickly removed from the line.
- This type of testing is only suitable for a small number of carcasses. It will likely give an incomplete picture of the level of boar taint in vaccinated pigs. Tainted meat may enter the supply chain as a result.
- This type of testing may be too expensive for some slaughterhouses. If 1 per cent of carcasses are tested, this will cost around 0.03 EUR per kilo of meat received from vaccinated pigs.

Things to consider

The use of this method depends on the need for assurance in the supply chain. The additional costs need to be balanced by price incentives.

7.5.2 Bonus payments

Although some slaughterhouses treat vaccinated pigs as boars and pay less for them (as compared to surgically castrated pigs), others do not issue penalties or choose to pay more (for example, an extra 0.01 EUR per kg is paid to farmers in Belgium for carcasses of vaccinated pigs). The price premium for vaccinated pigs is made possible by certification schemes and by demand from retailers who are interested in selling meat from vaccinated pigs.

Advantages

- Bonus payments increase the profitability of using vaccination against boar taint for farmers.
- Bonus payments contribute to aligning the interests of all actors in the supply chain.
- Bonus payments incentivize farmers to be particularly attentive to the risk of boar taint in the animals they supply to slaughterhouses.

7.6 Q6. Food processors – uncastrated pigs: deal with meat with detectable boar taint

This document lists good practice examples of dealing with meat with detectable boar taint at the processing stage. The practices mentioned are all currently used in commercial operations in the EU.

Different processing techniques are used to mask boar taint in tainted meat. They enable the sale and consumption of tainted meat in various markets, including those where consumers are sensitive to boar taint. Where appropriate, many of the practices described below can be used in combination.

Making the transition to processing meat from entire males requires careful consideration and planning on the part of processors. The following guide refers to practices that may be of interest to processors making such a transition. In addition to the practices described, it is important for all slaughterhouses to **communicate with their supply chain and customers** before and during any transition to processing meat from entire males. Understanding the costs and benefits to other parts of the supply chain will also help processors advocate for and lead the transition away from surgical castration.

Things to consider

- ➔ When it comes to processing pig meat, boar taint is only one of several relevant factors. Other factors, such as the ratio of fat to lean meat, pH levels, tenderness and fat quality (degree of unsaturation, iodine value), are also relevant. These are not covered in this document. They need to be considered alongside boar taint when transitioning to processing meat from entire males.
- ➔ For all techniques, their effectiveness depends on the level of boar taint in the meat before it is processed.

7.6.1 Use of tainted meat for products that are consumed cold

Boar taint tends to be less detectable when meat/meat products are consumed cold (for example, cold cooked ham or cold smoked meat).

The effectiveness of this approach depends on the level of taint in the raw material as well as on the level of fat required for the product. That is because the substances responsible for boar taint accumulate mostly in the fat.

Things to consider

Some products intended for cold consumption may in some instances end up consumed warm – such as where meat is included as a pizza topping. It is therefore important to consider actual likely end use of products when choosing where to use tainted meat.

7.6.2 Diluting/Mixing

Tainted and non-tainted meat can be mixed to produce sausages and other minced foods. Dilution reduces the proportion of substances responsible for boar taint in the final product.

There should be enough non-tainted meat in this mix to make sure the final product does not have boar taint – this depends on several factors, including how strongly tainted the meat is before dilution, the amount of fat in the meat, the type of processing used and the intended method of consumption.

This technique requires a relatively precise assessment of the level of boar taint to determine what quantity of untainted meat it must be mixed with. This in turn depends on the use of scales more granular than only untainted/tainted for measuring boar taint with the human nose method.

Advantages

- The practice is effective when tainted meat is mixed with enough non-tainted meat.

Disadvantages

- This technique may be more difficult to use when the level of boar taint is not clearly assessed earlier in the chain, in slaughterhouses.
- This technique applies only to minced products (sausages and other minced foods): for other meat products (e.g., ham), all of the meat must come in a single cut from a single pig, meaning that dilution is not an option. While any part of the pig can be minced in theory, mincing the highly valuable parts of the pig is avoided for economic reasons.

7.6.3 Dry curing

Dry curing is used for the production of cured ham. It involves rubbing a piece of meat with a dry-cure mixture of salt and other ingredients. Dry curing produces a salty product.

Advantages

- Dry curing changes the taste, aspect, smell and texture of the meat (e.g. salt, nitrites). This may help reducing the perception of boar taint.

Disadvantages

- Dry curing alone may not be sufficient to reduce the perception of boar taint. By contrast, there might be a further concentration of the taste in the dried product. Additional processing may be needed to mask this taste, such as the use of spices.

7.6.4 Fermentation

Fermentation is used for production of salami-type sausages. Sometimes this is applied together with smoke and/or edible mould.

Use of tainted meat in pickled products may also help.

Advantages

- Fermentation changes the taste, aspect, smell and texture of the meat, which helps reduce the perception of deviant smell and taste of boar meat.

7.6.5 Smoking

In sausages and cooked hams, liquid smoke can be used so it is distributed within the product as compared to “real smoke” which only can be applied to the outer surface.

Advantages

- This contributes to masking boar taint.

Disadvantages

- There is little information on how intense the smoking process should be to be effective.

- ➔ Smoking cannot be used excessively because it increases the concentration of polycyclic aromatic hydrocarbons (PAHs)⁶² that are known to be carcinogenic substances.

7.6.6 Thermal treatment

Tainted meat can be heated in an open cooking system before further processing (for wiener or liver sausages). Thermal treatment may also involve quickly decreasing the temperature of meat and storing it at colder temperatures.

Advantages

- ➔ Heating during processing, especially in the production of wiener or liver sausages, reduces boar taint concentration.

7.6.7 Use of spices

Spices are used on boar tainted meat to produce sausages (e.g. chorizo) and marinated meat products for fresh meat consumption.

Advantages

- ➔ The use of spices helps reduce the perception of boar taint in meat products such as sausages and marinated fresh meats.

Disadvantages

- ➔ The amount of spices per kilo of meat must not exceed a certain proportion to avoid dominating the product.
- ➔ Spices change the taste, aspect, smell and texture of the meat, which may repel certain consumers.

7.7 Q7. Retailers and food services – uncastrated pigs: promoting meat from uncastrated pigs

This document lists good practice examples for the marketing of meat from entire males, at retail outlets or in the food service sector. The document includes information on (i) how to increase the market value of meat from uncastrated pigs and (ii) how to prevent meat with detectable boar taint reaching consumers. The practices mentioned are all currently used in commercial operations in the EU.

Making the transition to selling meat from entire males requires careful consideration and planning on the part of the retailer. The following guide refers to practices that may be of interest to retailers making such a transition. In addition to the practices described, it is important for all retailers to **communicate with their suppliers** before and during any transition to selling meat from entire males. Understanding the costs and benefits to other parts of the supply chain will also help retailers advocate for and lead the transition away from surgical castration.

Things to consider

Consumers perceive boar taint in different ways, and this perception may differ depending on the product. Many consumers are unaware of the issue of boar taint and may not understand why their meat smells bad. Many consumers are also unaware of the issue of

⁶² These include benzoanthracene, benzo(a)fluoranthene, benzopyrene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene.

pig castration. These are important considerations when developing strategies to promote meat from uncastrated pigs.

Case study: Delhaize's successful marketing of meat from non-castrated pigs

In June 2018, Belgian retailer Delhaize launched its new castration-free pork products under its "Better for Everyone" (Mieux pour Tous / Beter voor Iedereen) label, a label established in 2014 with a focus on nutritional quality and sustainability.

Case study: Lidl Belgium's move to entire males

In 2012, Lidl Belgium decided to move fully to the sale of meat from entire, non-vaccinated pigs. Further details on these case studies are provided in Section 5.3.1.

7.7.1 Marketing techniques

Retailers have used marketing campaigns to increase the value of meat from uncastrated pigs. Techniques used to avoid boar tainted meat ending on shelves are the reliance on an agreed set of specifications.

7.7.1.1 Marketing campaigns

Retailers are often reluctant to communicate about non-castration practices to consumers. Therefore, marketing messages addressed to consumers generally do not mention the fact that the animals are not castrated. Rather, these messages generally mention broader better animal welfare standards. That is not always the case, however, and a few retailers have also communicated about stopping castration in pig production.

Marketing campaigns might also emphasise other benefits to non-castration alongside animal welfare, such as environmental or human health benefits.

In Belgium, Delhaize has recently included and publicised a 'castration free' policy for one of its pork labels.⁶³ The marketing for this label highlights the absence of castration, but also mentions several other aspects of this label:

- The meat has been carefully selected for taste, and comes from a specific low-taint breed
- Pigs are fed a balanced diet which also contributes to human health (through the inclusion of omega-3 fatty acids)
- The production is entirely Belgian and farmers receive an incentive per animal and reimbursement for additional feed costs; and
- There is a lower need for antibiotic use and therefore reduced use of antibiotics in the rearing of the pigs.

Rather than referencing it as part of a broader animal welfare policy, this example includes non-castration and better welfare alongside taste, quality, human health, an appeal to supporting local farmers and environmental concerns.

Advantages

- ➔ Marketing meat from uncastrated pigs with 'better animal welfare' messages matches the growing interest from EU consumers about animal welfare.
- ➔ Consumers are made aware of the topic of pig castration.

⁶³ Delhaize. (2018) Delhaize kiest voor exclusief varkensras met nog meer smaak en nog meer oog voor dierenwelzijn. Available at: https://www.delhaize.be/press_overview:exclusief-varkensras

Things to consider

- ➔ The provision of information about non-castration can usefully be combined with other messages on health, taste, and environmental benefits of raising entire males.

Further reading

Aldi in Germany have included a move away from pig castration in their animal welfare purchasing policy. More details of this are available at: https://www.craldinord.com/2017/wp-content/uploads/sites/4/2018/05/ALDI-North-Germany_National-Animal-Welfare-Purchasing-Policy.pdf

7.7.1.2 Buyer specifications addressed to suppliers

Producers hoping to sell to a retailer are required to comply with its product specifications. Specifications may forbid surgical castration of pigs and/or require the use of measures to reduce boar taint (e.g. breeding or feeding techniques, improved housing conditions). These specifications are the principal mechanism retailers have used to ensure that boar tainted meat does not end up on shelves at retail stores.

Advantages

- ➔ Existing purchasing systems are used to manage boar taint.
- ➔ Compliance with specifications is the condition for the supplier to continue selling its meat to retailers. This is a very strong incentive that may be passed down to processors, slaughterhouses and farmers.

7.7.1.3 Visits, information sharing and certification of boar taint detection methods

In several countries, slaughterhouses and processors have actively provided retailers and other clients with detailed information about their boar taint detection methods. This has involved:

- Full documentation on the protocols put in place for detecting boar taint;
- Certification by third party auditors of the boar taint detection protocol in place at the slaughterhouse;
- On-site visits to demonstrate to representatives of retailers and other buyers the efficacy and robustness of the method used.

Case study: COOPERL's transition to entire males

In France, COOPERL has organised numerous visits for retailer and B2B representatives to inspect the full process, and especially the human nose method, to convince them of its reliability for detecting boar tainted carcasses. The human nose method at COOPERL has also been audited and certified annually by the German company SGS, which provides additional reassurance to the rest of the supply chain. Further details on the COOPERL case study are provided in Section 5.1.1.

Advantages

- ➔ Transparency and demonstration of the checks help dispel distrust and build trust in the detection method and within the supply chain.

7.7.1.4 In-store trials

Retailers and food service operators can gain additional confidence in the feasibility of selling meat from entire males by running controlled trials in tight collaboration with their

suppliers. Such trials can involve an initial test period during which all the pig meat offered is from entire males. Sales and customer complaints are closely monitored during that time to identify any issues, and information is shared with the supplier throughout.

Case study: COOPERL's transition to entire males

In France, COOPERL has run trials with store managers, whereby they were informed in advance that, for a given period, they would only receive meat from entire males. There would be close interaction between a representative of the supplier and the store manager during that trial, to monitor any variations in sales and any consumer complaints. Further details on the COOPERL case study are provided in Section 5.1.1.

Advantages

- ➔ In-store trials can reassure store managers that the provision of meat from entire males from a supplier with a robust protocol for boar taint detection does not mean adverse impact on consumers and sales.

7.7.2 Food labelling

7.7.2.1 Animal welfare labels and other assurance schemes

A number of animal welfare certification schemes include standards on pig castration. Meat can be certified as being compliant with these standards on the basis of third-party audits of farms, slaughterhouses, or food processing companies. A label signalling conformity with the scheme is then added to the packaging. Such labelling can be relied on by consumers as additional information about how the meat was produced and an indicator of quality.

Various schemes within the EU certify pig meat products. The schemes specify standards on rearing, housing, bedding, the use of antibiotics, farrowing crates, etc. Some have specific requirements on non-castration, including:

- Approximately 95% of pigs reared in the UK are raised to Red Tractor Assured Food Standards and approximately 30% of these are raised to 'RSPCA' standards. Both standards do not allow surgical castration in the pork supply chain. These labels are widely recognised and used by UK consumers. Boar taint may be partially addressed, but the labels' focus is on welfare rather than meat quality.
- The reduction of boar taint in the UK is addressed more or less entirely by slaughtering boars at a lower weight. The British Meat Processors Association's British Quality Assured Pork (BQAP) scheme does not allow for the slaughter of males over 100 kg. This is specifically aimed at avoiding boar taint.
- The "Beter leven – Een ster" (Live better – One star) assurance scheme in the Netherlands forbids surgical castration. This standard is applied to pig meat products sold in retail markets. Various producers in the Netherlands have developed additional animal welfare programmes to comply with the "Beter leven" standard. The scheme also requires producers to test for boar taint and has a detailed standard for these tests.
- QS in Germany and IKB in the Netherlands allow for the production of entire males under their certification but require that participating slaughterhouses enact appropriate boar taint detection methods.

Advantages

- ➔ Labelled products can be sold at a higher price than non-assured meat.
- ➔ Better welfare may be associated with lower boar taint.

- ➔ Robust schemes and auditing systems provide additional guarantees to retailers and food service operators. Retailers and food service operators can easily require from their suppliers that they should be certified compliant with such a scheme.

Disadvantages

- ➔ Third party assurance schemes add to the costs of suppliers as they bear the cost of audits and the practices specified by the scheme required;
- ➔ Consumers may associate higher animal welfare with better quality – expect at least equal if not better quality. There is a risk that consumers will be put off by boar taint when eating without knowing what it is and will not repurchase.

Further reading:

More information on existing assurance schemes, their requirements and approaches to marketing can be found through their official websites:

- Red Tractor Assurance official website: <https://assurance.redtractor.org.uk/>
- British Meat Processors Association official website: <http://britishmeatindustry.org/our-work/bmpa-pork-scheme/>
- Royal Society for the Prevention of Cruelty to Animals Assured official website: <https://www.rspcaassured.org.uk/about-us/>
- Beter Leven official website [in Dutch]: <https://beterleven.dierenbescherming.nl/>
- QS official website: <https://www.q-s.de/en/>
- IKB official website [in Dutch]: <http://www.ikbnederland.nl/>

7.8 Q8. Retailers and food services – vaccinated pigs: promoting meat from vaccinated pigs

This document lists good practice examples for the marketing of meat from vaccinated pigs, at retail outlets or in the food service sector. The document includes information on (i) how to increase consumer acceptance of meat from vaccinated pigs and (ii) how to prevent meat with detectable boar taint from reaching consumers. The practices mentioned are all currently used in commercial operations in the EU.

Marketing campaigns are used by retailers as a technique to inform consumers about animal welfare, health and sustainability aspects of meat production.

Making the transition to selling meat from vaccinated pigs requires careful consideration and planning on the part of the retailer. The following guide refers to practices that may be of interest to retailers making such a transition. In addition to the practices described, it is important for all retailers to **communicate with their suppliers** before and during any transition to selling meat from vaccinated pigs. Understanding the costs and benefits to other parts of the supply chain will also help retailers advocate for and lead the transition away from surgical castration.

Case study: Colruyt's successful transition to vaccination against boar taint

In 2010, Colruyt conducted a trial to improve pigs' welfare by using vaccination against boar taint. It used Improvac on approximately 2,600 boars and monitored all production steps from vaccination to meat consumption. Further details on this case study are provided in Section 5.3.2.

7.8.1 Marketing campaigns that emphasise animal welfare, health and sustainability

Retailers are often reluctant to use the term "immunocastration" in their communications to consumers. They therefore opt for using "vaccination" which is more understandable to consumers. Marketing campaigns can combine information on improved animal welfare

with other benefits achieved with vaccination. This can include, for example, information on the improved health of pigs and sustainability.

Advantages

- ➔ Marketing meat from vaccinated pigs with 'better animal welfare' messages matches the growing EU consumer interest in animal welfare.
- ➔ Consumer studies suggests that, when informed about vaccination against boar taint and surgical castration without anaesthesia, consumers often prefer the vaccination as this is perceived as more animal-friendly.

Disadvantages

- ➔ There is a risk of raising awareness about physical/medical castration, which is not desired by retailers as it implies mutilation of pigs.
- ➔ Communicating about vaccination against boar taint to consumers who have limited awareness of this practice poses the risk of misconceptions and misunderstandings. Consumers may associate the use of medication with other practices, such as the use of hormones in animal production. Furthermore, there may be a risk that media amplify consumer concerns.

Things to consider

Consumer awareness of alternatives to physical castration may vary across countries and consumer groups. Although most consumers are unaware of castration practices, others may have more knowledge and show more interest in receiving information on these practices. Retailers may consider assessing the needs and characteristics of their consumers and adapting their animal welfare campaigns accordingly.

7.8.2 Farmer management

Retailers can impose the vaccination of pigs on their pig meat suppliers and support producers with specific training and control measures.

7.8.2.1 Control measures

The inoculation with the vaccine is often closely monitored at farm level. Retailers and/or slaughterhouses may choose to contract independent organisations to carry out annual checks at farms.

Advantages

- ➔ Control measures guarantee that farmers respect the production requirements agreed upon.

Disadvantages

- ➔ Retailers may bear the costs of control measures themselves. However, as audits are performed anyway there are in general no additional costs related to vaccination.

7.8.2.2 Training methods

Animal handlers can be trained on technical aspects regarding vaccine administration and treatment of piglets, livestock keeping, and to raise their awareness of animal welfare. This is often provided by technical support staff contracted by retailers.

Advantages

- ➔ Training reassures farmers who need to get used to new production practices.

Disadvantages

- ➔ Hiring technical staff increases the costs for retailers. However, vaccine suppliers often provide training on the correct use of the vaccine as well. Training costs may therefore be distributed among different operators, and not only borne by retailers.

8 Conclusions

This study has aimed to collect and synthesise information on best practices of pig meat production without the use of surgical castration. The information collected will provide a basis for communication materials that can be used to encourage more operators across supply chains in the EU to abandon the practice of surgical castration and instead move towards the production of entire males or males that have been vaccinated.

Information on best practices was collected from documentary sources, business operators, and experts on this subject. A variety of practices and experiences were found, including many examples of trials and some potentially viable practices still in the early phases of the development. The final report includes practices at farm-, feed provider-, breeder-, slaughterhouse-, processor- and retailer-level that have been used commercially and have been successful.

While the production of entire males, and even more so, of vaccinated pigs remain small in the EU by comparison to the overall production of pig meat, it involves major operators that have invested considerable resources, expertise, and effort to find solutions that work not only within individual organisations, but across whole supply chains. Evidence from these operators demonstrates that it is commercially feasible to transition from physical castration to raising entire males or vaccinating them against boar taint.

The practices documented in this study show that solutions require coordination and information exchange between different actors of the supply chain. Change has happened through exchanges of good practices, data sharing, and agreements on how to share the costs and the benefits of changes to the mode of production. Successful transitions have occurred where initiators have demonstrated to commercial partners that a different way of working is feasible, robust, and safe.

This project has aimed to contribute to this endeavour by extracting information from those operators and identifying specific best practices. The format used is meant to be accessible and should contain sufficiently actionable information for other business operators implement similar practices in their own country and business operations. At farm-level, this includes practices related to breeding, housing, feeding and scheduling the slaughter of pigs. Practices were also identified specific to vaccination against boar taint. For slaughterhouses, practices include human nose techniques to identify boar taint, practices that avoid boar taint detection and supply chain management. For vaccination against boar taint, practices were identified that may help slaughterhouses to transition and develop trust in the process. Techniques for processing meat to mask or reduce the impact of boar taint are identified as a method to retain the value in tainted meat. Finally, some examples of practices at retail level were found which offer an opportunity to add value to meat from entire males or vaccinated pigs for consumers.

Together, these individual practices provide a compelling portfolio of options for supply chains interested in making a transition away from surgical castration. Crucially, however, none of these practices are sufficient in isolation. For any transition to be successful, it will need to involve actors from across the supply chain working together. The study research identified many such examples of cooperation between actors. To that end, several case study examples of successful transitions have also been included in the report. The cases on Delhaize and Lidl in Belgium provide examples of retailer-driven transitions, the case on QS and IKB in the Netherlands shows how assurance schemes can contribute to a transition and the case on Cooperl in France shows how the transition can occur when production and processing supply chains are already integrated.

Gaps and obstacles remain. Some have to do with limitations in the study, which did not manage to extract as much information from some sectors of the industry as would have been desirable, and particularly within processing and retail/food services. Other gaps are due to many promising techniques still being under development and not yet commercially available, particularly techniques for the chemical detection of boar taint. They also reflect

the relatively poor degree of engagement from certain actors in the supply chain, and retailers in particular, in this mode of production.

Annexes

Annex 1 Terms of reference

Context/Introduction

Background of the initiative

This study will aim at supporting the improvement of the welfare of animals.

The European Parliament adopted as part of the Union's budget 2017 a pilot project entitled: *Establishment of a harmonised internal market for pigmeat obtained from pigs that have not been surgically castrated*.

This pilot project is accompanied with the following budgetary remarks:

As shown by the results of the latest special Eurobarometer on animal welfare, an overwhelming majority of European citizens care deeply for the welfare of farmed animals and believe that they should be better protected. The surgical castration of young piglets without pain relief is a common and increasingly controversial pig management practice, currently affecting 63 million animals every year. Yet practical experience from major pork supply chains within the European Union shows that viable and profitable alternatives to surgical castration exist. The pilot project will bring major stakeholders together – slaughterhouses, food processors and retailers, and involving farmers as needed – and foster the sharing and dissemination of techniques and best practices that eliminate the need to castrate pigs surgically. Emphasis will be given to knowledge transfer activities concerning (a) reliable and viable boar taint detection methods, (b) utilisation of boar- tainted carcasses during processing, and (c) marketing and promotion of meat from pigs that are not surgically castrated. Trust building and exchange of information among all market participants in a peer-to-peer environment will be an important communication activity. The project will deliver a practice-based guidance document paving the way for a harmonised internal market for pigmeat obtained from animals that are not surgically castrated.

The European Declaration on Alternatives to Surgical Castration of Pigs is a voluntary and stakeholder- driven agreement to phase out surgical castration of pigs by 2018. The declaration was signed by 33 parties representing European farmers, the meat industry, retailers, scientists, veterinarians and animal welfare NGOs. While some member states have taken concrete initiatives to this end, there is currently no harmonised internal market for pig meat obtained from pigs that have not been surgically castrated. This is hindering the progress of the Declaration. The pilot project will accelerate the process by providing and disseminating practical solutions to commonly perceived problems among key operators of the pork chain, while also showcasing the associated economic and societal advantages of ending the surgical castration of pigs.

Objectives of the initiative

The project will be implemented in two phases:

- The first phase will consist in collecting information on best available practices at various level of the food chain to market meat from uncastrated or immunocastrated pigs;
- The second phase will consist in disseminating the information collected during the first phase to raise awareness and transfer best practices among the relevant business operators.
- The present call only refers to the **first phase of the pilot project**.

Specifications of the assignment

Objectives of the study

The present study implies data gathering on different stages of the pork chain and for two types of meat obtained either from:

1. uncastrated pigs, or,
2. immuno-castrated pigs.

As regards meat from uncastrated pigs, the objective of the study is to collect information on how farmers reduce boar taint, how slaughterhouses detect boar taint, estimate the amount of carcasses with detectable boar taint, how the industry and food processors use these carcasses (i.e. with detectable boar taint) and how retailers market the meat from these animals.

As regards meat from immuno-castrated pigs, the objective of the study is to collect information on how farmers perform immuno-castration and how retailers market the meat from these animals.

The purpose of study is to collect successful experiences within commercial contexts. With this purpose in mind, best practices collected should be, when possible, science based, but should not contain recommendations solely based on research.

The study shall propose a series of technical, organisational and marketing tools and practices that could be used by business operators to successfully market meat from uncastrated or immuno-castrated pigs, including the meat with detectable boar taint.

The study shall include a series of case studies based on the Member States where such policies have been implemented, which are at least Germany, France, Spain, Belgium, the Netherlands and Denmark.

The contract will consist in the following steps:

- collecting information on current practices regarding the issues to be addressed,
- analysing and comparing the sources of information,
- proposing a toolbox for the various target audiences.

The progress and the final results of the study will be reported to stakeholders through a dedicated web platform and two meetings of an advisory board consisting of business operators concerned, representatives of the civil society, consumer associations and scientists.

The final document will be designed to be read by business operators and organised in a way that it will be easy to use for the second phase of the pilot project (dissemination).

Scope and issues

The scope and issues of the study are described under Table 10.

Establishing best practices on the production, the processing and the marketing of meat from uncastrated pigs or pigs vaccinated against boar taint (immunocastrated) – Final report

Table 10. Issues to be addressed

Target audiences	Meat from uncastrated pigs	Meat from immuno-castrated pigs
Farmers	Q1- Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)	Q2- Techniques and best practices to use immuno-castration in various type of pigs Q3- Techniques and best practices to ensure to slaughterhouses that immuno-castrated pigs do not present detectable boar taint
Slaughterhouse operators	Q4- Techniques and best practices to detect boar taint, quantify and manage positive carcasses	Q5- Techniques and best practices to trust farmers that immuno-castrated pigs do not contain detectable boar taint
Food processors	Q6- Techniques and best practices to quantify and deal with meat with detectable boar taint	<i>Not relevant</i>
Retail and food services	Q7- Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served	Q8- Techniques and best practices to increase the acceptance of meat from immuno-castrated pigs among consumers and to prevent meat with detectable boar taint to be on the shelves or served

The contractor is expected to collect information for each issue from at least the following six Member States, Germany, France, Spain, Belgium, the Netherlands and Denmark, reflecting the diversity in terms of size, geographical distribution and types of production and, when considered altogether, covering a significant proportion of the pig meat market.

Tasks under the assignment

The Commission expects the contractor to perform the following tasks:

Task 1: Update of methodology and work plan

On the basis of the discussions and conclusions of the kick-off meeting the contractor will establish an updated **general work plan** and methodology in order to meet the objectives and address all issues.

Deliverable 1: Updated methodology and work plan

The deliverable will contain in details the methodology, the timeframe, the final list of experts and the organisations to be consulted during the whole study. This document should serve as a monitoring tool of the study during the contract.

Task 2: Collecting data

The contractor will collect data based on desk research as well as by contacting experts in various Member States and preliminary visits in some Member States.

This task will mainly consist in collecting information on current good practices relevant to the issues to be addressed in Table 10.

Deliverable 2: State of play

This deliverable will contain a synthesis of the current state of knowledge on all issues to be addressed based on key references and a comparative analysis of the range of methods used by the different sources. The deliverable will also identify the gaps in information for each subject matter.

Task 3: Drafting elements for best practices

Based on the previous findings, the contractor will draft a set of possible techniques and best practices (later called "elements for best practices"). The elements for best practices should reflect existing practices performed under commercial conditions.

The document should address the key issues accompanied with relevant explanations on the possible options ("toolbox"), their advantages/disadvantages. The contractor will establish a gradation between various elements proposed depending on their feasibility in the various contexts observed in the EU including some quantitative data, such as:

- For Q4 the expected percentage of detectable boar taint carcasses compared to the number of uncastrated boars,
- For Q5 the expected risk of price reduction for farmers in case of detectable boar taint carcasses,
- For Q6 the percentage of detected boar taint meat compared to the quantity of meat they received, and the way such tainted meat can be used or marketed.
-
- The contractor is invited to present the best practices following a structure that reflects the target audiences (i.e. farmers, slaughterhouses, meat processors, retailers and food services) and the meat concerned (meat from uncastrated pigs and immuno-castrated pigs, including with detectable boar taint in both cases) so that each of the eight issues is addressed extensively.
-
- The contractor will take a particular attention in drafting the document in a simple and concise way (for non-specialised reader), putting priority to visual supports (pictures, diagrams, and drawings) rather than text when possible.
-

Deliverable 3: Elements for best practices for consultation

This deliverable will contain the elements for best practices covering all issues to be addressed.

Task 4: Consulting stakeholders on the elements for best practices

The contractor will present, discuss and finalise the elements of best practices with the relevant stakeholders. The contractor shall ensure at least a minimum period of consultation of eight weeks.

For that purpose, the contractor will establish an interactive web platform where draft documents will be shared to the stakeholders consulted and where they can provide comments and contributions directly online with a secure access. Comments and contributions will be only shared with the consultees who registered in the web platform.

The contractor will administer and moderate the web platform. The comments and contributions will be analysed and the synthesis should feed into the elements for best practices (Deliverable 4). The web platform does not need to be used or transferred beyond the duration of the contract.

In addition, the contractor will organise at least two meetings in Brussels of an advisory board consisting of the relevant business operators concerned, representatives of the civil society and scientists. This board shall be set up in agreement with the European Commission with a maximum of 25 members. The contractor will only bear the costs related to the meeting itself. Travel and accommodation expenses of the participants will not be reimbursed.

The contractor will also ensure that the interests of small undertakings, having local activities is also taken into account.

The contractor will consider the comments received from stakeholders and Member States, and after critical analysis, possibly amend the draft documents, where contributions are substantiated by factual arguments or/and a broad consensus of opinions.

Deliverable 4: Consultation and final elements for best practices

The deliverable will contain a summary of the consultation process and of the position of stakeholders consulted, presenting possible conflicts of opinions, the pros and cons of each option and a suggested line in case of various alternatives.

In addition the deliverable will present the final version of the elements of best practices in order to reflect the consultation and the opinion of the stakeholders consulted (Deliverable 3 revised).

Methodology

The contractor will have a free choice as to the methods used to gather and analyse information and for making the assessment, but must take account of the following:

- The study must be based on recognised techniques and triangulation methods are required.
- The choice and a detailed description of the methodology must form part of the offer submitted. Advantages, limitations and risks involved in using the proposed tools and techniques should be explained. There should be a clear link between the study questions addressed and the corresponding methodology proposed.
- Considerable emphasis should be placed on the analysis phase of the study. In addressing the study questions / issues, quantitative indicators should be sought and used as far as possible. The contractor must support findings and conclusions⁶⁴ by explaining the degree to which these are based on opinion, analysis and objectively verifiable evidence. Where opinion is the main source, the degree of consensus and the steps taken to test the opinion should be given.
- The approach proposed by the contractor must be clearly set out in the bid. It should clearly identify
 - a) data to be collected
 - b) consultation strategy (if applicable)
 - c) Analysis to be conducted.

⁶⁴ In some specific cases the contractor might also be requested to formulate recommendations.

As an indication stakeholders will be consulted following these different levels:

3. Stakeholders in some Member States;
4. EU stakeholders;
5. Member States' competent authorities;
6. Scientific institutes.

To perform its tasks the contractor will consider the references listed in Section 6.

Reporting and deliverables

General reporting requirements

The present assignment includes the submission of a series of deliverables: reports and presentations during a meeting in Brussels (3 meetings). The contractor will deliver the following reports at four key stages of the evaluation process: (1) inception report, (2) interim report, (3) draft final report and final report.

The contractor must deliver the study and all publishable deliverables in full compliance with the corporate visual identity of the European Commission, by applying the graphic rules set out in the European Commission's Visual Identity Manual, including its logo. The graphic rules, the Manual and further information are available at: http://ec.europa.eu/dgs/communication/services/visual_identity/index_en.htm

These reports will be submitted by the Commission to the established steering group, which may ask for complementary information or propose adjustments in order to redirect the work as necessary. Each draft report will be orally presented in Brussels to the Commission's steering group within 30 days after delivery.

Each report should be written in English, and critically assessed as it provides the basis for tracking the quality of the work done by the evaluator. Reports must be approved by the Commission. With work progressing and in the light of new findings, revisions of reports already approved may be necessary.

It is essential that all the reports must be clear, concise, unambiguous and comprehensive. They should also be understandable for non-specialists. The presentation of the texts, tables and graphs has to be clear and complete and correspond to commonly recognised standards for studies to be published. A structured and precise elaboration of add-ons based on previous deliverables at every stage of the process is requested (for example, this could be done via colour-coding parts of the report developed at the offer, inception, interim and draft final stage).

The maximum size⁶⁵ of each report to be provided is (excluding annexes):

- Inception report: up to 20 pages;
- Interim report: up to 100 pages
- Final report: up to 150 pages

In the average, the text addressing each of the eight issues should not exceed 10 pages, i.e. overall section addressing the issues shall not exceed 80 pages, the rest being dedicated to methodology and consultation. Deliverables that do not respect these limits will not be considered. The final report may exceed these limits only after explicit request from the Commission.

⁶⁵ Under this chapter a page shall not exceed 1500 characters without footnotes.

The reports must be provided to the Commission in both MS-Word and Adobe Acrobat (PDF) format with the charts in Excel (other formats may be added). They must be accompanied, where requested, by appropriate annexes and delivered in accordance with the deadlines and requirements set out in the terms of reference and confirmed in the kick-off meeting.

Reports must be designed as to respect the protection of private data so that they can be published or made available to the public without having to request any prior authorisation (see Annex V).

Each report (except the final version of the final report) should have an **introductory page** providing an overview and orientation of the report. It should describe what parts of the document, on the one hand, have been carried over from previous reports or been recycled from other documents, and on the other hand, represent progress of the study work with reference to the work plan.

All reports must be drafted in *English* and submitted according to the timetable defined in section 5.3 to the contracting authority. Electronic files must be provided in Microsoft ® Word for Windows format. Additionally, besides Word, the final report must be delivered in Adobe ® Acrobat pdf format and in three hard copies.

Inception report

After signature of the contract, the contractor will participate as soon as possible in a **kick-off meeting** with the steering group to present and discuss **Deliverable 1**. The report should describe how the methodology proposed by the Contractor is going to be implemented in detail, after e.g. having further examined the sources of secondary and primary data that will be used for the study. The report shall not exceed the number of pages mentioned in the 4.1 section.

Interim report

The report is to be produced after the desk and field research has been completed, and should, to the extent possible, include some preliminary conclusions. The report must as a minimum provide:

- This report will contain an **updated version of Deliverables 1 (work plan), 2 (state of play) and 3 (draft for consultation)** including:
 - An overview of the status of the study project;
 - A description of problems encountered and solutions found;
 - A summary of initial findings and results of the data gathering;
 - An assessment of the data, whether it meets expectations and will provide a sound basis for responding to the study questions;
 - A conclusion whether any changes are required to the work plan, or any other solutions should be sought in order to ensure that the required results of the study are achieved. If any such issues are to be identified, they must be discussed in the meeting with the steering group dedicated to this report;
 - A proposal for the final structure of the final report, as well as a structure of the Executive Summary.
- The report shall not exceed the number of pages mentioned in the 4.1 section.

Draft Final Report

This document shall deliver the results of all tasks covered by these terms of reference, and must be clear enough for any potential reader to understand.

It must contain an updated version of **Deliverables 1 (work plan), 2 (state of play), 4 (consultation process and final best practices in English)**.

The structure of the report should follow a broad classification into the following parts:

- **Main report:** The main report shall present, in full, the results of the analyses and conclusions arising from the study. It must also contain a description of the subject evaluated, the context of the study, and the methodology used (including an analysis of its strengths and weaknesses).
- **Annexes:** These must collate the technical details of the study, and must include questionnaire templates, interview guides, any additional tables or graphics, and references and sources.
- The report shall not exceed the number of pages mentioned in the 4.1 section.

Final Report

The final report follows the same format as the draft final report. Furthermore, it is accompanied by an **executive summary** (synthesis of analyses and conclusions), of no more than 15 pages. Each of the eight issues (Q1 to Q8) will be addressed within a maximum of one page.

The executive summary summarises the study's main conclusions, the main evidence supporting them and the recommendations arising from them. After being agreed with the Commission Services, it should be translated into English and French by a certified professional translation agency.

The document must take into account the feedback from the steering group on the draft final report, insofar as these do not interfere with the autonomy of the contractor in respect of the conclusions they have reached and the recommendations made.

The contracting authority will publish the final report, the executive summary, the abstract, the annexes on the Commission's central website.

In view of its publication, the final report by the contractors must be of high editorial quality. In cases where the contractor does not manage to produce a final report of high editorial quality within the timeframe defined by the contract, the contracting authority can decide to have the final report professionally edited at the expense of the contractor (e.g. deduction of these costs from the final payment)."

The contractor will establish robust means to ensure the reliability, validity, and comparability of the information collected as well as its analysis and of its reporting.

The Commission's shall assess the quality of the final report on the basis of the quality assessment criteria defined in annex VI.

Progress Reports

No progress reports are required but any delay in delivery of the reports or major difficulties shall be reported to the Commission as well as possible options to mitigate them.

Organisation, timetable and budget

Organisation

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The contract will be managed by Unit G2 – Animal welfare sector of the European Commission's Directorate-General for Health and Food Safety.

Meetings

It is expected that the contractor participates in three meetings in Brussels with the steering group/official in charge. For these meetings, **minutes should be drafted by the contractor**, to be agreed among the participants.

Timetable

The starting date is the date on which both parties have signed the specific contract. The period of execution of the contract is **eight months**.

The following outline work plan and indicative timetable are envisaged:

Month after signature	Reports	Presentation in Brussels	Deliverables	Payments
1	Kick-off meeting and inception report	Yes	Deliverable 1	No
4	Interim report	Yes	Deliverables 1+2+3	Yes
7	Draft final report	Yes	Deliverables 1+2+4	No
8	Final report	No	Draft final report approved	Yes

Budget

The estimated maximum budget for the study of the action, covering all the results to be achieved by the contractor as listed above, is within the band **EUR 150.000 to EUR 200.000**.

Tenders exceeding this estimated maximum budget shall be automatically rejected.

Award formula

The weighting of the award formula shall be 40/60 whereby price shall count for 40% and quality for 60%.

$$\text{score for tender X} = \frac{\text{cheapest price}}{\text{price of tender X}} * 100 * 40 \% + \text{total quality score (out of 100) for all award criteria of tender X} * 60 \%$$

References

Basic documents

- Commission activities
- http://ec.europa.eu/food/animals/welfare/practice/farm/pigs/castration_alternatives_en
- Study/questionnaire
<http://porcinehealthmanagement.biomedcentral.com/articles/10.1186/s40813-016-0046-x>. FVE:

- EU COSTS Project: Innovative approaches in pork production with entire males: http://www.cost.eu/COST_Actions/ca/CA15215

Documents and information to be provided after contract signature (not exhaustive)

- List of possible stakeholders and contacts

Requirements

Resources

The contractor shall ensure that experts are adequately supported and equipped. In particular, sufficient administrative, secretarial and interpreting resources, as well as junior experts, must be available to enable senior experts to concentrate on their core study tasks.

One member of the team must demonstrate work experience of at least four years at EU level in drafting of best practices, performing stakeholders' consultation and having knowledge on animal welfare issues related to the sectors covered by the scope.

The members of the team will be constituted of at least two experts with at least four years of scientific or technical experience in the welfare of pigs in order to analyse and sort the information collected.

Absence of conflict of interests

The contractor shall ensure that both their organisation and the individual experts proposed for this study are not in a situation of conflict of interest regarding this specific assignment, and shall include a declaration of absence of conflict of interest (Annex IV) as part of their offer.

Annex 2 Data collection protocol

The purpose of this task is to collect information on best practices regarding **production, the processing and the marketing of meat from uncastrated or immunocastrated pigs**.

Scope: practices need to be implemented in **commercial settings**: there should be evidence that **at least one** food operator (farmer, slaughterhouse, processor, or retailer/food service) is using the practice for its commercial operations. The target stakeholder groups and issues to be addressed by data collection are listed in the table below:

[Table to be tailored for each country, as some issues are not relevant to all countries]

Target audiences	Meat from uncastrated pigs	Meat from immune-castrated pigs
Farmers	Q1- Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)	Q2- Techniques and best practices to use immunocastration in various type of pigs Q3- Techniques and best practices to ensure to slaughterhouses that immunocastrated pigs do no present detectable boar taint
Slaughterhouse operators	Q4- Techniques and best practices to detect boar taint, quantify and manage positive carcasses	Q5- Techniques and best practices to trust farmers that immunocastrated pigs do not contain detectable boar taint
Food processors	Q6- Techniques and best practices to quantify and deal with meat with detectable boar taint	Not relevant
Retail and food services	Q7- Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served.	Q8- Techniques and best practices to increase the acceptance of meat from immunocastrated pigs among consumers and to prevent meat with detectable boar taint to be on the shelves or served.

More details of the areas to be investigated for each of these questions is provided in the data collection form.

Types of information sources: information sources may be of different types. It is expected that most information will be provided by businesses / individuals on the phone or through emails. It may also include websites, reports, guides, quality standards, and training material. Please reference all materials found in the data extraction forms.

Forms – please summarise the information found in the data collection forms provided separately. Please complete all the forms electronically; do not print them.

Modus operandi

Desk research – report all sources you are aware of, or are able to identify through your own research online; Secure copies of the material you reference in the data collection form, either digital or physical copies.

Consultation of country experts and stakeholders – a representation letter from the European Commission is provided separately, and can be used when contacting stakeholders.

When contacting stakeholders, consider relying on your professional network or that of the study team. This will increase the likelihood that information of good quality is sent back by stakeholders.

Field visit – with the Project Manager's agreement, a good/best practice may be witnessed in the field

Annex 3 List of presumptive good practices to be included in the data collection template

Stakeholder group	Question	Areas to be explored
Farmers	Q1 - Meat from uncastrated pigs: Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)	Feeding • Chicory root • Potato starch • Tanin extract • Pueraria lobate (kudzu root) • Non-nutritive adsorptive materials • Rye Flooring and housing • Floor types • Temperature • Density • Cleanliness • Enrichment • Sex separation during rearing Breeding • Use of specific low-taint breeds (such as Pietrain) • Use of new techniques developed by breeding organisations Early detection • Use of behavioural or physical characteristics to predict boar taint on-farm Organisation of slaughter operations • Selection for slaughter at a young age • Selection for slaughter at a specific weight
	Q2 - Techniques and best practices to use immunocastration in various type of pigs	Posology and administration of vaccine • Use of three injections for larger pigs • Administration techniques for heavier animals Equipment for large-scale vaccination
	Q3 - Techniques and best practices to ensure to slaughterhouses that immunocastrated pigs do	Checking that immunocastration has worked (on farm) • Use of physiological indicators

	not present detectable boar taint	• Use of behavioural indicators Supply chain assurance • Recognition of immunocastration by certification schemes
Slaughterhouse operators	Q4 - Techniques and best practices to detect boar taint, quantify and manage positive carcasses	On-line assessment (large slaughterhouses) • On-line chemical detection techniques • Colorimetric method to measure skatole equivalent • PTR-TOF-MS technique • Other fast GCMS techniques • Human nose method • Hot iron • Hot fans • Pyroopen/open flame Off-line assessment (small slaughterhouses) • Human nose method • Microwave • Hot water method • Soldering iron Consistency • Smell test and training for assessors • Techniques to avoid smell habituation • • Quantification of positive carcasses • Image capturing technologies • Pig classification systems Management of positive carcasses • Systems for monitoring complaints • Identification of markets for boar meat
	Q5 - Techniques and best practices to trust farmers that immunocastrated pigs do not contain detectable boar taint	Quality control techniques • Sample testing • Systems for monitoring complaints
Food processors	Q6 - Techniques and best practices to quantify and deal with meat with detectable boar taint	Dealing with meat with detectable boar taint • Curing • Smoking • Diluting

		• Use of spices / masks • Techniques to strip fat from meat • Use in PDO products • Injection of brine • Fermentation • Thermal treatment
Retail and food services	Q7 - Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served	Marketing techniques Food labelling Supply chain audits Buyer checks Supplier requirements • Requiring all pork suppliers to raise entire males
	Q8 - Techniques and best practices to increase the acceptance of meat from immunocastrated pigs among consumers and to prevent meat with detectable boar taint to be on the shelves or served	Content of communication to consumers Communication tools Supply chain audits Buyer checks Supplier requirements • Requiring all pork suppliers to use immunocastration

Annex 4 Model for the data collection template

Draft data recording template – an example for Q1: techniques and best practices to reduce boar taint through management techniques (feeding, breeding and organisation of slaughter operations). The actual data collection template is in the form of an excel spreadsheet.

Area	Feeding
Presumptive best practice description	Diet option 1
Source	Farm association (phone call on XX/XX/2017) Additional documentation received by email on XX/XX/2017
Evidence of use in commercial operations	Confirmed use in XX, number of farms known to use this diet: ... Quality of the evidence: ...
Rationale for qualifying the practice as “best”	Evidence on boar taint prevalence in entire males fed this diet: ... Quality of the evidence: ... Source of the evidence: ... Other relevant evidence: ...
Area	Breeding
Presumptive best practice description	Genetic selection procedure 1
Source	Individual expert in pig breeding, called on XX/XX/2017
Evidence of use in commercial operations	One confirmed case in ... Quality of the evidence: ...
Rationale for qualifying the practice as “best”	Evidence on boar taint prevalence in pigs selected: ... Quality of the evidence: ... Source of the evidence: ... Other relevant evidence: ...
Area	Organisation of slaughter operations
Presumptive best practice description	Slaughter of males under XX months of age
Source	Report title Published ...
Evidence of use in commercial operations	Confirmed use in country Y, number of farms known to schedule slaughter at that age: ... Quality of the evidence: ...
Rationale for qualifying the practice as “best”	Evidence on boar taint prevalence in entire males at the time of slaughter: ... Quality of the evidence: ... Source of the evidence: ... Other relevant evidence: ...

Annex 5 Consultation – Feedback received from the European Commission and through the online platform

Table 11. Cross-cutting

Comment	ICF response
In term of the structure of the chapter, I would rather group Questions addressed to farmers (Q1 to 3) then to slaughterhouses and food processors (Q4 to 6) and then retailers (Q7 and 8). To keep the logic, you should first introduce Deliverable 3 in general before going to specific, explaining the general structure of the text.	An introductory statement was added and the structure of the section was rearranged.
Quantitative data is lacking for some practices, e.g.: data is lacking on the quantification of positive carcasses (Q4) and meat with detectable boar taint (Q6). The report should better explain the reasons for these gaps.	The “State of play” section of the report has been revised to clearly identify data gaps, and the reasons why data was not available.
A way to simplify the title might be to make some short title like: Q1 Farms/uncastrated pigs /management techniques; Q2 Farms/immunocastrated pigs/vaccination; Q3Farms/ immunocastrated pigs/detection of pigs not properly vaccinated; Q4 Slaughterhouses/uncastrated pigs/Detection of boar taint; Q5 Slaughterhouses/immunocastrated pigs/Detection of pigs not properly vaccintated; Q6 Slaughterhouses/uncastrated pigs/use of positive carcasses; Q7Retailers/uncastrated pigs/promoting meat; Q8 Retailers/immunocastrated pigs/promoting meat.	The titles have been simplified.

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[Regarding the disclaimer] This is fine but use of editing to make it more visible. I wonder if we should not also put this disclaimer at the back of the cover page.	Disclaimer highlighted by using bold text
The further reading section is a good idea but unfortunately very rare while the text in many instances of this section remains relatively general. More details might conflict with the conciseness of the text. However, since the purpose of best practices is to give the reader the opportunity to change his/her practices, you should provide more specific and detailed references possibly in a well organised annex (i.e. by topics as presented in the text). This is definitively missing in the report.	An annex including sources organised by topic area has been included.
You may find attached the 4 documents with my suggested changes in red; the most important is trying to prevent the use of "immunocastration" for broader audiences, because general public confuses with chemical castration, and the word castration still seems the mutilation of the pig, which is not the case. We think is fair to explain what it truly is: immunization (or vaccination) against GnRF, which results in suppression of sexual activity and consequent boar taint in males.	Text revised – although some references to immunocastration have been kept, as this is also commonly used as a term referring to the vaccination

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Table 12. Q1 - Techniques and best practices to reduce boar taint through management techniques (including feeding and breeding)

Comment	Relevant topic	ICF response
I have different remarks about the paragraph 1.5 on Commercial feed designed to reduce boar taint. Firstly, the product mentioned (called TAINSTOP) is based on three main nutritional pillars: the use of fibers which allows to decrease skatole production of the hindgut microbiota by influencing the fermentation pattern, the use of natural additives which support the metabolism of the animal and an optimal balance between dietary protein parameters and specific fiber fractions. Therefore, TAINSTOP is a feeding concept more advanced than chicory alone. Secondly, this product is really efficient because it reduces highly significantly skatole levels (0% of samples with TAINSTOP feeding are above the cut-off level of sensorial detection) and it decreases numerically androstenone quantities. Moreover, it has to be given to boars just 2 weeks before slaughter. Thirdly, about the cost, it can be more relevant to compare the production cost between castrated pigs fed normally and boars fed with TAINSTOP than only to compare the cost of feeding. Indeed, TAINSTOP enables an additional revenue with a better carcass value, a better feed conversion index, a saving of anaesthetic and veterinary costs, time savings, and a saving on manure costs. There is also an additional feed cost for 2,2kg intake/pig/day for 14 days but the breeder can still expect a net profit per boar compared to castrated pig. Finally, there are other advantages with this commercial feed: it obviates castration and injection or manipulation on the pig, it improves animal welfare, it reduces the preventive use of antibiotics, it reduces nitrogen emissions in the environment and it enables to share a positive message for the consumer.	Feeding – commercial feed designed to reduce boar taint	No additional details on TAINSTOP have been added, however the section does mention that TAINSTOP combines many different feeding techniques to address boar taint.

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Remarks. New Danish results have shown that feeding a diet with chicory for 3 or 4 days has the same effect in reducing skatole as feeding for 2 weeks. This reduces the feed cost remarkably. Further feeding pure grain for 3 days has given a significant reduction in skatole around 50%, which is even cheaper. Jerusalem artichoke is also efficient in reducing skatole but not realistic to add to commercial diets (at the moment). No effect is seen on the level of androstenone. http://svineproduktion.dk/publikationer/kilder/lu_medd/2015/1055 (so far only in Danish). Just published Danish results has shown that selection of fathers with a low level of androstenone measured in biopsies from the neck can reduce the androstenone level remarkably. There were no effect on skatole. http://svineproduktion.dk/publikationer/kilder/lu_medd/2018/1138 (so far only in Danish). The level of androstenone increases linear with the weight from 60 to 120 kg liveweight. Results from a trial where biopsies were taken on the same male pig with an interval of 10 kg. http://svineproduktion.dk/publikationer/kilder/lu_medd/2017/1102 (so far only in Danish). All results have been presented at meetings in IPEMA.	Breeding, Feeding, Scheduling of slaughter	A reference to a shortened period for chicory use has been added. No mention was included of using biopsies for breeding as this does not appear to be used in commercial practice yet.
I have 3 remarks – breeding: it is possible to select boars with lower boar taint within a breed with the oestradiol level from a blood sample (Prunier and al., 2016) - sex separated rearing is not recommended for sanitary reasons due to over mixing piglets. By comparing mixing and separated rearing we have no effect on boar taint level if pigs are reared with good practices - it is more important to talk about slaughter age than slaughter weight to manage the boar taint	Breeding, Early detection, Flooring and housing, Scheduling of slaughter	Regarding breeding: This has not been included as selection based on blood samples does not appear to be a commercially-used practice at present. Regarding sex-separation: ICF's understanding is that different farmers have had very different experiences with sex separation and it is common practice in some countries but not others. The practice remained included in the drafts, but the differences in experiences were emphasised.

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		Regarding slaughter age/weight: Selection based on weight has been removed from the drafts as a best practice, although the use of weight cut offs will still be discussed.
I believe strongly in the possibility to lower boar taint levels by breeding and selection. It is possible to lower boar taint levels in all breeding lines of a breeding program, without harming economical genetic progress in general. It already implemented in specific breeding programs. generation by generations levels go down already. Also it is possible to sort boars on base of breeding values for boar taint levels to create special terminal boars to produce progeny with lower boar taint levels. This system is available and was proven it works. The problem in the market is that there is no incentive for producers to apply these special breeding lines (higher price for semen), because slaughter houses do not pay a bonus for low boar taint or put a penalty on high boar taint. If a bonus.malus system is implemented in slaughterhouses for boartaint the producers will start using boar taint low breeds and lines and we will move into the direction of lower boartaint. So implement a bonus system in slaughterhouses will be the best way to motivate the producers and breeding can solve the problem. Also this will stimulate the change of management on the farms with too high level to adapt hygiene and feed regimes etc.	Breeding, Bonus/Malus (Q4)	More details have been added regarding options for practices related to breeding. In addition to breeding, this comment also points to the need for cross-supply chain analysis. This is being addressed in the State of Play section of this report.
Under section 2.4, the following text is included: Low stress environments Good practices include: - Keeping a low animal density (recommendations differ depending on pig weight: at least 0.75 m2 per pig for pigs between 85 and 110 kg; at least 1 m2 for pigs above 110 kg). - Ensuring temperature control and proper ventilation. - Keeping pigs clean and dry.	Low stress environments	This has been revised to reflect that the figures provided only indicate the legal minimum. A more qualitative indicator has been included in the text regarding space allowances. Information on enrichment has also been revised, based on input from this comment and previous guidance published by the European Commission.

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- Providing enrichment, such as: balls on chains, hanging plastic pipes, wood and branches, straw in racks or as bedding. Enrichment objects that are destructible, edible and encourage rooting are most effective. This helps keeps boars calm and occupied. The space allowance quoted in the first bullet point for pigs over 110kg is the minimum required under EU legislation. Therefore, it is difficult to see how this can be described as 'good practice'. 'Good practice' should go above and beyond the basic minimum. The examples of enrichment suggested includes balls on chains and hanging plastic pipes. Whilst the paragraph goes on to say that enrichment objects that are destructible, edible and encourage rooting are best, including these non-destructible and non-edible materials appears to give credence to their use as acceptable materials. In addition, the Commission itself states that, in addition to being destructible and edible, materials should specifically also be 'investigable' and 'manipulable', categorising materials according to how many of these criteria a material fulfils. Under the Commission's own guidance and recommendations, these items would be classed as 'items of marginal interest' and should not be considered as fulfilling a pigs essential needs and therefore 'optimal' or 'sub-optimal materials' should also be provided where these are used. It would be useful to expand on these issues in this paragraph.		
I attached to this email a grafic of the different protein needs of boars and gilts. That is why you need different feed to get the best results. And it is also profitable to keep boars and gilts separate so you can give them a different diet. We made a flyer in The Netherlands about the behaviour of boars. I attached both documents. With this project we wanted to describe the best practices.	Feeding, flooring and housing	More information on protein needs and boar behaviour from the leaflet provided has been included in the guidelines.

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So it would be useful for other countries, slaughterhouses and farmers to use this information. I do not see this back in all the papers you have written at the moment. It is not about science but about using science in practice. It is a pity that you don't describe some cases. For instance the case of Cooperl in France from farmer to consumer, the case of VION in The Netherlands etc. Then you get a more integrated view that can be used by other parties.		
[On feeding protein-reduced diets four days before slaughter] To the best of my knowledge this is a research result from Hanne Maribo, and not a best practice, unless you have results from commercial farms that do use this already for a longer period. [On low protein diets leading to a slower growth rate] Already within four days?	Feeding – protein-reduced diets	This practice received positive feedback during the Advisory Board meeting and appears to be used in practice. Disadvantages related to this practice have been removed from the final version.
[On feeding with adjusted amino acids] Do we have farms with experience on this as a best practice?	Feeding – adjusted amino acids	Yes, ICF found evidence of this being used in practice. It is also recommended in guidelines produced by Wageningen.
[On commercial feed] Do they sell it to many farms, with the costs mentioned below?	Feeding – commercial feed designed to reduce boar taint	It is not clear how many farms this is sold to, but it is commercially available and we received evidence of it being used. As the feed is only provided in the period immediately before slaughter, additional costs only apply to that period.
Do not mention fully slatted floors, it is forbidden and therefore not a best practice	Slatted floors	Slatted floors has been removed as a practice and included within a section on 'Keeping pigs clean and dry'.

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I would state that dry floors keep pigs clean and dry [as opposed to slatted floors, under Advantages]		
[Regarding differing evidence for sex-separated rearing] This is correct: some report on this as a best practice and others just the other way round.	Sex-separated rearing	The variety of experiences related to sex-separated rearing has been elaborated on in the text.
Also smaller group size: large groups have higher risks	Low-stress environments	This has been added to practices under 'Low-stress environments'.
[Regarding reference provided] This information is so old: why did you not take a look at the annual report of Topigs Norsvin in which they report on the realized reduction in boar taint prevalence with genetic measures: the report is on the internet. We want to know about recent best practices, and not about what a researcher did write almost ten years ago	Breeding, scheduling of slaughter	References to studies have been removed from the final document. Where appropriate, these have been replaced with references to existing guidance or to examples of where transitions have already occurred.
This whole section has hardly to do with best practices. This is all theory that is not applied in practice.	Scheduling of slaughter	The scheduling of slaughter section has been amended to focus on slaughtering by a certain age, and discussing the various issues related to this, based on discussions at the Advisory Board Meeting.
[Regarding differentiating between quick and slow growers] This has nothing to do with boars. We do this also with castrates.	Selection for slaughter at a specific weight	This section has been removed from the draft.

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Do slaughter companies not mention more on this? Temperature, ease of handling, ?	Transport to the slaughterhouse	The section on transport has been removed from the final version of the best practices due to insufficient evidence on how transport impacts on boar taint
[On further reading] We are not interested in many issues but in the few best practices that work [On Civic Consulting resource] This report has nothing to do with best practices	Transport to the slaughterhouse	The section on transport has been removed from the final version of the best practices due to insufficient evidence on how transport impacts on boar taint
When referring to feed, be more specific and provide the latin name of the plant as well as the way it is used (which forms?)	Chicory root	The Latin name has been included in the text.
Again this is too vague to be practically useful see previous comment.	Protein-reduced diet	Additional details have been added to the text.
Again too vague. Good teaser but what do I do if I want to try this "best practice"?	Diet adjusted for amino acids	Additional details have been added to the text.
Again vague, please provide brands or feed manufacturers names...	Commercial feed designed to reduce boar taint	Brand names have been added to the text.
Again a bit too vague; Which Member States?	Slatted floors	References to specific Member States have been added.

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[Regarding practicality] What do you mean?	Sex-separated rearing	Further explanation has been added in the text.
This is not low density, it is the minimum requirement of the pig directive... Check with Directive 2008/120/EC	Low-stress environments	This section has been amended to indicate that the recommended figures are legal requirements and has provided a more qualitative indicator for ensuring pigs have enough space.
Again lack of references while there a detailed Commission Recommendation + staff working document + various educational materials produced by the Commission!! See https://ec.europa.eu/food/animals/welfare/practice/farm/pigs/tail-docking_en	Low-stress environments	This reference has been included in the text.
Any practical template to implement this method, (check list, etc.)	Early detection	Early detection has been removed from the draft as stakeholders indicated during the Advisory Board Meeting that this was not a feasible practice for entire males.
[Regarding "Farmers should regularly look for these signs and take decisions accordingly"] Be more specific.	Early detection	Early detection has been removed from the draft as stakeholders indicated during the Advisory Board Meeting that this was not a feasible practice for entire males.
[Regarding "farmers may choose to slaughter pigs before a certain age."] This is very very unprecise !!	Selection for slaughter at a young age	Decisions about scheduling for slaughter may be constrained by market requirements: for example, certain slaughterhouses may require a certain weight range for commercial reasons. These requirements may differ across

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		slaughtering plants. These observations limit the possibility to include precise ages at slaughter that would be broadly applicable in the EU pig industry. These limitations have been clarified in the text of the document.
[Regarding "Switching from an open system to a closed one may require significant resources."] Not very clear what is an open system and why this may require significant resources. Which ones?	Transport to the slaughterhouse	This disadvantage has been removed from the final version following review by a team expert.

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Table 13. Q2 - Techniques and best practices to use immunocastration in various type of pigs

Comment	Relevant topic	ICF response
Weight gain with Improvac. This is frequently quoted as a positive side effect or consequence which for the product of fresh pork would be a potential benefit. However, for larger or heavy weight pigs used to produce Continental Charcuterie (e.g Parma Ham, min 165kg slaughter weight & 9 months age); this would be a negative as potentially the legs would be too lean (insufficient fat) to meet the requirements of the Parma Ham PDO. From the research we have conducted in Italy with Improvac for Parma Pigs we were often using 4 vaccinations; experienced health issues with the animals at the vaccination site in the neck and had to adapt diet to slow the growth of the animal. A completed protocol with number of vaccinations and adapted diet that produces equivalent raw material to that of castrates has yet to be completed and trial work continues.	Weight gain and improvac	The issues have also been confirmed by ham producers. The 4 vaccinations protocol therefore cannot be considered a best practice.
There are some challenges with the effectiveness of immune-castration and specific breeds of males in preventing sexual development and taint. We have seen poor results when researching immune-castration with both Iberico males and Calabrian black pig. We have also been advised that immune-castration is not as effective with Duroc breed.	Immunocastration & genetics	Additional evidence was requested from the consultee but was not received. Other evidence gathered for this study, and feedback from other consultees suggest that the main issue associated with immunocastration is the potential incorrect administration of the vaccine, rather than the pig's breed. Therefore these observations have not been included in the best practice documents.

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The documentation makes no reference to replacing spraying of Iberico gilts (free range system) and use of immune-castration. We have demonstrated that immune-castration can be used for Iberico gilts.	Gilts and immunocastration	The study focusses on male pigs; castration of gilts is outside of the scope of the practices.
Edits to text indicated in red: The vaccine may be administered by farmers, or by others (such as external vaccinators trained and certified by vaccine suppliers), depending on the preferences and commercial arrangements of each farm. The vaccination requires the injection of two doses, occurring at different times of the pig's life. The first injection is done as early as eight weeks of age and has no physiological effect; the second should be given at least four weeks after the first. The second injection should occur within four to ten weeks before slaughter as the effect needs sufficient time to develop and is temporary, waning over time. The substances responsible for boar taint (mostly androstenone and skatole) decrease significantly two to three weeks after the second dose. Meat from vaccinated pigs can be safely eaten at any time after the vaccination, as the approved withdrawal time is zero days. An additional injection might be applied if pigs are observed to be non properly immunized (for example, if the size of the testes remains unchanged, or there is boar behavior)¹. At the beginning, farmers usually give a third dose to 3 or 4% of the pigs. When farms are well experienced and confident with the use of the vaccine, and staff receive regular training on vaccination, the proportion requiring a third dose may be as low as 0.3% of pigs. ... Farmers may adapt the timeline according to their needs (for example, based on specific characteristics of their production process, or according to slaughterhouses' requirements on market weights). ... It is injected subcutaneously under the skin behind the pig's ear (see picture below: the red mark indicates the correct site where the vaccine should be	Vaccination process	Text revised – the wording "vaccination (against boar taint)" has been used throughout

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injected). The person administering the vaccine should calmly enter the animal's pen and inject the dose with a special dosing gun (see below). ... The preparation, maintenance and cleaning of the special vaccination syringe;		
The vaccine reduces pigs' aggressiveness towards other pigs, which happens as they sexually mature during the finishing phase. Farmers may choose to vaccinate pigs as to benefit from these positive behavioural effects in comparison with the production of entire boars. ... Advantages ☐ Vaccination minimises undesirable pig behaviour, such as mounting and aggressiveness. This is beneficial to animal welfare and may also improve carcass quality. Disadvantages ☐ The time between the second dose of the vaccine and the slaughter should not exceed 10 weeks; if this happens, a new dose of the vaccine should be administered 4 to 10 weeks before slaughter to secure absence of boar taint in carcasses.	Early vaccination	Text revised as suggested, with the exception of text on the comparison with non-castration (as comparison between merits of immunocastration and non-castration are out of the scope of the documents)
Some farmers choose to administer the first dose as late as possible, to reduce the chance of individual animals not being treated. The interval between doses should be at least 4 weeks, and pigs should be slaughtered between 4 and 10 weeks after the second dose.	Late vaccination	Wording revised as suggested
Disadvantages If the technique is not properly executed, there may be animal welfare concerns, such as stress and risk of abscesses associated with the additional vaccination	Use of three injections for larger pigs	Wording revised as suggested

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Before the second dose of the vaccine against GnRF, pigs are fed the same way as entire males. ... For example, the average quantity of feed eaten daily by common breeds of pigs may be increased by 20% after the second dose. On a daily basis, this results in a weight gain approximately 5% higher than entire males. Advantages ☐ Vaccinated pigs grow faster and reach their slaughtering weight earlier than entire males. Overall, this can result in less time for vaccinated pigs to reach the market weight (not affecting their feed efficiency as the grow fast).	Feeding of immunocastrated pigs	Text revised; the wording "vaccination (against boar taint)" has been used throughout
The vaccine against GnRF can have the same effects in humans as in pigs. For this reason, it is necessary to avoid the risk of accidental self-injection. A special syringe (also called dosing gun – see picture below) should be used to administer the vaccine. This tool has a several safety mechanisms: the needle is protected, and it is only activated once the gun is pressed against the pig's body and the trigger is pulled.	Dosing gun	Wording revised as suggested
"The second injection should not occur within four to five weeks of slaughter as the effect needs sufficient time to develop." the above highlighted statement is not correct. The second vaccination should occur 4 to 6 weeks prior to slaughter and pigs should be send to slaughter latest 10 weeks after second vaccination or else be given a third vaccination (eg Parma or Iberico production). The European regulatory authorities have approved this vaccination schedule based on a significant dataset resulting from pivotal scientific studies. Maybe the statement is only a typo and should read ' the second injection should occur withing four to five weeks of slaughter...' In that case, there is only a small incorrection in that the registration dossier stipulates 4 to 6 weeks prior to slaughter instead of 4 to 5 weeks. This should also be corrected in the drawing of the schedule. The drawing is otherwise correct.	Vaccination process	Timeline revised as suggested, also consistently with feedback provided by vaccine suppliers

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"On average, between 3% and 4% of pigs may need a third dose. When farms are well experienced with the use of the vaccine and staff receive regular training on vaccination, the proportion of pigs requiring a third dose may be as low as 0.3% of pigs." This is an important statement and explains the confusion about so called 'non-responders': animals given both doses of vaccine correctly respond in virtually 100% of cases as is substantiated by a large volume of published studies. Therefore, in virtually all the cases in which animals do not respond, it is not due to the application of the vaccine, but rather due to the 'non-application' of the vaccine, and this explains the need for adequate training of the vaccine-administrators and explains why good administration combined with good certification (documentation) can ensure the slaughterhouses and retail of non-tainted pork product.	Vaccination process	These observations have been further emphasised in the best practice documents.
"With early vaccination there is an increased risk of individual animals not being treated as they are smaller at the time of the first vaccine and it may be more difficult to differentiate between piglets which have been vaccinated and those which still have to receive their dose. Some carcasses may therefore present boar taint." This is not correct: the system of vaccination of younger pigs is exactly the same as for older pigs. The vaccinated pigs receive a colour mark to distinguish them from the non vaccinated pigs. The only difference is that the smaller piglets have more space to run around, so you may have to use a handling board as is described higher, and you may have to 'bend your back' a little more to reach them, but vaccination should only start when the pigs have stopped running and group together in one side of the pen so that they can easily be reached. When done properly, there is no difference in accuracy between first and second vaccination.	Early vaccination	The text has been revised as suggested.
"Some farmers choose to administer the first dose as late as possible, to reduce the chance of individual animals not being treated." This is not a correct argument for later first vaccinations. There is a lot of flexibility for the timing of the first vaccination, so farmers can choose to vaccinate earlier or later depending on their time management. (The first vaccination only primes the	Late vaccination	Text revised as suggested.

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immune system, and does not have any other physiological effect.) I will elaborate on advantages and disadvantage of later or earlier vaccination below		
"Late vaccination may help ensuring that an increased proportion of pigs are correctly vaccinated" This is not correct (any data to substantiate this statement?) Examples for relevant advantages for late first vaccinations are: if piglets had to travel long distance between the nursery house and the fattening site, it is better to let them rest for a week and reduce their stress levels before starting to vaccinate. Another reason can be to streamline work-efficiency and have the first vaccination of a new batch fall at the same day of the second vaccination of an earlier batch.	Late vaccination	Text revised as suggested.

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Table 14. Q3 - Techniques and best practices to ensure to slaughterhouses that immunocastrated pigs do not present detectable boar taint

Comment	Relevant topic	ICF response
[Regarding “pig species”] Breeds?	Visual assessment of testes	This practice was considered by stakeholders to be ineffective at identifying at-risk pigs and will be removed from the final version.
[Regarding figure] Always provide a title to the picture and a numbering system like Figure x – visual assessment of the testes Regarding the drawing: provide picture of pigs with an ENTIRE tail since routine tail docking is prohibited by the EU legislation.	Visual assessment of testes	This practice was considered by stakeholders to be ineffective at identifying at-risk pigs and was removed from the best practice documents.
This document provides good practice examples that can be used by farmers to provide slaughterhouses assurance that pigs immunized or vaccinated to prevent boar taint do not present detectable boar taint. ... Farmers may inspect pigs on-farm, before sending them to the slaughterhouse, to verify whether the vaccination protocol was administered correctly. Additionally, it is good practice for farmers to keep records of vaccination and control procedures. Farmers may share this information with slaughterhouses to demonstrate that they are following the right quality assurance procedures.	Introduction	Text revised; the wording “vaccination (against boar taint)” has been used throughout
Figure 1. Example of potential testes’ size reduction as a result of vaccination	Visual assessment of testes	This practice was considered by stakeholders to be ineffective at identifying at-risk pigs and was removed from the best practice documents.

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Farmers may include information on the QA of vaccination process in their standard pig transport documentation, to share with slaughterhouses. ... Farmers may add the following details on vaccination: ☐The number of immunized males; and ☐A confirmation that vaccinated pigs have been checked prior to slaughter, and that farmers have identified pigs which are suspected to present boar taint (if any). Farmers may wish to share with slaughterhouses an additional document (vaccination declaration), with details on the vaccination process: ... ☐The number of immunized pigs sent for slaughter. A sample template for the vaccination declaration is presented below. Figure3.Example of a template for the vaccination declaration Documentation on vaccination is generally paper-based. ... It is also possible to transmit data on vaccination procedures followed with an electronic system. This system can be accessed in real time by several people, including those responsible for the administration of the vaccine, the farmer, the vaccine supplier, and the slaughterhouse staff. This system simplifies the tracking and verification of proper vaccination data. ... The vaccination declaration enables to identify the person who administered the vaccine.	Documentation	Text revised; the wording "vaccination (against boar taint)" has been used throughout
"Sexual behaviour may sometimes be confused with dominance behaviour: to establish a hierarchy in a group, for example, some pigs may try to mount other pigs. Dominance mounting is shorter and less frequent than sexual mounting.		A statement has been added to the best practice doc that this becomes a routine task when trained.

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Dominance behaviour does not necessarily indicate that the pig has not been correctly vaccinated.” remark: this is correct, but as is stated, the trained eye can make the difference between dominance behaviour and sexual behaviour. Farmers are with the pigs every day and are even required by European legislation to observe their pigs on a daily basis. When trained for the signs, it becomes a routine job to identify pigs that may have missed a dose.		
“The reduction in testes size may vary across pigs and pig species; this may make it more difficult to correctly identify pigs who may have not been correctly vaccinated. For example, the size reduction in Iberian-Duroc cross-bred pigs is higher and more homogeneous than in white pigs.” remark: an important sign and more reliable indicator than the ‘size of the testes’ is the size of the epididymis. This organ is empty of active spermatozoa and therefore hardly visible in the vaccinated animal, leaving two ‘cavities’ in the scrotal sac. This is a tell-tale for compliantly vaccinated boars.		Visual assessment of the testes was considered by stakeholders to be ineffective at identifying at-risk pigs and will be removed from the final version. A follow-up question was sent to the stakeholder regarding evidence of the commercial use of epididymis checks.

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Table 15. Q4 - Techniques and best practices to detect boar taint, quantify and manage positive carcasses

Comment	Relevant topic	ICF response
DMRI has developed an analytical method that can be used to analyse skatole and androstenone on a small fat biopsy taken from the carcass. The method uses laser diode thermal desorption mass spectrometry (LDTD-MS/MS) and is in compliance with the EU's reference laboratory method, which also uses mass spectrometry. The newly developed method makes it possible to perform a rapid, selective and quantitative analysis. Through further automation of the method, equipment installed at a slaughterhouse will be capable of analysing up to 2,800 fat samples per day. The same method has been set up in DMRI's laboratories. For further information: boartaint.dk	On line detection techniques	It does not appear that this technique has been used yet in commercial practice, and is therefore out of scope.
It is an error to consider that the carcass weight is an issue to avoid boar taint. Depending to the growth rate, there are light carasses (from older pigs) whith boar taint. That is better to think about slaughter age by asking to the farmer to manage the slaughter age.	Weight and age at slaughter	Weight appears to be the most commonly used threshold by stakeholders. This issue will be discussed at the stakeholder meeting and with experts.
We have a policy that if an animal is <120kg live weight at slaughter then we do not castrate or if castrated as farmers to change to non-castrated. We have a number of farms in Holland where pigs are being finished at 130kg and left entire.	Weight and age at slaughter	The document has been edited to reflect that age is more important than weight.

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[Regarding hot water method being used in smaller slaughterhouses] Did you interview a slaughter company doing this? If not, do not mention it as a best practice that has been reported to you. [Regarding hot water being a validated method] By the retailer?	Hot water method	This practice was confirmed by one expert and one slaughterhouse. The reference to validation refers to work done by the DMRI. Reference to this has been deleted, however, as it is unlikely to be understood by the end user.
[Regarding further reading section] We are talking about best practices that have been used in very recent years: Using a leaflet from 2011 is annoying. We need experiences from companies, no summing up of old leaflets.	Hot water method	References to studies have been removed from the final document. Where appropriate, these have been replaced with references to existing guidance or to examples of where transitions have already occurred.
[On instrumental method being used commercially] I really doubt this: if yes, how is it claimed that it is a best practice? Are we talking here about the old Danish method? What arguments can you provide that this is a succesful best practice. To the best of myy knowledge it was a complete catastrofic adventure. The reason for not becoming accepted was - among others - that it did not include androstenone.	Instrumental methods	The section on instrumental methods has been removed from the final version.
[On penalties] I do not think that there is one single penalty system for boar taint prevalence in operation. They charge a premium to the farmer, but independent of the boar taint prevalence. [On penalties being applied if boar taint indicators exceed a threshold] If you do not have a name of a slaughter company applying this successfully, you have to delete this. Because in that case it is not a best practice.	No penalties	References to the use of penalties have been removed from the final version, as there is little evidence that this is currently being used with success. This issue is discussed in further detail within the state of play.

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Larger, smaller or companies independent of size? I would be surprised if larger companies apply this.	Same-sex groups	This was reported by three large slaughterhouses.
I do not understand this.	Classification of carcasses	It is not clear what exactly this comment is referring to.
We do not want literature: we want to know about best practices from companies that you have interviewed. All the rest is redundant: please delete!	Further reading section	References to studies have been removed from the final document. Where appropriate, these have been replaced with references to existing guidance or to examples of where transitions have already occurred.
No reference or ways I can find a supplier?	Hot iron method	Information on suppliers has been added.
Provide references again	Smell tests and training	References to smell test providers will be added in the text.
[Regarding disadvantages] This point is about no penalty so I do not understand this here. Problem of formulation?	No penalties	This has been reworded to clarify the point.
[Regarding cost of infrastructure] Quite vague	Electronic classification of carcasses	No specific information was available.
"No. this is the problem. We do not immediately see a comprehensive, cheap and fast method that offers guarantees. The "human nose" method is still widely used and does provide a definite answer, but for that you must have	Detection methods	Human nose is now the only method referenced in this document. Since other chemical methods are not yet in

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well-trained people and once a pig with boar taint has been detected, this person cannot continue working for some time. That is why we are also interested in the methods that are under development, such as those with "iknife", whereby a chemical analysis can be done online very quickly. But to my knowledge, there is not yet a fast and affordable method available."		commercial use, these have not been included in the guidance.
Slaughterhouses should consequently sorting out such boars that are behaving strongly like sexually matured boars. If signs like heckle, foaming are shown and young boars are trying to jump on others these boars should be sorted out ideally already in the farm or at least at slaughterhouse lairage area for alive animals.		Feedback received from the advisory board meeting indicated that it was very difficult to use behavioural indicators with entire males and that this is therefore not a feasible best practice. It has been removed from the final version.
The biggest influence does have the stadium of puberty. The longer the boars are in puberty stadium the higher the risk that boar taint is strong.		For this reason, scheduling of slaughter has been amended to focus on age rather than weight.
For training and verification of human nose it is helpful to identify a critical limit of skatol and androstenon that people have to detect during training. 100% solutions of skatol and andostenon are may be smellable by many people. It is more interesting to define a minimum concentration that boar taint smellers have to identify. This minimum concentrartion can be defined by a sensorical testing panel where the sensoric penel members define upon which concentration boar taint is detectable for a "normal" human being.		This is being done by consulting groups that offer smell tests and training to slaughterhouses. As slaughterhouses do not appear to provide their own training at present, including further details on best practices for smell testing is out of scope.

Table 16. Q5 - Techniques and best practices to trust farmers that immunocastrated pigs do not contain detectable boar taint

Comment	Relevant topic	ICF response
[Regarding figure] See previous figure on testes – no tail docked please!!	Checks based on testes measurement	These checks were not considered to be good practice by consulted stakeholders and were removed from the best practice documents.
Since the gland is internal, does it require a particular care when the carcass is cut in half?	Checks based on bulbourethral gland	This relates to butchering and is therefore out of scope.
In order to make decisions based on the size of the testicles, we ask ourselves whether this is a reliable method. For some species/breeds vaccination has little or no influence at all on the size of the testes. A visual check can often give a wrong impression or lead to the wrong decision. Furthermore, we ask ourselves whether measuring the testes (in the slaughterhouse) is a good method that should be recommended. This will be very time-consuming and therefore also quite expensive despite being considered as inefficient.	Checks based on testes measurement.	These checks were not considered to be good practice by consulted stakeholders and will be removed from the drafts.
This document focusses on the topic of immunization or vaccination against GnRF (also called immunological castration) from the perspective of slaughterhouses ... Many slaughterhouse operators, and their customers, remain sceptical of the proposition that vaccination against GnRF is an effective means of preventing boar taint. Lack of trust in the vaccine as a means of preventing boar taint is an issue across the supply chain, from slaughterhouse operators onwards.	Introduction	Text revised; the wording "vaccination (against boar taint)" has been used throughout

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Consequently, building trust in immunization requires engagement with many different actors, from farmers to retailers and consumers. The following practices are used to increase confidence in vaccination and its effectiveness.		
Some slaughterhouses choose to conduct random checks for boar taint in vaccinated pigs on the slaughter line, using the same techniques that are used for entire males. The frequency of checks will depend on the slaughterhouse and farmer and their experience with the technology . More frequent checks may be necessary for less-experienced slaughterhouses and farmers. The person responsible for receiving the animals in the lairage may also check for the signs of improper immunization on arrival. ... □This can be used to enhance industry-wide confidence in the vaccination process .	Random checks for boar taint	Text revised; the wording "vaccination (against boar taint)" has been used throughout
The vaccine has been shown to significantly reduce the size of the testes. Immunized male pigs can be sampled for boar taint based on the size of their testes. The testes of all vaccinated pigs are measured on line using callipers. Pigs whose testes exceed a certain diameter (e.g. 110 mm) are then targeted as suspicious . A fat sample is taken and assessed for boar taint, generally using the human nose method off-line.	Checks based on testes measurement	The section on checks based on testes measurement has been removed as this practice was not considered sufficiently reliable.
The vaccine has been shown to significantly reduce the size of these glands. Immunized pigs can be selected for testing based on the size of these glands.	Checks based on bulbourethral gland	The section on checks based on bulbourethral gland has been removed as this practice was not considered difficult to implement and not sufficiently reliable.
The staff at the slaughterhouse can take a fat sample from a small number of immunocastrated pigs and send these to an external laboratory for chemical testing. The samples can be selected based on perceived risk, for example through the measurement of testes. This testing is used to detect the levels of androstenone (and other compounds) in the fat. ...	Chemical testing of a sample	Text revised; the wording "vaccination (against boar taint)" has been used throughout

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This type of testing is only suitable for a small number of carcasses. It will likely give an incomplete picture of the level of boar taint in immunized pigs. Tainted meat may enter the supply chain as a result. ☐ This type of testing may be too expensive for some slaughterhouses. If 1 per cent of carcasses are tested, this will cost around 0.03 EUR per kilo of meat received from vaccinated pigs.		
Farmers should keep documented records of vaccinated pigs.	Documentation	Text revised.
Although some slaughterhouses still treat vaccinated pigs as boars and pay less for them (as compared to physically castrated pigs), there are other slaughterhouses that do not issue penalties or who choose to pay more (for example, an extra 0.01 EUR per kg). The price premium for vaccinated pigs is made possible by certification schemes and by demand from retailers who are interested in selling meat from immunized pigs. Advantages ☐ Bonus payments increase the profitability of using vaccination for farmers. Disadvantages ☐ Bonus payments rely on slaughterhouses or their customers having increased demand for pork from vaccinated pigs.	Bonus payments	Text revised; the wording "vaccination (against boar taint)" has been used throughout
"These checks are not based on any specific risk factors and therefore may not be efficient." This is not correct. The checks are based on specific factors. Non-vaccinated pigs behave different (more active, more vocal and more sexual aggressive behaviour combined with less feeding and red, large, active testicles.) For a stockholder who is trained in looking for these signals, it is not difficult to assess them reliably.	Random checks	Text revised to emphasise the importance of carrying out risk-based checks.

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"These checks require that staff receive additional training to properly assess testes size." Note: testes size is only one parameter in the assessment. When testes size is looked at in combination with the checks on the live animals, a higher accuracy is achieved. The bottom line is that, when carcasses come in that give reasons for doubting good vaccination compliance, a fat sample can be taken as described higher. But the better assessment is on the live animals, because at that time corrective management can still be applied (revaccinating the pig or marking the pig as an entire boar.)	Checks based on testes measurement	The section on checks based on testes measurement has been removed as this practice was not considered sufficiently reliable.
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Table 17. Q6 - Techniques and best practices to quantify and deal with meat with detectable boar taint

Comment	Relevant topic	ICF response
Applications for meat from sorted entire male pigs. The meat that is sorted out because of boar taint odour and flavour must be used in products in which the odour and flavour have been masked. Different possibilities, such as smoke, fermentation, process temperature and masking with spices, have been investigated. Meat from entire males with higher concentrations of skatole and androstenone can generally be used for processed products rather than for fresh meat products without consumers reacting negatively to the boar taint odour and flavour. It is also an advantage to combine different strategies, such as dilution and smoke. For further information: boartaint.dk	Strategies for processing tainted meat	Many of these techniques are already included. The use of different strategies in combination should be highlighted in the report.
No techniques, only best practices!!!	Title of section	The wording used for the titles of individual documents has been amended.
Very confusing, is it about boar tainted meat or about meat from immuno vaccinated animals?	Introduction	This section is about boar tainted meat. Revisions to the title make this clear.

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Not very useful in practice. What percentage in weight?	Diluting and mixing	It is difficult to set a defined percentage as this depends on several different factors. This has now been explained more thoroughly in the text.
When providing reference, give the author and full title and not only the link since it might change overtime.	Thermal treatment	References to studies have been removed from the final document. Where appropriate, these have been replaced with references to existing guidance or to examples of where transitions have already occurred.

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Table 18. Q7 - Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served

Comment	Relevant topic	ICF response
Consumer response and sorting limits. The carcasses are sorted to ensure that the consumers do not receive meat that could result in a negative reaction. Consumer surveys are conducted in order to be able to set the optimum sorting limits. The consumers assess how much they like meat from entire males with varying concentrations of skatole and androstenone in the neck fat. There is a large variation in the extent to which the consumers like meat from the same entire male pig. This could partly be due to differences in our sensitivities to skatole and particularly androstenone and also differences in how much or how little we like the odour of the compounds. Furthermore, there are geographical differences in the extent to which the consumers react to boar taint odour and flavour. A European study has shown that Danish consumers are among those who react most negatively to skatole and androstenone. ARTICLES: Christensen, R., Nielsen, DB., Aaslyng, MD (2019) Food Quality and Preference 71, 209-216, Estimating the risk of dislike: An industry tool for setting sorting limits for boar taint compounds. Aluvé, M., Aaslyng, MD. et al...(2018) Meat Science vol 137, side 235-43. Consumer acceptance of minced meat patties from boars in four European countries Font-i-Furnols, M., Aaslyng, MD et al... (2016) Meat Science vol 121, side 96-103. Russian and Chinese consumers' acceptability of boar meat patties depending on their sensitivity to androstenone and skatole Aaslyng, MD., Broge, EHL., Brockhoff, PB., Haubo Christensen, R. (2016) Meat Science vol 116, side 174-85. The effect of skatole and androstenone on consumer response towards fresh pork from m. longissimus thoracis et lumborum and m. semimembranosus Aaslyng, MD., Broge, EHL., Brockhoff, PB., Haubo Christensen, R. (2015) Meat Science vol 110, side 52-61. The effect of skatole and androstenone on consumer response towards streaky bacon and pork belly roll	Consumer thresholds for tainted meat.	Although this is relevant information, this is currently not a practice used commercially and is therefore out of scope.

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This document states that: About 30% of pigs reared in the UK are raised to Red Tractor Assured Food Standards¹ and 'RSPCA'² standards that do not allow castration in the pork supply chain. These labels are widely recognised and used by UK consumers. Boar taint may be partially addressed, but the labels' focus is on welfare rather than meat quality. This is incorrect. Approximately 95% of pigs in the UK are reared to Red Tractor Assured Food Standards. Approximately 30% of UK pigs are reared to RSPCA standards under the RSPCA Assured, higher welfare food label. The actual figure for the latter was 27.2% for 2017. In addition, for clarification, the RSPCA welfare standards for pigs prohibit surgical castration; the use of Improvac is permitted. Justification, including welfare-related reasons, must be given to the RSPCA Farm Animals Department in writing and the Department's written response must be made available to Freedom Food assessors and RSPCA Farm Livestock Officers. The same paragraph is included in the document titled: Techniques and best practices to increase the market value of meat from uncastrated pigs and to prevent meat with detectable boar taint to be on the shelves or served. As such, it will also need correcting.	Welfare labels	These points have been corrected in the text.
It has been very clear from the beginning that we do not want lists of techniques, and only look for best practices	Entire section	Based on experts' and consultees' feedback, some practices have been removed as not considered best practices.
[Typo in section 1.2]	Buyer specifications addressed to supplier	This has been amended in the text.

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[On better welfare labels] Did you interview Dutch retailers on this? That would help making it realistic. Talking about Red tractor is talking about something implemented 15 years ago. We are not waiting for that. [On 'Beter leven'] This is false information: It certainly does include requirements to detect boar taint. Delhaize does explicitly talk about castration, and to the best of my knowledge they do consider it being a successful best practice [On further reading section] Very old information: do not use literature, and limit yourself to best practices from companies instead of referring to marketing leaflets.		Red tractor remains relevant as an assurance scheme that does not allow castration. A range of assurance schemes with policies regarding castration and detection have now been included, along with links to their websites for more information. Information on the Beter leven label and detection has been amended.
This is all theory: retailers do rarely get complaints, for the reasons you mention yourself. The question is whether they do analyse pork sales for specific products in which the risk of boar taint is quite high? In my opinion the only best practice is based on "The proof of the pudding is in the eating". And this is very complex because so many factors do influence sales. But if you have talked to a retailer who can do this, please let us know.	Consumer complaint management	This has been removed from the final version of the document.
See previous comment. Be more explicit so that if the link is corrupted or changed, we can still find the information.	Animal welfare labels	All references have been revised accordingly.

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Table 19. Q8- Techniques and best practices to increase the acceptance of meat from immunocastrated pigs among consumers and to prevent meat with detectable boar taint to be on the shelves or served

Comment	Relevant topic	ICF response
"often" means that you have few example when it was done. Could you give precise examples?	Marketing campaigns that emphasise animal welfare	Specific examples (Aldi, Colruyt) will be included in the text.
In the document "Practises to increase the acceptance of meat from IC pigs among consumers..." in section 3.1 "disadvantages", it is not entirely clear to me what is meant here. Controls indeed generate additional costs that eventually need to be borne by someone, but also for the use of adjusted feed or even the use of intact bears the retailer will have to carry out checks to assess whether the requested criteria are met. Therefore, I do not consider that this method generates extra costs.	Costs	The document does not refer to extra costs of immunocastration compared to costs of growing entire males; they only mention that, should retailers wish to implement these checks, they may have to face the costs of doing these checks. Therefore the text has not been revised.
This document provides good practice examples that can be used by business operators to successfully market meat from pigs immunized or vaccinated against GnRF , and prevent meat with detectable boar taint reaching consumers, whether via retail outlets or the food service sector.	Introduction	Text revised; the wording "vaccination (against boar taint)" has been used throughout
Marketing campaigns are used by retailers as a marketing technique to foster the acceptance of meat from vaccinated pigs among consumers.	Marketing techniques	Text revised; the wording "vaccination (against boar taint)" has been used throughout
Retailers are often reluctant to communicate about vaccination practices to consumers. Marketing messages addressed to consumers do not mention the fact that the animals are immunologically castrated . Rather, these messages generally mention broader better animal welfare standards. Advantages	Marketing campaigns that emphasise animal welfare	Text revised; the wording "vaccination (against boar taint)" has been used throughout

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☐ Marketing meat from vaccinated pigs with 'better animal welfare' messages matches the growing EU consumer interest in animal welfare, and avoids other practices that still imply mutilation (castration with or without anesthesia/analgesia). Disadvantages ☐ There is a risk of raising awareness about physical/medical castration, which is not desired by retailers.		The document also refers to consumer preference of immunocastration over physical castration.
Retailers may choose to train staff to properly respond to consumers' questions related to vaccination raised in stores; this may also include the preparation of leaflets with detailed information for highly involved consumers.	Consumer complaint management	The section on consumer complaint management has been removed as, based on stakeholder consultations, this practice does not appear to be used specifically to address issues associated with vaccination.
Retailers can impose the use of vaccination of pigs on their pig meat suppliers and support producers with specific training and control measures.	Farmer management	Text revised; the wording "vaccination (against boar taint)" has been used throughout
Animal handlers can be trained on technical aspects regarding vaccine administration and treatment of piglets, livestock keeping, and to raise their awareness of animal welfare. This is often provided by technical support staff contracted by retailers. The vaccine is a prescription product supervised by licensed veterinarians. Advantages ... ☐ Veterinarians guarantee the supply of safe and quality pigs for the food chain	Training methods	Text revised; the wording "vaccination (against boar taint)" has been used throughout
"There is a risk of raising awareness about surgical/medical castration, which is not desired by retailers." This is more or less correct. Some retailers (although others do like Lidl, Delhaize and Colruyt in Belgium) do not want to focus on		These retailers have been contacted to gather additional information on the

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the methods used, because consumers are mostly unaware about any methods. The message to consumers is to ensure them about improved welfare for the animals. But, there are no secrets and full transparency should be given to the more inquisitive consumers.		practices used. Additional information has been included in the documents.
"Hiring technical staff increases the costs for retailers" Costs can be shared in many ways. The producer of the immune-castration product has a vested interest in training farmers to vaccinate correctly and therefore can absorb some of the costs. Also: vaccinating pigs gives a better food conversion and therefor gives a financial benefit for the farmers.	Training methods	The text has been revised to specify that training is provided by vaccine suppliers.

Annex 6 Consultation – Advisory Board

This annex presents the notes from the two Advisory Board meetings. Notes were circulated to attendants for review, and the version presented here integrates comments received.

First Advisory Board meeting – 12 September 2018, Brussels

Introduction and objectives

These notes summarise the outcomes of the first Advisory Board meeting organised by DG SANTE and ICF for the Study on “Establishing best practices on the production, the processing and the marketing of meat from uncastrated or immunocastrated pigs”. Additional information on the meeting objectives and scope are detailed in the meeting presentation provided separately by ICF. The meeting was attended by 13 stakeholder representatives, DG SANTE and members of the ICF research team.

Action points

After the meeting, ICF will follow-up individually with participating stakeholders to gather additional information on various points raised during the discussion, namely:

- Practical challenges for farmers associated to implementing immunocastration
- Additional practices related to assuring immunocastration has been successful
- Harmonisation of detection schemes in DE and NL
- Use of immunocastration for the production of Parma ham
- Research results in Germany related to entire males production
- Research results on various processing options and their effectiveness

Next steps

ICF will revise the draft documents based on feedback and additional evidence received during the meeting and through follow-up research.

A second Advisory Board meeting will be held on 11 October 2018 to:

- Identify challenges associated with the implementation of the good practices
- Discuss the best ways to further disseminate materials and achieve maximum impact

Summary of the meeting

The meeting began with a round of introductions by the participants and an introduction to the pilot project’s context and following activities by DG SANTE. ICF then presented a brief introduction to the study, meeting objectives and the methodology.

The study is the first part of a two-part project.

This part of the project is meant to collect into a single document a basis of knowledge on best practices, presented in the form of a “toolbox” of different options, explaining what the options are and their advantages and disadvantages. The document is to be structured in eight sections addressing eight questions, and addressed at four distinct target audiences: (i) farmers, (ii) slaughterhouses, (iii) food processors, and (iv) retail and food services.

The second part of the study will build on the material collected in the first part, and will focus on disseminating the best practices in the form of communication material, and

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through events. There is an open call for tender that has just been published on the second part.⁶⁶

In the meeting the study team has presented the practices included in the draft documents and an open discussion followed.

Concerns were voiced at different points in the meeting regarding the overall structure of the report. Some stakeholders found the use of 'advantages', 'disadvantages' and 'further reading' to be inadequate. There was a desire for both more technical information and greater use of examples. ICF clarified that it was working towards providing more detail and more actionable information – including names and references of providers of equipment, feed, etc. – in the revised documents, based on information it had collected and insights shared by participants to the meeting. ICF clarified also that the document is not in itself the guidance that will be provided to target audiences. That is to be generated in phase 2 of the project, which has been recently put to tender. Instead, this report will constitute the knowledge base on which guidance and other communication materials will be elaborated.

Concerns were also voiced that in their current state the drafts are missing important information. ICF clarified that the purpose of the meeting was to identify gaps or errors and discuss with participants the most appropriate ways and sources to address those gaps before the document is finalized.

Throughout the discussions, several points were made that were applicable across the sections, including:

- Boar taint is only one factor of many and is generally not the most important factor that actors across the supply chain will pay attention to. This should be better acknowledged in the draft documents. Best practices should be identified as beneficial for factors other than boar taint (such as welfare, meat quality etc.), as long as these practices also result in reduced boar taint.
- The document should better reflect the demand driven nature of the sector and the level of control that actors further down the supply chain – retailers in particular – hold over the rest of the chain.

Furthermore, other more general comments also were made that shed a broader light on the overall initiative:

- There is a cross-cutting need for better communication between members of the supply chain and the harmonisation of standards wherever possible.
- While at present it is feasible to market meat with detectable boar taint in the EU, there are concerns that this may hit a ceiling should the production of entire males increase beyond a certain point.

Below is a summary of key points raised in the discussion on each of the topics presented.

Topic 1: Techniques and best practices at farming level

Feeding

- (1) In general, the section on feeding was felt by many to not include enough relevant detail. Information on how often boars are fed, whether feed should be

⁶⁶ The call for tender is available at: https://etendering.ted.europa.eu/cft/cft-display.html;eTenderingPublic=ImHX7_9ZI9T9NUnwwtPx64OUTFRaclXcuwgvizgZWroGn3nqOy0L!-1402313534?cftId=3905

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wet or dry and how often the feed is changed, for example, are important elements for inclusion.

- (2) The point was made that although chicory root has been shown to be very successful, it remains at present too costly.
- (3) Grain-based diets (providing low-protein feed) have been found to reliably reduce boar taint by a study in Denmark and are an inexpensive option.
- (4) Concern was raised that no incentive currently exists to adopt particular feeding practices at farming level. Payment schemes to encourage the uptake of farm-level best practices were cited as being extremely important. However no current scheme encouraging feeding through payment schemes has been reported.
- (5) The cost presented for the price of TaintStop feed (100/EUR per tonne) was questioned. It was pointed out that as this feed is only provided for the 3-4 days prior to slaughter, therefore the additional cost incurred is not as significant as one may think. Furthermore, ICF indicated that the manufacturer (Dumoulin) contributed comments on the draft and has not corrected the price information.
- (6) Reduced competition at feeding was noted as an aim that can be achieved in various ways and that this could be discussed in more detail in the document.

Housing/flooring

- (1) Group size can be an important factor and is currently not included in the draft documents. Keeping pigs in larger groups (over 30 pigs) increases the risk of boar taint.
- (2) The practice of selecting larger pigs for early slaughter is considered to be poor practice as it alters group dynamics and requires the re-establishment of a hierarchy within the group, leading to increased fights and stress.
- (3) There were differing opinions on the inclusion of slatted floors, given implications in terms of costs on the one hand, and animal welfare on the other. A suggestion was made to keep the practice to “keep pigs clean and dry” and mention slatted floors as an option to achieve that objective.
- (4) No conclusion was reached on the effectiveness of sex-separated rearing at reducing stress and aggressiveness among boars. It was established that different practices exist and farmers have experienced differing levels of success. It was pointed out, however, that sex-separation is required when pigs are raised to heavier weights. It was agreed that this practice should remain included but differing experiences should be explained.
- (5) More generally, more information needs to be included on managing boars. This is an important aspect to ensuring that farmers can make the transition effectively.

Breeding

- (1) Similarly to many feeding techniques, there is no real incentive for farmers to use these methods at present. An example was given of a German company that provided a premium to farmers for a year to use low boar taint sperm.
- (2) There is a risk with breeding for boar taint that other elements of the meat quality may be impacted by changes to genetics. Examples were given where there were

notable losses to quality following breeding experiments. Boar taint is only one factor of many and not the most important one.

- (3) There are two main breeding strategies to reduce boar taint: selecting a specific breed known for low boar taint (for example, Piétrain), or selecting within a breed boars that have low taint, based on a blood test of the animal.
- (4) Topigs Norsvin has successfully developed a method for offering sperm from low-taint boars of different breeds. That is commercially available but supply is currently limited. Nucleus in France has developed a line of Pietrain boars selected for low boar taint (INO Boar)

Early detection

- (1) Although early detection based on behavioural or physical characteristics is easily done for immunocastrated pigs (where the vaccine leads to calmer, less active pigs), it is not particularly easy to spot notable differences in entire males.

Scheduling – age versus weight

- (1) Age is a better predictor of boar taint although there is also a correlation with weight. Indeed the most at-risk boars are the slow growers that end up sent to slaughter at an older age. As such scheduling for slaughter on the basis of age is a better practice than selection on the basis of weight.
- (2) Ear tags were mentioned as a helpful practice for tracking the age of pigs.
- (3) Carcass weight standards differ between countries and markets. There are economic incentives that are linked to weight. This is another reason why raising to lower weights cannot be qualified as best practice.

Immunocastration

- (1) The effectiveness of immunocastration when implemented correctly is established. However, a comment was made that the draft documents should better explore challenges which farmers may face when implementing immunocastration. There is an added effort required that needs to be accurately recorded in the drafts.
- (2) An example was raised of experience in Italy raising heavy pigs for Parma ham using immunocastration. This example involved the use of three vaccinations instead of two. This example illustrates that much depends on farm management for the successful use of immunocastration, and this needs to be better reflected in the documents.

Transport

- (1) The conditions of transport were highlighted as an important aspect that needs to be covered in the documents. Good conditions of transport from farm to slaughterhouse can contribute to reducing boar taint, by limiting stress and aggressiveness in the hours that precede slaughter. This should include principles for the transport of boars together in their group, and in groups of appropriate size, as well as temperature regulation.

Topic 2: Boar taint detection methods along the supply chain

Detection instruments

- (1) The instrumental system introduced in Denmark is still in use. The human nose technique is not considered to be sufficient by the industry there. However, it was noted that there has not been further development in the use of the system elsewhere.
- (2) Other instrumental methods are under development, and this appears to be the way forward for the future but these are not yet commercially available. The point was also made that there have been proven discrepancies between different lab results and that even chemical testing methods are not fool proof.
- (3) At present, the human nose method seems to be the only viable option, although there are concerns both about its reliability and about the relative unpleasantness of the job for workers.
- (4) Efforts have been made to develop standardised and harmonised approaches. An example was given of the QS scheme in Germany working with an assurance scheme in the Netherlands to harmonise detection methods across the two countries. This was felt to be an important point for inclusion in the report, considering the broader objective of achieving coordination and mutual recognition of techniques across the EU.
- (5) Regarding the selection of boar taint assessors, the point was made that people who are highly sensitive (around 1% of the population) should not be used as they are more likely to be less accurate due to fatigue.
- (6) Some slaughterhouses use in-house staff to carry out detection, while others use external contractors or borrow trained staff from other slaughterhouses. There is little difference between large and small slaughterhouses in the use of one as compared to the other option. Additionally, the economic feasibility of using human nose techniques does not differ between slaughterhouse sizes. There is a fixed cost to setting up such a system. The more important factor is whether the slaughterhouse processes enough boars for the implementation of human nose procedures to be cost effective. It was noted that only slaughterhouses that would process boars on a continuous basis would find this a cost-effective approach.

Scales for detecting boar taint

- (1) Both Yes/No scales or more granular (e.g. 1-5) scales are considered to be effective ways for slaughterhouses to manage tainted carcasses, depending on the needs of the slaughterhouse.

Other practices

- (1) A question was raised about the use of boar free slaughter days and whether this is still practiced. One stakeholder mentioned that certain slaughterhouses in France have boar-free periods during the day, albeit not whole boar free days.
- (2) Handling of boars on entry to the slaughterhouse was identified as an important aspect currently missing from the documents. This is important to reduce stress levels, and involves considerations on group handling, handling of aggressive animals and lairage conditions.

Topic 3: Supply chain dynamics and assurance processes

- (1) The measurement of testes was not considered to be an adequate method for determining whether immunocastrated pigs are at risk for taint. There is too much variation for this to be a usable technique and therefore it should be removed from the report.
- (2) A method was described whereby blood samples are taken and tested for testosterone, as an indicator of boar taint. Testosterone is highly correlated with androstenone, so this can be used to determine what pigs are at risk for presenting boar taint.
- (3) The use of the bulbourethral (cowper's) gland was mentioned as something that has been tried, but the gland is comparatively small and risks being destroyed when carcasses are cut in half. As such it is not reliable.
- (4) An example was given from Germany where all non-castrated males, including immunocastrated pigs (rather than only testing a random or at-risk sample), are tested using the human nose.
- (5) The issue was raised that the document at present does not properly present the costs and benefits of immunocastration as a whole.
- (6) The point was raised that the advantages and disadvantages of immunocastration or raising entire males have a lot to do with market requirements as these are both 'special market' products. As such the feasibility of either approach depends on the size of the market and the size of the business handling such meat.
- (7) Having an objective method for detecting boar taint and a payment schedule that can be based on this is an important prerequisite to incentivising farmers to switch and to take up preventative practices (i.e. those in Topic 1). However, current commercial practices do not provide illustrations of this.
- (8) Records of immunocastration will be included in official medical records in some countries that accompany the pigs from farm to slaughterhouse.
- (9) The point was raised that the power to alter the supply chain is with retailers as they are the principal buyers, but that at the same time many other parts/pieces of meat from a carcass will end up elsewhere, to be processed and/or exported. The identification of outlets for the various parts of the carcass is a complex task. These other customers/markets may not accept certain practices, so slaughterhouses need to consider this carefully before making the transition towards slaughtering entire males.
- (10) The example was given of Cooperl in France, who own the transformation/processing part of the supply chain and are therefore better able to manage these risks. This suggests that operators that combine slaughtering and processing activities are better placed to transition towards the production of meat from entire males or immunocastrated pigs than others. Companies such as Tönnies or Vion also combine slaughtering and processing activities.

Topic 4: Processing practices to quantify and deal with meat with detectable boar taint

- (1) There is mixed evidence on some of the processing techniques – there is some evidence, for example, that dry curing may be less effective.

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- (2) Cooked products that are not to be re-heated for consumption were identified as another option in addition to those already listed in the report. One more option was the cooking of large batches of tainted meat in an open cooking system.
- (3) The discussion of processing also raised the issue of changes to aspects of the meat quality, such as the quantity of fat, which can make processing more challenging.
- (4) Exporting to countries or markets with 'low sensitivity' was considered to be a poor solution because it is not clear that such markets actually lack sensitivity to boar taint. One example was given of a market (Russia) that at some point was a large importer of products made with tainted meat.
- (5) Use of boar tainted meat as pet food was not considered an appropriate option, given that the objectives of the initiative are to provide meat for human consumption and enhance the prospects of producers to sell meat from entire males or immunocastrated pigs to consumers.
- (6) Boar taint is a relatively minor quality issue at the processing stage. Other factors, such as fat quality is more important, as are the PH levels or iodine levels. Different types of products will require different qualities that will be prescribed by the processors in their orders to the slaughterhouses. This may then be articulated to particular farming practices. For example, a certain type of processing may require meat that has low unsaturated fatty acids, and that can then be obtained through particular ways of feeding the animals.
- (7) The boar taint smell comes from the fat, so there is the possibility to address this by removing the back fat from the meat, for example. However, this is costly. It is not clear whether this is being done in commercial conditions in the EU.
- (8) An example was also given of how vaccination can be used to manage fat content. Scheduling the vaccination at different times produces different qualities (more fat or less). For example, in Italy Improvac is used at 8 weeks to manage the amount of fat in the animal so that it fits the requirements for Parma ham production. To apply this approach in a manner that is suitable to each market, conversations are required between farmers and processors.

Topic 5: Practices to raise consumer awareness and increase the market value of meat

- (1) The absence of active involvement from retailers and consumers in this domain was noted by several stakeholders.
- (2) Complaint management – there was an example provided from Germany of how complaints received by retailers in relation to boar taint are not passed further back down the supply chain. This was in line with the findings appearing in the report, whereby no examples were provided of retailers who have done this differently/successfully.
- (3) Stakeholders mentioned that it is difficult to add value to such products when consumers are not aware of these practices in the first place.
- (4) The use of the term 'consumer acceptance' was found to be problematic as consumers have little knowledge or say in the issue, and the critical points are really consumer attitudes and behaviour.

Second Advisory Board meeting – 11 October 2018, Brussels

Introduction and objectives

These notes summarise the outcomes of the second Advisory Board meeting organised by DG SANTE and ICF for the Study on “Establishing best practices on the production, the processing and the marketing of meat from uncastrated or immunocastrated pigs”. Additional information on the meeting objectives and scope are detailed in the meeting presentation provided separately by ICF. The meeting was attended by 11 stakeholder representatives, DG SANTE and members of the ICF research team.

Action points

- All documents will be revised to ensure that the terms ‘boar taint’, ‘androstenone’ and ‘skatole’ are being used accurately and these should be properly explained in the text.
- Additional specific edits will be made to the documents based on feedback presented at the meeting.
- Copies of the additional case study will be provided to the stakeholders if it is approved.

Next steps

ICF will finalise the draft documents based on feedback and additional evidence received during the meeting and through the remaining follow-up research.

Finalised versions of the best practice documents will be provided to all stakeholders.

Summary of the meeting

The meeting began with a round of introductions by the participants. ICF then presented a brief introduction to the study, meeting objectives and the current state of play.

- The study is the first part of a two-part project.
- This part of the project is meant to collect into a single document a basis of knowledge on best practices, presented in the form of a “toolbox” of different options, explaining what the options are and their advantages and disadvantages. The document is to be structured in eight sections addressing eight questions, and addressed at four distinct target audiences: (i) farmers, (ii) slaughterhouses, (iii) food processors, and (iv) retail and food services.
- The second part of the study will build on the material collected in the first part, and will focus on disseminating the best practices in the form of communication material, and through events.⁶⁷

In the meeting the study team presented the main revisions done to each of the eight documents, based on the feedback received from the previous meeting.

Cross-cutting comments

- (1) In the previous meeting, concerns were voiced on the overall structure of the report. Some stakeholders found the use of ‘advantages’, ‘disadvantages’ and ‘further reading’ to be inadequate. There was a desire for both more technical information and greater use of examples. ICF used this feedback to make amendments to the structure. ‘Things to consider’ have been included throughout the report to highlight important practical considerations and ‘further reading’ has been amended to focus only on practical guidance and including

⁶⁷ The call for tender is available at: https://etendering.ted.europa.eu/cft/cft-display.html;eTenderingPublic=ImHX7_9ZI9T9NUnwwtPx64OUTFRaclXcuwgvizgZWroGn3nqOy0L!-1402313534?cftId=3905

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highlighted examples throughout the text. The changes of the structure have been received positively by stakeholders. Additional editing would be welcome to highlight different elements and introduce additional break in the text. Additional visuals were also suggested as a way to improve readability. There will be a greater opportunity to invest in additional visuals during the dissemination phase of the project (phase 2).

- (2) At the previous meeting, it was felt that the format used did not provide appropriately engaging material to encourage stakeholders to transition away from surgical castration. Stakeholders felt that using success stories and a narrative approach would be helpful. The best practice documents are designed as a toolbox, which provides for limited opportunities to add examples. However, several references to specific experience and countries have been added throughout. Furthermore, ICF has written three case studies to be included in the final report as an Annex. Copies of two such case studies were provided to attendees. One additional case study has been written but was pending approval from the interviewee at the time of the Advisory Board meeting. Examples of the use of immuno-castration in Spain may also be added to the documents, pending the reception of additional information from the relevant stakeholders.
- (3) Concerns were voiced that the order of the documents does not flow and that it would be better to group information by entire males and by vaccinated pigs rather than by points in the supply chain. ICF clarified that the order and organisation of information was stipulated by the contract with DG SANTE. There may be opportunities to present the information in a different way during phase 2.
- (4) Across the documents, stakeholders felt that the use of 'skatole', 'androstenone' and 'boar taint' should be clearer and more accurate. Information explaining to the reader what these two compounds are and the causes of boar taint should also be included in the documents.

Below is a summary of key points raised in the discussion on each of the topics presented.

Q1. Farmers – uncastrated pigs: management techniques

Feeding

- (1) Following concern about the evidence for chicory root being effective within 3-4 days, the study team explained that this was on the basis of a scientific study. The study team clarified also that, although the literature is not included in the best practice documents, there is a more detailed section within the final report which describes each of the practices and is fully referenced.
- (2) For chicory root, silo management is a crucial issue and should be included as a 'thing to consider'.
- (3) For the cost information included, it would be helpful to not only have the overall cost of the food, but also how much feed options cost per pig.
- (4) The inclusion of grain-based or low-protein diets alongside diets with adjusted amino acids was felt to be potentially confusing and contradictory. This aspect needs further explanation in the text, to highlight to the reader trade-offs between different feeding solutions.
- (5) Under commercial feed solutions, the text currently states that these impact both androstenone and skatole. This is an error and should be amended to remove mention of an impact on androstenone.

- (6) The text on wet feeding currently lists lowered manure production as an advantage. This could be read as implying that if wet feeding is used, pigs do not need to be given access to additional sources of water. This is against EU regulations and not a best practice. The text should clearly mention that continuous access to water should still be provided in wet feeding systems.
- (7) The point was made that, when considering the use of additives and different types of feed, it is also important that the feed tastes good, as this may otherwise have a negative impact on intake. This should be included as a 'thing to consider' in the documents.
- (8) Reducing competition at feeding is more an issue of housing and infrastructure than of feeding and should be considered alongside other housing issues. It may make sense to reorganise the documents to better reflect the order in which considerations should be made. ICF will follow up to confirm what order makes the most sense.

Housing/flooring

- (1) When discussing sex separation and its advantages and disadvantages, the text presented in Q1 should be clearly aligned with the text on sex separation presented in Q4.
- (2) Under slatted floors, the text currently states that slatted floors may pose a welfare concern. This should be revised to state that 'fully slatted' floors may pose a welfare concern.
- (3) The question was raised of whether the use of edible materials as enrichment may have a negative influence on boar taint. There is no apparent research on this, but it cannot be removed as this is a legal requirement. As most edible enrichment is fibre, it is unlikely to have a negative effect but ICF will check to see if there is any research that suggests otherwise.

Breeding

- (1) The section on breeding should be revised to clarify that the use of sperm from terminal sires only represents one half of the genetic material of pigs.

Transport

- (1) There were several concerns regarding the inclusion of 'transport' as a best practice. Although one study has been published which found a link between length of transport and androstenone⁶⁸, some stakeholders have carried additional research on very large samples and have not been able to replicate these findings. ICF will therefore remove reference to this as a best practice but rather mention it as a 'thing to consider', while adding further information on this aspect in the main report.
- (2) Cleanliness during transport as well as the fasting period before slaughter were felt to have a clearer impact on boar taint. The section will be revised and shortened to highlight cleanliness and the use of a fasting period before slaughter. Reference to transport as an important welfare consideration and links to existing transport guidance will remain in the text.

⁶⁸ Wesoly et al. (2015) Pre-slaughter conditions influence skatole and androstenone in adipose tissue of boars. Meat Science 99: 60-67. Available at: <https://www.sciencedirect.com/science/article/pii/S0309174014002800>

Q2. Farmers – immunocastrated pigs: vaccination

- (1) There were some concerns around the terminology used for immunocastration, including the use of the term 'vaccination'. However, no logical alternatives were suggested.
- (2) Some additional edits to the text have been provided by the representative from Zoetis. It was also mentioned that heavier pigs are in fact easier to vaccinate than smaller pigs as they are less agile and the text should be revised to reflect this.

Q3. Farmers – immunocastrated pigs: provide assurance to slaughterhouses that immunocastrated pigs do not present detectable boar taint and Q5. Slaughterhouses – immunocastrated pigs: obtain assurance from farmers that immunocastrated pigs do not contain detectable boar taint

- (1) There was one question regarding the usefulness and the efficacy of checks at slaughterhouse level when checks are being performed at farm level. ICF clarified that the need to include both checks at farm level and at slaughterhouse level was a requirement for the project.
- (2) The text should better clarify the circumstances in which tests at slaughterhouse level take place, for example with farmers new to the process.
- (3) It was suggested that the section on visual checks at the farm in Q3 could be better presented, e.g. as a box.
- (4) Reference in Q3 to checks conducted by Zoetis should be in the present tense, not the future tense.

Q4. Slaughterhouses – uncastrated pigs: detect boar taint, quantify and manage positive carcasses

- (1) ICF clarified that the current information present on price per carcass for detection services will be replaced by information on price per hour, as this is how the relevant service is priced to customers, and the price per carcass is dependent on the speed of the slaughter line.
- (2) The text currently indicates that chemical testing is not yet available but new methods are under development. It was clarified that one such method is expected to be implemented in a slaughterhouse within a year. Considering this, it may be helpful to include information in the text on the benefits of using a chemical or instrumental method, including how it can be connected to the penalty system and how it can be used to set quantitative industry standards. ICF clarified that it cannot reference any method in development as the Commission's brief is for only methods currently used in commercial conditions to be included.
- (3) The text currently presents the human nose method as delivering 'robust results' but does not mention the risk of false negatives. The text will be amended to communicate the uncertainty that remains, since the method is not fool-proof.
- (4) The text should also mention providing information to clients on detection procedures as a best practice.
- (5) The Danish Technological Institute should be added to the list of contractors that may assist with boar taint detection.
- (6) The practice of 'Non-detection - slaughter of entire males at low weight' should be revised to reflect that although low weight is used in the UK and Ireland, in Spain and Portugal, pigs are raised to comparatively heavier weights and

masking is used as a solution to boar taint. The relevant text should therefore be "... through on-farm practices or by slaughtering animals at a lower weight or by masking techniques."

Q6. Food processors – uncastrated pigs: deal with meat with detectable boar taint

- (1) No specific comments were made on processing and dealing with meat with detectable taint.

Q7. Retailers and food services – uncastrated pigs: promoting meat from uncastrated pigs and Q8. Retailers and food services – immunocastrated pigs: promoting meat from immunocastrated pigs

- (1) The current text should further emphasise the practice of combining marketing material that highlights the animal welfare benefits of non-castration with information that highlights other benefits, such as environmental or human health aspects. Examples of this include Delhaize and Colruyt.
- (2) 'Red tractor' is described in the text as an animal welfare label, however it is a label used to highlight quality and Britishness. The text should be revised to reflect this.
- (3) The text on "Beter leven" should mention that non-castration applies not only to the "one star" label but also to the "two stars" label.
- (4) Consumers differ in their perceptions of boar taint, and these perceptions may differ again based on the type of product being consumed. This should be included in the text, as a 'thing to consider'. A suggestion was also made that this could be represented graphically, identifying the spectrum of differences in consumer tastes and differences in the level of boar taint. This suggestion will be included in recommendations for the dissemination phase.

Dissemination

The advisory board then discussed in broad terms the next phase of the dissemination of the information to stakeholders.

- (1) Rather than focusing dissemination on a specific point in the supply chain, it would be helpful to host dissemination activities that bring together actors across a supply chain.
- (2) Engaging stakeholders in the topic was cited as a main issue with dissemination. For much of the pig industry in Europe, there is no sense of urgency on this topic and in countries such as Romania and Poland, moving to entire males or immunocastration is not considered to be feasible.
- (3) There has been a historic lack of engagement with consumer organisations on this issue, and this was cited as a barrier to dissemination.
- (4) Retailers are also difficult to engage with on this issue. There is a fear for reputation loss.
- (5) Emphasising success stories would be an effective way of building interest in the topic – the best practices would then appeal to stakeholders who have first been convinced by success stories.
- (6) The communication strategy would be usefully structured around an understanding of the various bottlenecks in transitioning to entire males,

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including the lack of urgency, incentives to maintain the status quo and the fact that risks and benefits are not allocated evenly along the chain.

- (7) Videos provide a good option for dissemination. Any materials produced should be in all EU languages.

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Annex 7 References

This annex lists the references reviewed for the data collection task. References are mapped against the study topics and countries they cover.

Reference	ToR issues	Topic/practice	Country
ALCASDE (2009). Study on the improved methods for animal-friendly production, in particular on alternatives to the castration of pigs and on alternatives to the dehorning of cattle. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_alcasade_final-report.pdf	Cross-cutting	Cross-cutting	EU
Allen et al. (1997). Effect of nutrition and management on the incidence of boar taint. In: Boar taint in entire male pigs. Proceedings of a meeting of the EAAP working group "Production and Utilisation of Meat from Entire Male Pigs"; 1997 Okt 1-3; Stockholm, Sweden. Wageningen, the Netherlands: Wageningen Pers; 1997. p.88-91.	1	Wet feeding (incl. feeding with whey)	EU
Aluwé et al. (2009). Early and reliable detection of boar taint and genetic predisposition. Flanders Research Institute for Agriculture, Fisheries and Food. Available: https://pure.ilvo.be/portal/en/projects/vroegtijdige-en-betrouwbare-detectie-van-berengeur-en-van-de-genetische-aanleg-ervan(902ccf1a-403b-4087-ad4d-085938e2f550).html	4	Boar taint detection methods	BE
Aluwé et al. (2011a). Influence of soiling on boar taint in boars. Meat Science, 87:3, pp. 175-179. Available: https://pure.ilvo.be/portal/en/publications/influence-of-soiling-on-boar-taint-in-boars(c52065ec-c378-45d2-a37f-52c10eaae493).html	1	Housing	BE
Aluwé et al. (2011b). Influence of breed and slaughter weight on boar taint prevalence in entire male pigs. Animal, 5:8, pp. 1283-1289. Available: https://www.cambridge.org/core/journals/animal/article/influence-of-breed-and-slaughter-weight-on-boar-taint-prevalence-in-entire-male-pigs/139CA9B5D3C4A6D2477C0E3D5065DF8F	1	Breeding and selection at slaughter	BE
Andersson et al. (1997). The effects of feeding system, lysine level and gilt contact on performance, skatole levels and economy of entire male pigs. Live Prod Sci, 51:1-3, pp. 131-40.	1	Feeding - wet feeding (incl. feeding with whey)	N/A
Backus et al. (2008). Removing the taint: Bottlenecks and possible directions for a solution in the marketing of the meat of non-castrated male pigs. Wageningen UR.	Cross-cutting	Cross-cutting	NL
Backus, G. Best practices by Dutch farms and supply chain companies. Unpublished.	Cross-cutting (entire males)	Cross-cutting (entire males)	NL
Backus, G., Raedts, G., and van der Sanden, A. (2017). Praktisch en effectief oplossen en berengeur met inuline. Connecting agri&food.	1	Feeding	NL

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Baltussen et al. (2008). Ban on castration of boars in the Netherlands: modelling economic consequences of options. Available: https://www.researchgate.net/publication/41090322_Ban_on_castration_of_boars_in_the_Netherlands_modeling_economic_consequences_of_options	Cross-cutting	Cross-cutting	NL
Batorek et al. (2012). Meta-analysis of the effect of immunocastration on production performance, reproductive organs and boar taint compounds in pigs. <i>Animal</i> , 6:8, pp. 1330-1338. Available: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/S1751731112000146	2, 3	Cross-cutting	EU
Bekaert et al. (2013). Evaluation of different heating methods for the detection of boar taint by means of the human nose. <i>Meat Science</i> , 94:1, pp. 125-132. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174013000296	4	Boar taint detection methods	N/A
Berg et al. (2016). 'Pig castration: will the EU manage to ban pig castration by 2018?', <i>Porcine Health Management</i> , 2:29. Available: https://porcinehealthmanagement.biomedcentral.com/articles/10.1186/s40813-016-0046-x	Cross-cutting	Cross-cutting	EU
Binnendijk et al. (2013). Effect van licht, groepsgrootte en schuilwand op gedrag van beren. Wageningen UR Livestock Research.	1	Housing	NL
Boars heading for 2018. Available: http://boars2018.com/	Cross-cutting	Cross-cutting	EU
Bonneau et al. (2017). Potential sensitivity of pork production situations aiming at high-quality products to the use of entire male pigs as an alternative to surgical castrates. <i>Animal</i> 16:1-9. Available: https://www.cambridge.org/core/services/aop-cambridge-core/content/view/49AD5E79CDCC5B9C0A96118BA54D10BF/S1751731117003044a.pdf/potential_sensitivity_of_pork_production_situations_aiming_at_highquality_products_to_the_use_of_entire_male_pigs_as_an_alternative_to_surgical_castrates.pdf	Cross-cutting	Cross-cutting	EU
Boulet et al. (2017). Influence of TAINSTOP, an innovative feed concept on boar taint. BAMST. Available: http://www.ca-ipema.eu/download/289/documents/oieras/orals_oieras/2_N_3_Guy_Janssens.pdf	1	Feeding	EU
Burgers, R. (2018). Vuile beren stinken harder, <i>PigBusiness</i> , Available: https://www.pigbusiness.nl/artikel/82507-vuile-beren-stinken-harder/	1	Housing	FR
Byrne, D.V., Thamsborg, S.M. and Hansen, L.L. (2008). A sensory description of boar taint and the effects of crude and dried chicory roots (<i>Cichorium intybus</i> L.) and	1	Feeding – Chicory root	N/A

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inulin feeding in male and female pork. Meat Science, 79(2), 252-269.				
Čandek-Potokar et al. (2010). Effect of immunocastration (Improvac®) in fattening pigs I: growth performance, reproductive organs and malodorous compounds. Slov Vet Res 47:2, pp. 57-64. Available: https://www.researchgate.net/publication/228882912_Effect_of_imunocastration_ImprovacR_in_fattening_pigs_I_Growth_performance_reproductive_organs_and_malodorous_compounds	1, 2	Cross-cutting	SI	
Čandek-Potokar, M., Prevolnik, M., and Škrlep, M. (2014). 'Testes Weight is not a reliable tool for discriminating immunocastrates from entire males'. Paper presented to International Symposium on Animal Science, Belgrade-Zemun, 23-25 September. Available: https://www.researchgate.net/publication/273767098_TESTES_WEIGHT_IS_NOT_A_RELIABLE_TOOL_FOR_DISCRIMINATING_IMMUNOCASTRATES_FROM_ENTIRE_MALES	3, 5	Physical signs of immunocastration	SI	
Čandek-Potokar, M., Škrlep, M., and Zamaratskaia, G. (2017). Immunocastration as Alternative to Surgical Castration in Pigs, Theriogenology Rita Payan Carreira, IntechOpen, DOI: 10.5772/intechopen.68650. Available: https://www.intechopen.com/books/theriogenology/immunocastration-as-alternative-to-surgical-castration-in-pigs	2, 3, 5, 8	Immunocastration – cross-cutting	EU	
Castrum consortium (2016). Pig castration: methods of anaesthesia and analgesia for all pigs and other alternatives for pigs used in traditional products. European Commission. Available: http://boars2018.com/wp-content/uploads/2017/02/Castrum-study.pdf	Cross-cutting	Cross-cutting	EU	
Civic Consulting (2013). Study and economic analysis of the costs and benefits of ending surgical castration. Part 2 – Country studies. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_civic_pt2-country-studies_20131202.pdf	Cross-cutting	Cross-cutting	EU	
Claudi-Magnussen, C., Kristensen, L., and Tørrngren, M. Use of tainted boar meat for processed meat products. Danish Meat Research Institute. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_emp_use-of-tainted-boar-meat.pdf	6	Processing	EU	
Colruyt Group (n.d.). Alternative for castration of pigs.	7	Marketing of meat	Belgium	
COST (2016). Innovative approaches in pork production with entire males. Available: http://www.cost.eu/COST_Actions/ca/CA15215	Cross-cutting	Cross-cutting	EU	
Dahlmans et al. (2007). Sensorische beoordeling van spekmonsters op berengeur. CCL NUTRICONROL.	4	Detection	NL	

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Danish Meat Research Institute (2011). Validation of “human nose” based method for boar taint detection. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_dmri_human-nose-method.pdf	4	Detection – hot water method	DK
Danish Technological Institute. Sorting and optimized use of entire male pig meat. Available: https://www.dti.dk/specialists/sorting-and-optimized-use-of-entire-male-pig-meat/34918	6	Processing	DK
De Campeneere et al. (2017). Farm specific strategies to reduce boartaint. Flanders Research Institute for Agriculture, Fisheries and Food. Available: https://pure.ilvo.be/portal/en/projects/bedrijfsspecifieke-strategieen-voor-de-reductie-van-berengeur(6b2eb708-aa94-4c72-b248-4b3ae4da779e).html	1	Cross-cutting	BE
De Kimpe, K. Les alternatives à la castration chirurgicale des porcelets: immunocastration par l’improvac. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_vaccination_pres_de-kimpe_20110325.pdf	2	Immunocastration	EU
Deen et al. An economic model to assess costs and benefits of Improvac to the swine producer for control of boar taint. In the 20 th International Pig Veterinary Society Congress, 22-26 June 2008.	2	Costs and benefits of vaccination	N/A
DLO (2014). CAMPIG: Consumer acceptance in the European Union and in third countries of pig meat obtained from male pigs not surgically castrated. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_campig_20140706.pdf	7	Consumer acceptance	EU
Dunshea, F. R, et al. (2013) The effect of immunization against GnRF on nutrient requirements of male pigs.	2, 3	Nutrition of vaccinated pigs	N/A
Dutch Better Life Label (unpublished). Berengeur detectieregels uit de Beter Leven criteria voor varkensslachthuizen welke per 1-1-18 van kracht worden.	7	Cross-cutting	NL
European Commission (2017) Tail docking. Available: https://ec.europa.eu/food/animals/welfare/practice/farm/pigs/tail-docking_en	1	Cross-cutting	EU
European Commission. Alternatives to pig castration: European Declaration on alternatives to surgical castration of pigs. Available: https://ec.europa.eu/food/animals/welfare/practice/farm/pigs/castration_alternatives_en	N/A	N/A	EU
European Federation of Animal Science. Entire male pigs and immunocastration as alternatives to surgical castration of male piglets: opportunities and drawbacks (part 1) (with COST Action IPEMA). 69th Annual Meeting of the European Federation of Animal Science.	Cross-cutting	Cross-cutting	EU

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European Food Safety Agency (2004). Opinion of the Scientific Panel on Animal Health and Welfare (AHAW) on a request from the Commission related to welfare aspects of the castration of piglets. EFSA Journal, 2:7, pp. 1-18. Available: https://www.efsa.europa.eu/en/efsajournal/pub/91	1, 2	Cross-cutting	EU
European Medicines Agency. Improvac. Annex I. Summary of product characteristics. Available: http://www.ema.europa.eu/docs/en_GB/document_library/EPAR_-_Product_Information/veterinary/000136/WC500064060.pdf	1	Cross-cutting	EU
Font-i-Furnols (2012). Consumer studies on sensory acceptability of boar taint: A review. Meat Science 92(4): pp. 319-329. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_detection_2012_consumer-studies_sensory-acceptability.pdf	7	Consumer acceptance	EU
Font-i-Furnols et al. (2012). Effect of variation against gonadotrophin-releasing factor on growth performance, carcass, meat and fat quality of male Duroc pigs for dry-cured ham production. Meat Science, 91, pp. 148-154. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174012000095	3, 5	Effects of vaccination on quality of meat	Spain
Font-i-Furnols et al. (2016). Evolution of testes characteristics in entire and immunocastrated male pigs from 30 to 120 kg live weight as assessed by computed tomography with perspective on boar taint. Meat Science, 116: pp. 8-15. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174016300092	1, 2, 3, 4, 5	Physical characteristic	N/A
Fredriksen, B., Sibeko Johnsen, A.M., and Skuterud, E. (2011). Consumer attitudes towards castration of piglets and alternatives to surgical castration. Res. Vet. Sci. 90(2): pp. 352-357. Available: https://www.sciencedirect.com/science/article/pii/S0034528810002250	7, 8	Consumer attitudes	N/A
Gispert et al. (2010). Carcass and meat quality characteristics of immunocastrated male, surgically castrated male, entire male and female pigs. Meat Sci. 85(4): pp. 664-70. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174010000938	6	Processing	N/A
Guarini, C., Minelli, G., Pinna, A., Schivazappa, C., Ventura, G., and Virgili, R. Effect of immunocastration on some key technological and sensory quality parameters of Italian typical dry-cured ham. SSICA, Vet Practitioners, and Zoetis, at Congreso mundial del jamón/World congress of dry-cured hams, 28-30 May 2013.	2, 3	Cross-cutting	IT
Hansen, L., Larsen, A., Jensen, B., Hansen-Møller, J., and Barton-Gade, P. (1994) Influence of stocking rate and faeces deposition in the pen at different	1	Housing	N/A

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temperatures on skatole concentration (boar taint) in subcutaneous fat. <i>Animal Science</i> , 59(1), 99-110.			
Hansen, L., Mejer, H., Thamsborg, S., Byrne, D., Roepstorff, A., Karlsson, A., and Tuomola, M. (2006). Influence of chicory roots (<i>Cichorium intybus</i> L) on boar taint in entire male and female pigs. <i>Animal Science</i> , 82(3), 359-368.	1	Feeding – Chicory root	N/A
Haugen, J. Detection of Boar Taint: need for harmonised methods and rapid methods. Available: https://pdfs.semanticscholar.org/ee1/52141525231ddb5e595bb921db20537eefaf.pdf	4	Detection	NO
Improvac (n.d.). Environmental product declaration for IMPROVAC.	8	Cross-cutting	N/A
Improvac and Zoetis. Testosteron test.	2, 3	Cross-cutting	IT
Improvac. User Safety and Devices, Improvac Managed Males.	2	Immunocastration	N/A
Institute of Agriculture and Food Research and Technology (2015). Study on how to achieve reduction of boar taint compounds by breeding, feeding and management techniques. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_irta_20150216.pdf	1	Cross-cutting	EU
Janssens, G., Boulet, R., Reuter, W., and Hardy, N. (2018) TAINSTOP, an innovative feed concept: Influence on Boar Taint. Available: http://www.ca-ipema.eu/download/289/documents/oieras/orals_oeiras/2_N_3_Guy_Janssens.pdf	1	Feeding – Taintstop	EU
Jensen et al. (1997). Effect of various carbohydrate sources on the production of skatole in the hind gut of pigs and skatole concentration in blood plasma. In: Boar taint in entire male pigs. Proceedings of a meeting of the EAAP working group "Production and Utilisation of Meat from Entire Male Pigs"; 1997a Okt 1-3; Stockholm, Sweden. Wageningen, the Netherlands: Wageningen Pers; 1997. p.80-3.	1	Feeding - sugar beet (non-starch polysaccharides-dietary fibre)	N/A
Jensen, B. B. (2006). Prevention of boar taint in pig production. Factors affecting the level of skatole. <i>Acta Veterinaria Scandinavica</i> 48(1): S6.	1	Cross cutting	N/A
Kirk, G. (2016). 'Improvac could be Europe's high-welfare castration solution', <i>PigWorld</i> , 01 April. Available: http://www.pig-world.co.uk/news/welfare/improvac-could-be-europes-high-welfare-castration-solution.html	2	Immunocastration	UK
Kiss et al. (2017). 'Ceva Valora® as an Efficient Alternative to Surgical Castration'. <i>The Pig Site</i> , 22 February. Available: http://www.thepigsite.com/articles/5360/ceva-valora-as-an-efficient-alternative-to-surgical-castration/	2	Immunocastration	N/A
Kjeldsen, N. (1993). Practical experience with production and slaughter of entire male pigs. In <i>Measurement and prevention of boar taint in entire male pigs</i> , Roskilde,	1	Feeding - fasting prior	DK

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Lagerkvist, C.J., Carlsson, F., and Viske, D. (2006). Swedish consumer preferences for animal welfare and biotech: A choice experiment. <i>AgBioForum</i> . 9:1, pp. 51–58. Available: http://www.agbioforum.org/v9n1/v9n1a06-lagerkvist.pdf	7, 8	Consumer acceptance of immunocastration and production of entire males	SE
Le Rouzic (2016). 'The AROME project: developing a real alternative to the castration of piglets while preserving meat quality'. INRA Science & Impact, 19 January (updated 18 March 2016). Available: http://www.inra.fr/en/Partners-and-Agribusiness/Our-partners/All-the-news/Project-AROME	1	Breeding	FR
Lundström, K., Malmfors, B., Stern, S., Rydhmer, L., Eliasson-Selling, L., Mortensen, A. B., and Mortensen, H. P. (1994). Skatole levels in pigs selected for high lean tissue growth rate on different dietary protein levels. <i>Livestock Production Science</i> 38(2): 125–132.	1	Breeding	N/A
Mancini, C. M., Menozzi, D., and Arfini, F. (2017). Immunocastration: economic implications for the pork supply chain and consumer perception. An assessment of existing research. <i>Livestock Science</i> 203: pp. 10–20.	8	Cross-cutting	IT
Mancini, C. M., Menozzi, D., Arfini, F., and Veneziani, M. (2018). How do firms use consumer science to target consumer communication? The case of animal welfare. In: <i>Case Studies in the Traditional Food Sector</i> . Pp. 337–357.	8	Cross-cutting	IT
Martinez et al. (2016). Evaluation of different strategies to mask boar taint in cooked sausage. <i>Meat Science</i> 116: pp. 26–33. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174016300080	6	Processing	N/A
Mathur et al. (2012). A human nose scoring system for boar taint and its relationship with androstenone and skatole. <i>Meat Science</i> 91:4, pp. 414–422. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174012000708	4	Detection – human nose	N/A
Mons, G. (2018). Berenmesters Antonissen: 'Professie zit in de stal'. <i>PigBusiness</i> . 08 May. Available: https://www.pigbusiness.nl/artikel/80310-berenmesters-antonissen-professie-zit-in-de-stal/?tid=TIDP100319X153A73CA384A4E70BDA83C485E5403C3YI5&utm_campaign=2018_PigBusiness&utm_medium=Email&utm_source=E-mail&utm_content=201800805_PB_NB	1	Feeding – taintstop feed Flooring and housing – enrichment practices; wean to finish grouping	DE and NL
Morales et al. (2013). Growth performance and carcass quality of immunocastrated and surgically castrated pigs from crossbreds from Duroc and Pietrain sires. <i>J Anim Sci</i> . 91:8, pp. 3955–64. Available:	1	Breeding	N/A

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https://academic.oup.com/jas/article-abstract/91/8/3955/4731465?redirectedFrom=fulltext			
Morales et al. (2017). Surgical castration with pain relief affects the health and productive performance of pigs in the suckling period. <i>Porcine Health Management</i> , 3:18. Available: https://porcinehealthmanagement.biomedcentral.com/track/pdf/10.1186/s40813-017-0066-1	Entire males – cross-cutting	Cross-cutting	N/A
Mörlein, D., and Schübeler, A.S. So gelingt der Dialog mit den Kunden. <i>Fleischwirtschaft</i> , 10-2017, pp. 36-40.	7, 8	Cross-cutting	Germany
Nofima (2014). BoarCheck: a study on rapid methods for boar taint used or being developed at slaughter plants in the European Union. European Commission. Available: https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_research_boarcheck_20140901.pdf	4	Detection	EU
Nold, R. A., Romans, J. R., Costello, W. J., Henson, J. A., and Libal, G. W. (1997). Sensory characteristics and carcass traits of boars, barrows, and gilts fed high- or adequate-protein diets and slaughtered at 100 or 110 kilograms. <i>Journal of Animal Science</i> 75(10): 2641–2651.	1	Feeding – protein	EU
Palomo Yagüe, A. (2012). Inmunocastración en machos: resultados en cerdos ibéricos. Available: https://www.3tres3iberico.com/articulos/inmunocastracion-en-machos-resultados-en-cerdos-ibericos_817/	2	Immunocastration	ES
Panella-Riera et al. (2016). Consumers' segmentation based on the acceptability of meat from entire male pigs with different boar taint levels in four European countries: France, Italy, Spain and United Kingdom. <i>Meat Science</i> , 114: pp. 137-145. Available: https://www.sciencedirect.com/science/article/abs/pii/S0309174015301558	7	Consumer acceptance of tainted meat	EU
Parolari, G. Dry-cured ham from immunocastrated pigs. SSICA, at Welfare: Sustainable Future for Pig Meat, 07 March 2014.	2, 3	Cross-cutting	IT
Pinna et al. (2015). Effect of vaccination against gonadotropin-releasing hormone (GnRH) in heavy male pigs for Italian typical dry-cured ham production. <i>Meat Science</i> , 110, pp. 153-9. Available: https://www.ncbi.nlm.nih.gov/pubmed/26225931	2, 3, 5	Immunocastration	IT
Rossi, A. Meat quality of immunocastrated pigs at slaughter. Centro Ricerche Produzioni Animali S.p.A, at Welfare: Sustainable Future for Pig Meat, 07 March 2014.	2, 3	Cross-cutting	IT
Rydhmer et al. (2010). Immunocastration reduces aggressive and sexual behaviour in male pigs. <i>Animal</i> , 4:6, pp. 965-972. Available: https://www.cambridge.org/core/journals/animal/article/immunocastration-reduces-aggressive-and-sexual-behaviour-in-male-pigs/535F575B73AD3E5A36FF5F3104B65FD8	2, 3	Cross-cutting	Sweden

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Schübeler, A.S., and Mörlein, D. Wie reagieren Verbraucher auf Impfung gegen Ebergeruch? Fleischwirtschaft, 5-2017, pp. 34-39.	7, 8	Cross-cutting	Germany
ter Beek, V. (2016). '4 Take-home messages on boar taint'. Pig Progress, 14 December. Available: https://www.pigprogress.net/Finishers/Articles/2016/12/4-Take-home-messages-on-boar-taint-70561E/	Cross-cutting	Cross-cutting	N/A
ter Beek, V. (2018). 'Rye: Influence on Salmonella and boar taint in finishers'. Pig Progress, 08 February. Available: https://www.pigprogress.net/Finishers/Articles/2018/2/Rye-Influence-on-Salmonella-and-boar-taint-in-finishers-245681E/	1	Feeding	N/A
Tesco. Reports and Policies: more information on our UK animal welfare. Available: https://www.tescopl.com/little-helps-plan/reports-and-policies/animal-welfare-policy/more-information-on-our-uk-animal-welfare/	7	Marketing	UK
Tuytens et al. (2012). On farm comparison of different alternatives for surgical castration of male piglets. Flanders Research Institute for Agriculture, Fisheries and Food. Available: https://pure.ilvo.be/portal/en/projects/vergelijkende-studie-op-praktijkbedrijven-van-op-korte-termijn-implementeerbare-alternatieven-voor-het-onverdoofd-chirurgisch-castreren-van-beerbigen(c84374bd-aa5b-436c-8336-e10ccc3290bc).html	1, 2	Cross-cutting	BE
Tuytens et al. (2012). Pig producer attitude towards surgical castration of piglets without anaesthesia versus alternative strategies. Research in Veterinary Science 92:3, pp. 524-530. Available: https://www.sciencedirect.com/science/article/pii/S0034528811001172	Cross-cutting	Cross-cutting	N/A
Unknown (2014). 'New project to measure boar taint on slaughterhouse line', The Pig Site, 30 September. Available: http://www.thepigsite.com/swinenews/37729/new-project-to-measure-boar-taint-on-slaughterhouse-line/	4	Detection	UK
Unknown (2014). 'Race is on to find solution to boar taint'. Pig Progress, 03 September (updated 25 February 2016). Available: https://www.pigprogress.net/Sows/Articles/2014/9/Race-is-on-to-find-solution-to-boar-taint-1589900W/	1	Feeding	DK
Unknown (2016). 'Biennial Report 2015-2016', The Pig Health and Welfare Council. Available: https://pork.ahdb.org.uk/media/273917/phwc-biennial-report-2015-16.pdf	Cross-cutting	Cross-cutting	UK
Unknown (2016). 'NPA briefing note on castration', National Pig Association.	1	Cross-cutting	UK
Unknown (2017). 'Norway: Close Cooperation in Pig Supply Chain'. The Pig Site, 22 June. Available: http://www.thepigsite.com/swinenews/43714/norway-close-cooperation-in-pig-supply-chain/	Cross-cutting	Cross-cutting	NO

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Unknown (2017). 'Pigs 2022 – Battling taint to protect our market', PigWorld, 10 July. Available: http://www.pig-world.co.uk/pigs-2022-conference/pigs-2022-battling-taint-to-protect-our-market.html	Cross-cutting	Cross-cutting	UK
Unknown (2017). 'Topigs: Less boar taint with the Nador concept'. Pig Progress, 30 Jan. Available: https://www.pigprogress.net/Home/General/2012/1/Topigs-Less-boar-taint-with-the-Nador-concept-PP008280W/	1	Breeding	EU
Unknown (2017). 'Vitelia-voer dringt berengeur terug', Varkens, 20 January. Available: https://varkens.nl/vitelia-voer-dringt-berengeur-terug/	1	Feeding	NL
van Dooren, K. (2017). 'The right terminal sire can reduce tainted pig carcasses'. Pig Progress, 23 January. Available: https://www.pigprogress.net/Sows/Articles/2017/1/The-right-terminal-sire-can-reduce-tainted-pig-carcasses-84853E/	1	Breeding	EU
Vanhonacker, F. and Verbeke, W. (2011). Consumer response to the possible use of a vaccine method to control boar taint v. physical piglet castration with anaesthesia: a quantitative study in four European countries, Animal (2011), 5:7, pp 1107–1118 & The Animal Consortium 2011	8	Consumer acceptance of immunocastration	FR, NL, DE, BE
Wäckers et al. (2011). Boar taint detection using parasitoid biosensors. Journal of Food Science, 76:1, S41-7. Available: https://www.researchgate.net/publication/51091768_Boar_Taint_Detection_Using_Parasitoid_Biosensors	4	Detection	N/A
Wageningen UR (2013). Boars on the way: results of the 5 year Dutch research programme 'Boars heading for 2018'. Available: http://boars2018.com/wp-content/uploads/2014/02/Boars-on-the-way.herzien-11-2-2014.pdf	Entire males – cross-cutting	Cross-cutting	The Netherlands
Wouda, T. (2017). 'Vitelia vervolgt onderzoek beergedrag', Nieuwe Oogst, 29 April. Available: https://www.nieuweoogst.nu/nieuws/2017/04/29/vitelia-vervolgt-onderzoek-beergedrag	1	Feeding	NL
Xue et al. (1996). Breed differences in boar taint: relationship between tissue levels of boar taint compounds and sensory analysis of taint. Journal of Animal Science, 74. pp. 2170-2177. Available: https://www.researchgate.net/publication/14327322_Breed_Differences_in_Boar_Taint_Relationship_between_Tissue_Levels_of_Boar_Taint_Compounds_and_Sensory_Analysis_of_Taint	1	Breeding	N/A
Zamaratskaia, G., and Krøyer Rasmussen, M. (2015). Immunocastration of male pigs – situation today. Procedia Food Science, 5, pp. 324-327. Available: https://www.sciencedirect.com/science/article/pii/S2211601X15001546	2, 3	Age at immunocastration; checks to ensure absence of boar taint	International

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Zammerini, D., Wood, J. D., Whittington, F. M., Nute, G. R., Hughes, S. I., Hazzledine, M. and Matthews, K. (2012). Effect of dietary chicory on boar taint. Meat Science, 91(4), 396-401.	1	Feeding – Chicory root	N/A
Zeng et al. (2002). Effects of active immunization against GnRH on serum LH, inhibin A, sexual development and growth rate in Chinese female pigs. Theriogenology, 58:7, pp. 1315-26. Available: https://www.researchgate.net/publication/11074883_Effects_of_active_immunization_against_GnRH_on_serum_LH_inhibin_A_sexual_development_and_growth_rate_in_Chinese_female_pigs	2	Immunocastration	N/A
Zoetis (n.d.) Implementation on-farm. Training program for the implementation of Improvac – Vaccine for the control of boar taint (unpublished)	2	Supply chain assurance – control documents	ES

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