Boars on the way

Results of the 5 year Dutch research programme 'Boars heading for 2018'

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Foreword

Annechien ten Have-Mellema – Chairman of the Steering Committee Boars 2018

It is my great pleasure to introduce the report on the five-year Dutch research program 'stopping the castration of piglets'. Many results were obtained from the research that was started in 2009. Researchers from various disciplines and institutions of Wageningen University and Research Centre participated and cooperated with many partners within the Dutch pork supply chain.

During these five years the Dutch pork supply chain succeeded in making a remarkable transformation. In 2009 less than 5 per cent of male piglets in the Netherlands were not castrated, whereas by the end of 2013 well over 50 per cent of the Dutch male piglets is not castrated anymore. The research results have provided important directions for solutions. The scientists involved have gradually unravelled the consumer response to products from entire male pigs, which is important for the appropriate use of detection methods. We have also identified the factors that determine successful boar management on the farm. Although still some challenges remain to be solved, we are convinced that we are on the right track towards a more sustainable production and marketing of pork products.

This report summarizes the knowledge gained up to the present. Further information can be found in the reports of various studies, to which reference is made in the text. We hope that sharing our knowledge with experts throughout the member states of the European Union contributes to the ambition of the Declaration of Brussels, stopping piglet castration by 2018.

To underline our ambition for international cooperation the Steering Committee of the Dutch research programme 'Stopping the castration of piglets' will from now on be named 'Steering Committee Boars2018'.

The Netherlands, December 2013

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Chairman of the Steering Committee Boars2018

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Steering Committee

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This research was conducted by Wageningen UR in cooperation with VION Food Group and TOPIGS Research Center IPG. It was funded by the Dutch Ministry of Economic Affairs and the Dutch Product Board Livestock, Meat and Eggs. More information can be found at www.boars2018.com.

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Introduction

Gé Backus – Programme manager

One of the main challenges for the European pork supply chain is to adapt pig production to societal demands with regard to animal welfare, especially to stop the current practice of castrating male piglets. Although it is also more profitable and efficient to produce entire males due to their enhanced feed conversion and higher proportion of lean meat on their carcasses, it is recognized that the quality of meat from some entire male pigs is negatively influenced by odour and taste, referred to as boar taint. Although castration has been partially abandoned in a number of European countries, in most countries all males except those retained for breeding are castrated.

In 2009 the Dutch pig sector agreed with the Declaration of Noordwijk on the ambition to ban castration of male piglets. A number of efforts to address the issue of castrating piglets have been and are being undertaken. This report is the product of one such effort, the Dutch five-year research program "Stopping the castration of piglets" during the years 2009-2013. The research program was initiated by the Noordwijk partners, and had an integrated approach aimed at limiting the occurrence of meat with an off-flavour. This is a pre-condition for realizing market acceptance and industry acceptance of meat from non-castrated pigs.
The research program also aimed at identifying, optimizing and evaluating alternative combinations of preventive and corrective measures across the pork supply chain. An important condition is that stopping with castrating piglets does not lead to excessive mounting and aggressive behaviour on farms with entire male pigs. We determined the success and risk factors for preventing mounting and aggressive behaviour in boars.

The main results of the research program are presented in this report, using a fixed format for each project. The report contains six chapters, each of them including several project results. The chapters are: (1) setting the stage, (2) consumer, (3) detection, (4) preventive measures (5) behaviour of boars and (6) boar taint economics and international developments.

To guarantee maximum accessibility of the research results for every project format the name of a contact person is included.

Wageningen, December 2013

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Table of contents

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Table of contents

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I
Setting the stage

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Boar Taint prevalence at Pig Farms

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To detect carcasses with an off odour slaughterhouses have introduced hot iron methods to detect boar taint by human nose. This detection method is immediate, fast and cheap, three elements of high relevance for detection of boar taint prior to processing of boar carcasses. In the Dutch National Research Program an in-line detection method for boar taint by Human Nose Scores (HNS) was evaluated. A statistical study was conducted to do a post hoc analyses to estimate the importance of farm effects of an in-line boar taint detection by HNS.

Data collected at the slaughter line

Data of slaughter results and human nose sores of 1.7 Million boars were collected at a commercial Slaughterhouse during the period August 2012 till October 2013.

GenStat GLM was used to examine the variance components of Boar Taint measured by using human nose scores (Mathur et al., 2012). During the mentioned period the boar taint detection was conducted by 34 trained testers on individual boar carcasses delivered from batches of 1585 farms.

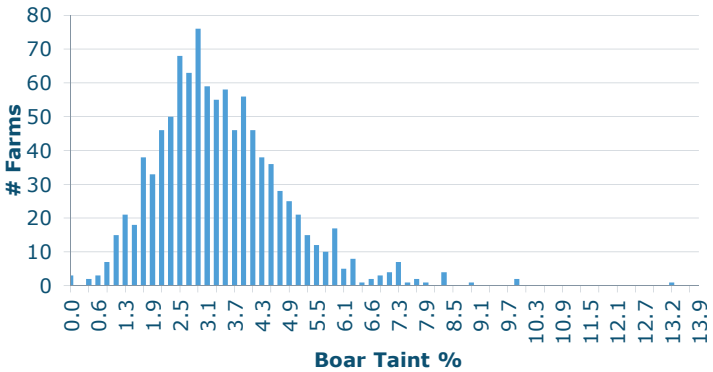

Figure 1. Distributions of farm averages for boar taint (period August 2012 till October 2013, only farms with at least 150 delivered boars)

Data collected at the Slaughter line	
# records	1.716.292
# records (after data selection)	1.562.811
# Producing farms	1.585
# Delivery batches	18.030
# Testers	34
Average Percentage Boar taint	3,31%

Figure 2. Data collected at the slaughter line

Prevalence Boart Taint at Farms

The average percentage Boar Taint during the period August 2012 to October 2013 was 3,31%. As the percentage of boar taint is rather low, we used only the farms with at least 150 delivered boars to demonstrate the range in farm averages. This range for 90 percent of the farms is 1.4% - 5.8%. These differences between farms are highly significant. Farms averages below 1% and above 10% were still due to fairly small numbers of delivered boars (less than 400 boars).

Main conclusions of the variance analyses of Boar Taint measured by the detection of boar taint in the slaughter line:

- Significant differences in average level of boar taint between boar producing farms were found; with an average of 3,31%, 90 percent of the farms were within the range of 1.5 to 5.8%.

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Boar taint categories of farms based on repeated deliveries

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According to outcomes of boar taint tests based on human nose scoring system, see Mathur et al. (2012) for the system description, the average prevalence of boar tainted carcasses in the Netherlands is about 4% (Van Wagenberg et al., 2013). Preventing of entrance of these carcasses to the fresh meat market implies about €3.50 million lower returns for slaughter plants. The general prevalence of boar taint must therefore be reduced. Different potential solutions are available in the chain to reduce boar taint prevalence (Valeeva et al. , 2009 and van Wagenberg et al., 2013). For a non-integrated chain potential solutions will probably only be widely implemented when incentives are imposed that induce chain actors to prevent boar taint.

Objective

This study analyses the repeated deliveries of entire male pigs to the slaughter plant. The study provides the first understanding of how pig farms are stable in their boar taint performance and suggests primary division of farms that make repeated deliveries into categories as based on boar taint performance.

The results are useful for designing a farm performance-based incentive system implying that a farm is penalized depending on its boar taint category as based on repeated deliveries.

Methods

Data

Initial data set: 632 790 entire male pigs slaughtered at the specific slaughter plant in the Netherlands, during June 2010 – July 2012, in total 26 months.

Selection criteria per farm for repeated deliveries:

- Percentage of entire males delivered in one month, during the 12-month period: ≤20%;
- The number of months when entire male pigs are delivered: at least 8 months during the 12-month period.

Final sample for the detailed statistical analysis: 101 farms that make repeated deliveries to the slaughter plant:

- 281 427 entire mails delivered total on these farms;
- average boar taint prevalence 4.43%.

Statistical analysis

Statistical model:

Average boar taint prevalence on the farm , as measured by human nose scoring system (Mathur et al., 2012), was calculated for each delivery. The average prevalence's were considered lognormal and were analyzed in a mixed model (Genstat REML) where farm effects were estimated. Within-farm variance was estimated for each farm. There were no corrections made for farm size or season. Range of estimated within-farm variance (on log-scale): max = 0.695; min = 0.217; median=0.382.

Results

Table 1 shows the division of farms that make repeated deliveries into five categories and farms' performance per category, as measured by

Performance category	Boar taint prevalence range, % (human nose scoring system)	% farms per category
"Very Low"	0 – 3.14	5%
"Low"	3.15 – 3.87	20%
"Average"	3.88 – 4.85	50%
"High"	4.86 – 5.77	20%
"Very High"	>5.77	5%
Total		100%

Table 1. Boar taint categories of farms based on repeated deliveries(n=101 farms).

The observed differences between the repeated performance of farms in different categories are rather small, in particular between the neighbor interval categories, in contrast to our initial considerations to define categories as: >10%; 8 - 10%; 6 - 8%; 4 -6%; <4%.

These small differences suggest that most farms can potentially rather easily move to the better category by adopting certain practices on their farms (for example, by buying "low-taint" piglets), when proper incentives are imposed.

In each performance category there is almost the equal number of farms with high/low within-farm variability. This indicates that variability can also be further explored as separate information to define boar taint categories of farms.

The outcomes are used for further modeling of incentive systems.

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Carcass weight and boar taint

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To detect carcasses with an off odour slaughterhouses have introduced hot iron methods to detect boar taint by human nose. This detection method is immediate, fast and cheap, three elements of high relevance for detection of boar taint prior to processing boar carcasses.

In the Dutch National Research Program an in-line detection method for boar taint by Human Nose Scores (HNS) was evaluated. A statistical study was conducted using a *mixed model* analyses to estimate the effect of individual carcass weight on the risk of boar taint in an in-line boar taint detection by HNS.

Data collected at the slaughter line

Data of slaughter results and human nose sores of 1.7 million boars were collected at a commercial Slaughterhouse during the period from August 2012 till October 2013.

GenStat GLMM was used to examine the variance components of Boar Taint measured by a Human Nose Scoring method at the slaughter line (Mathur et al., 2012). During the mentioned period the boar taint detection was conducted by 34 trained testers on individual boar carcasses delivered from batches of 1.585 farms.

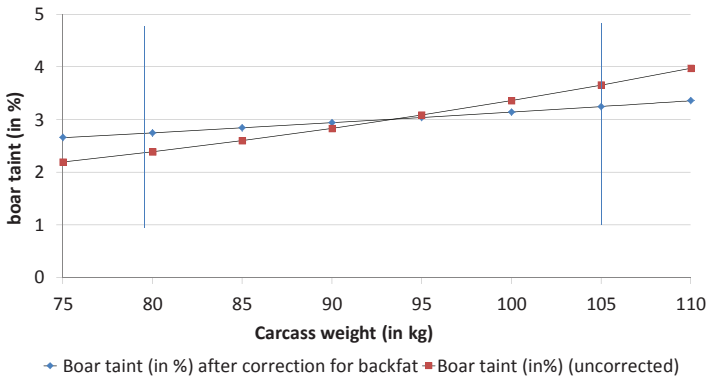

Figure 1. Risk of boar taint for different carcass weights

Data collected at the Slaughter line	
# records	1,716,292
# records (after data selection)	1,562,811
# Producing farms	1,585
# Delivery batches	18,030
# Testers	34
Average Percentage Boar taint	3.31%

Figure 2. Data collected at the slaughter line

Predictive value of carcass weight for Boart Taint

The average percentage boar taint during August 2012 and October 2013 was 3,31%. For backfat thickness 90 % of the boars were in the range between 9 - 18 mm. of backfat. The average slaughter weight is 91.9 kg and almost 95% of the carcass weights are in the range 80-105 kg. The correlation of carcass weight with boar taint was highly significant ($p<0.001$) and strongly positive.

Correcting for backfat thickness made the relationship between carcass weight and boar taint much weaker. The estimated regression coefficient on the logit scale decreased from +0.017 (se=0.002) to 0.007 (se=0.002), but was still significant ($p<0.01$).

Main conclusion of the variance analyses of boar taint measured by the detection of boar taint in the slaughter line:

- Carcass weight is a risk factor with, corrected for backfat thickness, a slightly positive correlation with Boar taint;
- As predictive parameter for boar taint, backfat thickness seems to be of more importance then carcass weight.

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Age at Slaughter and boar taint

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To detect carcasses with an off odour slaughterhouses have introduced hot iron methods to detect boar taint by human nose. This detection method is immediate, fast and cheap, three elements of high relevance for detection of boar taint prior to processing of boar carcasses. In the Dutch National Research Program an in-line detection method for boar taint by Human Nose Scores (HNS) was evaluated. A statistical study was conducted to do a *post hoc* analyses of the effect of age at slaughter for the risk of boar taint detection by HNS.

Data collected at the slaughter line

Data of slaughter results and human nose scores of 455 boars, delivered in 6 delivery batches were collected at a commercial slaughterhouse from September 2011 till February 2012.

GenStat GLM was used to examine the effect of age at slaughter on the incidence of boar taint measured by a HNS method (Mathur et al., 2012). During the mentioned period the boar taint detection was parallel conducted by 4 trained testers on individual boar carcasses delivered from batches from a farm, were individual information of age of the boars was available. As boars were delivered as they reached their target weight, the variation of age in the data was mainly caused by difference in growth rate. In this farm each group of pigs that started together (round) was delivered in 2 delivery batches, were the second delivery batch was two weeks after the first delivery batch.

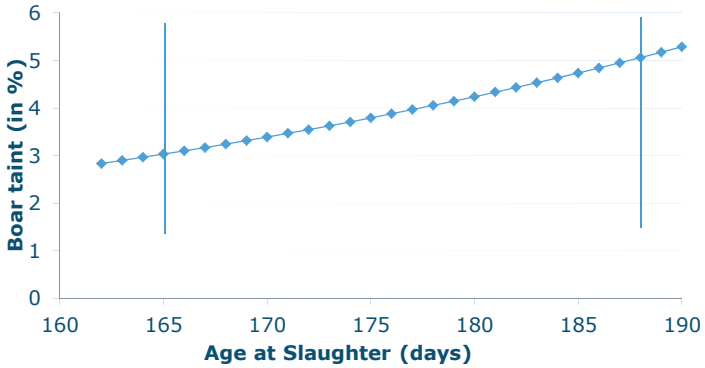

Figure 1. Risk of boar taint for different levels of age (within the same farm)

Data collected at the Slaughter line	
# records	455
# Delivery batches	6
# Testers	4
Average age at Slaughter	177
Average Percentage Boar taint (after scaling in Genstat)	4.00%

Figure 2. Data collected at the slaughter line

Effect of age at slaughter

The average percentage boar taint (BT) of the boars selected for the experiment was 4,0%. 90 percent of the boars were within de range of 165-188 days of age at slaughter.

Carcasses of boars with a higher age at slaughter appeared to have a substantial higher probability ($p<0.10$) of having boar taint.

In this experiment the BT percentage of boars slaughtered at 185 days is almost 1.7% higher compared with boars slaughtered at 165 days. (4,7% versus 3,0%).

Conclusion: In this study age at slaughter is a predictive parameter for the risk of boar taint.

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Backfat thickness and boar taint

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To detect carcasses with an off odour slaughterhouses have introduced hot iron methods to detect boar taint by human nose. This detection method is immediate, fast and cheap, three elements of high relevance for detection of boar taint prior to processing of boar carcasses. In the Dutch National Research Program an in-line detection method for boar taint by Human Nose Scores (HNS) was evaluated. A *mixed model* analysis was conducted to estimate the effect of individual backfat thickness on the risk of boar taint in an in-line boar taint detection by HNS.

Data collected at the slaughter line

Data of slaughter results and human nose scores of 1.7 million boars were collected at a commercial slaughterhouse from August 2012 till October 2013.

GenStat GLMM was used to examine the variance components of Boar Taint measured by a Human Nose score method at the slaughter line. (Mathur et al., 2012). During the mentioned period the boar taint detection was conducted by 34 trained testers on individual boar carcasses delivered from batches of 1585 farms.

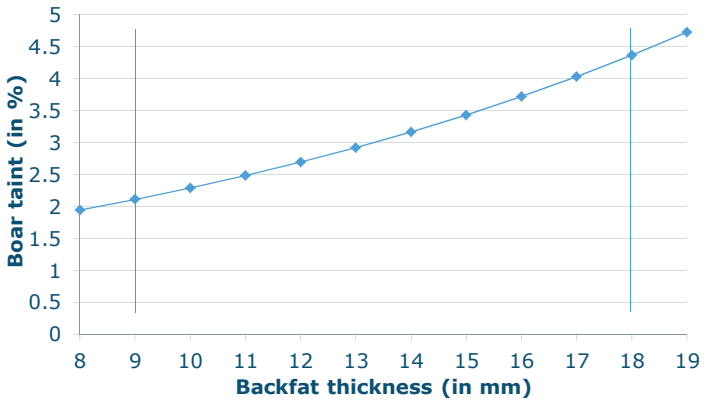

Figure 1. Risk of boar taint for different levels of backfat thickness

Data collected at the Slaughter line	
# records	1,716,292
# records (after data selection)	1,562,811
# Producing farms	1,585
# Delivery batches	18,030
# Testers	34
Average Percentage Boar taint	3.31%

Figure 2. Data collected at the slaughter line

Predictive value of backfat for Boart Taint

The average percentage boar taint from August 2012 till October 2013 was 3,31%. For backfat thickness 90% of the boars were in the range between 9 en 18 mm. of backfat. The correlation of backfat with Boar Taint was highly significant ($p<0.001$) and strongly positive.

The estimated regression coefficient on the logit scale was +0.083 (se=0.004). This indicated for example that boars with 18 mm of backfat have a much higher probability of having boar taint when compared to boars with 9 mm of backfat (4,4% versus 2,1%).

Conclusion: in this study backfat thickness of the carcass is an important predictive parameter for boar taint.

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Performance of boars and castrates

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The performance of boars and castrates was investigated at Pig Innovation Centre Sterksel and at the experimental farm of TOPIGS at Beilen. In Sterksel growing pigs with a Tempo boar were used. In Beilen growing pigs with a Tempo, TopPi and Talent boar were used.

Results VIC Sterksel

In the trial at Sterksel boars were fed ad libitum. Castrates were fed according to a feeding scheme. The boars ate less feed, grew faster and had a better feed conversion ratio than the castrates (Table 1). The castrates had a lower meat percentage and thicker backfat than the boars. Muscle thickness was lower in boars than in castrates.

	Boars	Castrates
Daily gain (g/d)	855	838
Feed intake (kg/d)	1.98	2.12
Feed conversion	2.32	2.53
HGP meat%	57.2	55.4
HGP muscle (mm)	55.9	57.3
HGP fat (mm)	14.9	17.6

Table 1. Performance Tempo boars and castrates at VIC Sterksel

Source: Wageningen UR

	Tempo		TopPi		Talent	
	boars	castrates	boars	castrates	boars	castrates
Daily gain (g/d)	902	878	818	853	883	883
Feed conversion	2.31	2.58	2.20	2.43	2.29	2.44
HGP meat%	57.4	55.2	58.2	56.8	57.5	55.8
HGP muscle (mm)	56.5	57.4	58.5	60.8	57.1	57.7
HGP fat (mm)	14.9	18.0	14.2	16.5	14.9	17.3

Table 2. Performance boars and castrates at Beilen

Results Beilen

In the trial at Beilen, boars and castrates were fed ad libitum.

The difference in performance between Tempo boars and castrates was similar at Beilen and VIC Sterksel. Tempo boars grew faster, had a better feed conversion ratio, a higher meat percentage, thinner backfat and thinner muscles than the Tempo castrates (Table 2).

TopPi boars grew less than TopPi castrates but they had a better feed conversion ratio, a higher meat percentage, thinner backfat and thinner muscles.

Talent boars and castrates had a similar daily gain. Feed conversion ratio was better in Talent boars than in Talent castrates but the difference was smaller than in Tempo and TopPi boars and castrates. Talent boars had a higher meat percentage, thinner backfat and thinner muscles than castrates.

Implications

Genetics influence the difference in performance between boars and barrows. Savings of around 8% in feed can be realized by keeping boars in stead of castrates. Roughly, this means 20 kg per grower-finisher pig or 200.000 ton of feed per year in NL. Depending on payment on leanness and cost of feed, economic difference is in the range of 5-8 euros per grower-finisher pig, or around 5% of the cost price of a grower finisher pig.

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Farm and management characteristics associated with boar taint

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The farm and management characteristics of Dutch pig producers who are keeping boars were gathered in a survey and related to their farm-level boar taint prevalence. Lower farm-level boar taint prevalence was associated with a smaller group size, a smaller pen surface per boar, newer housing equipment, not practicing restricted feeding in the last period before delivery, a longer fasting period before slaughter, a higher stocking weight and a lower fraction of boars from purebred dam line sows or from Pietrain terminal boars. These characteristics can be used to develop farm-level intervention strategies for boar taint.

Pig farmers

December 2011, 152 Dutch pig producers, who delivered at least 100 boars in at least 2 consignments in the 9 months prior to the survey, received a questionnaire. Results from 90 producers were analysed.

Questionnaire

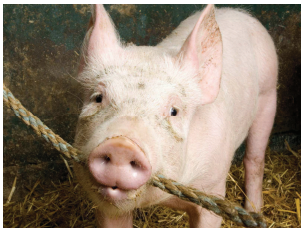
Questions concerned subsets of related characteristics:

- Housing conditions (pen surface per boar, straw use, age of housing equipment, floor type, number of boars per pen);
- Hygiene (drying after cleaning, pen fouling);
- Lighting strategy (light per day, natural light);
- Growth rate;
- Fraction of boars of line of dam or of sire of boar.
- Feeding strategy (feed type, feeder type, feeding strategy, higher energy feed, higher protein feed, fasting time before delivery);
- Stocking/marketing strategy (number of deliveries per pen, piglet stocking strategy, piglet grouping on sexes, regrouping after delivery, piglet stocking weight, growing period finishers);

Farm and management characteristic	Odds ratio[a]	p-value
Number of boars per pen ≤10	0.85	0.000
Pen surface ≥1.0 m^2 per boar	1.19	0.000
Age of housing equipment <5 years	0.87	0.003
Restricted feeding last period (ad libitum before)	1.10	0.057
Fasting before delivery <6 hours	1.10	0.088
Stocking weight	0.97	0.017
Fraction of boars from Pietrain terminal boar	1.56	0.010
Fraction of boars from purebred dam line sow	1.27	0.013
Adjusted R-squared	0.470	

[a] Odds ratio = $e^{\text{regression coefficient}}$.

Figure 1. Farm and management characteristics associated to farm-level boar taint prevalence



Source: Wageningen UR

Farm-level boar taint prevalence

- Farm-level prevalence was calculated as the mean of all deliveries from July 2010 to June 2011.
- Each carcass was assessed at the slaughter line on a score from 0 (no deviation in smell) to 4 (strong boar taint) by smelling the released odour when pressing a metal plate heated with a gas burner against the neck fat. Carcasses with score 3 or 4 were considered to have boar taint;

Statistical analysis

- Stage 1: linear multivariate regressions with forward selection on each subset of characteristics;
- Stage 2: one linear multivariate regression model with the significant characteristics of stage 1.

Results

The table shows odds ratios of the stage 2 analyses. An odds ratio of <1 indicates that farms with these characteristic had a lower boar taint prevalence. Farm-level boar taint prevalence was lower for producers who had 10 or less boars per pen, a pen surface per boar of less than 1.0 m2, housing equipment younger than 5 years, not fed the boars restrictedly in the last period before delivery, a fasting period of 6 or more hours prior to delivery, a higher stocking weight, and a lower fraction of boars from Pietrain terminal boars or from purebred dam line sows.

Acknowledgements

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WAGENINGEN UR
For quality of life

Risk factors for boar taint prevalence

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Experiences with keeping boars differ between pig farmers. On some pig farms, the percentage of boars with boar taint is high while on other farms it is low. It is not clear why the percentage of boars with boar taint differs between farms. The goal of the study was to determine the success and risk factors for reducing boar taint prevalence.

Farm visits

In 2012, data on 70 farms were collected by means of an (oral) questionnaire with questions about farm and management characteristics and by means of observations on the farms. Data on annual boar taint prevalence on the 70 farms were provided by the slaughter company. Behavioural measurements, skin lesions, lameness score, pig fouling and human-directed behaviour were measured in boars that were kept in the fattening barn for about 5, 9 and 13 weeks.

Results

The percentage of boars with boar taint differed from 1.6 to 5.9% between farms. On the 25% farms with the lowest level of boar taint compared to the 25% farms with the highest level, boars were more often housed in pens with less than 30 pigs, pigs were cleaner, gap width of the slats was more often higher than 18 mm and quality of the floor was more often good.

	25% farms with highest level of boar taint (> 4.6%)	25% farms with lowest level of boar taint (< 3.6%)
Number of pigs per pen:		
≤ 12	44	67
13 – 30	19	28
≥ 31	38	6
% of clean boars	47	81
Gapwidth of the slats ≤ 18 mm (vs wider)	88	50
Quality of the floor good (vs rough)	62	89

Table 1. Factors associated with boar taint

Source: VION Food Group

Conclusions

- Lower farm level boar taint prevalence is associated with a smaller group size (less than 30 pigs per pen), cleaner pens and pigs, wider gaps of the slats and a good quality of the floor.
- No clear relation is observed between measured boar behaviour during the farm visit and annual farm level boar taint prevalence.

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For quality of life

Towards successfully keeping boars

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Experiences with keeping boars differ between pig farmers. Some pig farmers observe high levels of sexual and aggressive behaviour of the boars on their farms while others farmers do not observe this behaviour. It is not clear how these differences in the level of sexual and aggressive behaviour between farms relate to farm management measures. The goal of the study was to determine the success and risk factors for preventing mounting and aggressive behaviour in boars.

Farm visits

In 2012, data on 70 farms were collected by means of an (oral) questionnaire with questions about farm and management characteristics and by means of observations on the farms. Behavioural measurements, skin lesions, lameness score, pig fouling and human-directed behaviour were measured in boars that were kept in the fattening barn for about 5, 9 and 13 weeks. Four pens per age group were monitored. Behavioural measurements (number of mountings, number of head against another pig and number of screams) were recorded in three observation periods of 5 minutes per pen (14.00 h, 15.00 h and 16.00 h).

Conclusions

Successful keeping boars

- It is possible to keep boars successfully. On some farms no mounting and aggressive behaviour and no skin lesions were observed.

Behaviour

- *Animal directed approach:* An animal directed approach (attention for the needs of the pigs) is associated with less sexual and aggressive behaviour and less skin lesions. This means that human-directed behaviour (pigs are less afraid of people), ad libitum feeding, less pigs per eating place, feeding diets with a high level of amino acids, clean pens and pigs, a good hygiene of the feeding and drinking system and sufficient water supply of the drinking system are associated with less sexual and aggressive behaviour and less skin lesions.
- *Rest and routine:* Factors that cause stress or give a negative stimulus are associated with a higher level of sexual and aggressive behaviour and more skin lesions. This means that too few eating places, restricted feeding, a low level of amino acids in the diet, insufficient water supply of the drinking system, illness of the pigs, a

Source: Wageningen UR

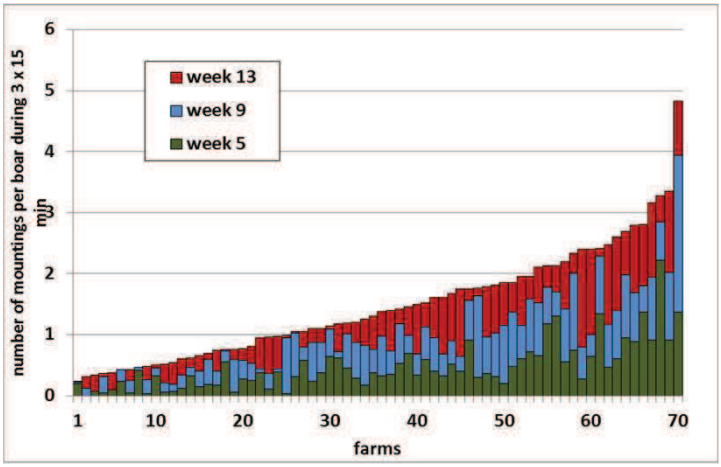

Figure 1. Ranking according to number of mountings on 70 farms

level of sexual and aggressive behaviour and more skin lesions.

- *Housing:* A partly open pen wall, clean pens and pigs and wider gaps of the slats are associated with less sexual and aggressive behaviour and less skin lesions.
- *Feeding and drinking water:* Feeding by a long trough, ad libitum feeding, feeding wet by-products, feeding diets with a high level of amino acids, a good hygiene of the feeding and drinking place and sufficient water supply of the drinking system are associated with less sexual and aggressive behaviour and less skin lesions.

It can be concluded that it is possible to keep boars successfully. The risk of increased levels of sexual and aggressive behaviour is limited when everything is optimal for the boars. When the farm conditions regarding feeding and drinking water, housing and climate, health of the pigs and/or management are not optimal, there is a risk that increased levels of sexual and aggressive behaviour and skin lesions will occur.

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II
Consumer

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Targeting consumer markets with un-castrated pig meat

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In a field experiment among German consumers, the pig meat odour perception of consumers during actual consumption, in relation to other product attributes, including appearance, taste, and texture, was studied. The participants ate loins, chops, and belly from boars (that were selected through inline human nose ratings) one day a week, for a five-week period. Each week they evaluated the meat they consumed during dinner. Using a structural equations model, it was found that taste and texture have a direct impact on the quality perception of consumers during the actual intake at home. Although appearance and odour are substantially related to taste and texture judgments, there is no empirical evidence that these two product attributes directly affect consumer quality perception during dinner. A potential reason may be that the cook in the household is a co-producer of the final product. That is, she can improve a undesired appearance or odour within the cooking process. If consumers are seen as the golden standard for product evaluation, which is a common strategy for many food companies, the empirical results suggest that one should focus on a port-folio of product attributes rather than on a single attribute. More specifically, not only odour, but also texture and taste play a key role in the consumer quality perception of uncastrated boar meat.

Selection of the boars

To ensure that the entire range of potential uncastrated boars was considered in the survey, inline human nose scores were used as selection instruments. For each possible inline human nose score (ranging from 0 to 4) eleven boars were selected. The total number of boars used in the survey was 55.

Selection of the households

A total of 115 German respondents of eighteen years and older participated in the main study. ISI GmbH & Co. KG, a German research institute recruited respondents from a consumer panel, hereby ensuring that the participant was the regular cook in the household, the household consumed pork meat at least once a week, and the household normally purchased pork meat in a supermarket or from a butcher.

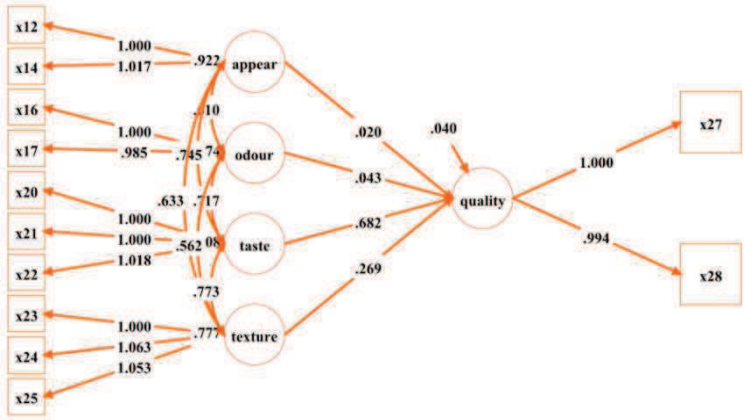

Figure 1. Graphic representation of a structural equation model

Effect on quality of	Loading (s.e.)
Appearance	.020 (.016)
Odour	.043 (.028)
Taste	.682 (.049)*
Texture	.269 (.038)*
*** significant (at the 1% level)**	

Table 1. Effect on quality

Experimental design

During their consumption of the pig meat, the participants were asked to respond to 12 importance statements about taste (x20, x21, x22 in the figure), texture (x23, x24, x25), odour (x16, x17), appearance (x12, x14), and overall quality (x27, x28) about the pork meat that the households consumed on a nine-point scale with 'completely disagree' and 'completely agree', 'very untasty' and 'very tasty', or 'very unpleasant' and 'very pleasant' on the extremes. Based on these item questions, the underlying constructs regarding taste, texture, odour, appearance and quality were measured and related to each other by means of a structural equation model. The structure is graphically depicted in figure 1.

Results of the survey

The empirical outcomes revealed that taste and texture have a substantial direct impact on the quality perception of consumers during the actual intake at home, but that the relation of which between appearance and odour is less manifest. The latter does not imply that such a relation is absent. Indeed, appearance and odour are related to taste and texture judgments (as is represented in the figure by a red ellipse). All in all, taste and texture play a key role in the consumer quality perception of boar meat.

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For quality of life

Quality perception of boar meat with high levels of androstenone and skatole in a home environment

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We explored the evaluation by untrained consumers in a home environment of boar meat with high androstenone and skatole levels. Meat was evaluated before, during, and after preparation by the cooks and after preparation by a family member during 5 successive weeks in which 2 times boar and 3 times gilt meat was tested. We found that the quality of boar meat with high levels of androstenone and skatole was rated lower than gilt meat, both cooks and family members rated boar meat lower. Androstenone and skatole sensitivity of the consumers were related to lower quality scores of boar meat.

Consumer evaluation at home

This research project aimed to determine how meat with high risk on boar taint is evaluated during cooking and consumption in a home environment. To determine whether preparation affects acceptance rate, the scores of the cook were compared with those from a family member.

Therefore 328 households judged gilt meat and boar tainted boar meat (selected with human nose scores and androstenone and skatole levels) according to the randomization scheme.

Boar versus gilt meat

Figure 2 shows the scores for the cooks on boar meat compared to gilt meat that is indexed on 100. Boar 1 indicates the first judgement of boar-tainted boar meat, and Boar 2 indicates the second judgment of boar-tainted boar meat. Boar meat was rated lower than gilt meat. Similar results were found for the family members. The scores of the second-time boar-tainted boar chops were significant and negative, comparable to the first-time measurements.

Sensitivity to androstenone and skatole levels

There is a relationship between the perceived odour and sensitivity for skatole and androstenone during cooking. 21.3% of the cooks was low sensitive for androstenone en skatole, 45.7% medium sensitive and 33.0% was high sensitive. High risk of boar-tainted boar chops were rated lower than gilt chops, and the scores for boar chops were even lower when the cook was highly sensitive to androstenone and skatole levels. Similar results were found after preparation and for both the cook and the family member.

	Baseline	Randomization			
Random experimental groups	Gilt	Gilt	Gilt	Boar	Boar
	Gilt	Gilt	Boar	Gilt	Boar
	Gilt	Gilt	Boar	Boar	Gilt
	Gilt	Boar	Gilt	Gilt	Boar
	Gilt	Boar	Gilt	Boar	Gilt
	Gilt	Boar	Boar	Gilt	Gilt
Control group	Gilt	Gilt	Gilt	Gilt	Gilt

Figure 1. Randomized scheme

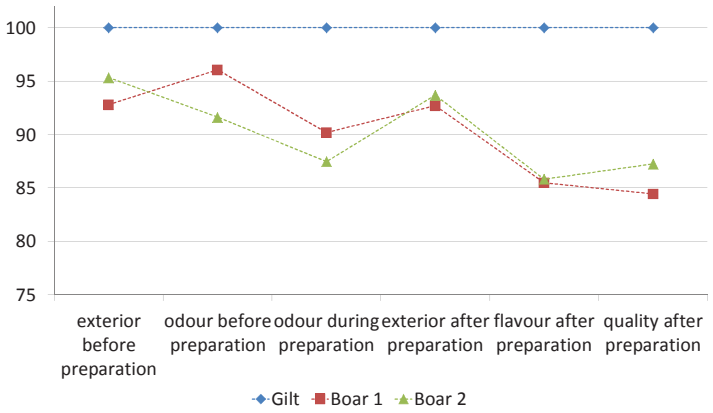

Figure 2. Boar meat compared to gilt meat

Application/Perspective

We do not find empirical evidence for adjustment effects, as the scores of the second-time boar-tainted boar chops were also significant and negative. The rating of gilt meat after a respondent has encountered boar-tainted boar meat was not significant different from the overall mean. We also find that 25.8% of the people is very sensitive to boar taint, and 45.7% medium sensitive what means that a substantial part of the population will identify boar taint. Both findings make fierce testing on boar taint necessary.

Acknowledgements

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For quality of life

Consumer odour perception during cooking and dinner: boars versus gilts

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In a field experiment, including 202 households in the Netherlands, the pig odour perception of consumers during cooking and actual consumption was studied. The participants ate loins, that were based on inline human nose ratings, one day a week for a five-week period. Each week they evaluated the meat they consumed. Using a random coefficient model to allow for potential differences between households, it was found that boars with a high risk for boar taint were rated lower on odour during cooking and dinner, and lower (i.e. more negative) on taste and overall quality. In addition, it was found that the product attribute of androstenone was a significant predictor of the odour rating during cooking, but not during dinner. This suggests that the impact of potential boar taint may be conditional on the phase in the meal preparation process of households. In the cases where households ate boars with a high boar taint risk more than once, it was studied whether there occurred learning effects in the evaluations of the meat. No such effects were found in the empirical study.

Selection of the boars

For this project, regular pork loins were used. The loins came from two sources: breeding animals from IPG and regular pigs from VION. Both uncastrated boars and gilts were used in the study. Male animals were selected by a team of more than ten trained assessors using the inline human nose method. For the boar meat pieces, adrostenone, skatole, and indole was measured as well. Because the boars may differ in these values. The gilt meat was assumed to have zero androstenone, skatole, and indole levels.

Selection of the households

A representative sample of 202 households in three areas of The Netherlands was recruited. The participants were regular pork meat eaters (at least once a week). Inclusion criteria were further that family members were willing to participate for 5 consecutive weeks. Respondents were told that the research was about evaluation of pork meat, there was no mention of boar taint or animal welfare.

	Week				
Group	**1**	**2**	**3**	**4**	**5**
1	Gilt	Gilt	Gilt	Boar	Boar
2	Gilt	Gilt	Boar	Gilt	Boar
3	Gilt	Gilt	Boar	Boar	Gilt
4	Gilt	Boar	Gilt	Gilt	Boar
5	Gilt	Boar	Gilt	Boar	Gilt
6	Gilt	Boar	Boar	Gilt	Gilt
7	Gilt	Gilt	Gilt	Gilt	Gilt

Figure 1. Experimental design

	Cooking	Dinner		
Explanatory variables:	**Odour**	**Odour**	**Taste**	**Quality**
Overall mean score	6.15 *	6.15 *	6.36 *	6.18
1st boar meat	-0.40 *	-0.74 *	-1.27 *	-1.07
2nd boar meat	-0.40 *	-0.91 *	-1.03 *	-0.89
Androstenone	-0.05 †	not sign	not sign	not sign
† significant at the 10% level; * significant at the 1% level				

Figure 2. Results

Experimental design

Figure 1 presents the experimental design. A household was randomly assigned to one of the seven groups, and could receive two boar tainted, and three gilt loins for one day a week during the five-week period. The household rated the meat products on odour during cooking and dinner, and on taste and quality during dinner. A random coefficient model was used to account for potential variation among households.

Results of the survey

The outcomes in the figure 2 show that boar tainted meat scored lower on odour, taste and quality scores, as compared to gilt meat, as is reflected by the negative signs in the table. For example, the overall odour score of gilt meat during cooking was found to be 6.15. When encountering boar meat for the first time, the score lowers to 6.17-.40-.05×(androstenone score). When encountering boar meat for the second time, the score is 6.17-.40-.05×(androstenone score), which appeared not significantly different from the first-time boar meat. Androstenone, rather than skatole or indole appeared to be a significant predictor of the odour score during cooking, but not during dinner. This can be explained by the fact that meat fat is heated during cooking, so that the taint could get away. In addition, no substantial differences between the first and second time of the boar meat evaluation was found. So, we do not find empirical evidence for enhanced or reduced learning effects among consumers.

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For quality of life

Consumer quality ratings of loins, chops, and belly during cooking and dinner

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In a nationwide survey among 120 Dutch households, it was investigated to what extent consumers perceive differences in the quality of three pig-meat types of uncastrated boars: belly, chops, and loins. The household were asked to prepare the meat products at home, one type a week, as a part of their regular main dish. A questionnaire was handed out, in which consumers were asked to score on quality statements about the odour of the meat product. Loins received the most high quality ratings, followed by chops and belly, respectively, as was the expectation. Further empirical findings indicate that there are not only variances in odour quality among the different types of meat, but also that these variances differ between the cooking and the actual intake during dinner. Indeed, consumers may change the perceived quality in the meal preparation process. They may therefore be seen as co-producers of meat quality

Selection of the boars

To ensure that the entire range of potential uncastrated boars was considered in the survey, inline human nose scores were used as selection instruments. For each possible inline human nose score (ranging from 0 to 4) eleven boars were selected. The total number of boars used in the survey was therefore 55.

Selection of the households

- The selected households ranged in size from 1 person (singles) to 4 household members.
- The selected household members ranged in age from 20 to 75.
- The selected households were regular pig meat eaters (at least once a week).

Research assessment

- The total number of participants that completed the questionnaires were 109 for loins and chops, and 99 for belly.
- The participants were asked to response to the statement: "The odour of this pigmeat is [very unpleasant-very pleasant]" on a 9-point scale, where 1 denoted "very unpleasant" and 9 denoted "very pleasant".
- The participant responded to this statement during cooking and during dinner.

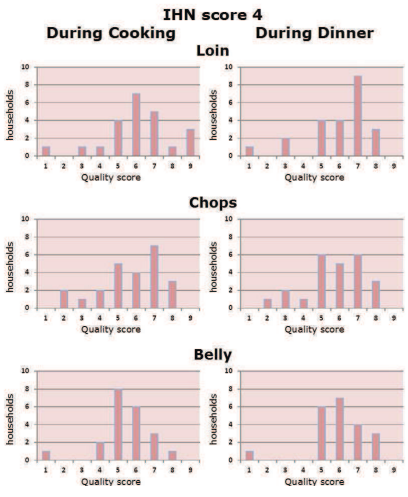

Figure 1. Frequency distribution of the households in their scores ranging from 1 to 9 for IHN 4

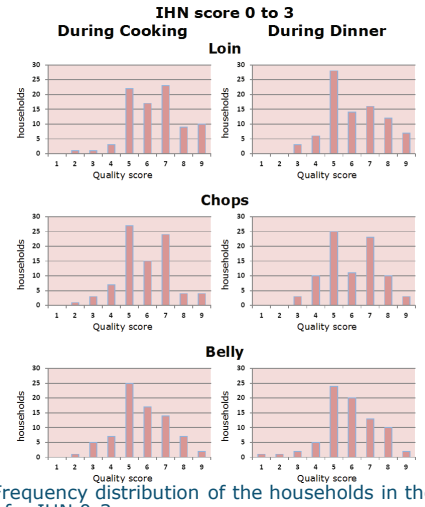

Figure 2. Frequency distribution of the households in their scores ranging from 1 to 9 for IHN 0-3

Results of the survey

The figures display the frequency distribution of the households in their scores of un-castrated boars ranging from 1 to 9. A distinction was made between the inline human nose score of 4 (IHN 4) and the inline human nose score of 0 to 3 (IHN 0 to 3). Overall, loins received the most high quality ratings, followed by chops and belly, respectively, as was the expectation. The frequencies between cooking and dinner differ substantially, suggesting that the households themselves may affect the odour quality perception. For example, by seasoning the product, or by removing fat during cooking. Furthermore, the boars with a IHN score of 4 show consumer score along the scale, ranging from 1 to 8. This suggest that even this type of meat may be appreciated by some of the consumers. Even more important, as compared to the IHN-4 scores, the IHN-0to3 scores show relatively more scores in the higher part of the scale, suggesting that concentrating out the IHN scores of 4 may be a defendable prediction for the aggregated consumer quality perception.

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For quality of life

Are there boar-meat market segments?

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In an international survey among 120 German and 120 Dutch households, it was investigated to what extent consumers perceive differences in the quality of three pig-meat types of uncastrated boars: belly, chops, and loins. The household were asked to prepare the meat products at home, one type a week, as a part of their regular main dish. A questionnaire was handed out, in which consumers were asked to score on statements about the odour and overall quality of the meat product. The consumer perception of meat quality is often considered as the golden standard for long-term market success. For pig-meat suppliers it is of interest to understand if the quality perception among German consumers differs from Dutch consumers. This study does not give empirical evidence that Dutch and German consumers can be seen as two distinct market segments in terms of cooking odour and overall quality perception.

Selection of the boars

To ensure that the entire range of potential uncastrated boars was considered in the survey, inline human nose scores were used as selection instruments. For each possible inline human nose score (ranging from 0 to 4) eleven boars were selected. The total number of boars used in the survey was 55.

Selection of the households

- The selected households ranged in size from 1 person (singles) to 4 household members.
- The selected household members ranged in age from 20 to 75.
- The selected households were regular pig meat eaters (at least once a week).

Household judgment of the boars

- The quality statements of each boar were based upon survey questions about odour during cooking and overall quality of the meat.
- Each boar was judged by 16 to 30 German and Dutch households.
- The households prepared and consumed the meat at home.

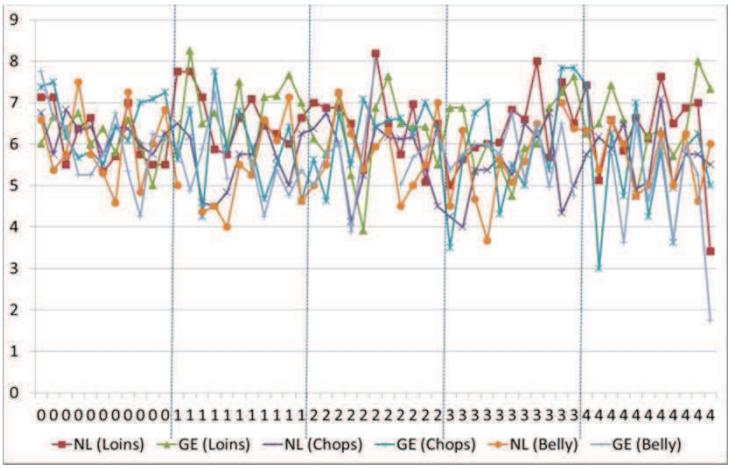

Figure 1. Quality scores of the households for 55 boars (inline human nose score 0 to 4, eleven boars per HNS score)

Segment	A (34%)	B (45%)	C (21%)	Total
Mean quality score	7.9	5.9	2.6	
Loins	46%	43%	11%	100%
Chops	27%	48%	25%	100%
Belly	31%	43%	26%	100%
NL	30%	53%	17%	100%
GER	37%	39%	25%	100%

Figure 2. Mixture model results

Results of the investigation

In addition, we considered the overall quality perception of the Dutch and German consumers. Using a finite mixture model, we superimposed three segments (A, B, and C) on the overall quality scores for the 55 boars. Figure 2 shows the mixture model results. Most quality scores (45%) are in the midrange of the 9-point scale (mean quality score of 5.9), followed by scores in an above-midpoint segment (34% with 7.9), and a below-midpoint segment (21%, 2.6). It is now of interest to see if a particular meat type has a higher probability to belong to one these three segments. The highest probability is 48% for Chops in Segment B. The frequencies, however, are not skewed enough to attribute a particular meat type to one of the three segments. In addition, we studied whether the frequencies of the Dutch and German consumers are distinctive across segments. Substantial percentages of both nationalities can be found in all three segments. It is however interesting to see that the German consumers scores (37%, 39%, and 25%) are more equally divided across the segments than the Dutch scores (30%, 53%, and 17%). The Dutch scores show the highest percentage for segment B (53%). This finding suggest that, at the national level, the German consumers have a more outspoken opinion about the quality of boar meat than the Dutch consumers. Finally, there is no empirical evidence that Dutch and German consumers belong to a distinct segment in the market in terms of overall quality ratings.

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For quality of life

What you read is what you smell

how product information affects consumer quality perception

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In a field experiment, including 190 Dutch households, it was studied how added product information affected the odour perception of pig meat. In the experiment, one half of the households received pig meat with a strongly aberrant odour, whereas the other half received pig meat with a non-aberrant odour. In addition, one part of the household received product information about the possibility of an aberrant aroma, another part received product information about animal welfare, and the remaining group of households served as a control group. In contrast, added product information lead to a lower appreciation of non-aberrant meat if the cook in the family was a outspoken quality seeker. So, the consumer response to offered pig-meat products can be seen as an interplay between the absence/presence of product information, the characteristics of the consumer, and the characteristics of the meat itself.

Selection of the boar meat sample

From a pool 55 non-castrated boars, boars were indicated as aberrant and non-aberrant meat on the basis of an inline human nose score, and consumer judgments of a related but a distinct research. We selected meat from a boar with strongly aberrant odour.

Selection of the households

The selected households were 2-person households in the municipal of Ede in central part of the Netherlands, that ate pig meat at least once a week, in which the cook ranged in age from 20 to 70.

Selection of the households

- Two types of product information were used: (1) information about the possibility of an aberrant odour; (2) information about animal welfare reasons for the non-castration of boars.
- The households were randomly distributed over six treatment groups, resulting from all possible combinations as can be seen in the Table.

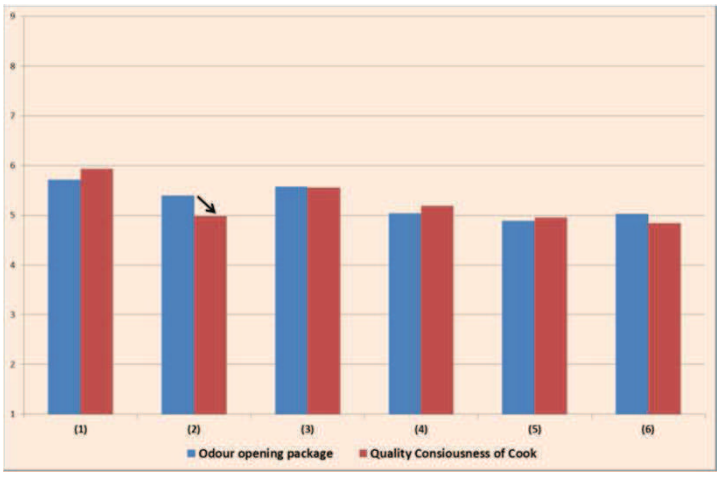

Figure 1. Quality scores of the households

Group	Treatment
(1)	**No aberrant odour, no product information, no animal welfare explanation**
(2)	**No aberrant odour, product information, no animal welfare explanation**
(3)	**No aberrant odour, product information, animal welfare explanation**
(4)	**Aberrant odour, no product information, no animal welfare explanation**
(5)	**Aberrant odour, product information, no animal welfare explanation**
(6)	**Aberrant odour, product information, animal welfare explanation**

Figure 2. Product information households

odour of this pig meat is [very unpleasant-very pleasant]" on a 9-point scale, where 1 denoted "very unpleasant" and 9 denoted "very pleasant".

- The participant responded to this statement twice: when opening the package and cooking the diner.

Results of the survey

The figure displays the quality scores of the households ranging from 1 to 9 (vertical axis) when opening the package. When the cook in the household scored higher on quality consciousness (a common scale used in consumer research), the quality perception of pig meat with a non-aberrant odour decreased as compared to other households. This is indicated by the arrow in the Figure. So, even in the absence of an aberrant aroma, product information about the possibility may already lead to a lower quality perception for a part of the consuming audience.

Acknowledgements

This research was conducted by Wageningen UR in cooperation with VION Food Group and TOPIGS Research Center IPG. It was funded by the Dutch Ministry of Economic Affairs and the Dutch Product Board Livestock, Meat and Eggs. More information can be found at www.boars2018.com.

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For quality of life

Consumer remarks about boar meat that would have been accepted for the market

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The performance of a specific pig-meat product inherently varies across the individual items that come out of the production process. Even if all available information indicates that a meat product is of very high quality, there is still a change of a major flaw when buying an individual item. As a consequence, a retailer and/or a food producing firm may always face consumer remarks about meat products. When these remarks are systematic, in the sense that meat products with specific characteristics lead structurally to consumer remarks, decision makers within the supply chain may wish to improve the within-firm quality system to reduce these remarks. Often, however, remarks appear seemingly unsystematic, and this may raise the question whether the remark is actually caused by a meat-product characteristic. In other words, whether the remark should be dealt with through communication or production lines.

Participants

To shed a light on this issue, the more than 300 households that participated in the various consumer studies within the current project, were explicitly given the opportunity to send emails to a specific email address, or to write down remarks on the hardcopy questionnaires. It is of interest, that none of these participants emailed any complaint during the sample periods, which often involved more than five weeks of commitment.

Many participants, however wrote down remarks, which contain very valuable information about the consumer response to un-castrated boar meat. It shows the complexity of a systematic approach in dealing with potential remarks, as the consumer opinions can differ dramatically regarding the same un-castrated pig.

Illustration

As an illustration, we provide citations of four consumers for a pig, which were derived from the field research among German and Dutch consumer in fall 2011. This boar, with a code number of 0002, would have been accepted for the market on the basis of the inline human nose score. Indeed, we could easily find a household that wrote down a compliment about the meat: "sweet odour". In contrast however, we also encountered more neutral judgments ("mayonnaise flavor" and "sugared apple turnover flavor") and even a complaint ("Nasty, as if it had been lying on a stove").

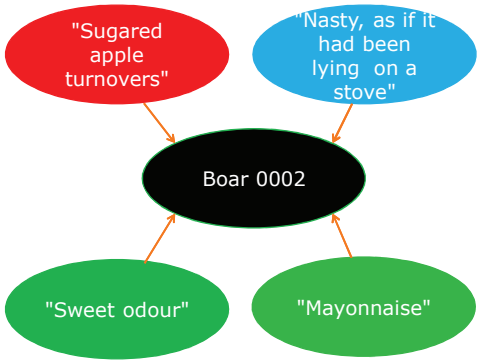

Figure 1. Consumer reactions when evaluating meat from boar 0002

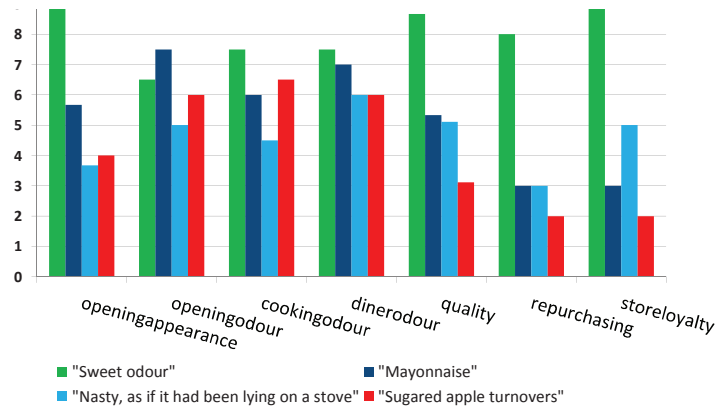

Figure 2. Meat scores Boar 0002 by four households

Conclusion

The second figure shows how these four households score the meat in terms of the visual appearance and meat odour when opening the package, the odour when cooking and consuming the meat, the overall perceived quality, the intention to repurchase similar meat again, and the loyalty to the store where the meat may potentially have been bought. All questions were measured on a nine-point scale, where a higher score represents a higher appreciation by the consumer. It is of interest to see how dramatically the results differ among consumers.

The figure indicates that this accepted meat is depreciated by some of the consumers. These observations suggest that in case of a complaint, a dialogue between the complaining consumer and the offering firm of retailer is an essential first step in uncovering the exact cause of the complaint. In one of the above cases, for example, one would like to know if the cook himself laid down the meat on a stove for a while.

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Consumer remarks about boar meat that would have been rejected for the market

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The performance of a specific pig-meat product inherently varies across the individual items that come out of the production process. As a consequence, a retailer and/or a food producing firm may always face consumer remarks about meat products. When these remarks are systematic, in the sense that meat products with specific characteristics lead structurally to consumer remarks, decision makers within the supply chain may wish to improve the within-firm quality system to reduce these remarks. Often, however, remarks appear seemingly unsystematic, and this may raise the question whether the complaint is actually caused by a meat-product or by a consumer-based characteristic. In other words, whether the complaint should be dealt with through communication or production lines.

Participants

To shed a light on this issue, the more than 300 households that participated in the various consumer studies within the current project, were explicitly given the opportunity to send emails to a specific email address, or to write down remarks on the hardcopy questionnaires. It is of interest, that none of these participants emailed any complaint during the sample periods, which often involved more than five weeks of commitment.

Many participants, however wrote down remarks, which contain very valuable information about the consumer response to un-castrated boar meat. It shows the complexity of a systematic approach in dealing with potential remarks, as the consumer opinions can differ dramatically regarding the same un-castrated pig.

Illustration

As an illustration, we provide citations of four consumers, which were derived from the field research among German and Dutch consumer in fall 2011, about a boar with a code number of 4050. This boar would have been rejected for the market on the basis of the inline human nose score. Indeed, we could easily find a household that wrote down a complaint about the meat: "sweat odour". In contrast however, we also encountered a more neutral judgments ("artificial fat odour" and "pistachio nuts flavor") and even a compliment ("fresh bread").

Figure 2 shows how these four households scored the meat in terms of the visual appearance and meat odour when opening the package, the odour when cooking and consuming the meat, the overall perceived quality, the intention to repurchase similar meat again, and the loyalty to the store where the meat may potentially have been bought. All questions were measured on a nine-point scale, where a higher score represents a higher appreciation by the consumer.

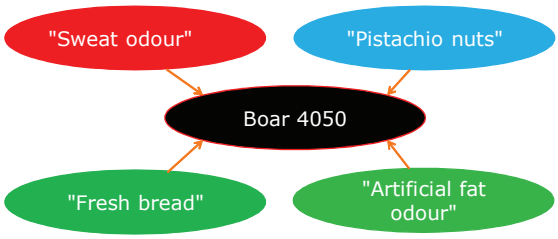

Figure 1. Consumer reactions when evaluating meat from boar 4050

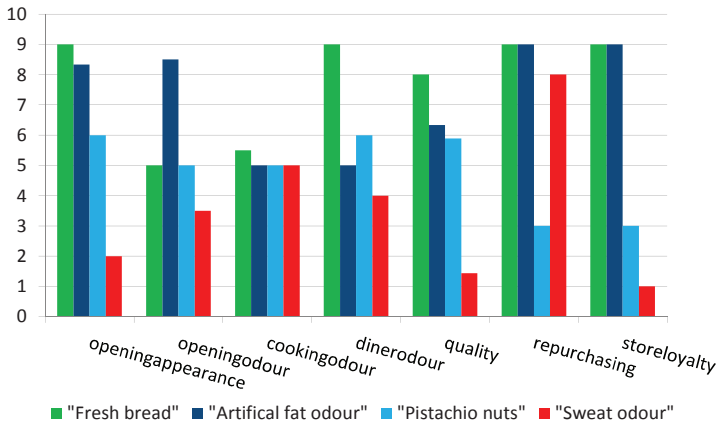

Figure 2. Meat scores Boar 4050 by four households

Conclusion

It is of interest to see how dramatically the results differ among consumers. For example, store loyalty varies from 9 ("Fresh bread" and "artificial fat odour" to 1 "sweat odour", the two extremes of the scale. The figure indicates that this rejected meat is appreciated by some of the consumers. These observations suggest that in case of a complaint, a dialogue between the complaining consumer and the offering firm of retailer is an essential first step in uncovering the exact cause of the complaint. In one of the above cases, for example, one would like to know if a "pistachio nut" flavor is actually a depreciation of the meat product.

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For quality of life

Home-test versus sensory lab test

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Consumer perception of tainted boar meat is essential in making decisions in pig breeding, husbandry, and in-line testing in slaughterhouses. In 5 years of research we tested boar meat in both sensory lab environments and home environments. At the start of the project we expected that a test in a sensory lab environment could approach the results in a home environment since it is easier to control the experimental environment and thus reduce measurement error. However, our studies showed that for tainted boar meat home tests seem to be more reliable for than lab tests. Probably this is because part of the distinguishing smell can be detected during cooking and home environments are more suitable for detection in this phase.

Methodology

From earlier research it is learned that the smell and taste of boar taint comes free during cooking and on prepared meat. In this project several consumer tests have been performed to test the consumer perception of tainted boar meat. In 2008 and 2009 lab tests have been done, in which consumers were asked to rate their perception of pre-prepared tainted boar meat and in which they were invited in the kitchen to rate the smell of the meat during cooking. In 2010 and 2011 home cooking tests have been done, in which consumers are asked to rate the exterior, smell, taste and texture of the meat before, during, and after preparation.

Home-test more predictive than sensory lab tests

Sensory lab tests resulted, although meat with high androstenone and skatole levels was presented, in only low - though - significant differences between tainted boar meat and gilt meat. Tests in the sensory lab kitchen did not show any differences in rating of liking of odour as well. This could be explained because these kitchens had industrial cooker hoods that when switched on take too much odour and when switched off lead to smells in the sensory lab.

In the home tests we learned that consumers perceived significant odour and taste differences during cooking and after preparation. The differences seemed more pronounced than in the lab tests while the androstenone and skatole levels were in the same range. Therefore we conclude that a home test is more predictive for the real experience of tainted boar meat than a sensory lab test.

Source: Wageningen UR

Source: Wageningen UR

Application and perspective

This research program shows that the test method for sensory tests has impact on the results regarding consumer perception of a food product. For a product like tainted boar meat a home-test gives a better insight in the consumer perception than a sensory lab test.

For companies and research institutes that seek for a untrained consumer reference it is important that meat or fat samples are tested in an environment that resembles the home situation.

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Boar taint: relevant attributes for consumer tests

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We explored which attributes are relevant for testing differences in consumer evaluation of boar meat compared to gilt meat. The hypothesis was that (tainted) boar meat would be rated different from gilt meat in appearance, odour, taste, and texture. We found that untrained consumers rated tainted boar meat as more juicy, but the scores for tainted boar meat on smell and taste were significantly lower compared to gilt meat. This sheet describes which attributes should be used in consumer tests the determine the liking of different types of pig meat: tainted boar meat and untainted gilt meat.

Lab and home tests to determine relevant attributes

Methodology. Boar taint is a specific odour that is expected to be detectable during cooking and after preparation. Therefore attributes have to be defined that measure whether tainted boar meat is having a significant different odour and taste. Both in technical lab tests and home cooking tests (from 2009 until 2012) attributes are tested that indicate the differences between boar and gilt meat in terms of smell, odour, colour, texture and other characteristics. In the first years lab tests have been done (2009, 2010), additionally in later years we conducted home studies (2010, 2011). The meat is selected by the HNS-method were meat with scores 3 and 4 (see sheet HNS) is selected as tainted boar meat.

Relevant attributes

Androstenone and skatole sensitivity. Androstenone and skatole as considered as important parameters of boar taint. Since earlier research shows that consumers differ in androstenone and skatole sensitivity a reference for the scores on odour and smell is needed. In our tests we operationalized this attribute by providing the respondents fat samples with high levels of androstenone and skatole, and letting them score the smell on the attributes attractive smell (very unattractive to very attractive on a 9-point Likert scale) added by a qualitative description of the smell.

Rating of the meat. For the attributes appearance, odour, taste, and texture the questions were posed on a general level (e.g how is the texture) and on a more specific level (e.g. how is the juiciness). This resulted in the following attributes.

The relevant attributes to describe the smell of boar taint are odour in general (very bad to very good, 9-point Likert scale), tastiness of the odour (very bad to very good, 9-point Likert scale), pleasant odour (very unpleasant to very pleasant, 9-point Likert scale) and strength of the odour (very light to very strong, 9-point Likert scale).

The relevant attributes for testing on boar taint taste are this meat has good taste, good quality, is sour, is juicy, is tender, is good chewable, has good fat content, has an attractive taste and is a good piece of meat (all on a 9-point Likert scale from totally disagree to totally agree). The relevance attributes for texture are fat content (very unattractive to very attractive on a 9-point Likert scale).

Procedure. In several tests a list of relevant attributes is determined for testing tainted boar meat in relation to gilt meat.

Source: Wageningen UR

Most relevant attributes in consumer tests

Consumers perceive hardly any differences on appearance of boar meat in relation to gilt meat and colour of boar meat. For introduction and getting started with the test these attributes are relevant to use.

Odour. On odour differences are detected by consumers who can detect androstenone and skatole. All attributes are relevant to use.

Taste. Taste differences between tainted boar meat and gilt meat are only found for consumers that are sensitive for androstenone and skatole. All attributes are relevant to use.

Texture. Boar meat in general seems to be more tender than gilt meat, but it´s structure is equal to the structure of gilt meat.

The attribute **leanness** is also relevant since the leanness of the meat has impact on the scores in general on the meat.

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For quality of life

Introduction of meat from entire male pigs in retail outlets

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Although boar taint detection methods provide a safety net to prevent consumers from experiencing boar tainted meat, the introduction of non-castrated boar meat by retailers calls for monitoring in order to minimize the risk of effects on consumer behaviour. Research in the Netherlands and other EU countries shows that consumers hardly complain if they are confronted with boar taint, but either choose a different meat product or go to another store. Since these effects are difficult to observe directly, thorough monitoring is needed to prevent impact on sales. The setup and logistics of a stepwise introduction and an early warning system is described below.

Determination of acceptable sales bandwidth

Before, during and after the introduction of the boar product, sales should be monitored. Before the boar products are introduced, the retailer collects data on both store and product level, such as turnover, volume, price elasticity of the product and its substitutes, seasonal adjustments, out of stock effects, and other potential sources of volatility in sales data such as price promotions. If possible, a number of comparable outlets (in terms of store size and consumer profile) are monitored, one of which is randomly determined to be the focal outlet in which the boar product will be introduced.

After a number of weeks (we propose 8 weeks) the sales bandwidth of the specific product can be determined. If no decline or increase outside the bandwidth occurs after introduction, a second, more risky product within three different outlets ensues. Again, sales should be monitored for a substantial number of weeks; if sales remain within the determined bandwidth, the introduction can be scaled up.

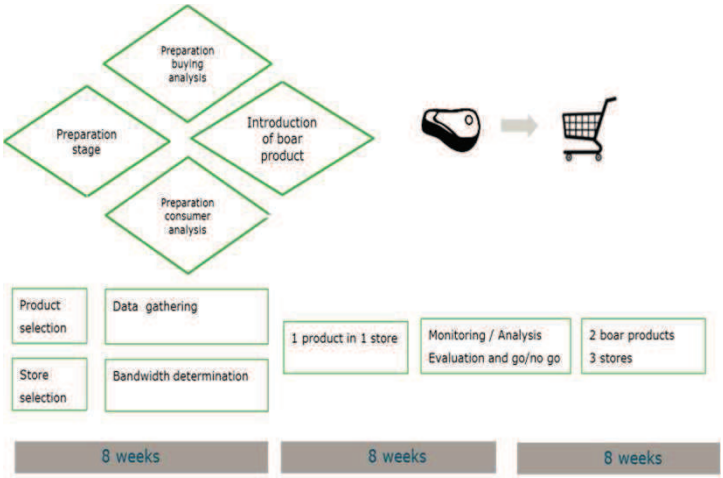

Figure 1. Schematic setup of retail introduction

Source: Shutterstock

Early warning system

A questionnaire on consumer acceptance, conducted simultaneously with the introduction of boar meat, may function as an early warning system for future sales fluctuations. To derive latent store-loyalty parameters, the inclusion of a quality perception questionnaire within a long term consumer panel is advisable.

In order to accurately predict a potential decline in consumer satisfaction, the questionnaire protocol should contain for example:

- choice of attributes of meat quality
- choice of psychological items
- consumer profile determination
- selection procedure of respondents
- communication protocol for store personnel
- distribution procedure
- setup of the statistical model

Together, the results of the questionnaire and the bandwidth provide a safety net for retailers introducing boar-meat products. A more extensive checklist and an example of such a protocol will soon be outlined at www.boars2018.nl/protocol.

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It's more than neckfat

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When we started research on tainted boar meat, the hypotheses of experts were that the strength of the boar taint would be stronger for the parts near to the head of the animal, since androstenone and skatole are both compounds that have higher concentrations in parts with more (intramuscular) fat. We found that the more fat in the product (belly in relation to the lean loin and chops) the less positive the score of the consumers. Next to that the more near to the neck of the animal (loin versus chops) the more positive/negative the scores of the consumers.

Methodology

In the first test in January 2009 we used shoulder loin in the consumer test. This was stopped in the other tests, because of unexpected side effects (to be explained below). After long discussion with international experts, in the following tests in September 2009, Spring 2010 and Autumn 2011 we used loin filets. Next to that in 2011 we used pork chops and belly, to find out whether more (intramuscular) fat effected the ratings of the consumers.

In all the tests within subjects designs were used in which every respondent was asked to rate all types of samples of the test. These samples were both untainted and tainted meat in different androstenone and skatole levels, and in 2011 each respondent rated the three different products that were included in the tests (i.e. from different parts of the same animal).

Lean versus more fat

Consumers in the Netherlands prefer lean meat in general. So when we started with shoulder loin in the first test in 2009, we learned that the negative scores were mainly related to the fat content and less to the fact that it was tainted boar meat. The next product after the neck would be loin fillet, which is more lean. Since androstenone and skatole are most found in the fat, this could implicate that the odour would be smelled less easy. Tests revealed however that the loins in general were rated as more attractive than the shoulder loin, and although loin is more lean the odour was still detected.

Source: VION Food Group

Figure 1. Types of meat

The question remained whether the odour would be recognised more easy in the more lean meat or in the more fat parts of the pig. Therefore we conducted the test described above, in which three products from different parts of the same animal were tested. This test learned that in products with higher fat percentages, the odour of boar taint was better detected during cooking and eating. Pork chops are rated more negative than loin. This implicates that the more fat the meat contains, the better boar taint is detected and the more near the neck the more positive/negative the meat is rated.

Application/Perspective

In case animals are detected as tainted by the in line neck fat test (human nose score), slaughter houses must be aware that consumers will detect this boar taint most in more fat parts of the animal. No relations were found between the distance to the neck and the detection of boar taint.

But what to do with tainted meat? Another test learned that consumers only detect very high percentages of taint boar meat in sausages. To prevent too high food waste, tainted meat can be used in production in sausages.

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Consumer perceptions on castration

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Twenty six focus group discussions were held in The Netherlands as a part of a consumer study in 2009. In this study, pork with boar taint, pork without boar taint and gilts were first presented to consumers to test the appearance, odour, taste and mouth feel of the prepared pork samples. Immediately after the hedonic session, focus group discussions followed.

Problem Statement

The major obstacle for a direct transition to non-castrate pork is the unpopularity of pork from non-castrated boars. Simply because boar taint may occur during preparation of the meat. Boar taint is generally considered an unpleasant, offensive odour with accompanying taste. Centuries ago castration was introduced to prevent this, but from a society's point of view castration of male piglets is becoming less accepted by the public.

Insight into current consumer perceptions is required and consequently an explanatory research study has been carried out.

Method

In total, twenty six focus group discussions with a total of 196 participants were held in three Dutch cities (Utrecht, Heerlen en Wageningen). The number of participants per focus group session was relatively low to provide for greater in depth discussion. Participants were recruited through a recruitment agency, and were excluded if they did not eat pig meat on a regular basis. Participants were recruited to represent variation in terms of gender, education, household composition, and age. They received monetary compensation for participation.

In the 1 hour discussion sessions a structured approach was chosen, with a focus on [1] castration, and the familiarity of participants with this subject and [2] the acceptance of castration by participants.

Some quotes concerning the acceptance of castration

"Yes, I agree. The odour is really predominating."
"Only if carried out neatly, I agree. So with the use of anaesthesia."
"No, not acceptable at all. There are all kinds of meat, why can't this be another, separate product group?"
"No, on the other hand I'll have to like the meat. If I have to choose between a tasty chop and a not tasty chop...."
"I don't really know what I need to find."

Source: focus groups consumer study (2009)

Source: Wageningen UR

Results

- The reactions of participants can be divided into those that indicated that castration is well-known to them and another part that says not to be familiar with castration at all.
- The level of knowledge of participants who indicated to be familiar with boar castration varies. The sources of information differ as well (e.g. through NGO's or childhood). From those for whom castration is not known, it appears that a number of participants already had an opinion about the subject.
- Not everyone had an (clear) image of boar castration, some do but others state that they do not know exactly. Some indicate that they have no idea. The representations that do exist relate basically to the act itself, the supposed odour and taste of the meat.
- According to the participants, the time needed to castrate a male piglet ranges from a few seconds to a couple of minutes.
- Castration is a subject that evokes emotions, which is shown by words like "horrible", "terrible" or "pityful".
- Male piglets are castrated to prevent boar taint. This fact is known to only a small number of participants, while most of the participants did not know about the reasons behind castration. In addition, most of the participants did not know that smell and taste have to do with it, or sometimes thought of another reason. Participant's views towards acceptance of castration varies widely, from "definitely" to "absolutely not" and everything in between.

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For quality of life

Predicting consumer quality ratings

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In an international survey among 120 German and 120 Dutch households, the consumer quality perception of 55 uncastrated boars was measured. The consumer perception of meat quality is often considered as the golden standard for long-term market success. For pig-meat suppliers it is of interest to foresee the quality perception *before* the product enters the market. A composite of quality measures is available, including the use of chemical lab tests, inline human nose scores, and representative consumer panels. Concentrating on odour as the main quality measure, it was investigated which composite of measures has the most predictive power. A combination of inline human nose, and consumer panel information gave the best results, demonstrating that for consumer quality perception, the selected human assessors work well as compared to chemical lab tests, even though the chemical lab test has the highest predictability.

Selection of the boars

To ensure that the entire range of potential uncastrated boars was considered in the survey, inline human nose scores were used as selection instruments. For each possible inline human nose score (ranging from 0 to 4) eleven boars were selected. The total number of boars used in the survey was 55.

Household judgment of the boars

- The quality statements of each boar were based upon survey questions about taste, texture, odour, and appearance of the meat.
- Each boar meat sample was judged by 4 to 6 households.
- The households prepared and consumed the meat at home.

Research assessment

- Five alternative models were considered using 45 randomly selected boars of the 55 boars: (1) only the mean quality score as predictor (benchmark model), (2) all inline human nose scores (IHNS model), (3) lab tests on androstenone, skatole, and indole (ASI model), (3) taste panel judgments (taste panel model), and a model with inline human nose score 4 (extreme aberrant odour) and sour taste (odour and taste model). The remaining 10 boars were used to investigate the forecast performance of the models.
- The fit indices were the R^2, which indicates how well the model can explain the variation in the observations, and the Bayesian Information Criterion (BIC), which indicates the trade-off between the goodness of fit and the number of predictors in the model. High R^2 and low BIC values are preferable. The predictability was measured by the Root Mean Squared Error (RMSE), which indicates the size of the forecast error. Low RMSE values are preferable.

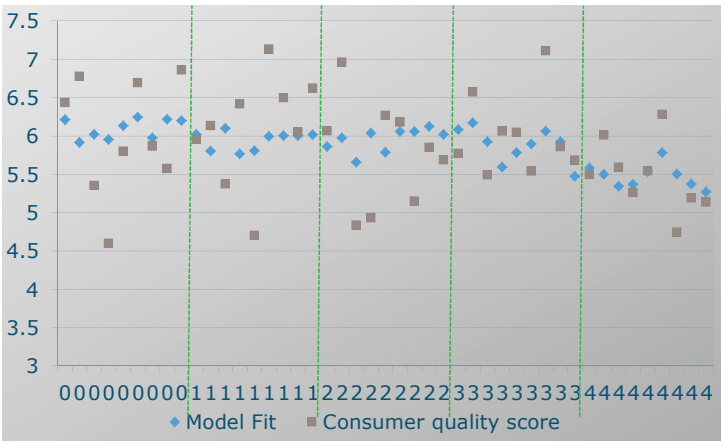

Figure 1. Consumer quality score and model fit

Model	R^2	BIC	RMSE
Benchmark	-	2.05	.69
IHNS	.12	2.26	.65
ASI	.08	2.22	.62
Taste panel	.13	2.42	.70
Odour and taste	.16	2.05	.66

Figure 2. Model explanation for variation

Results of the investigation

Figure 2 shows the model statistics. If we trade-off between fit and predictability, the odour and taste model performs the best. Its BIC is not higher than the benchmark model, its R^2 is the highest of all models, and its RMSE is lower than the benchmark and the taste model. In addition, all predictors in the odour and taste model were found to be significant following their t-values, which was not the case for the ASI and IHNS models. The above figure displays the consumer quality scores of the 45 boars and the odour-and-taste model approximation. The consumer quality score ranges between 4.5 and 7.5 on a 9-point scale, where 1 is the lowest and 9 is the highest quality, respectively. Visually, one can observe that the spread of the actual consumer quality scores around the model fit values is smaller for meat with a odour score of 4, reflecting the fit performance of the odour-and-taste model.

Acknowledgements

This research was conducted by Wageningen UR in cooperation with VION Food Group and TOPIGS Research Center IPG. It was funded by the Dutch Ministry of Economic Affairs and the Dutch Product Board Livestock, Meat and Eggs. More information can be found at www.boars2018.com.

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For quality of life

Pig meat quality perception of consumers

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The consumer perception of meat quality is often considered as the golden standard for long-term market success. For pig-meat suppliers it is therefore of interest to foresee the quality perception *before* the product enters the market. In one of our studies, it was found that a combination of inline human nose, and consumer panel information about the potential sour taste gave the best prediction of consumer quality perception.

For food companies, two target values may be of key interest. First, the firm has to decide what the targeted consumer-quality score of its products will be. One may, for example, wish to offer the complete quality range of products, but exclude the unacceptable ones from the offerings. Second, the firm has to decide what the appropriate within-firm prediction value of the target consumer-quality score will be. This second value may be based upon the trade-off between the costs and benefits of false negative and false positives. False positives occur when a firm excludes products from the market, which are actually acceptable in the perception of the consumers, and false negatives are unacceptable products which are actually offered to the consuming audience.

The figure below is an illustration of these practices based upon the empirical findings of the current project. In this illustration, the consumer quality score was based on a nine-points scale, and the within-firm prediction was based upon the above mentioned prediction model, with information about the inline human nose score and the sour-taste score of a consumer panel. The chosen consumer target value was 5.0, which is the midpoint of the scale. Within the figure, 45 un-castrated boars with consumer quality scores were plotted. A within-firm prediction score of 5.55, would, in this example, lead to the following decision calculus: 33 correctly accepted boars (panel B in the figure), 1 correctly rejected boar (panel A), 4 falsely accepted boars (panel C), and 7 falsely rejected (panel D).

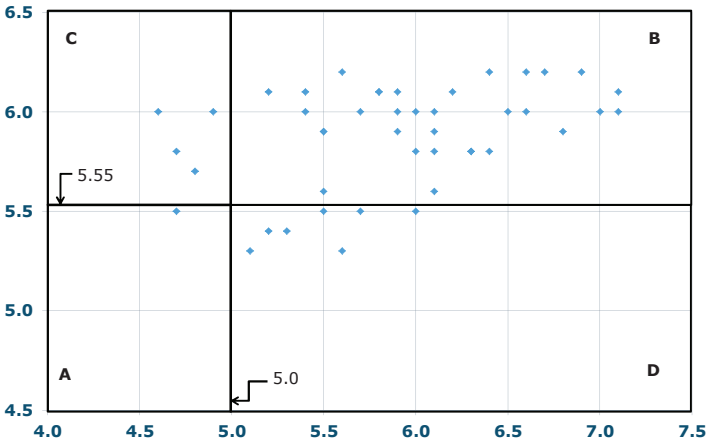

Figure 1. Illustrative example of decision calculus

	Correctly		Falsely	
Within-firm prediction score	rejected (A)	accepted (B)	accepted (C)	rejected (D)
5	0	40	5	0
5.5	0	36	5	4
5.55	1	33	4	7
5.75	2	31	3	9
5.95	3	21	2	19
6	5	12	0	28
6.25	5	0	0	40

Table 1. Illustrative example of prediction score per panel

Based upon the relation between the consumer quality scores and the odour and taste model, one can derive the expected number of boars in each panel (A, B, C, and D). This is given in the table for a consumer quality score of 5.0. Of course, in this illustrative example, the target values are hypothetical. In practice, they should be based upon a cost-benefit analysis of each of the sizes of the four panels A to D in the Table. Such a decision will have consequences for the positioning in a market, as it may please or irk the consumers. Optimizing the trade-off between pleased and irked consumers is well within the concept of market segmentation. Apart from this, it is of interest to see that the combination of both taste and odour is relevant for decisions about the acceptance or rejection of un-castrated boar meat.

Acknowledgements

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III Detection

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Sensory detection system for boar taint

Author: Coen van Wagenberg coen.vanwagenberg@wur.nl

A sensory detection system for boar taint to be used at the slaughter line was developed by Dutch companies and evaluated within the Dutch boar taint program "Stopping with castration of entire male piglets". The system is based on sensory assessment of all entire male carcasses by trained assessors at the slaughter line.

Characteristics of the sensory system

- A 5-point scoring scale with 0 for no detectable boar taint, 1 for no boar taint but some off odour, 2 for more off odour but no boar taint, 3 for some boar taint odour and 4 for strong boar taint odour;
- Heating of subcutaneous fat in the neck of the boar with a metal plate heated by a gas burner;
- Maximum half an hour of continuous assessment of carcasses by an assessor, after which a minimum of 15 minutes of resting is required;
- Maximum 1000 tests per assessor per day;
- A selection and training protocol with the following demands for potential assessors:
  - sensitive to androstenone and skatole (solutions);
  - training in a laboratory setting for on average 3 days, during which they should show satisfactory performance in assessing neck fat samples of real carcasses heated with a soldering iron by comparing their scores with those of a trainer;
  - training at the slaughter line, during which they show satisfactory performance in assessing neck fat of carcasses compared to a trainer;
  - the trainer is an experienced assessor;
- Daily control of assessor performance by monitoring the percentage of carcasses assessed with boar taint of each assessor and reinstruction or removal if performance is insufficient;
- At least weekly, quality assessment of each assessor by comparing scores of a random sample of carcasses between multiple assessors;
- Slaughter line speed of up to 650 pigs per hour;
- Located in the slaughter line after splitting before the cooling area.

Source: VION Food Group

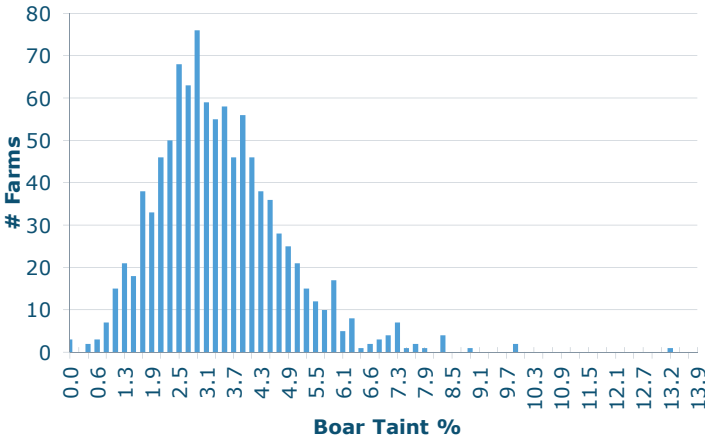

Figure 1. Detected deviant smell

Application in a commercial slaughterhouse

This sensory system is applied in large commercial slaughter houses in The Netherlands. The mean percentage of entire male pigs with boar taint per farm detected with this sensory system was around 4% in 2011-2013, with a spread from 0 to 10%.

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Relationship between human nose scores and boar taint compounds

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Consumers perceive boar taint through the unpleasant odour in pork from some boars when the meat is heated. However, boar taint is often measured through two malodour compounds, androstenone and skatole, mainly responsible for boar taint. Another approach is to heat the same fat samples and record the intensity of the boar taint as human nose scores (HNS), similar to the perception of consumers. This study was conducted to investigate the relationship between the two approaches.

Human nose scores

Samples of fat from 6574 intact males were collected after slaughter. The samples were then heated by a hot iron and scored by a total of eight panelists from the Topigs Research Centre IPG (Beuningen, The Netherlands) and one panelist from VION Food Nederland (Boxtel, The Netherlands). Each sample was scored by three panelists. The panelists recorded the intensity of boar taint on a scale of 0 to 4. They were asked to record 0 for no detectable boar taint, 1 for no boar taint but some off odor, 2 for more off odor but no boar taint, 3 for some boar taint odor and 4 for strong boar taint odor. In this way, they were asked to record scores 3 and 4 if they expected that those samples will be rejected by most consumers who can smell boar taint.

Boar taint compounds

In addition to HNS, the levels of two main boar taint compounds, androstenone and skatole were also determined for a subset of 5,025 of the animals. Some of them had more than 3 observations each for human nose scores. The levels of these boar taint compounds were determined through chemical analyses. The fat samples were initially analysed at the Norwegian School of Veterinary Science (NSVS) in Oslo, Norway and later at Co-operative Central laboratory (CCL) in Veghel, the Netherlands for both boar taint compounds. Necessary adjustments for lab differences were made in the statistical analysis.

Source: TOPIGS Research Center IPG

		Poly-serial correlations	
Panellist	N	Androstenone	Skatole
A	1763	0.34	0.32
B	1608	0.31	0.46
C	1280	0.38	0.47
D	1958	0.25	0.57
E	1603	0.32	0.57
F	2697	0.45	0.89
G	2483	0.34	0.54
H	903	0.55	0.56
I	2930	0.45	0.53
All	17225	0.35	0.50

Figure 1. Relationships between HNS and boar taint compounds. Source: Mathur et al. (2012) Meat Science. 91:414-422

Relationships

The relationship of HNS with androstenone and skatole was estimated by calculating polyserial correlations due to the categorical nature of HNS. As shown in the table, different panellists had different sensitivities to androstenone and skatole, very much like average pork consumers. In general, the correlations of HNS with skatole were higher than those with androstenone.

Implications for genetic selection

The relationships on the genetic level were even stronger. The genetic correlation of HNS with androstenone was 0.65 and that with skatole was 0.90, suggesting that genetic selection against boar taint using human nose scores is expected to substantially reduce the levels of the boar taint compounds as well.

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Compounds associated with boar taint: a GC-Sniff feasibility study

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Within the Dutch program "Stopping with castration of entire male pigs" a feasibility study was conducted at NIZO food research to identify more compounds than skatole, indole and androstenone related to boar taint. A GC-Sniff analysis on fried pig meat with and without boar taint was conducted. Several other compounds like toluene, butyric acid and 2,4-heptadienal were identified to be related to the boar tainted samples. Because this was only a feasibility study, the identification of other compounds requires further investigation.

Sample selection and preparation

The experiment was performed on a mixture of 4 meat samples with fat without boar taint and a mixture of 4 meat samples with fat with a strong to very strong boar taint. These samples were selected in a Dutch slaughterhouse using a human nose scoring system. All samples were fried in their own rendered fat in a frying pan.

GC Sniff

The three female panellists could identify 5 ppb skatole solution in water and 50 ppb androstenone solution in ethanol. They were made familiar with boar taint as perceived from fried meat samples with boar taint. The GC Sniff was carried out via a heated (200°C) and humidified sniff port, where the panellists received the GC effluent into the nasal cavity. The panellists were asked to push a button every time they perceived an odour associated with boar taint. This signal was recorded with the GC-MS data. The compounds that were identified in the sample with boar taint and not in the sample without boar taint were assumed to associated with boar taint.

Dynamic headspace sampling and MS identification

Dynamic headspace sampling (purge and trap) was used to extract volatile compounds from the samples by purging a helium gas stream through 10 grams of fried meat or 15 grams of fat at 100 °C for 90 min. The extracted compounds were trapped on absorption tubes containing Carbosieve SIII and Carbotrap. These compounds were thermally desorbed and separated on a GC column. The GC separation started at 40°C for one minute and then the temperature was raised with 6.5°C/min till 250°C. This final 250 °C was kept for another 6 minutes. The GC effluent was split to a sniff port and an MS in a ratio of five to one. The MS operated in scan mode over a mass range from 25 to 350 amu (1s/decade), with electron impact at 70 eV. The compound structures were assigned by retention time index, odour description and MS spectrum interpretation and comparison of the spectra with bibliographic NIST/EPA/NIH Mass Spectral Library and Wiley Mass Spectral Library.

Figure 1. Source: NIZO Food Research

Compounds associated with boar taint with GC-Sniff and GC-Sniff description of the compounds

Compound	GC Sniff description
2,3 dihydro-5-methylfuran*	boar taint, urine
toluene	boar taint, sweaty, urine
isovaleric acid +unknown*	boar taint, sweaty, cheesy
5-methyl -3-heptene-2-one*	boar taint, mousy, skatole
cis-2-nonenal*	barn, cardboard
indole	boar taint, skatole, sweaty
skatole	boar taint skatole, urine
butyric acid	boar taint, sweaty (feet)
2,4 heptadienal	fatty, sweaty
propene thiol*	boar taint, barn
N-N compound	boar taint, mousy
branched pyrazines	boar taint, mousy, barn

* possible compound, further investigation required

Table 1. Compounds with boar taint with GC-sniff and GC-sniff description of the compounds

Results

The table shows the compounds that were associated with deviating odour in the samples with boar taint and not in the samples without boar taint. It also provides the sensory description given by the panellists. These include skatole and indole. Androstenone was not identified due to the used conditions of dynamic headspace and GC analysis. This supports the hypothesis that more compounds than androstenone, skatole and indole are involved in the perception of boar taint by humans. Because this was only a feasibility study, the identification of other compounds requires further investigation.

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Feasibility IMS Electronic Nose for Boar Taint Detection

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In the Dutch National Program "Stopping with castration of male pigs" a feasibility study was conducted to detect Boar Taint compounds Androstenon and Skatole by an Electronic Nose, based on Ionisation Mass Spectrometry (IMS). The feasibility study took place in the period April – September 2011 in close cooperation with the French research institutes IFIP and INRA and a commercial supplier of IMS equipment.

Primary Objectives Study

The overall research objective was to develop a device that can detect boar taint in a slaughterhouse environment with the following desired performance:

- Detection of "boar taint" as Androstenon at 1 ppm and/or Skatole at 0.25 ppm;
- Can be measured online at a speed of maximum 3 seconds;
- Can be measured from ½ carcass in the back fat area with a combined heater/sampler device.

The first phase of the program was a feasibility test that indicates that both compounds are detectable as pure compounds, and molecular ions or logical breakdown product signals. Fat samples of boars from Dutch and French farms were used. The Dutch fat samples were provided with sensory scores (Human Nose Score) and compound concentrations of Androstenon and Skatole in melted fat extract.

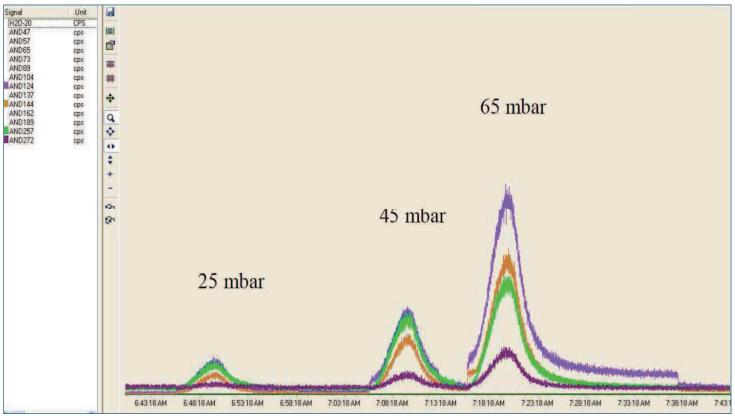

Figure 1. Androstenon samples analyzed with different sample pressures

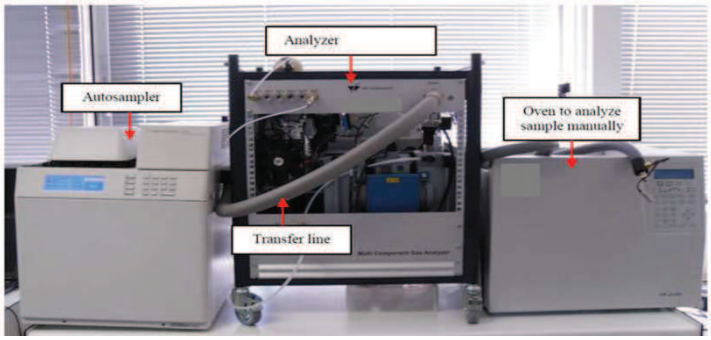

Figure 2. Equipment used during the Feasibility Study

Detection Androstenon and Scatole by Electronic Nose (IMS)

Main conclusions of the feasibility study to detect Boar Taint compounds by an Electronic Nose based on IMS:

- At optimized IMS conditions (for example headspace temperature and pressure) both Androstenon and Skatole can be detected in headspace as pure compounds or in MeOH solution at the detection limit required;
- As pure compounds and at optimized IMS conditions Skatole is detectable within 10 seconds. Androstenon however is detectable at approximate 5 minutes;
- When switching to the analysis of spiked fat, it is obvious that the fat matrix has a very important retention factor on both molecules. Moreover, in the fat matrix are interferences with other molecules on the marker peaks. These interferences are variable even within the same piece of fat;
- With the currently available configuration the IMS Electronic Nose is not meeting the requirements of online application at slaughterhouses. More research regarding the fat sampling and processing conditions are needed to develop an accurate and quick electronic detection method.

Acknowledgements

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Trained analytical sensory panel for boar taint

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If a trained analytical sensory panel can replace consumers as the reference benchmark for boar taint, it may help to assess the accuracy of boar taint detection systems at the slaughter line, such as trained assessors. Such a panel was developed in cooperation with Essensor in Ede, the Netherlands. Protocols for establishing and functioning of the panel were established. Consensus between panellists was unfortunately found to be insufficient to replace consumers by the trained analytical sensory panel.

Selection of panellists

- A group of consumers were preselected based on their sense of smell according to ISO 8586.
- Panellists were to identify different concentrations in water of androstenone (0.01, 0.1, 0.5 and 2.0 ppm) and of skatole (0.001, 0.01, 0.1 and 0.5 ppm).
- Selected panellists had to at least give two out of three correct answers on a R-index difference test for the lowest androstenone and skatole concentrations.
- 12 female panellists were selected.

Training of panellists

- Group session 1: Establish a gross list of attributes for boar taint by individual attribute generation.
- Group sessions 2-4: Reduce gross list to final attribute list with iterative procedure of evaluation and discussion.
- Trial measurement session 1: Test final attribute list.
- Group sessions 5-6: Further train panellists and reach consensus about final attributes.
- Trial measurement session 2: Test final attribute list.

Attribution of the variance in panellists' score on an attribute to boars, panel members, interaction boars-panel members and the pieces of meat (residue).

Attribute	Boars	Panel members	Interaction boars-panel members	Meat (residue)
Odour above plate				
Intensity	3.0%	49.5%	1.6%	46.0%
Fat	0.5%	48.2%	0.0%	51.4%
Baking	0.3%	24.4%	0.0%	68.1%
Skatole	13.9%	15.6%	2.3%	69.2%
Androstenone	16.9%	9.4%	4.5%	75.2%
Odour in booth				
Intensity	2.6%	68.0%	2.7%	26.7%
Pig meat	0.1%	73.9%	1.8%	24.3%
Baking	0.3%	61.6%	1.7%	36.3%
Skatole	18.7%	18.8%	7.2%	55.4%
Androstenone	15.1%	25.3%	9.9%	49.7%
Taste in booth				
Intensity	2.3%	63.8%	3.3%	30.5%
Fat	2.3%	29.4%	2.6%	65.6%
Sour	2.8%	53.4%	2.2%	41.5%
Skatole	13.3%	20.0%	15.5%	51.2%
Androstenone	18.1%	24.9%	13.7%	43.2%

Figure 1. Attribution of the variance in panellists' score on an attribute to boars, panel members, interaction boars-panel members and the piece of meat (residue)

Source: Essensor

Experiment with the trained analytical sensory panel

To identify if a trained analytical sensory panel could replace consumers as a reference benchmark for boar taint.
Heating of pieces of loin of 55 boars without seasoning and without oil on a baking plate at 180 °C under a cooker hood at highest suction level.
Each boar was assessed three times by each panellist.
Each panellist assessed odour above the baking plate and odour and taste in a booth.
Each attribute was assessed on a continuous 0 to 100 scale.
In a booth, panellists had water and crackers to neutralize their senses.

Results of experiment

The table shows how the variation in panellists' score on each attribute was assigned to boars, panel members, interaction between boars and panel members, and meat samples. The more variation is assigned to boars, the better the attribute can distinguish boars without boar taint from boars with boar taint. The variation assigned to boars was highest for attributes androstenone and skatole, but even for these the variation assigned to boars was low. In this experiment, consensus between panellists was insufficient to replace consumers by a trained analytical sensory panel.

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Assessor fatigue during sensory detection of boar taint

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A sensory detection system for boar taint to be used at the slaughter line was developed by Dutch companies and evaluated within the Dutch boar taint program "Stopping with castration of entire male piglets". The system is based on sensory assessment of all entire male carcasses by trained assessors. When the nonstop assessment of carcasses by the assessors selected for this experiment does not exceed one half hour, fatigue does not play a role in their judgement.

The sensory detection system

In the detection system, a person heats subcutaneous fat in the neck of the boar with a metal plate heated by a gas burner and smells if the carcass has boar taint. A 5-point scoring scale is used, with 0 for no detectable boar taint, 1 for no boar taint but some off odour, 2 for more off odour but no boar taint, 3 for some boar taint odour and 4 for strong boar taint odour. Assessors are only allowed to assess carcasses for a maximum of half an hour nonstop. After this period a minimum of 15 minutes of recovering is required. On a daily basis, assessors judge boars for a maximum of four hours. The slaughter line speed is up to 650 pigs per hour and the detection system is located in the slaughter line after splitting before the cooling area.

Research question and data

If people perform a certain assessment task too long, they can become tired so that their judgement may become insecure. Therefore, in a commercially system, assessors need to be replaced prior to the moment that such changes occur. We analysed if assessors in a commercial slaughter house in the Netherlands showed a change in their scoring performance for boar taint in the half hour they continuously assess carcasses for boar taint.

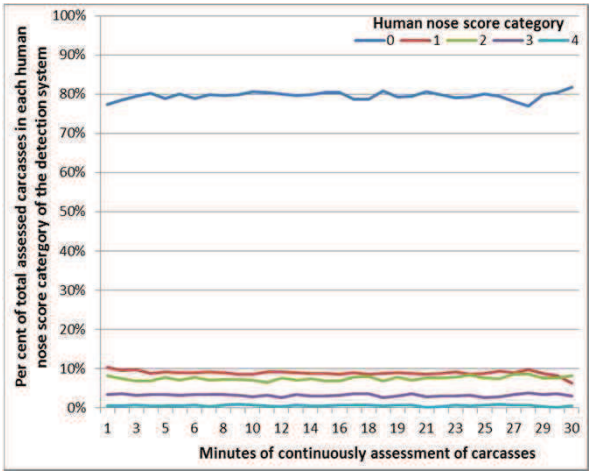

Figure 1. Percentage of carcasses assed in the 5 categories of the human nose score

Source: VION Food Group

Fatigue does not occur within 30 minutes

The figure presents the percentage of carcasses assessed in each of the 5 categories of the human nose score. The percentage of carcasses in each of the five categories remained stable for 30 minutes of continuous assessment of boar carcasses. This indicates that in the half hour of nonstop assessment no fatigue of the selected assessors occurred.

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Human Nose Score - assessor protocol

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The inline human nose score (HNS) is a fast instrument to detect boar taint. Assessors score heated neck fat samples at the slaughter line on a 5-point scoring scale. Strict quality controls and a thorough selection and training protocol for assessors are key to the performance of the HNS system. Therefore a standardized protocol for assessor training, testing and system feedback has been developed.

Training the assessor

The training protocol consists of a number of steps. First, potential assessors are tested and selected for sensitivity to androstenone and skatole. During the laboratory training, assessors should show satisfactory performance in assessing neck fat samples of real carcasses heated with a soldering iron. Their scores (with 0 for no detectable boar taint to 4 for strong boar taint odour) are compared with those of a trainer.

Training is repeated until no improvement in precision is observed. After that the training continues at the slaughter line. In total several weeks of training at in the lab and at the slaughter line is needed, although more might be necessary to reach adequate performance levels.

Training is repeated every 3 months.

Testing the assessor

Throughout and after the training procedure, the assessors are monitored on specific performance measures. These include:

- Accuracy, the percentage of correctly determined scores
- Precision, the percentage of correctly identified samples with score 3 or 4

Source: VION Food Group

Source: VION Food Group

System feedback

Gauging the system is important for the performance and validity over time. At the system level a number of parameters to be monitored is defined. The data quality should be good enough for time series analysis to ensure the detection of systematic failures.

Data include checks for satisfying procedural and logistic steps (IKB/QS); sensitivity; specificity; repeatability and reproducibility (assessor variance) of the system.

Finally, in a *what if* scenario specifications for preventive or corrective measures on all levels are described.

- Tester based: a threshold below which the assessor is retrained
- System based; if the reproducibility falls below a certain threshold, the assessors are retrained
- Batch-based; if an unusual percentage of boars has a high score, the farm should be given notice;
- Systematic failure detection

Summarizing, a HNS protocol and system feedback can be used to detect the influence of individual assessors on the system; to report to individual farms on their progress over time in minimizing boar taint; and to maintain a reliable detection system. A more extensive checklist and an example of such a protocol will soon be outlined at www.boars2018.nl/protocol.

Acknowledgements

This research was conducted by Wageningen UR in cooperation with VION Food Group and TOPIGS Research Center IPG. It was funded by the Dutch Ministry of Economic Affairs and the Dutch Product Board Livestock, Meat and Eggs. More information can be found at www.boars2018.com.

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WAGENINGEN UR
For quality of life

What is the reproducibility of the human nose testers?

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An actual operating quality system for preventing consumers to being confronted with boar taint is the inline human nose score approach. In this approach, a tester judges a sample of boars on the basis of heated neck fat to select out boars with an aberrant odour. In a series of two experiments, the reproducibility of such testers was investigated. It was found that for three testers the reproducibility was about 9% of the total variation in boar meat judgments. This results indicated that selecting of testers is may be more important than increasing the judgment time from 7 to 14 seconds. The advocated approach may guide improvements on the precision of the inline human nose system as a quality instrument within the meat industry, and thus contribute to a better offered quality.

R&R gauge experiment

A key question regarding the precision of a quality system is: "Would another tester give the same score to the same boar?" This is a question about the reproducibility of the testers. A natural way of answering this question is the use of a so-called repeatability and reproducibility-gauge experiment. In such an experiment, one decomposes the total variation of the pig meat products into a repeatability (or, random error), a product, and a reproducibility (or: tester) variation. Within the context of our study, we performed an R&R gauge-experiment.

Selection of the boars

The boars were selected on the basis of a two tester judgment using inline-human nose scores. The boars were classified as having an non-deviant odour, and having a deviant odour. One hundred boars were selected: eighty boars with a non-aberrant, and twenty with an aberrant odour.

Design of the R&R gauge experiment

The individual boar meat items were scored by three testers in a random order. The three testers worked in the same room, standing next to each other. They could not see each other's scoring judgments. Two main experiments were executed. In the first one, the time to judge for each tester was fourteen seconds, in the second one, it was seven seconds. Each tester judged each boar three times, in a random order (unknown to the testers). The testers heated the meat themselves and assessed the odour of the melted fat. The melted neck fat was cut off after each run. In sum, the design resulted in 900 observations as is shown in Figure 1.

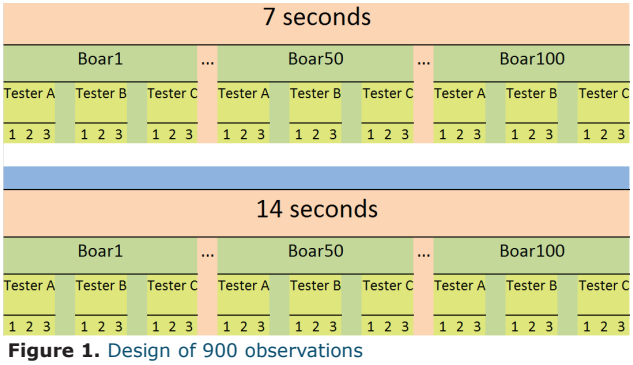

Figure 1. Design of 900 observations

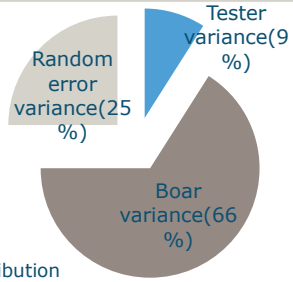

Figure 2. Frequency distribution

Results of the investigation

For the seven seconds case it was shown that the repeatability was significant and about 9% of the total variance, as is displayed in the pie chart. Further, a large portion of the spread in judgments could be attributed to the spread of individual items, i.e. repeatability(25%). So, it is of interest to investigate if an improvement of the measuring system, would decrease this measure, and thus improve the precision of the system. Note that, ideally, one would have both these variances to be equal to zero, so that all observed variation is indeed boar-meat variation. In the second experiment, when the testers were given more time for their judgment (14 seconds), the tester variance diminished to 0%. So, the reproducibility became maximal.

Studying the score frequencies of the hundred samples showed that in 81% there was agreement about the aberrant versus non-aberrant nature of the boars. The fourteen seconds experiment shows an almost similar percentage of 79%. Further analysis focussed on the disagreement of score 4 versus all other scores. For the 7 seconds case 3.0% of comparisons showed disagreement, compared to 2.3% for the 14 seconds case. In 15 of the 16 cases of disagreement this was related to one (and the same) tester. The other two testers were in close agreement. Although care must be taken in the interpretation, as a limited number of three testers were investigated, the preliminary results indicate that the selection of testers may be more important than increasing the judgment time from 7 to 14 seconds.

For reducing the proportion of false negatives and positives one needs to know what portion of the variation can be attributed to tester reproducibility, measurement errors, and the boars themselves, so that one can opt for the most effective actions for detection improvement. This is complex task, for which an R & R gauge may be a useful tool. It is important to notice that such actions are related to the precision, but not the accuracy of the detection system, as the latter involves a "golden standard" target setting. In principle, the advocated R&R gauge approach reveals, although, implementation may be difficult, how much improvement upon the actual quality system may theoretically be possible.

Acknowledgements

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Feasibility of detecting only strong boar taint odour

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The research question addressed is whether designating only strong boar taint odour as boar taint is a possible decision rule without compromising on quality and consumer complaints. We address this by an analysis of available data from a consumer survey from late 2011 and an analytical panel of 2012.

Perception of boar taint

A sensory detection system for boar taint to be used at the slaughter line has been developed. The system is based on sensory assessment of all entire male carcasses by trained assessors at the slaughter line.

For boar taint detection a 5-point scoring scale is applied with 0 for no detectable boar taint, 1 for no boar taint but some off odour, 2 for more off odour but no boar taint, 3 for some boar taint odour and 4 for strong boar taint odour.

Key questions are (1) whether the assessment of consumers of pork from boars with an taint score 3 differs from that of boar taint score 4; (2) whether pork from boars with taint score 3 is acceptable; and (3) Do attribute scores of the panel differ with boar taint score 4 versus a 3-4 score?

Perceived quality of meat with boar taint score 4 is significantly lower than for meat with boar taint score 3 (Figure 1). These results are in accordance with the expectation that perceived quality is lower because the meat's odour is more aberrant. At score 3 it is more ambiguous whether the meat's odour is aberrant from lower boar taint scores and therefore the quality perception may be less deviant from lower boar-taint scored meat. In Figure 1, the consumer perceptions of meat samples with scores 2 to 4 are given. In addition, the total perception scores (i.e. the overall mean of all meat samples ranging from score 0 to 4) are included as a benchmark. As can be seen in the figure, score 3 meat always scores more positively (higher) on the various attributes, and its quality score is even above the overall perception score. So, there is empirical evidence for a key discrepancy between score-3 and score-4 meat.

The values of androstenone, skatole and of sour taste increase from score 0 to 4, with score 4 being a clear outlier. The difference between 4 and 3 is significantly ($p<0.05$) larger than between 2 and 3 (Figure 2).

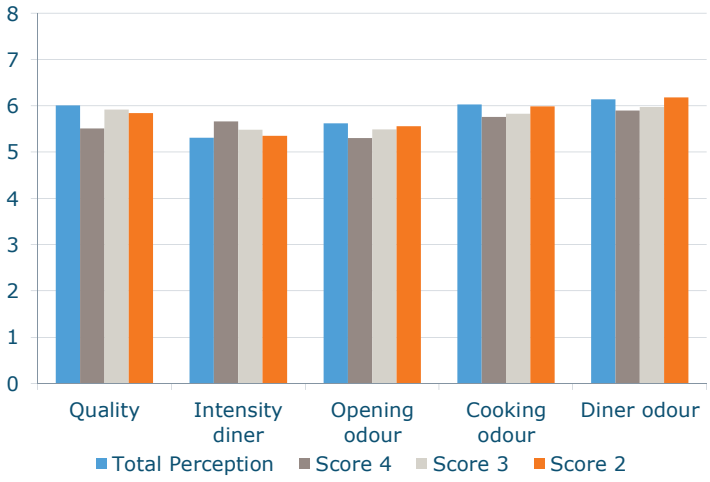

Figure 1. Consumer perception of boar taint

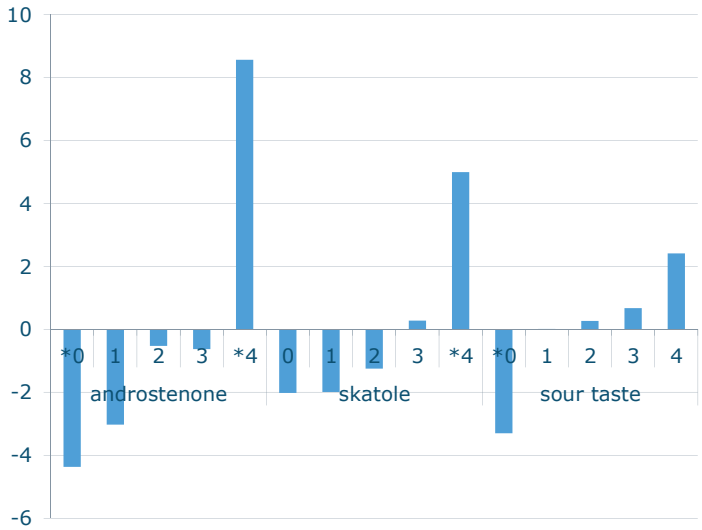

Figure 2. Attribute scores of panel

Results and recommendation

Results are consistent with the finding that odour score 4 leads to a different quality perception. Meat with odour score 3 is more ambiguous, as its difference with odour score 2 is much more limited, and as its quality perception was not lower than score 2. (In the sample, the score was even higher, albeit non-significant).

It is recommended not to use pork meat with odour score 4 pigs for the fresh meat market. Whether to discard also score 3 pigs from the fresh meat market will depend for what market is produced, and the inclusion criteria applied in these markets.

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Predicting consumer perception of meat from entire male pigs with different boar taint detection systems

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Any detection system should predict consumer perception as good as possible. We evaluated three boar taint detection systems: sensory assessment of odour at the slaughter line by trained experts, chemical analysis of neck fat on androstenone, and chemical analysis of neck fat on skatole. The sensory assessors were sensitive to androstenone and skatole and received extensive training. The maximum time for continuously assessment was half an hour and the line speed was 600 pigs per hour.

Consumer perception of odour was measured during preparation and during eating, the perception of taste during eating, and the overall quality in a representative sample of 120 Dutch and 120 German households. Of 55 entire male pigs – with a large variation in boar taint level – we measured the human nose score at the slaughter line and androstenone and skatole levels.

Ranking consumer perception

We ranked the entire male pigs from lowest to highest odour, taste and overall quality perception of consumers. The entire male pigs with the lowest values have the highest risk of negative consumer experience. These pigs need to be identified to be excluded from the market (if this low quality is deemed too low). If a boar taint detection system could predict the same rank order as consumers do, then these entire male pig carcasses at the bottom end can be identified accurately. Therefore, we investigated which of the three boar taint detection systems resulted in the most similar rank order of the entire male pigs compared to the rank order of consumer perception. We measured similarity of the rank orders with Kendall's W. This non-parametric statistic is also known as Kendall's coefficient of concordance. It is a normalization of the statistic of the Friedman test, and can be used for assessing agreement among assessors. Kendall's W ranges from 0 (no agreement between rank order) to 1 (complete agreement).

The table shows the results of the pig rank order comparison between consumer perception and the selected boar taint detection systems. For all consumer perception attributes Kendall's W was the highest for the sensory assessment at the slaughter line, indicating that in this comparison the Human Nose Score is the best predictor of the rank order of consumer perception of the three. This is under the condition of using well trained boar taint assessors and appropriate procedures on the length of the testing period. Chemical analysis of skatole was the second best and chemical analysis of androstenone last.

Source: VION Food Group

Consumer perception attribute	Boar taint detection system	Kendall's W	P-value
Odour perception (opening, backing, diner)	HNS	0.63	0.092
	AND	0.50	0.482
	SKA	0.56	0.263
Taste perception diner	HNS	0.66	0.055
	AND	0.49	0.532
	SKA	0.57	0.22
Taste + odour perception (opening, backing, diner)	HNS	0.65	0.064
	AND	0.51	0.428
	SKA	0.58	0.186
Overall quality perception	HNS	0.65	0.065
	AND	0.49	0.510
	SKA	0.58	0.198

Table 1. Comparison between consumer perception and the selected boar taint detection systems

Perspective

The sensory assessment of odour at the slaughter line by trained experts is currently one of the two commercially available methods to predict the boar rank order by consumer perception. Although room for improvement remains and still a substantial amount work needs to be done. For all four attributes Kendall's W had significant values.

Acknowledgements

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Boar taint in neck, belly and ham fat

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An assessment was done whether boar taint and boar taint compounds are the same in neck fat, belly fat and ham fat. The neck fat is most frequently used to assess boar taint. This experiment shows that the neck is preferred over the belly for reasons of convenience. The sensory data suggest that the ham fat may be a less sensitive sampling place for boar taint detection in entire male carcasses

Materials and Methods

300 boars were selected in 3 slaughterhouses, based on an in-line boar taint score. Fat samples from the cutting side of the neck, the belly and from the ham at dorsal side were collected by excision of fat and skin. From a subset of 75 boars Androstenone and Skatole analysis were done at CCL – Veghel (boars originated from 16 farms). The 3 fat samples from all 300 boars were tested "at-line" by 5 testers with the HNS-method. The median scores of 5 testers were used to compare the results at the different sides. Statistical analysis of the Androstenone and Skatole levels with log transformed data with GLM - method with excision part as fixed and animal as random effects.

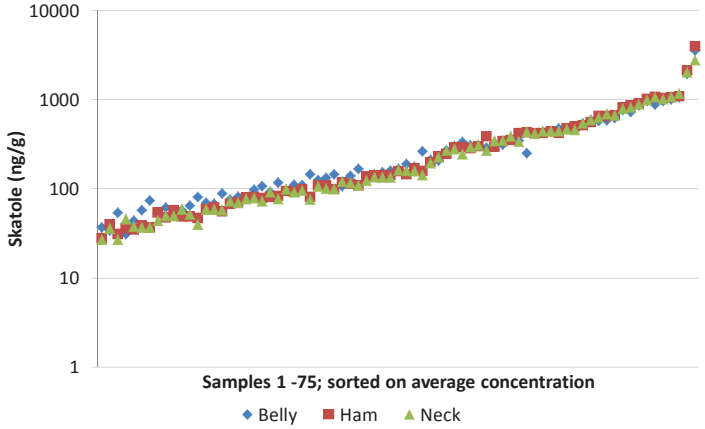

Figure 1. Skatole levels in Neck, Belly and Ham fat (n=3*75)

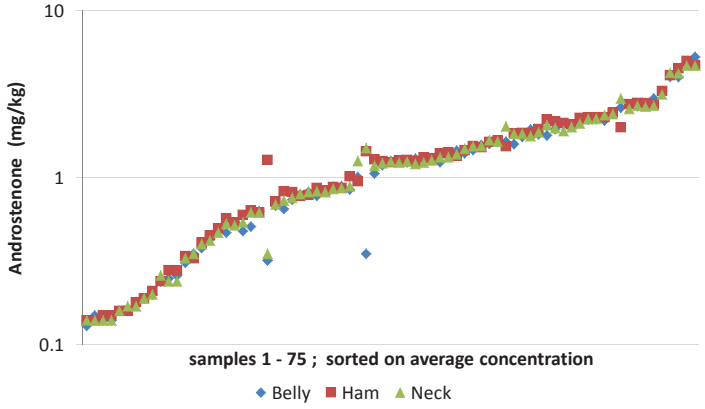

Figure 2. Androstenone levels in Neck, Belly and Ham fat (n=3*75)

	Comparison of:		
	1. Ham vs 2. Belly	1. Ham vs 2. Neck	1. Belly vs 2. Neck
Agreement:			
both parts no-taint:	215 (72%)	214 (71%)	212 (71%)
both parts boar taint:	64 (21%)	64 (21%)	75 (25%)
Dis-agreement:			
1. boar taint - 2. no-taint:	4 (1%)	4 (1%)	6 (2%)
1. no-taint - 2. boar taint:	17 (6%)	18 (6%)	7 (2%)
Total	300 (100%)	300 (100%)	300 (100%)

Table 1. Comparison of sensory evaluation of boar taint with HNS-method (median of 5 testers) for three different fat sampling sides of 300 carcasses

Results

The correlation between the chemical concentrations in the different fat parts was > 98%. The Skatole concentrations in the belly is significantly higher than in ham and neck fat. The Androstenone concentrations in ham fat is significantly higher than in belly. The differences found are however not numerically significant.

During the sensory evaluation of the belly fat it was observed that the belly fat needed extra attention to have no remaining urine spilled on the carcass during slaughtering. The fat of the belly is therefor not the first choice for routine testing.

Comparing the different sampling sides, we can observe that using ham samples does lead to 22% (21% plus 1%) carcasses that are identified as boar taint, whereas using neck samples does lead to 27% (21% plus 6%) detected boar tainted carcasses. Therefore the ham is not the preferred sampling place. Comparing belly versus neck (column 3) reveals no differences between them (both 27% boar tainted carcasses). Taking into account the urine spillage risk when using belly samples, we do conclude that the neck sample is the preferred one to use.

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IV Preventive measures to reduce boar taint

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Prospects to reduce aggressive and sexual behaviour in entire male pigs

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A literature study has been conducted by Tette van der Lende of ProPhys Animal Science Consultancy on aggressive and sexual behaviour of entire male pigs compared to female and castrated male pigs. This is due to the fact that the entire male pigs have testicular steroid-induced masculinised brains, whereas the brains of the neonatal castrated male pigs remain feminised. The early neonatal wave of testicular steroids is involved in the masculinisation (i.e., defeminisation) of the developing brain (see Figure 1). Between birth and the early post pubertal stage of development entire male pigs produce large amounts of testicular steroids (including e.g. testosterone, oestrogens and androstenone) with peak concentrations in plasma at 2 to 4 weeks of age (early neonatal wave of testicular steroid hormones), followed by lower levels from 2 to approximately 5 months of age and a progressive increase thereafter in association with pubertal development (Figure 1).

Role of neurotransmitters

Neurotransmitters with important roles in sexual and aggressive behaviours are dopamine, serotonin and norepinephrine.

As illustrated in figure 2, increased dopamine activity has a positive (stimulatory) effect on the display of both sexual and aggressive behaviour, whereas increased serotonin activity has a negative (inhibitory) effect on both sexual and aggressive behaviour.

Effects of dietary modulation

The prospects to attenuate unwanted behaviours in entire male pigs by means of specific dietary supplementations is substantially better when targeting the central serotonergic rather than the central dopaminergic system.

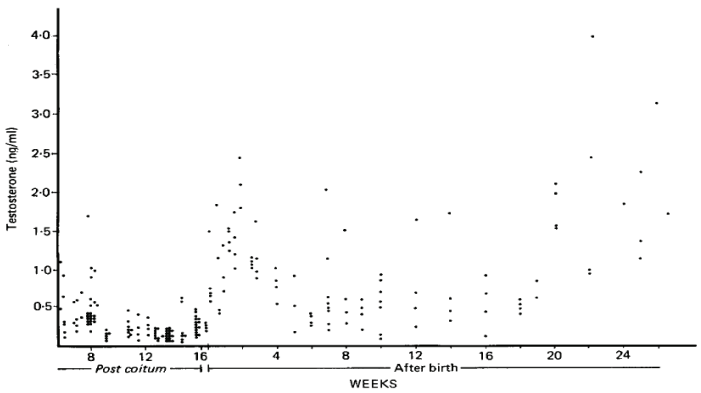

Figure 1. Changes in blood testosterone concentrations in entire male pigs between day 40 after conception and 25 weeks after birth

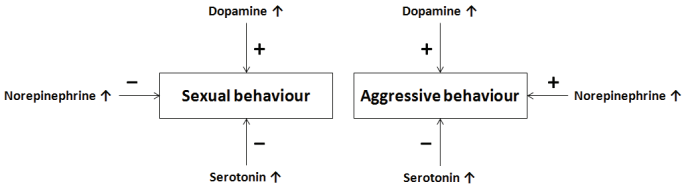

Figure 2. Schematic summary of the effects of dopamine, serotonin and norepinephrine on sexual and aggressive behaviour

Dietary tryptophan supplementation stimulates serotonin production in the brain and suppresses aggressive behaviour and most likely also sexual behaviour. Serotonin synthesis in the brain is influenced by three factors:

- the plasma concentration of free plasma tryptophan;
- the transfer rate of free plasma tryptophan through the blood-brain barrier, which depends on the ratio between free tryptophan and the other neutral amino acids in plasma;
- the activity of tryptophan hydroxylase in the brain.

5-Hydroxytryptophan may be a good alternative for tryptophan as dietary supplement to attenuate aggressive and sexual behaviour in entire male pigs, but its possible negative effect on feed intake, growth rate and feed conversion needs further investigation. High dietary cholesterol intake or intake of rations causing an increased level of total plasma cholesterol leads to increased central serotonergic activity, resulting in decreased aggressive behaviour. There is some evidence that a decreased plasma ratio between n-6 and n-3 polyunsaturated fatty acids (n-6:n-3 PUFA) decreases the risk of aggressive behaviour. The effect of the n-6:n-3 PUFA ratio in plasma on aggressive and sexual behaviours in entire male pigs needs further research. In conclusion, diets supplemented with tryptophan, relatively low in protein, wit a positive effect on blood cholesterol concentration and wit a negative effect on the n-6:n-3 PUFA ratio in blood, might reduce the risk of aggressive and sexual behaviour.

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For quality of life

Effectiveness of a boar taint reducing diet

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Producing entire male pigs can result in boar taint. High levels of androstenone and skatole are indicators for boar taint. Especially, the level of skatole can be influenced by diet composition. At Swine Innovation Centre Sterksel it was investigated whether the percentage of boars with boar taint can be reduced by feeding male pigs a boar taint reducing diet the last week before delivery to the slaughterhouse.

Composition diet to reduce boar taint prevalence

In total 392 growing and finishing male pigs (Tempo boar x (Dutch Landrace x Dutch Large White) sow) were allotted to the experiment. In the last week before delivery of the first pigs to the slaughterhouse, boars were fed a boar taint reducing diet or a conventional diet. The most important changes in the boar taint reducing diet compared to the conventional diet were:

- reducing the crude protein content from 15.0 to 13.3%;
- increasing the level of fermentable non-starch polysaccharides from 9.65 to 13.75% by adding 10% sugar beet pulp and 3% chichory pulp (inulin) to the diet;
- adding 0.5% sepiolite (a clay mineral that among others binds nitrogen) to the diet;
- adding synthetic tryptofan to the diet to decrease the level of undigestible tryptofan;
- adding 0.25% benzoic acid to the diet.

In the literature, it was shown that these changes in the diet may reduce the level of skatole.

Source: Wageningen UR

No clear effect on boar taint

Feeding a boar taint reducing diet did not reduce the level of androstenone ($p = 0.96$; Table 1). The level of skatole was numerically, but not significant, lower ($p = 0.16$) by feeding a boar taint reducing diet compared to feeding a conventional diet

	Boar taint reducing diet	
	Yes	No
No. of boars	197	195
Androstenone (mg/kg fat):	0.78	0.76
% < 0.5	44.8	45.1
% between 0.5 and 2.0	49.0	49.3
% > 2.0	6.2	5.6
Skatole (µg/kg fat):	91.6	105.1
% < 100	73.2	68.2
% between 100 and 150	9.3	10.3
% > 150	17.5	21.5

Table 1. Boar taint reducing diet

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Effect of feeding system on mounting behaviour of boars and on boar taint

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Producing entire male pigs can result in higher levels of sexual and aggressive behaviour and in higher boar taint levels. High levels of androstenone and skatole are indicators for boar taint. At Swine Innovation Centre Sterksel it was investigated whether sexual and aggressive behaviour of boars and the percentage of boars with boar taint can be reduced by feeding boars using a long trough compared to using a single space feeder.

Feeding system

Treatments were: 1) simultaneous dry feeding using a long trough (12 feeding places for 12 growing and finishing pigs); 2) sequential dry feeding using a single space feeder (1 feeding place for 12 growing and finishing pigs). In total 576 growing and finishing pigs (Tempo boar x (Dutch Landrace x Dutch Large White) sow) were allotted to the experiment. Twenty-four pens with litters and 24 pens with single sex mixed boars were involved in the trial. There were 12 pigs per pen. The growing and finishing pigs that were fed by a single space feeder were fed ad libitum. Those that were fed using a long trough were fed three times a day. Mounting behaviour per pen (in pens with litters and in pens with boars) was recorded at week 7, 9, 11 and 13 and the day after first delivery to the slaughterhouse from 7.00 to 19.00 h every 15 minutes. Skin lesions and lameness were recorded per pig in all pens at week 7 and 11 and the day before and after first delivery to the slaughterhouse.

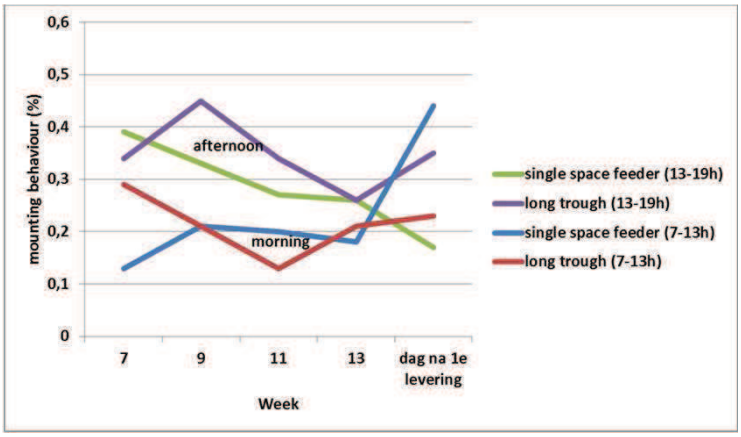

Figure 1. Pigs (%) showing mounting behaviour

Source: Wageningen UR

Mounting behaviour and boar taint

The percentage of pigs with mounting behaviour and the scores for skin lesions and lameness were similar in pigs that were fed using a long trough (simultaneous feeding) or using single space feeder (sequential feeding). Thus, simultaneous feeding did not reduce mounting and aggressive behaviour of the boars.

In the afternoon, the percentage of pigs with mounting behaviour was higher than in the morning. The percentage of pigs with mounting behaviour was highest at week 9. Thereafter it did not increase. Moreover, it did not increase after delivery of the first pigs in a pen.

The percentage of boars with boar taint and the level of androstenone were not affected by feeding system. The level of skatole, however, was lower in boars that were fed by a long trough than in boars fed by a single space feeder.

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Genetic solution to stop castration: Low boar taint sires

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There has been an increasing demand to stop castration and raise intact males. However, the unpleasant boar taint odour from pork of some entire males has been a bottle neck. Research on genetics and genomics with respect to boar taint compounds and human nose scores was implemented to offer a group of boars that would produce finishers with lower risk of boar taint. Semen from this special group of low boar taint boars was marketed under the 'Nador' concept. The concept was essentially developed to provide meat processors with pigs that have better animal welfare, better feed efficiency and higher food safety.

Selection of boars

The low boar taint producing boars were selected based on eight sources of information:

a) Levels of boar taint compounds, androstenone, skatole and indole estimated using fat biopsies of the sire itself and from the carcass samples of sibs and half-sibs
b) Human Nose Score measured on carcass fat samples of sibs and half-sibs
c) Genomic information using specific DNA markers with significant association with boar taint

The information from these sources was combined to estimate genomic breeding values. Only the top ranking boars with lowest risk of boar taint received the Low Boar Taint (LBT) designation.

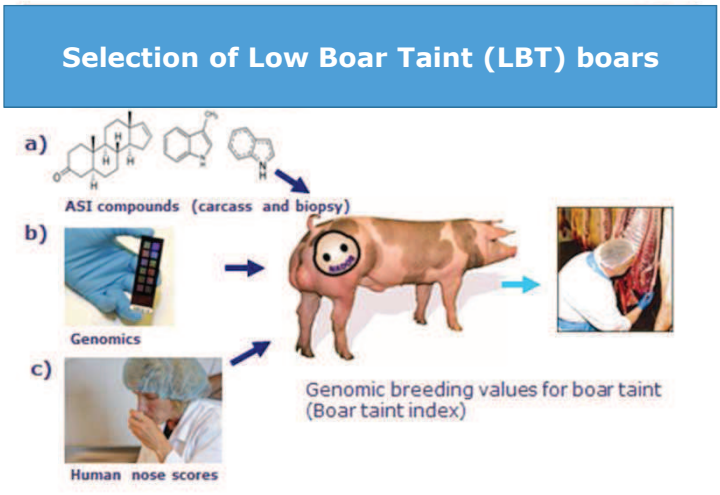

Figure 1. Criteria used to select Low Boar Taint

Human nose score	Levels of compounds			Frequencies		
	AND µg/g	SKA µg/g	IND µg/g	In overall Population	In LBT offspring	Diff. due to LBT
4	2.6	.40	.14	.014	.008	-41%
3	2.2	.26	.10	.032	.019	-40%
2	1.7	.17	.07	.063	.051	-19%
1	1.3	.12	.05	.123	.114	-8%
0	1.1	.08	.04	.768	.808	+5%

Figure 2. Results of Low Boar Taint (LBT) boars

Results

The results of our analysis suggests that use of the Low Boar Taint boars would reduce the proportion of tainted carcasses by about 40% while slightly increasing the proportion of carcases with normal pork odour.

Advantages of low boar taint boars

40% less boar tainted meat.
Less costs for the slaughterhouse, so higher value meat.

Boar finishing resulting in no labour costs for castration, higher feed efficiency, higher meat percentage, higher animal welfare and access to the new retail concepts

Tracking and tracing

In addition, the concept is supported by a DNA based trace back system. The purpose is to check if the meat is really produced with semen from these Low Boar Taint boars, just by testing a piece of meat from the slaughter line, retailers or even pork consumers. This way the concept also helps ensure customer satisfaction.

Acknowledgements

This research was conducted by Wageningen UR in cooperation with VION Food Group and TOPIGS Research Center IPG. It was funded by the Dutch Ministry of Economic Affairs and the Dutch Product Board Livestock, Meat and Eggs. More information can be found at www.boars2018.com.

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Genetic markers for androstenone, skatole and Human Nose Score for boar taint

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Modern technology allows a much better analysis of the influence of the DNA structure on traits measured in humans, plants, and animals. Locations on the DNA that show variability among animals can be used as markers in genetic analyses. For pigs, a chip with 60,000 DNA markers distributed across the genome, is available at reasonable costs. Nowadays, a standard procedure is to collect observations on individuals, genotype those individuals using the chip and establish the relation between the markers and the collected observations to determine which regions (genes) on the genome are involved that can be used for genetic improvement.

Androstenone and skatole

In this study, androstenone and skatole levels were measured in fat samples of over a thousand animals. Differences in these levels were family dependent, indicative for genetic effects. The graph shows the porcine chromosomes (except the sex-chromosome) on the x-axis, where the individual markers were ordered based on their position within the chromosomes. For each marker, the strength of its relation with androstenone is expressed on the Y-axis. The triangles indicate markers with higher relationship beyond the range of the Y-axis. A cluster of markers with a high Y-value on the chromosome strengthens the idea that the specific region on the genome has significant effect on androstenone levels.

In addition to androstenone and skatole, markers affecting the composite measure of boar taint, Human Nose Score (HNS) were also investigated. The Figure shows the percentage of genetic variance in HNS explained by markers on most relevant chromosomes 6 and 7. The markers affecting HNS also overlap with those affecting androstenone and skatole.

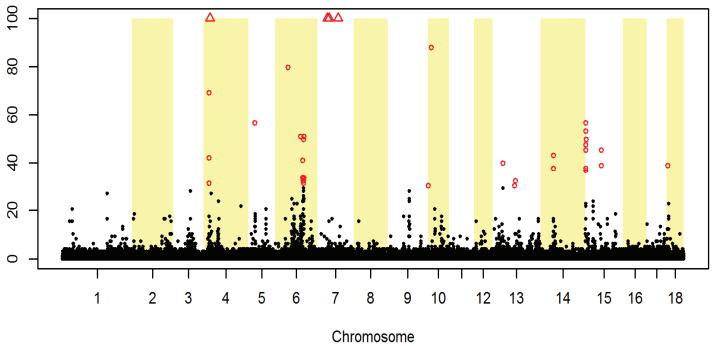

Figure 1. Porcine chromosomes

Marker	Chromosome	Variance explained by the marker (%)
1	6	0.40
2	6	0.36
3	6	4.30
4	7	1.58
5	7	0.12
6	7	0.24

Figure 2. Proportion of genetic variance in HNS explained by markers on SSC 6 and 7.

Use of genetic markers

Boar taint, using androstenone, skatole or HNS, can only be assessed in male animals. Use of DNA markers makes it possible to estimate the genetic merit for boar taint in females as well. This is highly relevant for genetic reduction of boar taint from the dam side as well.

DNA markers also allow for early selection for cost efficiency. A tissue or hair sample from a pig as young as 1 day of age can be used to assess the DNA markers for boar taint.

These genetic markers along with pedigree information and own levels of boar taint compounds could be very effective for genetic selection to produce entire males with lower boar taint.

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V
Behaviour of boars

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Mounting behaviour of boars

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Producing entire male pigs (boars) can result in higher levels of sexual and aggressive behaviour and impair animal welfare compared to castrated male pigs and gilts. At Swine Innovation Centre Sterksel, the sexual and aggressive behaviour of mixed housed boars and gilts was studied.

Sexual behaviour

Aggressive and sexual behaviour was studied in 864 mixed housed growing and finishing boars and gilts (Tempo boar x (Dutch Landrace x Dutch Large White) sow). Behavioural measurements were carried out in week 5, 7, 9, 11, 13 and on the day after first delivery to the slaughterhouse. In observation periods of 5 minutes every hour sexual (mounting) and aggressive behaviour of the boars and gilts was recorded.

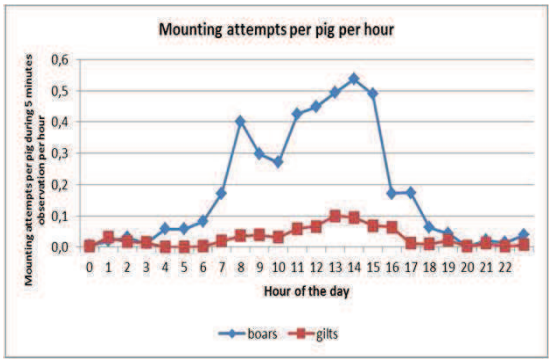

Figure 1. Mounting attempts per pig per hour

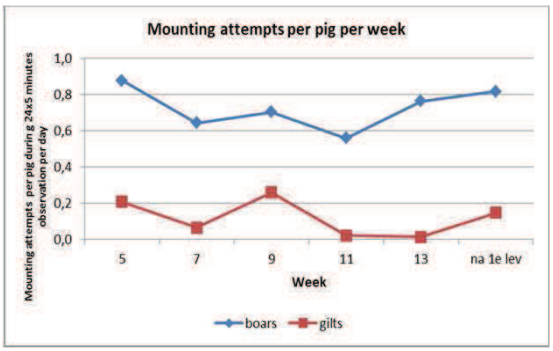

Figure 2. Mounting attempts per pig per week

Source: Wageningen UR

Mounting attempts

The percentage of active boars and gilts was similar. Mounting behavior, however, was clearly much higher in boars than in gilts. Similar results were found in the literature.

The number of mountings per boar was higher during the day than during the night and higher in the afternoon than in the morning (figure 1).

The number of mountings per boar did not increase from week 5 until delivery to the slaughterhouse. Moreover, it did not increase after delivery of the first pigs in a pen (figure 2). Skin lesion score was similar in boars and gilts.

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Effect of light on mounting behaviour of boars

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Producing entire male pigs (boars) can result in higher levels of sexual and aggressive behaviour and impair animal welfare compared to castrated male pigs and gilts. At Swine Innovation Centre Sterksel it was investigated whether sexual and aggressive behaviour of boars can be reduced by green light or by an increasing light schedule compared to normal light.

Light regime and light colour

Aggressive and sexual behaviour was studied in 864 mixed housed growing and finishing boars and gilts. Behavioural measurements were carried out in week 5, 7, 9, 11, 13 and on the day after first delivery to the slaughterhouse. In observation periods of 5 minutes every hour sexual (mounting) and aggressive behaviour of the boars and gilts was recorded. Treatments were: 1) normal light (artificial light from 8.00 to 16.00 h); 2) a gradually increasing light schedule (artificial light from 8.00 to 16.00 h at the start and from 5.00 to 21.00 h at the end); 3) green light (artificial green light from 8.00 to 16.00 h). In all treatments light intensity was 40 lux.

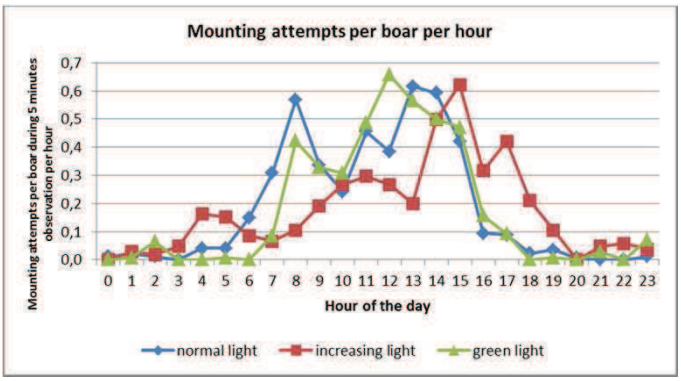

Figure 1. Mounting attempts per boar per hour

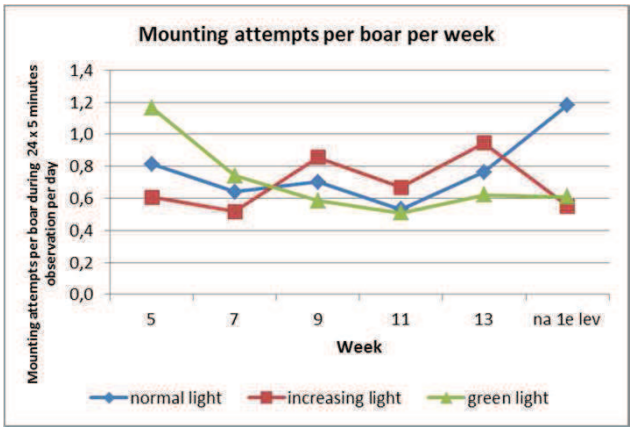

Figure 2. Mounting attempts per boar per week

Source: Wageningen UR

Mounting attempts

Green light did not reduce mounting and aggressive behaviour of the boars compared to normal light (Figure 2). The increasing light schedule did not reduce mounting behaviour but it did reduce aggressive behaviour of the boars around delivery of the pigs. Boars that were exposed to the increasing light schedule started earlier in the morning with mounting behaviour and stopped at a later hour than boars that were exposed to normal or green light but the number of mountings between 8.00 and 13.00 h was lower (Figure 1).

Conclusion

It can be concluded that green light and an increasing light schedule did not reduce mounting behaviour of the boars. The increasing light schedule, however, did reduce aggressive behaviour around delivery of the pigs.

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Effect of a hiding wall on mounting behaviour of boars

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Producing entire male pigs (boars) can result in higher levels of sexual and aggressive behaviour and impair animal welfare compared to castrated male pigs and gilts. In a study at Swine Research Centre Raalte, it was shown that a dummy to mount on (Picture 1) can reduce the number of pigs with leg problems because they use the dummy as a hiding place. The dummy did not reduce the number of mounting attempts. At Swine Innovation Centre Sterksel, the effect of a hiding wall (Picture 2) on the sexual and aggressive behaviour of 864 mixed housed boars and gilts was studied. Pigs were kept in groups of 12 or 24 pigs per pen (1m^2 per pig).

Mounting behaviour

Behavioural measurements were carried out in week 5, 7, 9, 11, 13 and on the day after first delivery to the slaughterhouse. In observation periods of 5 minutes every hour sexual (mounting) and aggressive behaviour of the boars and gilts was recorded.

Picture 1. Dummy to mount on (source: Wageningen UR)

Picture 2. Pen with a hiding wall (source: Wageningen UR)

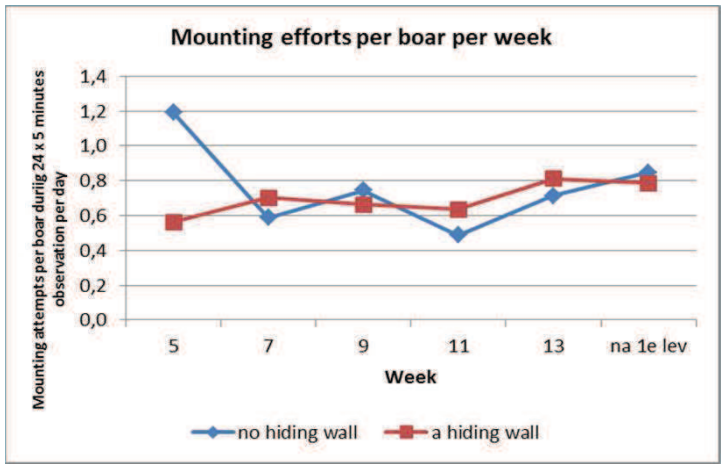

Figure 1. Mounting attempts per boar per week

No clear effect on boar taint

A hiding wall did not reduce the number of mounting attempts per boar ($p = 0.46$). The number of mountings per boar did not increase from week 5 until delivery to the slaughterhouse. Moreover, it did not increase after delivery of the first pigs to the slaughterhouse (Figure 1). The score for skin lesions and the number of boars with leg problems was similar in pens with or without a hiding wall.

It can be concluded that a hiding wall did not reduce mounting and aggressive behaviour of the boars in this trial.

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Keeping boars in litters did not reduce mounting behaviour and boar taint

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Producing entire male pigs can result in higher levels of sexual and aggressive behaviour and in higher boar taint levels. High levels of androstenone and skatole are indicators for boar taint. At Swine Innovation Centre Sterksel it was investigated whether sexual and aggressive behaviour of boars and the percentage of boars with boar taint can be reduced by keeping boars in litters compared to single sex mixed groups of boars.

Litters versus single sex groups

Treatments were: 1) boars kept in litters from birth to slaughter; 2) single sex groups; at the start of the growing finishing period, boars from different litters were mixed and housed in pens with only boars. In total 576 growing and finishing pigs (Tempo boar x (Dutch Landrace x Dutch Large White) sow) were allotted to the experiment. Twenty-four pens with litters and 24 pens with single sex mixed boars were involved in the trial with 12 pigs per pen. Mounting behaviour per pen (in pens with litters and in pens with boars) was recorded at week 7, 9, 11 and 13 and the day after first delivery to the slaughterhouse from 7.00 to 19.00 h every 15 minutes. Skin lesions and lameness were recorded per pig in all pens at week 7 and 11 and the day before and after first delivery to the slaughterhouse.

	Litters	Single sex groups: boars
No. of boars	140	252
Androstenone (mg/kg fat):		
% < 0.5	46.8	44.0
% between 0.5 and 2.0	49.6	48.8
% > 2.0	3.6	7.2
Mean content	0.70	0.81
Skatol (µg/kg fat):		
% < 100	72.7	69.6
% between 100 and 150	8.6	10.4
% > 150	18.7	20.0
Mean content	89.2	103.5

Table 1. Levels of androstenone and skatole

Source: Wageningen UR

Mounting behaviour and boar taint

The percentage of boars with mounting behaviour was similar in pens with litters and in pens with only boars. The percentage of boars showing mounting behaviour, however, was low in this trial. Mixing strategy (litters versus single sex pens) did not affect the skin lesions score. The lameness score was higher in litters than in single sex pens but the lameness score was very low.

Boars showed more mounting behaviour, skin lesions on the forehand and lameness than gilts. The skin lesions score on the hind quarters was numerically, but not significant, higher in boars than in gilts.

The percentage of boars with boar taint and the levels of androstenone and skatole (Table 1) were similar in boars kept in litters and in boars kept in single sex pens.

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VI

Boar taint economics and international developments

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Boar taint prevention and detection within the pork supply chain

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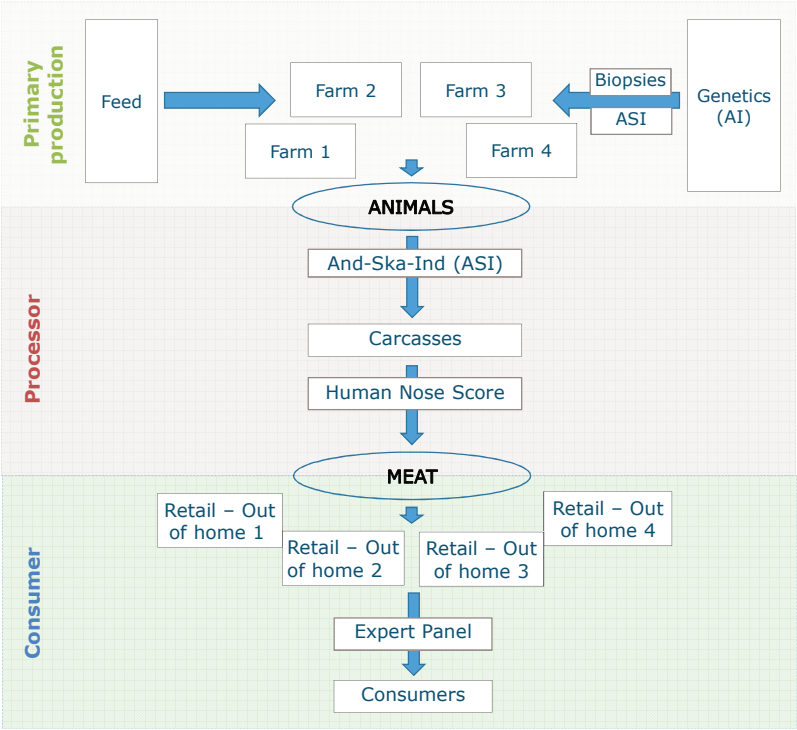
Boar taint is a penetrating odour (and accompanying taste) in pork. Where it is very strong, the unpleasant smell is associated with manure, urine and sweat. Occasionally this odour (and taste) is sensed when the meat is heated, i.e. in the pan or during eating of the prepared meat. The intensity of boar taint can be different, and depends on the concentration and combination of certain substances in the fat, especially androstenone and skatole. With castrated and female pigs, the likelihood of boar taint is very low. With older non-castrated male pigs this likelihood is higher. In theory, the evaluation of boar taint by cooks and consumers is the golden standard. But in practice, other methods have to be applied in order to detect boar taint to finally achieve market acceptance.

Source: VION Food Group

Preventive measures

Measures to prevent the risk of boar taint are breeding, feeding, housing and management. The content of boar taint compounds has been found to be heritable. Clean pens and adjusted feed can contribute to reduce boar taint prevalence, but this does not give a 100% guarantee for the absence of boar taint. For realizing market acceptance, detection as a safety net is necessary.



Detection as a safety net and for breeding

Detection as a safety net can be applied in-line in the slaughter plant, using trained assessors as in-line testers who use a hot iron to score the boar taint (HNS). The information on boar taint presence can be fed back to farmers. HNS detection of boar taint can also be applied in a laboratory setting by an expert panel, for example as part of a breeding program to reduce the prevalence of boar taint. With the panel there are less time constraints, and it enables using more assessors for every fat sample. A costly alternative is chemical analyses of androstenone, skatole and indole levels (A,S,I analyses) in fat samples.

Need for a reference benchmark

Ultimately, we do need a reference benchmark as a derivative for the sensory evaluation by cooks and consumers, i.e. a derivative of the golden standard. Alternatives for this bench mark are setting up a boar taint expert panel, developing a procedure for maintaining a standardized meat sample, or developing a formula – using available attributes - to estimate consumer reaction. These alternatives have all to be validated against consumer perception. Further research on this is needed.

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Economic feasibility of a detection system for boar taint

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Stopping with castration of male piglets can result in boar taint in a limited number of male pigs. A detection system for boar taint can be implemented in the slaughter line to select the carcasses of these male pigs. Their meat can be marketed separately to prevent customer complaints. It is advisable to implement a detection system as a safety net, if the costs of a detection system in the slaughter line and revenues due to less negative customer experience, outweigh the costs of having no detection system. A condition for implementing a detection technology is that the costs of such a technology should not exceed the difference in expected revenue of non tested meat and tested meat.

Economic effects of boar taint detection

To determine if a detection system for boar taint in the slaughter line is economically feasible, the following effects need to be considered:

- Additional costs of the detection system itself;
- Additional revenue of the testes;
- Costs of dealing with boar taint related complaints of customers;
- Reduced revenue price of meat of *untested* boars;
- Reduced price of meat of boars tested as *with* boar taint;
- Reduced price of meat of boars tested as *without* boar taint;
- The number of boars assessed to have boar taint, which in fact do not have boar taint (false positives);
- The rate of boars assessed not to have boar taint, which in fact do have boar taint (false negatives).

We compared these costs and benefits of a situation with a boar taint detection system with those in the situation without a detection system, assuming that the model requires a safety net.

Figure 1 shows the comparison of the costs in a scenario where no detection system is implemented and a scenario where boar taint is detected. The maximum costs for a boar taint detection system is the difference between these two scenario's.

Costs (€/boar)	Without boar taint detection (A)	With boar taint detection (B)
Sales of meat of non-tested boars (devaluation)	13.65	
Complaints	0.02	
Sales of meat of positive tested boars (devaluation)		0.57
Sales of meat of negative tested boars (devaluation)		6.11
Costs	**13.67**	**6.68**
Maximum costs boar taint detection (= A-B)		***7.01***

Figure 1. Calculated costs of the basic scenario for the situation with and without boar taint detection and the maximum costs for boar taint detection (€/boar)

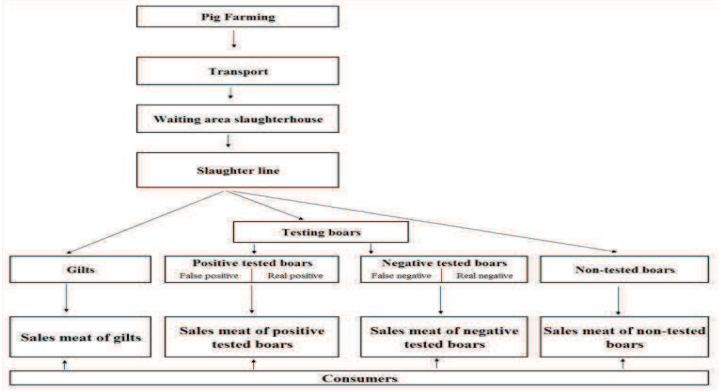

Figure 2. Boar taint detection system

Most costs in the supply chain in the scenario with a detection system occur during the post harvest stage. This has to do with the running costs in the slaughter line, depreciation of the boar meat, complaints and/or negative experience of the consumers and logistical changes in the slaughter process.

Boar taint detection in the slaughter line is economically feasible

Comparison of the two scenario's shows that the loss in revenue, due to devaluation of the boar meat, is largest in meat of untested boars. Boar tainted meat can be processed differently, which overall results in less devaluation of the boar meat (see figure 2), currently around 4% of slaughtered the boars in the Netherlands have boar taint.

Calculations show that as long as the costs are limited to the current level of a few euro's, it is economically feasible to have a detection system in place.

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Cost-effectiveness of preventing boar taint without surgical castration in the pork chain

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In 2010 several European actors in the pig chain agreed on a plan to voluntary end the surgical castration of pigs in Europe by 2018. It is expected that by that time there will be a animal welfare friendly and sustainable way to produce boar taint-free pig meat. Development of the tools to ensure that costs and benefits involved are fairly shared among the chain actors is central in the above European initiatives.
This study provided first insights into economics of currently feasible alternatives to surgical castration along the pork chain.

Objective

In 2009-2010, this research explored cost-effectiveness of multiple alternatives to surgical castration of pigs along the pork chain in order to determine the most promising ones.
An analysis was performed for different penning systems of boars: mixed-sex (50% boars 50% gilts) and single-sex (100% boars).

Methods

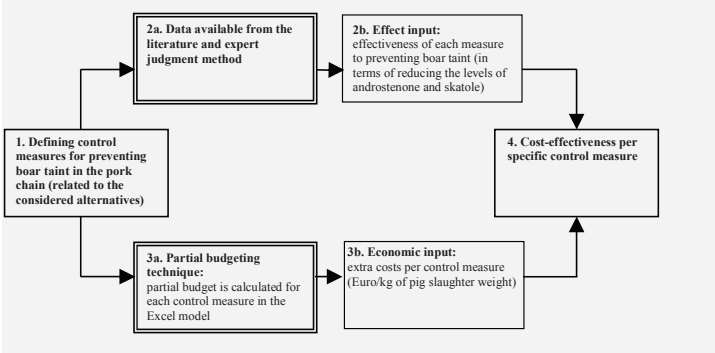

Figure 1. Cost-effectiveness analysis of preventing boar taint in the pork chain. Note: in 2009-2010, regarding effectiveness of control measures in boar taint reduction, available literature mainly reported effects of measures as determined by reduction in the levels of main boar taint compounds, namely androstenone and skatole.

Results

The considered alternatives referred to genetic selection, altering management strategies and slaughtering before sexual maturity. These alternatives were expressed via relevant control measures. The effect of control measures was derived from the literature or assessed by experts. The extra costs of implementing the measures were calculated using partial budgeting. This information on various measures, impacts and costs was used to examine the cost-effectiveness of preventing boar taint in the pork chain (Fig. 1).
Findings show that the cost-effectiveness of alternatives to surgical castration varies greatly. Some control measures even have a negative cost-effectiveness ratio. In the pig growing stage, the control measures related to the single-sex option of raising entire males are more cost effective than the measures related to the mixed-sex option. In particularly, this is true for the measures for skatole reduction. At the same time, the control measure "single-sex groups

	Mixed-sex		Split-sex	
	A	S	A	S
BREEDING STAGE				
Breeding goal of selection on androstenone and skatole (sire selection)				
Selection pressure on boar taint only (100%)	**0.13**	0.02	**0.13**	0.02
Selection pressure on both economics (90%) and boar taint (10%)	**1.02**	0.13	**1.02**	0.13
GROWING STAGE				
Housing environment and hygiene				
Cleanness in the last week before slaughter				
Keeping boars constantly in extra clean environment, also in the last week before slaughter	–	0.08	–	**0.15**
Stocking rate				
Keeping boars at the low stocking rate (ca. 1.0 m^2 per animal)	–	0.04	–	0.08
Air temperature during summer				
Keeping boars in constant temperature environment (ca. 20°C), extra regulation of temperature by means of a climate control system	–	0.03	–	0.07
Keeping boars in rather constant temperature environment (no heat peaks), extra regulation of temperature by means of a sprinkler system	–	**+0.01**	–	**+0.02**
Social environment				
Stable social groups				
No mixing of unrelated animals: a strict all-in all-out ("birth to slaughter")	**+0.13**	–		
Sex grouping of animals				
Split-sex groups rearing: boar and gilt groups in different compartments			**16.3**	–
Split-sex groups rearing: boar and gilt groups in different pens			10.0	–
Feeding				
Feed system / dry diets vs. wet diets				
Restricted wet feeding / water	–	+0.003	–	+0.006
SLAUGHTERING STAGE				
Slaughtering before sexual maturity: slaughter at 90 kg live weight	**0.11**	–	**0.11**	–

Figure 2. Chain: Cost-effectiveness of control measures (A = androstenone; S = skatole), A/S reduction in mg/kg fat per eurocent. Cost-effectiveness of each measure is calculated as ratio of obtained reduction of A and S levels (Δeffect) to extra costs associated with implementation of this measure (Δcosts). Reduction of A and S levels and extra costs are expressed relative to the basic situation.

rearing: boar and gilt in different compartments" is itself the most cost-effective for androstenone reduction. In the pig breeding stage, the breeding programs that combine selection on boar taint and on economics are more cost-effective than programs focusing on boar taint only. The optimal combination of selection pressure on economics and boar taint still needs to be determined. In the slaughtering stage, slaughter at a younger age and lower weight is considerably less cost-effective than the alternatives in the other stages, even compared to the breeding program with focusing on boar taint only, which is not very cost-effective (Fig. 2).

Further reading

Valeeva, N. I., de Smet, A., Hoste, R. and Backus, G. B. C. (2010). Economics of boar taint prevention without surgical castration in the pork chain. Paper presented at the 9th Wageningen International Conference on Chain and Network Management, Wageningen, The Netherlands, May 26-28 (Digital Proceedings). http://edepot.wur.nl/169482

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Boar train moving forward slowly but steadily

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During the summer of 2012 an international survey has been conducted to get insight into the status quo of pig castration in the European pork supply chain. The study showed that slowly but steadily the boar train is moving forward and the European landscape is changing.

Status quo European Pork supply chain

In several European countries steps are taken to increase the number of entire male piglets. The figure shows that Southern and Eastern European countries are more reluctant and hesitating. In these countries the subject is not on the agenda or the countries have a negative stance regarding the subject.

The use of anaesthesia is only very common in The Netherlands, in few other countries this is only used (very) seldom. The use of analgesia is in most countries (very) common. Poland and the Czech Republic are very reluctant and not engaging with the issue.

Over 80% of the 2012 survey respondents in the slaughter companies and farming community think they will be working with entire male pigs before 2018. The figure shows the development of rearing entire male pigs European countries. In these 12 European countries over 90% of pig meat in the EU is produced.

More then 80% of chain partners are convinced that the developments are irreversible. However there do remain issues that need to be solved. Most important issues are market demand, consumer wishes and animal welfare.

The principal obstacle is acceptance by the retail and foodservice sectors. They have a need for:

- recognised detection methods;
- information/knowledge; decreasing the resistance within retail and out of home;
- last minor issue is consumer acceptance.

Solutions to overcome the obstacles are:

- providing proper information;
- set-up of a recognised certification system; and
- introduction of well documented detection methods.

Source: Wageningen UR

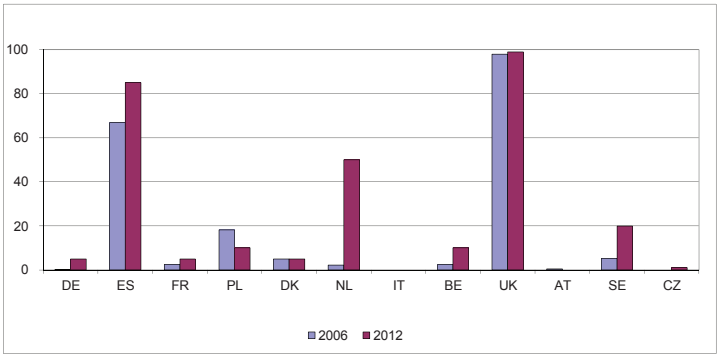

Figure 1. Estimated entire male pigs per country (2006 data from PIGCAS project)

Moving forward in Europe

In order to move forward, a European taskforce should be set up consisting of representatives from the EU countries. The taskforce should be supported by a number of targeted (EU-wide) working groups with specific assignments. Currently, the primary challenges are in the field of communication and research and development.

Obstacles in two essential links in the supply chain (retail and foodservice) need to be resolved:

- Information needs to be provided in a better way and knowledge on the subject needs to increase in every EU country, the subject has to end up on the agenda in all EU countries.
- Further research into creating good, well documented detection methods and into the introduction of cost-efficient, preventive measures in European pork farming is needed.

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Moving towards boar taint-free meat:
An overview of alternatives to surgical castration from a chain perspective

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In 2008-2009 LEI Wageningen UR examined the key technical and economic considerations associated with the presently feasible alternatives to surgical castration. In particular, we reviewed the state of the art of these issues from a chain perspective, namely possible alternatives to surgical castration, factors influencing boar taint development and economic considerations associated with the presently feasible alternatives to surgical castration. The following potential alternatives per chain stage were considered:

Pig breeding	*Genetic selection* Gender selection
↓	
Pig growing	Immunocastration *Management strategies*
↓	
Slaughtering	Early slaughtering (before sexual maturity) On-line boar taint detection
↓	
Processing	Mixture of tainted & untainted meat Masking unpleasant odors & flavors

While moving from potential alternatives to best alternatives it is important to consider the following issues:

Potential alternatives – state of the art:

- Different chain participants are involved in implementation
- All alternatives have advantages and disadvantages
- No single alternative offers a total solution for the problem
- Some alternatives are not yet practically applicable

Best alternatives – the choice should be based on:

- Whole-chain perspective might be necessary => combination of alternatives might be needed
- Economic feasibility
- Coherent with improvements of other aspects of animal production (food safety, animal health & welfare, environment)
- No negative effect on meat qualities
- Satisfy exiting regulations (housing environment and hygiene)

Prevention of boar taint itself without surgical castration is complex. Basically, at present, a 100% reliable alternative guaranteeing entire elimination of boar taint is not possible. We concluded that prevention of boar taint is a challenge and task for the entire pig production chain and an integrated approach is needed to evaluate the best combination of alternatives. At that time we suggested that genetic selection in the animal breeding stage, altering management strategies in the animal growing stage and early slaughtering (before sexual maturity) in the slaughtering stage were the primary alternatives to be considered in development of such an approach. When sufficient knowledge is available, the approach could be elaborated by including on-line detection of carcasses with (possibly) high levels of boar taint and/or other alternatives (Valeeva et al., 2009).

Implementation of any above-suggested alternatives would have economic implications. Basically, it would involve additional costs that should be balanced against advantages and disadvantages

Source: Wageningen UR

associated with raising boars, compared to raising barrows, and should account for costs and benefits at the individual level of each chain segment as well as at the entire chain level. The economic analysis was performed in the later stage of the project. Early slaughtering (before sexual maturity) did not appear to be an economically viable option in the Dutch situation (low cost-effectiveness). More details, also about analysis of feasible options of genetic selection and altering management strategies can be found in Valeeva et al. (2010).

In the current Dutch situation, on-line detection based on human nose scoring is used by slaughterhouses as a safety net. Stimulating farmers to prevent developing boar taint on the farm by adopting altering management strategies or using animals selected against boar taint is an additional direction for solution. But this this requires adequate bonus-malus incentives.

Further reading

- Valeeva, N. I., Backus G. B.C. and Baltussen W. H. M. (2009). Moving towards boar taint-free meat: an overview of alternatives to surgical castration from a chain perspective. In H. H. Guither, J.L. Merry and C.E. Merry (eds), *Agriculture: Food, Fiber and Energy for the Future* – Proceedings of the 17th International Farm Management Congress, July 19-24, 2009. Menomonee Falls, WI: Burton & Mayer Printers & Lithographers, vol. 2, 131-144. http://www.ifmaonline.org/pdf/congress/09_Valeeva_etal.pdf
- Valeeva, N. I., de Smet, A., Hoste, R. and Backus, G. B. C. (2010). Economics of boar taint prevention without surgical castration in the pork chain. Paper presented at the 9th Wageningen International Conference on Chain and Network Management, Wageningen, The Netherlands, May 26-28 (Digital Proceedings). http://edepot.wur.nl/169482

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