# Alternatives for surgical castration: report on the state of the art and ILVO research

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## 1. Introduction

Surgical castration is effective to reduce boar taint and to ease pig management by preventing the development of male sex characteristics and hence stop aggressiveness, fighting, harassment of the females and unwanted pregnancies [1]. Boar taint is an off-odour which is present when heating meat or fat from some boars or entire male pigs that may impair consumer acceptance. Therefore, boars are castrated in most countries before the age of 7 days. Until recently, this castration was done surgically without anaesthesia or analgesia. However, the procedure as traditionally performed is painful and negatively affects performance [2]. In Belgium, the discussion on alternatives started in 2001, with an agreement to evolve towards alternatives in 2006, but this deadline was not successful as various conditions had not been met. The discussion is now also ongoing at EU level and at the end of 2010, the declaration of Brussels was announced by the European Commission. In this declaration, several main actors in the pig meat chain agreed on a plan to voluntarily end the surgical castration of pigs in the EU by January 1, 2018. As a first step, from January 2012 onwards, surgical castration of pigs, if carried out, should be performed with prolonged anaesthesia and/or analgesia. The complete ban of surgical castration may be more ethically acceptable. It may increase farmers' income as well, as castration decreases carcass leanness and increases feed conversion ratio [3]. In general, the meat industry and retail remain reluctant though to accept meat from boars. And although this alternative as well as several other alternatives have been investigated intensively, some questions remain to be answered. During the past 10 year, several studies have been conducted at, or in collaboration with the Institute for Agricultural and Fisheries Research (ILVO). This paper provides an overview of the state of the art and some considerations, and the most relevant findings of the research performed at ILVO.

## 2. State of the art

Several alternatives for surgical castration have been investigated worldwide: surgical castration with anaesthesia, surgical castration with analgesia, immunocastration, raising boars and sperm sexing [4]. A variety of local anesthetics (e.g lidocaine), general anesthetics (gass: e.g isoflurane, carbon dioxide or injection: e.g. ketamine/azaperone) as well as analgetics (meloxicam) have been tested.

### 2.1. Castration with anaesthesia or analgesia

These alternatives are mainly seen as a short term solution. It allows farmers to continue producing barrows with a known end-quality, without boar taint and with a reduced risk of male-related

behavioral problems. However, performing castration with anaesthesia or analgesia increases production costs and labour and the application of anesthetics is a veterinary practice which cannot be done by the farmer himself. Another drawback is the fact that checking correct implementation on farms is difficult. Local anaesthesia combined with analgesia performed by a vet is mandatory in Norway. Switzerland only accepts castration with general anaesthesia, i.e. isofluran gas anaesthesia or injection with ketamin. In other EU countries, castration with anaesthesia and analgesia remained mainly theoretical. Anno 2009, $CO_2$ anaesthesia was introduced in the Netherlands. Around the same time Q&S in Germany requested the use of analgesia (Metacam®).

### 2.2. Production of boars

The production of boars is not yet generally accepted as a suitable alternative for castration. The main issue with this alternative is the presence of boar taint, mainly caused by androstenone and skatole and to a lesser extent indole. Based on our studies, average boar taint prevalence in Belgium seems to be around 3 to 5%, but varies between farms and slaughter batches. Androstenone has a urine-like or sweaty odour and is produced in the testes, in parallel with anabolic testicular hormones [5]. It acts as a pheromone when released in the saliva and thus stimulates reproductive function in the female pig [6]. The odour of skatole has been described as faecal-like, naphthalene, sweet, warm, and fruity. Skatole (as well as indole) is produced by microbes in the hindgut from L-tryptophan, which originates from cell debris of the gut mucosa. To enable the production of boars, boar taint prevalence should be reduced and boar taint should be detectable online. Selection against boar taint is being investigated as a long term solution. In the short-term, research focuses on the reduction of boar taint by adaptation of management, mainly feed ingredients, breed and slaughter weight [7-10]. However, an adequate elimination of boar taint by implementing these management strategies seems difficult.

A major hurdle for shifting towards the production of boars remains the lack of an objective, rapid online method to detect boar taint at the slaughterline. The hot iron or human nose method is a sensory method which can be performed in the slaughterhouse. If this method can be further optimized, validated and standardized, this detection method could be used to identify animals with boar taint as a temporary solution. Further effort is needed to develop an automated objective, online detection method, preferably differentiating between skatole and androstenone to enable the optimization of reduction strategies.

Another issue is the lack of a clear definition of boar taint. For research purposes, chemical as well as sensory methods are used to evaluate boar taint. Chemical analysis can be used to reveal the concentration of androstenone and skatole in fat, but the cut-off levels as well as the contribution of other compounds are still under discussion [11;12].

### 2.3. Immunocastration

Since 2009, the EU registered a vaccine against gonadotropin-releasing hormone (GnRH). This vaccination, also called immunocastration effectively reduces boar taint and potential aggressive and sexual behaviour after the second vaccination [13-15]. This alternative can be interesting in practice, as

results for performance, carcass and meat quality are in between boars and barrows [16], but further research is needed to clarify the influence of the timing of the second vaccination, housing, and genotype [17-20]. Considering the advantages of immunocastration, this management strategy seems to be an ideal tool to ban any form of surgical castration and to cope with the negative aspects of raising boars. However, most European retailers do not yet accept meat from immunocastrates. Contrary to this general situation, a Belgian retailer requested this practice, which induced a partial shift towards immunocastration. More objective data about consumer acceptance and more information about the product safety may convince farmers as well as retailers to shift towards immunocastration.

### 2.4. Sperm sexing

Another alternative is sperm sexing. This practice would enable the exclusive production of gilts, but sperm sexing is not yet ready for practice as the speed of separation as well as the viability of the sexed sperm need further improvement. Further development of this technique seems to evolve, although slowly [21].

## 3. Research results related to ILVO projects

### 3.1. Reduction of boar taint

#### *3.1.1. Strategies to reduce skatole (and indole) based on feed ingredients and soiling*

Several studies have been performed to evaluate strategies to reduce boar taint with a series of experiments mainly focusing on skatole (and indole). Two main strategies were evaluated: the inclusion of various ingredients to the feed and improved soiling conditions.

No reducing effects for skatole and indole were found in a first feeding trial of a project (2005-2009) in which the effect of feeding with a control diet versus experimental diets including 1% clinoptilolite, 5% inulin, 10% lupins, 10% raw potato starch, or 10% raw potato starch + 5% wheat bran during the last 4 to 6 weeks before slaughter were evaluated [22]. In these trials, prevalence of boar taint was low and the number of animals may have been insufficient to prove effectiveness of the treatments. This low prevalence was taken into account in our subsequent trials. In a second trial, inclusion of chicory pulp with dried chicory roots during the last 10 days before slaughter did reduce skatole, but slightly increased indole concentration in backfat (CASPRAK, 2009-2012). In a more recent trial [23], addition of 5% chicory fructanes during the last three weeks before slaughter also reduced skatole, this time without effect on indole. Nevertheless, sensory evaluation was not affected in the latter two studies.

In the FOD project (2005-2009), we also conducted an experiment on the effect of soiling on boar taint [24]. One group of boars was washed daily and pens were mucked on and littered down daily, a second group was rubbed with faeces daily and a third group was kept in control conditions. The treatments were imposed during the last four weeks before slaughter. Improving the soiling conditions was only effective according to the consumer panel. So although literature indicated that

feeding and hygiene can reduce skatole levels, this was not clearly substantiated in our experiment. A more recent study even questions whether soiling has an impact on skatole levels [25].

According to these results and literature, inclusion of boar taint reducing ingredients seems to be a good strategy to reduce skatole. Results for indole are more variable, but the importance of this compound is also not yet well defined.

### *3.1.2. Strategies to reduce androstenone and skatole based on breed, slaughter weight and selection*

The accumulation of skatole and androstenone in fat is genetically determined. Selection towards low androstenone levels is possible, but may coincide with reduced production of androgens and estrogens, which negatively affects reproduction results [7;10;26]. Several QTLs have been identified for androstenone and skatole, but results differ between studies and between breeds. Data indicates that boar taint is affected by many genes and not by one major metabolic gene controlling boar taint [10;26]. Therefore, the combined effect of breed and slaughter weight may still be relevant as a short term solution, while further efforts are done towards the selection against boar taint.

The effect of breed and slaughter weight was evaluated in a FOD project (2005-2009), with Belgian Landrace Stressnegative (BN), Large White (LW) and Pietrain (P) boars slaughtered at 50, 70, 90 and 110 kg. The effectiveness of reducing boar taint by lowering slaughter weight appeared to be breed dependent. Skatole levels in backfat were significantly higher for LW and BN compared to P. The androstenone levels and the hot iron method revealed a significant interaction between breed and slaughter weight. BN and P had higher androstenone levels at 90 kg compared to 50 kg of slaughter weight. For the hot iron method, this weight dependency was only found for the LW breed, with more off-odour for boars slaughtered at 110 kg compared to 50 or 90 kg. Breed differences were only found at a slaughter weight of 110 kg, with higher androstenone levels and hot iron scores for LW compared to P. The results of this experiment indicate opportunities to minimise the risk of boar taint by carefully selecting a combination of breed and slaughter weight. Correlations between slaughter weight and some of the various boar taint parameters were higher for LW than for P. Since the boar taint level was also highest for LW, a reduction of slaughter weight may therefore be more effective for LW than for P. More insight is needed in the evolution of boar taint in the different breeds/lines of hybrid meat pigs.

KU Leuven and ILVO cooperated in a project to find a genetic marker that is linked to the occurrence of boar taint (IWT, 2009-2014). The study yielded a promising marker, namely a polymorphism of the MC4R gene [27]. In a follow-up experiment with animals selected on the presence of this polymorphism, a clear link between the genotype and the level of boar taint components was observed with lower levels of skatole, indole and androstenone in selected animals [28;29]. Pigs selected on this polymorphism had a lower daily feed intake, lower fat deposition, a higher meat percentage (64.4% versus 62.8%) and a wider ham. Although boar taint was not eliminated completely, this marker is promising, especially because the selected animals showed favourable production characteristics and fertility properties. Still, management measurements could be necessary to reduce undesirable behaviour.

### 3.2. Effect of slaughter related factors on boar taint

Currently, ILVO performs a study (2013-2017) in cooperation with KULeuven en UGent to determine slaughter and farm related factors that can be linked with boar taint prevalence in order to develop farm specific strategies to reduce boar taint. The current transition towards boar production in Belgium enables the opportunity to perform such large-scale studies. In the first phase of this project, boar taint prevalence was determined on 78 slaughter batches from 34 participating farms [30]. Skin lesions, carcass weight and lean meat percentage were recorded on animal level and data on slaughter transport time and the time spent in the lairage, season, hours of daylight, shortening of days and mean temperature at slaguhter were recorded on batch level. The mean boar taint prevalence on all farms ranged from 2.2% to 11.6% with an average of 5.6±2.5%. The difference between the maximum and minimum boar taint prevalence of different slaughter batches from the same farm ranged from 0.2% to 13.1%. This indicates that factors varying from one batch to the next may, at least in part, influence boar taint. The chance of a boar tainted carcass increased with increasing skin lesion score (indicating increased stress and aggression), increasing outside temperature and decreasing lean meat percentage. Pigs spending more time in lairage also tended to have a higher chance on boar, indicating that events occurring shortly before slaughter also affect boar taint levels as also shown in more recent studies [25]. In the second phase of this project, several slaughter batches from 25 farms are followed up in detail to get more insight in the factors related to boar taint. Furthermore, experiments will be done to evaluate reducing strategies and to identify mating boars with high and low risk for boar tainted progeny.

### 3.3. Boar taint detection

#### *3.3.1. Evaluation of various detection methods*

In the experiments performed in the FOD project (2005-2009), various boar taint detection methods were compared: the hot iron method, a standardised and a home consumer panel, an expert panel assessment of meat and fat, and laboratory analysis of androstenone, skatole and indole in fat. Correlation coefficients were generally weak, and indicated that results of one detection method cannot be generalised. The choice to use one or more detection methods therefore deserves consideration depending on the aim of the study. The home consumer evaluation was correlated with the concentration of indole (r=0.27) but not with skatole or androstenone. We therefore recommend that chemical analyses also include indole testing. Moreover, the consumers also indicate that boar meat was less tender compared to barrow meat, which may also influence comparison between boar and barrow meat, apart from boar taint. The hot iron method seems to be an easy and fast detection method which yielded comparable or better correlation coefficients with the other detection methods than an expert panel evaluating fat samples. However, the reliability of the hot iron method depends on the training and reliability of one or two assessors. More efforts are needed to further optimize this method by evaluating the effect of testing conditions.

### *3.3.2. Rapid sensory methods*

Several questions on the use of the rapid sensory methods were evaluated in the study of Bekaert et al. [31], by comparing three types of heating methods (microwave, soldering iron and pyropen) and evaluating the effect of habituation, cleaning the soldering iron, singeing the fat twice on the same place, and variations in the technical procedures. Boar taint was scored by trained experts. All methods seemed to be suitable for detecting boar taint. The pyropen is probably most suitable because it does not contact the fat and is easy to handle (wireless). Finally, the intensity score was also influenced by contamination from not cleaning the soldering iron in between measurements, by singeing the fat twice on the same spot, and by habituation.

Further effort towards a better understanding of the hot iron method and the use of experts to assess boar taint is currently performed in an ongoing IWT project on boar taint reduction (2013-2017). The first trials were related to the effect of training and familiarity with boar taint and the effect of the previous sample on the scoring of the subsequent sample. Familiarity was defined as 1) trained, 2) previous contact with the boar taint compounds and/or boar tainted samples but no further training, or 3) no previous conscience contact. For all groups of participants, boar taint scores were on average lower if the preceding sample was tainted. Inter and intra reliability increased with increasing training and familiarity [30].

Future experiments will evaluate the effect of storage time and conditions on boar taint and the possibilities to differentiate between androstenone and skatole by sensory methods.

### *3.3.3. Sensory acceptability of boar meat*

An EU study was performed (DG SANCO, 2013-2014) in cooperation with ILVO to evaluate the consumer acceptance of boar meat based on consumer tests performed in four European countries: Italy, France, Denmark and Poland [32]. Eight boar meat patties were evaluated with concentrations varying from 0.1 to 0.4 ppm for skatole, and from 0.5 to 2.0 ppm for androstenone. Moreover, consumers' sensitivity towards these compounds was tested. Depending on the country, between 21 and 29% of the consumers were sensitive to androstenone and between 51 and 67%, were sensitive to skatole. Consumers' preference regarding odour and flavour for boar meat patties over castrate meat patties mainly decreased with increasing skatole level and increasing sensitivity. Clear threshold levels for impaired consumer acceptance could not be defined.

UGent and ILVO are currently also evaluating the valorization of carcasses with boar taint in several fresh and processed meat products. Results of this Flanders Food project (2013-2015) will be released in 2015.

## 3.4. Evaluation of immunocastration

Several studies have been performed in collaboration with ILVO to evaluate the effect of immunocastration on behavior, performances, carcass and meat quality in boars, but also in barrows and gilts, and the effect of early versus late administration of the second vaccination.

### *3.4.1. Carcass and meat quality of boars, barrows and immunocastrates*

This study was performed shortly after the registration of Improvac® in Europe and investigated carcass quality, meat quality and palatability of barrows, immunocastrates and boars (CASPRAK, 2009-2012)[33]. Immunocastrates and boars showed higher carcass lean meat percentage than barrows. Drip and cooking loss were lowest for the barrows, while ultimate pH was lowest in boars. The hot iron method only revealed off-odour in the boars. Nevertheless, consumers were not able to detect boar taint in those samples, but results indicated that they preferred the tenderness and juiciness of meat from barrows over immunocastrates and boars. These results indicate that not only boar taint, but also meat quality traits such as waterholding capacity and tenderness should be taken into account when evaluating the effect of alternative strategies for surgical castration.

### *3.4.2. Immunocastration in boars, barrows and gilts*

While the effect of immunocastration is well studied in boars, less is known about its possible effect in gilts and barrows. The effect of immunocastration in boars, barrows and gilts was therefore investigated in an ongoing IWT project (2013-2017) [34]. Immunocastration had only minor effects on performance in barrows, indicating that the observed effects in boars and gilts are probably not caused by the GnRH vaccination itself but by the withdrawal of gonadal hormones. In boars, the higher feed intake after immunocastration, was associated with withdrawal of estradiol or/and testosterone, and led to faster growth, higher backfat thickness and lower meat percentage and an elimination of boar taint. The increased feed intake after immunocastration was also observed in gilts, which could be related to the withdrawal of progesterone, and led to faster growth and lower shear force of the meat without sensory differences.

### *3.4.3. Optimal timing of immunocastration in boars*

Before the second vaccination, pigs behave and perform like boars. Afterwards, the pigs behave like barrows and feed intake increases which may result in a lower lean meat percentage. It can therefore be expected that the timing of the second vaccination is crucial to find the right balance between the advantages of entire males and barrows. We therefore evaluated behaviour, performance, carcass and meat quality of gilts, and immunocastrates vaccinated at 6 versus 4 weeks prior to slaughter (ADLO, 2013-2015)[35]. Gilts had a lower daily feed intake and daily gain in the late finishing phase, a higher feed conversion ratio overall and a higher lean meat percentage compared to both immunocastrated groups. Within the studied time frame of two weeks, early vaccination improved dressing percentage and tended to increase intramuscular fat content, while maintaining performances and carcass characteristics. Earlier vaccination improved the dressing percentage by the decreased weight of the gastro-intestinal tract and increased the calmness in the stable at the end of the fattening period.

## 3.5. Field experiment with different alternatives for surgical castration

Large scale results about the consequences of implementing alternatives on farm are currently still lacking. We therefore investigated the practical applicability of four alternatives that can be

implemented in the short-term in a large field trial on 20 farms with approximately 120 male pigs per farm per treatment and all treatments performed on each farm. Tested alternatives were surgical castration with analgesia with Metacam® administered 10 minutes before castration, surgical castration with general anaesthesia with 100% $CO_2$, vaccination against boar taint, and the production of boars.

Mortality in the farrowing crates, nursery pens and fattening stable did not differ between treatments. Immunocastrates and boars showed a better feed conversion ratio compared to the barrows. Lean meat percentage was higher for boars compared to the barrows, and intermediate for immunocastrates, while carcass yield was lowest for the immuncoastrates. The hot iron method indicated that boar taint was eliminated by immunocastration. In boars, average prevalence of boar taint was 3%, but varied from 0 to 14% between farms [35].

Pig farmer attitudes towards the alternatives were also investigated before (ex-ante) and after (ex-post) applying all four alternatives on their farm [35]. When applying anaesthesia or analgesia during castration, farmers mainly experienced disadvantages in terms of labour, costs, and complexity in the case of anaesthesia. External factors such as legal requirements or monetary incentives may be required to encourage farmers to shift to these alternatives. Hands-on experience promoted boar production as a valid alternative, mainly due to the reduced labour demand, the ease of the method and the improved performances. However, management adaptations may be necessary on some farms to cope with the increased aggressive and sexual behaviour. Experience with immunocastration did not fulfil the high expectations. Our study shows that farmers should be well instructed about the correct administration of the vaccine, they should be supported in their management to optimise performances, and they should get a correct view on the final economical results when introducing immunocastration. A major concern for the farmers, however, is the current lack of market opportunities for both boars and immunocastrates. This study demonstrates that allowing the farmers to try and learn while implementing these alternatives on a small scale on their own farm may enhance the voluntary introduction of alternatives for surgical castration.

## 4. Conclusion

Castration with anaesthesia or analgesia can be considered as short term solution, but correct implementation is difficult to check. For farmers, these practices require extra effort in terms of labour, costs, or complexity. External factors such as legal requirements or monetary incentives are probably required to stimulate farmers to shift to these alternatives. Transition towards the production of boars or immuncoastration is only possible if the market is willing to accept these alternatives. These alternatives can result in economic profit for the farmer, and most farmers are therefore willing to perform these, but correct information is needed in order to create the right expectations. To enable the transition towards boar production, further effort is needed toward the reduction and (online) detection of boar taint, but also regarding carcass and meat quality as well as management strategies to improve animal behaviour. Immunocastration shows a lot of potential, but is hindered by the low market acceptance in several EU countries. Although the current situation

in countries as Belgium, Brazil and New Zealand indicates that commercialisation is possible, large scale consumer studies and a well thought-out European information programme seem to be necessary before the EU meat processing chain and retailers will fully accept immunocastration.

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