Pig castration: methods of anaesthesia and analgesia for all pigs and other alternatives for pigs used in traditional products

Study on methods of anaesthesia and analgesia for the castration of all pigs and on alternative methods to the castration of pigs used in traditional products.

Written by CASTRUM consortium
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Directorate-General for Health and Food Safety
Animal Welfare

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Call for tender SANCO/2014/G3/026 concerning a study:

"Pig castration: methods of anaesthesia and analgesia for all pigs and other alternatives for pigs used in traditional products"

Title of contract

Study on methods of anaesthesia and analgesia for the castration of all pigs and on alternative methods to the castration of pigs used in traditional products.

FINAL REPORT

Tender application from the CASTRUM Consortium:

CASTRUM – Pig Castration for Traditional and Conventional Products: a Report on Methods and their Impacts on Animal Welfare, Meat Quality and Sustainability of European Pork Production Systems.

22nd December 2016

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Table of Contents

0. Executive summary

The European Treaty with its amendment in the Lisbon Treaty that entered into force in 2009 has defined a general concept on animal welfare as reported in Article 13 of Title II:

"In formulating and implementing the Union's agriculture, fisheries, transport, internal market, research and technological development and space policies, the Union and the Member States shall, since animals are sentient beings, pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage."

According to European legislation male pig castration after seven days of age, shall only be carried out under anaesthetic and prolonged analgesia by a veterinarian.

In 2010, representatives of several actors (farmers, meat industry, retailers, scientists, veterinarians and non-governmental organizations) of the European pig sector endorsed the European Declaration on alternatives to surgical castration of pigs (https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_declaration_en.pdf). The document constituted a voluntary initiative aimed at stopping surgical castration of male pigs by 1 January 2018. Derogations were considered according to the technical and practical possibility to avoid boar taint of meat produced from entire males following also the second part of the cited Article 13 of the Lisbon Treaty that considers the respect of *legislative or administrative provisions and customs of the Member States* relating *in particular to … cultural traditions and regional heritage.*

It is in this context that the Directorate General for Health and Food Safety (DG SANTE) of the European Commission has commissioned a "Study on methods of anaesthesia and analgesia for the castration of all pigs and on alternative methods to the castration of pigs used in traditional products" to the CASTRUM Consortium.

The CASTRUM Consortium has prepared a Final Report based on i) a collection of scientific data already produced and information available in this field, ii) combined with information related to the current practices on male pig castration and opinions of different stakeholders operating in this field according to the two main specific objectives of the project:

1) Identify, specify and evaluate recognized methods for the anaesthesia and/or prolonged analgesia at the time of male pig castration in Europe;
2) Evaluate and review the alternatives to surgical castration for heavy pigs used in traditional products considering quality assurance systems, meat quality and animal welfare.

Both parts of the study included whether and how the methods are embedded in national quality assurance systems and affect meat quality parameters, in particular for traditional pork products (e.g. Protected Designation of Origin or PDO, Protected Geographic Indication or PGI, Traditional Speciality Guaranteed or TSG), and animal welfare criteria comparing castration and alternative methods.

CASTRUM mainly covered 16 different countries (South Europe: Portugal, Spain, Italy; West Europe: France, United Kingdom, Belgium, Germany and Austria; North Europe: Denmark, Norway, Sweden; East Europe: Poland, Hungary, Slovenia, Croatia and Bulgaria). Reported activities are from 11 Project Partners from 10 different European countries (including Norway) and 7 other Associated National Contact Points (for Austria, Bulgaria, Denmark, Hungary, Poland, Spain and UK). Information was also in part collected for Finland, Luxembourg, Malta, Netherlands and Switzerland.

The final report includes information from i) a bibliographic survey that collected information and data that have been produced mainly for the last 10 years (till September

2016); ii) a questionnaire survey that collected information from different stakeholders from June 2016 to October 2016.

Despite the voluntary initiative defined in 2010 in the "European Declaration on alternatives to surgical castration of pigs", very heterogeneous situations still exist in Europe on this practice.

The survey for the first part of the project provided a general overview on the methods of surgical castration of male piglets across countries and the use of anaesthesia and or analgesia for this practice. In particular, it emerged that castration of male piglets is predominantly done without analgesia and/or anaesthesia. The use of anaesthesia (local or general) is mandatory in only a few countries and prior analgesia is used as part of national assurance programmes in some other countries. Limited advancements have been obtained in the last 10 years on the use of anaesthesia and/or analgesia in male piglet castration, from both scientific and technical points of views. Furthermore, effectiveness of pain mitigation interventions has been questioned for all methods of anaesthesia if not combined with analgesia. Analgesics given alone do not fulfill this requirement as they are mainly effective to mitigate pain post-surgically. Applications of analgesics and anaesthetics impose additional handling and stress on piglets. Long lasting pain reducing drugs that could be effective during and after castration are not available for the use on piglets. The systematic use of analgesia and/or anaesthesia for pain relief during surgical castration of male piglets is presently rarely used. Some of the anaesthetics and/or analgesics assessed do not seem to meet the demand for a sustainable and welfare friendly production system. However, it seems also that some practices, such as local anaesthesia and inhalation anaesthesia with Isoflurane, both combined with analgesic preemptive treatment, could be considered for pain relief as these methods seem to be superior to other methods considering effectiveness, drawbacks and risks.

In most European countries, pork products from heavy pigs are rooted in ancient traditions and traditional nutritional habits. Only part of these products has been issued official denominations, such as PDO or PGI. In some cases, local pig genetic resources (i.e. autochthonous pig breeds) support traditional products or rural economies, so that traditional products can be essential in maintaining biodiversity across Europe. Pig meat traditional products often come from carcasses of pigs slaughtered at "higher than standard weights", assuming as "standard weight" the slaughtering weight of butchery pigs, or pigs meant to produce fresh meat. If general consensus exists among stakeholders on the range 95-120 kg live weight for standard slaughtering weights, no general agreement among European stakeholders (i.e. producers, slaughter houses, retailers), scientists, practitioners and even Member States exist on a definition for heavy pigs. This point is crucial because some of the traditional products usually come from heavier pigs and heavier pigs tend to be more sexually mature with a higher likelihood for males to present boar taint if not castrated. Therefore, heavy slaughtering weight is an important criterion to evaluate the risk of boar taint in pork products coming from entire males. But it is not the only one. Other factors also play important roles in determining the frequency of boar taint in non-castrated males. In particular, males of slow growing lines or local breeds can reach sexual maturity before they reach a heavy weight.

Besides their higher slaughter weight, other considerations make the issue of castration of pigs destined for traditional products particularly complex:

1) many registered traditional products officially require castration of male pigs;
2) many traditional products have high fat levels, do not include masking spices, are cooked at home or are to be consumed warm, all situations in which boar taint perception is magnified;

3) some traditional products require meat with specific characteristics of fat content, coverage and quality, absence of defects associated with *post mortem* conversion of muscle to meat;
4) heavier pigs require longer growing periods, and older entire males raise serious security issues for the farmers; Sexually mature males and females must be kept in separate batches.

Being performed so early in life (within 7 days post partum), it is irrelevant, from meat quality viewpoint, whether surgical castration of the piglets is done with or without anesthesia/analgesia.

Theoretically, surgical castration could be replaced by entire male pig production, immunocastration, chemical castration or sperm sexing. Sperm sexing is not available for the porcine species in commercial conditions while chemical castration is not a viable alternative because it is painful. Therefore, in view of meat quality assurance in production systems with heavy/older pigs, this study only took into consideration entire male production and immunocastration.

There are a number of well-known advantages and disadvantages to the use of entire male pigs in standard productions. In the case of heavy pigs raised for traditional high quality products, the number of advantages decreases whereas the number of disadvantages increases and those disadvantages are more serious than in standard productions. The use of entire males was tentatively (with the collected information) evaluated as difficult/impossible to implement and/or damaging for meat quality in a large majority of the situations that were analysed in the present study. Moreover, a large majority of the chain actors (i.e. producers, slaughterhouses and retailers) that are using only surgical castrates are not currently prepared to change their position.

Immunocastration is a practice that uses a vaccine against gonadotrophin-releasing hormone (GnRH) to prevent the development of boar taint in the meat obtained from non-surgically castrated male pigs. It uses the natural immune system of the pig to form specific antibodies that bind and neutralize GnRH; thus hypothalamic-pituitary-gonadal axis is blocked and sexual steroids synthesis is effectively inhibited. Immunocastration becomes effective after the second vaccine injection and is technically feasible in heavy pigs. It prevents most of the disadvantages associated with entire males. There are however a number of remaining issues that should be investigated or further considered: the incomplete efficacy of the vaccination in some pigs, the economic convenience of this practice, the quality of the meat, the security of the operators during the vaccination procedures and the practical feasibility of the interventions on pigs that are raised in free ranging systems and on pigs with heavy weights that might require a third vaccination. The study reports a general concern about the acceptability of pork from immunocastrated pigs by slaughterhouses, retailers and consumers. This problem seems one of the main drawbacks for the application of this technique in all production systems, including the standard production systems. In general, immunocastrated male pigs exhibit similar meat quality to surgically castrated males. Processing aptitude of the meat for high quality seasoned products derived by immunocatrated heavy pigs should be further investigated.

Answers to the questionnaire confirmed all of the above: in most systems, surgical castration of male piglets is a common practice, integrated in the production chains, and alternatives are generally not taken into consideration or considered too problematic for the production systems rearing heavy pigs.

1. Introduction

The European Treaty with its amendment in the Lisbon Treaty that entered into force in 2009 has defined a general concept on animal welfare as reported in Article 13 of Title II:

"In formulating and implementing the Union's agriculture, fisheries, transport, internal market, research and technological development and space policies, the Union and the Member States shall, since animals are sentient beings, pay full regard to the welfare requirements of animals, while respecting the legislative or administrative provisions and customs of the Member States relating in particular to religious rites, cultural traditions and regional heritage."

According to these general principles related to animal welfare the Council Directive 91/630/EEC (Annex I, Chapter II) has indicated that piglets over four weeks of age cannot be surgically castrated without anaesthetic and only by a veterinarian or by a qualified person. Subsequently the Directive 2008/120/EC indicated that male pig castration can only be carried out by trained personnel under hygienic conditions and if done after seven days of age, only under anaesthetic and additional analgesia administered by a veterinarian.

In 2010, representatives of several actors (farmers, meat industry, retailers, scientists, veterinarians and non-governmental organizations) of the European pig sector endorsed the European Declaration on alternatives to surgical castration of pigs (https://ec.europa.eu/food/sites/food/files/animals/docs/aw_prac_farm_pigs_cast-alt_declaration_en.pdf). The document constituted a voluntary initiative aimed at stopping surgical castration of male pigs by 1 January 2018. Derogations were considered according to the technical and practical possibility to avoid boar taint of meat produced from entire males following also the second part of the cited Article 13 of the Lisbon Treaty that considers the respect of *legislative or administrative provisions and customs of the Member States* relating *in particular to … cultural traditions and regional heritage.*

It is in this context that the Directorate General for Health and Food Safety (DG SANTE) of the European Commission has commissioned a "*Study on methods of anaesthesia and analgesia for the castration of all pigs and on alternative methods to the castration of pigs used in traditional products*" to the CASTRUM Consortium.

The various alternatives to traditional way of piglet castration (physical castration without use of anaesthesia and analgesia) fall into two categories: reducing the pain of castration or avoiding physical castration. The first category aims to reduce the discomfort of castration by administering anaesthesia or analgesia. The second category leaves the male piglets entire, but attempts to reduce boar taint via management strategies or immunocastration.

Before alternatives can be implemented, it is important to determine whether they are sustainable, feasible in practice and acceptable for the stakeholders. This is particularly relevant for pork production chains that are usually based on prolonged fattening i.e. where pigs are older and heavier like pork chains for special traditional products.

A quite large number of publications (e.g. scientific, grey, reports, positions papers, opinion papers) have been recently obtained in this field (or derived) from different national and European projects but few of them have been specifically focused on alternatives to piglet castration in heavy pig production chains or studied and evaluated the impacts of these alternatives on traditional pork products. Considering these gaps, it is particularly important to cover the potential advantages and disadvantages of alternative solutions in diverse situations in the pig sector occurring in different European countries and to enable solutions for small scale and large scale production systems. The most critical aspect in pig castration is to evaluate the possible alternatives of surgical castration for (older) heavy pigs used for traditional pork products. As these animals are slaughtered when they have already reached sexual maturity, and furthermore their products are considered by consumers as of special

and better sensory quality, boar taint is a very problematic and limiting factor that needs to be considered. Alternative solutions for these production situations are indispensable.

1.1 The CASTRUM Consortium: scope, geographical coverage and time period

CASTRUM has addressed its activity to fill these gaps. The Final Report is based on i) the collection of scientific data already produced and information available in the relevant literature for this field and ii) the collection of information related to the current practices on male pig castration and opinions of different actors and stakeholders operating in this field. Data and information have been collected according to the two main specific objectives of the project:

1) Identify, specify and evaluate recognized methods for the anaesthesia and/or prolonged analgesia at the time of male pig castration in Europe;
2) Evaluate and review the alternatives to surgical castration for older heavy pigs used in traditional pork products considering quality assurance systems, meat quality and animal welfare.

Both parts of the study include whether and how the methods are embedded in national quality assurance systems and affect meat quality parameters, in particular for traditional pork products (e.g. PDO, PGI, TSG), and animal welfare criteria comparing castration and alternative methods.

CASTRUM mainly covered 16 different countries (South Europe: Portugal, Spain, Italy; West Europe: France, United Kingdom, Belgium, Germany and Austria; North Europe: Denmark, Norway, Sweden; East Europe: Poland, Hungary, Slovenia, Croatia and Bulgaria). Reported activities are from 11 Project Partners from 10 different European countries (including Norway) and other 7 Associated National Contact Points (for Austria, Bulgaria, Denmark, Hungary, Poland, Spain and UK). Information was also in part collected for Finland, Luxembourg, Malta, Netherlands and Switzerland.

The final report includes information from (see the paragraph on Methodology): i) a bibliographic survey that collected information and data that have been produced mainly for the last 10 years (till September 2016); ii) a questionnaire survey that collected information from different stakeholders from June 2016 to October 2016.

Table 1.1. The CASTRUM Consortium.

Partner Institutions	Acronym	Country	Role	Authors
Alma Mater Studiorum – University of Bologna	UNIBO	Italy	Coordinator (P1)	Luca Fontanesi, Leonardo Nanni Costa
Martin-Luther-Universität Halle-Wittenberg	MLU	Germany	Partner (P2) - Part 1 Leader	Eberhard von Borell
Institut de la Filière Porcine	IFIP	France	Partner (P3) - Part 2 Leader	Michel Bonneau, Patrick Chevillon, Valerie Courboulay
Institute for Agricultural and Fisheries Research	ILVO	Belgium	Partner (P4) - Communication Leader	Marijke Aluwé, Evert Heyrman

Instituto de Recerca i Tecnologia Agroalimentàries	IRTA	Spain	Partner (P5)	Maria Font i Furnols Marina Gispert Núria Panella-Riera M.Àngels Oliver
Norwegian Meat and Poultry Research Center	ANIMALIA	Norway	Partner (P6)	Bente Fredriksen
Kmetijski Institut Slovenije (Agricultural Institute of Slovenia)	KIS	Slovenia	Partner (P7)	Marjeta Čandek-Potokar, Martin Škrlep
Swedish University of Agricultural Sciences	SLU	Sweden	Partner (P8)	Galia Zamaratskaia
Instituto Nacional de Investigacao Agraria e Veterinaria	INIAV	Portugal	Partner (P9)	Sandra Cavaco-Gonçalves, Olga Mafalda Salvador Conde Moreira, João Almeida
Council for Agricultural Research and Economics	CREA	Italy	Partner (P10)	Luca Buttazzoni, Sebastiana Failla, Michela Contò
Faculty of Agriculture in Osijek	PFOS	Croatia	Partner (P11)	Goran Kušec, Vladimir Margeta, Ivona Djurkin Kušec, Kristina Gvozdanović
Collaborating Institutions				
University of Natural Resources and Life Sciences	BOKU	Austria	Collaborator	Christine Leeb
Trakia University	TRAUNI	Bulgaria	Collaborator	Todor Stoyanchev, Ivan Penchev Georgiev, Ekaterina Vachkova
Danish Meat Research Institute	DMRI	Denmark	Collaborator	Susanne Støier, Margit Dall Aaslyng, Lene Meinert
Debrecen University	DEUNI	Hungary	Collaborator	Csaba Szabo, Jozsef Ratky
Polski Zwiazek Hdowcow i Producentow Trzody Chlewnej	POLSUS	Poland	Collaborator	Katarzyna Skrzymowska
Centro de Investigaciones Científicas y Técnologicas de Extremadura	CICYTEX	Spain	Collaborator	Mercedes Izquierdo, Francisco I. Hernández-García
The Research Institute of Organic Agriculture	FIBL	Switzerland	Collaborator	Früh Barbara
British Pig Association	BPA	United Kingdom	Collaborator	Rex Walters

2. Methodology

Activities of the CASTRUM project were divided into four Work Packages (WPs) that matched the structure of the tender call and that facilitated the organization of the consortium to reach the main objectives.

The coordination and management of the project was defined in WP0. **WP1** included all activities related to **Collection and evaluation of information on methods for anaesthesia and analgesia**. **WP2** included all activities related to the **Evaluation of alternatives to surgical castration for heavy pigs used in traditional products**. WP3 served and coordinated the preparation of the interviews, surveys and questionnaires that were used by WP1 and WP2.

CASTRUM focused on two main activities that provided information to fulfil the objectives of the project: 1) a bibliographic survey, to collect and extract the information from already available literatures and reports; 2) a questionnaire survey to obtain data on current practices and opinions from stakeholders and practitioners operating at different levels in pork production chains.

These activities were carried out by 18 National Contact Points (11 project partners and 7 associated National Contact Points) covering 15 European Union countries (Austria, Belgium, Bulgaria, Croatia, Denmark, France, Germany, Hungary, Italy, Poland, Portugal, Slovenia, Spain, Sweden and United Kingdom) and Norway. NCPs collected relevant documents and extracted needed information following the structure of the questionnaires. For some aspects, the information was also collected for other countries including Luxembourg, Malta, Switzerland and The Netherlands.

All activities were filtered and summarized by WP leaders that are experts in their specific areas covering.

For these purposes, a bibliographic survey guideline has been prepared and distributed to all NCPs together with two structured excel files including pre-filled columns to facilitate the collection and extraction of relevant information. A drop-box repository has been designed to gather together all original documents.

Briefly, the bibliographic survey covered: 1) Scientific publications; 2) Grey literature; 3) DOOR database information for PDO, PGI and TSG products (including production rules and specification available); 4) Official EU reports and projects; 5) Other production rules/specifications available for several products or group of products; 6) National regulations; 7) Not disclosed information or still not published information.

The questionnaire survey was translated in 14 different European languages to facilitate the contact and the answers from all actors of pork production chains who might not speak English: English, Bulgarian, Croatian, Dutch, French, German, Hungarian, Italian, Norwegian, Polish, Portuguese, Slovenian, Spanish and Swedish.

The Questionnaires was prepared as online survey with a web-platform as well as on paper.

The questionnaire was divided in two main parts to answer the questions needed for WP1 and WP2. It was mainly addressed to veterinarians, producers, slaughterhouse operators and processors (but also to other stakeholders of pork production that were asked to describe their role (e.g. advisor, governmental officer etc.).

It was made by a total of 60 questions that stakeholders answered according to their role in the production chains: Veterinarians (questions 35 to 56); producers (questions 1 to 10 and 12 to 56), slaughterhouse operators and processors (questions 1 to 34); other actors (all questions, to capture relevant information for the whole production chain).

2.1. Numbers and statistics

This paragraph includes general information on statistics related to the bibliographic survey and questionnaires that were filled.

2.1.1. Bibliographic survey

Table 2.1.1 reports the numbers of documents that were retrieved from different sources divided by countries included in the survey. A Dropbox repository has been implemented and divided by country, in which all retrieved documents have been deposited. This resource was used only for the purpose of this study and can be available only as list of documents. A total of 593 documents has been listed.

From the bibliographic survey, it emerged that a quite large number of documents have been already produced from different studies, or are already available from other European reports on topics related to male pig castration. It is also clear that there is a large variability in terms of types and number of documents among and within countries. Scientific literature (including original research works and scientific reviews), grey literature (including proceedings of congresses, i.e. abstracts, popular articles, dissertations and other similar documents) and DOOR database (http://ec.europa.eu/agriculture/quality/door/list.html) providing PDO, PGI and TSG rules and specifications are the most important sources of information for all countries.

Table 2.1.1. Number of documents related to male pig castration and their alternative or containing relevant information for the purpose of this study retrieved in different European countries. In parenthesis: the number of documents in national languages.

Countries	Scientific	Grey	DOOR†	Reports	Others	Total
Austria	-	-	2	-	-	2
Belgium	6	3 (2)	2	-	2 (2)	10 (4)
Bulgaria	-	-	4	-	-	4
Croatia	-	-	6	-	-	6
Denmark	31	3 (3)	-	2 (2)	3 (3)	-
France	69 (8)	78 (67)	26	-	-	173 (75)
Germany	6	8 (8)	18	-	-	32 (8)
Hungary	-	-	4	-	-	4
Italy	1	33 (30)	41	-	-	75 (30)
Norway	-	-	-	-	2 (2)	2 (2)
Poland	-	-	9	-	-	9
Portugal	1	-	43	-	-	44
Slovenia	29 (3)	11 (10)	8	-	-	48
Spain	31	62 (30)	17	-	-	110 (30)
Sweden	18	4 (2)	1	3 (3)	-	26 (5)
UK	-	-	6	-	-	6
International§	-	-	-	11	-	1
Total	**191 (11)**	**202 (152)**	**187**	**15 (5)**	**7 (7)**	**603 (175)**

§ Official EU documents or reports

† Documents are usually both in English and in the national languages

2.1.2. Questionnaires

The web tool allowed gathering the answers for all questions for all different language versions in one dataset. The questionnaire was closed at the end of October. In total, 819 entries were present in the dataset. As next step, the dataset was cleaned for further use, by removing the entries which were clearly incomplete, resulting in 364 entries. Further quality control was performed to check entries with incomplete answers, doubles, test versions, resulting in a final dataset ready for back-translation and to English and quality check by the national contact points of 293 entries. Finally, this resulted in dataset with 280 entries, representing respondents from 20 countries (Table 2.1.2) that have been selected and contacted by the NCPs in the different countries to fill in the questionnaire.

Table 2.1.a. Final numbers of respondents per country that filled in the questionnaire after the cleaning steps.

Countries	Abattoirs/ Processors	Veterinarians	Pork chains	Others	Producers	Totals
Austria	2	1	0	1	2	6
Belgium	2	7	3	0	3	15
Bulgaria	0	9	0	1	1	11
Denmark	0	0	0	0	2	2
Finland	0	1	0	0	0	1
France	6	3	4	7	2	22
Germany	6	0	0	6	3	15
Hungary	1	6	0	5	66	78
Italy	11	2	0	2	4	19
Croatia	0	14	0	0	8	22
Luxembourg	0	1	0	0	0	1
Malta	0	1	0	0	1	2
Netherlands	0	0	0	1	0	1
Norway	2	0	0	1	5	8
Poland	0	1	0	1	3	5
Portugal	0	0	0	2	4	6
Slovenia	11	1	0	4	9	25
Spain	13	5	0	3	11	32
Sweden	0	3	0	0	3	6
UK	0	0	0	3	0	3
Total	54	55	7	37	127	280

Tables 2.1.2b and 2.1.2c present the number of questionnaires that have been filled in for the two parts of the study, respectively. A total of 132 and 173 respondents replied to questions for the two parts respectively. The number of questionnaires that were retained for the different analyses varied according to the different questions that were answered in a meaningful way, as indicated in the legend of the subsequent tables. In addition, not all

questions of the questionnaire were always answered. These are the reasons of the reduction of numbers.

Table 2.1.2b. Distribution of the questionnaires related to WP1 completed according to country and stakeholder category. The numbers indicate the number of questionnaires that were used for the final report after cleaning.

Countries	Veterinarians	Producers	Others	Abattoirs /Processors	Pork chains	Totals
Austria	1	1	1	0	0	3
Belgium	6	3	0	0	3	12
Bulgaria	9	0	0	0	0	9
Croatia	7	2	0	0	0	9
Denmark	0	2	0	0	0	2
Finland	1	0	0	0	0	1
France	3	1	4	0	1	9
Germany	0	3	3	0	0	6
Hungary	4	31	1	0	0	36
Italy	2	1	0	0	0	3
Luxemburg	1	0	0	0	0	1
Malta	1	0	0	0	0	1
Netherlands	0	0	0	0	0	0
Norway	0	3	1	0	0	4
Poland	1	3	0	0	0	4
Portugal	0	4	0	0	0	4
Slovenia	1	6	4	0	0	11
Spain	4	8	1	0	0	13
Sweden	2	2	0	0	0	4
UK	0	0	0	0	0	0
Total	43	70	15	0	4	132

Table 2.1.2c. Distribution of the questionnaires related to WP2 completed according to country and stakeholder category.

Countries	Veterinarians	Producers	Others	Abattoirs /Processors	Pork chains	Totals
Austria	0	2	1	2	0	5
Belgium	0	3	0	2	3	8
Bulgaria	0	1	1	0	0	2
Croatia	0	8	0	0	0	8
Denmark	0	2	0	0	0	2
Finland	0	0	0	0	0	0
France	0	2	7	6	4	19
Germany	0	3	6	6	0	15
Hungary	0	66	4	1	0	71
Italy	0	4	2	11	0	16
Luxemburg	0	0	0	0	0	0
Malta	0	1	0	0	0	1
Netherlands	0	0	0	0	0	0

Countries	Veterinarians	Producers	Others	Abattoirs /Processors	Pork chains	Totals
Norway	0	5	1	2	0	8
Poland	0	3	1	0	0	4
Portugal	0	4	2	0	0	6
Slovenia	0	9	3	11	0	23
Spain	0	11	1	13	0	25
Sweden	0	3	0	0	0	3
UK	0	0	3	0	0	3
Total	0	127	31	55	7	220

3. Collection and evaluation of information on methods for anaesthesia and analgesia

3.1. Definitions of anaesthesia and analgesia

Anaesthesia is an artificially induced loss of sensation, especially of pain, through the use of drugs. It can be either general or local. General anaesthesia suppresses the central nervous system activity and results in unconsciousness and total lack of sensation. Local anaesthesia means that only a specific area of the body is involved. Local anaesthesia (or regional anaesthesia), is blocking transmission of nerve impulses between a targeted part of the body and the central nervous system, causing loss of sensation in the targeted body part. An animal under regional or local anaesthesia remains conscious. There are many types of local anaesthesia, either by injecting into the tissue itself, a vein that feeds the area or around a nerve trunk that supplies sensation to the area. The latter are called nerve blocks and are divided into peripheral or central nerve blocks. For male pig castration, the most common routes of injection are intratesticular, subcutaneous and intrafunicular (into the spermatic cord).

Analgesia means the loss of the ability to feel pain without the loss of consciousness. Nociceptive stimuli are perceived, but are not interpreted as pain. Analgesia is also referred to as the relief of pain. Analgesics are distinct from anaesthetics, which temporarily affect, and in some instances completely eliminate, sensation.

3.2. General considerations on anaesthesia and analgesia for male pig castration

Two main sources of information were used in this section:

- Bibliography (literature): information available in the literature (scientific, grey, expertise, and reports). Reports included six EU documents (Council regulation, EFSA and DG SANTE) and four other international reports.
- Questionnaire: information obtained from the questionnaire that was specifically developed for this project.

The use of anaesthesia and analgesia for male pig castration has been extensively reviewed. The following brief summary of the main reviews shows the development in the different techniques and gives information about their possible use at farm level. The most promising systems and methods are then developed in the following parts.

Based on the current knowledge, surgical castration is generally considered as painful regardless of pig's age and procedures known or applied have been described in previous reports and scientific reviews (EFSA, 2004; Prunier et al., 2006; von Borell et al., 2009). At that time, local anaesthesia was recommended to be used for the castration of piglets in addition to analgesia to prevent pain in piglets which are surgically castrated. In these reports, however, general anaesthesia was not recommended to be used in commercial farms (EFSA, 2004). It was also concluded that there is no validated protocol for the use of long-lasting analgesics which could be applied in commercial herds for reducing mid and long-term pain due to castration.

The FP6 specific support action PIGCAS demanded for studies on the feasibility of surgical castration with anaesthesia (general or local) under commercial conditions. Such studies should include investigations on its practicality, the possibility that the farmer can perform it by him(her)self, the real welfare benefits obtained from the procedure, the need for complementary analgesia and its economic feasibility in various situations (PIGCAS, 2009).

In 2011, a technical report was submitted to EFSA that included an update on welfare aspects related to piglet castration (EFSA, 2011). It was concluded "*whilst new methods of general anaesthesia by inhalation and injection have been researched and applied in*

practice, there is no consensus that these offer an appropriate and widely applicable solution". At that time, although still controversial, the use of CO_2 for general anaesthesia was also considered as a promising way forward.

More recent updates on the scientific knowledge regarding alternatives to piglet castration were issued by the American Veterinary Medical Association (AVMA, 2013) and by the Danish Ministry of Food, Agriculture and Fisheries (DCA Report 42, 2014). The Animal Welfare Information Center (AWIC, 2011) compiled a number of relevant articles for the period of 2000 until 2010 on the general use of anaesthesia/analgesia for pigs. O'Connor et al. (2014, 2016) reviewed pain relief intervention studies in neonatal pigs and graded the quality of evidence and the strength of recommendations. Recommendations were developed for three interventions (CO_2/O_2 general anaesthesia, non-steroidal anti-inflammatory drugs or NSAIDs, and lidocaine) for use during castration. The ability to make strong recommendations was limited by low-quality evidence and strong certainty about variation in stakeholder values and preferences. The expert panel strongly recommended against the use of a CO_2/O_2 general anaesthesia mixture, weakly recommended for the use of NSAIDs and weakly recommended against the use of lidocaine for pain mitigation during castration of 1- to 28-day-old piglets.

There is very little information available about the age of the piglets for the different methods. It is reasonable to believe that castration without anaesthesia is most often done within seven days of age, since according to legislation this is the age limit in EU to perform the castration without anaesthesia and analgesia. For piglets castrated under anaesthesia, the age is probably more variable. For some types of anaesthesia (mostly general anaesthesia), castration the first 3-4 days of age is commonly avoided due to increased risk of mortality. In Norway, the upper age limit for castration (with obligatory use of anesthesia and analgesia) is 28 days.

The survey revealed that 15 out of the 21 countries under consideration reported cases where anaesthesia (general: 9 cases; local: 11 cases) was used (see Table 3.3). However, only four countries (Netherlands, Norway, Slovenia and Switzerland) reported anaesthesia as their main method used during surgical castration. Cases for analgesia were reported from 11 countries of which five countries (Austria, Belgium, Denmark, France and Germany) use analgesia before castration as their main method as mandatory by national quality assurance programmes.

In addition, from the answers received in the questionnaire survey addressed to different stakeholders, it could be possible to deduce that, even among specialized people who are expected to be informed on surgical practices for male pig castration, there could be a lot of confusion on discriminating anaesthesia and analgesia and on their use and potential implications. This seems a field in which lack of general information, lack of expertise and sound scientific evidences are preventing uptake of common or useful practices. This is also demonstrated by the difficulties in finding stakeholders (in particular representatives from veterinary organisations) willing to answer questions related to anaesthesia and or analgesia.

Table 3.2 reports a summary of the methods of surgical castration used in different European countries.

Table 3.2. Overview on the methods of surgical castration across countries. The table is based on information from the NCPs as well as on the answers from the questionnaire.

Countries	Not castrating	Without anaesthesia or analgesia	With general anaesthesia	With local anaesthesia	Analgesia or given castration	Analgesia only - given after castration
Austria		(x)			XX	
Belgium	X	(x)			XX	X
Bulgaria	(x)	XX	X			
Croatia		XX	(x)	(x)	(x)	(x)
Denmark					XX	
Finland					XX	
France	X	XX		(x)	XX	(x)
Germany	X	(x)	X	(x)	XX	(x)
Hungary	(x)	XX	(x)	X	(x)	(x)
Italy		XX		X	X	
Luxembourg		XX				
Malta		XX				
Netherlands			XX			
Norway				XX		
Poland	(x)	XX				
Portugal		XX	(x)	(x)		
Slovenia	(x)	XX	(x)	(x)		(x)
Spain	XX	XX		(x)	(x)	(x)
Sweden		(x)		XX		(x)
Switzerland			XX			
United Kingdom	XX			(x)		

XX= reported as the main method(s) in the country.
X=reported as a regular method for a minor part of the population.
(x)=reported, but by a low number of responders and for very minor situations.

3.3. Existing methods for the use of anaesthesia at the time of castration - including used drugs

Table 6 summarizes the different methods used with anaesthesia and/or analgesia in male pig castration. General anaesthesia is not widely used, but can be either by inhalation (isoflurane or CO_2/O_2) or by intramuscular injection (ketamine in combination with the neuroleptic drug Azaperone). The questionnaire survey indicated that lidocaine is the main local anaesthetic used, either through subcutaneous or intratesticular injection.

Table 3.3. General summary of existing methods for the use of anaesthesia at the time of castration - including used drugs.

Type of anaesthesia	Route of administration	Anaesthetic substance	Reported use
General anaesthesia	Inhalation	Isoflurane	Switzerland (and Germany[1])
		CO_2/O_2	The Netherlands
	Intramuscular injection	Ketamine (+ Azaperone as sedative)	Croatia, Bulgaria, Germany, Portugal, Switzerland
Local anaesthesia	Subcutaneous injection	Lidocaine	Hungary, Croatia
	Intratesticular injection	Lidocaine	Hungary, Croatia, Sweden
	Subcutaneous + intratesticular injection	Lidocaine	Norway
	Topical gel	Lidocaine/meloxicam	Only experimental

[1] Only for veterinary student training and in one quality assurance programme.

3.3.1. General anaesthesia by inhalation

Two main techniques have been developed and are still in use today.

The use of CO_2 for general anaesthesia was considered as a promising way in 2011 (EFSA, 2011). For CO_2/O_2 anaesthesia, simple equipment (boxes for the piglets) can be used. Piglets are placed in the box or in a specific device and inhale a mixture of CO_2/O_2 for at least 30 seconds that leads to unconsciousness for 59 seconds while castration is performed. Then piglets are replaced in the home pen where they can rapidly recover (Gerritzen et al., 2008). Anaesthesia with CO_2/O_2 is currently being used in the Netherlands.

Isoflurane is an anaesthetic that requires more expensive and advanced equipment to be used. Three devices are currently used on farm in Switzerland, even if only two of them are still marketed. They use isoflurane in combination with air or O_2. As for CO_2/O_2 equipment, piglets are placed on a specific device and inhale the gas for at least 90 seconds before being castrated. Recovery from anaesthesia takes about the same time (Henchoz, 2009). Comparisons of isoflurane and sevoflurane for short-term anaesthesia revealed no statistical differences in age, weight or total anaesthetic time, although the cost of anaesthesia was much less with isoflurane than with sevoflurane (Hodgson, 2007). As part of a code of practice in Switzerland, this inhalation has to be combined with an analgesic pre-treatment, and can be performed up to 14 days of age. Specific training and authorizations have been developed in Switzerland in order to allow the farmer using this type of anaesthesia (that can be used in other countries only by a veterinarian). In our questionnaire survey, mask inhalation with isoflurane was also reported from Germany (but only for teaching veterinary students and in one welfare label programme). N_2O is another inhalation gas with narcotic properties. Its analgesic effects, however, appeared to be insufficient in preventing castration-induced pain (Rault and Lay, 2011).

3.3.2. General anaesthesia by injection

A combined general injection anaesthesia with azaperone and ketamine in combination with an analgesic drug is possible, and was reported by a few respondents in our questionnaire survey, eventually in combination with lidocaine/xylacine (n. 2), or both lidocaine and azaperone (n. 1). The dosage reported is 11-33 mg/kg for ketamine and 2.2 mg/kg for azaperone. The injections should be intramuscularly, just behind the ear or into the rump (*semitendinosus* and *semimembranosus* muscle).

3.3.3. Local anaesthesia by injection

Local anaesthesia is more commonly used, most often with subcutaneous and/or intratesticular injection with lidocaine. Subcutaneous injection at the site of incision can reduce the pain related to cutting the skin. Also, a topical gel treatment (with lidocaine and NSAIDs) might be effective in this respect. However, the most painful part of the castration has been shown to be the tearing and cutting of the spermatic cord. To relief this pain, injection directly into the spermatic cord (intrafunicular injection) or indirectly by the testicles seems to be necessary (Haga & Ranheim 2005).

Lidocaine has no maximum residue limits (MRL) for pigs. The use might therefore be restricted in several countries. The Committee for Medicinal Products for Veterinary Use (CVMP, 2015) has recently issued an opinion in relation to the potential risk for the consumer resulting from the use of lidocaine in food producing species in accordance with Article 30(3) of Regulation (EC) No 726/2004: "*For pigs no residue data are available and it is therefore not possible to calculate residue levels that will remain following the cascade withdrawal period. However, since metabolism is comparable to that in cattle, it is expected that the minimum cascade withdrawal period of 28 days for meat is sufficient to ensure that residues deplete to negligible levels. Furthermore, considering that lidocaine is used for castration within the first weeks of life, therefore far from slaughter, the risk to the consumer is considered negligible*." Concentrations of lidocaine/xylocaine varies from 0.5 – 2%. It is used either with or without adrenaline/epinephrine, (5-36 μg/ml)**.** The advantage of using adrenaline/epinephrine in addition to lidocaine is that the bleedings are reduced, and that the duration of the anaesthesia is extended. However, the risk of infections might be increased because of reduced blood flow in the tissue. A total of 0.5-1 ml (dependent of the age and size of the piglet as well as the concentration of the drug) is injected in each testicle. A common method is to administer most of it into the testicle, while a small amount is injected subcutaneously into the scrotum when pulling the needle out. Procaine has been assessed by the European Medicines Agency (EMEA) as a local anaesthetic which can be used without an established maximum residue limit (MRL) in production animals. Procaine was previously widely used, but has been replaced by other local anaesthetics such as lidocaine, which has a faster onset and longer duration. Based on cortisol measurements Zöls et al. (2006a) concluded that intratesticular injection of procaine hydrochloride does not provide the demanded pain reduction during castration.

Epidural anaesthesia with lidocaine, in combination with a sedative as Azaperone is a type of central nerve block that can be used in pigs. Because it is labour intensive and time consuming and has to be done by a veterinarian, it is probably only used when castration is done at the same time as surgery for inguinal hernia or hermaphroditism. In the present survey, it was reported from Finland only.

3.4. Existing methods for the use of analgesics for pigs which can be used to reduce pain during and after castration - including used drugs

All types of anaesthesia can be used in combination with analgesia (commonly known as painkillers), given either before or after castration. But analgesia is also commonly used alone.

Different types of NSAIDs given by intramuscular (or subcutaneous) injections are the drug of choice. The injections should be intramuscularly, just behind the ear or into the rump.

Meloxicam is a non-steroidal anti-inflammatory drug which blocks the enzyme cyclooxygenase (0.4 mg/kg BW intramuscular, half-life: 2.5 hours, withdrawal period (meat): 5 days, age: not to be used for pigs < 2 days old). Metamizole is a non-opioid pyrazolone derivated with analgesic and antipyretic properties, and a half-life of only 2.5 hours (20-50 mg/kg). Flunixin meglumine is a non-steroid anti-inflammatory drug with analgesic and anti-pyretic effect (1-2 mg/kg, withdrawal period (meat): 21 days). Carprofen (2-4 mg/kg) is an NSAID which cause analgesia by suppressing the formation of prostaglandins through inhibition of cyclooxygenase 1 and 2 (COX-1 and COX-2). Prostanoids generated by COX-2 play an important role in inflammatory and painful reactions to tissue damage. Ketoprofen (1-3 mg/kg given subcutaneous or intramuscular) can also be used pre-operatively for pre-emptive analgesia as well as post-operatively.

Analgesia is primarily used for post castration pain mitigation, but has also been shown to improve the effect of anaesthesia when given before castration.

Use of analgesia only (without concurrent use of anaesthesia) was reported by a total of 55 respondents in the current questionnaire survey. Meloxicam was the most commonly reported drug, reported by 37 responders (from 14 countries). Flunixine was reported by 11 responders, metamizol by 9 responders, whereas ketoprofene was reported by two responders. The use of carprofen was not reported.

In Austria, Belgium and Denmark, only analgesia without anaesthesia was reported, and in Luxembourg, Malta, Netherlands and Poland, the use of neither anaesthesia nor analgesia was reported.

Analgesia was reported to be given by the farmers only in Austria, Belgium, Denmark, France, Croatia and Sweden, while it is given by the veterinarians only in Bulgaria, Finland, Norway, Portugal and Slovenia. In Germany, Hungary, Italy and Spain, both farmers and veterinarians were reported to give analgesia.

3.5. Other methods and results reported from scientific research and other literature

There are reports on the use of topical treatments for pain relief during and after castration. A scientific study evaluated the effects of a short and long term anaesthetic that was applied topically into to the castration wound. Both treatments were not effective to reduce the pain caused by on-farm castration of piglets as indicated by cortisol level, vocalizations, behaviour and haematological parameters (Sutherland et al., 2010). Another attempt was reported by using an antiseptic wound spray containing iodine and lidocaine that was applied into the castration wound. It was postulated that the anaesthetic effect should be effective after 15 to 30 seconds up to 60 to 120 minutes. As a result, painful behaviour was seen as very subtle and there were no different behaviour scores observed in comparison to the positive controls (Strobel and Hawkins, 2012). A Canadian group recently tested a topical gel that contains lidocaine and meloxicam (Turner, 2015). So far there are no publicly accessible results available on this study. Based on what is known from other species and applications it can be expected that these topical treatments are effective in reducing the

impact of skin incisions as well as mitigating the postsurgical pain when applying the local anaesthetic into the wound but not alleviate the pain associated with tearing and cutting of the spermatic cord. Another route of administration was evaluated by intranasal application of ketamine, climazolam and azaperone (Axiak et al., 2007). Intranasal application resulted into significant higher reaction scores (behaviour and vocalizations) compared to the intramuscular route of administration. Courboulay et al. (2015) compared intramuscular injection of meloxicam and butorphanol, an opioid with sedative and analgesic properties, to meloxicam alone and reported only a slight decrease in plasma cortisol levels with butorphanol and meloxicam.

None of the above mentioned other methods were reported to be currently used in any of the countries that we had surveys from.

3.6. Facts and opinions on the effect of the methods used for anaesthesia or analgesia on several parameters

3.6.1. Secondary effect on the environment and human health

General anaesthesia by inhalation must be performed in a well-ventilated room, with an outside access for the gas to be evacuated. The use of isoflurane (as currently practiced in Switzerland) has been previously questioned regarding its environmental impact as well as for user safety and hygiene issues. It is a greenhouse gas whose global warming capability is 595 CO_2 equivalents (Myrhe et al., 2013). In a survey in Switzerland, nearly a quarter of farmers reported headache or dizziness when performing anaesthesia with Isoflurane (Enz et al., 2013a).

The use of general anaesthesia by injection with ketamine is restricted due to security reasons because it is a hallucinogenic drug with a high abuse potential (Schmidt et al., 2012).

3.6.2. Indicators of efficiency to reduce pain during castration and during the recovery period

A summary of the advantages and disadvantages on animal welfare are reported in Table 3.6.7. Specific considerations of different aspects are analysed in the following paragraphs.

3.6.2.1. General anaesthesia by inhalation

Even if pain is relieved through unconsciousness, it is still present when the piglet wakes up and additional pre-injection of a NSAID is therefore recommended. In the 2011 EFSA report (EFSA, 2011), CO_2 was evaluated as promising, while there was no consensus that general anaesthesia by inhalation and injection offered an appropriate and widely applicable solution".

For CO_2/O_2 anaesthesia by inhalation, an updated evaluation of the method considered it as not recommendable. Its previously reported aversive impact on the animal and limited safety margin (AVMA, 2013; Zimmermann et al, 2011; O'Connor et al., 2014) led the veterinary associations strongly argue against the use of this inhalation gas for the purpose of general anaesthesia. Van Beirendonck et al. (2011) concluded that piglets castrated with or without CO_2 anaesthesia displayed behaviours indicative of pain and discomfort for up to 6 days after castration. They recommended additional analgesia to be used to eliminate the

long-term pain caused by castration even in piglets anesthetized with CO_2 before castration. Sutherland et al. (2012) reported that neither CO_2 anaesthesia nor a NSAID, given separately or combined, markedly reduced the pain-induced distress caused by castration in pigs.

The use of Isoflurane (as currently practiced in Switzerland) has been previously questioned regarding its pain reducing efficiency (leads to consciousness without reducing pain). Anaesthesia depth and duration under Isoflurane, however, seems to be better under control as for general injection anaesthesia (Steigmann, 2013), although a level of 77% for sufficiently anaesthetised piglets was recently considered inadequate for commercial application of this automated technology (Schwennen et al., 2016). A recent survey on its use in Switzerland indicates that 14% of the piglets were insufficiently anaesthetized (Enz et al, 2013a). The authors also reported more bleeding after castration and recommend the use of an emasculator. Nevertheless, this technique presents a low level of mortality (< 0.1%).

3.6.2.2. General anaesthesia by injection

The effect of anaesthesia by injection of ketamine and azaperone are not consistent between studies (EFSA, 2011). Recovery takes time, body temperature decreases, and losses may occur. Special attention must be paid to the environment of the piglets to prevent hypothermia and crushing by the sow (Lahrmann, 2006). General anaesthesia by injection is performed by veterinarians in some farms in Switzerland. Enz et al. (2013b) reported that 34% of the anaesthetized piglets presented reactions during castration and that 38% of the piglets had excessive bleeding. The body temperature decreased by 3.1 °C over the hour of post castration.

3.6.2.3. Local anaesthesia

A main issue of concern is that the use of anaesthetics and analgesics may increase the risk of reduced welfare and stress due to additional handling, injection pain and side effects outweighing the benefits for using these interventions (Weiler et al., 2016). Central questions for the use of anaesthetics relate to the efficiency for pain reduction, safety margin for the products, user safety and proportionality (cost and benefit) and side effects such as environmental and health related impacts. As in previous reviews, results of the more recent studies do not provide uniform recommendations for or against one or another method, although local anaesthesia (e.g. by lidocaine) in combination with analgesia (e.g. by meloxicam) was reported to be effective in reducing pain in several studies (Hansson et al., 2011; Kluivers-Poodt et al., 2013; Bonastre et al., 2016), even if it was not effective in all treated piglets (Courboulay et al., 2010). Convulsions were observed in some piglets with increasing concentration of lidocaine (Courboulay et al., 2012). However, this treatment combination only seems to be effective during castration and in the immediate post-surgical period (Bonastre et al., 2016).

3.6.2.4. Analgesia

Heinritzi et al. (2006) investigated the impact of preoperative administration of analgesics (meloxicam, metamizol) and a local anaesthetic (procaine hydrochloride). Post- and intra-operative castration pain of the piglets was evaluated by comparing cortisol concentration in the blood sera of piglets subjected to five different treatments. Cortisol concentrations 1, 4 and 28 hours after castration indicated that treating with procaine hydrochloride caused no alleviation of castration pain. Metamizol seemed to reduce castration pain only after 4 hours, while piglets castrated after meloxicam administration showed no significant increase in cortisol concentration during the entire experiment,

suggesting effective pain relief. The results of this study were supported by another study about the use of meloxicam (Zöls et al., 2006b). In contrast with piglets that were castrated without pre-operative analgesia, piglets castrated after administration of meloxicam showed no significant increase in the serum concentration of cortisol 1 and 4 hours after surgery.

Contradictory results of a Dutch study on the use of anaesthesia and/or analgesia during castration were reported in 2007 (Kluivers-Poodt et al., 2007). Specific parameters such as vocalisation, physiology and behaviour related to pain were compared. This study reported that the pain and stress responses during castration were significantly reduced, but not eliminated, by the use of local anaesthetic (lidocaine), whereas the effect of the analgesic (meloxicam) was very limited. Regarding pain after castration, these authors failed to demonstrate clear effects of local anaesthesia and meloxicam treatments on pain-related behaviour during the initial days after castration.

The preemptive use of analgesics (meloxicam, flunixin, metamizole or carprofen) for the reduction of pain induced by the castration of suckling piglets was investigated by measuring cortisol and by post-surgical behaviour (Langhoff, 2009). All tested non-opioid analgesics reduced the rise of the cortisol concentration after castration. Piglets receiving meloxicam and flunixin had significantly lower values 30 minutes, 1 hour and 4 hours after castration than the control group, and already after 1 hour they did not differ significantly from the corresponding handling groups. The frequency of occurrence of tail wagging, drooping the tail and changing the position was explicitly reduced when meloxicam and flunixin were injected before castration. On the other hand, AVMA (2013) reported that the effectiveness of flunixin is unknown and may be poor. Courboulay et al. (2010) compared castration without pain relief, sham castration, castration with anaesthesia (using lidocaine) and castration with analgesia (using ketoprofen). Analgesia had no effect on pain at castration but induced a significant decrease in cortisol compared to castration with anaesthesia or without pain relief; after castration, piglets tended to behave like the manipulated ones.

Pain intervention studies in neonatal pigs were reviewed by O'Connor et al. (2014, 2016). A major problem is that a number of intervention studies rely only on indicators of pain that are in effect indicators for the stress associated with the intervention. It is therefore questionable, whether studies that measured cortisol as the only indicator for an intervention to be effective or not are sufficiently valid to draw conclusions on the effectiveness of a pain treatment. As an outcome of this grading process, the use of NSAIDs for pain mitigation during castration was weakly recommended for piglets 1- to 28-day-old.

Potential long acting pain reducing drugs that are effective during and after castration are currently not available. Substances used in other species such as the morphine derived butorphanol have not been proven effective in pigs (Amirthamaseb, 2015; Courboulay, 2015).

In the EFSA report from 2004 it was also concluded that there is no validated protocol for the use of long-lasting analgesics which could be applied in commercial herds for reducing mid and long-term pain due to castration.

3.6.3. Practical and effective applicability of anaesthesia and/or prolonged analgesia by herdsmen or veterinarians

Isoflurane requires expensive and advanced equipment. Specific training and authorizations have been developed in Switzerland in order to allow the farmer using this method of anaesthesia (that can be used in other countries only by a veterinarian). The time spent per piglet varied from 1.48 to 13.7 minutes, with an average at 4.3 minutes (including the setting up and cleaning). Nearly a quarter of farmers reported headache or dizziness.

CO_2/O_2 inhalation anaesthesia is also used by farmers in the Netherlands, otherwise general anaesthesia is almost exclusively used by veterinarians.

General anaesthesia with ketamine does not seem to be a true alternative in terms of costs/benefits and its constraints regarding practicability (long duration > 4 hours of narcotism) (Schmidt et al., 2012).

Local anaesthesia is exclusively given by the veterinarians in Norway, while in the other countries, application by the farmers are more common. In some countries like Sweden and Spain, special authorisation and training/education is required.

3.6.4. Economic costs/benefits derived from the use of anaesthesia and/or prolonged analgesia during and after castration

Economic costs and benefits were previously estimated by the Food Chain Evaluation Consortium (FCEC) Final Report (2013) on the "Study and economic analysis of the costs and benefits of ending surgical castration of pigs" as part of a tender contract for the DG SANCO. In that report consulted stakeholders agreed that meat price for consumers is not differentiated according to the different sources, i.e. coming from surgically castrated male pigs without anaesthesia and or analgesia or with anaesthesia and or analgesia or other alternatives to surgical castration. In another report produced by FCEC as a tender contract for the DG SANCO on the on the "Study on information to consumers on the stunning of animals" (2015) a stakeholder indicated that communication to the consumers of different stunning methods better addressing animal welfare is similar to the problem of communication of different male pig castration methods as "*consumers do not understand the technical issue and therefore they are not willing to pay more for this additional information, even if they are interested in animal welfare*" (FCEC, 2015).

Castration with analgesia, if done by the farmer, was estimated at 0.31 € per male pig and 0.68 € if done by a veterinarian. Costs for inhalation anaesthesia with CO_2/O_2 performed by farmers were estimated at 0.46 €. The other options using Isoflurane with analgesia and injection anaesthesia with Ketamine and Azaperone performed by veterinarians were estimated at 4.04 € and 3.13 € respectively. Costs for local anaesthesia were not estimated in this report. Countries that use already local anaesthesia (Norway and Sweden) estimated the costs at 2 € when done by the veterinarians (Fredriksen and Nafstad, 2006) and less than 1 € when done by the farmers (de Roest et al., 2009). Isoflurane is an anaesthetic that requires more expensive and advanced equipment to be used (about 8000 € for three posts of anaesthesia). Furthermore, the machines must be frequently checked (every 1500 piglets). The cost per piglet has been evaluated at 2.3 to 3.5 Swiss francs, depending on the size of the farm (Henchoz, 2009). Since 2010, Switzerland has implemented the isoflurane option to be performed by the farmer. This option was previously estimated at extra costs of 1.34 € per male pig (Raaflaub et al., 2008). Extra cost in the range of 1.20 € (600 sows/farm) up to 2.54 € (200 sows/farm) per male pig are reported from Germany if a veterinarian is required (Waldmann and Höltig, 2013).

The study on economic analysis calculated net cost/benefits of +1.82 € and +1.45 € for the analgesia alone if done by farmers or veterinarians and of + 1.66€ for the CO_2/O_2 option. A negative cost/benefit balance was estimated for the Isoflurane (-1.91 €) and ketamine/azaperone (-1.00 €) options (FCEC, 2013). These predictions confirm previous estimations by de Roest et al. (2009). The costs largely depend on the size of the farm and whether a veterinarian has to do the treatment or not. The local anaesthesia option costs for large-scale farms usually do not exceed 1 € cent per kg, whereas the inhalation option with isoflurane and injection with ketamine/azaperone is much more expensive, depending again on farm size and investment costs for the equipment of the narcotic apparatus. No additional

updates on economic evaluations on costs/benefits on the use of anaesthesia and/or prolonged analgesia during and after castration have been produced by any other study.

These costs/benefits were calculated based on the assumption that consumers are willing to pay more for these animal welfare improvements. If not, the full costs have to be covered by the farmers as this is already the case in those countries that use analgesia.

3.6.5. Use of antibiotics as a routine procedure at castration

From the questionnaire it emerged that in some countries the use of antibiotics as a routine procedure at castration seems a quite common practice, whereas antibiotics are not usually used in other countries (Table 3.6.5). However, the information does not seem to be consistent and representative for some of these countries, as we obtained feedback that antibiotics are routinely used or not from different responders within the same country. We therefore assume that this information was given based on individual cases, presumably mainly reported when there are post-surgical complications. Penicillin and amoxicillin seem to be the most common types, but also tetracyclines, cephalosporins and fluoroquinolones are reported to be used. In some cases, it is specified that long acting antibiotics are used. From the available information, however, it is not possible to estimate a precise use of antibiotics, in terms of quantity, for surgically castration of male pigs.

In the event of consumption of meat from very young piglets (that is a non-common practice), specific withdrawal periods have to be considered.

In general, the routine use of antibiotics during the surgical castration of pigs poses a risk in terms of resistance formation among pathogens for the consumer depending on the type of antibiotic drug used.

Table 3.6.5. Reported use of antibiotics during surgical castration of male pigs as indicated in the questionnaire survey.

Countries	Use of antibiotics as a procedure at castration (n. of answers in the questionnaire survey)			Reported antibiotics
	No	Yes	NA	
Austria	3	-	3	-
Belgium	-	6	3	Amoxicillin, ampicillin, penicillin
Bulgaria	8	1	2	Amoxicillin
Denmark	2	-	-	-
Finland	1	-	-	-
France	9	-	13	-
Germany	5	1	9	Penicillin
Hungary	32	13	31	Not specified
Italy	-	5	14	Amoxicillin, cephalosprines
Croatia	5	10	7	Penicillin, penicillin/DHS/ tetracyclines
Luxembourg	-	1	-	Not specified (but long acting)
Malta	1	-	1	-
Netherlands	-	-	2	-
Norway	5	-	3	-
Poland	-	4	1	Amoxicillin, penicillin
Portugal	-	3	3	Penicillin

Countries	Use of antibiotics as a procedure at castration (n. of answers in the questionnaire survey)			Reported antibiotics
	No	Yes	NA	
Slovenia	11	-	14	-
Spain	5	8	19	Amoxicillin, tetracyclines, fluoroquinolones
Sweden	5	-	1	-
United Kingdom	2	-	1	-

Our study provided a first evaluation on the use of antibiotics at male pig castration. Half of the countries surveyed reported cases where antibiotics were used routinely at castration. However, further information should be collected at farm level from a higher number of respondents to evaluate if this reflect the real situation for a country in using antibiotics among their male piglets during castration.

3.6.6. Effect of anaesthesia and /or analgesia administered during and after castration on the meat quality parameters for non-traditional products

No cases are reported in the literature and nobody has indicated that methods for anaesthesia/analgesia could affect meat quality in any way. It can be assumed that products deriving from pigs that underwent pain interventions have the same quality as products coming from pigs that did not receive this treatment. In case meat is consumed from very young piglets (this practice is not common) that were treated with drugs for pain intervention, withdrawal periods have to be considered, e.g. 5 days for the use of meloxicam.

3.6.7. Summary table of facts and opinions of different methods and practices of anaesthesia and analgesia used or proposed in male pig castration

Table 3.6.7 gives an overview of the effects and impacts of different methods and practices of anaesthesia and analgesia on animal welfare, environmental and human and animal health issues, including information on economic costs and benefits, practical applicability and actual use in different countries.

Table 3.6.7. Summary table.

Method	General anaesthesia CO_2/O_2 gas with/without NSAID	General anaesthesia isoflurane/sevoflurane/ N_2O gas with/without NSAID	General anaesthesia ketamine/azaperone with or without analgesia	Local anaesthesia lidocaine with or without analgesia	Preemptive analgesia NSAID meloxicam/flunixine/ metamizol	Postsurgical analgesia NSAID meloxicam/flunixine/ metamizol
Animal welfare advantages	Fast and short acting efficient anaesthesia; analgesia for postoperative pain required	Short and fast acting; efficient only in combination with analgesia	Deep and effective anaesthesia	Effective only if properly administered in combination with an analgesic drug	Only effective for postoperative pain depending on half-life	Only effective for the period after injection depending on half-life
Animal welfare disadvantages	Aversive during initiation; handling stress; risk of suffocation; risk of over-/under dosage	Stress of handling; risk of over-/under dosage (anaesthetic depth decreases with weight and age)	Very long anaesthetic sleep with risk of hypothermia, dehydration, deprivation of milk; little control for dosage (individual variation)	Requires authorisation for farmers; stress of handling; injection may induce pain if not done properly (slow injection with buffered solution)	Pain and stress during castration not alleviated if not combined with anaesthesia	Pain and stress during and immediately after castration not alleviated if not combined with pre-emptive analgesia and anaesthesia
Practical applicability	Used in NL by producers /veterinarians; automatisation of process (standard operation procedure)	Requires authorisation (for farmers) careful handling and substantial hygienic measures, uniform piglets (weight to be considered)	Not practicable; enormous labour effort (monitoring piglets); strictly under control of veterinarian	Requires authorisation and specific training if not done by veterinarian (i.t./s.c./i.f. injections)*	Easy to apply (i.m.)* problem of monitoring the actual use	Easy to apply (i.m.)* problem of monitoring the actual use

Method	General anaesthesia CO_2/O_2 gas with/without NSAID	General anaesthesia isoflurane/sevoflurane/ N_2O gas with/without NSAID	General anaesthesia ketamine/azaperone with or without analgesia	Local anaesthesia lidocaine with or without analgesia	Preemptive analgesia NSAID meloxicam/flunixine/ metamizol	Postsurgical analgesia NSAID meloxicam/flunixine/ metamizol
Environmental effects and human/animal health risks	Potential hygienic risk if not properly cleaned and disinfected	Potent climatic effect if not properly controlled for; leakages > risk of user inhalation; risk for spreading diseases when sharing equipment	Risk of ketamine abuse for human consumption (hallucinogenic drug)	Not reported	Not reported	Not reported
Actual use in various countries	Only used in NL	Broadly used in CH by farmers; scarcely used in DE by veterinarians	Not used broadly on farm	Broadly used in NO by veterinarians and farmers in SE	Broadly used by farmers in various countries (AT, BE, DE, DK, FR)	Used in some cases based on info from survey
Economic costs and benefits	Moderately high cost for equipment and moderate costs for gases (CO_2/O_2)	High costs for equipment and gas; costly hygienic measures	Very high labour costs and management efforts: costs for drugs	Moderate costs for drugs and veterinary services if required	Relatively low costs for drug and extra labour	Cost for drug; relatively inexpensive
Overall evaluation of method pros (+) and cons (-)	- - -	+ -	+ - -	+ + -	+ -	+ - -

* i.m.= intramuscular; s.c.= subcutaneous; i.t.= intratesticular; i.f.= intrafunicular.

Countries are reported considering the international acronyms.

Other alternatives, such as topical anaesthetics are not proven to be efficient or applicable and are not considered in this summary table.

3.7. Additional information

The heterogeneous pig production systems and related practices on male pig castration are creating different situations across countries in Europe that, from one hand could complicate the transfer of different experiences on the use of pain relief methods, but from the other hand they could make it possible to better evaluate pros and cons in the application of various methods to specific and various production systems.

Considering the progress in this area that our surveys reviewed, it seems that there have been limited advancements, from both scientific and technical point of views, on the use of anaesthesia and/or analgesia for male pig castration for the last 10 years. The summary table reported on paragraph 3.6.6 identified solutions that could positively answer only in part all possible listed questions and aspects, related to animal welfare, economic sustainability, practical applicability and environmental and human health impacts.

Some interventions using pain treatment and anaesthesia as a requirement for the production of meat from male pigs that were in previous reports considered promising solutions such as CO_2/O_2 inhalation or ketamine/azaperone injection anaesthesia do not seem to meet the demand for a sustainable and welfare friendly production system, considering the serious risks associated with these methods including aversiveness, limited safety margins, handling stress, practicability as well as economic feasibility. It should be noted that the latter method of general injection anaesthesia is rarely used in practice.

However, it seems also that some practices, such as local anaesthesia and inhalation anaesthesia with Isoflurane, both combined with analgesic preemptive treatment, could be considered for pain relief as these methods seem to be superior to other methods considering effectiveness, drawbacks and risks.

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4. Evaluation of alternatives to surgical castration for heavy pigs used in traditional products

4.1. Introduction

Several sources of information were used in this section:

- Bibliography (literature): information available in the literature (scientific, grey, expertise).
- Bibliography (product specifications): information derived from written specifications describing a situation of pork production systems or product(s).
- Questionnaire: information obtained from the questionnaire that was specifically developed for this project.

4.1.1. Definitions of "heavy pigs"

There is no general agreement among European stakeholders, scientists and practitioners on a definition of heavy pigs. Differences are also present among countries. In this document, we considered three possibilities regarding the threshold separating heavy pigs from standard pigs:

- 115 kg live weight: this threshold was suggested by the expert group on piglet castration on 26th February 2015, and included in contract as threshold weight to be considered;
- 130 kg live weight: is a threshold including most of the European standard pig productions;
- 110 kg of carcass weight: this is an official classification derived by the Decision 2014/38/EU of the European Commission of the 24th January 2014 "*authorising methods for grading pig carcases in Italy*" (notified under document C (2014) 279) that indicates two formulae to estimate lean meat content of the carcass using measures obtained with different instruments or systems – from 70 to 110 kg (light carcasses) and from 110.1 to 180 kg (heavy carcasses). The 110 kg threshold corresponds to a live weight of about 135-137 kg. This latter threshold was considered to describe the Italian production system in addition to the other two thresholds.

It should be noted that the use of different live weights in the definition of heavy pigs defines only partially the potential likelihood or frequency of boar taint in entire males. It would be better to consider the probability of boar taint presence in meat from entire male pigs at a defined weight, which is strongly related to the probability of reaching sexual maturity at that specific weight (other factors such as age and genotype have a significant role in this context). This information was not available for the present study because it could only be obtained from a detailed case by case study of specific situations. Considering just live weight in this context is not sufficient to define a potential likelihood of boar taint presence in the meat from entire male pigs. There are other influential rearing factors (breeding, feeding, health, welfare). In view of traditional high quality pork products above all, the type of product (its fat %), its way of processing (e.g. masking of taint by spices, smoking) and way of consuming (warm, cold) is inseparable part of boar taint risk assessment.

The proportion of pigs slaughtered at more than 115 kg or 130 kg live weight is presented in Table 4.1. Number of slaughtered heads and total weight of meat (expressed as carcass equivalent) for pigs slaughtered in slaughterhouses and outside of slaughterhouses have been retrieved from Eurostat. Average carcass weight at slaughter was obtained as total

meat weight divided by number of heads. The percentage of animals slaughtered above threshold was calculated under the assumption of normal distribution and standard deviation of 10 kg live weight.

Table 4.1. Estimated proportion of pigs in each country that are slaughtered at more than 115 kg or 130 kg live weight. Information for countries not included in our surveys is evidenced in grey.

Countries	**Slaughtered pigs**						**Total**	
	In slaughterhouses			**In other places (estimates)**				
	Million heads	**% > 115 kg**	**% > 130 kg**	**Million heads**	**% > 115 kg**	**% > 130 kg**	**% > 115 kg**	**% > 130 kg**
Austria	5.414	84%	31%	0.000	?	?		31%
Belgium	11.887	73%	19%	0.001	93%	49%	73%	19%
Bulgaria	0.919	0%	0%	0.088	6%	0%	1%	0%
Croatia	1.089	0%	0%	0.312	0%	0%	0%	0%
Denmark	18.717	29%	2%	0.024	3%	0%	29%	2%
France	23.680	20%	1%	0.085	62%	12%	20%	1%
Germany	59.292	70%	17%	0.110	56%	9%	70%	17%
Hungary	4.459	61%	11%	0.384	100%	97%	64%	18%
Italy	11.304	100%	100%	0.088	97%	66%	100%	100%
Netherlands	15.485	71%	17%	0.000	?	?	71%	17%
Norway*	1.487	43%	5%	?	?	?	43%	5%
Poland	21.243	50%	7%	0.486	45%	5%	50%	7%
Portugal	5.638	0%	0%	0.338	0%	0%	0%	0%
Slovenia	0.238	27%	2%	0.084	100%	93%	46%	26%
Spain	46.380	23%	1%	0.000	?	?	23%	1%
Sweden	2.560	58%	10%	0.013	59%	10%	58%	10%
Switzerland	2.734	40%	4%	0.009	73%	19%	40%	4%
UK	10.848	19%	1%	0.000	?	?	19%	1%
Cyprus	0.577	3%	0%	0.000	?	?	3%	0%
Czech Republic	2.508	56%	9%	0.112	36%	3%	55%	8%
Estonia	0.533	10%	0%	0.014	66%	14%	11%	1%
Finland	2.080	63%	12%	0.001	30%	2%	63%	12%
Greece	1.505	0%	0%	0.096	0%	0%	0%	0%
Ireland	3.226	30%	2%	0.000	?	?	30%	2%
Latvia	0.369	9%	0%	0.079	22%	1%	12%	0%
Lithuania	0.837	9%	0%	0.179	93%	48%	23%	9%
Luxembourg	0.158	6%	0%	0.006	0%	0%	6%	0%
Malta	0.062	48%	6%	0.000	?	?	48%	6%
Romania	4.038	16%	1%	0.838	100%	100%	30%	18%
Slovakia	0.497	57%	9%	0.105	94%	52%	63%	17%
EU 28	**255.544**	**51%**	**7%**	**4.408**	**72%**	**18%**	**51%**	**7%**

* For Norway, statistics obtained from expert. All other figures calculated from Eurostat.
? Statistics not available.

These figures are just rough estimates and do not cover production systems with heavy pigs that are not captured by official statistics (this is for instance the case for Croatia, Hungary, Slovenia, where such situations are quite numerous, but difficult to estimate). We believe however that these figures can give some idea of the overall reality, at least for the dominant production systems, providing that some adjustments might be considered as mentioned above. Because of the default 10 kg standard deviation that was used, these figures underestimate the proportion of heavy pigs, particularly in those countries (for instance Spain or Portugal) that have significant but not dominant production systems with heavy pigs.

4.1.1.1. Threshold of 115 kg live weight

On average in the EU, more than half of the pigs are slaughtered at more than 115 kg live weight. This proportion is extremely different according to countries, from 10% or less in Bulgaria, Croatia, Portugal, Cyprus, Greece and Luxembourg to more than 50% in Austria, Belgium, Germany, Hungary, Italy, Netherlands, Poland, Sweden, Czech Republic, Finland and Slovakia. A threshold of 115 kg live weight would result in more than half of the European pigs as defined heavy pigs. Moreover, a relevant part of the entire male pigs that are currently being produced in UK, Ireland, Portugal, Spain, Netherlands, Belgium, Germany and France are slaughtered at more than 115 kg live weight.

4.1.1.2. Threshold of 130 kg live weight

On average in the EU, 7% of the pigs are slaughtered at more than 130 kg live weight. This proportion is extremely different according to countries, being less than 10% in most countries, but 30% in Austria and 100% in Italy. As stated above, the presented proportions are very likely underestimated in countries such as Spain and Portugal but also Slovenia and Croatia (and probably other East European countries) for different reasons.

4.1.1.3. Threshold of 110 kg of carcass weight

In Italy, a more general overview of the relevance of slaughtering weight of pigs can be obtained by the carcass classification as defined by the Decision 2014/38/EU (January 24th, 2014). Data reported by the Italian Ministry of Agriculture (MiPAAF, 2016) for 2015 indicated that in 2015, only 16.78 % of pig carcasses were classified as “light” (≤ 110 kg). This means that the production of pigs with slaughter weight less than 115 kg is extremely marginal in Italy and can only be found in some piggery in South of Italy and Sardinia. Other traditional production systems from Portugal to Balkan regions raise pigs that are slaughtered at about 150 kg live weight or more.

4.1.2. Other factors that can preclude the use of entire male pigs as alternative to surgical castration of male pigs

Heavy weight at slaughter is not the only factor that could disqualify the use of entire males. We identified five main reasons why the use of entire males could be difficult or impossible to implement and/or damaging for product quality:

- castration of males is made compulsory in the specifications describing the production systems and/or the products;

- increased likelihood of the presence of boar taint in entire males because of sexual maturity issues (heavy weight, old age at slaughter, for instance in local breeds);
- increased sensitivity of product to boar taint detection by the consumer (high fat, no masking, cooked at home, consumed warm);
- other meat quality issues for the product (fat quantity and quality for dry cured products);
- problems due to farming practices or management issues (rearing sexually mature entire males with sexually mature females).

In this document, the use of entire males was evaluated as problematic (difficult or impossible to implement and/or damaging for product quality) in all situations where at least one of the above-mentioned reasons is present (see section 4.4.3.7).

4.2. General overview on the production of traditional products: the situations that were described and evaluated

A total of 552 situations were considered, including:

- 272 from specifications described in the literature or from expertise, 174 from the Door database describing PGI, PDO and TSG products and 98 other situations, most of them having a claim on higher quality (see table 4.2). France, Portugal, Italy, Spain and Bulgaria accounted for ¾ of those situations. Although there are relevant situations in Germany and Switzerland (including 18 PGI products in Germany), no input could be obtained from those 2 countries.
- 280 answers to the questionnaire that was specifically developed for this project (see table 4.3). It should be noted that the methodological approach in the survey was specific; it was guided so as to get the answer from key actors for each country as "representative cases". The number of responses varied according to countries, with clear over-representation of answers from Hungary.

Table 4.2. The situations that were described from the bibliography (pork product specifications).

Countries	PGI	PDO	TSG	Quality	Organic	Welfare	Other	Total
Austria	2	-	-	-	-	-	-	2
Belgium	3	-	-	2	1	-	-	6
Bulgaria	-	-	4	24	-	-	-	28
Croatia	6	2	-	-	-	-	-	8
Denmark	-	-	-	2	1	3	1	7
France	21	7	-	17	5	-	2	52
Germany	-	-	-	-	-	-	-	-
Hungary	3	1	-	1	-	-	2	7
Italy	19	22	-	-	-	-	-	41
Netherlands	-	-	-	1	1	-	-	2
Norway	-	-	-	1	-	-	-	1
Poland	3	-	6	-	-	-	-	9
Portugal	39	4	-	-	-	-	-	43
Slovenia	8	-	-	5	1	1	3	18
Spain	10	6	1	22	-	-	-	39

Countries	PGI	PDO	TSG	Quality	Organic	Welfare	Other	Total
Sweden	-	-	1	-	-	-	-	1
Switzerland	-	-	-	-	-	-	-	-
UK	4	-	2	-	-	1	1	8
Total	**118**	**42**	**14**	**75**	**9**	**5**	**9**	**272**

4.3. Existing available alternatives to surgical castration for pigs used in traditional productions

4.3.1. From bibliography (literature): possible alternatives

In view of meat quality aspects relevant for traditional pork products, surgical castration with or without anesthesia and/or prolonged analgesia can be considered as equivalent. The theoretically possible alternatives to surgical castration (with or without anaesthesia and/or prolonged analgesia) include (EFSA report AHAW/04-087 on "welfare aspects of the castration of piglets", 2004; PIGCAS final activity report, 2009; ALCASDE final report, 2009):

- entire male pig production;
- immunocastration;
- chemical castration;
- sperm sexing.

Sperm sexing is not currently feasible in practice in the porcine species. Chemical castration is not a viable alternative because it is painful.

Entire male production and immunocastration are therefore the only alternatives that will be considered. The answers to the questionnaires did not show any other alternative being used in practice or being considered by stakeholders.

The reduction of boar taint risk is potentially possible through breeding, feeding and management techniques, which denotes that by choice of breed, inclusion of specific diet ingredients and by good housing conditions the risk of boar taint could be reduced. However, it is not possible to say that the problem of boar taint in sexually mature animals could be avoided by such approaches.

4.3.2. From questionnaires: existing alternatives

The number of respondents that are using (yes) or are not using (no) one or the other alternative (i.e. entire males and immunocastrated males) is presented in Table 4.3.2a together with the mean of the reported percentage of pigs in which the alternatives are used. It should be noted that these means do not represent an actual percentage of uncastrated male pigs or immunocastrated pigs used for meat production but the specific situations of the responders.

Table 4.3.2a. Number of situations using entire males or immunocastrates (from the questionnaires).

Countries	Entire males (n)		Mean of reported percentage*	Immunocastrated males (n)		Mean of reported percentage*
	No	Yes	If yes	No	Yes	If yes
Austria	4	-	-	4	-	-
Belgium	2	5	25	4	3	52
Bulgaria	1	1	100	2	-	-
Croatia	6	-	-	6	-	-
Denmark	1	1	4	2	-	-
Finland	-	-	-	-	-	-
France	14	5	25	19	-	-
Germany	4	8	19	9	3	5
Hungary	39	18	73	55	2	5
Italy	15	2	14	16	1	1
Luxembourg	-	-	-	-	-	-
Malta	-	1	60	-	1	5
Netherlands	1	-	-	1	-	-
Norway	7	0	5	4	3	18
Poland	2	1	99	3	-	-
Portugal	3	1	90	3	1	2
Slovenia	21	1	100	22	-	-
Spain	10	9	67	19	-	-
Sweden	1	2	1	1	2	51
UK	-	3	100	3	-	-
Overall	**131**	**58**		**173**	**16**	

* It represents only the specific situations of the responders in the evidenced case and does not represent a mean of uncastrated male pigs or immunocastrated pigs at the national level.

Out of the 189 answers to the questionnaire:

- 58 (31%) of the respondents reported to have reared entire males (including those who rear breeding boars). Entire males were reported to be reared in 15 of the 20 surveyed countries. In 6 of them (Denmark, France, Germany, Italy, Norway and Sweden) entire

males, when produced, most often represent a minority of the production of the described situations and it concerns mainly rearing of entire males as future breeding boars (N.B. questionnaire survey was answered also by breeders who produce entire boars for reproduction). Similar situation is well known for other countries, including Bulgaria, Hungary, Poland, Slovenia and Croatia. In Belgium, some producers shifted to the production of entire male pigs. In the remaining countries (Malta, Portugal, Spain and UK), entire males, where produced, represent a majority or all of the production of the described situations.

- 16 (8.5%) of the respondents reported to have reared immunocastrated male pigs, most often to a very small extent, except for the situation in Belgium. Immunocastrated male pigs are reported to be used in 8 of the 20 surveyed countries. Here again, interpretation of the reported data is needed. In particular, the two positive answers among the Italian questionnaires (1 for entire male pigs and 1 for immunocastrated pigs) which were given by two organizations with Boar A.I. stations that used immunocastration for old boars at the end of their reproductive services. No immunocastrated male pigs are used in Italy for meat production.

The use of entire male pigs and immunocastrated male pigs was also evaluated for those situations with heavy weight, i.e. at least 5% of the slaughtered pigs higher than 130 kg live weight at slaughter (see section 4.1.1. above). Again, interpretation of the columns "Mean of reported percentage" should be as mentioned for Table 4.3.2a.

Table 4.3.2b. Number of situations with heavy pigs (> 130 kg live weight) using entire males or immunocastrated males (from the questionnaires; this table only includes the entries that reported weight at slaughter).

Countries	Entire males (n)		Mean of reported percentage	Immunocastrated males (n)		Mean of reported percentage
	No	Yes		No	Yes	
Austria	1	-	-	1	-	-
Belgium	2	5	25	4	3	53
Bulgaria	-	-	-	-	-	-
Croatia	2	1	-	3	-	-
Denmark	-	-	-	-	-	-
Finland	-	-	-	-	-	-
France	13	5	25	18	-	-
Germany	1	-	-	1	-	-
Hungary	2	1	1	3	-	-
Italy	16	0	15	15	1	1
Luxemburg	-	-	-	-	-	-
Malta	-	-	-	-	-	-

Countries	Entire males (n)		Mean of reported percentage	Immunocastrated males (n)		Mean of reported percentage
	No	Yes		No	Yes	
Netherlands	1	1	-	2	-	-
Norway	3	-	-	3	-	-
Poland	2	1	99	3	-	-
Portugal	2	-	-	1	1	2
Slovenia	14	-	-	14	-	-
Spain	8	3	1	13	-	-
Sweden	-	2	1	1	1	2
UK	-	-	-	-	-	-
Overall	67	19		82	6	

Out of 88 answers to the questionnaire with enough information to be classified as heavy weight (> 130 kg live weight):

- 19 (22%) respondents confirmed the use of entire males. In 8 out of 20 countries (Belgium, France, Hungary, Croatia, Poland, Spain and Sweden) such situations with heavy weights have been identified. However, in many cases the positive answers represent just the residue of breeding selection (as it was clearly explained by Italian NCP) or may be due to the definition of "heavy pig" situation (as in Belgium).
- 6 (7%) respondents reported the use of immunocastrated males – 5 if answer from Italy is not considered (because immunocastration is used in breeding boars eliminated from breeding service). Based on the survey, immunocastrated males were reported to be used in 3 countries (Belgium, Portugal and Sweden) in percentages lower or equal to 2% except for Belgium, with 52.3%. It is worth mentioning here that contrary to the result of the survey, NCP of Norway reported about 5% of immunocastrated pigs being used in 2015.

4.4. Alternatives to surgical castration for heavy pigs compared to the use of anaesthesia and/or prolonged analgesia

Analysis of the information reported in the answered questionnaires is summarized below following the schematic structure of the survey and its questions.

4.4.1. Are chain actors prepared to abandon surgical castration?

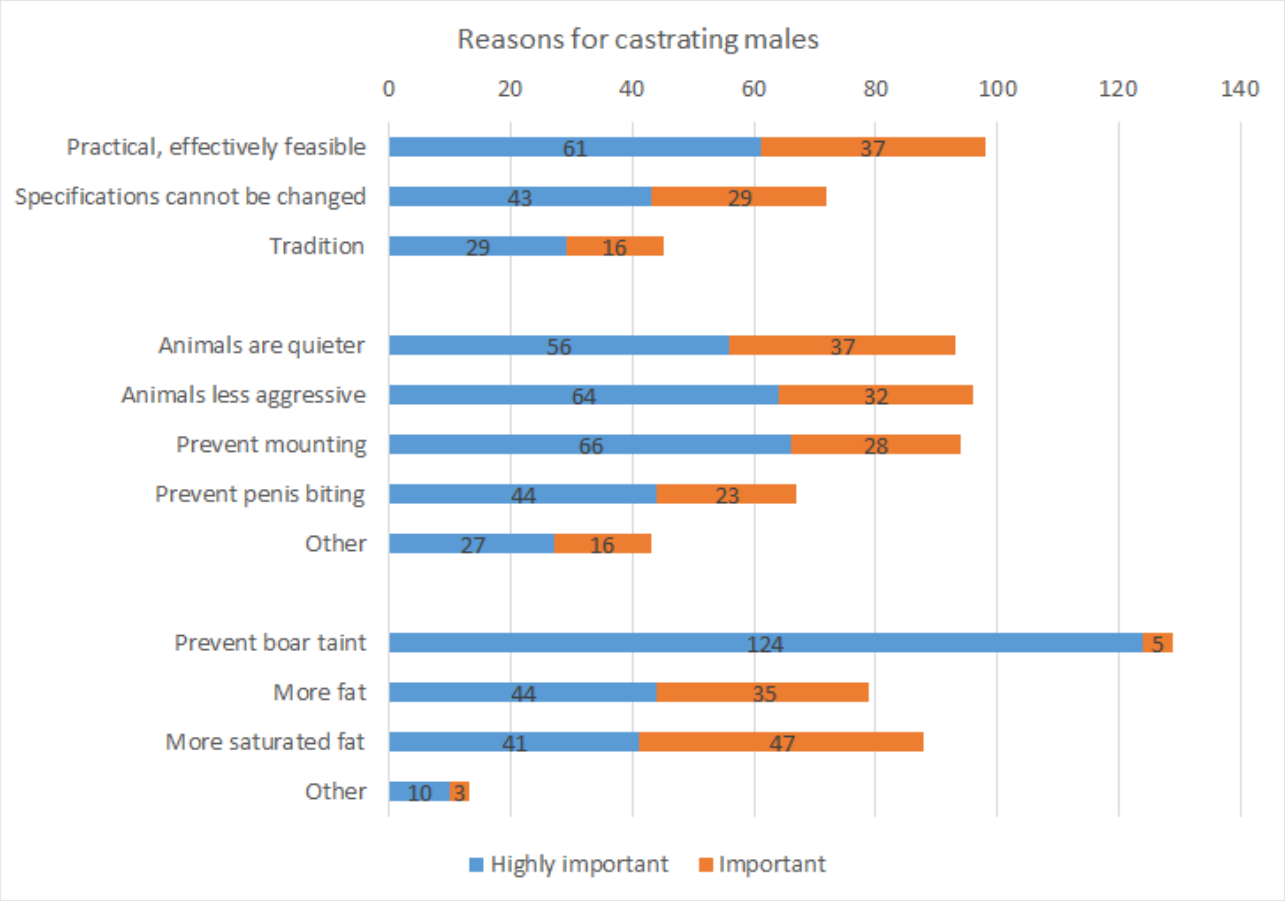
4.4.1.1. Do chain actors consider male surgical castration as essential, and what are their reasons?

Table 4.4.1.1a. Number of respondents considering that male surgical castration is essential for their product situation (from the questionnaires; calculated from the 166 answers - 75% of the total 220 answers - reporting they are using surgically castrated males).

Countries	No answer or Not applicable	No	Yes	Total	% of Yes
Austria	1	-	3	4	75
Belgium	-	1	4	5	80
Bulgaria	-	-	1	1	100
Croatia	2	-	4	6	67
Denmark	-	-	2	2	100
Finland	-	-	-	-	-
France	3	2	12	17	71
Germany	2	5	5	12	42
Hungary	8	1	38	47	81
Italy	6	-	10	16	63
Luxemburg	-	-	-	-	-
Malta	-	1	-	1	0
Netherlands	1	-	-	1	0
Norway	1	3	3	7	43
Poland	1	-	2	3	67
Portugal	3	-	1	4	25
Slovenia	1	-	19	20	95
Spain	2	1	15	18	83
Sweden	-	1	1	2	50
UK	-	-	-	-	-
Total	31	15	120	166	72

Surgical castration was reported to be essential by 120 out of 166 (72 %) respondents that are using this practice. However, 15 (9 %) respondents stated that they think surgical castration was not essential while 31 respondents (19 %) did not reply to this question. It is difficult to guess if by skipping the answer they just considered surgical castration as essential or the opposite.

Figure 4.4.1.1a. Reasons for castrating males (from the questionnaires; calculated from the 170 answers - 77% of the total 220 answers - reporting they are using surgically castrated males).



The most important reason for castrating was the prevention of boar taint. A majority of respondents considered surgical castration as being practical/effectively feasible. That means that in most of the systems surgical castration of male pigs is already a common practice that is integrated in the production system and alternatives are not taken into consideration in most cases. Another important answer relates to products' specifications which are already part of the game and are difficult to be changed (considering that they constitute the founder legislative context of many traditional productions whose production rules are formally approved with a European legislative act). Tradition was not rated as very important for continuing surgical castration, which might suggest that stakeholders could already consider the specifications as the core of the production system. This is in line with the observation that in 29% of the situations analysed from the bibliography (specifications; see Table 4.4.1.1b below), castration of males is explicitly written down as mandatory in the specifications. Moreover, some specifications that do not make castration mandatory do state that the meat should not be tainted (should have typical aroma without off-flavour). Additionally, it can be speculated that in some cases, specifications that are relatively old do not mention castration as mandatory because, at the time when they were written, considering anything else than surgical castrates was not even envisaged. The reasons for using castration were also related to better animal welfare in fattening stage and were also recognized as very important by the respondents.

Furthermore, it has to be considered that in most countries of Mediterranean Europe dry-cured pork products obtained using heavy pigs (>130 kg live weight, to account for meat quality needs) play a very important role, based on cultural traditions and traditional diet. These traditions, that are relevant from Portugal through the Balkan region, have reached different levels of official recognition, i.e. PDO or PGI, or other forms of valorizations derived by local traditional uses not always organized in defined production chains but important to support rural economy. Traditional products (including PDO products but not only) are in many cases obtained from local pig genetic resources. Therefore, traditional products for which meat quality is an essential parameter are considered important to support biodiversity in the pig production chains across Europe.

Table 4.4.1.1b. Number of situations where castration of males is mandatory in the specifications (from bibliography, specifications) as directly mentioned. This table does not consider the cases in which this aspect is evaluated important according to the main features of the different products (age of the animals, fat content, etc.).

Countries	Yes	No*	Don't Know	NA	Missing	Total
Austria	-	2	-	-	-	2
Belgium	2	3	1	-	-	6
Bulgaria	12	16	-	-	-	28
Croatia	3	5	-	-	-	8
Denmark	-	7	-	-	-	7
France	17	35	-	-	-	52
Germany	-	-	-	-	-	-
Hungary	2	5	-	-	-	7
Italy	28	13	-	-	-	41
Netherlands	-	2	-	-	-	2
Norway	-	-	1	-	-	1
Poland	-	7	-	-	2	9
Portugal	7	36	-	-	-	43
Slovenia	2	16	-	-	-	18
Spain	7	31	-	-	1	39
Sweden	-	1	-	-	-	1
Switzerland	-	-	-	-	-	-
United Kingdom	-	7	-	1	-	8
Total	80	186	2	1	3	272
% of situations	29%	68%	1%	0%	1%	100%

* In many cases, it is not indicated directly that castration is mandatory but it is possible to deduce that the practice is important considering characteristics of the products or production chain.

In summary, the answers regarding the reasons for castration can be divided into concerns about product quality (boar taint; fat quantity and quality) and concerns regarding animal management/welfare issues during the fattening period (restlessness, aggressiveness, mounting, penis biting) and both proved as important reasons for continuing with surgical castration. The key reason however remains the prevention of boar taint.

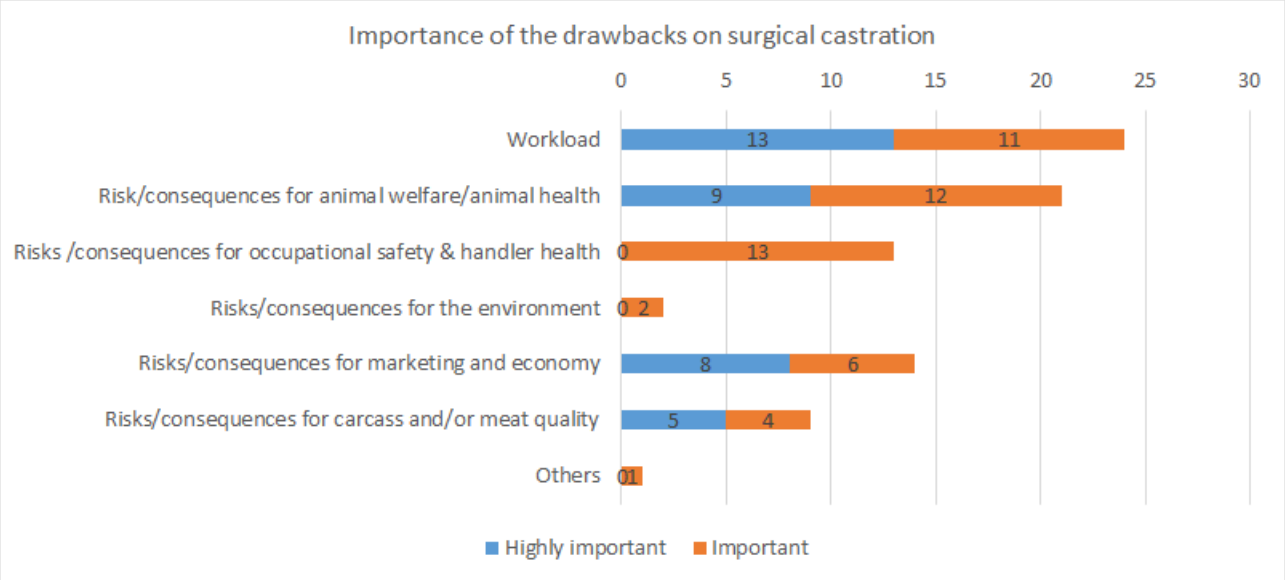
See also Appendix A3: “Comments on the reasons for castrating males”.

As shown in Table 4.4.1.1c, only 34 respondents (20%) reported drawbacks to the use of surgical castration while 110 respondents (66%) stated that there were none. In addition, 22 respondents did not express their opinion in regard to this question.

Table 4.4.1.1c. Number of respondents who identified drawbacks in the use of surgical castration (from the questionnaires; calculated from the 166 answers -75% of the total 220 answers- reporting they are using surgical castrated males).

Countries	N/A	No	Yes	Total	% of Yes
Austria	-	4	-	4	0
Belgium	1	4	-	5	0
Bulgaria	1	-	-	1	0
Croatia	-	5	1	6	17
Denmark	-	2	-	2	0
Finland	-	-	-	-	-
France	1	5	11	17	65
Germany	2	7	3	12	25
Hungary	8	36	3	47	6
Italy	4	11	1	16	6
Luxemburg	-	-	-	-	-
Malta	-	1	-	1	0
Netherlands	1	-	-	1	0
Norway	1	4	2	7	29
Poland	-	3	-	3	0
Portugal	2	-	2	4	50
Slovenia	1	15	4	20	20
Spain	-	13	5	18	28
Sweden	-	-	2	2	100
UK	-	-	-	-	-
Total	**22**	**110**	**34**	**166**	**21**

Figure 4.4.1.1c. Importance of the drawbacks on surgical castration (from the questionnaires; calculated from the 170 answers - 77% of the total 220 answers - reporting the use of surgically castrated males).



Only a small part (20%) of the respondents declared seeing drawbacks of surgical castration. Workload and possible risks for animal welfare were the most important drawbacks that have been identified in the answers to the questionnaire. See also Appendix A4: "Comments on some of the drawbacks for surgical castration".

Regarding whether they have documentation they could provide to support their claims, 15 answered Yes, 78 No and 188 N/A. A total of 16 files/documents were finally provided, from France (3), Germany (3), Hungary (1), Poland (1), Portugal (1), Slovenia (1) and Spain (3).

4.4.1.2. Have chain actors used immunocastration before?

Table 4.4.1.2. Respondents that have used immunocastration before (from the questionnaires).

Have you used immunocastrated males before?	**Why did you abandon it?**
Yes (n=8) • France • Croatia • Hungary • Italy (n=3) • Norway • Spain No (n=183)	• Bad meat quality • Far too heavy • Ham not suitable for processing • Not allowed by Label Rouge specifications, problem of aggressiveness during rearing, 3 injections are needed instead of 2 because of age at slaughter, Farmers not satisfied with the technique • Not efficient • Not enough intramuscular fat

Eight answers reported having used immunocastration before and having abandoned it. If this is to be compared to the 17 answers that are currently using immunocastration, it would suggest that one third of those who tried immunocastration have abandoned it. However, in the context of this question the prudence in interpretation is needed as the respondents confused between using immunocastration in everyday business practice and using immunocastration for testing this new alternative.

4.4.1.3. Have chain actors used entire males before?

Table 4.4.1.3. Respondents that have used entire males before (from the questionnaires).

Have you used entire males before?	Why did you abandon it?
Yes (n=16) • Austria • Belgium • Croatia (n=2) • France • Germany • Hungary (n=6) • Italy • Slovenia (n=2) • Spain No (n=128)	• Boar taint, feed conversion, • Ham not suitable for seasoning • Low quality of fat (fatty acid composition), backfat too thin • Meat quality, boar taint, stress and animal welfare • No demand • Test station for herd renovation/sell; cheaper purchase, no possibility to sell culled animals • The spontaneous mating has negative impact on the fattening, condemnations in slaughter house cause economic loss, pen mates cannot rest. • Tradition, way of thinking

Sixteen answers reported having used entire males before and having abandoned it. If this is to be compared to the 60 answers that are currently using entire males it would suggest that one fourth of those who tried entire males have abandoned it. Again here, the prudence in interpretation of results is needed as it is not possible to distinguish the respondents that actually used entire males for fattening (meat production) from those that rear entire males for future breeding males.

4.4.2. Use of immunocastration for heavy pigs

4.4.2.1 Acceptability (from bibliography, literature)

Although the vaccine for immunocastration has been registered for use in the EU in 2009, implementation has been evolving slowly due to a generally low market acceptance (Aluwe et al., 2015). The survey from the PIGCAS project, involving European stakeholders (breeders, meat processors, governmental institutions, welfare organisations and consumers), rated the prospects of immunocastration low, giving priority to surgical castration with anaesthesia/analgesia, and indicated the fear from consumer response as the main drawback of the immunocastration (Bonneau et al., 2009). However, public opinion about

immunocastration has been rather poorly investigated. In general, consumers are not well informed about boar taint and the methods used to avoid it. Actually, the majority of them does not associate pork with castration (Kallas et al., 2012, 2013). Consumers, however expect healthy, safe and tasty meat, therefore boar taint can represent a serious issue for consumer acceptance (Kallas et al., 2013). The few existing studies on immunocastration showed rather large differences across Europe. In Switzerland, the most acceptable alternative was surgical castration with anaesthesia/analgesia, and immunocastration was disfavoured (Huber-Eicher et al., 2011). On the opposite, Swedish consumers preferred immunocastration over rearing entire males or standard surgical castration (Lagerkvist et al., 2006). Belgian consumers favoured immunocastration to surgical castration, after being well informed about the alternatives (Tuyttens et al., 2011). The same conclusion was drawn for German consumers (Sattler and Schmoll, 2012). In Belgium, some farmers have started to practice immunocastration since 2011 based on their retailers' demand (Aluwe et al., 2015). An extensive research with over 4000 consumers from France, Germany and The Netherlands (Vanhonacker and Verbeke, 2011) showed that the fear from negative response to immunocastration might be overestimated, as the method was acceptable for over 70% of the respondents. A study with Flemish farmers (Aluwe et al., 2015) showed that after having real experience with rearing of different alternatives, they preferred entire males and immunocastration did not fulfil their previous favourable expectations. Worth noting, the most disadvantageous for them was surgical castration with anaesthesia and surgical castration with analgesia, as they experienced this alternative as the most demanding (labour intensive, costly and complex).

For the non-governmental animal welfare organisations, immunocastration is acceptable, although they give priority to rearing entire males. Scientific experts perceive immunocastration as much better alternative to surgical castration with anaesthesia/analgesia, as it is, to their opinion, better for animal welfare, more economical and easier to put in practice (Edwards et al., 2009). The use of immunocastration could be beneficial to obtain raw material for high-quality meat products in the case of special production systems, like fattening to higher age/weight or in extensive conditions, and especially interesting (though marginal) for castration of boars after breeding service or performance testing (Čandek-Potokar et al., 2015).

Generally, it seems that the key reason to oppose immunocastration is the fear of consumers' acceptance. Other drawbacks may be related to feasibility, i.e. work security measures, additional workload and management (handling), and to the fact that many issues are not yet sufficiently explored (i.e. restitution after vaccination, adaptation of vaccination protocols to specific rearing systems, effect on certain meat quality parameters influencing quality after long maturation processing, nutrition of immunocastrates, lack of experiences by breeders, economic effectiveness, immunocastration success rate).

Advantages	**Disadvantages**
• In general, more positive than negative public reaction, but may depend on the country, stakeholder, and the level of information (considered also a disadvantage, see the other column) • Positive attitude of the scientific/expert public	• Acceptability has not been extensively investigated • Lack of real experiences by the users • Fear of stakeholders of negative public response

4.4.2.2. Impact on animal welfare (from bibliography, literature)

Immunocastration is generally considered as a relatively welfare friendly alternative. Compared to surgical castration without pain relief, it avoids acute pain and post-operational complications related to the procedure (especially cryptorchidism or inguinal hernia). The pain encountered by immunocastration is limited only to the needle insertion during vaccination (Prunier et al., 2006), with some authors reporting no notable side reactions caused by the vaccination (Einarsson, 2006; Bilskis et al., 2012), while others (Bjerke et al., 2016) noticed local tissue inflammatory reaction in a relatively high number of vaccinated animals.

Immunocastration is not applicable only for small/young pigs but also for older animals (i.e. culled adult boars) or females (as practiced in free range rearing of Iberico breed), where castration wounds, post-operative complications/infections and associated pain present a major welfare problem, especially when the application of anaesthesia/analgesia is not properly conducted. Compared to entire male production, immunocastration reduces aggressive and sexual/mounting behaviours that come with the onset of puberty (i.e. 5-6 months of age). Soon after effective immunisation, the behaviour of immunocastrates becomes similar to that of surgical castrates including increased feed intake (Cronin et al., 2003; Zamaratskaia et al., 2008a; Rydhmer et al., 2010; Fabrega et al., 2010; Albrecht et al., 2012). Calmer behaviour is important not only for animal welfare but also for carcass and meat quality (lower incidence of skin lesions, as a consequence of less fighting and mounting prior to slaughter). In this period, the animals are often mixed, which triggers aggression related to establishment of social hierarchy between the animals (Bolhuis et al., 2005; Turner et al., 2006). For immunocastrates, as compared to entire males and surgical castrates), an intermediate level of skin lesions caused by teeth (i.e. direct aggression) was shown (Škrlep et al., 2011).

Restrictive feeding of immunocastrates (Batorek et al., 2012a; Quiniou et al., 2012) pointed out some negative aspects. Restrictively fed immunocastrates exhibited similar levels of skin lesions as entire males, whereas immunocastrates fed ad libitum were more similar to surgical castrates, but cortisol (as a marker of stress) was the highest in restricted immunocastrates and the lowest in entire males. Because immunocastrates have much enhanced appetite after the second immunization, higher than surgical castrates at the same period, it may be hypothesized that they experience greater stress from restricted feeding, as suggested by their higher cortisol levels. The aspect of restrictive feeding is of importance in production systems with heavy/older pigs, where this is a common practice for fatness controlling (e.g. Italian heavy pigs) or being a part of a restriction-realimentation feeding protocol, aiming to gain more intramuscular fat (e.g. free range Iberico).

Advantages	Disadvantages
• Minimal pain, no side effects • Reduces aggressiveness, body lesions (in group rearing, mixing unfamiliar animals, especially prior to slaughter) • Possible at higher ages/weights, in females (avoiding large castration wounds and difficult castration procedures). Applicable to free range systems (no aggression, no mating)	• Possible higher stress level in restrictive feeding (adaptations in herd management needed)

4.4.2.3. Practical and effective applicability, including consistency with specifications on the production process (from bibliography, literature)

Vaccination against GnRH (immunocastration) in pigs affects the production of testicular steroid hormones in males resulting in reproductive tract atrophy, boar taint elimination and reduced aggressiveness (Dunshea et al., 2001, Hennessy, 2006; Zamaratskaia et al, 2008a,b) whereas in females it results in the suppression of ovarian cyclicity and estrus behaviour (Hernandez-Garcia et al., 2013). Immunocastrated pigs quickly change metabolism to castrate-like with increased feed consumption and fat deposition. If pigs are slaughtered around six months of age, the longer is the time elapsed from V2 to slaughter, the higher is the differences between immunocastrates and entire males and the similarity to surgical castrates (Lealiifano et al., 2011; Škrlep et al., 2012a).

Two vaccinations are required in order to reach its effectiveness, with pigs having the physiological status practically the same as in entire (not castrated) animals until the second vaccination (V2). A minimal period of 4 weeks-period should be allowed between first and second vaccination, whereas another 4-6 weeks is required before slaughter to control boar taint (Dunshea et al., 2001), although physiological effects (GnRH antibody titre rise, drop in steroid hormone level) take place already in the first week post V2 (Claus et al., 2007).

In the case of intensive rearing systems (slaughter at 6 months of age), double vaccination scheme is completely sufficient in order to avoid boar taint and also to benefit from the boar-like production properties of immunocastrates. The situation is however different when fattening pigs to higher weight and/or age. Contents in boar taint compounds increase with age, which makes heavy pigs far more susceptible to boar taint, since they are slaughtered in their full adulthood. In case of pigs intended for dry-cured production in Italy this is at 9-10 months of age and 160-170 kg (Della Casa et al., 2010), whereas Iberian pigs in extensive rearing systems pigs are slaughtered even older, at 15-16 months (Martinez-Macipe et al., 2016).

The effectiveness of the vaccine was reported “reversible” by the vaccine producer. According to the available studies, no restitution of reproductive function has been reported for as long as 8 (Kubale et al., 2013), 10 (Brunius et al., 2011) or even 16 - 22 weeks (Zamaratskaia et al., 2008a; Einarsson et al., 2009) after effective immunisation. There are even indications that irreversible loss of reproductive ability may be associated with earlier vaccination (Einarsson et al., 2009). However, there are also several indications of the opposite (Hilbe et al., 2006; Claus et al., 2008; Rottner & Claus, 2009), raising concern regarding the number of vaccinations needed (two or three) and the vaccination timing (early or late scheme), with a 3-dose regime considered to be the most appropriate for heavy pig production (Allison et al., 2009). A comparison of double (V2 in weeks 26-27) and triple vaccination (V3 in weeks 36-37) protocol (Pinna et al., 2016) in heavy pigs (165 kg, slaughtered in weeks 40-41) showed an increased probability of boar taint presence (S>100 ng/g, A>500 ng/g) along with higher boar taint sensory perception in double compared to triple vaccination protocol where no boar taint was detected. Triple vaccination protocol was already tested and is practiced in free range rearing of Iberian pigs in both male and female animals (Hernandez-Garcia et al., 2013, 2015a), with long lasting immunity at least 20 weeks after V3 (Dalmau et al., 2015) also benefiting from faster growth and more homogenous batches in immunocastrated gilts (Fernandez-Moya, 2011).

Apart from beneficial properties of immunocastration, there are also several drawbacks (Škrlep et al., 2014; Čandek-Potokar et al., 2015). Namely, the anti-GnRH vaccine is effective also in other species and humans bringing forward the danger of abuse and autoimmunisation of the operators. Accidental self-injection may produce similar effects in people to those seen in pigs. The risk of these effects is greater after a second or subsequent accidental injection than after a first injection (European Medicine's Agency, 2010).

Furthermore, despite high efficiency of the method, immunocastration is not 100% reliable, there is always a certain number of so called "non-responders" (1-3%) as demonstrated by several reports on modern breeds (Kubale et al., 2013; Hilbe et al., 2006; Jaros et al., 2005; Škrlep et al., 2012c; Fredriksen et al., 2016) but also on traditional ones (Hernandez-Garcia et al., 2015a). The reasons may be purely technical (insufficient/missed vaccine application) or due to true immunological non-reactivity (due to factors such as poor health, severe feed restriction or stress), which is not yet sufficiently explored. Once vaccinated, it is difficult to evaluate whether the pigs were effectively immunized (only on the base of testes size observation). This is possible only after slaughter. At farm level, change in behaviour can be observed after the second vaccination. Even with a small chance of tainted carcasses, this calls for a need of slaughter line detection of boar taint/success of immunization, which denotes additional costs for the meat processor. As for the special production systems (i.e. free range rearing) the vaccination itself can be technically more demanding, as animals are less accustomed to human presence and therefore more difficult to handle (catch and fix at the time of vaccination). Some rearing systems include periods of food restriction, which could be associated to lower immunisation response (Hernandez-Garcia et al., 2016), however this could probably be solved by adaptation of the feeding and vaccination protocols.

Advantages	**Disadvantages**
• Eliminates boar taint (along with effects on reproductive functions and behaviour); • Effective for males and females	• Effective on humans (autovaccination or potential abuse) – security measures by operators • Possible restitution (insufficient and contradictory information is available), • More difficult to perform in heavy/older pigs (likely 3 vaccinations needed) or free range pigs (difficult handling) • Non-responders (always present, difficult to detect prior to slaughter)

4.4.2.4. Husbandry and Management issues (from bibliography, literature)

In regard to the management and husbandry issues, there are several points that should be addressed and need further research prior to the effective application of immunocastration in practice in special production systems (i.e. extensive, higher age/weight, traditional breeds) including adaptation of the vaccination protocol (in relation to breed and rearing system), ensuring the efficiency of immunocastration and boar taint prevention (in relation to health status and stress), properly control growth and consequently carcass traits (in relation to rearing system and diet).

Vaccination protocol adaptation

As already discussed, usual double vaccination protocol may not be always applicable in the case of the special production systems characterized by lengthy fattening periods (10-16 months) of different (usually lower) level of intensity (Pinna et al., 2016; Martinez-Macipe et al., 2016). The adjusted protocol (i.e. triple vaccination) should take into account earlier sexual maturation (as shown for Iberian breed) and intervals between subsequent vaccinations (i.e. to ensure no restitution).

Health/stress in relation to immunocastration effectiveness and boar taint prevention

Immune response may be affected by factors like stress or infections, and could (hypothetically) hinder the effectiveness of immunocastration (could be one of the reasons for "non-responders"). According to Hernandez-Garcia et al. (2016), severe feed restriction in pre-Montanera as practiced in free range systems with Iberico pigs, significantly lowers the immunocastration effectiveness, with special adjustments of the feeding regime (allowing a short *ad libitum* feeding period prior to V3) being under development. However, despite effective immunocastration, boar taint may not be sufficiently eliminated, at least in the case of skatole. Factors like severe intestinal infections (Škrlep et al., 2012b) or sub-optimal rearing conditions (Škrlep et al., 2016a) can result in increased skatole levels in surgical castrates, immunocastrates and entire males with low androstenone (i.e. sexually immature).

Castration of older boars

As mentioned before, the application of immunocastration in adult (culled) boars would improve welfare status of these animals and/or increase economic profitability after being sold to slaughter. To the best of our knowledge, there are only two studies available on this topic. The first (Agudelo-Trujillo et al., 2012) reports immunocastration of 29 month-old boars. After vaccine applications at 9 and 5 weeks prior to slaughter, this resulted in complete clearance of boar taint, significant testicular atrophy and, in contrast to control surgically castrated boars, no weight losses. The second study on 34.9 months old boars (Bilskis et al., 2012) tested the protocol with three vaccinations in four-week intervals, and confirmed that immunocastration effectively reduces testosterone, sexual behaviour, ejaculate volume and total number of normal spermatozoa. Although immunocastration seems to work also with this age category, several issues (like exact time for boar taint clearance, vaccination protocol, interfering factors) still need further research.

Control of feed intake/carcass composition

As already mentioned, in standard pigs the resemblance of immunocastrates to surgical castrates increases with the time elapsed from the effective vaccination to slaughter, especially in terms of fatness (Turkstra et al., 2002; Lealiifano et al., 2011; Škrlep et al., 2012a). As demonstrated in recently published meta-analysis (Batorek et al., 2012b; Dunshea et al., 2013), the most pronounced effect of immunocastration is an increase in feed intake associated with a faster growth, increased lipid deposition and reduced feed efficiency, while protein deposition does not change and basal metabolism drops significantly.

Free range systems

Practice of immunocastration could prove beneficial for free range rearing systems. For instance, in Iberian breed reared in dehesa, castration of both males and females was traditionally practiced in order to avoid boar taint and prevent unwanted mating. Since female spaying is restricted by the EU regulations, immunocastration of females may be a possible alternative (Martinez-Macipe et al., 2016), with extra benefits from faster growth and more homogenous batches (Fernandez-Moya, 2011), with no need for separation of sexes before immunization or during rearing, which would simplify herd management. There is however a need to establish special immunization protocols (i.e. early immunocastration in pre-pubertal period, Hernandez Garcia et al., 2015b).

Advantages	Disadvantages
• Suitable for heavy/older pig production including extensive/free range systems (after some adaptation of the vaccination protocol) • Suitable for culled boars and females (effective, no post-operational complications)	• Feeding and vaccination protocols need to be adapted to production system with older/heavy pigs

4.4.2.5. Economic costs and benefits (from bibliography, literature)

The extra cost associated with immunocastration includes the price of the vaccine and extra labour at vaccination, however in standard pigs this is compensated by more efficient feed utilisation, faster growth and leaner carcass compared to surgical castrates (Batorek et al., 2012a,b), while in heavy pigs used for traditional productions these may not be advantages. The literature dealing with economic evaluation of immunocastration is not abundant, whereas the actual costs are also difficult to assess, as the factors mentioned before, vary due to the costs of labour, equipment, pharmaceuticals and pig production parameters (differences in growth intensity due to rearing system/conditions, breed, vaccination protocol). According to de Roest et al. (2009), direct additional costs of immunocastration are from 3.00-3.65 EUR/pig, excluding costs of screening for tainted carcasses at slaughter or the loss of income due to possible boar taint presence and additional carcass trimming (remaining reproductive tract). This is higher in comparison to the conventional surgical castration (1.03 EUR according to Rodriguez-Estevez, 2012; or 0.78 to 2.99 EUR/piglet according to de Roest et al, 2009) partly even when additional costs of applying analgesia and/or anaesthesia (0.19 to 1.67 EUR/piglet, de Roest et al., 2009; or 0.29 EUR/piglet, Aluwé et al., 2012) are taken into account.

On the other hand, benefits from better growth and feed conversion can be expected when compared to surgical castrates (i.e. ranging from 7.5% in Duroc to even 18% in Pietrain crosses; Škrlep et al., 2010; Batorek et al., 2012a). Overall reported economic benefit of the immunocastration differ according to the study i.e. management applied (from -0.02 to + 0.12 EUR/kg carcass, de Roest et al., 2009; Kastelic & Košorok, 2010; Aluwé et al., 2012). For the rearing of heavy pigs (including the local breeds, extensive and free range rearing usually to higher age), no direct economic evaluation of immunocastration is available. For example, in Iberian breed in Montanera system, 3 instead of regular 2 vaccinations of both males and females are performed due to higher slaughter age (Hernandez-Garcia et al., 2013, 2016) increasing the costs of such treatment and being associated to slight decrease in carcass fatness. According to project ALCASDE projection for Italy (deliverable D1.4.2., 2009), raising heavy immunocastrates (including triple vaccination protocol) may still bring a benefit of 13.16 EUR/pig/year in comparison to surgical castrates. It is worth mentioning, that although of marginal importance, immunocastration would be profitable in the case of culled boars from breeding or performance test. These pigs are often sold for slaughter at a very low (zero) price. Alternatively, they are castrated by a veterinarian, at considerable costs because at that age this procedure is very demanding. However, the use of immunocastration on culled boars is considered to be marginal compared to the fattening pigs.

Advantages	Disadvantages
• Cost of the vaccine is compensated by several other benefits (by better production traits, lower losses due castration) • Suitable for production systems with older/heavy pigs, where meat and fat quality requirements are high	• Economic aspect of immunocastrates has not been sufficiently studied for production systems with older/heavy pigs and may vary according to the production system

4.4.2.6. Impact on meat quality parameters with special emphasis on those which are critical for the specificity of the traditional product (from bibliography, literature)

As regards meat quality, meta-analytical results (Batorek et al., 2012b; Trefan et al., 2013) show that there are no major differences between immunocastrates and surgical castrates. Compared to entire males, immunocastrates are mostly superior exhibiting higher intramuscular fat, tenderness, but also lighter meat colour and a tendency for lower water holding capacity. Similar conclusions are valid also for the comparison between surgical castrates and entire males (Pauly et al., 2012; Batorek et al., 2012a; Aluwé et al., 2013), the latter exhibiting inferior water holding capacity, lower tenderness, lower fatness (and lower intramuscular fat) with less saturated fat, which makes it more prone to oxidation. Besides that, entire males need to be slaughtered at earlier age to avoid boar taint, making their meat less suitable for processing into dry-cured meat products, where raw material of specific quality is required (Čandek-Potokar & Škrlep, 2012; Škrlep et al., 2016b) and this is significantly improved at higher weight and age. The use of immunocastration overcomes the drawbacks of entire males and could prove beneficial in the case of fattening to higher age and weight especially in the case of extensive rearing conditions (i.e. free range, organic) (Čandek-Potokar et al., 2015). Available studies (Boler et al., 2011; Font i Furnols, 2009, 2012; Pinna et la., 2016), which evaluated suitability of immunocastrates for dry-cured products, concluded that they are similar to surgical castrates in regard to meat and fat quality (including quantity and fatty acid composition) and were (also in the case of heavier hams) considered suitable for prolonged maturation process. A comparison of dry-cured hams originating from immunocastrates and entire males slaughtered at 130 kg (Škrlep et al., 2015) showed that hams from immunocastrates were more suitable for processing due to lower seasoning losses, lower salt intake and softer product with more intramuscular fat. Due to the increasing resemblance between immunocastrates and surgical castrates after V2, depending on the need (fresh meat or dry-curing process), the protocol of vaccination can be adjusted (late or early vaccination, respectively). It is also worth noting that, to our knowledge, no literature is available, which would give an idea on proteolytic activity of meat from immunocastrates, which is of relevance in dry-curing process, in particular in the case of high quality products like long-matured dry-cured hams with PDO. Namely their changed metabolism after V2 is likely to affect protein turnover, and thus also proteolytic activity. Due to the possible recovery from immunocastration, triple vaccination protocol is to be considered in heavy pigs. From study comparing surgical castrates vs. twice or three times vaccinated heavy pigs (Pinna et al., 2015) it can be deduced that there are some signs of boar-like features (i.e. recovery from ICA) in IC2 (higher boar taint presence, weight losses, meat redness, cathepsin activity, lower subcutaneous fat, rheological cohesiveness and force decay coefficient) slaughtered 14 weeks after V2 (higher boar taint presence, weight losses, meat redness, cathepsin activity, lower subcutaneous fat, rheological cohesiveness and force decay

coefficient), and that three-dose immunocastration should be applied to meet the requirements for such products (i.e. Italian PDO hams). The same study pointed out some indications of higher proteolytic potential in immunocastrates compared to surgical castrates. In the Iberian pigs (Martinez-Macipe et al., 2016; Izquierdo et al., 2013; Gamero-Negron et al., 2015), immunocastration (triple vaccination protocol) has been found to be a suitable alternative as no major differences on carcass or technological and sensory meat quality was observed compared to surgically castrated females, whereas immunocastration of male pigs resulted in somewhat leaner carcasses with less intramuscular fat and lower tenderness and higher rancidity than in surgical castrates.

Advantages	Disadvantages
• In general immunocastrated pigs exhibit similar meat quality (considering some uses) as surgical castrates and better than entire males	• Potential impact on meat quality needs further investigations, in particular regarding production systems with heavy/older pigs aimed at dry-cured products

IC = Immunocastrates; SC = Surgically castration; EM = entire males

4.4.2.7. Are chain actors prepared to use immunocastration? (all respondents from the questionnaire)

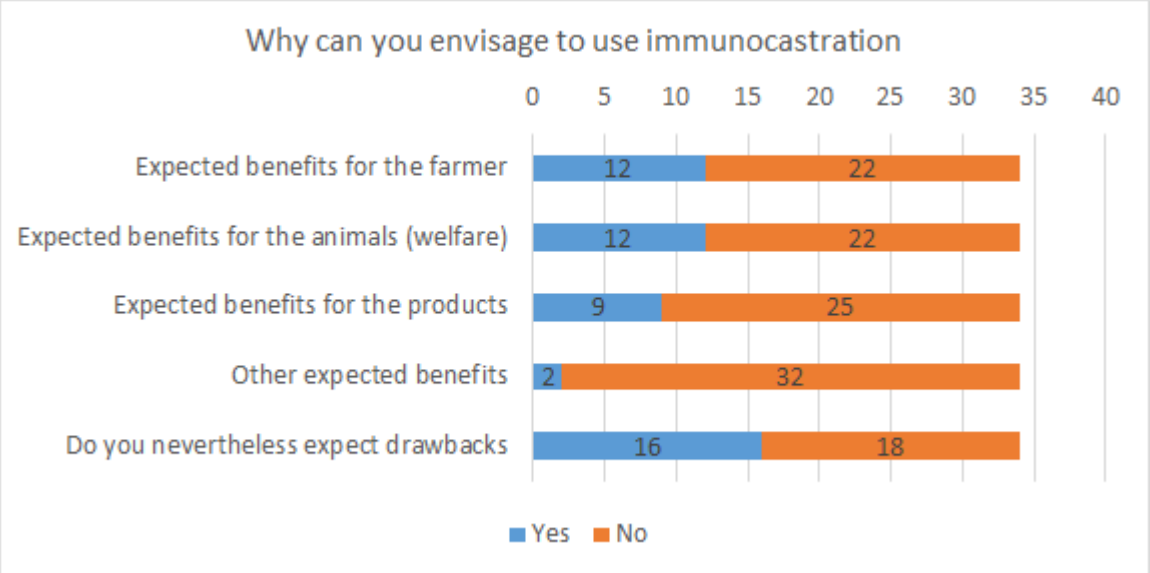
Table 4.4.2.7. Respondents that can envisage immunocastration (from the questionnaires; calculated from the 198 answers - 90% of the total 280 - who reported that they did not use immunocastration).

Countries	N/A	No	Yes	Total	% of Yes
Austria	2	3	0	5	0
Belgium	0	3	1	4	25
Bulgaria	1	1	0	2	0
Croatia	3	4	1	8	13
Denmark	2	0	0	2	0
France	4	13	2	19	11
Germany	6	4	1	11	9
Hungary	30	28	10	68	15
Italy	3	12	1	16	6
Netherlands	1	0	0	1	0
Norway	1	4	0	5	0

Countries	N/A	No	Yes	Total	% of Yes
Poland	1	3	0	4	0
Portugal	3	0	2	5	40
Slovenia	1	15	3	19	16
Spain	7	8	10	25	40
Sweden	0	0	1	1	100
United Kingdom	1	0	2	3	67
Total	66	98	34	198	17

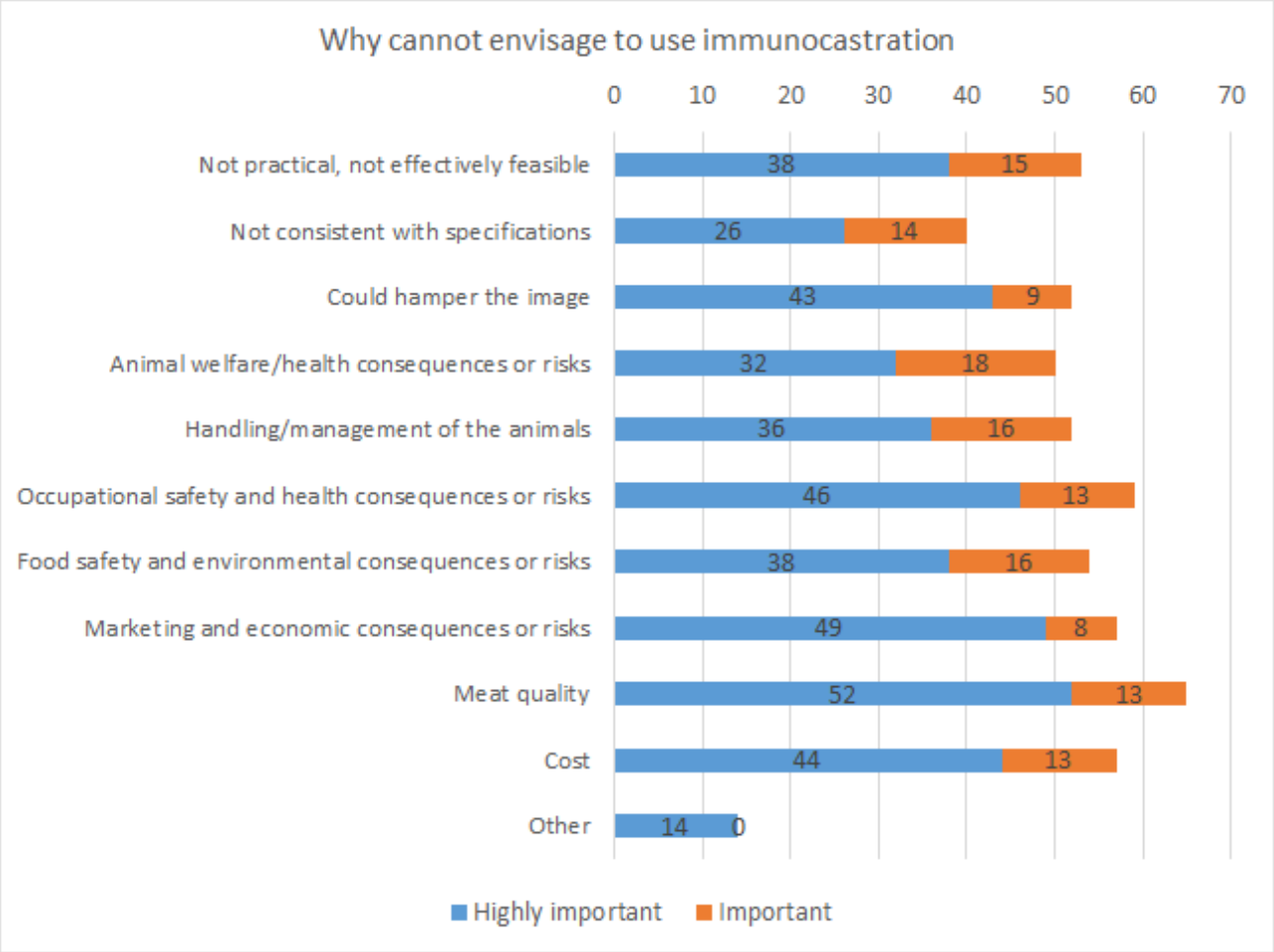
Only 34 respondents (reflecting 17% of the respondents who have not yet used the immunocastration) could consider using immunocastration whereas 98 (49%) respondents stated that they could not consider it. One third of respondents (n=66) did not provide the answer to this question.

Figure 4.4.2.7a. Reasons why respondents can envisage immunocastration (from the questionnaires; calculated from the 34 answers reporting they can envisage using immunocastration).



From the situations where immunocastration is not used, but stakeholders can envisage immunocastration (n=34), the most important reasons are expected benefits for the farmers and for the animals (welfare), both with 35% of the answers, followed by expected benefits for the product (26%). Nevertheless, 47% of the respondents expected drawbacks. See also Appendix A5: “Comments from answers stating they can envisage immunocastration”.

Figure 4.4.2.7b. Reasons why respondents cannot envisage immunocastration (from the questionnaires; calculated from the 98 answers reporting they cannot envisage using immunocastration).



Out of 98 respondents stating that they could not envisage to use immunocastration 74 provided a reason why. The most important turned out to be Meat quality followed by Occupational safety. It should be noted however that the majority of given reasons was considered important or highly important (63 to 89% of respondents) denoting strong concerns of the stakeholders about this practice. See also Appendix A6: "Comments from answers stating they cannot envisage immunocastration".

In reply to the question if they have documentation they could provide to support their answer, 20 answered Yes, 77 No and 183 N/A. A total of 20 files were finally provided, from Belgium (2), France (3), Germany (1), Italy (3), Portugal (2), Slovenia (4) and Spain (5).

4.4.2.8. Are chain actors prepared to use immunocastration? (respondents of the questionnaire using heavy pigs - > 130 kg live weight)

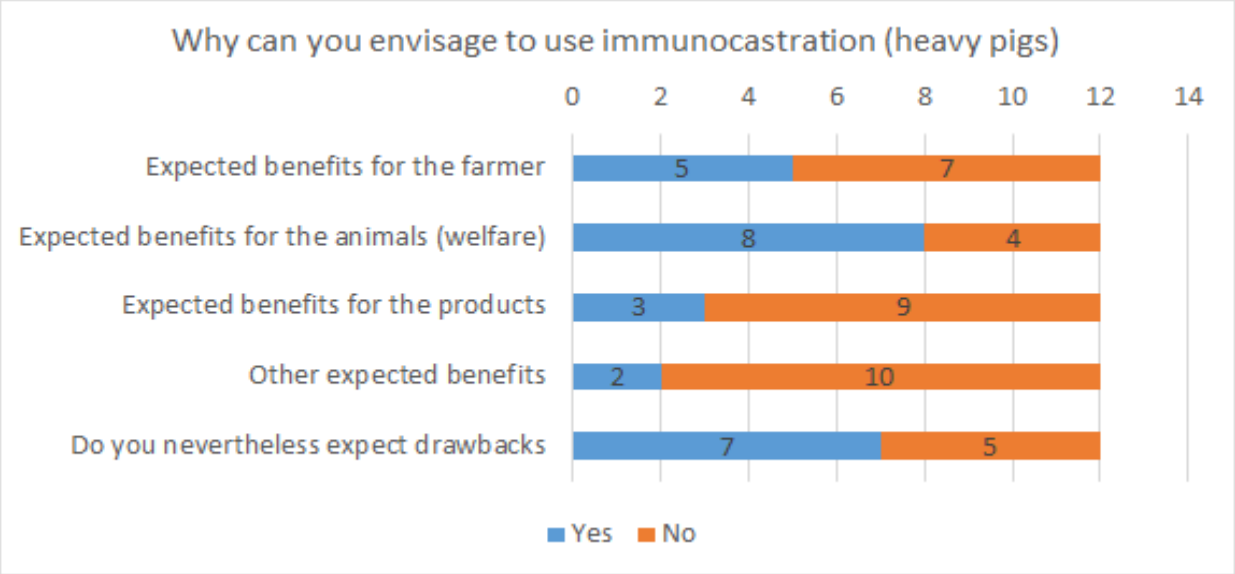
Table 4.4.2.8. Respondents using heavy pigs (> 130 kg live weight) that can envisage to use immunocastration
(from the questionnaires; calculated from the 77 answers - 28% of the total 280 - who have been identified as using heavy pigs AND reported that they did not use immunocastration.

Countries	N/A	No	Yes	Total
Austria	-	1	-	1
Belgium	-	3	-	3
Bulgaria	-	-	-	-
Croatia	1	2	-	3
Denmark	-	-	-	-
Finland	-	-	-	-
France	4	12	2	18
Germany	1	-	-	1
Hungary	2	1	-	3
Italy	3	11	1	15
Luxembourg	-	-	-	-
Malta	-	-	-	-
Netherlands	1	-	-	1
Norway	-	3	-	3
Poland	1	2	-	3
Portugal	-	-	1	1
Slovenia	-	11	1	12
Spain	1	5	6	12
Sweden	-	-	1	1
United Kingdom	-	-	-	-
Total	**14**	**51**	**12**	**77**

Twelve (16%) of the 77 respondents identified as producing heavy pigs (> 130 kg live weight) stated that they could envisage to use immunocastration whereas 51 (66%) of them stated the opposite (could not envisage using it).

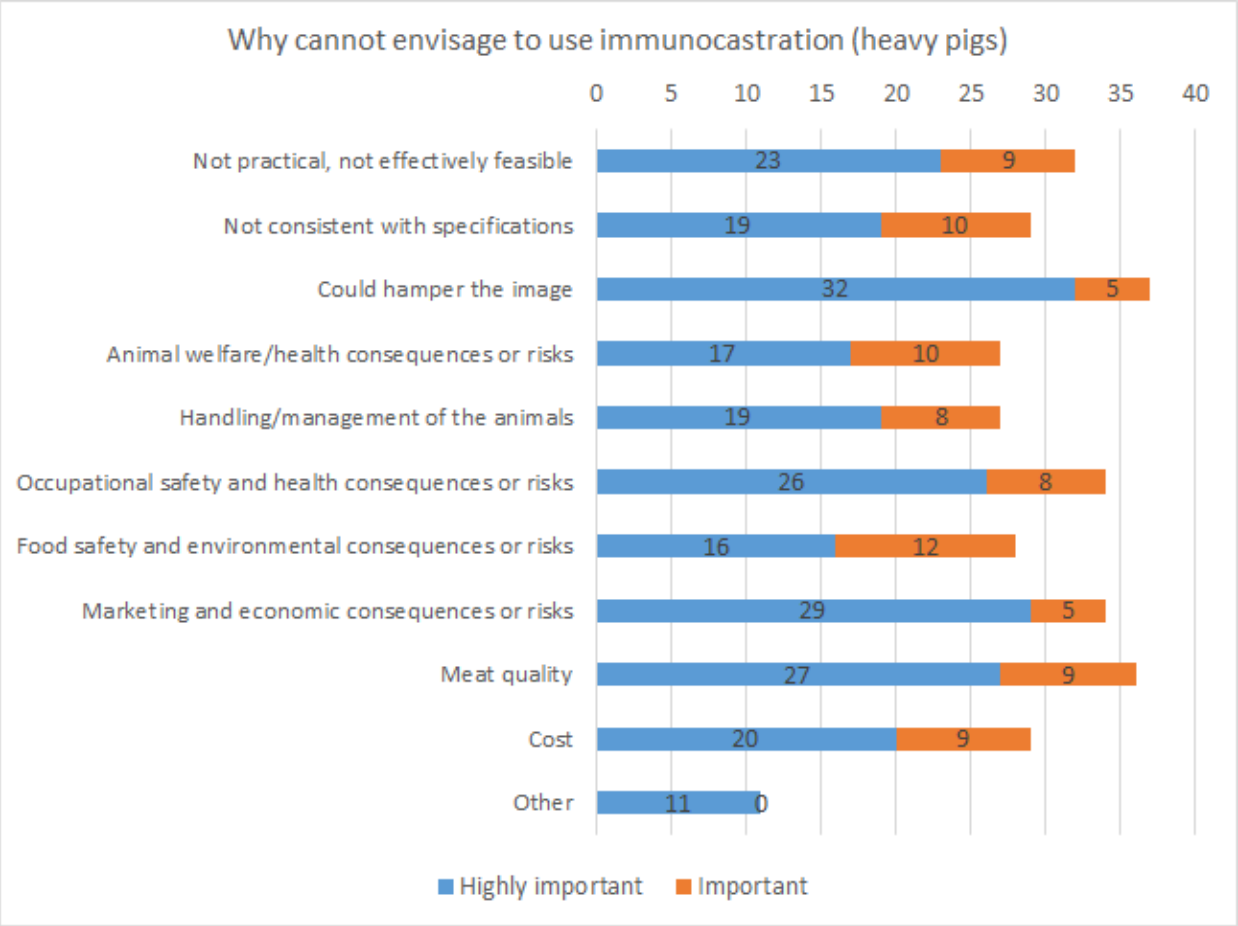
Expected benefits for the animals (welfare) was the main reason why it could be envisaged immunocastration given by respondents identified as producing heavy pigs (see figure below). Nevertheless, 58% of them expect drawbacks.

Figure 4.4.2.8a. Reasons why respondents using heavy pigs (> 130 kg live weight) can envisage immunocastration (from the questionnaires).



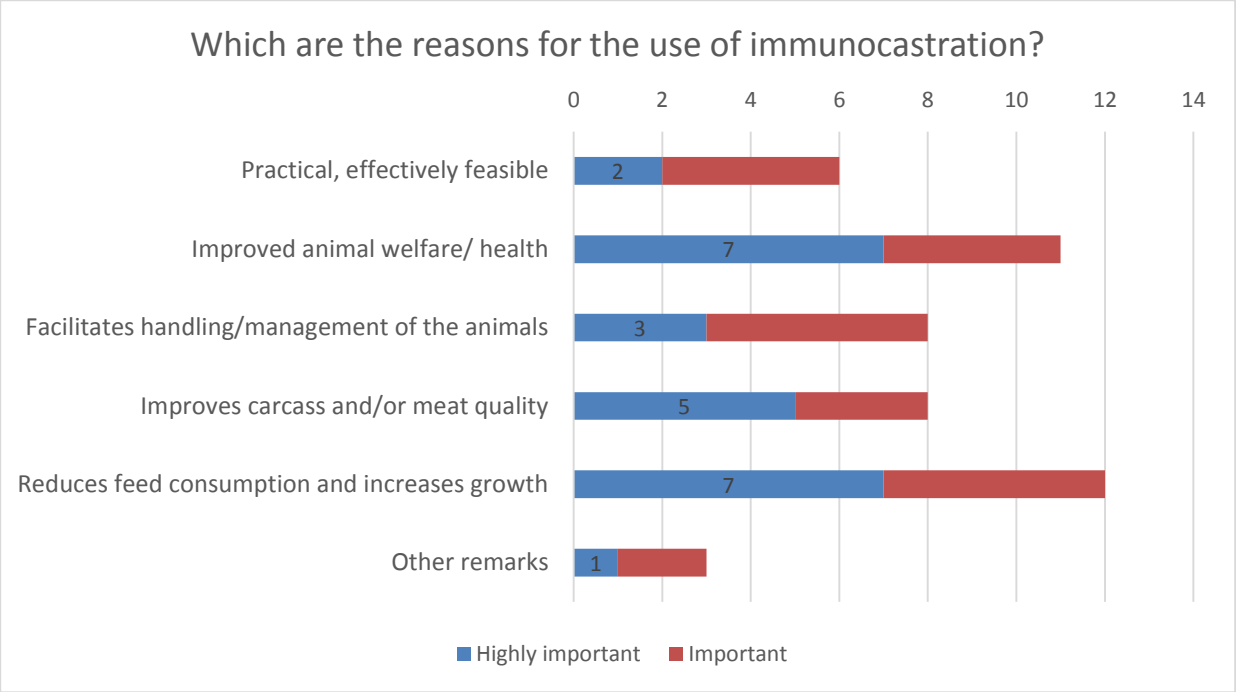
Out of 51 producers identified as using heavy pigs (> 130 kg live weight) 42 provided a reason why they cannot envisage the use of immunocastration. The most frequent reason was fear that its use could hamper the image" although several other reasons like meat quality, occupational safety, marketing consequences, not practical/feasible were also similarly important. It should be noted that more than a half of respondents ticked all listed reasons as important.

Figure 4.4.2.8b. Reasons why respondents using heavy pigs (> 130 kg live weight) cannot envisage immunocastration (from the questionnaires).



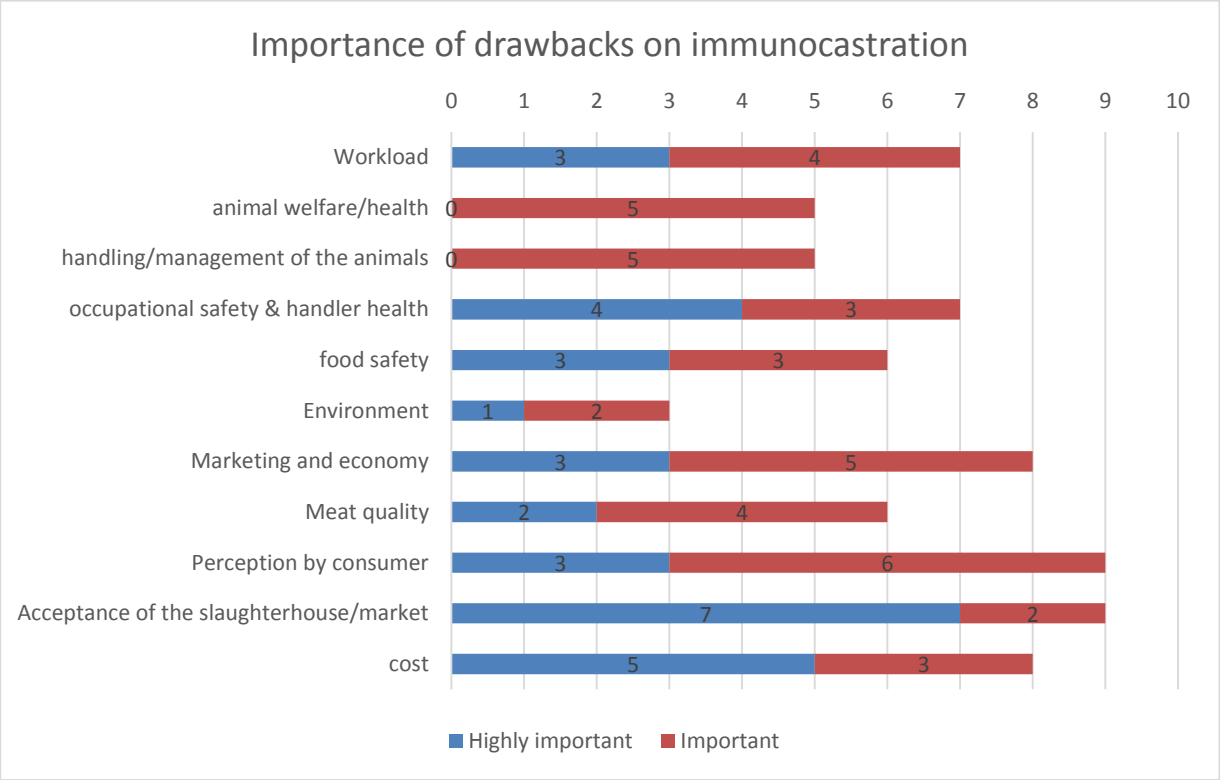
4.4.2.9. Chain actors using immunocastration: why do they use it and do they identify drawbacks?

Figure 4.4.2.9a. Reasons for the use of immunocastration (from the questionnaires).



The main reasons for using immunocastration are driven by economical convenience (better feed conversion and carcass composition) and improved welfare. Practicality and feasibility seems less important as reason.

Figure 4.4.2.9b. Importance of the drawbacks on applying immunocastration (from the questionnaires).



The most important drawbacks that are expected or perceived are related to the acceptance of immunocastration as a practice for meat production that leads to negative perceptions by the consumers and, in turn, negative acceptance by slaughterhouses and retailers. Workload, occupational safety and cost are also significant issues. See also Appendix A7: "Comments on the reasons for using immunocastration".

4.4.3. Use of entire males for heavy pigs

4.4.3.1. Acceptability (from bibliography, literature)

Entire male pig production is readily accepted in those countries which have been producing entire males for a long time (UK, Ireland, Spain and Portugal) for standard productions. However, in Spain and Portugal, male pigs are surgically castrated in all situations targeted to higher quality products (such as PDO, PGI, TSG). In the other countries, consumers, the general public, NGOs and stakeholders of the pork production chain were prepared to accept entire male pig production, provided that the boar taint problem is solved, so that the quality of the pork provided to the consumers can be preserved (PIGCAS final report, 2009). At the time of the PIGCAS report, pig producers and consumers were rather reluctant to raise entire males and most of them preferred to stick to surgical castration (PIGCAS deliverable 3.3, 2009). The attitude of at least part of the pig production chains has changed in some countries such as The Netherlands, Germany, Belgium and France where a significant production of entire male pigs is now occurring.

There is however still a large variation between production chains in their readiness to produce entire males, both within those countries that started entire male production recently and among countries. The recent trend towards increasing entire male production observed in some countries applies only for standard production systems.

4.4.3.2. Impact on animal welfare (from bibliography, literature)

Raising entire males improves welfare of these animals in early life, in that they are not subjected to the pain and discomfort of castration. On the other hand, welfare of fattening/slaughter pigs may be impaired because entire males are more aggressive and perform more mounting behaviour than castrates (von Borell et al., 2009).

4.4.3.3. Practical and effective applicability (from bibliography, literature)

Some producers find raising entire male pigs more difficult because they do not display the same behaviour as castrates. The animals are more restless, more aggressive and exhibit increased mounting behaviour compared to surgically castrated males (von Borell et al., 2009). It can be observed however, that most producers easily move from surgical castration to entire males whenever their customers (slaughterhouses) buy their pigs without any economic penalties. This is not the case where the potential high frequency of boar taint (derived by a high slaughtering weight) is considered a very important problem affecting the quality of fresh or processed meat.

In situations involving heavy weights and/or old age at slaughter, it is not practically feasible to raise sexually mature male and female pigs together.

4.4.3.4. Economic costs and benefits (from bibliography, literature)

Raising entire males is economically beneficial for the farmer as evaluated in standard production systems. The advantages of entire males over castrates can be summarised as follows (Lundström et al., 2009):

- Superior growth rate of entire males up to 13%;
- Entire males may eat up to 9% less feed;
- Feed conversion (to live-weight) up to 14% more efficient;
- Entire males are generally leaner than castrates by up to 20%.

The annual benefit of raising entire males has been found to be in the range of 7-8 € per pig (ALCASDE final report, 2009) in The Netherlands and France, under the assumption that testing costs and price reduction for tainted meat (2% of the pigs) amount to 0.36 € per pig.

Another study performed by Civic Consulting for DG Sanco (Béteille, 2014) estimated the benefit of raising entire males between 5.2 and 10.8 € per pig, including 2.8 € of animal welfare benefit for the society. The above-mentioned calculations were performed for standard pig production. They certainly do not apply to non-standard pig production (i.e. local breeds, specific feedstuffs, heavy weight and/or old age at slaughter, outdoor rearing). For typical products that require a high fat thickness, minimizing fat cannot be considered as an advantage.

4.4.3.5. Impact on meat quality parameters with special emphasis on those which are critical for the specificity of traditional products (from bibliography, literature)

An excellent summary of the impact of raising entire males instead of surgical castrates on meat quality is given by Lundström et al. (2009). Considering the parameters that are

critical for the specificity of traditional products, impact of entire males is in general negative and can be summarized as follows:

- Presence of boar taint. The incidence of boar taint increases in situations involving heavy weight and/or old age at slaughter. Boar taint is a particularly important problem for products that are cooked at home, consumed warm, have a high fat content and do not include smoke and/or spices that could mask boar taint.
- Lower amount of fat: This is particularly critical for products that include a lot of fat (e.g. pâtés) or need a thick layer of fat (e.g. dry-cured hams).
- Higher unsaturation and higher water content of the fatty tissues: This is critical for all dry cured products that are processed with a long maturation time and need firm fat.

4.4.3.6. Advantages and disadvantages, pros and cons, opportunities and threats (from bibliography, literature)

Table 4.4.3.6 summarizes different aspects on raising entire males. This analysis is mainly focused on situations involving heavy pigs.

Table 4.4.3.6. Summary of different effects on raising entire males.

Advantages	**Disadvantages**
• Reduced feed costs • Reduced workload (castration)	• Some producers find it difficult to raise entire males. • Rearing sexually mature male and female pigs together is not really feasible. • Leaner animals are a disadvantage in all situations where the product contains much fat. • More unsaturated and more aqueous fat is a disadvantage for products requiring firm and/or saturated fat. • Boar taint more likely in situations involving heavy pigs and/or old age at slaughter. • Boar taint more readily perceived by consumers in high fat products, particularly if they are cooked at home and/or consumed warm and do not include any masking ingredient.
Opportunities	**Threats**
• Improved image of the production process, particularly regarding animal welfare (pain associated with castration).	• Deteriorated image of the production process, particularly regarding animal welfare (aggressiveness, mounting behaviour, harassment of females and other males). • Market loss: Consumers paying a higher price for high quality product disappointed with lower quality products not meeting their expectations.

4.4.3.7. Evaluation of problematic situations regarding the use of entire males

The possibility for a given situation to use entire males is evaluated according to the following parameters:

- presence of product specifications requesting male castration;
- high incidence of boar taint of the meat because of sexual maturity of the animals;
- high likelihood of boar taint perception by consumers because of high fat content, absence of masking ingredient, mode of consumption (cooked at home, consumed warm);
- other meat quality issues and management issues, as defined in section 4.1.1 and 4.1.2.

Table 4.4.3.7a. Number of situations where the use of entire males was evaluated as problematic (difficult or impossible to implement and/or damaging for product quality). (from bibliography, specifications).

Countries	PGI	PDO	TSG	Quality	Organic	Welfare	Other	Total problematic	Problematic % of total
Austria	2	-	-	-	-	-	-	2	100%
Belgium	3	-	-	2	1	-	-	6	100%
Bulgaria	-	-	4	24	-	-	-	28	100%
Croatia	6	2	-	-	-	-	-	8	100%
Denmark	-	-	-	2	1	3	1	7	100%
France	21	7	-	17	5	-	2	52	100%
Germany	-	-	-	-	-	-	-	-	-
Hungary	3	1	-	1	-	-	2	7	100%
Italy	19	22	-	-	-	-	-	41	100%
Netherlands	-	-	-	1	1	-	-	2	100%
Norway	-	-	-	1	-	-	-	1	100%
Poland	3	-	6	-	-	-	-	9	100%
Portugal	39	4	-	-	-	-	-	43	100%
Slovenia	7	-	-	5	1	1	3	17	94%
Spain	9	6	1	14	-	-	-	30	77%
Sweden	-	-	-	-	-	-	-	-	-
Switzerland	-	-	-	-	-	-	-	-	-
UK	4	-	2	-	-	1	1	8	100%
Total	**116**	**42**	**13**	**67**	**9**	**5**	**9**	**261**	
% of situations	**43%**	**15%**	**5%**	**25%**	**3%**	**2%**	**3%**	**96%**	
Reminder: Total number of situations	118	42	14	75	9	5	9	**272**	
% of situations in the column	98%	100%	93%	89%	100%	100%	100%		

The evaluation of whether the use of entire males is problematic has been a subjective process based on the available information.

In almost all (96%) the situations considered in the bibliography (specifications), the use of entire males was evaluated as problematic for at least one of the five reasons considered above.

Table 4.4.3.7b. Reasons why the use of entire males was evaluated as problematic (from bibliography, specifications).

Countries	Castration in specifications (1)	Increased incidence of boar taint (2)	High sensitivity of product to boar taint perception (3)	Other meat quality issues (4)	Management issues (5)	Problematic for at least one of the 5 reasons	Problematic % of total
Austria	-	2	-	2	2	2	100%
Belgium	2	6	3	2	6	6	100%
Bulgaria	12	16	7	20	16	28	100%
Croatia	3	8	1	6	8	8	100%
Denmark	-	3	7	-	3	7	100%
France	17	52	36	14	52	52	100%
Germany	-	-	-	-	-	-	-
Hungary	2	7	3	4	7	7	100%
Italy	28	41	8	33	41	41	100%
Netherlands	-	2	2	-	2	2	100%
Norway	-	1	-	1	1	1	100%
Poland	-	9	2	7	9	9	100%
Portugal	7	43	2	40	43	43	100%
Slovenia	2	13	-	8	13	17	94%
Spain	7	15	7	22	15	30	77%
Sweden	-	-	-	-	-	-	0%
Switzerland	-	-	-	-	-	-	-
U K	-	2	7	1	2	8	100%
Total	**80**	**220**	**85**	**160**	**220**	**261**	
% of situations	**29%**	**81%**	**31%**	**59%**	**81%**	**96%**	

1. Castration of males made compulsory in specifications.
2. Increased likelihood of boar taint in entire males: Sexual maturity issues (heavy weight, old age at slaughter, for instance in local breeds).
3. Increased likelihood of boar taint in entire males: Sensitivity of product to boar taint detection by the consumer.
4. Other meat quality issues for the product, particularly regarding fat quantity and quality.
5. Management issues: raising sexually mature male and female pigs together.

The most important reasons why the use of entire males was evaluated as difficult to implement is advanced sexual maturity at slaughter because of heavy weight and/or old age, resulting in likely increased incidence of boar taint and in management problems. Reduced quantity of fat and increased unsaturation of fat is also an issue for all dry-cured products that represent 59% of the situations.

Table 4.4.3.7c. Number of situations where the use of entire males was evaluated as problematic (difficult or impossible to implement and/or damaging for product quality). (from questionnaires).

Overall	Castration in specifications (1)	Increased incidence of boar taint (2)	High sensitivity of product to boar taint perception (3)	Other meat quality issues (4)	Management issues (5)	Problematic for at least one of the 5 reasons
Yes	103	109	5	63	109	152
No	178	51	240	218	51	26
?		121	36		121	103

? Information provided in the questionnaire is not sufficient for any evaluation. (1) to (5): see legend of Table 4.4.3.7b.

Following the same rationale as above, situations described by the respondents to the questionnaire were also tentatively evaluated as to whether the use of entire males is difficult or impossible to implement and/or damaging for product quality. For 103 of the 281 answers, the information that we have was not sufficient to make an evaluation. Among the 178 remaining answers, a large majority (85%) was analysed as problematic for at least one of the 5 considered reasons.

4.4.3.8. Are chain actors prepared to use entire males?

Table 4.4.3.8. Number of respondents for WP2 who can envisage to use entire males (from questionnaires; Calculated from the 148 answers stating that they are not using entire males).

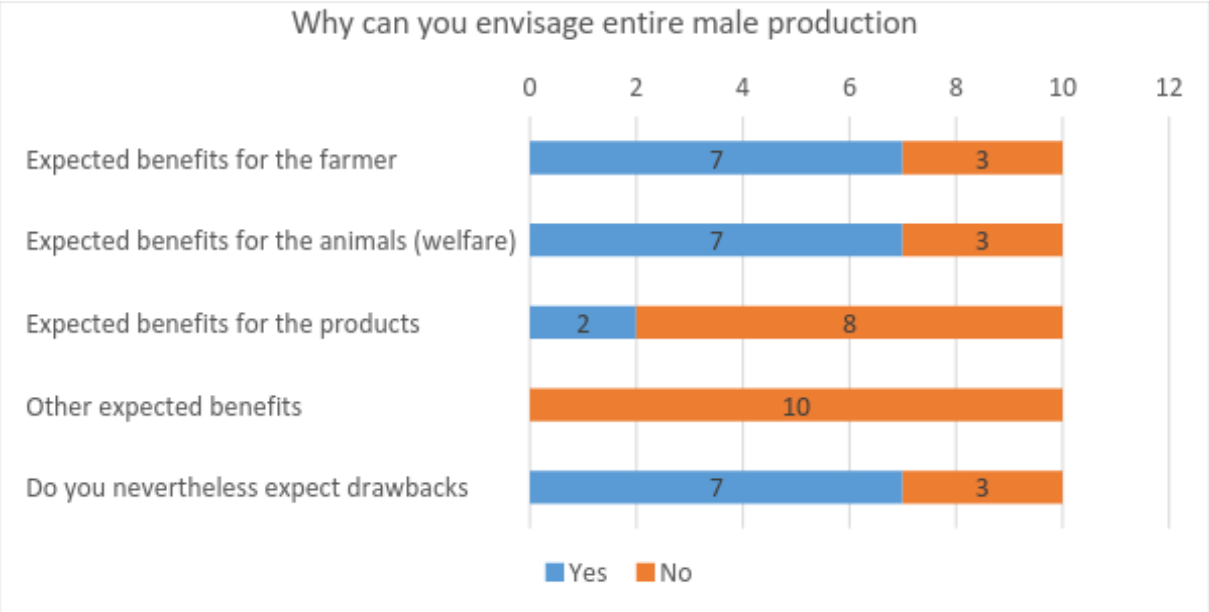
Countries	N/A	No	Yes	Total	% if yes
Austria	2	3	0	5	0
Belgium	1	1	1	3	33
Bulgaria	0	1	0	1	0
Croatia	3	3	1	7	14
Denmark	0	1	0	1	0
France	2	9	3	14	21
Germany	5	0	1	6	17
Hungary	24	21	3	48	6
Italy	4	11	0	15	0
Netherlands	1	0	0	1	0
Norway	3	4	0	7	0

Countries	N/A	No	Yes	Total	% if yes
Poland	1	2	0	3	0
Portugal	1	4	0	5	0
Slovenia	2	12	1	15	7
Spain	7	9	0	16	0
Sweden	1	0	0	1	0
United Kingdom	0	0	0	0	-
Total	57	81	10	148	7

Only a small minority of the respondents (10, i.e. 5%) that do not use entire males are prepared to do so whereas 81 (40%) stated that they are not prepared to use entire males. Many other respondents (57) did not answer this question.

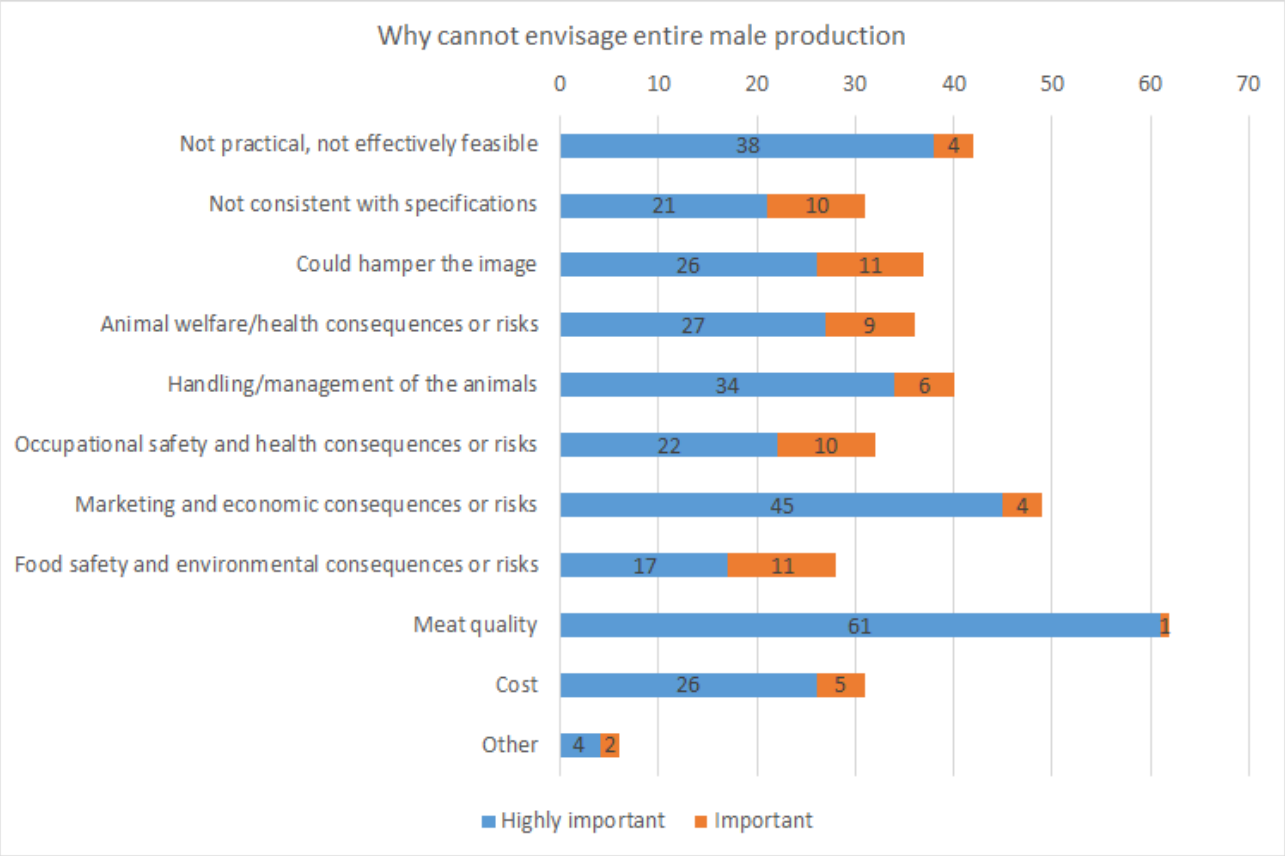
For the 10 respondents that do not currently produce entire male pigs and can envisage to do so, the main reasons are expected benefits for the farmer and for the animals (as described in Figure 4.4.3.8). Nevertheless, 70% of them expect drawbacks. See also Appendix A8: "Comments on the reasons why respondents can envisage entire male pig production". No answers were obtained in UK as in this country the majority of the male pigs are already slaughtered as entire males.

Figure 4.4.3.8a. Reasons why respondents can envisage to use entire males (from questionnaires).



For the 81 respondents that do not currently produce entire male pigs and cannot envisage to do so, all the reasons are considered as important (see below figure). They are, in decreasing order of importance marketing and economic consequences or risks, meat quality, not practical, not effectively feasible, handling/management of the animals, could hamper the image, other, animal welfare/health consequences or risks, occupational safety and health consequences or risks, not consistent with specifications and, finally, food safety and environmental consequences or risks. See also Appendix A9 "Comments on the reasons why respondents cannot envisage entire male pig production".

Figure 4.4.3.8b. Reasons why respondents cannot envisage to use entire males (from questionnaires).



4.5. Comparative summary of advantages and disadvantages of surgical castration and alternatives to surgical castration

Table 4.5 reports a summarized overview of the pros and cons of alternative practices (immunocatsration and use of entire males) to surgical castration. Only one method for surgical castration has been included in this table. Other methods are reported in Table 3.6.7. Comparative analysis is referred mainly on heavy pig productions.

Table 4.5. Summary table comparing the advantages and disadvantages of surgical castration with local Lidocaine with analgesia, immunocastration and use of entire males. Advantages are indicated in the table with [+] before the description of the specific aspect related to this evaluation. Disadvantages are indicated with [-]. When both advantages and disadvantages are present the [+/-] is used. When no or poor information is available to tentatively provide an evaluation a question mark is used: [?].

	Surgical castration with local anaesthesia lidocaine with analgesia	**Immunocastration**	**Entire males**
Acceptability	[+]	[-] There is a strong opposition of chain actors that consumer would not accept this method. [+] Good according to scientists and animal welfare NGOs. Farmers approve/seek it in marginal situations (breeding boars). [+/?] Farmers might be prepared if they can sell their pigs (e.g. standard production in Belgium). [-] Currently one producer of the vaccine	[+] Good in countries where entire males have been produced for many years. [+/-] In other countries: OK provided that quality is maintained. Recent change to more positive attitudes in some standard production chains in NL, BE, DE, FR. [-] Positive attitude does not apply for situations with differentiated production systems aiming at high quality products.

	Surgical castration with local anaesthesia lidocaine with analgesia	Immunocastration	Entire males
Practical applicability	[-] Requires authorisation and specific training.	[+] Females may be neutered. Mixed sex groups possible in fattening [+/-] Vaccination protocols need adaptation to production system. Might be more difficult in heavy pigs and free range situations. [+/-] Training/assistance when starting to implement this practice is recommendable to optimise economic results and effectiveness [-] Concerns for the safety of the operators.	[+] Some producers adapt quite easily. [+/-] Some producers find it difficult to raise entire males. [-] Difficult management in heavy/old sexually mature animals [-] Sexual maturity reached before required min. age at slaughter set in specification.

	Surgical castration with local anaesthesia lidocaine with analgesia	Immunocastration	Entire males
Animal welfare	[+] Effective only if properly administered with an analgesic drug. [+/-] May be painful if not done properly.	[+] Pain at castration avoided. [+] Unwanted behaviour suppressed after 2nd vaccination. [-] Stress at handling in heavy pigs [-] Stress when restricted feeding used after 2nd vaccination.	[+] Pain at castration avoided. [-] Mounting, aggressiveness, penis biting, restlessness; these problems are aggravated in heavy/old sexually mature animals.
Economic costs and benefits	[-] Additional costs, particularly if done by veterinarian; [-] No compensating benefit	[+/-] Economic aspect of immunocastrates has not been sufficiently studied for production systems with older/heavy pigs and may vary according to the production system	[+] Economic advantages for farmers (save castration time and costs). [+/-] Economic advantages reduced or annihilated if penalties apply; [-] Increased cost for slaughterhouses. [-] Entire males not accepted in case of chains producing heavy/old pigs for high quality products.

	Surgical castration with local anaesthesia lidocaine with analgesia	Immunocastration	Entire males
Impact on meat quality	No impact	[+] Efficiently prevents boar taint. [-] Non responders. [+] Meat quality higher than in entire males. [+/?] Meat quality similar to that of surgical castrates [?] Aptitude for processing of high quality dry-cured product might be impaired. Further investigation needed.	[-] High chance of boar taint for pork from heavy/old pigs. [-] Some products (particularly the dry-cured ones) require more fat and saturated fat; reduced tenderness.

4.6. General remarks

In most European countries, pork products from heavy pigs are rooted in ancient traditions and traditional nutritional habits. Only part of these products has been issued official denominations, such as PDO or PGI. In some cases, local pig genetic resources support traditional products or rural economies, so that traditional products can be essential in maintaining biodiversity in the autochthonous pig populations across Europe.

In general, traditional products come from carcasses of pigs slaughtered at “higher than standard weights”, assuming as slaughtering standard the weight of butchery pigs, or pigs meant to produce fresh meat. If general consensus exists among stakeholders on the range 95-120 kg live weight for standard slaughtering weights, no general agreement among European stakeholders, scientists, practitioners and even Member States exist on a definition for heavy pigs. This point is crucial because traditional products usually come from heavier pigs and heavier pigs tend to be more sexually mature with a higher risk for males to present boar taint. Therefore, heavy slaughter weight is an important criterion to evaluate the risk of boar taint in

pork coming from entire males, even if other factors also play important roles in determining the frequency of boar taint.

Besides their higher slaughter weight, other considerations make the issue of castration of pigs destined to traditional products particularly complex:

- many registered traditional products officially require castration of male pigs;
- many traditional products have high fat levels, do not include masking spices, are cooked at home or are to be consumed warm, all situations in which boar taint perception is magnified;
- some traditional products require meat with specific characteristics of fat content, coverage and quality, *post-mortem* muscle proteolytic activity and water holding capacity;
- heavier pigs require longer growing periods, and older entire males raise serious security issues for the farmers;
- sexually mature males and females must be kept in separate batches.

From meat quality viewpoint, surgical castration being done with or without anesthesia/analgesia is considered equivalent in practice.

Theoretically, surgical castration could be replaced by entire male pig production, immunocastration, chemical castration or sperm sexing. Sperm sexing is not available for the porcine species in commercial conditions while chemical castration is not a viable alternative because it is painful. Therefore, this study only took into consideration entire male production and immunocastration.

There are a number of well-known advantages and disadvantages to the use of entire male pigs. In the case of heavy pigs raised for traditional high quality products, some advantages remain (lower production costs, pain associated with surgical castration is avoided, workload for castration is avoided) but other advantages change to disadvantages (quicker growth turns out to be a disadvantage where minimal age at slaughter is specified, leaner meat and more unsaturated fat become a disadvantage for the processing of many high-quality products). The disadvantages associated with entire males (management issues, welfare issues associated with aggressiveness and mounting behaviour, boar taint, etc.) are more serious for heavy pigs than for standard pigs.

Immunocastration is technically feasible in heavy pigs and prevents most of the disadvantages associated with entire males. There are however a number of remaining issues such as non-responding pigs, cost, feasibility and safety for the operator of vaccination in heavy pigs, particularly in free range animals and/or where a third shot is needed, lower quality of dry cured products. Our surveys (bibliographic and questionnaire) pointed out a general concern about the acceptability by slaughterhouses, retailers and consumers of pork from immunocastrated animals that seems one of the main drawback for the application of this technique in all production systems, including the standard production systems. In general, immunocastrated pigs exhibit similar meat quality, but processing aptitude of the meat for high quality seasoned products derived by heavy pigs should be further investigated.

Answers to the questionnaire confirmed all of the above: in most systems, surgical castration of male piglets is a common practice, integrated in the production chains, and alternatives are generally not taken into consideration or considered too risky for the production systems.

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5. Conclusions

Despite the release of the voluntary initiative to stop surgical castration of piglets as practiced today (European Declaration on alternatives to surgical castration of pigs) in 2010, very heterogeneous situations in EU continue to exist and there seem to be a big difference between different parts of Europe regarding the societal sensibility to the problem as well as willingness of stakeholders to discuss the issue. Prior to ending of this widespread traditional practice in pig husbandry, a lot of potential problems need to be addressed in view of the adaptation of pig sector which were depicted in the European Declaration. In 2011 EC answered to the demands of the stakeholders by financing studies on a) development of reference methods recognised by the EU for the detection and measurement of the main compounds responsible for boar taint, b) study on consumer acceptance in the EU and in third countries of pig meat and meat products obtained from male pigs, c) rapid detection methods for boar taint used or being developed at slaughter plants in the EU, d) reduction of boar taint compounds by breeding, feeding and management techniques, e) economic analysis of the costs and benefits of ending surgical castration.

Our study is a continuation of EC efforts to assess the needs of the sector in relation to stopping of castration, in particular related to the specific situations with higher risks and assessment of the sustainable alternatives. Thus, we surveyed which are the methods of anesthesia and analgesia currently used in male piglet castration and assessed the suitability of raising entire and immunocastrated males in heavy pig production systems with the emphasis on meat quality and aptitude for traditional products.

The systematic use of analgesia and/or anaesthesia for pain relief during surgical castration of male piglets is currently only used in some countries (Netherlands, Norway, Sweden and Switzerland). Our study evidenced big heterogeneity among practices in different countries. There has also been only limited advancement in the last 10 years on the use of anaesthesia and/or analgesia in male piglet castration, from both scientific and technical point of views.

Interventions using pain treatment and anaesthesia as a requirement for the production of meat from male pigs that were in previous reports considered promising solutions such as CO_2/O_2 inhalation or ketamine/azaperone injection anaesthesia do not seem to meet the demand for a sustainable and welfare conform production system, considering the serious risks associated with these methods including aversiveness, limited safety margins, handling stress, practicability as well as economic feasibility.

The effectiveness of pain intervention during and after surgical castration is only given when anaesthesia is combined with preemptive analgesia. Analgesics given alone do not fulfill this requirement as they are mainly effective to mitigate pain post-surgically.

However, it seems also that some practices, such as local anaesthesia and inhalation anaesthesia with Isoflurane, both combined with analgesic preemptive treatment, could be considered for pain relief as these methods seem to be superior to other methods considering effectiveness, drawbacks and risks.

It should however be noted that the analgesics currently used have a limited half-life time of a few hours. Long lasting pain reducing drugs that are effective during and after castration are currently not available.

Regarding the sustainability of alternatives to surgical castration for heavy pig production used for traditional pork products, the surveys demonstrated that besides value chains based on EU protected pork products (PDO, PGI, TSG) there are many other situations that need special attention. These are often small scale productions important for sustainable local rural development. Simplistic approach with setting a threshold on weight/age at slaughter (to prevent boar taint in entire males) is not sufficient and boar taint risk assessment should always be considered together with the type of product (particularly its fat content and the presence/absence of masking ingredients), and the way it is consumed. In addition, there is no general agreement on a definition for heavy pigs. In this study, we tentatively used the

threshold of 130 kg live weight to define heavy pigs even if we considered also other definitions.

With the information that was available for the present study, the use of entire males in production systems that practice prolonged fattening for high quality traditional products has been regarded as difficult or impossible to implement and/or damaging to product quality in almost all situations. The evaluation of whether or not individual situations can accommodate entire males needs however more detailed, case by case, studies. Immunocastration as the second studied alternative prevents most of the disadvantages associated with entire males but there a number of remaining issues regarding feasibility, cost, meat quality for dry-cured products, and acceptability by consumers and stakeholders. The sustainability of this practice is not sufficiently explored for the production of traditional products obtained with heavy pigs as discussed in more details in section 4.

6. Key messages

Collection and evaluation of information on methods for anaesthesia and analgesia

- Male piglet castration is predominantly done without analgesia and/or anaesthesia.
- Use of anaesthesia (local or general) is mandatory in only few countries.
- Preemptive analgesia is used as part of national assurance programmes in some countries.
- Sustainability of the routine use of anaesthesia with analgesia has been questioned.
- Effectiveness of pain mitigation has been questioned for all methods of anaesthesia if not combined with analgesia.
- Analgesia with NSAIDs is mainly effective to mitigate pain post-surgically.
- Half-life time of currently used analgesics is limited to a few hours (in average 2.5 hours).
- Long lasting pain reducing drugs effective during and after castration are currently not available.
- Welfare drawbacks and risks outweigh the benefits of using general injection anaesthesia by ketamine/azaperone and inhalation anaesthesia with CO_2/O_2.
- Local anaesthesia or inhalation anaesthesia with isoflurane combined with analgesia is superior to other methods considering effectiveness, drawbacks and risks.
- The use of isoflurane inhalation gas poses a risk for the environment and the user if not handled properly.
- Inhalation anaesthesia requires expensive and advanced equipment and hygiene control measures.
- Application of analgesics and anaesthetics impose additional handling and stress on piglets.
- Acceptance and likelihood of anaesthesia implementation will depend on authorisation of farmers to do the pain interventions after special training.
- Costs for pain interventions largely depend on the size of the farm and whether a veterinarian has to do the treatment or not.
- Withdrawal periods have to be considered if meat from very young pigs treated with antibiotics or pain reducing drugs is consumed.
- The heterogeneous pig production systems in Europe and related practices on male pig castration are creating different situations across countries that complicate the transfer of different experiences on the use of pain relief methods.

Evaluation of alternatives to surgical castration for heavy pigs used in traditional product

- Besides EU protected pork products frequently based on heavy pig production, there are many other products and production situations that need to be considered.
- Entire male production and immunocastration are currently the only potential alternatives to surgical castration.
- There is no general agreement among European stakeholders, scientists and practitioners on a definition of heavy pigs. Weight is just one of many factors that are important to determine the possibility to use entire males in a given situation.
- On average in the EU, more than half of the pigs are slaughtered at more than 115 kg live weight, but this proportion strongly differs between countries.
- Other factors that can preclude the use of entire males are: i) castration of males being made compulsory in the specifications of the production systems; ii) increased

incidence of boar taint because of sexual maturity issues (old age at slaughter, for instance in local breeds); iii) sensitivity of product to boar taint detection by the consumer (high fat, no masking, cooked at home, consumed warm); iv) other meat quality issues for the product (fat quantity and quality for dry cured products); v) management issues (e.g. rearing sexually mature entire males with sexually mature females).

- Raising entire males improves welfare of these animals in early life, in that they are not subjected to the pain and discomfort of castration. On the other hand, welfare of fattening/slaughter pigs may be impaired because entire males are more aggressive and perform more mounting behaviour than castrates; this holds particularly true for heavy/old pigs.
- Compared to standard productions, there are less advantages and more disadvantages in using entire males for heavy pigs aimed at high quality products.
- A large proportion of the respondents to the questionnaires expressed concerns about product quality (boar taint; fat quantity and quality) and animal management/welfare issues during fattening (restlessness, aggressiveness, mounting, penis biting) as reasons for continuing with surgical castration in heavy pig production systems.
- In almost all (96%) situations across Europe that were analysed on the basis of their specifications, the use of entire males was tentatively evaluated as difficult (management issues) or impossible (castration compulsory in specifications) to implement and/or potentially damaging for the quality of the product.
- A large majority of the respondents to the questionnaire are not prepared to use immunocastration or entire males as alternatives to surgical castration of male pigs.
- Immunocastration of heavy pigs is technically possible but it might require three vaccinations to be effective.
- In general, immunocastrated pigs exhibit similar meat quality as surgical castrates, but processing aptitude of the meat for high quality seasoned products from heavy pigs should be further investigated.
- Acceptability of immunocastration by chain actors is low in most countries. The example of the use of immunocastration for standard production in Belgium might not be easily extended to heavy pigs aimed at high quality products.
- The use of entire males to produce heavy pigs results in substantial risks of boar taint, less fat and lower fat quality. For these reasons this practice is not practical in situations in which meat quality is a fundamental issue.
- With the information that was available for this study, it can be stated that the use of entire males is problematic in a large majority of systems using heavy pigs.

7. Appendixes

7.1. Additional tables from the questionnaire survey

Appendix 1.1

Overview on answers about how surgical castration is performed in the different countries.

Countries	Not castrating	Without anaesthesia or analgesia	With general anaesthesia	With local anaesthesia	Analgesia given before castration	Analgesia given after castration
Austria		1			3	
Belgium		1			6	6
Bulgaria	1	9	1			
Denmark					2	
Finland			1			
France		4		2	9	4
Germany		3	5	1	2	1
Hungary	1	41	5 (6)*	17 (16)*	5	8
Italy		5		1	2	
Croatia		8	6 (7)*	4 (3)*	5	3
Luxembourg		1				
Malta		1				
Netherlands		1				
Norway				5		
Poland	1	4				
Portugal		4	1	1		
Slovenia	1	8	1	1		2
Spain	1	14		1	2	1
Sweden		1		5		1
United Kingdom	3					
Total	8		20 (22)*	38 (36)*	36	26

* Corrected numbers since subcutaneous injection reported as a route of administration for general anaesthesia obviously was meant to be related to local anaesthesia.

Appendix 1.2

Distribution of answers for those who reported the use of local anaesthesia.

Countries	N	Analgesia				Route of administration	Who performs the anaesthesia	Use of AB
		Before castration	After castration	No	NA			Yes/No/NA
France	2	1		1		1 im/1 NA	Farmer**	0/1/1
Germany	1	1				1 NA	Veterinarian	0/1/0

Hungary	17	11	1	1	4	4 sc/ 3 im/ 2 it/ 2 other/ 6 NA	Farmer 2/ Veterinarian 11	5/10/2
Italy	1	1				1 im	Veterinarian	1/0/0
Croatia	4	2		1	1	2 im/ 1 sc/ 1 it	Veterinarian	3/0/1
Norway	5	3			2	2 it/sc/ 1 it/ 1 other/1 NA	Veterinarian	0/4/1
Portugal	1		1			1 NA	Other (not specified)	1/0/0
Slovenia	1				1	1 NA		0/0/1
Spain	1	1				1 im	Farmer (trained)	1/0/0
Sweden	5	1	4			1 it/sc/ 4 it	Farmer (trained)	0/5/0
Total	38	21	6	3	8			11/21/6

im= intramuscular, sc= subcutaneous, it=intratesticular, NA= not available
Farmer= farmer, producer or employee at the farm

Appendix 1.3

Comments on the reasons for castrating males (from questionnaire).

Items	Comments
Practical, effectively feasible	• if castration happens during first days • According to farmer, it would be necessary to train them more • Only under anaesthesia (injection/inhalation anaesthesia) • There is no other true alternative • No one buys it • Very wide time frame for slaughter, very hard to plan chemical castration according to this • Easy of outdoor management practices • Farmer can do castration on its own • Surgical castration is the simplest procedure
Specifications cannot be changed	• Regulations could always be changed • According to requirements • uncastrated pigs cannot be used for raw-dried meat products • Label Rouge specifications • Are castrated when arriving the farm • Entire males are not accepted by market • there should be no sensory defects in the product (i.e. boar taint)
Tradition	• It is part of our culture that we eat meat that is not tainted • Iberian
Management, Animals are quieter	• Sometimes fattening is performed to relatively high weights, up to 300 kg
Management, Animals less aggressive	• No need for separate housing • Many rearing facilities are small (only one pen), therefore it is difficult to prevent pregnancies in sows
Management, Prevent mounting	• No comments
Management , Prevent penis biting	• Our high end weights of boars would not allow this • Pregnancy of sows • No stress before slaughter • Separating according to sex • Handling with EM is more dangerous • Group housing in small herds (many farmers have <5 animals and only one pen) • They do not bite and make pain • Higher replacement • By batches of different ages
Management, other	• No reliable method to detect boar taint

Items	Comments
	• predominately rules through marketing • Fattening pigs sold to individuals. No one would buy fattening pigs with testicles! • no boar taint
Improved meat quality, prevent boar taint	• Problems are more related to drip loss • important for processing into meat products, salt uptake, product quality • Fattening can also be get using genetic
Improved meat quality, more fat	• Intramuscular fat is flavour carrier • Fat quality parameters of entire males are different • Improved meat quality is obtained in this breed by increasing unsaturation through acorn finish feeding • higher meat quality is important for processing into meat products • it can also be get using genetics
Improved meat quality, More saturated fat	• Boars must be slaughtered at young age > bad meat quality • Greater meat cuts as from young boars • Less drip/cooking losses, not PSE meat and tastier meat • No PSE meat • Better adaptation regarding slower growth • Meat quality is the main objective of our production • Avoid too quick growth in order to get a more mature meat • Fat quality parameters of entire males are different • End products has less moisture. • Known dynamics of salting/water or weight loss, good control over the process • Improves the intramuscular fat/marbling • It is get using genetics • Higher intramuscular fat/marbling of the meat
Other	• Boars in organic farming are not adequately to be fed - lack in protein amino acids forbidden. Many small farmers. • Killing less animals for the same amount of meat • Old age at slaughter • Ham not suitable for processing • The scrotal skin comes loose from the leg • Production cost • consumer acceptance • it is a traditional way of fattening, any kind of change may cause cessation of production especially in small self-sufficient farms • surgical castration can be performed by the breeder himself, while immunocastration requires a veterinarian attendance • castration is needed to preserve the quality of "Kraški Pršut" • Boar purchased from parent stock

Appendix 1.4

Comments on some of the drawbacks for surgical castration (from questionnaire)

Drawnbacks	Comments
Workload	• Should be carried out professionally
Risk or consequences for animal welfare/animal health	• Animal welfare • Errors / unsuccessful surgical procedure • Perception of castration by NGOs defending animal rights

Risks or consequences for marketing and economy	• Boar taint • Consumer perception • image in the media • more expensive
Risks or consequences for carcass and/or meat quality	• Fatter carcass

Appendix 1.5

Comments from answers stating they can envisage immunocastration (from questionnaire)

Items	Comments if yes
Benefits for farmer	• Save time and easier operation • Avoid surgical castration • reduced stress (castration as a psychological stressor) • meat quality • we do not cause pain, the development of the animal is uninterrupted • It is practical
Benefits for animals (welfare)	• Improvement of welfare • Welfare, less risks (infections…) • no painful intervention, stress of injection is significantly less stressful • Stress free • gentle • risk and pain free • Less stress • better welfare, less skin lesions than boars • Lack of problems post vaccination • Animal welfare • We suppose that yes • Reduced riding behaviour and aggression • Less pain than is caused by surgical castration. The use of Improvac reduces the risk of any gilts being pregnant when slaughtered. Some concerns have been raised within the industry that in-pig gilts
Benefits for products	• better meat and lard quality • no boar taint, castrate-like • to keep the same quality as surgical castration • Boar taint
Other benefits	• Meet the demands of a market segment • easier handling
Do you nevertheless expect drawbacks	• Societal acceptance of chemical castration • Calm handling of pigs, > no problems with injections • expensive • side effects • The main risk is the unacceptability by some segment of the market and the potential persistence of boar taint • Concern of consumers • consumer opinion • raw material characteristics are not known, difficult to adapt the processing conditions • Immunocastration has higher costs than surgical castration • Is not effective 100% and it is difficult to apply • Effectivity • The customers do not accept it, plus the slaughter personnel • public perceptions of its use, potential cost, reliance on Improvac to reduce welfare issues instead of improving management • In the UK surgical castration is rare and if we do not need it then maybe this method shouldn't be encouraged. Despite there being a zero day

	withdrawal period for the product, there are concerns with

Appendix **1.6**

Comments from answers stating they cannot envisage immunocastration (from questionnaire).

Variable	Comments
Not practical, not effectively feasible	• Specifically small farms would have problems • Would need to vaccinate probably 3 times in organic production • Free range pigs on pasture • Slaughter age • We did not hear about that, but certainly not economical, therefore we will not do it. • Wide range of slaughtering. Have to be between 100-120 kg slaughter weight. Interval of 8 weeks from start slaughtering until finished slaughtering • procedure requires a veterinary service and additional expense • procedure difficult for smaller farms (3-10 pigs), procedure requires a veterinary service and additional expense • 3 or 4 vaccines are necessary to be effective
Not consistent with specifications	• Does not fit to organic farming • Label Rouge specifications • not relevant/no specifications • castrates prescribed in the specifications (in the process of approval by the state authorities)
Could hamper the image	• no medication • traditionally, pigs are fattened to higher weights, then often sold to the final buyer, who slaughters and processes the pig • fear of consumers
Animal welfare/health consequences or risks	• stress, abscesses • Aggression between entire males • Stress due to repeated treatment on adult animals on pasture
Handling/management of the animals	• stress and death risk • Outdoor extensive • Outdoor • Assessment of stinkers • complicated • The entire males are less calm • Extreme difficulty in repeated handling of entire males on pasture • difficult to perform it by the farmer himself • yes, at vaccination
Occupational safety and health consequences or risks	• How should we vaccinate 40 pigs with 100kg in one box?? • Forbidden for pregnant women and for people who accidently shot themselves previously • utilisation of the hormone • catch animals + hormonal product • risk for stockman/farmer • can inject himself or workmate • High probability of injury to handling operations for heavy pigs • Are highly probable accidents for interventions on heavy pigs • Extreme difficulty in repeated handling of entire males on pasture • Yes, at vaccination • dangerous to treat heavier boars, danger of autovaccination
Food safety and environmental consequences or risks	• When humans consume meat that comes from shrinked testes, who guarantees for long term consequences for humans? • Residues in meat

Variable	Comments
	• not compatible • unknown long-term outcome • risky for health-hormones
Marketing and economic consequences or risks	• end of product specificity • not consistent relatively to traditional product • degraded image • not consistent with tradition • Low acceptability / will not be accepted • Low acceptability by the consumer for the increased use of not natural pharmaceutical and veterinary products • additional burden for small farmers with pig breeding as only additional activity • entire breed existence may be put on risk • unacceptance by the market
Meat quality	• It still remains a boar, protein supplementation is problematic in organic farming • residues • abscesses on the carcass and meat that is less mature, therefore less tasty • Slaughter age • efficacy relatively to high age at slaughter • when mistreated boar taint and taste remains • The ham could have low fat cover • Ham quality • consumer opinion • difficulties to sell specific carcass parts • quality reduction: low fat, boar taint
Cost	• labs • The veterinarian interventions on heavy pigs are expensive • The expected 3 interventions for heavy pigs are expensive both for the purchase of the product and more work • additional expense and workload (small farmers would perform it only on one animal at once) • higher expenses - vaccine, veterinarian • additional workload
Other	• no medication in our farms unless there is some disease • Organic specifications • we tried already, extremely complicated • if someone using the common sense, no doubt that surgical castration is the best solution. • Ham is not good for products • Because the pig is slaughtered more than 270 days should repeat this action more times • The product could be unacceptable by consumers for cultural reasons • consumer response • public opinion • many breeders have small stables, or free-range rearing, animals are not separated according to categories • dependent on the vaccine producer • dependent on the vaccine producer • do not know the procedure/consequences • minimum of 3 vaccines are needed, we cannot reach the intramuscular levels needed that are reached with surgical castrated and the testis are not sufficiently reduced (25% of the cases) and some carcasses • not enough intramuscular fat • difficulty in lots of different ages and difficulty in extensive rearing conditions

Appendix **1.7**

Comments on the reasons for using immunocastration (from questionnaire).

Immunocastration is	Comments
Practical, effectively feasible	• More complicated • labour intensive • extra work • easy to do
Improved animal welfare/ health	• less inflammations • no surgery needed for the small animals • requested by retailers
Facilitates handling/management of the animals	• More moving/mixing • Single sex rearing
Improves carcass and/or meat quality	• Higher lean meat (similar to boars) • Risk of boar taint • Requested by retailer
Reduces feed consumption and increases growth	• Feed consumption is better, but higher cost on the farm • When compared to barrows
Other remarks	• More boars to choose from for breeding (Norsvin boartest) (breeding company) • Save labour

Appendix 1.8

Comments on the reasons why respondents can envisage entire male pig production (from questionnaire).

Items	**Comments if yes**
Expected benefits for the farmer	• Better performances: FCR, higher proportion of lean meat • Work organisation, working time • abolition of an unpleasant task, no (psychological) stress through castration • Save time
Expected benefits for the animals (welfare)	• Welfare, reduction of health risks and stress • no painful surgical intervention and no stress through immunisation • no additional drugs • Natural mating
Expected benefits for the products	• lean meat, less fat • Better processing yield • Breed dependent
Other expected benefits	• Image • Export
Do you nevertheless expect drawbacks	• Boar taint, unclear proportion of animals with boar taint • Aggression, unrest, increased mortality, lameness due to mounting (puberty) • Decreased meat quality, product quality • necessary to have an accurate and reliable method to detect tainted carcasses • difficulties in animal management • not every farm is suited for that, different requirements for management/housing of boars - if fulfilled, no problem • disfavoured by other parts of the value chain • Boar taint in animals heavier than 115 kg

Items	Comments if yes
	• Problem of limitation of weight of males • Leaner animals

Appendix 1.9

Comments on the reasons why respondents cannot envisage entire male pig production (from questionnaire).

Variable	Comments
Not practical, not effectively feasible	• small mixed group in one building • same as question 28 • piglets from bigger farms • due to small facilities, it is difficult to separately rear boars and gilts, while heavy pigs are often reared • most of the traditional fattening is performed over 150 kg, when the boars are sexually mature and have boar taint • not relevant in our case • more rustic males and with very high sexual necessities
Not consistent with specifications	• the odour of meat • some customers do not want it • technology on the farm • does not exist • not in the specifications • need meat free of boar taint
Could hamper the image	• odour risk • The odour may put into a difficult position regarding the consumer • Taste • consumer opinion • boar taint • boar taint can compromise product reputation • consumers reject boar tainted products • boar taint and lower quality
Animal welfare/health consequences or risks	• Penis biting must be hell for the farmer! • Decreased welfare, too much stress in fighting, lesions and higher mortality • fight between animals • Aggressiveness for animals • Significant increase of conflicts • Aggression-leg injuries • More fighting • aggression • lesions inflicted to animals • unwanted matings • not relevant • management
Handling/management of the animals	• impossible to divide males and females at pasture • Must mix pigs more than we do today • in heavier boars it may cause lesions • not relevant • do not know the procedure/consequences • male and female together
Occupational safety and health consequences or risks	• Older animals more aggressive • Aggressiveness of heavy pigs >100kg, and we slaughter at >160 kg • difficult to handle heavier boars • not relevant • do not know the procedure/consequences

Variable	Comments
Marketing and economic consequences or risks	• outdoor at more than 182 days • boar taint • not relevant • do not know the procedure/consequences
Food safety and environmental consequences or risks	• Gilt meat will have to be sold at a higher price to compensate for boar meat that cannot be sold • Odour risk • Not compatible with specifications • Heavy weight pig production is impossible! • Downgrade / product depreciated • no value, low price • any additional requirements in regard to pig rearing may make the economic situation of the many farms so difficult that they abandon pig production • boar taint - low price • boar taint, loss of the market • disfavoured by consumers
Meat quality	• Boar taint • PSE meat, smelly and dry at cooking • it's getting worse • taste and odour + meat too lean • not suitable meat • boar taint • characteristic boar taint • Boar taint • meat of heavy boars cannot be used • inferior meat quality • inferior meat quality = boar taint • boar taint and lower quality
Cost	• Boar meat has a lower value, which has a direct consequence on the price of the batch • important devalorisation of entire male • the cost of a pig of 165 kg discarded • need to create spaces and separate pastures • better housing and equipment • higher losses • Not acceptable product
Other	• unsuitable meat • putting on risk the existence of the Krškopolje breed as additional expenses, low sell… can reduce the profitability • batches of animals of different sexes and ages

7.2. Summaries of information by countries

Summary of the national situations related to the anaesthesia and analgesia practices on male pig castration and alternatives to surgical castration for heavy pigs used in traditional products. Information adapted to summaries provided by National Contact Points for the different countries.

AUSTRIA

In Austria using prolonged analgesia is compulsory by law.

BELGIUM

Transition to the production of immunocastrated male pigs and entire male pigs was stimulated by the request of national retailers in 2011. Several farmers shifted to the production of entire male pigs or immunocastrated male pigs for the standard production systems. Further transition is currently not possible due to the lack of market acceptance as a high proportion of pig carcasses are exported. Currently, the number of immuncoastrated male pigs is higher than the number of entire male pigs, mainly due to the better carcass and meat quality characteristics of these animals and the elimination of boar taint. It is estimated that 6% of the male pigs are produced as immunocastrates and 4% as entire male pigs, but no official numbers are available. The use of analgetics (melovem, metacam) is mandatory for the most relevant assurance programme.

BULGARIA

Growing fattening pigs in large pig farms in Bulgaria are all male surgically castrated. The most common category of fattened pigs is up to 100-120 kg. Castration in applied the first two weeks after piglets are born, and it is usually without any applied analgesia or anesthesia, and without antibiotics. The number of home growing pigs (domestic pigs reared in family farms) are about 25-30% of all fattened pigs in Bulgaria. They are intended only for consumption in the households. Live weight of home growing pigs is between 130 and 150 kg. Owners in the home growing systems want all pigs to be surgically castrated (both males and females) and castration is done by veterinarians at pig weight about 40 to 60 kg. Analgesia or anesthesia is used in castration of pigs weighing 40-60 kg. Common preparations: Ketamine. Usual choice of antibiotic is amoxicillin, tetracycline. Antibiotic are used is in post-operative complications only. Alternative methods of castration in Bulgaria are not popular. Immunocastration is not in use in Bulgaria and only grey literature information is available on Bulgarian language (just one publication). A few uncastrated pig batches were grown (in the last 5 years) (a few producers), but the boar taint in the carcasses at slaughterhouse is much more than in castrated pigs from the same farm. Smell is well detectable in 4 up to 12% of pig carcasses, and is intensive in 0.13 up to 4.7%. Studies to evaluate the effect of immunocastration are planned for the 2017-2018.

Bulgaria has over 30 traditional meat products produced by a technology of raw dried meat products, some of them without spices. Individual products such as Sudzhuk, Lukanka, Slanina are quite commonly used by consumers, and production is from meat originated from castrated pigs. Meat from castrated pigs is written down in specification of: Lukanka Chumerna; Lucanka Smyadovska; Lukanka Trapezitsa; but po Elenski; file Arabanasi; Lukanka Pleven; Lukanka Shopska; salam Medven; salam Ambaritsa; salam Deboya; salam Diavena. Homemade meat products (lukanka, sudzhuk, file Elena, slanina) from domestic rearing pigs of a live weight of more than 130 kg are also only from castrated pigs. If there is a boar taint in the meat, consumers consider that the meat (pig carcasses) was not undergone veterinary meat inspection or is from diseased animals. Meat with boar taint will not be included in the production of traditional raw-dried meat products.

CROATIA

In Croatia, all male pigs that are not aimed for reproduction but for fattening are surgically castrated at young age (1st or 2nd week of life; in Crna slavonska breed up to 4th week) without the use of anaesthesia or analgesia. Right after the procedure has ended, antimicrobial powder or spray is applied on the wound. The most used agents for such purpose are Bivacyn (combination of neomycin and bacitracin) and Geokorton (combination of oxytetracycline and hydrocortisone). From the year 2006, the national regulations require the use of anesthesia/analgesia in case when the piglets are castrated at the age higher than 1 week.

The boars used for the reproduction purposes are usually slaughtered after the culling. Prior to slaughter these boars are surgically castrated with the obligatory use of anaesthesia/analgesia (ketamine hydrochloride, xylazine chloride, detomindine chloride, etc.).

The traditional pork products originate from female (gilts and sows) and castrated male pigs as there are no traditional procedure in pork processing that is based on entire male pigs. In fact, physiological status of the pigs is mentioned only in the specification of the two PDO (Istarski pršut and Meat of Crna slavonska pig) and one PGI (Slavonski kulen) pork products. The immunocastration has never been evaluated officially in Croatia.

DENMARK

The production of entire male pigs is approximately 5 % of the whole male pig population. Most of the male piglets are castrated using prolonged analgesia which is compulsory by law. The Danish industry does worry about acceptance of meat from entire male pigs especially outside the EU. The same is applied for the immunocastrated pigmeat. Immunocastration is not considered a solution. Some Danish pork products have a national (but not a European) labelling based on specifications deviating from conventional productions described in documents usually written in the national language. These products use different breeds, feed sources, access to out-door etc., all factors leading to a lower growth potential, higher age at slaughter and thereby a higher risk of boar taint. Today, meat from entire males are not used for these pork products. The expectation for the future is that the number of specific products is increasing and therefore, a higher amount of meat from entire males becomes even more difficult.

FINLAND

Piglets are surgically castrated "traditionally" but they get pain killers. The use of analgesics is not mandatory, so not in legislation but at least one of the large slaughterhouses demand it. Anesthesia is not used.

FRANCE

In France, most males are surgically castrated. However, Cooperl, the largest pig production chain in France, started producing entire males from 2012. Entire male pig production from other chains is marginal. Overall 2.5 million entire males are currently produced per year, representing 20% of the males produced in France. Production of immunocastrated males is extremely marginal (12 000 per year in North East France).

Surgical castration is performed within the first week of age. Most French pig producers take part into a national quality assurance scheme called QT (quality, traceability). These farmers have been using analgesia before castration since 2012, using meloxicam. There is no use of antibiotics at castration.

All of the 52 situations that have been considered in the present study (21 PGI, 7 PDO, 17 quality oriented, 5 organic and 2 others) have been evaluated as problematic regarding the use of entire males:

- 17 of them because castration of males is compulsory in specifications;
- All of them because sexual mature animals (heavy weight, old age at slaughter, for instance in local breeds) would result in increased incidence of boar taint and serious management issues;
- 36 of them because of enhanced sensitivity of product to boar taint perception by consumers;
- 14 of them because of meat quality issues regarding fat quantity and quality (dry-cured products).

Immunocastration has been tried in France for standard production. In most cases, the trial has not be followed by regular use of immunocastration (see above). Immunocastration has been tried on heavy pigs for Italian market but this market has stopped and no heavy pigs are currently immunocastrated in France.

GERMANY

About 90% of all male piglets are currently surgically castrated of which the majority is treated by farmers with pre-emptive analgesia using meloxicam, flunixin or metamizol. Disinfectants but not antibiotics are used for wound treatment following surgical castration. The use of analgetics is mandatory since 2009 for most of the producers within the quality assurance programme (QS) where > 90% of all farmers are members in. National animal welfare legislation (2013) demands for additional anaesthesia from the beginning of 2019 on. It is predicted that by that time 30 % to 50 % of male piglets will be raised as entire males. The proportion of entire males currently slaughtered is about 8% to 9% of all males. There is currently no anaesthetic treatment licensed for the use of castration unless it is used as an exemption to be strictly applied only by a veterinarian. Isoflurane anaesthesia is used in that way on a very small scale in one welfare label programme (Neuland). Other alternatives are currently not used. Although licensed, immunocastration is mainly restricted to be used for experimental purposes and marketing tests. Currently the major slaughterhouses/processors do not take imunnocastrated pigs. It is not clear yet whether this will be an option for the time period after 2018. Veterinary association so far clearly stated that anaesthesia will only be allowed to be conducted by a veterinarian.

Pigs are currently slaughtered in Germany with an average live weight of about 120 kg with a range in slaughter weight between 90 to 102 kg. The production of traditional products

that require very heavy pigs is limited in Germany. The production of entire males is currently (in relation to the existing proportion) not seen as a risk for marketing and processing meat.

HUNGARY

Hungary produced 1,409,000 tons of meat in 2014, and 557,000 tons was from pigs. The number of pigs in Hungary is about 3.0 million (2016, June), while the number of sows is 183,000. Pork consumption is about 25 kg/capita. Based on the latest data (2016, first half year), pigs are slaughtered on average at 115.7 kg live weight. There were more than 9,000 sows and 33,000 fatteners (pure and crossed) of Mangalica breed in 2014. Mangalica pigs are slaughtered between 140-170 kg live weight and at 12-17 month of age. About one third of the population is kept in outdoor systems. The importance of traditional home slaughter is decreasing, but still significant in rural areas. About 778 000 pigs are kept in small scale farms (2016 June). About 5 % out of that number is slaughtered on the traditional way. These pigs are usually slaughtered between 150-200 kg live weight. When piglets are purchased buyers prefer castrates over gilts (problems with gilts due to oestrus i.e. low appetite). The number of pigs registered in organic farms was about 4 000 in 2014. Short chain marketing channels are not yet quite developed, however there are good examples of small scale meat processors and farmers supplying local markets. They do prefer heavier and older pigs of which has more mature meat, therefore more suitable for processing. The brand of Mangalica products is protected by the breeding association. They issue fattening pigs certificate for slaughter, in order to prove the genuine origin of meat. There is an initiative of national protection brand KMS (Excellent Quality Pork) which requires that pigs are fattened in Hungary with EU approved feed components, diet must be cereal based, at least 30% GMO free corn, non-plant origin by-products is maximum 5%, and no food industry by-products and animal protein sources allowed. Carcass weight must be at least 80 kg (i.e. 100 kg live weight). The brand is part of the Hungarian Pig Development Strategy (rise the currently 3 million live pigs to 6). This brand refers to fresh meat and products as well.

The piglets are surgically castrated within the first week (mainly at 3-5 days of age) mostly without anaesthesia/analgesia at the time of iron injection. The process carried out by veterinarians, vet assistants or trained farm personnel. Equipment's are hold in disinfectant liquid, while the skin also disinfected and some cases the wound also treated by covering spray. Antibiotics are not used routinely as at that age the colostrum provided Ig protection still works. Some producers tested the immunocastration. Their experiences and opinions can be summarized as follows: there was interruptions in vaccine supply, much more expensive than surgical castration, pose higher health and accident risk to farm workers and consumers, the efficiency is about 90 % of which causing economic loss, production profitability is not improved in case of immunocastration, the two-times injection is considered a high stress for the animals.

ITALY

<u>Male pig castration practices</u>

Currently, trained personnel castrate male piglets under 7 days of age with no tissue tearing. In general, Iodine disinfectants are applied and veterinarians prescribe antibiotics only in case of complications.

Recently, some production chains interested in exporting pig meat products has required farmers to use analgesia and/or local anesthesia. Currently, about 5 % of pig farms use analgesia by injection (NSAID such as meloxicam or sodic diclofenac) even if the latter requires cautions because it is dangerous to wildlife. Injectable procaine or lidocaine are used for local anesthesia in about 1 % of the Italian pig farms.

The use of both analgesia and anesthesia is becoming more common. However, farmers say that local anesthesia makes piglets stiffy in their movements and requires the farmer to move them away from the sow until they completely recover in order to avoid crushing.

Even if a debate is ongoing, it should be currently legal for Italian farmers to perform local anesthesia.

Pork productions

In 2015, 11.304.236 pigs were slaughtered, with an average live weight of 164 kg and a dressing up percentage of 80.5. Nearly all pigs were raised to heavy weights for typical productions, with the exception of very few pig farm in the southern regions of Puglia and Sicily and some traditional consumption of weaning piglets in Sardinia. Most pigs are grown in intensive farming systems, at a very competitive technological level.

In Italy there are 22 PDO, 19 PGI products and about 400 traditional products (https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/3276). With the exception of "Porchetta di Ariccia" PGI and few others, all of the products above come from cuts of heavy pig carcasses. Among PDO and PGI pig products, 34 explicitly requires a slaughter weight above 144 kg at a minimum age of 9 months.

The production of entire male pigs is not considered possible because of the strong boar taint impossible to mask by the use of spices. This is especially true for the 15 PDO and PGI hams produced by adding salt only.

Pig farmers do not use entire males because of the high weight and age at slaughter: in Italy, carcasses with boar taint are considered unfitted for human consumption and destroyed.

Moreover, the use of whole or immunocastrated pigs do not allow for the achievement of qualitative parameters specified in the product specification for PDO and PGI, particularly with regard to fat thickness and composition, and to water holding capacity, important quality parameters for the production of high quality cured products.

NORWAY

In Norway, all male pigs have been surgical castrated for many years. Since 2002, anaesthesia performed by a veterinarian has been mandatory at castration, and long acting analgetics should also be used. The most commonly used method for anaesthesia is local anaesthesia with a combination of subcutaneous and intratesticular injection in combination with NSAIDs given as intramuscular injection. Antibiotic treatment is not used at castration.

The last years immunocastration has also been an option, and the percentage of immunocastrated pigs has increased to 5 % of the male pigs in 2015. It has been a goal to increase this share. Samples from 1 % of the carcasses are analysed for androstenone, and there has been a problem with high levels of androstenone in some of these samples. There is no production of entire males in Norway.

The production of traditional products is very limited in Norway, but there are some niche products as well as one commercial product of cured ham from heavy pigs (Santa Kristina).

POLAND

Piglet castration is a very common practice used in Poland. Almost 100% of male pigs are castrated surgically. The procedure was introduced because meat of uncastrated male pigs is smelly. Surgical castration of male pigs can be done up to the 7th days of the piglets' age by a trained farm worker. Beginning from the 7th days of piglets' age this can be done only by a vet or a vet technician using analgesia and anesthesia. In practice analgesia and anesthesia are not used because in Poland as there is no medication registered for piglets nor for fatteners anesthesia. The only substance registered and allowed to be used on pigs is Stresnil of neuroleptic activity and of 7 days waiting period. The vaccination against boar taint is available in Poland but is regarded as a very expensive alternative comparing to surgical castration and is also controversial from the Polish slaughterhouses point of view. According to the Ministry of Agriculture regulation on the testing methods of slaughter animals and meat as well as the meat of game animals, the annex 6 point 13 says that the meat giving the sexual, urine, fish oil or other smell caused by the medication or disinfectants is regarded as unfit for human consumption. The same annex point 6 says that the meat originated from entire males, hermaphrodites, rigs and late castrates is classified as the meat that is fit for human consumption under special conditions. Such meat should be treated before processed in the meat processing plants. The meat should be treated in the separated chilling area in the temperature 0-2°C. It is a common practice though, which is the meat plants' internal procedure, used in the slaughterhouses in Poland to eliminate carcasses with testicles found on the slaughter line. So in practice such meat is regarded as unfit for human consumption. The price for entire boars offered by Polish slaughterhouses is usually much lower, almost half the price of gilts or castrates.

It should be stressed that the average carcass weight in Poland have been increasing systematically from 87.5 kg in 2011 up to 92.5 kg in 2015 and possibly 93.5 kg in 2016 (prediction). So the pigs slaughtered in Poland are heavier and older year to year and the risk of smelly meat from older and heavier pigs is obviously higher.

According to the official statistical data published in June 2016 there are 10.2 million of pigs in Poland. The yearly drop down in pigs' number was 12% comparing to 2015. Number of sows is 0.8 million.

PORTUGAL

In Portugal, all fattening males are surgically castrated, and usually without the use of general anesthesia. In the few identified situations castration is performed under general anesthesia (less than 5%), azaperone is the anesthetic of choice. Similarly, analgesia and antibiotic therapy are not a routine practice. When analgesia is used, it is administered either before or after castration. The most used antibiotic is penicillin.

PDO and PGI products using meat of heavy pig breeds (Alentejano and Bísaro) require the use of castrated males. Not only because in some cases it is required by the specifications, as well as entire male products are not accepted by market. The non-acceptance results from

the high weight (higher than 130 kg live) and high age (over 12 month) at slaughter, leading to boar taint if animals are not castrated. Castration is also required when rearing outdoors without sex separation, which is laid down in the specifications of most of PDO and PGI products using meat of Alentejano and Bísaro breeds. Immunocastration has not been evaluated.

SLOVENIA

Castration practice

In Slovenia *apriori* all male piglets intended for fattening are surgically castrated within 7 days after birth (only in rare cases and very seasonally piglets are not castrated and used for roasting during summer). When castrating, anaesthesia/analgesia is not used in most cases and piglets are castrated without any additional antibiotic treatment, especially when performed by farmers. Only some larger pig breeding facilities with their own veterinary service use pain reliefs (ketamin, lidocain, meloxican, flunixine), but with no supplementary antibiotic treatment. Antibiotic treatment is used only in case of post-operative infections. Immunocastration is not used.

Problematic situations

Slovenian pig sector is specific. The market of fresh meat is mainly covered by organised pig sector (integrated economic entities) with competitive technological level. On the other hand, domestic pig rearing (family farms) preserves a particular character of traditional way of farming and is associated strongly with production of traditional pork products. Despite its low efficiency, it represents an important factor for pork (products) supply. Pig fattening allows many family farms to round up the production and generate additional income. These situations are not covered by specific quality schemes and concern family farms not integrated in any system. These situations are characterised by more extensive production systems, slaughter at higher age and weight and selling their products in short supply chains. Besides selling pigs to local abattoirs (butchers/meat processors) they often practice home processing for direct sale of products to consumers, or for family consumption. Many of these farms are touristic and/or ecological farms and farms with pork products fabrication as supplementary activity on the farm. This is also the situation with local pig breed (Krskopolje pig). Krskopolje pigs are fattened more extensively, their growth rate is lower and they are older and heavier at slaughter. Their products are sold in short chain circuits (on farm sale, local butchers, tourist farms, hotels, restaurants).

There are 8 traditional products protected at EU level as PGI. The specifications for these products concerning the raw material (provenience of pigs, breed, weight and age at slaughter) are vague. For some products (e.g. Kraški pršut, Prekmurska šunka) the specification mentions that weight of pigs is expected to be greater than 110 kg or that meat must be from gilts and castrates (e.g. Prleška tunka). But it is not included in the certification denoting no control over the weight, age, breed or sex of pigs. With respect to boar taint issue it is worth noting that for all products the specification demands typical sensory quality and the absence of off-flavours, which is regularly checked within certification, and this indirectly implies to the problem of boar taint.

Regarding other quality schemes, besides EU brands, the law on agriculture foresees a scheme denominated "selected quality", and a scheme "delicacies of our farms" (this last one is likely to be removed from the legislation because a similar trademark exists i.e. "delicacies of Slovenian farms"). The "selected quality" scheme foresees the certification and is presently

in preparation for pork and pork products by stakeholders, whereas the second (trademark "delicacies of Slovenian farms") is already well implemented and coordinated by the Chamber of agriculture. The collective trademark for products of local pig breed is also in registration process.

SPAIN

In Spain, males can be surgically castrated and entire. There is also a small production of immunocastrated. Usually no anaesthesia/analgesia is being used in the surgically castration of the pigs. However sometimes some analgesia like flunixine and antibiotics like oxitetracicline can be applied.

In Spain there are several traditional products, some of them PDO, IGP or TSG that require (although is not always written in the specifications) meat from castrated pigs. In some products, like those from Iberian breeds, this is due to the fact that animals are reared mainly extensively and until heavy weights (higher than 130 kg live weight) and castration is necessary mainly for management and handling of the animals, for tradition, to prevent mounting and penis biting and for the quality of the final product in terms of amount of fat, intramuscular fat and meat free of boar taint. Dry cured ham is one of the most important products, and for its production it is necessary a certain amount (and quality) of fat and also, for a high-quality product it is important to have lack of off odours. In fact, one of the most important complains in the use of immunocastration is that these pigs sometimes could not reach the necessary levels of intramuscular fat and fat according to the requirements of the producers. Regarding boar taint, some of the products are problematic since they have an important amount of fat, they come from heavy pigs, they are consumed fresh or cured and with few spices. The requirement of castration of pigs is not only for heavy pigs. White commercial pigs used to produce certain traditional products of quality are also required to be castrated.

SWEDEN

Until 1th January 2016, male piglets intended for meat production were castrated without anaesthesia if castration was performed before the animal reached the age of seven days. Castration of piglets older than seven days of age should be performed by veterinarians and under anesthesia.

From 1th of January 2016 is it not allowed to physically castrate male piglets without anaesthesia. This means that in practice producers in Sweden have three options:

• Physical castration with anaesthesia

• Vaccination with Improvac to produce a temporary immunological suppression of testicular function and minimize risk of boar taint

• Raise entire (uncastrated) male pigs

Producers, who are going to use anesthesia before physical castration, must first undergo special education (obligatory course/training) as it is very important that the

anesthetics are given properly. The injection of local anaesthetic Lidocaine into the testicle is preferred anaesthetic method in Sweden.

A small proportion of the male piglets in Sweden are immunocastrated with help of vaccine Improvac. Many pig producers in Sweden are still skeptical to the use of the vaccine. There is still a fear of vaccination and it is generally believed that the production system is already adapted for regular physical castration today and benefits of vaccination do not prevail over traditions, according to some pig producers in Sweden. Another concern is that countries which today buy some pig parts from Sweden (for example China) would not like to buy meat from vaccinated pigs, which would mean economic losses.

A traditional popular sausage in Sweden, Falukorv, which has TSG status, is made of several ingredients including pork, but also beef or veal with potato starch flour, onion, salt and mild spices. There is no study showing that meat for Falukorv production must be originated from castrated pigs. Effect of meat from immunocastrated animals on Falukorv quality was not either evaluation.

SWITZERLAND

In Switzerland in general all male piglets intended for fattening are surgically castrated. Only a few farms with direct sales do not castrate and keep entire males. There is a very small production of immunocastrated pigs. Anaesthesia and analgesia is mandatory for the surgical castration of the pigs. Anaesthesia is undertaken with isoflurane if it is done by inhalation (2/3 of all piglets) and the analgesia is made with meloxicam. The farmer is allowed to do the anaesthesia with isoflurane and the castration by himself, after successful participation of a course. On some farms, the smaller ones, the veterinarian will use narcotize with ketamine and azaperon together with meloxicam as an analgesia. Antibiotic treatment is used only in case of post-operative infections.

In Switzerland there are no pig products produced from heavy pigs. Fatteners are slaughtered at about 105 kg live weight.

Immunocastration was tested on several farms. Due to the fact, that slaughterhouses charge an extra fee for the immunocastrated pigs for checking the testes and for a possible subsequent boar taint test the immunocastration method still has very limited adoption.

In Switzerland there is little discussion about fattening boars. The retailers are too afraid of receiving meat with boar taint. There are several projects about processing meat with boar taint. Pig producers have to pay special fees for testing the boar taint in the slaughterhouses and they will not get any payment for the carcass, if boar taint is detected. Boar taint would be a problem in fresh meat when cooked and in processed products when heated.

The castration is accepted by producers and retailers because of the mandatory anaesthesia. The consumers do not care about castration.

UNITED KINGDOM

Unlike many parts of Europe, castration is very rare in the UK.

Boar taint is not considered to be a significant issue in UK pigs as they are traditionally sold at lighter weights than most EU member states.

In the UK more than 90% of pigs are in the national high welfare scheme (Assured Food Standards Red Tractor) which prohibits castration (including immunocastration).

Other welfare-oriented schemes (such as that provided by the Royal Society for the Protection of Animals) also forbid castration and immunocastration.

The view on castration from the national pig organisations is that farms which castrate should be encouraged to trial the different options in order to make a well-considered choice for the best practical and profitable alternative for the individual farm, whilst maximising on-farm pig welfare. At the same time, it is imperative that any action is acceptable to the commercial market. National statistics are not recorded on the number of castrated males but most commentators suggest that it is less than 1% of the national kill.

However, views were sought from the industry for the CASTRUM project and the best estimate is that out of an annual kill of some 10.6 million pigs, only 8,000 to 16,000 pigs are castrated (0.075 to 0.150%).

Virtually all of the castrated pigs are from small 'hobby' farms using the rarer traditional breeds which are classed as 'Vulnerable' or 'At Risk' on the Rare Breeds Survival Trust (RBST) criteria listing.

There are two qualified traditional products which are linked to the Gloucestershire Old Spot breed and the Welsh breed - both are classed 'Minority' breeds on the RBST lists. Castration is not a requirement for either of these products and is rare in both breeds.

Immunocastration is only permitted in scientific trials as there are concerns regarding consumer acceptance of the meat as well as human safety due to the close handling of finishing pigs and potential health risks from self-injection.

On the small number of UK farms where surgical castration is practiced it is believed that the majority use analgesics, such as lidocain, and (usually) the administration of antibiotic powder.

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