CAMPIG

Consumer acceptance in the European Union and in third countries of pig meat obtained from male pigs not surgically castrated.

Dissemination level: CONFIDENTIAL

Project start date: 20/12/2012

Duration: 18 months

Contract number SANCO/2012/G3/SI2.639774

Due date of deliverable:	Month 18
Lead beneficiary	DLO
Authors:	Gé Backus and Harriette Snoek (DLO), Maria Angels Oliver and Maria Font i Furnols (IRTA) Marijke Aluwé and Frank Tuyttens (ILVO) Michel Bonneau and Patrick Chevillon (IFIP) and Margit Dall Aaslyng (DMRI) Daniel Moerlein, Lisa Meier-Dinkel, Johanna Trautmann (UGo) John/Erik Haugen (Nofima)
State:	Draft
Version:	20-06-2014
Dissemination nature:	CONFIDENTIAL

Project partners
Agricultural Economics Research Institute LEI DLO (Netherlands) Instituut voor Landbouw- en Visserijonderzoek ILVO (Belgium) Danish Meat Research Institute DMRI (Denmark) Institut de la Filière Porcine IFIP (France) Georg-August-Universität Göttingen UGo (Germany) Institut de Recerca i Tecnologia Agroalimentaries IRTA (Spain) Nofima AS (Norway)
This report presents results of the CAMPIG project and provides recommendations to the EU Commission with respect to the acceptability of boar taint from non-surgically castrated pigs in the selected EU countries.

Table of Contents

EXECUTIVE SUMMARY

The objective of this study is to determine consumer perception towards meat from non-surgically castrated male pigs. Basic principle of the study is to establish the relationship between the levels of compounds responsible for boar taint and the results on the sensory assessment of meat obtained from male pigs non-surgically castrated. In order to meet the objectives the project: (1) Studied consumer acceptance in the European Union and in third countries of pig meat patties obtained from male pigs not surgically castrated; (2) Identified and addressed differences between the different Member States in consumer acceptance of pig meat patties obtained from male pigs non-surgically castrated; and (3) Identified and addressed differences in consumer acceptance of pig meat patties obtained from male pigs non-surgically castrated in third countries to which the Union exports pig meat. In addition to the sensory acceptance, consumer attitudes towards factors related to the acceptance of alternatives of surgical castration of male pigs are also assessed.
The study is organised in four work packages (WP). The objective of WP "Harmonisation" is to identify the levels of androstenone and skatole suitable for consumer acceptance threshold tests and to design both a protocol for preparing pork meat products and for a central location test (CLTs). The objective of WP "Sensory acceptance EU" is to assess the sensory acceptance of meat obtained from surgically castrated and non-castrated pigs in member states from 4 different EU regions. The objective of WP "Sensory acceptance 3rd countries" is to carry out CLTs to assess the sensory acceptance of meat obtained from surgically castrated and non-castrated pigs in third countries. The objective of WP "Consumer perceptions" is to assess consumer perceptions that influence food choice behaviour and are relevant to acceptance of alternatives of surgical castration of male pigs in the EU and important non-EU countries.

Sensory study: pilot, EU study, and study in third countries

Methods

A pilot consumer test is conducted with 383 consumers in Germany. Sensory consumer studies are performed in 4 EU countries with a total of 476 women (Denmark n=109, France n=128, Italy n=121 and Poland n=118) and 2 non EU countries: Russia (n=120) and China (n=120).
The study comprises four steps: (i) the assessment of consumers' preference (odour and flavour) of castrate over boar meat, (ii) the assessment of consumers' acceptance (overall liking) of castrate and boar meat, (iii) smell tests to assess olfactory acuity to androstenone and skatole, and (iv) a post hoc questionnaire on demographics. Consumers are classified according to their sensitivity to skatole and androstenone. They evaluated 16 (pilot) or 8 (main study) different types of boar meat patties with different levels of androstenone and skatole in pair-wise comparison with patties from castrates.
For the pilot study, standardized pork patties made of either castrate or boar meat containing 15 to 21% fat are served. While the castrate sample is always of the same batch, the boar patties vary with respect to androstenone (.41 to 2.17 µg/g fat) and skatole (.07 to .48 µg/g fat). For the main sensory study, minced meat is prepared. An analysis of the ASI components of the back fat is also included as well as a sensory profiling of the meat patties. The chemical analysis shows that the fat content of the minced meat is approximately between 16 and 20 %. The skatole and androstenone content of the back fat in the pigs selected for the study is very close to the aimed variation up to .2 µg/g androstenone and .4 µg/g skatole. The sensory profiling analysis shows that the fried meat patties primarily vary in the boar taint attributes going from meat flavour and odour of the castrate to boar taint in the sample highest in androstenone and skatole content.
Consumers' sensitivity to and appreciation of androstenone and skatole are assessed using smell strips after they had evaluated the meat.
Consumer studies are performed in Russia and China with a different procedure. Consumers evaluated meat from 3 types of boars with different levels of androstenone and skatole (low/low, medium/medium and high/high) each in comparison with meat from castrated male pigs. Consumers had to indicate which sample they preferred (boar or castrated) for smell and flavour and rate the overall liking. Data is analysed considering also the sensitivity of consumers to androstenone and skatole that is obtained by means of several triangular tests.

Results sensory studies

Meat patties evaluation are analysed from 3 different points of view: (1) consumer preferences for smell and flavour of meat patties from boars over castrates; (2) liking scores for meat from boars *vs.* castrates; and (3) liking scores of boar meat patties depending on the sensitivity of the consumers to androstenone and skatole. For all consumers average liking scores are higher for

boar meat with low skatole content compared with those with high skatole content. In the third countries study the analysis is performed at three levels: (1) Study the preferences for smell and flavour, (2) Study the difference in liking score between boar and castrated meat, and (3) Study of liking score.

In the pilot study the preference for meat patties from castrates over boars is more pronounced for odour compared to flavour when levels of androstenone and skatole are low. Preference for boar is lower when consumers are sensitive to androstenone or skatole. Consumer acceptance of boar meat is significantly affected by boar meat type, i.e. overall liking is decreased with increasing androstenone and skatole levels.
The main sensory study in the EU countries confirmed that castrate patties were preferred to boar patties. It also confirmed that smell and flavour of boar meat patties with high levels of skatole had lower preference. Odour preferences (for meat patties from boars over castrates) are lower in Denmark and Poland compared with France. Flavour preferences are lower in Denmark compared with France and Italy. Androstenone insensitive consumers had lower smell and flavour preferences compared with very sensitive consumers. Skatole sensitivity also affected smell preferences of meat patties from boars *vs.* castrates. This difference in scores is higher in meat patties with high skatole levels and for androstenone and skatole sensitive consumers. Moreover, these differences between boar *vs.* castrate liking scores are higher in Denmark than in France and Italy. The higher the skatole levels the larger the differences in scores between meat from boars *vs.* castrates.
In the third countries, the acceptability of boar meat is significantly impaired with increasing levels of androstenone and skatole.

According to the smell tests in the pilot study to evaluate consumers' olfactory acuity to androstenone and skatole, 72% and 47% of consumers are classified as sensitive towards skatole and androstenone, respectively; 18% are even very sensitive to androstenone. The proportion of consumers perceiving androstenone as unpleasant is highest among very sensitive subjects (94%) compared to sensitive (58%) and insensitive subjects (22%).
Results of the sensitivity test to androstenone and skatole in EU studies show that, depending on the country, between 62.0 and 71.2% of the consumers are insensitive to androstenone, whereas between 21.2 and 29.4% are sensitive to androstenone and between 5.5 and 16.5% are very sensitive. Regarding skatole, between 33.1 and 48.6% of the consumers are insensitive (and between 51.4 and 66.9% are sensitive).
A total of 63.3% of Russian consumers are classified as anosmic to androstenone being this percentage 68.3% in China. Regarding skatole, 30% of Russian consumers are anosmic while in China this percentage is 40%. In Russia a total of 13% of very sensitive consumers to androstenone liked its smell, being this percentage 7% for sensitive consumers. Regarding Chinese consumers these percentages are 21.4% for very sensitive and 8.3% for sensitive. Regarding skatole, in Russia 8.3% of sensitive consumers liked its smell while this percentage is 36.1% for sensitive consumers in China.

In the pilot study, consumers' sensitivity to androstenone affects the overall liking of boar meat. Very sensitive subjects reported more frequently slight to extreme dislike (54.9%) compared to sensitive subjects (39.6%) and non-sensitive subjects (33.4%). Consumers often preferred the castrate sample even when the levels of androstenone and skatole in both samples are low. When skatole and androstenone levels in the boar sample are higher, also consumer preference for the castrate meat is increased. Results of the pilot study indicate rejection thresholds in between 1.5 and 2.0 ppm for androstenone and around 0.3 ppm for skatole. Using such tentative thresholds will not guarantee totally boar taint free meat, but reduce consumer dissatisfaction. Sorting limits should be derived according to the extent of consumer dissatisfaction that is accepted by a given company. Besides androstenone and skatole, other compounds in boar meat may contribute to decreased liking as observed for individual samples.
For the EU countries, preference maps show the importance of skatole in the liking of boar meat patties and also of androstenone when skatole levels are low. The relation between scores given by the trained sensory panel and the consumers preferences confirmed the importance of skatole in the sensory evaluation of pork.

Dissatisfied consumers (%) 34.2% sensitive-65.8% insensitive consumers

Androstenone (ppm) \ Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	16.3	19.2	22.0	24.6	27.1	29.4	31.6	33.7	35.7	37.6	39.4	41.1	42.7	44.3	45.7	47.1
0.67	18.0	20.8	23.5	26.0	28.4	30.6	32.7	34.6	36.5	38.2	39.9	41.5	43.0	44.4	45.7	47.0
0.87	19.3	22.1	24.7	27.1	29.4	31.5	33.5	35.3	37.1	38.7	40.3	41.7	43.1	44.5	45.7	46.9
1.07	20.4	23.1	25.7	28.0	30.2	32.2	34.1	35.9	37.5	39.1	40.5	41.9	43.3	44.5	45.7	46.8
1.27	21.3	24.0	26.5	28.8	30.9	32.8	34.6	36.3	37.9	39.4	40.8	42.1	43.4	44.6	45.7	46.8
1.47	22.2	24.8	27.2	29.4	31.4	33.3	35.1	36.7	38.2	39.6	41.0	42.3	43.5	44.6	45.7	46.7
1.67	22.9	25.5	27.9	30.0	32.0	33.8	35.5	37.0	38.5	39.9	41.2	42.4	43.5	44.6	45.7	46.7
1.87	23.6	26.1	28.4	30.5	32.4	34.2	35.8	37.3	38.7	40.1	41.3	42.5	43.6	44.7	45.7	46.6
2.07	24.2	26.7	28.9	31.0	32.8	34.5	36.1	37.6	39.0	40.3	41.5	42.6	43.7	44.7	45.7	46.6

Preference map for % dissatisfied consumers (liking scores between 1 and 4) in the EU study for boar meat patties depending on the levels of androstenone and skatole and considering all the consumers weighted by the proportion of sensitive and non-sensitive ones (green = lower % of dissatisfaction - red = higher % of dissatisfaction).

In third countries acceptability is mainly related with consumers' sensitivity to skatole. For sensitive consumers, the preference for boar over castrate meat decreased with increased levels of androstenone and skatole as measured in backfat of the carcasses used to manufacture the patties. There are differences on preferences for boar meat between countries. Russian consumers are more reluctant to prefer boar with medium or high levels or androstenone and skatole. But, because acceptability is linked to sensitivity of consumers to skatole, this difference can be due to the fact that in the Russian sample there are 10% more sensitive consumers than in the Chinese sample.

Conclusions sensory study

- In meat patties with 15-20% fat content and within the range of concentrations explored in this study (0.1-0.4 ppm skatole per g fat tissue; 0.5-2.0 ppm androstenone per g fat tissue), skatole levels more strongly affected consumer acceptance than androstenone levels. Increasing levels of skatole are related to a decreasing preference for boar over castrate meat over the whole range of skatole included in this study. For androstenone sensitive consumers, increasing androstenone levels are also related to a decreasing preference for the boar meat, but only in the low skatole range. Over the whole range of skatole and androstenone included in this study the % dissatisfied consumers is higher for boar meat compared to meat from castrated male pigs. It has to be stated, however, that androstenone levels higher than 2 ppm, which occur not seldom in boar populations, have not been explored in this study. Also the very low androstenone and skatole levels (in the same range as observed in castrates and gilts), need further investigation.
- We are able to determine the excess percentage of consumers who have a lower preference for boar meat compared to castrate meat, and to specify these percentages depending on the consumers' sensitivity to androstenone. We cannot specify single threshold values for androstenone and skatole based on the results of this study, as the decrease in liking is not accelerating at a certain threshold value, but is rather continuous instead. Companies can determine their own threshold, depending on the products and given their own risk assessment.
- Differences in consumer acceptance of pork with varying levels of skatole and androstenone between four EU member states are not significant. The explorative study in Russia and China revealed a stronger disfavour of boar meat with medium to high levels of skatole and androstenone, which increases in consumer sensitive to skatole.

Consumer attitudes survey study

Methods

An online survey is conducted in 10 EU member states and in four 3rd countries: Belgium, Denmark, France, Germany, Greece, Italy, Latvia, The Netherlands, Poland, Spain, China, South Korea, Russia and the USA. A total of 11294 consumers are recruited, roughly 800 in each country. For recruiting, quota are set to get a good spread on educational level, sex, age (between 18 and 65), and urbanisation degree. In designing the questionnaire an important assumption is that the alternatives to surgical castration (immuno-vaccination, raising boars) are too complicated to directly ask consumers for their opinion on this. Rather, we addressed the underlying aspects. For this, a combination of approaches is used: 1. Consumer perception of motives that are relevant to acceptance of alternatives of surgical castration of male pigs are reported for the different countries and differences are described between the countries. 2. We studied differences within

and across countries by identified groups of consumers (segments) that are similar importance they attach to the different motives. 3. A choice experiment is done in Italy, Poland, France, and Denmark to determine the importance of the aspects relative to each other.

Results consumer attitudes survey

For aspects that consumers find important for their consumption of food in general, four different dimensions of motives are identified. The dimension that included both nutritional content, natural ingredients and no additives (e.g. keeps me healthy, contains natural ingredients; labelled *health and natural*) is considered most important or second most important in all countries compared with *price*, *sensory quality*, and *animal welfare*. *Sensory quality* is considered most important in USA, Belgium, France, Latvia, The Netherlands, and Spain. *Animal welfare* is considered least important or third most important, except in Germany where it is second most important along with sensory appeal. For aspects related to the production of pork, four dimensions of motives are identified that determine the attitude of consumers. Consumers in all countries rated their perceived *"food safety and quality"* on average as most important. *"Animal and environmental friendliness"* is rated second in Belgium, China, Denmark, Germany, France, Greece, Italy, The Netherlands, Poland and Spain; third in South Korea and Russia, and fourth in Latvia. *"Costs"* and *"regional identity"* are the other two dimensions of pork-production related motives for consumers. In all countries except China we found groups of consumers (population clusters) who rated *animal friendliness* as important, next to *food safety and quality* that is always rated high in all clusters in all countries. In several countries we identified population clusters for whom production *costs* are rated important (next to perceived *safety and quality*) while *animal and environmental friendliness* and *regional identity* are rated low *Regional identity* is considered important and production *costs* are less important in three clusters in Germany and Poland. Finally, a substantial share of the studied populations does not have a clear opinion on pig production aspects.

Dimensions of pork production motives (mean values) per country and ranking of the motives within the country

Country	Quality & health	Costs	Animal and environment	Regional identity
USA	5,77[1]	5,27[2]	4,79[3]	4,40[4]
Belgium	5,95[1]	5,04[3]	5,27[2]	4,42[4]
China	6,14[1]	5,04[4]	5,27[2]	5,22[2]
Denmark	5,84[1]	4,54[3]	5,07[2]	3,45[4]
Germany	6,02[1]	4,30[4]	5,38[2]	4,64[3]
France	5,99[1]	5,08[3]	5,23[2]	4,59[4]
Greece	6,31[1]	5,11[3]	5,37[2]	4,65[4]
Italy	6.22[1]	5.06[4]	5.62[2]	5.08[3]
South Korea	5,62[1]	5,29[2]	5,05[3]	4,93[3]
Latvia	5,97[1]	4,99[2]	4,61[4]	5,01[2]
Netherlands	5,73[1]	4,76[3]	5,06[2]	3,50[4]
Poland	6.10[1]	4.97[3]	5.27[2]	5.15[3]
Russia	6.46[1]	5.06[2]	4.69[3]	4.97[3]
Spain	6,09[1]	5,24[2]	5,29[2]	4,60[4]

[1234] Ranking within the country

When respondents are asked to choose three main motives for buying and eating meat from a set of 11 generic formulated motives; *Quality, price* and *taste* are most often selected, and *no artificial ingredients, animal welfare,* and *convenience* least often selected. *Safety* is chosen more often as a main motive in China, Italy, Korea, Greece, and USA and less often in Denmark, Germany, Belgium, Latvia, Poland, and France. *Animal friendly* is considered relatively more important (rank 4 or 5) in Denmark, Germany, Belgium, and The Netherlands. In a choice experiment on the importance of production aspects respondents ranked *produced in a natural way* as the most important, followed by *avoiding human health risks, ensuring the best taste*, and *avoiding stress* and *avoiding pain*. *Produced at low costs* and *pharmaceutical interventions only in case of medical need* scored lowest.

Conclusions consumers attitudes survey

Based on the results of the online survey on consumer attitudes we conclude that:

- For aspects related to the production of pork, four dimensions of motives are identified that determine the attitude of consumers. Consumers in all countries perceived *food safety and quality* on average as most important. *Animal and environmental friendliness* is rated second in Belgium, China, Denmark, Germany, France, Greece, Italy, The Netherlands, Poland and Spain; third in South-Korea and Russia, and fourth in Latvia. *Price* and *regional identity* are the other two dimensions of pork-production related motives for consumers.
- When respondents are asked to choose three main motives for buying and eating meat from a set of 11 generic formulated motives; *Quality, price* and *taste* are most often selected, and *no artificial ingredients, animal welfare,* and *convenience* least often selected.
- In a choice experiment on the importance of production aspects consumers ranked *produced in a natural way* as the most important, followed by *avoiding human health risks, ensuring the best taste*, and *avoiding stress* and *avoiding pain*. *Produced at low costs* and *pharmaceutical interventions only in case of medical need* scored lowest. Consumer perception of immuno-vaccination is not studied directly. Based on the results it is, however, expected to depend on how consumers relate this to pork production aspects at a general level - such as *naturalness* - and at a more specific level - such as *pharmaceutical interventions*.
- In all countries except China we found groups of consumers (population clusters) who rated *animal friendliness* as important, next to *food safety and quality* that is always rated highest in all clusters in all countries. Large population clusters for which *animal and environmental friendliness* is rated important are identified in Germany, Italy and the US. In several countries we identified population clusters for which production costs are rated important (next to food safety and quality) while animal and environmental friendliness and regional production are rated lower in these clusters in Denmark, Germany, France, Spain, and the US. Three population clusters are similar in the way that regional production identity is considered important, whereas production costs are considered less important in Germany and in Poland. Finally, a substantial share of the studied populations does not have a clear opinion on pig production aspects.
- Differences in consumer attitudes between EU and Asian countries are smaller than the differences between the EU countries in the studied populations.

Discussion and conclusions

The major strength of this study is that consumer preferences of boar meat are studied in several European countries with the same study design and with meat samples from one production batch. This product can serve as a reference for future studies with different products. Additionally, an exploratory study is conducted in China and Russia. Another strength is the testing of the consumers' sensitivity to androstenone and skatole that allows us to show the reactions of both higher and lower risk groups. Combining insight in consumers' preference for androstenone and skatole levels with an effective quality control at the slaughter line will be an important step forward towards market acceptance. The Boarcheck study concluded that there are a few detection methods with potential for this, but these methods need to be further properly validated to prove their fitness at industrial level.

Consumer attitudes are tested in a similar way and within the same time period in 10 European countries and 4 countries outside Europe. This enables us to compare the different countries and make Europe-wide conclusions as well as tentative conclusions for some countries outside Europe. An additional strength of the survey is the use of different types of measures, more specifically the combination of questionnaire and choice experiment. The studies have however some limitations and challenges that ought to be addressed.

The CAMPIG project successfully introduced a more objective, standardized smell test procedure for determination of olfactory acuity. The proportion of sensitive subjects is determined using a series of standardized triangle tests, with two blank strips and one strip with skatole or androstenone solutions pipetted on that allows assessment of consumers' ability to discriminate between blank and target odorant samples. The odorant solutions are prepared in advance and then distributed to the partners. The percentage of sensitive subjects affects the % dissatisfied consumers.

The study aimed to identify thresholds (of androstenone and skatole in the boar meat) for impaired consumer satisfaction. When evaluating the results, several limiting factors should be taken into

account: First, the results are only representative for the studied levels of androstenone and skatole in the meat. Testing the very low and very high levels of androstenone and skatole would allow for a more thorough modelling of the consumer response, but would imply the need of more consumers to be tested. Second, consumers are assigned randomly to the various combinations of androstenone and skatole levels, as each consumer only tasted four out of the eight combinations, with their sensitivity status yet unknown. Thus, the percentage of consumers sensitive to androstenone varies between the combinations, which affect the frequency of dissatisfaction. Third, the central location test differs from a home situation which should be taken in consideration when interpreting the results. For example consumers are absent during the cooking process, results are based on a prepared product and a single exposure with a small amount of meat compared to a normal portion size, no seasoning or salt is used, etc. Fourth, results are only representative for the used meat product that is relatively high in fat. The product could however serve as a benchmark for future studies.
The survey study had an overrepresentation of highly educated people in the Asian samples (South Korea, China). The attitude and motives survey is to be conducted online. Thus, highly educated people are overrepresented in the sample in China and South Korea as they have more access to Internet. Second, we did not observe real behaviour but collected self-reported attitudes which are often divergent from real life situations.

Our overall conclusion is that increasing levels of skatole and, to a lesser degree androstenone, in the meat lower the consumer acceptance of boar meat compared to castrate meat. The effect of skatole is found over the whole range of skatole levels tested in the study whereas the effect of androstenone is found only for samples that are low in skatole and for consumers that are sensitive to androstenone. Consumers considered perceived "health and quality" as the most important production aspects of pork; the production aspect "animal welfare" is second most important in a number of countries.

Recommendations

Based on the research results we recommend further study into:

- Consumer preference for and liking of pork products from boars with very low levels of androstenone and skatole. This would allow us to gain insight if lowering these levels is sufficient to solve the boar taint problem;
- Consumer preference for and liking of pork products from boars with high levels of androstenone, and the degree of dissatisfaction at these high levels;
- If we want to model the response of the highly sensitive consumers more in depth –in addition to the sensitive and non-sensitive ones – we need to include substantially more consumers than we had in this study;
- The response of consumers in a home test;
- The impact of the long term consumption of boar tainted meat, to test whether the acceptance of boar taint does increase or decrease with repeated exposure;
- The effect of varying levels of skatole and androstenone in different meat products and in meat products that are treated, using masking techniques, culinary treatments and natural compounds like herbs and spices to reduce boar taint and flavour;
- How human sensory perception works and what goes on in the brain when meat from boars is consumed;
- Understand which factors are underlying the main consumer motives: *quality and safety perception* of consumers and *naturalness* and how these can be influenced;
- The relationship between boar meat and other quality attributes of the meat form boars, including a full evaluation of technological, health, and sensory properties of meat from different genetic crosses;
- The relationship between consumer attitudes and actual buying behaviour, for example the trade-off between quality and safety perceptions and costs;
- Online methods for the selection of boar taint.

I. SENSORY STUDY

I.1. PILOT STUDY

A pilot consumer test was conducted with 383 consumers in Germany. Shortly, the study comprised four steps: (i) the assessment of consumers' preference (odour and flavour) of castrate over boar meat, (ii) the assessment of consumers' acceptance (overall liking) of castrate and boar meat, (iii) smell tests to assess olfactory acuity to androstenone and skatole, and (iv) a post hoc questionnaire on demographics. Standardized pork patties made of either castrate or boar meat with 15 to 21% fat were served. Each consumer was sequentially served with four pairs of meat patties following a balanced design for the serving order. While the castrate sample was always of the same batch, the boar patties varied with respect to androstenone (.41 to 2.17 µg/g fat) and skatole (.07 to .48 µg/g fat). In total, 16 combinations of various androstenone and skatole levels were tested. Consumers' sensitivity to and appreciation of androstenone (2 levels) and skatole (1 level) were assessed using smell strips after they had evaluated the meat.

I.1.1. Sample preparation

Pigs were selected after slaughter based on a combination of skatole equivalence and a human nose analysis. The day after slaughter, samples from the back fat was excised for analysis of ASI in the laboratory. The fore-end and the back-fat was excised, vacuum packed and frozen the day after slaughter and kept at -40 °C until use.
The aimed concentration of the batches of minced meat is presented in Table 1. The batches of minced meat were prepared by mixing meat and fat from two or more animals per batch. This reduces the influence of individual animal to animal variation and was furthermore necessary to create a sufficient amount of meat for the entire consumer study.

Table 1. Planned content of androstenone and skatole in the back-fat of meat (batch number is further referred to in Table 3).

	Androstenone [ng/g]			
Skatole [ng/g]	**500**	**750-1000**	**1500**	**2000**
100	x (1)			X (2)
150		X (3)	X (4)	
300		X (5)	X (6)	
400-500	X (7)			X (8)

From the laboratory analysis, animals were selected for the eight batches of entire males. The meat and fat was thawed. The meat was weighed, and fat similar to 20 % of the meat weight was added to the meat. Equal amounts of meat and fat were taken from every pig in each batch. The meat was minced through 3 mm hole sizes, mixed thoroughly and portioned for the sensory and chemical analysis and for the consumer study before refreezing.
For the tests in China and Russia, three pigs were selected. Back fat and the fore-end was send to the two countries. The meat and fat was minced and mixed in the individual countries keeping the animals separate. A sample from Russia was send to DMRI and analysed for fat and water content.

I.1.2. Chemical analysis

The backfat of the individual pigs was analysed for the content of androstenone, skatole and indole using an HPLC-FD method. The back fat was homogenized using methanol to extract androstenone, skatole and indole. After a centrifuging, the androstenone and skatole was derived using dansylhydrazin and injected into the HPLC system. The compounds were detected using fluorescence. The fat content was analysed using a modified Soxtech method. The water content was analysed by a gravimetric method.

I.1.3. Data simulation and design of the pilot study

The pilot study design was developed given the fact that the sensory laboratory can hold up to 16 consumers each session and that each meat patty should serve four consumers. While balancing the serving order of the meat types 1 to 16 and the serving order within the pairwise comparisons, 24 sessions á 16 consumers were scheduled resulting in n = 96 observations for each meat type.

Initially, a total sample size of approximately 500 consumers was suggested in the proposal. This was based on the assumption that (i) 18 boar meat samples shall be tested and (ii) that each sample shall be assessed by about 120 consumers[1]. Based on power simulations made by DTU (Figure 1) the CAMPIG management team agreed on using 96 consumers per meat type.

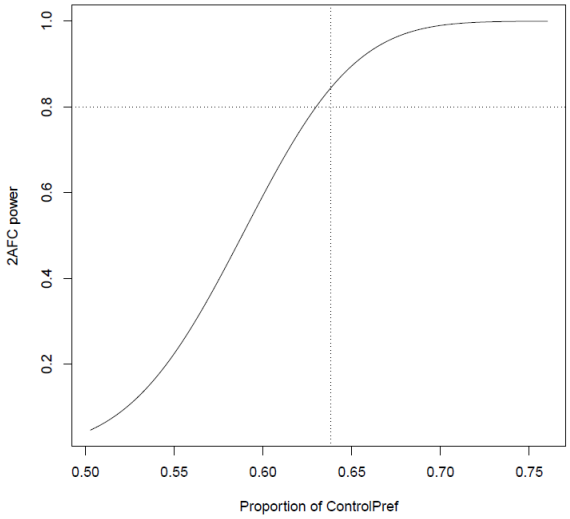


Figure 1: Predictive power to find a significant preference for castrate over boar meat depending on the % consumers preferring the castrate patties using a sample size of n = 96 consumers. Here, a proportion of 62.5 % of consumers preferring the castrate over boar will be detected with 80% power.

I.1.3.1. Sample stratification

Following the approach to elucidate consumer rejection thresholds, a paired comparison test was chosen. Each pair consists of a boar and a castrate sample while the boar meat varies in androstenone and skatole content. Due to budget restrictions, the CAMPIG project partners agreed on 16 meat types; the scheduled levels of the 16 boar meat samples are given in Table 2. Prior to that decision detection threshold experiments were performed at DMRI that resulted in lowest detectable levels of androstenone (.5 to .75 ppm) and skatole (.1 ppm) using trained assessors.

Table 2: Sample stratification plan for CAMPIG pilot study

	Androstenone levels [ng/g backfat tissue]				
Skatole [ng/g backfat tissue]	**500**	**750**	**1000**	**1500**	**2000**
100	1	2	3	4	5
150	6	10		16	
200	7	15	11		
250	8			12	
300	9		14		13

The color (green, yellow, orange, red) indicates the four sub-blocks (= taint categories) used to generate the design for the consumer test.

I.1.3.2. Meat collection

Castrate and boar meat from commercial pig carcasses was collected at DMRI. On the day of slaughter, carcasses from entire males were sorted based on analyses of the skatole equivalent (a combination of skatole and indole), and a sample of the back fat was excised. Those samples were

[1] Due to international standards consumer studies shall comprise 60 consumers at least (e.g. DIN 10974 Consumer tests). Assuming that 50 % of the consumers are insensitive to androstenone, 120 consumers would thus be needed to assess each boar meat type. The management team agreed on a sample size of about 100 consumers per cell. With four servings per boar meat type this would require a total number of n=400 consumers for the pilot test.

analysed off-line using two assessors smelling the fat after pouring with boiling water[2]. Based on these initial assessments, carcasses were selected for further analysis of androstenone and skatole using a HPLC method (see CAMPIG deliverable D1.1). Based on these results, animals were selected for the sensory study. On the day after slaughter, pork from the fore-ends of both carcass sides (Bov 1313, Essfood specification (http://www.ess-food.com/index.php?option=com_content&view=article&id=16&Itemid=23)) and the back fat was excised, vacuum packed, frozen at -20 °C and then kept at -40°C until use. Previously, data has shown a fat content in the fore-end meat of approximately 12%. Backfat was therefore added to a calculated fat content of 20%. Meat and fat were minced using a whole size of 3 mm, mixed thoroughly thereafter and divided into 500 g packages. The packages were evacuated and frozen at -20 °C. Results of chemical analysis are given in Table 3.

Table 3: Chemical characteristics of the minced boar meat and of the back fat.

CAMPIG ID	DMRI animal ID	Fat [%]	Water [%]	Skatole [µg/g]	Androstenone [µg/g]
1	237	16.1	66.1	0.07	0.41
2	223	19.3	63.3	0.08	0.82
3	272	17.0	65.4	<0.03	1.06
4	274	16.3	66.0	0.10	1.50
5	255	15.1	65.7	0.09	2.00
6	221	17.1	65.2	0.14	0.51
7	206	17.2	64.1	0.21	0.53
8	234 + 211*	16.1	66.0	0.25	0.57
9	218	21.4	61.9	0.45	0.57
10	246 + 242*	18.3	63.9	0.17	0.79
11	233	17.4	64,5	0.21	1.03
12	279	18.0	64.0	0.21	1.49
13	232	17.1	64.2	0.44	2.17
14	231 + 222*	16.7	65.1	0.48	0.96
15	210	16.3	65.1	0.26	0.80
16	214	15.0	66.5	0.26	1.90

* made by mixing the lean and fat of two carcasses to reach the scheduled levels of androstenone and skatole

A graphical illustration of the actual levels of androstenone and skatole in the back fat is given in Figure 2. The frozen meat, packed with ice, was shipped to Germany by day-to-day shipping.

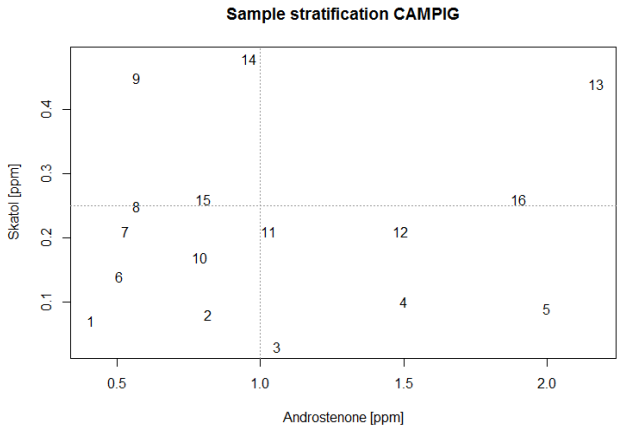


Figure 2: Androstenone and skatole levels in the backfat of the boar carcasses used to produce the minced meat for the CAMPIG pilot study. Numbers indicate the boar meat types (1 to 16) according to the design in table 2. Androstenone and skatole values refer to g tissue of backfat of the carcasses used to produce the minced meat. Dotted lines indicate tentative rejection thresholds for androstenone (1 µg/g fat) and skatole (.25 µg/g fat) as suggested by Walstra et al., 1999[3].

[2] Meinert, L., Claudi-Magnussen, C., Støier, S. (2013). Limits for the detection of boar taint. Fleischwirtschaft 2/13.

[3] Walstra, P., Claudi-Magnussen, C., Chevillon, P., von Seth, G., Diestre, A., Matthews, K. R., et al. (1999). *An international study on the importance of androstenone and skatole for boar taint: levels of androstenone and skatole by country and season*. Livestock Production Science, 62, 15–28.

I.1.3.3. Preparation of meat patties

The aim was to produce visually identical patties, which are fried to the same degree without excessive surface browning. Prior further use, the meat was thawed at +4°C for 48 hours. Fresh patties were prepared each morning prior to the tasting sessions (up to three sessions of 16 consumers per day).
The initial step in making a patty was to weigh out 110 g of minced meat. This portion was subsequently formed into a bolus, each of which was placed into a household patty maker and flattened. These flat portions were then made into patties using a press whose upper part was lightly oiled using "No-stick baking spray" before pressing. For each session patties were placed on an appropriate plates affixed with a three digit code and individually covered using aluminium foil. Upon further use the patties were then again stored at +4 °C (maximum storage time 6 hours). Immediately before tastings, the patties were fried in preheated pans using three identical household induction ovens (NEFF Constructa München, Germany; Type HMIIV0C, 7200 W). At the beginning of each session, ovens were set to reach pan surface temperature of 170°C. Later, the power of the ovens needed individual adjustments. No additional oil was used for frying. Each boar patty was fried in a separate pan; pairs of control samples were fried together (i.e. four pans for four boar samples, two pans for four castrate samples per session). Total cooking time was 10 minutes resulting in a core temperature of 81 ± 4.5°C[4]. To avoid excessive surface browning/burning patties were turned after 2, 4, 6, and 8 minutes. Upon end of cooking, each patty was placed on its respective cutting board and sliced into 4 equal pieces. Samples were encoded with three-digit codes written on small flags. Patty pieces (approximately 25 g) were served on preheated plates (oven set to 55°C) and served immediately to the consumers. Serving temperature of the patties was 72°C at the moment they were entering the booth. As each session had four serving rounds using the same products (boar meat samples) the pans were wiped with paper towels and used again while making sure that each pan was used for the same meat type again.
The pilot study was conducted in a commercial sensory laboratory in accordance with international standards (ISO 8589:2010; sensory analysis: general guidance for the design of test rooms). Consumers could follow the procedure and enter their ratings via LCD monitors using an electronic evaluation form. The procedures were made using the software EyeQuestion (logic8, The Netherlands). Meat samples were prepared in a separate room/kitchen with sufficient cooking facilities, i.e. 3 commercial ovens to hold up to 8 (identical) pans per session. The individual tests booths (n=16) were equipped with a sufficient ventilation and air conditioning. Positive pressure ensured that no kitchen odours entered the evaluation booths. Ambient temperature was 22°C. Daylight was excluded; booths were individually lightened by incandescent light bulbs.

I.1.3.4. Consumers' sensory evaluation of meat samples

Prior to each session, consumers were informed on the procedures, the duration of the session, and the scales to be used throughout the test. They were told that they get four pairs of meat samples to indicate (i) their preference in terms of odour (= smell), (ii) their preference in terms of flavour (= taste), and (iii) to report overall liking for each sample on a 8pt hedonic scale (1 = dislike extremely, 8 = like extremely). They were instructed to eat at least half of the piece. There were not informed that they could spit out the sample. Consumers were instructed about the use of water and wheat bread for cleansing the palate, and about not to communicate with other participants. For the pairwise comparisons, the option 'no preference' was not allowed, i.e. consumers were forced to indicate which sample they preferred.
Each consumer was served four out of 16 boar meat types (each together with a castrate sample) while the sample order was balanced following the sub-block structure of taint categories. This way each consumer got a boar sample from each sub-block in a random order balanced across all consumers. Also the presentation order of the castrate sample within the respective pairwise comparisons was balanced within consumers.

I.1.3.5. Smell test

To assess consumers' olfactory acuity to androstenone and skatole, the substances were presented on paper smell strips.

[4] Initially, a core temperature of about 72 °C was agreed on. During the first sessions, however, consumers apparently disliked the pinkish color of the fried patties. The frying time was thus extended to increase the internal temperature of the patties in order to serve a product of which the consumers are familiar with.

1. Form into bolus	2. Put the bolus into the patty-press and press flat	3. "Quarter- *Pounder"*
		
4. Preheat pan to 170 °C; no oil	**5. Fry**	**6. Slice patty into 4 equal pieces**
		
7. Place Portions on Plates	**8. Frying Station**	**9. Cutting Station**
		

Figure 3: Preparation of the meat patties.

The smell tests were conducted immediately after the assessment of the meat patties. Each participant evaluated 10 triangle tests that each consisted of one odd sample (the respective odorant) and two identical samples (solvent only, i.e. propylene glycol). Odor discrimination was assessed in triplicate for each level. The probability of a correct guess was thus lowered to 3.7 %. Upon completion of the discrimination task, subjects assessed odor liking of androstenone (5 µg/g) and skatole (1 µg/g) using 9 point hedonic scales. For data analysis purposes subjects were later

classified as sensitive (=YES) whenever three out of three triangles were correctly discriminated for androstenone (5.0 µg/g) or skatole (1.0 µg/g). Subjects were classified as highly-sensitive to androstenone (=VERY) when they also correctly discriminated both at the lower and at the higher concentration in triplicate each.

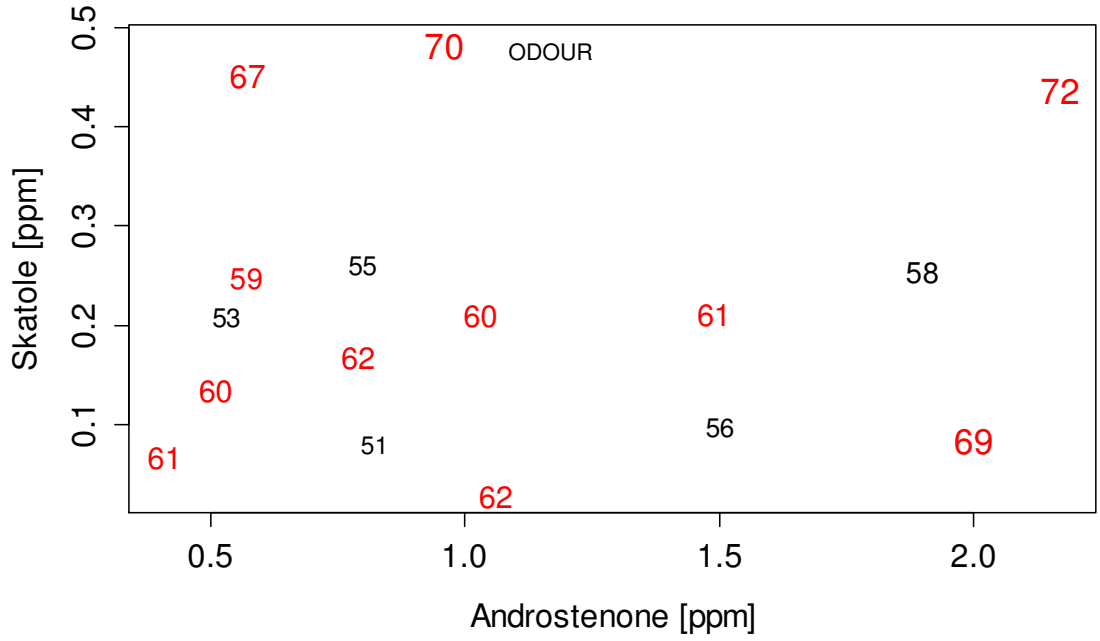
I.1.3.6. Consumers

For the pilot study, three requirements needed to be met: gender (female), age (18 to 65 years), and pork consumption (eating pork as a hot dish at least twice per month). Only female consumers were recruited to increase the probability of getting androstenone sensitive consumers. Recruiting was done by an external company (isi GmbH Göttingen, Germany) using their data base. For most of the 24 sessions, 18 consumers were recruited in order to have 16 consumers showing up (= 12.5% over recruiting). Thus, 12 consumers had to be given incentives although they did not participate in the study. Upon completion of the test, consumers were compensated financially for their time (25 € for a 90 min).
The consumers were on average 41.7 ± 13.4 years old. One quarter was younger than 29 years and older than 52 years, respectively. More than half of the consumers (52%) reported to consume pork once to twice a week, close to one third (28%) consumed pork three to four times a week.

I.1.4. Results

I.1.4.1. Pairwise comparisons

Figure 4 displays the consumer preference of castrate over boar meat with respect to ODOUR and FLAVOUR in accordance with the levels of androstenone and skatole content of the respective boar meat. The consumer preference of castrate meat is less pronounced for flavour compared to odour ($p<.001$, Wilcoxon signed-rank test).



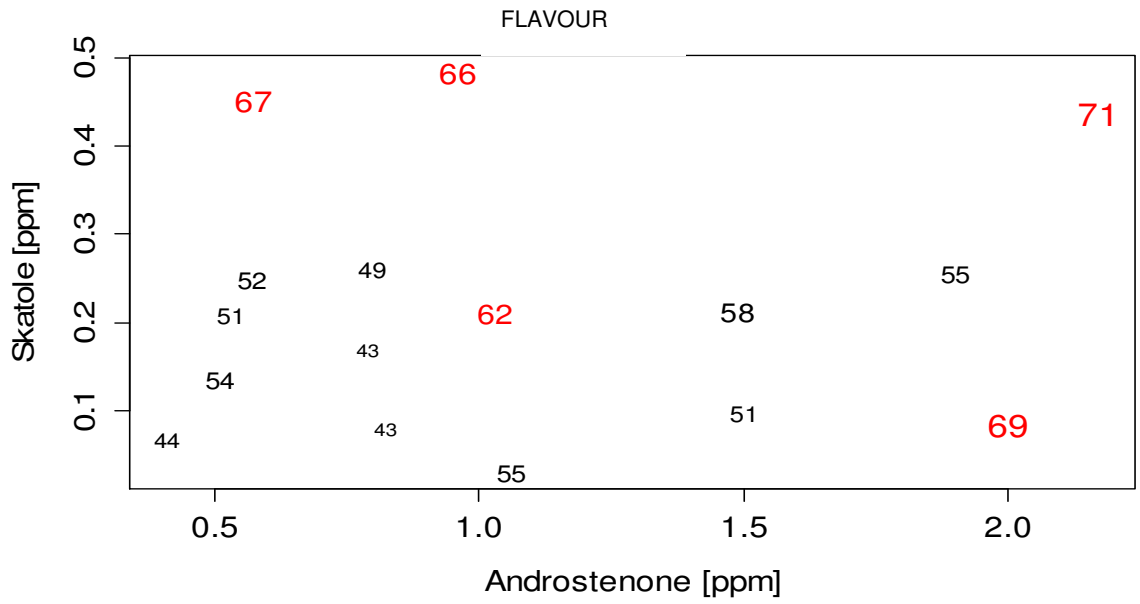
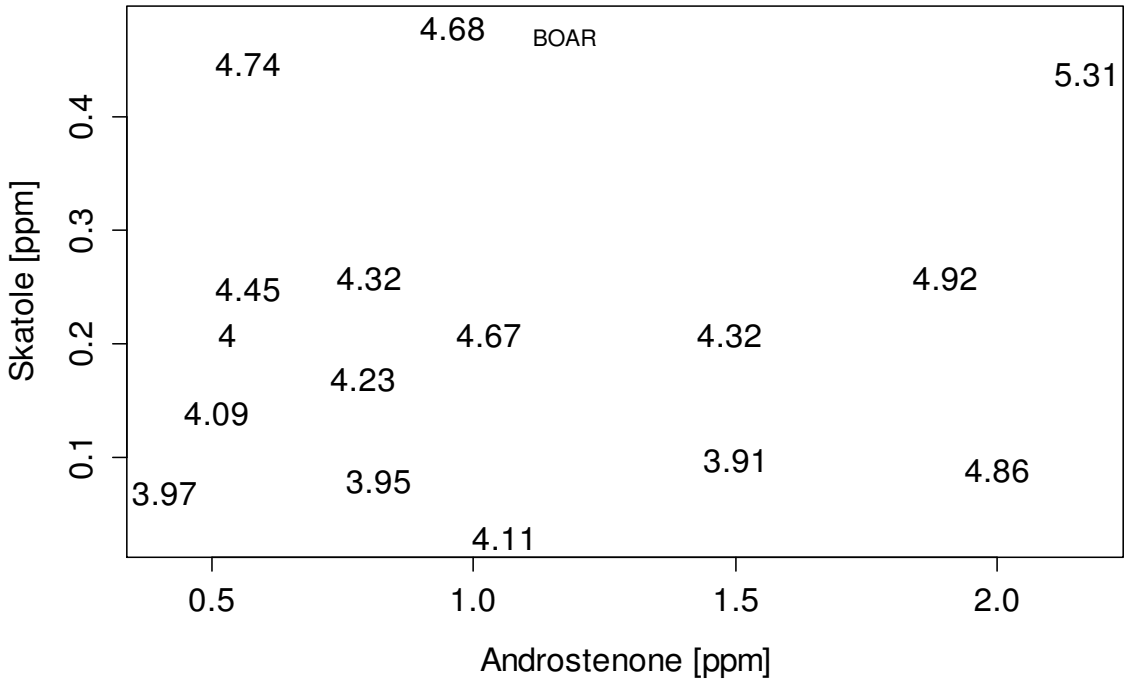


Figure 4: Proportion of consumers (in %) preferring castrate over boar meat with respect to ODOUR (upper panel) and FLAVOUR (lower panel) in accordance with respective levels of androstenone and skatole content of the boar meat. The total no. of consumers within each of the pairwise comparisons varies from 95 to 96 due to one missing observation. When indicated in red, the given proportion is significantly greater ($p < 0.05$) than 50 %.

I.1.4.2. Overall liking

Raw means of overall liking of the BOAR and CASTRATE meat are given in Figure 5. Consumer liking of boar meat samples is decreased with increasing androstenone and skatole levels. By trend, liking of the castrate meat is affected by the levels of androstenone and skatole of the corresponding boar sample, too.



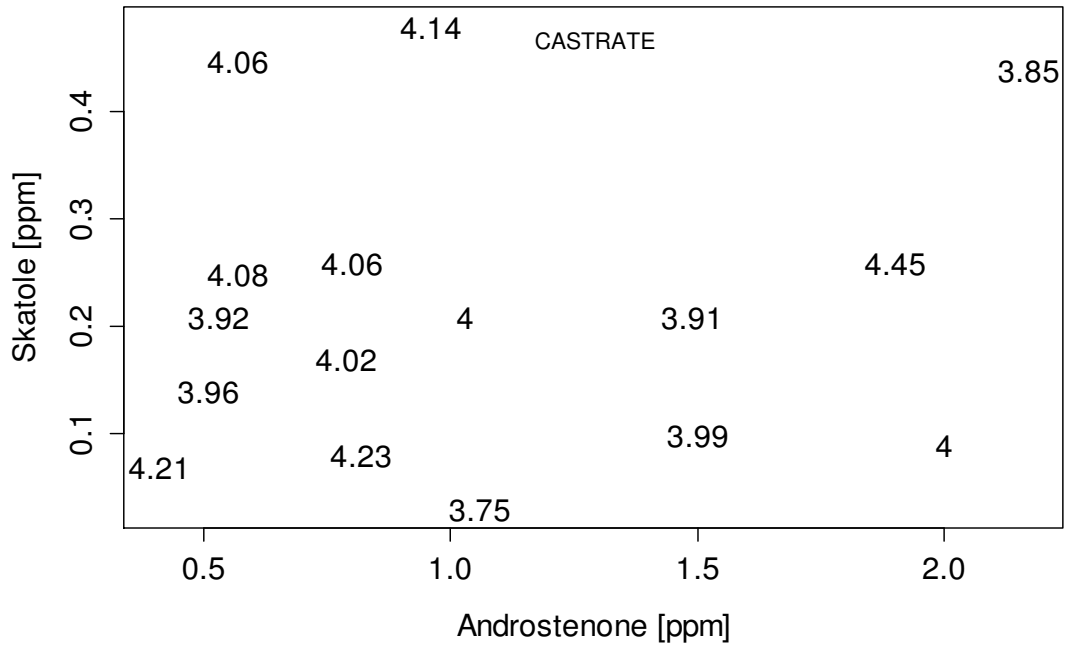


Figure 5: Overall liking of the BOAR meat (upper panel) and the CASTRATE meat (lower panel) with respect to varying androstenone and skatole levels. Overall liking was evaluated using 8pt hedonic scales (1= like extremely, 8 = dislike extremely) – higher values indicate higher dislike. Liking of the castrate samples is displayed together with the androstenone and skatole levels of the boar meat it was served with.

Figure 6 illustrates the varying distribution of overall liking for the most divergent meat samples, i.e. boar meat samples with very low and very high androstenone and skatole in comparison to the castrate meat.

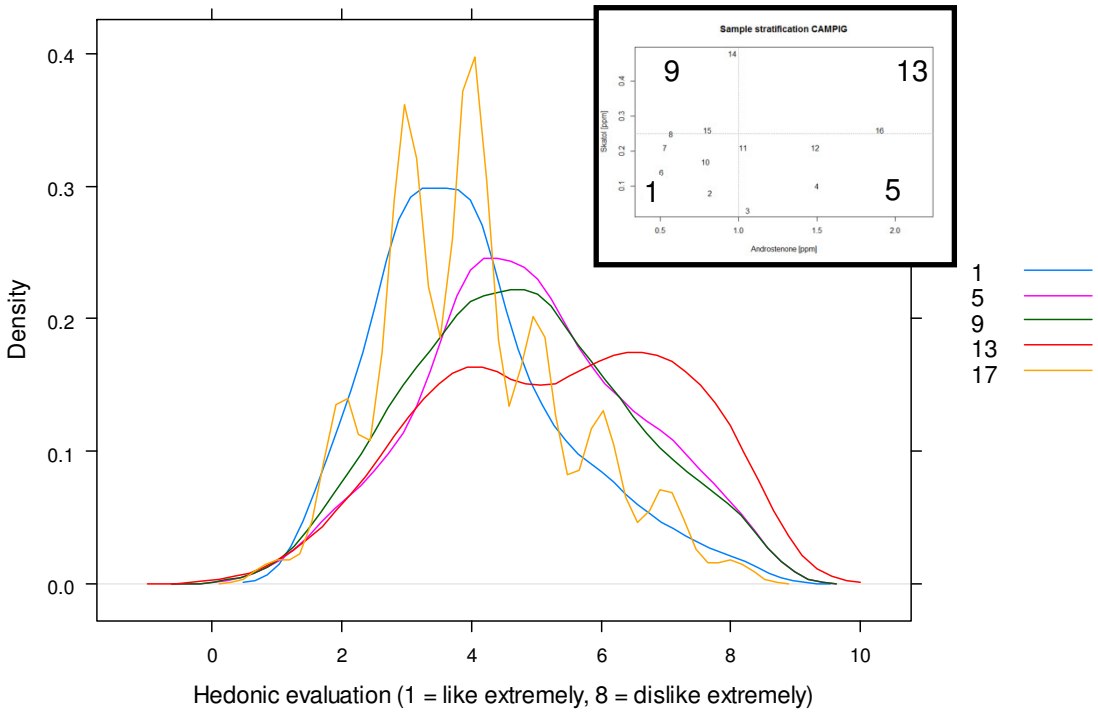


Figure 6: Density plot of OVERALL LIKING ratings for selected boar (No. 1, 5, 9, 13) and castrate (No. 17) meat samples. A smaller copy of figure 2 is displayed in the upper right corner to show androstenone and skatole levels in the boar meat samples.

The boar meat with the highest androstenone and skatole (no. 13) yields a higher proportion of dislike scores while the boar meat with the lowest levels of androstenone and skatole (no. 1) is similar to castrate meat (no 17). Liking was reported on a 8pt hedonic scale (1=like extremely, ..., 8=dislike extremely).

I.1.4.3. Smell test results

Based on the olfactory discrimination task, consumers' olfactory sensitivity is given in Table 4. In total, 72.3% and 47.0% of consumers were able to correctly discriminate skatole and androstenone in triplicate; 19.8% of consumers correctly discriminated at the low level of androstenone indicating increased olfactory acuity.

Table 4: Results of the smell tests – given is the proportion of consumers [%] with their no. of correct discriminations (triangle test) according to odorant type and level (n = 383 consumers.

No. of correct triangles	skatole 1.0 µg/g*	androstenone 0.5 µg/g	androstenone 5.0 µg/g
0	5.48	21.41	16.19
1	10.70	34.20	19.58
2	11.49	24.54	17.23
3	72.32	19.84	47.00

* Diluted in propylene glycol, presented on smell strips with 20 µl solution

Table 5 shows the consumers olfactory acuity to androstenone and skatole. In total, 18% were classified as being insensitive to both androstenone and skatole at the chosen levels. Less than 10% of consumers were sensitive or highly sensitive to androstenone but unable to correctly discriminate skatole while 37% were classified as being sensitive both to androstenone and skatole.

Table 5: Cross tabulation of consumers' olfactory ability to discriminate androstenone and skatole on smell strips (in percent; total n = 383). Given is the proportion of consumers [%] in the respective class.

	skatole sensitivity		
Androstenone sensitivity	NO	YES	
NO	18.0	35.0	*53.0*
YES	6.5	22.7	*29.2*
VERY	3.1	14.6	*17.8*
ALL	*27.7*	*72.3*	100.0

YES: three correct triangles at 5.0 µg/g androstenone, 1.0 µg/g skatole; VERY = three correct triangles at 0.5 µg/g androstenone

Subjects' appreciation of androstenone and skatole as presented on smell strips is given in Figure 7. For both odorants, increased olfactory acuity is suggested to be associated with decreased liking, i.e. higher scores on the hedonic scale.

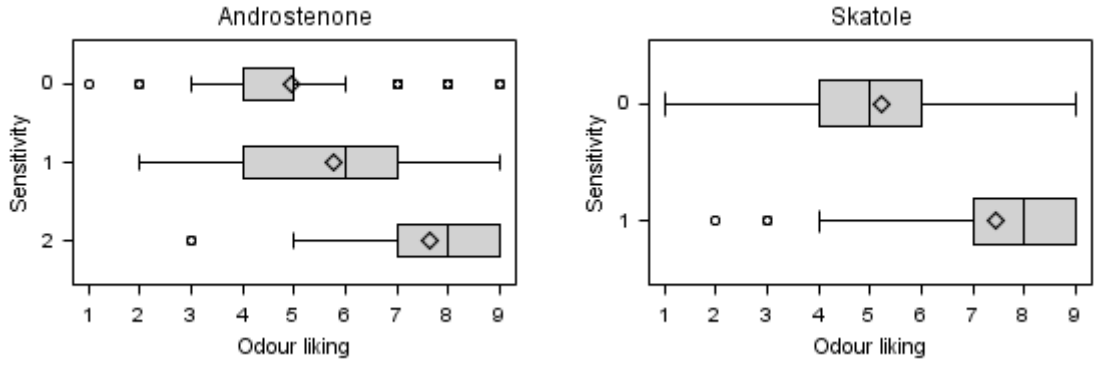


Figure 7: Odour appreciation with respect to olfactory acuity for ANDROSTENONE (left panel) and SKATOLE (right panel). Consumers were classified as being non sensitive (0), sensitive (1) or very

sensitive (2). Odour liking was reported on a 9pt scale (1 = like extremely, ..., 5 = neither like nor dislike, ..., 9 = dislike extremely).

The proportion of subjects with dislikes[5] varied between androstenone non-sensitive (22%), sensitive (58%), and very sensitive subjects (94%). Accordingly, the percentage of dislikes for skatole was higher among consumers sensitive to it (88%) compared to the non-sensitive consumers (32%). Kernel density plots of odour liking with respect to acuity level are shown in Figure 8 to illustrate the divergent distribution of odour liking between sensitivity groups.

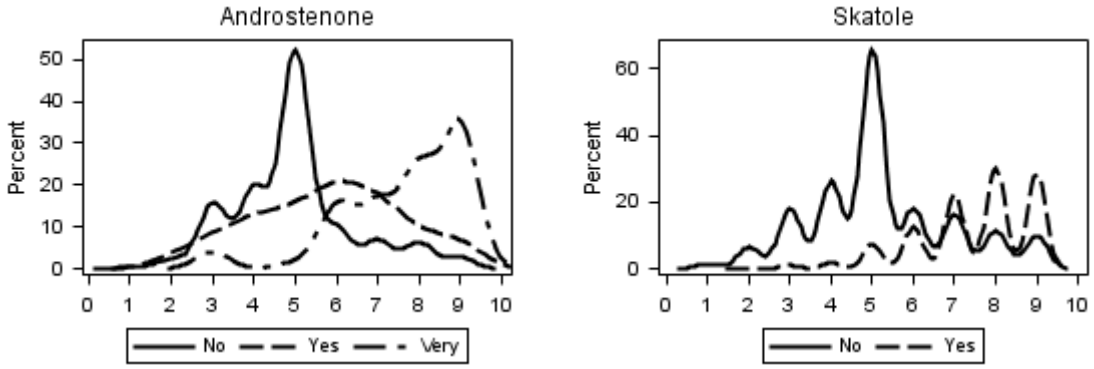


Figure 8: Kernel density plot of odour appreciation with respect to olfactory acuity for ANDROSTENONE (left panel) and SKATOLE (right panel). Consumers were classified as being non-sensitive (No), sensitive (Yes) or highly sensitive (Very). Appreciation of the odorant was reported on a 9pt scale (1 = like extremely, ..., 5 = neither like nor dislike, ..., 9 = dislike extremely).

I.1.4.4. Overall liking of the meat

Within separate ANOVAs for boar meat and castrate, respectively, consumer acceptance (i.e. overall liking) was analysed while considering fixed effects of product, serving order between pairs (sequence), serving position within a pair (position), and sensitivity to androstenone and skatole. Consumer was considered as random effect due to replicate observations per subject. If not significant, factors were removed and models were recalculated. Results of the ANOVA analysis are given in Table 6.

Table 6: ANOVA results (type III) for overall liking of the BOAR samples (n=383). Position was not significant and thus removed from the final model.

source of variation	dF (Num)	dF (Den)	F-value	p
product (boar meat type, 1 to 16)	15	1273	8.43	<.0001
sequence (1 to 4)	3	1129	6.43	0.0003
sensitivity to androstenone (no, yes, very)	2	377	12.80	<.0001
sensitivity to skatole (no, yes)	1	376	8.72	0.0033

Overall liking of boar meat with respect to androstenone and skatole level is shown in Figure 9.

[5] Dislike % = Σ of scores 6 to 9 on the 9pt hedonic scale (1 = like extremely, ... 9 = dislike extremely).

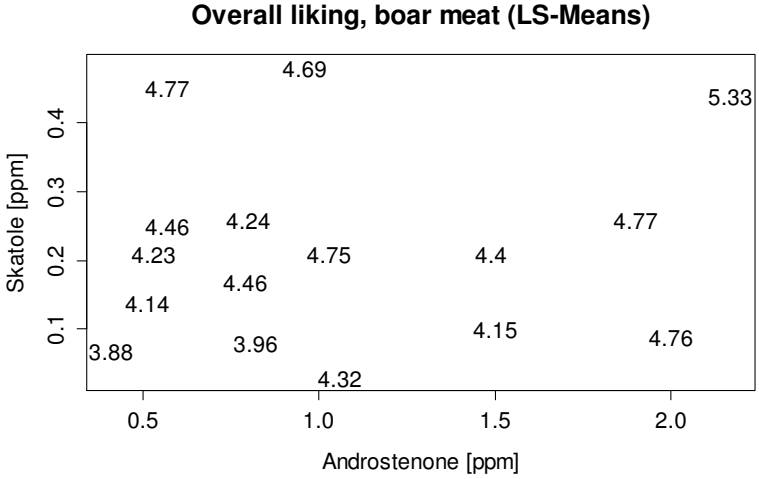
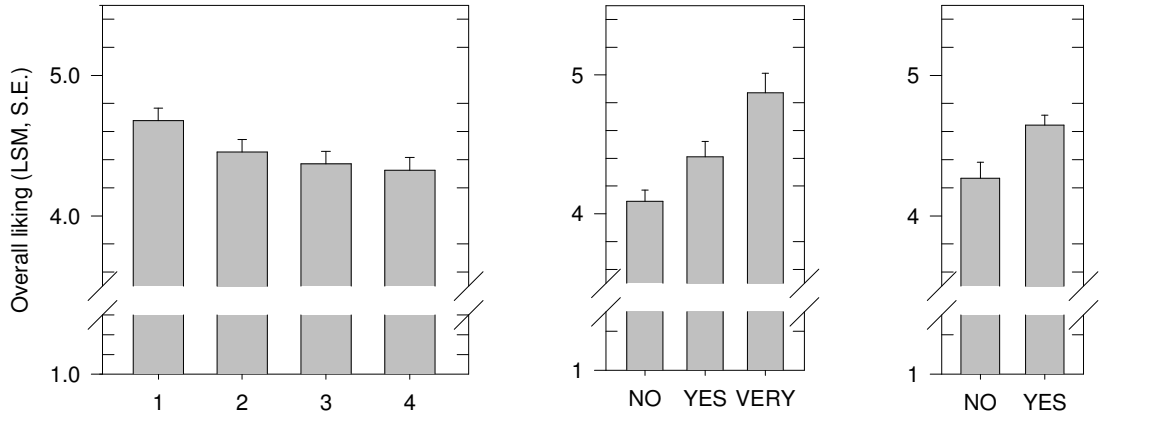


Figure 9: Overall liking of BOAR samples (least squares means) taking into account consumer's sensitivity to androstenone and skatole as well as design variables (sequence, order of the boar meat within pairs). Overall liking was reported on a 8pt hedonic scale (1 = like extremely, ..., 8 = dislike extremely), so higher values indicate higher dislike. Total n=383, n per meat type = 95/96.

Overall liking of the boar meat was significantly higher in androstenone non-sensitive subjects (4.09) compared to sensitive subjects (4.41) and very sensitive subjects (4.87). Similarly, overall liking was higher in subjects non-sensitive to skatole (4.26) compared to skatole sensitive subjects (Figure 10).



a) serving order

b) androstenone sensitivity

c) skatole sensitivity

Figure 10: LS-Means of overall liking of boar meat with respect to serving order (a), androstenone sensitivity (b), and skatole sensitivity (c). Liking was reported on a 8pt hedonic scale (1=like extremely, ..., 8=dislike extremely). Bars indicate standard error of the means.

A strong effect of sequence, i.e. whether it was the first, second, third, or fourth pair of meat samples, was observed for overall liking of the castrate meat, too (see Table 7). Furthermore, skatole sensitivity tended to affect the liking of the castrate meat, too.

Table 7: ANOVA results (type III) for overall liking of the CASTRATE samples (N=383)

source of variation	dF (Num)	dF (Den)	F-value	p
product (boar meat type, 1 to 16)	15	1267	1.20	0.2684
sequence (1 to 4)	3	1129	16.95	<.0001
position (first, last)	1	1129	3.38	0.0664
sensitivity to androstenone (no, yes, very)	2	378	1.71	0.1831
sensitivity to skatole (no, yes)	1	377	3.44	0.0643

I.1.4.5. Analysis of consumer preference for castrate over boar meat

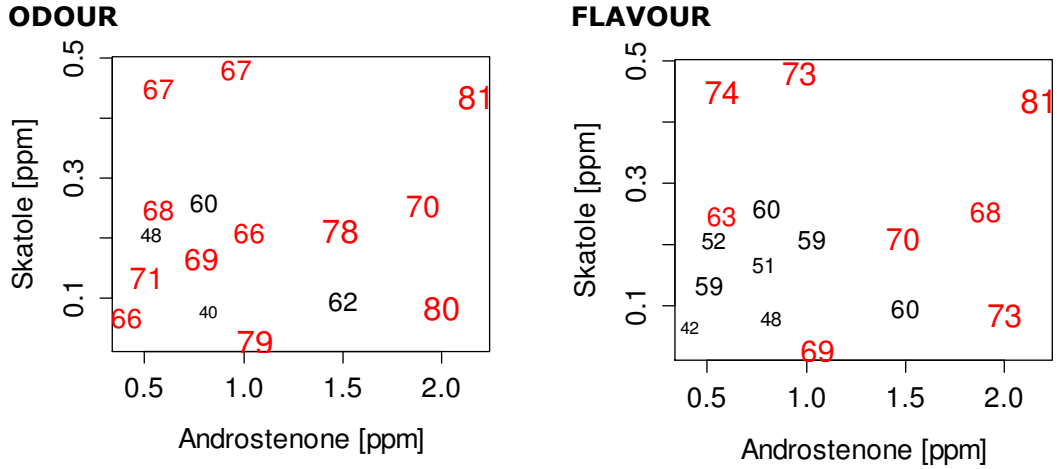
Consumer preferences were analysed using logistic models (PROC GLIMMIX). Similar to the ANOVA for consumer acceptance data, fixed effects include boar meat type, sequence, sensitivity to androstenone, and sensitivity to skatole. Consumer was included as random effect. Results for odour and flavour preference are given in Table 8 and Table 9, respectively. Olfactory acuity of consumers strongly affected their preference of castrate over boar meat both for odour and flavour. This is also reflected in Figure 11.

Table 8: Results of logistic regression for ODOUR preference of castrate over boar meat, n=383

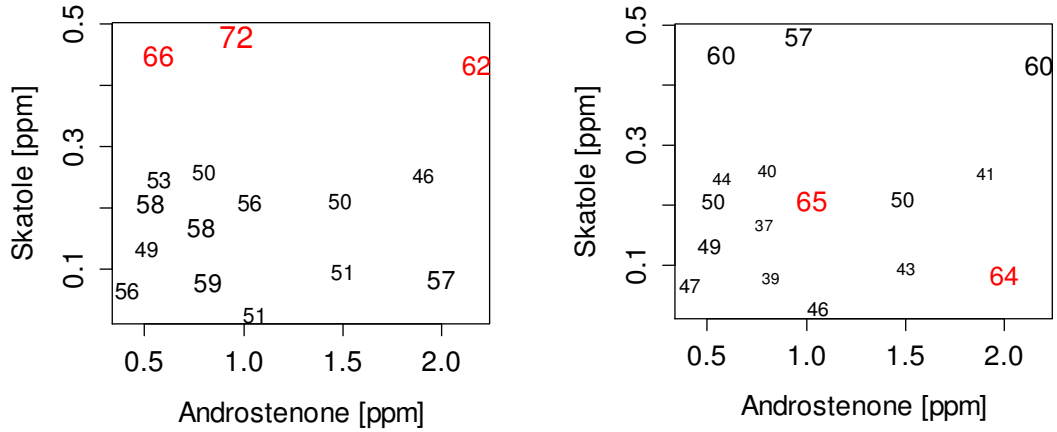
source of variation	dF, Num	dF, Den	F-value	p
product	15	1510	1.42	0.1302
sequence	3	1510	2.83	0.0372
sensitivity to androstenone	2	419.8	13.80	<.0001
sensitivity to skatole	1	352.6	4.52	0.0343

Table 9: Results logistic regression for FLAVOUR preference of castrate over boar meat, n=383

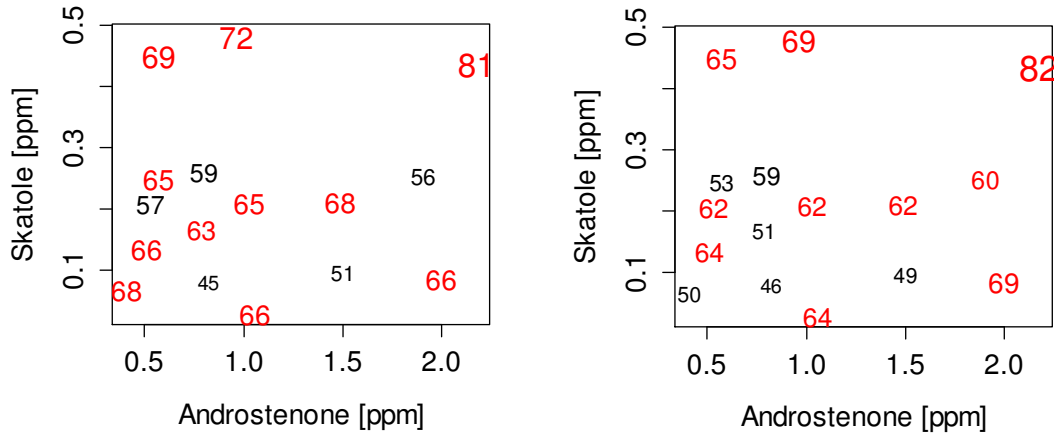
source of variation	dF, Num	dF, Den	F-value	p
product	15	1510	3.13	<.0001
sequence	3	1510	0.83	0.4766
sensitivity to androstenone	2	385.4	11.76	<.0001
sensitivity to skatole	1	353.9	21.53	<.0001



a) Androstenone sensitivity = YES & VERY (39 ≤ n ≤ 50).



b) Androstenone sensitivity = NO (45 ≤ n ≤ 57).

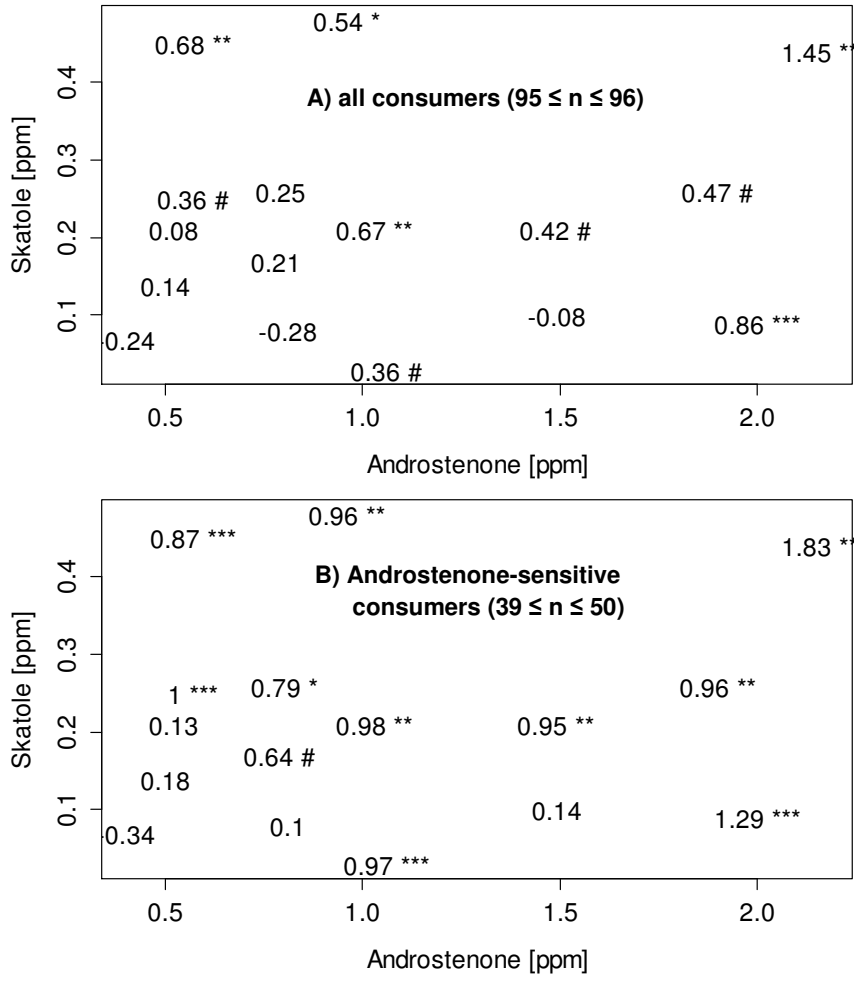


c) Skatole sensitivity = YES (64 ≤ n ≤ 75).

Figure 11: Consumer preference (in %) of castrate over boar meat for ODOUR (left panel) and FLAVOUR (right panel) with respect to olfactory acuity to androstenone and skatole. Numbers in brackets indicate the minimum/maximum number of consumers in the respective sensitivity class for each paired comparison. When indicated in red, the given proportion is significantly greater ($p < 0.05$) than 50 %.

I.1.4.6. Liking difference between boar and castrate meat

For each of the 16 boar meat types it was tested, whether the liking compared to the castrate meat was significantly different using a paired t-test. Results are given in Figure 12.



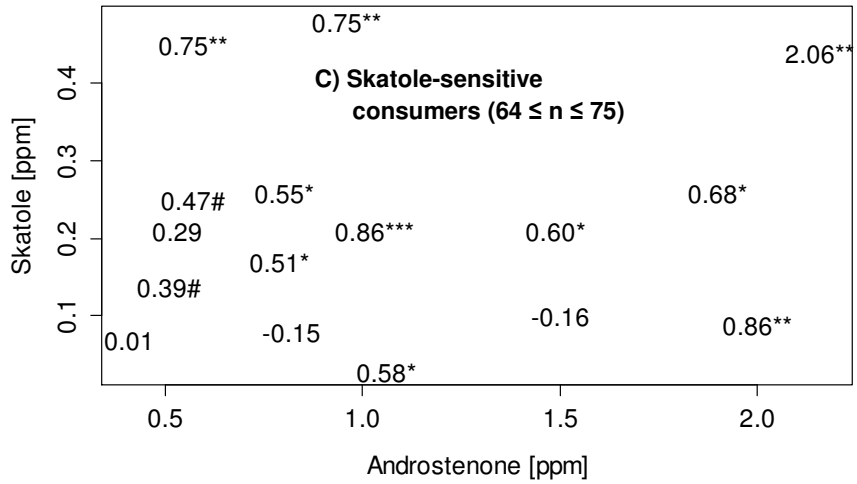
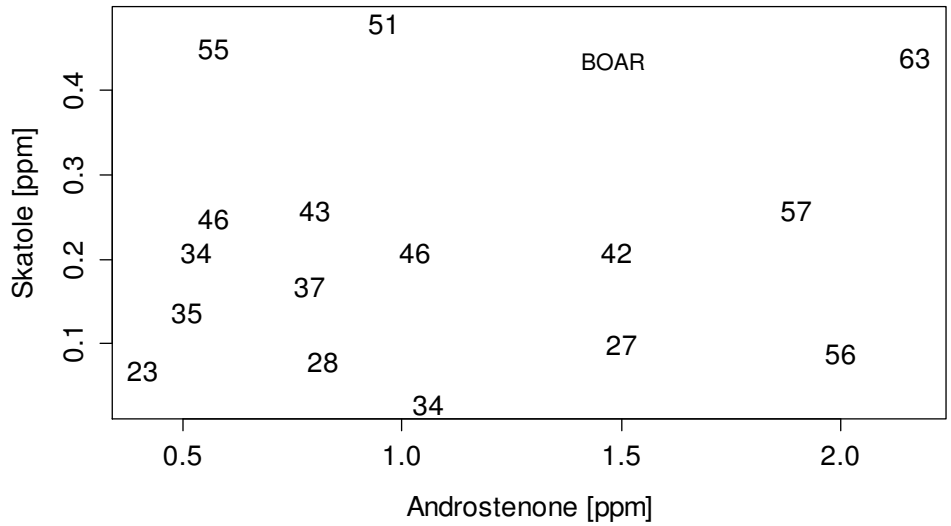


Figure 12: Overall liking differences of BOAR-CASTRATE for all consumers regardless of olfactory acuity (A), for consumers sensitive or highly sensitive to androstenone (B) and skatole sensitive consumers (C). Greater positive difference indicates higher dislike for the boar samples compared to castrate; greater negative values indicate better liking of boar sample compared to castrate (p-values: * p < .05, ** p < .01, *** p < .001, # p < .1).

I.1.4.7. Consumer dissatisfaction

Overall, the dislike[6] frequency varied significantly between castrates (31.4%) and boar meat samples (42.0%). Liking of boar meat is significantly lower compared to castrate meat. Dislike of boar meat was significantly affected by meat type, sequence, androstenone sensitivity, and skatole sensitivity. Consumer dissatisfaction for boar meat increases with higher levels of androstenone and skatole (Figure 13).



[6] Hedonic scores were converted into a binomial variable DISLIKE = 'YES' for overall liking scores greater than 4, else dislike = 'NO'). Dislikes thus comprise slight and extreme dislike scores.

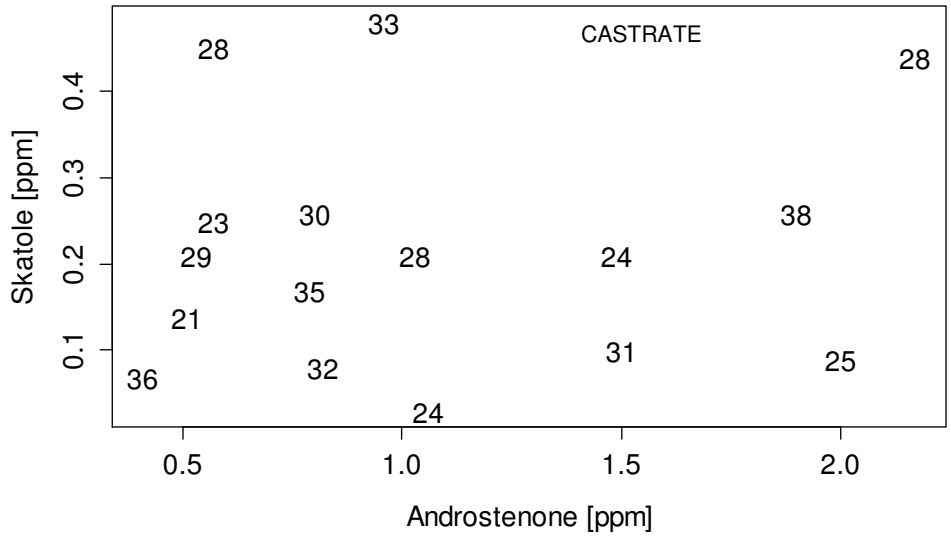
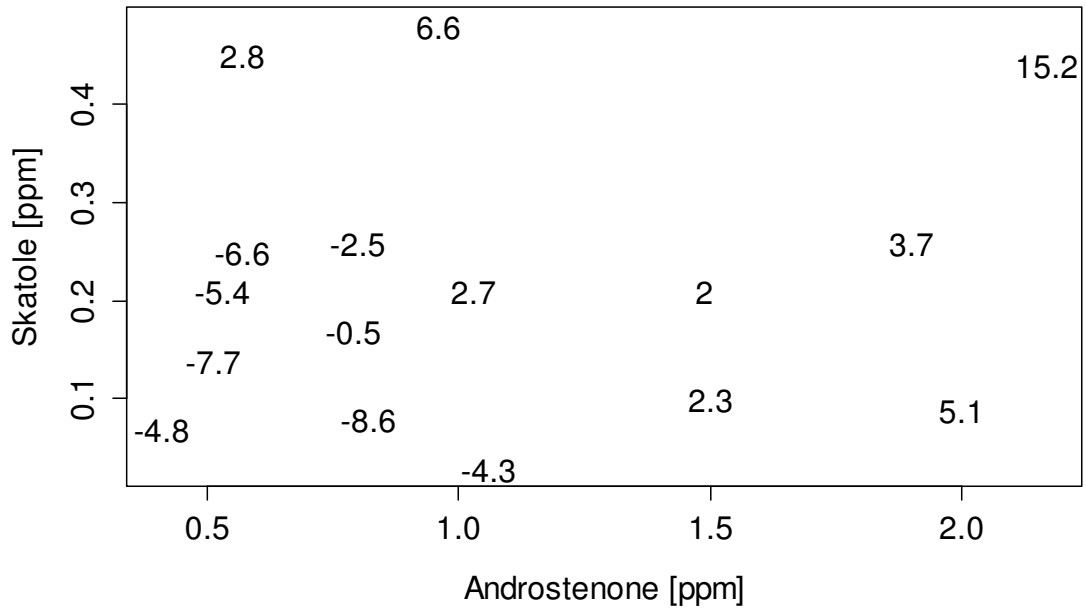


Figure 13: Frequency of dislike scores (in %) for BOAR MEAT (upper panel) and CASTRATE meat (lower panel). Results are obtained using a logistic regression using PROC GLIMMIX in SAS. Overall liking was recorded using 8pt hedonic scales (1 = like extremely, 8 = dislike extremely). Liking scores were converted into a binomial variable DISLIKE = 'YES' for overall liking scores greater than 4, else dislike = 'NO').

Accordingly, subjects VERY sensitive to androstenone, more often reported slight to extreme dislike of boar meat (54.9%) compared to sensitive subjects (39.6%) and non-sensitive subjects (33.4%). Considerable variation of dislike frequency of the castrate meat is observed, too. By trend only (p=.27), dislike of castrate meat is affected by the androstenone and skatole level of the boar meat it was served with (and thus compared to by the consumers). Sequence, i.e. number of pairs tested, significantly affected dislike of castrate meat, too (F=6.60; p=0.0002). Dislike was highest for the first castrate sample (38%) compared to the later servings.

I.1.4.8. Correlations of sensory, chemical and consumer data

At DMRI, trained panellists evaluated the boar meat samples. A principal component analysis (PCA) using all sensory attributes indicates, that the main variation in the sensory data is due to boar taint attributes (Figure 14).



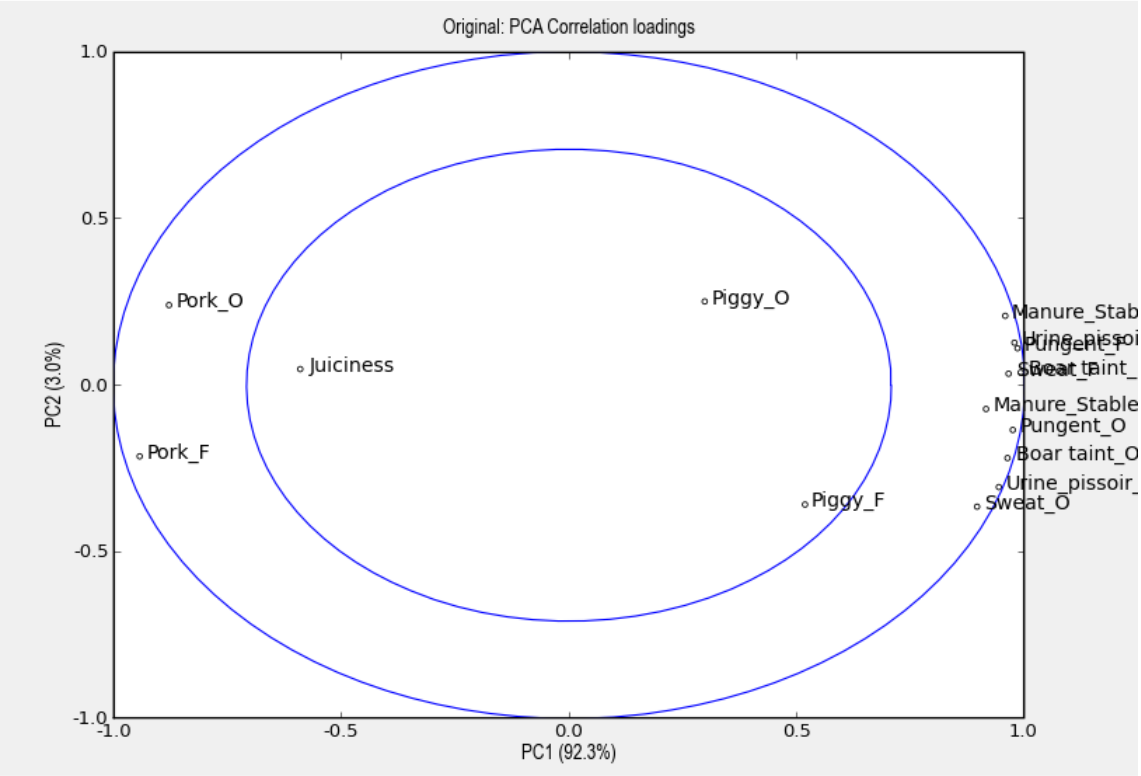


Figure 14: Sensory description by the trained panel at DMRI. Herein, scores for the first principal component (PC1) obtained from a PCA on the sensory data are shown with respect to the androstenone and skatole content of the boar meat samples (upper panel), the correlation loading plot illustrates the correlations of the original variables with PC1: PC1 is mainly explaining boar taint related attributes, e.g. manure/stable odor, sweat odor, urine/pissoir odour, as shown by the correlation loadings plot (lower panel).

Scores of PC1, trained panel evaluations of boar taint odor and flavor, chemical values and consumer data were further used for a correlation analysis as shown in Table 10.

Table 10: Correlation analysis of chemical data, trained panel data (raw means of two attributes, scores of PC1) and consumer data for the different BOAR meat types, n=16. Given is the Pearson correlation coefficient and its corresponding p-level (in brackets).

	SKA	boar_F	boar_O	PC1	acc	dislike%
AND	.10 *(n.s.)*	.73 *(.0012)*	.74 *(.0011)*	.76 *(.0007)*	.63 *(.0088)*	.55 *(.03)*
SKA		.63 *(.0087)*	.49 *(.0518)*	.61 *(.0123)*	.68 *(.0035)*	.69 *(.0029)*
boar_F			.94 *(<.0001)*	.99 *(<.0001)*	.86 *(<.0001)*	.72 *(.0016)*
boar_O				.96 *(<.0001)*	.82 *(<.0001)*	.64 *(.0069)*
PC1					.86 *(<.0001)*	.71 *(.0020)*
acc						.91 *(<.0001)*

AND = backfat androstenone (ppm),
SKA = backfat skatole (ppm),
boar_F = boar taint flavor (trained panel),
boar_O = boar taint odor (trained panel),
PC1 = scores from PC1 on sensory data (trained panel),
acc = overall liking least squares means (consumer test),
dislike% = frequency of dislikes (consumer test).

Increased boar taint as evaluated by trained panellists was highly correlated with consumer acceptance. Skatole more pronouncedly distressed dislike frequency among consumers compared to androstenone. For trained panellists, however, androstenone contributed more to boar taint perception than skatole.
Using a linear regression to predict overall liking least squares means of the boar meat from androstenone and skatole levels, an adjusted R^2 of .74 is achieved (acc = 3.70 + .37 x AND + 1.67 x SKA). This reflects that consumer liking is explained to a great extent by the key boar taint compounds.

I.1.5. Summary results pilot study

The preference for castrate over boar meat is more pronounced for odour compared to flavour when the levels of androstenone and skatole was low. In total, for 11 out of 16 boar samples, the corresponding castrate meat was significantly preferred for odour. For flavour, castrate meat was preferred for only 5 out of 16 boar meat types. Considering only significant pairwise preferences, 59 to 72% of all consumers preferred castrate over boar samples in terms of odour and 62 to 71% in terms of flavour. Preference for castrate was higher when consumers were sensitive to androstenone or skatole (up to 82% preference for castrate).
According to the smell tests to evaluate consumers' olfactory acuity to androstenone and skatole, 72% and 47% of consumers were classified as sensitive towards skatole and androstenone, respectively; 18% were even very sensitive to androstenone. The proportion of consumers perceiving androstenone as unpleasant was highest among very sensitive subjects (94%) compared to sensitive (58%) and insensitive subjects (22%).
Consumer acceptance of boar meat was significantly affected by boar meat type, i.e. overall liking was decreased with increasing androstenone and skatole levels (R^2 = .74). Overall, the dislike frequency for castrates and boar meat samples was 31.4 and 42.0%, respectively. Consumers' sensitivity to androstenone affects the overall liking of boar meat such as very sensitive subjects reported more frequently slight to extreme dislike (54.9%) compared to sensitive subjects (39.6%) and non-sensitive subjects (33.4%).
Consumers often preferred the castrate sample even though the levels of androstenone and skatole were low. When skatole and androstenone were further increased, also consumer preference for the castrate meat was increased. This is also reflected in the increased liking difference between boar and castrate sample with increased androstenone or skatole. Results indicate rejection thresholds in between 1.5 and 2.0 ppm for androstenone and around 0.3 ppm for skatole. Using such tentative thresholds will not guarantee totally boar taint free meat, but reduce consumer dissatisfaction. Sorting limits should be derived according to the extent of consumer dissatisfaction that is accepted by a given company. Besides androstenone and skatole, other compounds in boar meat may contribute to decreased liking as observed for individual samples (no. 11).

I.2. SENSORY STUDY IN FOUR EU COUNTTRIES

This chapter provides the results of the consumer tests performed in 4 EU countries (Denmark, France, Italy and Poland, n=736) with boar and castrate meat patties. It also presents results of the sensitivity test performed in the 4 EU countries. Data has been analyzed using 3 different approaches: preferences for smell and flavour of boar meat patties compared with castrate meat, difference in liking scores for meat from boars vs. castrates and liking score for meat from boars, including analysis of dissatisfied consumers (low liking scores). Preference maps were built for each approach depending on androstenone and skatole levels of the meat. This may allow stakeholders to establish thresholds according to their necessities.

Consumers were classified according to their sensitivity to androstenone and skatole. They evaluated 8 different types of boar meat patties (4 types/consumer) with different levels of androstenone and skatole in pair-wise comparison with patties from castrates. Results of the sensitivity test to androstenone and skatole show that, depending on the country, between 62.0 and 71.2% of the consumers were insensitive to androstenone, whereas between 21.2 and 29.4% were sensitive to androstenone and between 5.5 and 16.5% were very sensitive. Regarding skatole, between 33.1 and 48.6% of the consumers were insensitive (and between 51.4 and 66.9% were sensitive). The liking of androstenone and skatole smell was evaluated within each sensitivity group as well.
Meat patties evaluation has been analysed from 3 different points of view:
First, preferences of the consumers for smell and flavour of meat patties from boars over castrates. In general, smell and flavour of boar meat patties with high levels of skatole had lower preference. Odour preferences (for meat patties from boars over castrates) were lower in Denmark and Poland compared with France. Flavour preferences were lower in Denmark compared with France and Italy. Androstenone insensitive consumers had lower smell and flavour preferences compared with very sensitive consumers. Skatole sensitivity also affected smell preferences of meat patties from boars *vs.* castrates.
Second, since consumers were not trained in patties evaluation, the liking scores given to meat from boars *vs.* castrates were also compared. This difference in scores was higher in meat patties with high skatole levels and for androstenone and skatole sensitive consumers. Moreover, these differences between boar *vs.* castrate liking scores were higher in Denmark than in France and Italy. The higher the skatole levels, the larger the differences in scores between meat from boars *vs.* castrates.
Third, liking scores of boar meat patties depended on the sensitivity of the consumers to androstenone and skatole and for all the consumers on average they were higher for boar meat with low skatole content compared with those with high skatole content. Within liking scores the % of dissatisfied consumers (liking scores from 1 to 4) have also been studied.
For all three approaches preference maps have been developed considering the levels of androstenone and skatole of the patties and the sensitivity of the consumers to androstenone. These preference maps show the importance of skatole in the liking of boar meat patties and also of androstenone when skatole levels are low. Finally, the relation between scores given by the trained sensory panel and the consumers preferences confirmed the importance of skatole in the sensory evaluation of pork.

I.2.1. Meat patties evaluated

Eight different types of boar minced meat were prepared at DMRI as a mixture of meat from various animals (3 or 4 for each boar type) with known levels of androstenone and skatole. Levels of androstenone and skatole were selected according to results obtained in the pilot trial performed in Germany. Moreover, meat from castrates was also used to compare.
Characteristics of the meat evaluated in terms of androstenone and skatole in the backfat are presented in Figure 15 and Table 11. The values are the average value of the androstenone and skatole content of the backfat of the carcasses used to prepare the different patties. We are going to work with these contents since those levels can be evaluated and used at the slaughter plant.

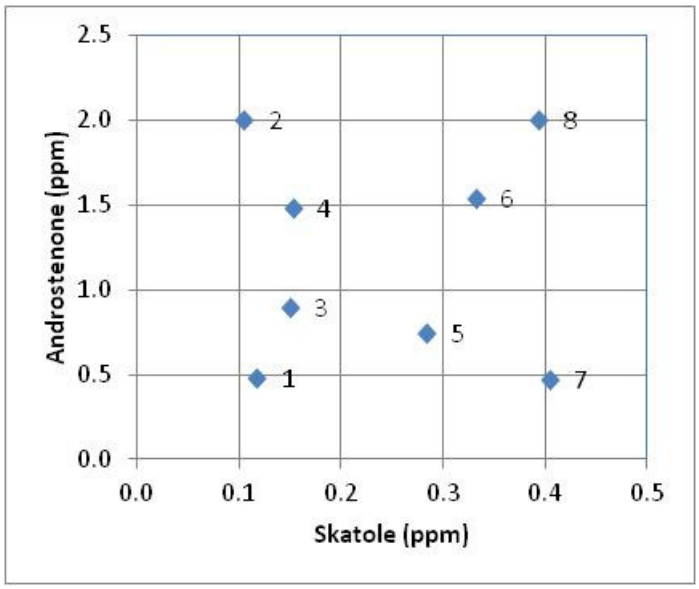


Figure 15: Average androstenone and skatole in the backfat of boar carcasses used to elaborate the minced meat for the patties used in the consumer studies.

The fat and water content of the minced meat used to prepare the patties of each type of boar is also presented in Table 11.

Table 11: Fat and water content of minced meat (uncertainty is the relative uncertainty) and skatole and androstenone content of back fat depending on the type of sample.

Type of sample	Fat (g/100 g)		Water (g/100g)		Skatole (µg/g)	Androstenone(µg/g)
1	16.2	± 5.8%	64.8	± 1.3%	0.117	0.482
2	17.3	± 5.8%	64.3	± 1.3%	0.104	2.003
3	17.5	± 5.8%	64.7	± 1.3%	0.150	0.897
4	16.9	± 5.8%	65.4	± 1.3%	0.152	1.481
5	20.2	± 5.8%	62.7	± 1.3%	0.283	0.747
6	16.8	± 5.8%	65.3	± 1.3%	0.331	1.541
7	15.5	± 5.8%	65.9	± 1.3%	0.404	0.469
8	17.4	± 5.8%	64.9	± 1.3%	0.393	2.000
castrate	20.1	± 5.8%	62.3	± 1.3%	-	-

I.2.2. Sensory profile meat patties

The sensory profiling analysis was carried out using a trained panel based on ASTM-MNL 13, ISO 4121 and ISO 13299, the training was based on ISO 8586-1. Eight assessors were used, all sensitive towards androstenone and skatole. They had a general training in assessing boar tainted meat using references for the attributes. The trained panel evaluated the 8 types of boar meat patties samples and the castrate in two sessions. In each session, panellists evaluated the 8 types of boars and the castrated meat patties. A Principal Component Analysis was performed on all the attributes. The plot of the correlations of the attributes with the first two components, as well as the consensus coordinates of the different type of meat patties in a scale from 0 to 1 is presented in Figure 16. The first Principal Component explains 53.6% of the variation accounted for and it is related in the positive part with the boar taint attributes. Positive first PC included patties with high skatole level, while negative first PC those patties with lower skatole level. Furthermore, the second Principal Component explains only 15.5% of the variance accounted for and in its positive part it includes mainly patties with high androstenone content while in its negative part those with lower androstenone content. When only boar taint attributes are considered, results are presented in Figure 17, and in this case the first principal component explained 70.3% of the variance. The consensus without transformation to 0 and 1 and depending on the levels of androstenone and skatole of the patties are presented in Figure 18.

The plots indicate that only samples 5 to 8 show panel related boar taint attributes, thus, samples with high skatole content and varying androstenone content. This effect is even stronger in patties with higher skatole levels, 6 to 8. Castrated meat patties are related to low levels of these boar taint attributes, and in a lesser extent patties 1 to 4, with low skatole levels. Thus, factor 1 is related with skatole content and factor 2 with androstenone content and the variance accounted for is much higher for factor 1 than 2, indicating the higher importance on skatole content. Moreover, factor 2 separates in the positive side flavour attributes and in the negative side odour boar taint attributes. Thus, it seems that androstenone content might be mainly related with flavour attributes.

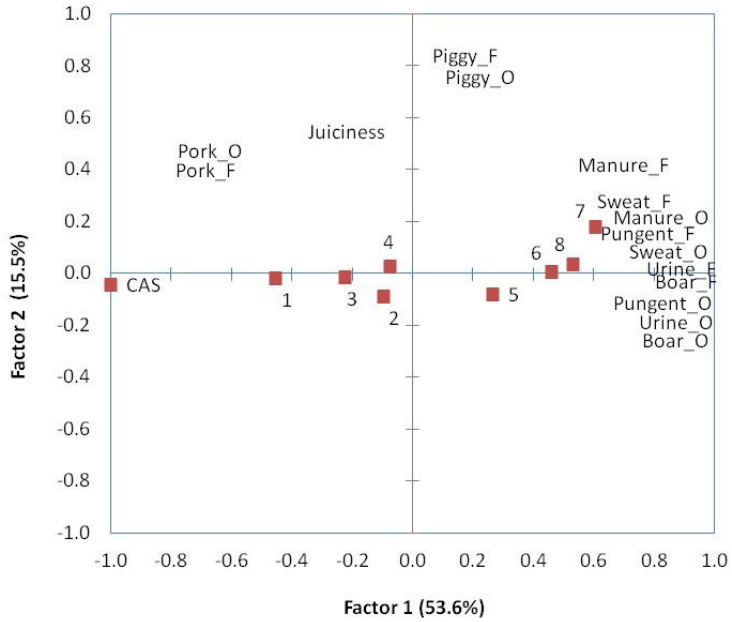


Figure 16: Scores of the first and second principal components for the different sensory attributes and the averaged coordinates for the meat patties from boars (1 to 8) and castrated (CAS) (transformed to a scale from 0 to 1).

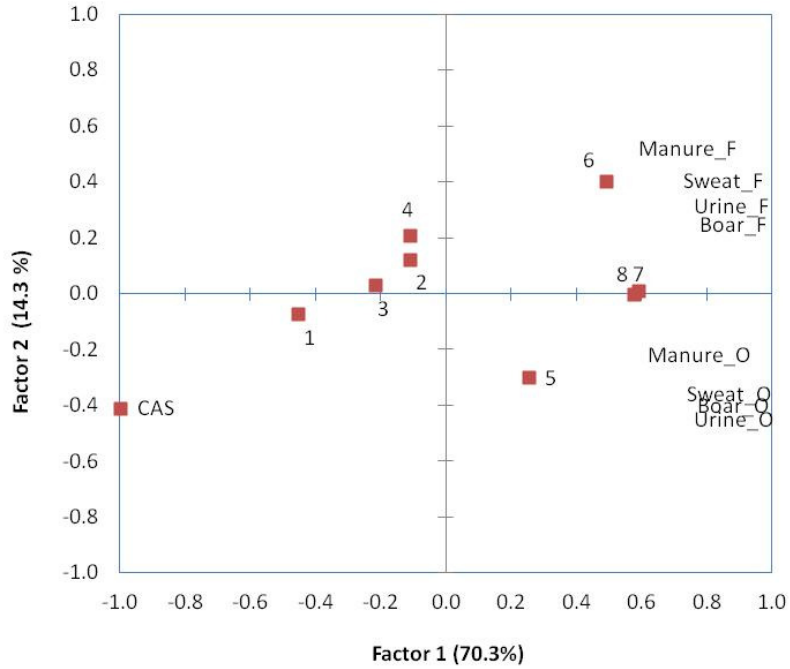


Figure 17: Scores of the first and second principal components for the different sensory attributes related with boar taint and the averaged coordinates for the meat patties from boars (1 to 8) and castrated (CAS) (transformed to a scale from 0 to 1).

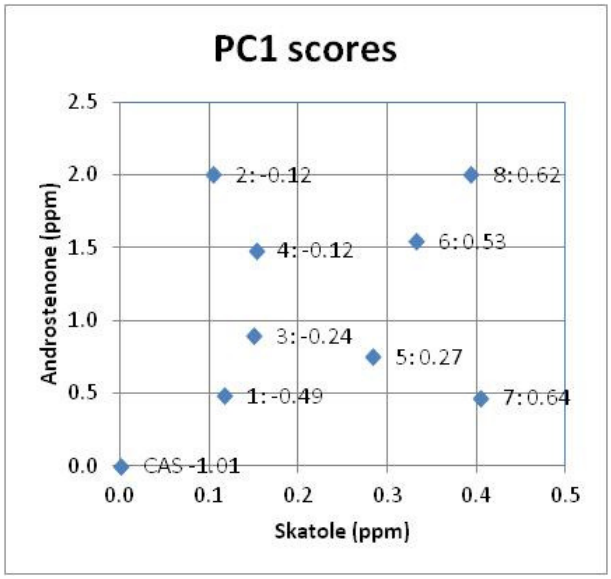


Figure 18: Consensus coordinates of the different boar and castrate patties, placed in the plot depending on their level of androstenone and skatole.

Correlation between the androstenone and skatole contents (averaged) and the PC1 consensus component for each type of boar is presented in Table 12 by country and for all the EU countries together. It is possible to see that liking score decreases with skatole content and it is not affected by androstenone content. Also situation of the patty depending on their classification on boar taint attributes affects the liking scores, higher PC1 (more boar taint attributes), lower liking scores. Also, it is related with higher skatole content.

Table 12: Correlation coefficients between least square means of like scores, skatole and androstenone content and scores of PC1 of the consensus by type of boar.

All-EU	Skatole	Androstenone	PC1
Like	**-0.62**	-0.07	**-0.69**
Skatole		0.03	**0.95**
Androstenone			0.18
Denmark			
Like	**-0.89**	-0.12	**-0.95**
France			
Like	**-0.76**	-0.10	**-0.83**
Italy			
Like	*-0.67*	-0.16	**-0.85**
Poland			
Like	**-0.79**	0.01	**-0.86**

Bold: P<0.05;Italics: P<0.10

I.2.3. Consumer characteristics

1.2.3.1. Description of the consumers and their culinary habits

A total of 476 consumers (women) performed the consumer test in 4 EU countries, Denmark (n=109), France (n=128), Italy (n=121) and Poland (n=118). The demographic characteristics of the consumers and their cooking and pork liking characteristics are presented in Table 13. These were evaluated in part 3 of the questionnaire. Characteristics of the consumers regarding their consumption of pork and meat are presented in Table 14.

Table 13: Description of the consumers that participate in each study (in %).

	Denmark[a]	France	Italy	Poland	Total
Number of consumers	109	128	121	118	476
Cold-allergy	17.1	8.6	11.6	19.5	14.0
<25 yr	5.8	21.9	13.2	22.9	16.3
25-44 yr	29.8	49.2	43.0	22.9	36.7
45-59 yr	43.3	18.8	24.0	33.9	29.3
>60 yr	21.2	10.2	19.8	20.3	17.6
Education level					
Primary	19.8	3.9	6.6	0.8	7.4
Secondary	13.2	20.3	24.0	57.6	29.0
Higher	56.6	27.3	44.6	7.6	33.4
University	10.4	48.4	24.8	33.9	30.2
Cooking main dishes at home					
Mainly me	69.5	76.6	66.1	72.0	71.2
Mainly others	10.5	5.5	6.6	5.9	7.0
Sometimes	20.0	18.0	27.3	22.0	21.8
Pork liking					
Dislike extremely	0.0	0.0	0.8	0.0	0.2
Dislike very much	0.0	0.0	3.3	0.0	0.8
Dislike	0.0	0.0	0.0	0.8	0.2
Dislike slightly	1.0	0.0	0.0	0.0	0.2
Neither like nor dislike	2.9	3.1	5.0	2.5	3.4
Like slightly	8.6	22.7	5.8	7.6	11.4
Like	33.3	47.7	59.5	50.8	48.3
Like very much	47.6	25.0	24.0	31.4	31.4
Like extremely	6.7	1.6	1.7	6.8	4.0

Table 14: Description of consumers' characteristics regarding their meat consumption.

	Denmark	France	Italy	Poland	Total
Consume pork in a hot dish (times/week)					
> 4	8.6	3.9	4.1	9.3	6.4
3-4	20.0	14.8	13.2	36.4	21.0
2-3	54.3	54.7	59.5	46.6	53.8
< 1	17.1	26.6	23.1	7.6	18.9
Consume pork in a cold dish					
> 4	16.0	2.3	5.8	22.0	11.2
3-4	27.4	17.2	34.7	29.7	27.1
2-3	38.7	43.0	50.4	28.0	40.3
< 1	17.9	37.5	9.1	20.3	21.6
Frequency (%) of pork in meat consumption					
0-25	47.2	24.2	30.6	27.1	31.8
26-50	34.0	52.3	40.5	43.2	43.0
51-75	14.2	21.9	26.4	22.9	21.6
>75	4.7	1.6	2.5	6.8	3.8
Frequency (%) of beef in meat consumption					
0-25	49.5	47.7	66.9	87.3	62.9
26-50	40.0	39.8	28.9	11.0	29.9
51-75	10.5	11.7	4.1	1.7	7.0
>75	0.0	0.8	0.0	0.0	0.2
Frequency (%) of poultry in meat consumption					
0-25	49.1	46.1	38.0	24.6	39.4
26-50	39.6	45.3	38.0	33.1	39.2
51-75	10.4	7.0	23.1	37.3	19.5
>75	0.9	1.6	0.8	5.1	2.1
Frequency (%) of other meats in meat consumption					
0-25	86.5	97.7	93.4	94.1	93.0
26-50	12.5	2.3	6.6	5.1	6.4
51-75	1.0	0.0	0.0	0.8	0.4
>75	0.0	0.0	0.0	0.0	0.0

I.2.3.2. Sensitivity of the consumers

Sensitivity of the consumers was evaluated according to a set of triangular tests with different concentrations of androstenone and skatole.
According to the two sets of 3 triangular tests with two different concentrations of androstenone (low: 0.5 ppm and high: 5 ppm), consumers were classified in:
Very sensitive to androstenone (very): Correct answers in the three triangular with high androstenone levels and in the three with low androstenone levels.
Sensitive to androstenone (yes): Correct answers in the three triangular with high androstenone levels and incorrect in some or all the triangulars with low androstenone levels.
No sensitive to androstenone (no): Incorrect answers in some or all the triangular with high androstenone level.

According to the set of 3 triangular tests with skatole consumers were classified in:
Sensitive to skatole (yes): Correct answers in the three triangulars with skatole.
Insensitive to skatole (no): Incorrect answers in at least one of the three triangulars with skatole.

The percentage of consumers that answered correctly at the minth triangular depending on their sensitivity to androstenone and skatole is presented in Table 15. It is possible to see that in Denmark and Poland consumers sensitive to androstenone had also a higher number of correct answers in the minth test. No differences can be found in the other countries. Also, no differences regarding skatole sensitivity of the consumers in their assessment of the triangular with minth were found.

Table 15: Sensitivity to androstenone and skatole of the consumers (by country and overall) that answered correctly the minth triangular test.

Minth correct (%)	Denmark	France	Italy	Poland	Total
Androstenone					
Non sensitive	32.86[b]	32.14	58.67	35.71[ab]	39.62
Sensitive	53.49[a]	37.84	61.54	44.00[a]	42.50
Very sensitive	57.14[a]	42.86	70.00	22.22[b]	53.49
Skatole					
Non sensitive	41.51	27.45	52.50	36.73	38.86
Sensitive	26.79	38.96	65.43	36.23	43.46

[ab] per component, different superscripts within the same column represent significant differences (P<0.05)

The percentage of non-sensitive to androstenone is on average equal to 65.8%, being the percentage of sensitive 25.2% and those of very sensitive 9.0%. The percentage of very sensitive consumers to androstenone is highest in Italy (16.5%). In general, the percentage of sensitive consumers is lower than that obtained in the pilot study in Germany, i.e. 53% were non-sensitive, 29% sensitive and 18% very sensitive.
Regarding skatole, around 40,5% of the consumers are not sensitive, while the percentage of sensitive was 59,5%. The percentage of sensitive is surprisingly low. In the pilot test in Germany it was 72.3%.
Differences can be due to real differences in sensitivity between countries or to differences in the preparation of the triangular, although the preparation protocol was the same.
The percentage of consumers that like androstenone is 13% on average and varied between 0% in Denmark and 37.5% in Poland. It is surprising that an average of 24.6% of consumers that were classified as not sensitive to androstenone did not like the odour. Regarding skatole, on average 10% of the consumers liked the smell. This percentage was very similar in all the countries evaluated, except for France (6.5%).

I.2.4. Meat patties evaluation by the consumers

Consumer test was carried out in several sessions with different number of consumers:

Denmark: 16 sessions, 2 to 10 consumers per session
France: 8 sessions of 16 consumers each
Italy: 15 sessions, 3 to 8 consumers per session
Poland: 8 sessions, 14 to 15 consumers per session

Consumers performed 5 paired tests. The first pair consisted of twice the same type of meat patties for both samples, castrated, in order to train the consumer. The next 4 paired tests were a comparison of one of the eight boar meat patties with a castrate patty. The experiment was designed considering, in each session, the type of comparison performed, the position of both patties (first or second to be evaluated) and the sequence of each one (2^{nd} to 5^{th} pair). The cooking of the patties was performed following the same protocol of the pilot study. For each pair, consumers were asked to say which patty they preferred regarding their smell and their taste. After that, they were asked to give a liking score for each of the patties on a 9-point scale, from 'dislike extremely' (1) to 'like extremely' (9) without the level 'neither like nor dislike' (5).

I.2.4.1. Preferences of boar meat patties

I.2.4.1.1. Percentages of preference of boar meat patties

The consumer preference of boar meat patties for smell and flavour in comparison with castrate meat has been calculated for each type of boar by country. Figure 19 illustrates the preferences for smell and flavour per type of boar when all the countries were considered together.

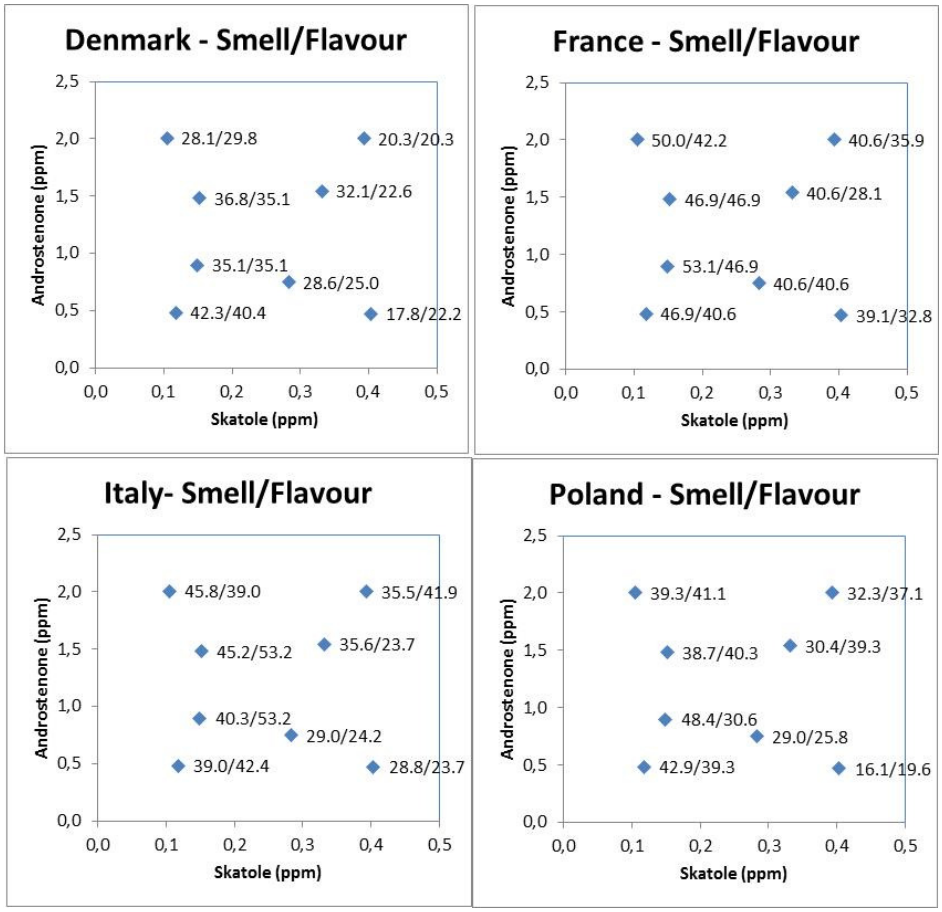


Figure 19: Consumer's preference (in %) for smell / flavour of boar meat patties over castrate by country and by androstenone and skatole content (Number of consumers within each pairwise comparison varies from to 45 to 59 in Denmark, 64 in France, 58 to 62 in Italy and 56 to 62 in Poland).

The preference for smell and flavour of boar meat patties over castrate by sensitive and insensitive consumers to androstenone is presented by country or considering all the countries together in Figure 20 to Figure 24.

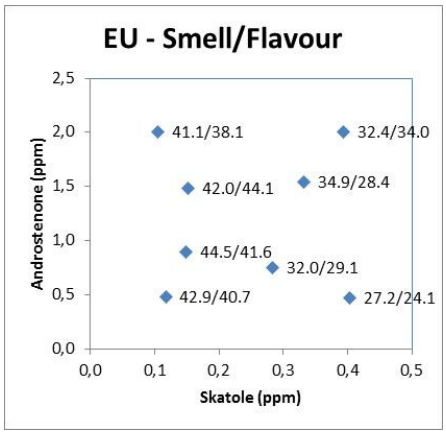


Figure 20: Consumer's preference (in %) for smell / flavour of boar meat patties over castrate by androstenone and skatole content when all four EU countries evaluated were considered together. (Number of consumers within each pairwise comparison varies from to 224 to 247).

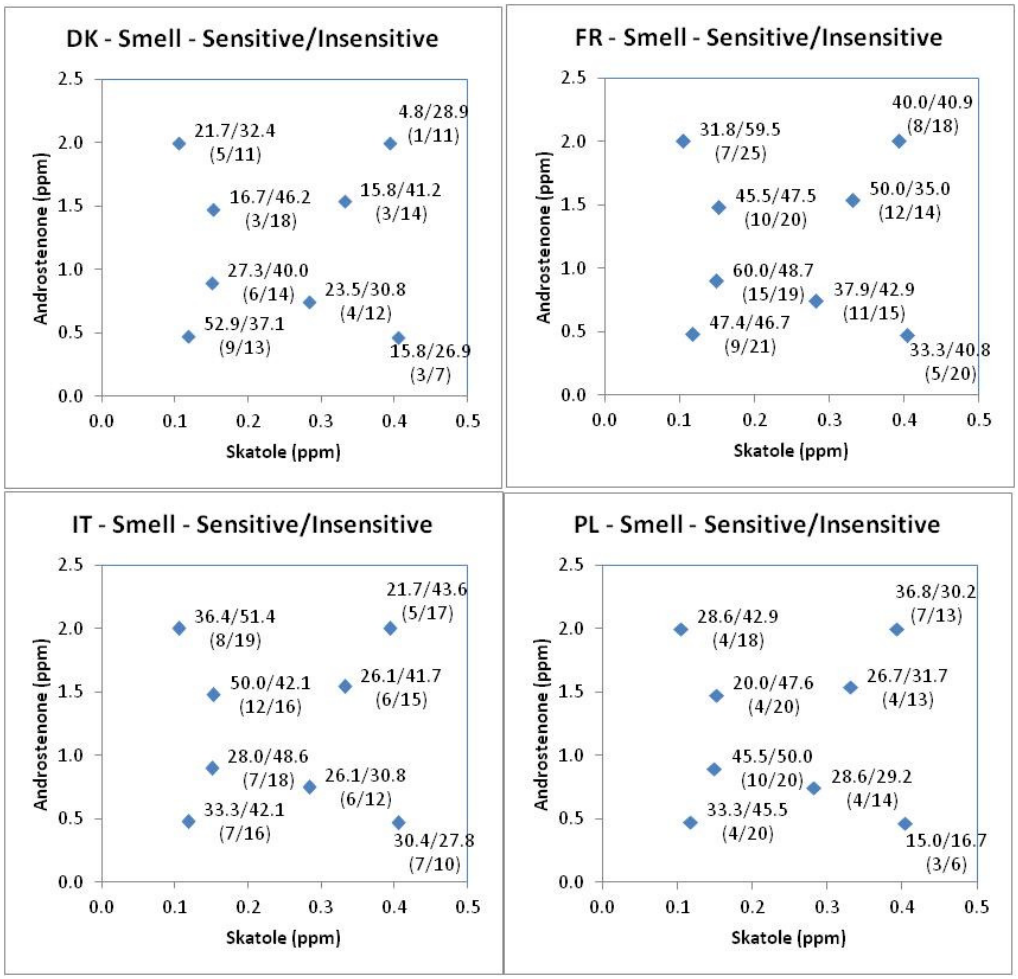


Figure 21: Percentage (number) of consumers that preferred the smell of boar (depending on their content of androstenone and skatole) over castrate by country and sensitivity of consumers to androstenone (Sensitive consumers include sensitive and very sensitive consumers according to the performed triangular test).

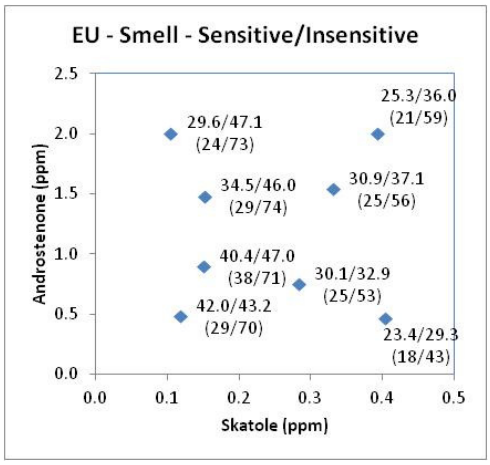


Figure 22: Percentage (number) of consumers that preferred the smell of boar (depending on their content of androstenone and skatole) over castrate by sensitivity of consumers to androstenone for all the EU countries together (Sensitive consumers include sensitive and very sensitive consumers according to triangular test performed).

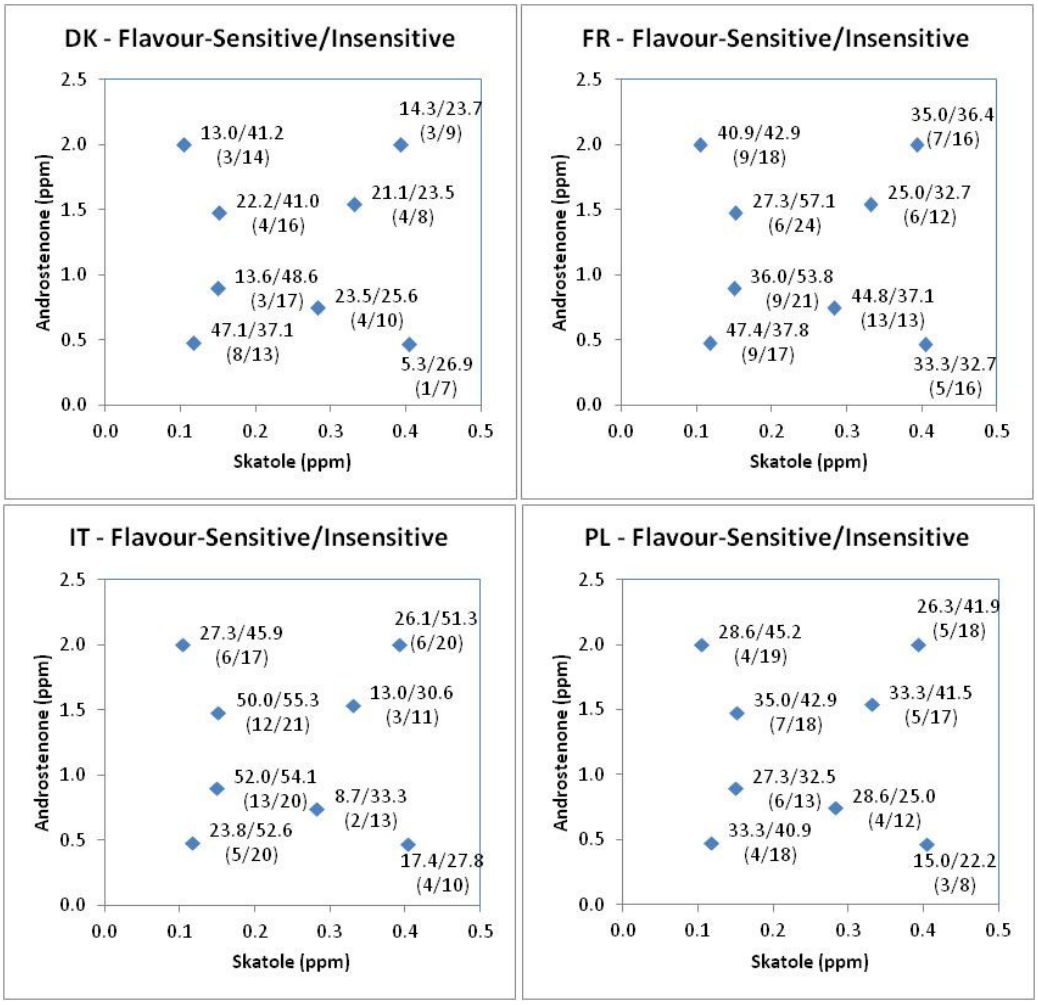


Figure 23: Percentage (number) of consumers that preferred the flavour of boar (depending on their content of androstenone and skatole) over castrate by country and sensitivity of consumers to androstenone (Sensitive consumers include sensitive and very sensitive consumers according to triangular test performed).

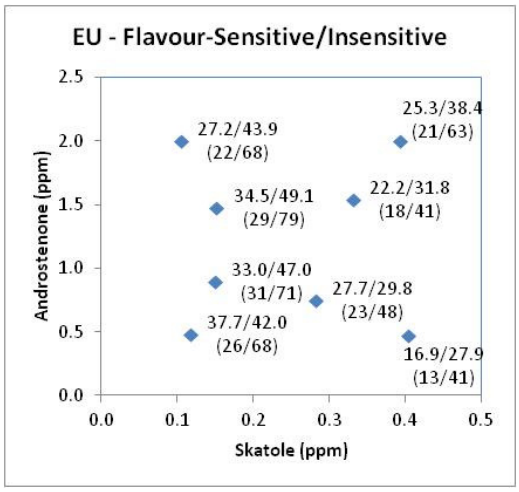


Figure 24: Percentage (number) of consumers that preferred the flavour of boar (depending on their content of androstenone and skatole) over castrate by sensitivity of consumers to androstenone for all the EU countries together (Sensitive consumers include sensitive and very sensitive consumers according to triangular test performed).

If consumers that are sensitive or very sensitive to androstenone are further classified in two groups, those that like the smell or don't care (scores 5 to 9 on a nine point scale) *vs.* those that dislike the smell (scores 1 to 4 on a nine point scale), consumer's preferences for odour and flavour by group and country or for all the countries together are presented in Figure 25 to Figure 28.

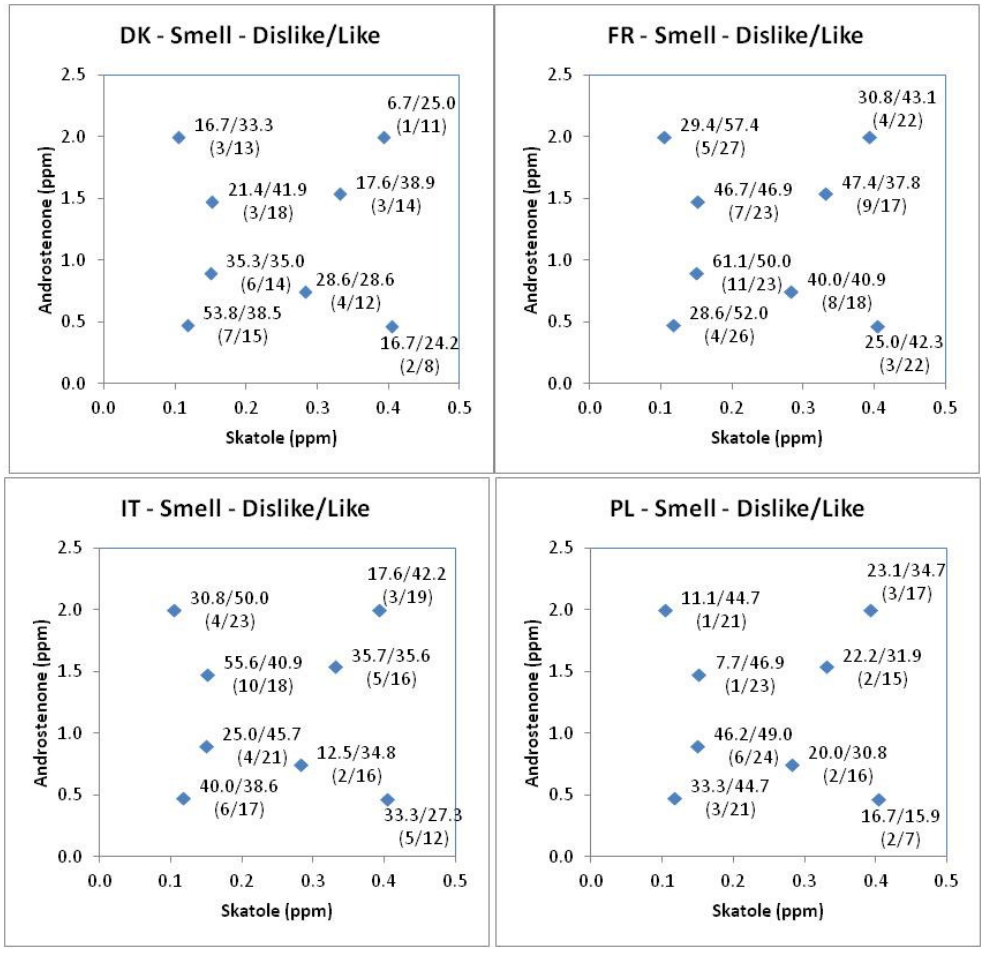


Figure 25: Percentage (number) of consumers sensitive to androstenone that preferred the smell of boar (depending on androstenone and skatole) meat patties over castrate by country and liking of androstenone smell (on a 9-point scale: like or neutral: scores 5 to 9, or dislike, scores 1 to 4).

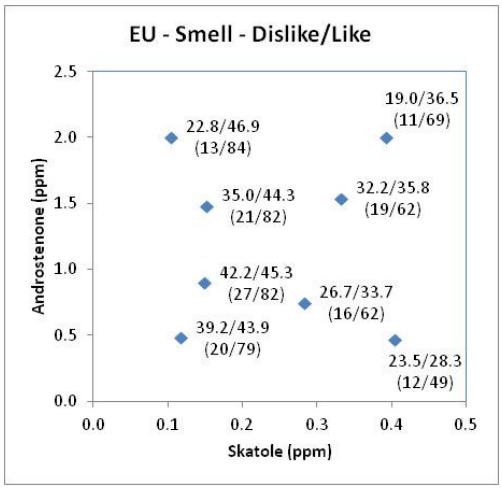


Figure 26: Percentage (number) of consumers sensitive to androstenone that preferred the smell of boar meat patties (depending on their content of androstenone and skatole) over castrate by country and liking of androstenone smell (on a 9-point scale: like or neutral: scores 5 to 9, or dislike, scores 1 to 4) for all the EU countries together.

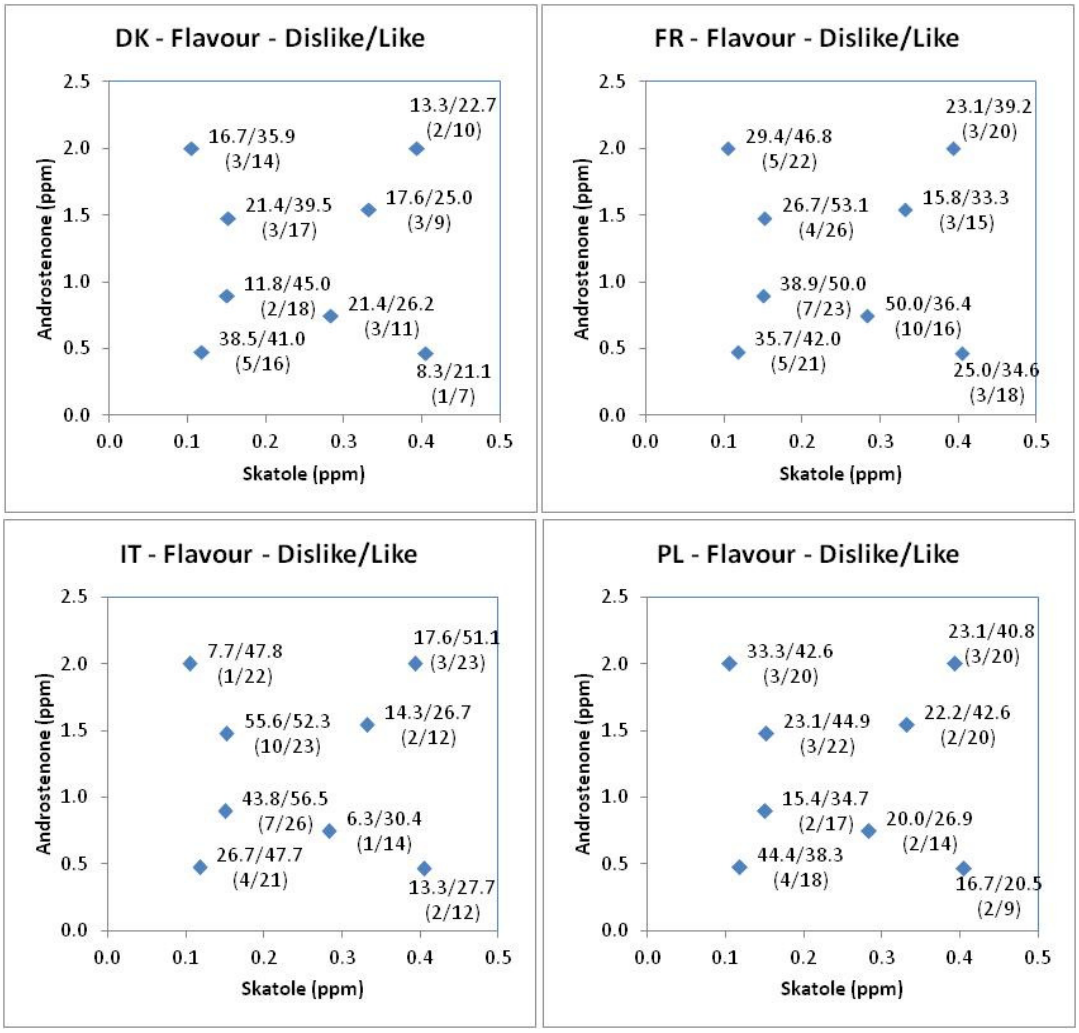


Figure 27: Percentage (number) of consumers sensitive to androstenone that preferred the flavour of boar meat patties (depending on their content of androstenone and skatole) over castrate by country and liking of androstenone smell (in a 9-point scale: like or neutral: scores 5 to 9, or dislike, scores 1 to 4).

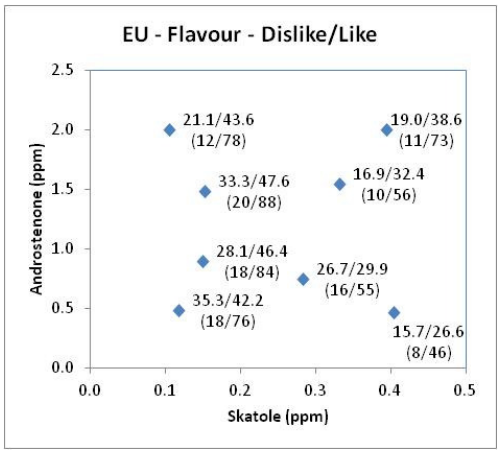


Figure 28: Percentage (number) of consumers sensitive to androstenone that preferred the flavour of boar meat patties (depending on their content of androstenone and skatole) over castrate by country and liking of androstenone smell (in a 9-point scale: like or neutral: scores 5 to 9, or dislike, scores 1 to 4) for all the EU countries together.

I.2.4.1.2. Preference by type of boar meat patties

Consumers' preference was analysed using the GLIMMIX procedure of SAS for smell and flavour separately. The model included as fixed effects type of boar, sequence, position, country, sensitivity to androstenone and sensitivity to skatole. Double interactions between sensitivities, country and type of boar were removed because they were not significant. Assessor was considered as random effect. Results for odour and flavour are presented in Table 16 and Table 17, respectively. For smell preferences, the significance of androstenone sensitivity disappeared when country was removed as fixed effect, indicating the link between this sensitivity and the country. If country was included as random effect, similar results were obtained as when it was considered a fixed effect. For flavour, sensitivity to skatole was not significant and therefore removed from the model. If sensitivity to androstenone was considered at two levels (no sensitive *vs.* sensitive or very sensitive), final results were similar.

Table 16: Logistic regression results for boar preference of smell over castrated.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	7	1886	4.63	<.0001
Sequence (2 to 5)	3	1886	6.23	<0.001
Position (1 or 2)	1	1886	37.05	<0.001
Country (DK, FR, IT, PL)	3	441.3	5.54	0.001
Sensitivity to androstenone[1]	2	507.6	6.25	0.002
Sensitivity to skatole[2]	1	431.2	7.45	0.007

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm: yes; no>5ppm
[2]Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

Table 17: Logistic regression results for boar preference of flavour over castrated.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	7	1888	5.67	<.001
Sequence (2 to 5)	3	1888	2.14	0.093
Sensitivity to androstenone[1]	2	1888	15.46	<.001
Country (DK, FR, IT, PL)	3	1	3.06	0.392

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm: yes; no>5ppm

Differences between meat patties for smell and odour are presented in Table 18. The mean values showed the percentage of preference for boar depending on the patties. This percentage varies between 22 and 39% for odour and between 18 and 37% for flavour. In general, smell type 7 boars is less preferred than the smell of the other boar patties (1, 3 and 4) while type 3 was most preferred for smell, although not significantly different than those from type 1, 2, 4, 6 and 8. Moreover, boars evaluated in the 2nd and 3rd pair were more often preferred than those evaluated in the 4th and the 5th pair. Also, when the boar meat patty was evaluated in the first position within a pair, it was more often preferred (38%) than when it was evaluated in the second position (25%). Preferences for boar smell were higher in France compared to Denmark and Poland. In Italy this preference was in between. Regarding sensitivity of consumers to androstenone the non-sensitive or sensitive consumers presented higher preference for boar over castrate patties compared to the very sensitive consumers. Consumers sensitive to skatole had a lower smell preference for boar patties compared to castrated patties than non-sensitive consumers. In general, flavour of meat patties with high skatole levels presented lower preference than those with low skatole levels. Flavour preferences were not significantly affected by sequence of the pair and position of the boar. In France and Italy, consumers flavour preference for boar meat patties over castrate patties was higher than in Denmark. Preference for boar meat patties decreased with increasing androstenone sensitivity. Nevertheless, no effect of consumer' sensitivity to skatole on the flavour preference for boar meat patties over castrate was found.

Table 18: Estimates and mean for smell and flavour preferences.

	Smell				Flavour			
Effect	Estimate	Mean		Std Error	Estimate	Mean		Std Error
Type of boar								
1	-0.54	0.37	ab	0.039	-0.74	0.32	ab	0.035
2	-0.69	0.33	abc	0.037	-0.84	0.30	ab	0.034
3	-0.45	0.39	a	0.038	-0.62	0.35	a	0.035
4	-0.48	0.38	ab	0.038	-0.52	0.37	a	0.036
5	-1.12	0.25	bc	0.031	-1.24	0.22	bc	0.029
6	-0.88	0.29	abc	0.035	-1.29	0.22	bc	0.029
7	-1.26	0.22	c	0.032	-1.53	0.18	c	0.026
8	-1.07	0.26	abc	0.032	-1.00	0.27	abc	0.031
Sequence								
2	-0.54	0.37	a	0.030	-0.78	0.31		0.026
3	-0.65	0.34	a	0.029	-0.99	0.27		0.025
4	-1.04	0.26	b	0.026	-1.15	0.24		0.023
5	-1.02	0.26	b	0.026	-0.98	0.27		0.025
Position								
1	-0.50	0.38	a	0.025				
2	-1.12	0.25	b	0.021				
Country								
Denmark	-1.16	0.24	b	0.028	-1.31	0.21	b	0.025
France	-0.45	0.39	a	0.034	-0.78	0.31	a	0.028
Italy	-0.71	0.33	ab	0.031	-0.78	0.32	a	0.028
Poland	-0.93	0.28	b	0.031	-1.03	0.26	ab	0.027
Sensitivity to androstenone[1]								
no	-0.46	0.39	a	0.019	-0.50	0.38	a	0.017
yes	-0.63	0.35	a	0.029	-0.86	0.30	b	0.025
very	-1.35	0.21	b	0.040	-1.55	0.17	c	0.033
Sensitivity to skatole[2]								
no	-0.63	0.35	a	0.029				
yes	-0.99	0.27	b	0.021				

[abc] Different superscripts indicate significant differences (P<0.05) within effect
Std. Error: standard error of the Mean
[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm: 0.5ppm<yes <5ppm: yes; n >5ppm
2Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

I.2.4.1.3. Preference as effected by androstenone and skatole content

Analysis of preferences was also performed considering naeperian logarithm of androstenone and skatole levels (average) and its interaction as covariates together with sequence, position, country, sensitivity to androstenone, sensitivity to skatole as fixed effects and consumer within country as random effect. For flavour, position, sequence and sensitivity to skatole were removed since they

were not significant. Results are presented in Table 19 for smell and Table 20 for flavour. If logarithm transformation of androstenone or skatole was not performed, skatole became similarly significant than with logarithm (P<0.001 for smell and flavour), androstenone much less significant (P=0.249 for smell and P=0.234 for flavour) and its interaction slightly less significant (P=0.127 for smell and P=0.033 for flavour). For the final model the naeperian logarithm of both compounds will be used.
Both skatole and androstenone level affect the smell and flavour preference although the level of skatole is more significant than the level of androstenone. Also the interaction between skatole and androstenone is important, because the effect is close to significance. If sensitivity to androstenone was considered at two levels (no sensitive *vs.* sensitive or very sensitive), final results were similar.

Table 19: Logistic regression results for boar preference for smell over castrates including levels of androstenone and skatole.

Effect	Num DF	Den DF	F Value	Pr > F
Sequence (2 to 5)	3	1890	5.55	<0.001
Position (1 or 2)	1	1890	36.92	<0.001
Country (DK, FR, IT, PL)	3	444.4	5.53	0.001
Sensitivity to androstenone[1]	2	510.5	6.22	0.002
Sensitivity to skatole[2]	1	433.1	7.13	0.008
Logarithm of androstenone content LnA	1	1890	2.76	0.097
Logarithm of skatole content LnS	1	1890	25.7	<0.001
LnA x LnS	1	1890	2.49	0.115

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm; no>5ppm
[2]Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

Table 20: Logistic regression results for boar preference for flavour over castrates including levels of androstenone and skatole.

Effect	Num DF	Den DF	F Value	Pr > F
Country (DK, FR, IT, PL)	3	457	4.26	0.006
Sensitivity to androstenone[1]	2	564.8	11.65	<0.001
Logarithm of androstenone content LnA	1	1895	5.49	0.019
Logarithm of skatole content LnS	1	1895	28.45	<0.001
LnA x LnS	1	1895	3.79	0.052

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm; no>5ppm

In order to develop a map of preferences, a logistic regression was carried out for smell and flavour preferences considering naeperian logarithm of androstenone and skatole, and its interaction as predictors. Consumer and country were considered as random effects. If type of boar was also included as random effect, in order to account for any effects that are not related with androstenone and skatole, the androstenone and skatole content effects were strongly reduced. This probably indicates that androstenone and skatole explain most of the variation of the sensory data (consumer preferences). For this reason, type of boar was not included in the model as random effect. Thus, prediction equations obtained for flavour and odour preferences for all the consumers together are presented in Table 21.

Table 21: Logistic regression results for boar smell and flavour preferences over castrates including levels of androstenone and skatole

				Confidence limit (95%)	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
SMELL					
Intercept	-1.323	0.205	<0.001	-1.465	-1.182
Logarithm of androstenone content (LnA)	0.402	0.254	0.114	0.231	0.574
Logarithm of skatole content (LnS)	-0.482	0.097	<0.001	-0.548	-0.416
LnA x LnS	0.218	0.152	0.151	0.116	0.321
FLAVOUR					
Intercept	-1.461	0.193	<0.001	-1.593	-1.328
Logarithm of androstenone content (LnA)	0.591	0.257	0.021	0.418	0.765
Logarithm of skatole content (LnS)	-0.516	0.098	<0.001	-0.581	-0.450
LnA x LnS	0.293	0.152	0.054	0.19	0.396

I.2.4.1.4. Preference for smell/flavour of boar meat patties and sensitivity of consumers

A regression was performed for smell and flavour by sensitivity of consumers to androstenone. For non-sensitive consumers androstenone content and the interaction were removed from the model because they were not relevant for this type of consumers. Results for smell are presented in Table 22. Confidence limits of the estimates at 95% level are also provided.
The smell preference map depending on the levels of androstenone and skatole for sensitive consumers and depending on the levels of skatole for less sensitive or insensitive consumers is presented in Figure 29. Higher acceptability values are in green and lower acceptability values are in red and the change between both colours can be seen gradually depending on the levels of the boar taint compounds. The map includes those levels of skatole (0.10 to 0.40 ppm) and androstenone (0.47 to 2.07 ppm) that were present in the fat of which the boar patties originated.

Table 22: Logistic regression results for boar smell preferences over castrated including levels of androstenone and skatole, by sensitivity of consumers to androstenone.

SMELL				Confidence limit (95%)	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
Non-sensitive					
Intercept	-1.173	0.206	<.0001	-1.312	-1.033
Logarithm of skatole content	-0.475	0.115	<.0001	-0.552	-0.397
Sensitive					
Intercept	-1.604	0.367	0.0003	-1.856	-1.352
Logarithm of androstenone content (LnA)	0.449	0.474	0.344	0.129	0.768
Logarithm of skatole content (LnS)	-0.491	0.180	0.007	-0.612	-0.369
LnA x LnS	0.409	0.284	0.151	0.217	0.601

Sensitivity to androstenone threshold in odorant dilution: sensitive <5ppm, non-sensitive>5ppm

Preference SMELL(%)

Sensitive	Skatole (ppm)															
Androstenone(ppm)	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
0.47	47.4	43.8	40.8	38.3	36.1	34.2	32.5	31.0	29.6	28.4	27.3	26.3	25.3	24.5	23.7	23.0
0.67	43.1	40.2	37.8	35.8	34.0	32.5	31.2	29.9	28.9	27.9	27.0	26.2	25.4	24.7	24.0	23.4
0.87	40.0	37.6	35.7	34.0	32.6	31.3	30.2	29.2	28.3	27.5	26.8	26.1	25.4	24.8	24.3	23.8
1.07	37.6	35.6	34.0	32.6	31.4	30.4	29.5	28.6	27.9	27.2	26.6	26.0	25.5	25.0	24.5	24.1
1.27	35.6	34.0	32.6	31.5	30.5	29.6	28.9	28.2	27.5	27.0	26.4	25.9	25.5	25.1	24.7	24.3
1.47	34.0	32.6	31.5	30.6	29.7	29.0	28.4	27.8	27.2	26.8	26.3	25.9	25.5	25.1	24.8	24.5
1.67	32.6	31.5	30.5	29.8	29.1	28.5	27.9	27.4	27.0	26.6	26.2	25.9	25.5	25.2	24.9	24.7
1.87	31.4	30.5	29.7	29.0	28.5	28.0	27.5	27.1	26.8	26.4	26.1	25.8	25.5	25.3	25.0	24.8
2.07	30.3	29.6	28.9	28.4	28.0	27.6	27.2	26.9	26.6	26.3	26.0	25.8	25.6	25.3	25.2	25.0

	Skatole (ppm)															
Non Sensitive	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
Preference SMELL(%)	48.0	45.9	44.1	42.5	41.1	39.9	38.9	37.9	37.0	36.2	35.4	34.7	34.1	33.5	32.9	32.4

Figure 29: Map of preferences (%) for smell of boar meat patties over castrated meat patties depending on the levels of androstenone and skatole and the sensitivity of the consumer to androstenone. Variation from green (higher preference) to yellow and red (lower preference).

It is possible to see that, the higher the skatole content, the lower the preference of smell. Moreover for sensitive consumers higher androstenone content decreases smell preferences when skatole levels are low.
Regarding flavour, regression equations for sensitive and insensitive consumers are presented in Table 23. Confidence limits of the estimates at 95% level are also provided.
A preference map depending on the levels of androstenone and skatole for sensitive consumers and depending on the levels of skatole for less sensitive or insensitive consumers is presented in Figure 30.

Table 23: Logistic regression results for boar flavour preferences over castrated including levels of androstenone and skatole, by sensitivity of consumers to androstenone.

FLAVOUR				Confidence limit (95%)	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
Non-sensitive					
Intercept	-1.236	0.206	<.0001	-1.376	-1.096
Logarithm of skatole content	-0.491	0.114	<.0001	-0.568	-0.414
Sensitive					
Intercept	-1.870	0.349	<.0001	-2.108	-1.631
Logarithm of androstenone content (LnA)	0.756	0.486	0.120	0.428	1.084
Logarithm of skatole content (LnS)	-0.548	0.182	0.003	-0.671	-0.425
LnA x LnS	0.518	0.287	0.072	0.324	0.712

Sensitivity to androstenone threshold in odorant dilution: sensitive <5ppm, non-sensitive>5ppm

Preference FLAVOUR(%)

Sensitive	Skatole (ppm)															
Androstenone(ppm)	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
0.47	43.1	39.0	35.6	32.8	30.4	28.3	26.6	25.0	23.6	22.4	21.3	20.3	19.4	18.5	17.8	17.1
0.67	39.4	36.1	33.5	31.3	29.4	27.8	26.4	25.1	24.0	23.0	22.1	21.2	20.5	19.8	19.1	18.5
0.87	36.7	34.1	32.0	30.2	28.7	27.4	26.2	25.2	24.3	23.4	22.7	22.0	21.3	20.7	20.2	19.7
1.07	34.6	32.5	30.8	29.4	28.1	27.0	26.1	25.2	24.5	23.8	23.1	22.6	22.0	21.5	21.1	20.6
1.27	32.9	31.2	29.9	28.7	27.7	26.8	26.0	25.3	24.7	24.1	23.5	23.1	22.6	22.2	21.8	21.4
1.47	31.5	30.2	29.1	28.1	27.3	26.6	25.9	25.3	24.8	24.3	23.9	23.5	23.1	22.8	22.4	22.1
1.67	30.3	29.3	28.4	27.6	26.9	26.4	25.8	25.4	24.9	24.6	24.2	23.9	23.6	23.3	23.0	22.7
1.87	29.3	28.5	27.8	27.2	26.6	26.2	25.8	25.4	25.1	24.8	24.5	24.2	24.0	23.7	23.5	23.3
2.07	28.4	27.8	27.2	26.8	26.4	26.0	25.7	25.4	25.2	24.9	24.7	24.5	24.3	24.1	24.0	23.8

	Skatole (ppm)															
Non Sensitive	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
Preference FLAVOUR(%)	47.4	45.2	43.3	41.7	40.3	39.0	37.9	36.9	36.0	35.2	34.4	33.7	33.0	32.4	31.9	31.3

Figure 30: Map of the preferences (%) for flavour of boar meat patties over castrated meat patties depending on the levels of androstenone and skatole and the sensitivity of the consumer to androstenone. Variation from green (higher preference) to yellow and red (lower preference).

As well as for smell, it is possible to see that, the higher the skatole content, the lower the preference of flavour. Moreover for sensitive consumers higher androstenone content decreases smell preferences when skatole levels are low.

Final model for smell preferences

A global equation has been obtained considering both, sensitive and very sensitive *vs*. insensitive consumers to androstenone weighted by the proportion of each type of consumer. In the four EU countries studied 65.8% of the consumer were defined as insensitive and 34.2% as sensitive, thus, the final prediction equation for smell would be:

Smell preference = 0.658 * (smell preference insensitive consumers) + 0.342*(smell preference sensitive consumers)

Smell preference (%) = -1.320 + 0.153*LnA -0.480*LnS +0.140*LnS*LnA

Where LnA and LnS are the naeperian logarithm of androstenone and skatole content, respectively.

The map of preferences for smell considering both consumers proportionally is presented in Figure 31.

Preference SMELL(%) 34.2% sensitive-65.8% insensitive consumers

Androstenone(ppm) \ Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	47.8	45.2	42.9	41.0	39.4	37.9	36.6	35.4	34.4	33.4	32.5	31.7	30.9	30.2	29.5	28.9
0.67	46.3	43.9	41.9	40.2	38.7	37.3	36.1	35.1	34.1	33.2	32.4	31.6	30.9	30.3	29.7	29.1
0.87	45.2	43.0	41.1	39.5	38.1	36.9	35.8	34.8	33.9	33.1	32.3	31.6	31.0	30.3	29.8	29.2
1.07	44.4	42.3	40.5	39.0	37.7	36.5	35.5	34.6	33.7	33.0	32.2	31.6	31.0	30.4	29.9	29.4
1.27	43.7	41.7	40.0	38.6	37.4	36.3	35.3	34.4	33.6	32.9	32.2	31.6	31.0	30.4	29.9	29.4
1.47	43.1	41.2	39.6	38.2	37.1	36.0	35.1	34.2	33.5	32.8	32.1	31.5	31.0	30.5	30.0	29.5
1.67	42.5	40.7	39.2	37.9	36.8	35.8	34.9	34.1	33.4	32.7	32.1	31.5	31.0	30.5	30.0	29.6
1.87	42.1	40.3	38.9	37.7	36.6	35.6	34.8	34.0	33.3	32.7	32.1	31.5	31.0	30.5	30.1	29.6
2.07	41.7	40.0	38.6	37.4	36.4	35.5	34.6	33.9	33.2	32.6	32.0	31.5	31.0	30.5	30.1	29.7

Figure 31: Map of the preferences (%) for smell of boar meat patties over castrated meat patties depending on the levels of androstenone and skatole and considering all the consumers weighted by the proportion of sensitive and non-sensitive. Variation from green (higher preference) to yellow and red (lower preference).

Final model for flavour preferences

For flavour also a global equation has been obtained considering both, sensitive and less sensitive-insensitive consumers to androstenone weighted by the proportion of each type of consumer. As well as for smell, the final prediction equation for flavour would be:

Flavour preference = 0.658 * (flavour preference insensitive consumers) + 0.342*(flavour preference sensitive consumers)

Flavour preference (%) = -1.453 + 0.259*LnA -0.511*LnS +0.177*LnS*LnA

Where LnA and LnS are the naeperian logarithm of androstenone and skatole content, respectively.

The map of preferences for flavour considering both consumers proportionally is presented in Figure 32.

Preference FLAVOUR(%) 34.2% sensitive-65.8% insensitive consumers

Androstenone(ppm) \ Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	45.9	43.0	40.6	38.5	36.8	35.2	33.8	32.6	31.4	30.4	29.5	28.6	27.8	27.1	26.4	25.8
0.67	44.6	42.0	39.8	38.0	36.4	35.0	33.7	32.6	31.6	30.7	29.8	29.0	28.3	27.7	27.0	26.4
0.87	43.6	41.3	39.3	37.6	36.1	34.8	33.7	32.6	31.7	30.9	30.1	29.3	28.7	28.1	27.5	26.9
1.07	42.9	40.7	38.8	37.3	35.9	34.7	33.6	32.7	31.8	31.0	30.3	29.6	29.0	28.4	27.8	27.3
1.27	42.3	40.2	38.5	37.0	35.7	34.6	33.6	32.7	31.9	31.1	30.4	29.8	29.2	28.7	28.1	27.7
1.47	41.7	39.8	38.2	36.8	35.6	34.5	33.6	32.7	31.9	31.2	30.6	30.0	29.4	28.9	28.4	27.9
1.67	41.3	39.4	37.9	36.6	35.4	34.4	33.5	32.7	32.0	31.3	30.7	30.1	29.6	29.1	28.6	28.2
1.87	40.8	39.1	37.6	36.4	35.3	34.4	33.5	32.7	32.0	31.4	30.8	30.3	29.7	29.3	28.8	28.4
2.07	40.5	38.8	37.4	36.2	35.2	34.3	33.5	32.7	32.1	31.5	30.9	30.4	29.9	29.4	29.0	28.6

Figure 32: Map of the preferences (%) for flavour of boar meat patties over castrated meat patties depending on the levels of androstenone and skatole and considering all the consumers weighted by the proportion of sensitive and non-sensitive. Variation from green (higher preference) to yellow and red (lower preference).

In all cases (smell and flavour preferences) the higher the skatole content, the lower the preference of boar over castrate. Moreover higher androstenone content decreases preferences mainly when skatole levels are low.

I.2.4.2. Boar scores over castrated scores

According to the liking scores given to boar and castrate patties of each pair consumers have been classified as:

- Boar like (boar): score given to boar was higher than that given to castrate.
- Castrate like (cast): score given to boar was lower than that given to castrate.
- Indifferent (none): same score for boar and castrate.

Differences in liking scores were obtained for each type of boar and country. Results (in %) when all the countries are considered together are presented in Figure 33; individual results for each country are presented in Figure 34.

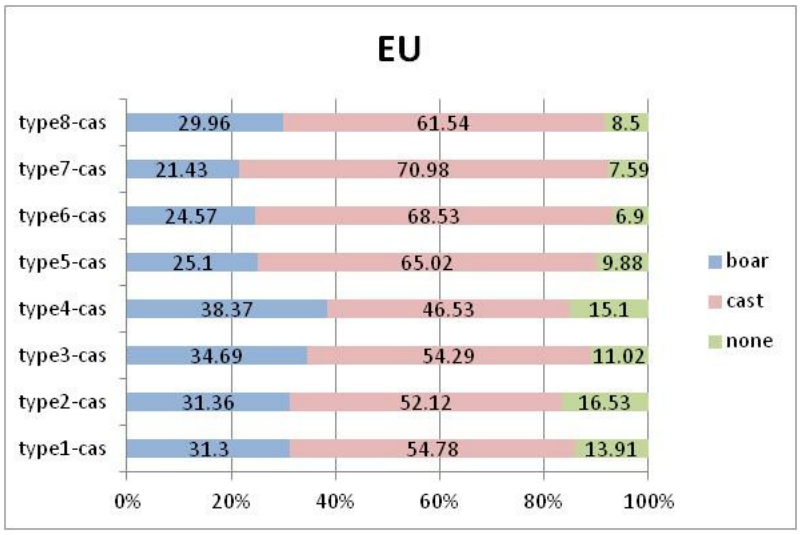


Figure 33: Percentage of consumers that scored higher liking for boar, higher liking for castrate (cas) or score the same value of liking to both patties, for all the EU countries evaluated together (Number of consumers within each pairwise comparison varies from to 224 to 247).

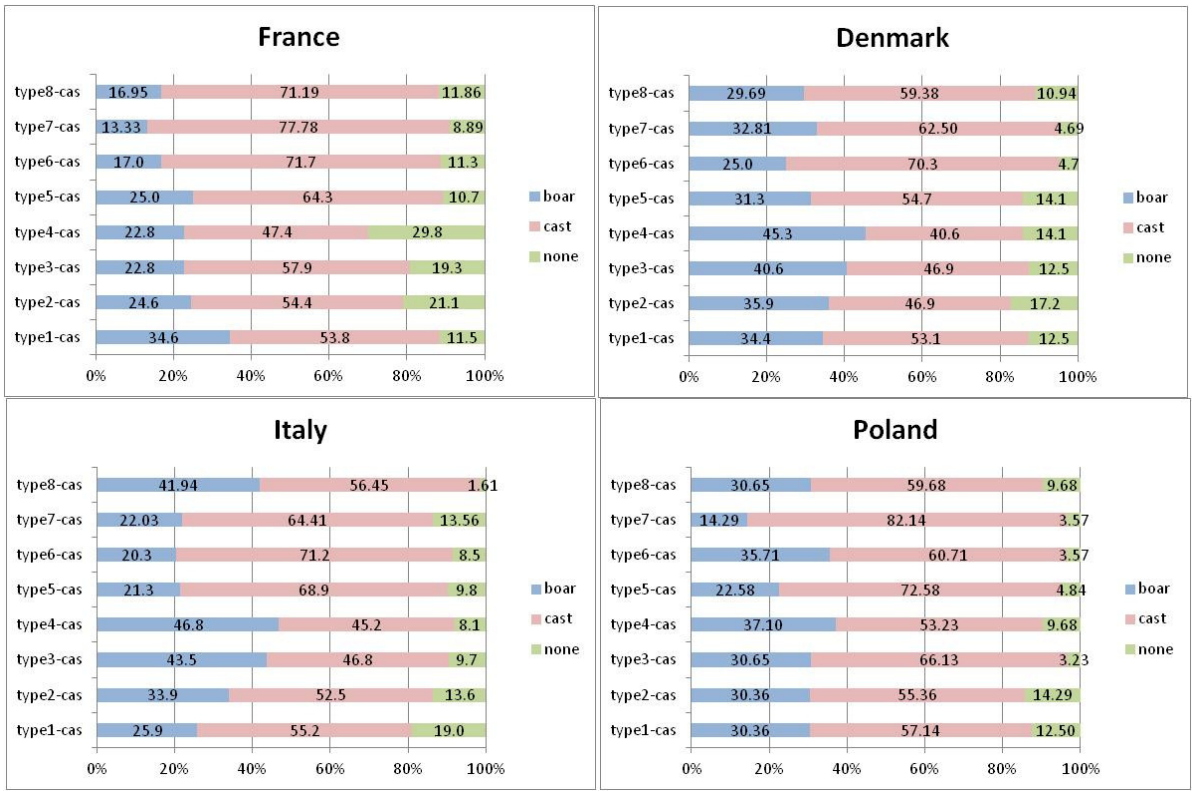


Figure 34: Percentage of consumers that scored higher liking for boar, higher liking for castrate (cast) or score the same value of liking to both patties, by country (Number of consumers within each pairwise comparison varies from to 45 to 59 in Denmark, 64 in France, 58 to 62 in Italy and 56 to 62 in Poland).

Different analytical approaches were considered to evaluate the differences between the boar and castrate meat patties. Evaluation of the difference in scores (boar – castrated) was performed with the MIXED procedure of SAS including as fixed effects the type of pair, the position of the boar patties, the sensitivity to androstenone, sensitivity to skatole and country. The sequence and interactions between sensitivity and country with type of pair were excluded because they were not significant. Consumer was added as random effect. Significance of each factor is shown In Table 24. It is possible to see that all the factors included in the final model were significant. The differences between the levels of the different effects, after applying Bonferroni test are presented in Table 25. Differences between boar and castrate were always negative, thus, boar meat patties

was scored lower than castrate patties. Moreover, these differences were always significantly (P<0.001) different from zero. Thus, all boar meat patties types, i.e. with any combination of androstenone and skatole, were scored significantly worse than castrate meat patties. When evaluating the differences between the boar patties, it is possible to see that differences in scores were most important in patties 5, 6, 7 and 8, i.e. patties with high skatole levels and several androstenone levels. Thus, it seems that the level of skatole more strongly affects preference than the level of androstenone. This can be seen graphically in figure 35. Differences were bigger (i.e. relative dislike was higher) when boars were evaluated on the second position of a pair (after a castrate patty). Finally there were higher differences in scores for consumers sensitive to androstenone and skatole. Regarding countries, Danish consumers presented bigger differences in scores compared to consumers from France and Italy, results for Poland were in between.

Table 24: ANOVA results for the difference in liking between boars and castrate meat patties.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	7	1609	15.64	<0.001
Position of boar (1 or 2)	1	1428	15.46	<0.001
Sensitivity to androstenone[1]	2	468	18.36	<0.001
Sensitivity to skatole[2]	1	468	8.2	0.004
Country (DK, FR, IT, PL)	3	468	6.55	<0.001

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm: yes; no>5ppm
[2]Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

If sensitivity to androstenone was considered at two levels (no sensitive *vs.* sensitive or very sensitive), final results were similar although the interaction between sensitivity and type of boar had a P-value closer to the significance level.

Table 25: Least square means of the liking difference (boar – castrate patty); negative values indicate decreased liking for boar compared to castrate.

ALL	LSMean[+]		s.e.	Pr > |t|
Type of comparison				
Type1-Castrate	-1.10	cd	0.18	<0.001
Type2-Castrate	-1.26	bcd	0.18	<0.001
Type3-Castrate	-0.98	d	0.17	<0.001
Type4-Castrate	-0.75	d	0.17	<0.001
Type5-Castrate	-1.72	abc	0.17	<0.001
Type6-Castrate	-2.08	a	0.18	<0.001
Type7-Castrate	-2.39	a	0.18	<0.001
Type8-Castrate	-1.79	ab	0.17	<0.001
Position of boar				
First	-1.31	b	0.12	<0.001
Second	-1.71	a	0.12	<0.001
Androstenone sensitivity				
no	-0.82	c	0.09	<0.001
yes	-1.32	b	0.15	<0.001
very	-2.38	a	0.26	<0.001
Skatole sensitivity				
no	-1.29	b	0.15	<0.001
yes	-1.73	a	0.11	<0.001
Country				
Denmark	-1.99	a	0.17	<0.001
France	-1.16	b	0.17	<0.001
Italy	-1.24	b	0.16	<0.001
Poland	-1.65	ab	0.17	<0.001

[+]Boar score – Castrate score: both of them evaluated in a 9-point scale from 1: 'extremely dislike' to 9: 'extremely like' without the intermediate level 'neither like nor dislike'.
Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm: yes; no>5ppm
Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

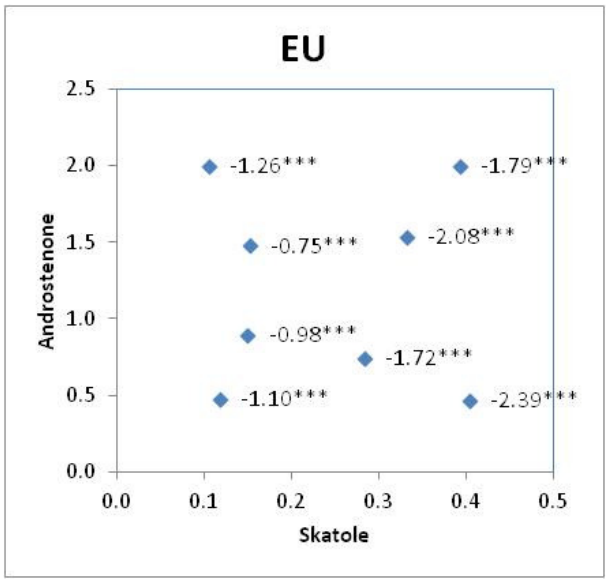


Figure 35: Least square means of the difference between the scores given to boar meat patties classified according to its androstenone and skatole content compared with castrated meat patties. ***: P<0.001.

The same model as before but considering country as random effect was also applied. This is important if general conclusions want to be drawn independently on the country. Results were very similar and all the scores were significantly lower in boar meat patties than in castrated patties although the degree of differences was somewhat less significant than in the previous analysis (see Figure 36).

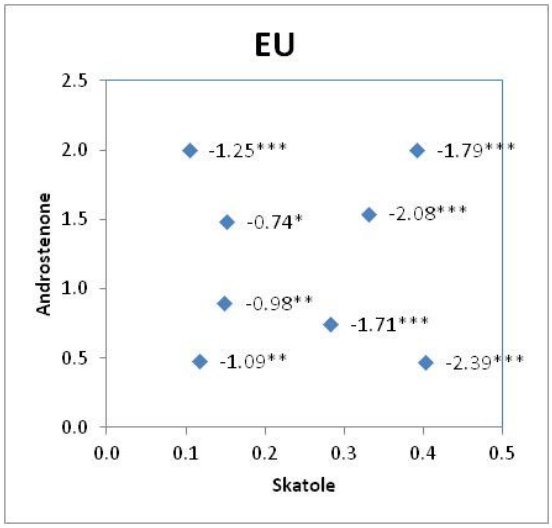


Figure 36: Least square means of the difference between the scores given to boar meat compared with castrated patties. ***: P<0.001; ** P<0.01; * P<0.05.

If instead of sensitivity to androstenone and skatole, the model (point 1) included liking of androstenone and skatole, the interactions between type of comparison and liking of androstenone and between type of comparison and liking of skatole were significant. Significance of the different effects is presented in Table 26.

Table 26: ANOVA results (type III) for the difference in liking between boars and castrates.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	7	1593	9.21	<0.001
Position of boar 1 or 2)	1	1403	12.24	<0.001

Androstenone liking	2	467	18.59	<0.001
Skatole liking	2	469	6.93	0.001
Country (DK, FR, IT, PL)	3	466	6.61	<0.001
Androstenone liking x Type of pair	14	1582	1.88	0.025
Skatole liking x Type of pair	14	1590	1.86	0.026

Androstenone/skatole liking evaluated in a 9-point scale: 'dislike' scores 1 to 4;' neutral' (include those that cannot smell androstenone/skatole and those that smell it but neither like nor dislike the smell) score 5 and 'like' scores 6 to 9.

Least square means of the interaction between liking and type of pair is presented in Figure 37 for androstenone and Figure 38 for skatole. It is possible to see that consumers that dislike these compounds presented in general the biggest differences between liking score given to meat patties from boars compared with those given to meat patties from castrated pigs. This is especially important in boar patties with low skatole content, because only consumers that dislike androstenone scored boar meat patties significantly worse than patties from castrated.

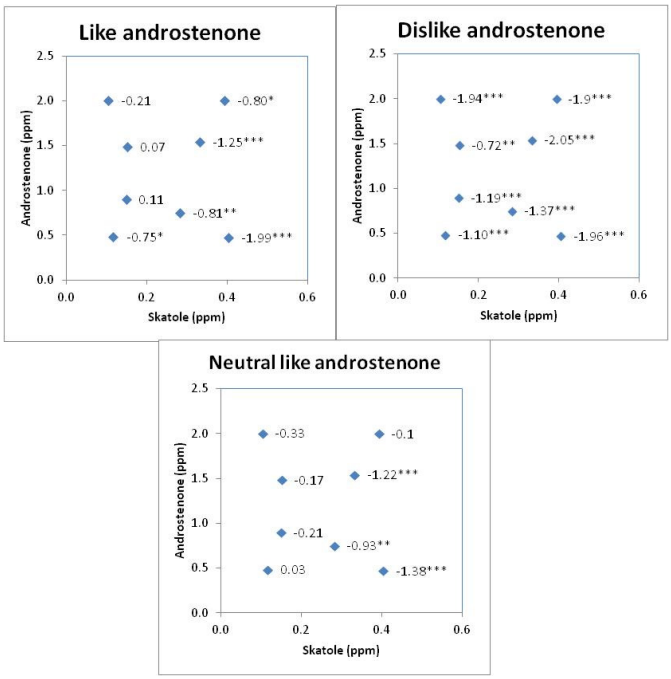


Figure 37: Least square means of the difference between the scores given to boar meat patties compared with castrated meat patties depending on the liking of androstenone (dislike androstenone, scores 1 to 4; like androstenone, scores 6 to 9 and neutral (include those that cannot smell androstenone and those that smell it but neither like nor dislike the smell), 5.

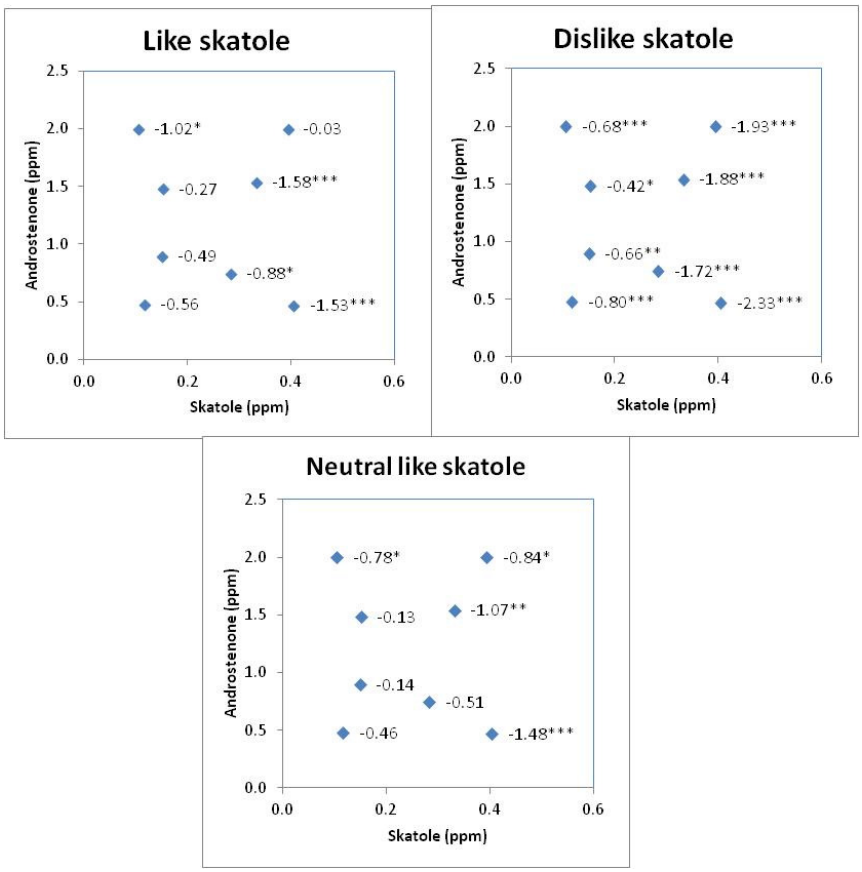


Figure 38: Least square means of the difference between the scores given to boar meat patties compared with castrated meat patties depending on the liking of skatole (dislike skatole, scores 1 to 4; like skatole, scores 6 to 9 and neutral (include those that cannot smell skatole and those that smell it but neither like nor dislike the smell), 5.

An analysis was performed considering the naeperian logarithm of the levels of androstenone and skatole of the patties. In this case a mixed model ANOVA was performed including position of boar patty, country and androstenone sensitivity and skatole sensitivity as fixed effects and consumer within country as random effects. Androstenone and skatole levels (average levels in backfat from the animals from which meat patties was used to do the mixture for the patties) and its interaction were included in the model as covariates. Results obtained are presented in Table 27.

Table 27: ANOVA results (type III) for the difference in liking between boars and castrates.

Effect	Num DF	Den DF	F Value	Pr > F
Position of boar pattie (1 or 2)	1	1431	15.22	<0.001
Sensitivity to androstenone	2	468	18	<0.001
Sensitivity to skatole	1	468	8.08	0.005
Country (DK,FR,IT, PL)	3	468	6.42	<0.001
Logarithm of androstenone content - LnA	1	1515	5.73	0.017
Logarithm of skatole content – LnS	1	1458	84.24	<0.001
LnA x LnS	1	1530	4.21	0.040

Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm: 0.5ppm<yes <5ppm: yes; no>5ppm
Sensitivity to skatole threshold: yes<1.0 ppm; no>1.0ppm

If sensitivity to androstenone was considered at two levels (no sensitive *vs.* sensitive or very sensitive), final results were similar. We can observe that all the factors are significant indicating that all of them influence consumer response. Thus, difference in scores between boars and castrates is influenced by both, androstenone and skatole as well as by its interaction. If instead of naeperian logarithm of androstenone and skatole content, its contents without transformation were included in the model the results were almost the same was found for skatole (P<0.001), but the effect of androstenone and the interaction between androstenone and skatole become non-significant (P=0.377 and P=0.568, respectively).
In order to know the difference in liking scores between boar and castrate depending only on the

levels of androstenone and skatole of the meat patties, an analysis of variance was performed for all the consumers together considering naeperian logarithm of androstenone and skatole and its interaction as predictors. Consumer within country and country were considered as random effects.

Table 28: ANOVA results (type III) for the difference in liking between boars and castrates depending on androstenone and skatole levels of the fat (transformed with naeperian logarithm).

						Confidence Limit (95%	
Effect	Estimate	Error	DF	t Value	Pr > |t|	Lower	Upper
Intercept	-2.537	0.231	<0.001	-3.05	-2.02	-2.537	0.231
Logarithm of androstenone content LnA	0.597	0.257	0.020	0.093	1.101	0.597	0.257
Logarithm of skatole content LnS	-0.916	0.100	<0.001	-1.11	-0.72	-0.916	0.100
LnA x LnS	0.312	0.158	0.048	0.003	0.621	0.312	0.158

Sensitivity of the consumers to androstenone has a significant effect on consumer response. For this reason the difference in liking scores between boar and castrate was studied by regression analysis considering the sensitivity of the consumers in order to develop a map of preferences. For sensitive consumers the model included logarithm of androstenone and skatole content and its interaction, while for non-sensitive consumers ('yes' and 'very' groups together) it included only logarithm of skatole because androstenone was not relevant. In both cases, consumer within country and country were considered as random effects. Results are presented in Table 29. Confidence limits of the estimates at 95% level are also provided.

Table 29: ANOVA results (type III) by sensitivity of consumers to androstenone for the difference in liking between boars and castrates depending on androstenone and skatole levels of the fat (transformed with naeperian logarithm).

				Confidence limit (95%)	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
Non-sensitive					
Intercept	-2.24	0.237	<0.001	-2.73	-1.76
Logarithm of skatole content	-0.92	0.126	<0.001	-1.17	-0.67
Sensitive					
Intercept	-3.039	0.384	<0.001	-3.906	-2.173
Logarithm of androstenone content (LnA)	0.642	0.416	0.123	-0.175	1.458
Logarithm of skatole content (LnS)	-0.902	0.163	<0.001	-1.221	-0.583
LnA x LnS	0.564	0.258	0.030	0.056	1.071

Sensitivity to androstenone threshold in odorant dilution: sensitive <5ppm, non-sensitive>5ppm

The map of differences in scores (9 point scale) between boar and castrated meat patties depending on androstenone and skatole levels and the previous models is presented in Figure 39.

Sensitive	Skatole (ppm)															
Boar-Castrate																
Androstenone (ppm)	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
0.47	-0.47	-0.71	-0.91	-1.09	-1.25	-1.39	-1.51	-1.63	-1.74	-1.83	-1.93	-2.01	-2.09	-2.17	-2.24	-2.31
0.67	-0.70	-0.91	-1.08	-1.23	-1.36	-1.48	-1.59	-1.69	-1.78	-1.86	-1.94	-2.01	-2.08	-2.14	-2.21	-2.26
0.87	-0.87	-1.05	-1.20	-1.33	-1.45	-1.55	-1.64	-1.73	-1.81	-1.88	-1.95	-2.01	-2.07	-2.13	-2.18	-2.23
1.07	-1.01	-1.16	-1.30	-1.41	-1.51	-1.61	-1.69	-1.76	-1.83	-1.90	-1.96	-2.01	-2.06	-2.11	-2.16	-2.20
1.27	-1.12	-1.26	-1.38	-1.48	-1.57	-1.65	-1.72	-1.79	-1.85	-1.91	-1.96	-2.01	-2.06	-2.10	-2.14	-2.18
1.47	-1.21	-1.34	-1.45	-1.54	-1.62	-1.69	-1.75	-1.81	-1.87	-1.92	-1.97	-2.01	-2.05	-2.09	-2.13	-2.16
1.67	-1.30	-1.41	-1.50	-1.59	-1.66	-1.72	-1.78	-1.84	-1.88	-1.93	-1.97	-2.01	-2.05	-2.08	-2.12	-2.15
1.87	-1.37	-1.47	-1.56	-1.63	-1.70	-1.75	-1.81	-1.85	-1.90	-1.94	-1.98	-2.01	-2.05	-2.08	-2.11	-2.13
2.07	-1.44	-1.53	-1.60	-1.67	-1.73	-1.78	-1.83	-1.87	-1.91	-1.95	-1.98	-2.01	-2.04	-2.07	-2.10	-2.12
Non sensitive																
Boar-Castrate																
Skatole (ppm)	**0.1**	**0.12**	**0.14**	**0.16**	**0.18**	**0.2**	**0.22**	**0.24**	**0.26**	**0.28**	**0.3**	**0.32**	**0.34**	**0.36**	**0.38**	**0.4**
	-0.13	-0.29	-0.44	-0.56	-0.67	-0.76	-0.85	-0.93	-1.00	-1.07	-1.14	-1.20	-1.25	-1.30	-1.35	-1.40

Figure 39: Map of the difference of scores between boar meat patties and castrated meat patties depending on the androstenone and skatole levels and consumers sensitivity to androstenone. Variation from green (less differences between boar and castrated) to yellow and red (higher differences between boar and castrated)

It is possible to see that the difference between boar and castrate increases with the increasing skatole content, and since the values are negative, the higher the score given to castrated compared to those given to boar meat patties. At low levels of skatole, the higher the androstenone content the higher the difference between boar and castrate meat patties.

Final model for difference in liking scores between boar and castrate meat patties

A global equation has been obtained considering both, sensitive and less sensitive-insensitive consumers to androstenone weighted by the proportion of each type of consumer. In the four EU countries studied there are 65.8% of insensitive consumers and 34.2% of sensitive, thus, the final prediction equation for smell would be:

Boar-Castrate liking scores= 0.658 * (liking score difference insensitive consumers) + 0.342*(liking score difference sensitive consumers)

Boar-Castrate liking scores (%)= -2.515 + 0.219*LnA -0.913*LnS +0.193*LnS*LnA

Where LnA and LnS are the naeperian logarithm of androstenone and skatole content, respectively.

The map of preferences for smell considering both androstenone sensitive and androstenone non sensitive consumers proportionally is presented in Figure 40.

Boar-Castrate

Androstenone(ppm) \ Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	-0.24	-0.44	-0.60	-0.74	-0.86	-0.98	-1.08	-1.17	-1.25	-1.33	-1.41	-1.47	-1.54	-1.60	-1.66	-1.71
0.67	-0.32	-0.50	-0.66	-0.79	-0.90	-1.01	-1.10	-1.19	-1.27	-1.34	-1.41	-1.47	-1.53	-1.59	-1.64	-1.70
0.87	-0.38	-0.55	-0.70	-0.82	-0.93	-1.03	-1.12	-1.20	-1.28	-1.35	-1.41	-1.47	-1.53	-1.59	-1.64	-1.68
1.07	-0.43	-0.59	-0.73	-0.85	-0.96	-1.05	-1.14	-1.22	-1.29	-1.35	-1.42	-1.47	-1.53	-1.58	-1.63	-1.68
1.27	-0.47	-0.62	-0.76	-0.87	-0.98	-1.07	-1.15	-1.22	-1.29	-1.36	-1.42	-1.47	-1.53	-1.58	-1.62	-1.67
1.47	-0.50	-0.65	-0.78	-0.89	-0.99	-1.08	-1.16	-1.23	-1.30	-1.36	-1.42	-1.47	-1.53	-1.57	-1.62	-1.66
1.67	-0.53	-0.68	-0.80	-0.91	-1.01	-1.09	-1.17	-1.24	-1.31	-1.37	-1.42	-1.47	-1.52	-1.57	-1.61	-1.66
1.87	-0.55	-0.70	-0.82	-0.92	-1.02	-1.10	-1.18	-1.25	-1.31	-1.37	-1.42	-1.47	-1.52	-1.57	-1.61	-1.65
2.07	-0.58	-0.72	-0.84	-0.94	-1.03	-1.11	-1.18	-1.25	-1.31	-1.37	-1.42	-1.47	-1.52	-1.57	-1.61	-1.65

Figure 40: Map of the difference of liking scores between boar meat patties and castrated depending on the levels of androstenone and skatole and considering meat patties all the consumers weighted by the proportion of sensitive and non-sensitive to androstenone. Variation from green (less differences between boar and castrated) to yellow and red (higher differences between boar and castrated).

Boars scored on average worse than castrates. As well as with preferences it is possible to see that the difference is higher when skatole levels increases. In case of androstenone, its influence in liking scores is mainly important when skatole levels are lower.

I.2.5. Liking scores to boar meat patties

I.2.5.1. Description of liking scores

Average liking scores of consumers for the meat patties of each boar type have been calculated by country (Figure 41) and for all the countries together (Figure 42).

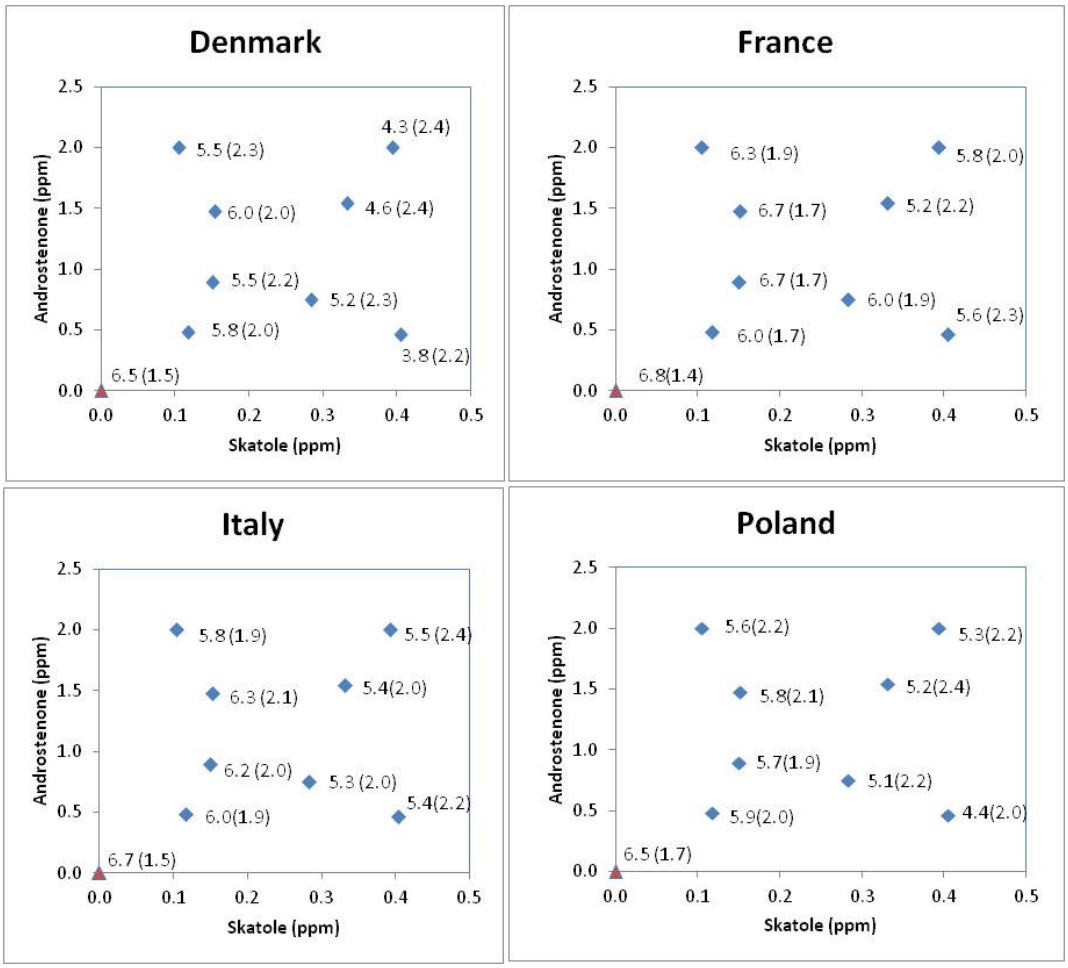


Figure 41: Mean (standard deviation) of liking score for boar meat patties (1= dislike a lot to 9= like a lot) by country depending on the levels of androstenone and skatole. (Number of consumers within each pairwise comparison varies from to 45 to 59 in Denmark, 64 in France, 58 to 62 in Italy and 56 to 62 in Poland).

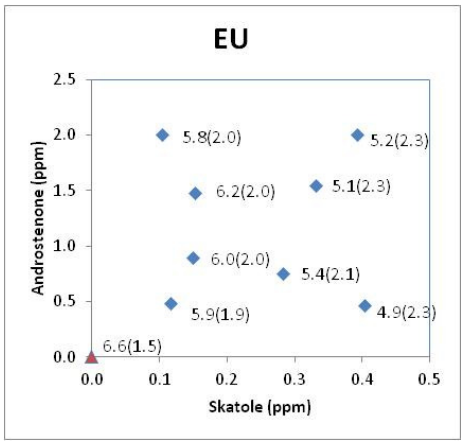


Figure 42: Mean (standard dev.) of liking score (1= dislike a lot to 9= like a lot) for boar meat patties for the EU countries together depending on androstenone and skatole levels. Average liking score of the castrate patty is indicated at the red triangle (nr. of consumers within each pairwise comparison varies from to 224 to 247).

Liking scores given by consumers to meat patties from castrates, depending on the boar patty of the pair, are presented in Figure 43 country and in Figure 44 for all the countries together.

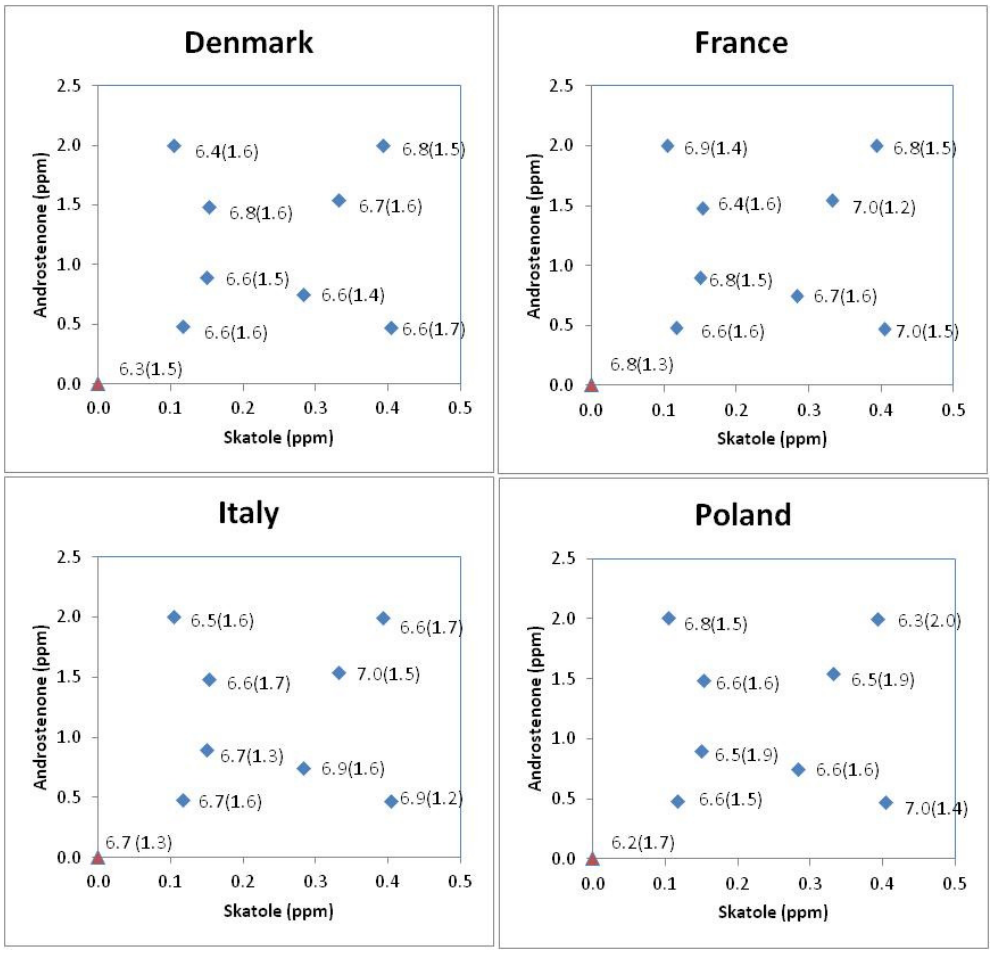


Figure 43: Mean (standard deviation) of liking scores (1= dislike a lot to 9= like a lot) of meat patties from castrated depending on the levels of androstenone and skatole of the boar of the pair and country. The average liking score of the castrate patty is indicated at the red triangle (Number of consumers within each pairwise comparison varied from to 45 to 59 in Denmark, 64 in France, 58 to 62 in Italy and 56 to 62 in Poland).

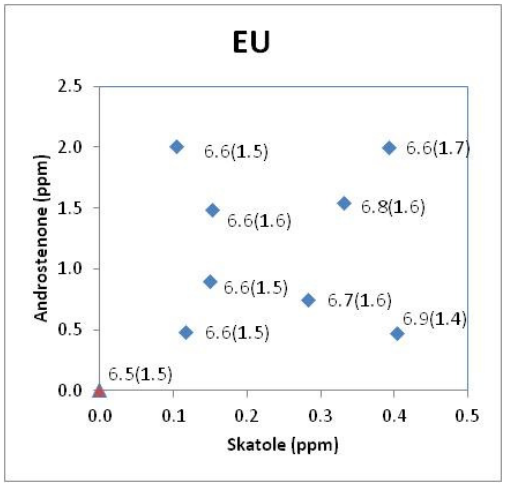


Figure 44: Mean (standard deviation) of liking score (1= dislike a lot to 9= like a lot) of meat patties from castrated depending on the levels of androstenone and skatole of the boar of the pair for all the EU countries. (Number of consumers within each pairwise comparison varied from to 224 to 247).

I.2.5.2. Liking scores by type of boar meat patties

An ANOVA has been performed on boar patties with the mixed procedure of SAS. The final model included as fixed effects the type of boar, position, country, sensitivity to androstenone, sensitivity to skatole, interaction between country and type of boar and interaction between boar and sensitivity to androstenone. The other interactions were removed because they were not significant. Consumer was included as random effect. Results are presented in Table 30. Interaction between boar and sensitivity to androstenone, although P-value higher than 0.05, was kept in the model. The liking of boar meat patties depended on the country (P>0.043).
If sensitivity to androstenone was considered at two levels (no sensitive *vs.* sensitive or very sensitive), final results were similar although interaction between type of boar and country presented a P-value of 0.054.
The least square means of the different effects and the interaction are presented in Table 31. It is possible to see that, when the boar patties were evaluated in the first position of the pair, the scores were higher (i.e. liking was higher) than when it was served in the second position. This probably could be an indicator that consumers score by comparison, and that there is an effect of the first-patty evaluated. In all the countries, the lowest scores were given to patties with high skatole levels (type 5 to 8).

Table 30: ANOVA results (type III) for the liking scores of boar patties.

Effect	Num	Den	F Value	Pr > F
Type of boar (1 to 8)	7	1517	12.13	<.001
Position (1 or 2)	1	1393	23.52	<.001
Country (DK, FR, IT, PL)	3	467	10.64	<.001
Sensitivity to androstenone	2	471	15.67	<.001
Sensitivity to skatole	1	469	11.27	0.001
Type of boar*Country	21	1513	1.59	0.043
Type of boar*Sensitivity to androstenone	14	1516	1.58	0.078

Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm: 0.5ppm<yes <5ppm: yes; no>5ppm
Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

To look at the differences in liking scores depending on the country, they have been plotted in Figure 45. In general Italian and French consumers used a higher part of the liking scale and consumers from Denmark and Poland a lower part. In patties with higher skatole level (6 to 8), consumers from Denmark used the lowest liking scores.

Table 31: Least square means of the different effects.

Effect				
Position				
1	5.42	a		
2	5.07	b		
Skatole sensitivity				
no	5.49	a		
yes	5.01	b		
Androstenone sensitivity				
no	5.83	a		
yes	5.42	b		
very	4.49	c		
	Country			
Type of Boar	*Denmark*	*France*	*Italy*	*Poland*
1	5.63	5.89	6.08	5.80
2	5.24	5.97	5.49	5.10
3	5.06	6.26	5.81	5.28
4	5.32	6.15	6.07	5.36
5	4.96	5.81	5.50	5.06
6	4.12	4.89	4.92	4.88
7	3.64	5.25	5.11	3.95
8	3.84	5.34	5.42	4.76

Liking score (1-dislike extremely to 9-like extremely without the intermediate level 'neither like nor dislike')

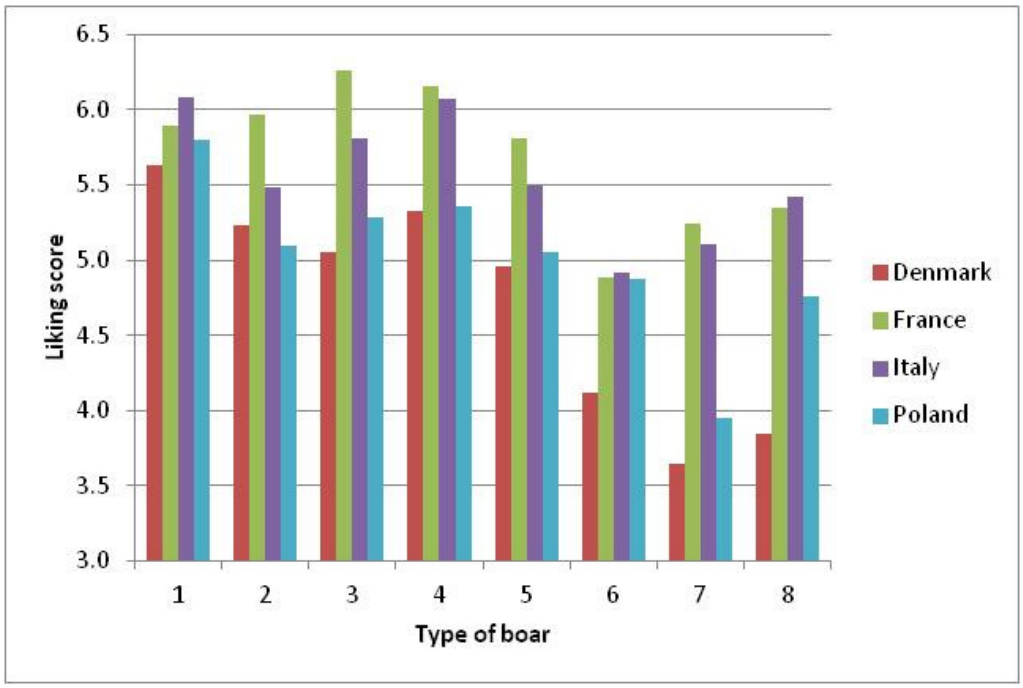


Figure 45: Least square means of the liking scores (1-dislike extremely to 9-like extremely) depending on the type of boar and country. (Number of consumers within each pairwise comparison varies from to 45 to 59 in Denmark, 64 in France, 58 to 62 in Italy and 56 to 62 in Poland).

I.2.5.3. Liking scores by androstenone and skatole content

Liking scores were also studied considering sequence, position, country, and sensitivity of consumers to androstenone and to skatole as fixed effects and naeperian logarithm of androstenone and skatole levels (average) and its interaction as covariates. Consumer was considered as random effect. Results are shown in Table 32.

Table 32: Regression results for boar liking scores (9 point scale) including levels of androstenone and skatole.

Effect	Num DF	Den DF	F Value	Pr > F
Sequence (2 to 5)	3	1421	0.18	0.908
Position (1 or 2)	1	1427	22.73	<.001
Country (DK, FR, IT, PL)	3	469	10.57	<.001
Sensitivity to androstenone	2	469	15.5	<.001
Sensitivity to skatole	1	469	10.83	0.001
Logarithm of androstenone content LnA	1	1478	4.72	0.030
Logarithm of skatole content LnS	1	1443	128.8	<.001
LnA x LnS	1	1488	3.8	0.051

Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm; no>5ppm
Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

It is possible to see that compounds, androstenone and skatole, as well as their interaction are important in the liking score of boar patties. If naeperian logarithm was not applied significance of skatole remains the same, while significance of androstenone diminishes (P=0.140) and significance of the interaction increases slightly (P=0.040).
To develop a map of preferences only the log-transformed levels of androstenone, skatole and its interaction were considered in the model, as well as consumer and country as random effects (Table 33).

Table 33: Regression results for boar liking scores (9 point scale) including levels of androstenone and skatole.

Effect	Estimate	Std. Error	Pr > |t|	Confidence limit (95%) Lower	Upper
Liking scores					
Intercept	4.308	0.235	<.001	3.703	4.913
Logarithm of androstenone content (LnA)	0.392	0.186	0.035	0.028	0.755
Logarithm of skatole content (LnS)	-0.813	0.072	<.001	-0.954	-0.671
LnA x LnS	0.215	0.114	0.059	-0.008	0.439

Due to the importance of sensitivity of consumers to androstenone, a regression analysis is performed for liking scores of boar meat patties by sensitivity of consumers to androstenone. Consumer and country were added as random effects. Results are presented in Table 34.

Table 34: Regression coefficients for liking scores depending on androstenone and skatole levels of the fat (transformed with naeperian logarithm) by sensitivity of consumers to androstenone.

Effect	Estimate	Std. Error	Pr > |t|	Confidence limit (95%) Lower	Upper
Non-sensitive					
Intercept	4.514	0.242	<.001	4.341	4.686
Logarithm of skatole content	-0.847	0.090	<.001	-0.908	-0.787
Sensitive					
Intercept	3.942	0.324	<.001	3.711	4.174
Logarithm of androstenone content	0.518	0.302	0.087	0.314	0.722
Logarithm of skatole content (LnS)	-0.755	0.118	<.001	-0.834	-0.675
LnA x LnS	0.484	0.188	0.010	0.357	0.611

Sensitivity to androstenone threshold in odorant dilution: sensitive <5ppm, non-sensitive>5ppm

The map of liking scores of boar meat patties depending on the levels of androstenone and skatole and the previous models is presented in Figure 46.

Sensitive
Liking scores

Androstenone \ Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	6.13	5.93	5.75	5.60	5.47	5.35	5.25	5.15	5.06	4.98	4.90	4.83	4.76	4.70	4.63	4.58
0.67	5.92	5.75	5.60	5.47	5.36	5.26	5.17	5.09	5.01	4.94	4.88	4.82	4.76	4.70	4.65	4.60
0.87	5.76	5.61	5.49	5.38	5.28	5.19	5.11	5.04	4.98	4.92	4.86	4.81	4.76	4.71	4.67	4.62
1.07	5.64	5.51	5.40	5.30	5.22	5.14	5.07	5.01	4.95	4.90	4.85	4.80	4.76	4.71	4.68	4.64
1.27	5.54	5.42	5.32	5.24	5.16	5.09	5.03	4.98	4.93	4.88	4.84	4.79	4.76	4.72	4.68	4.65
1.47	5.45	5.35	5.26	5.18	5.12	5.06	5.00	4.95	4.91	4.87	4.83	4.79	4.75	4.72	4.69	4.66
1.67	5.37	5.28	5.20	5.14	5.08	5.02	4.97	4.93	4.89	4.85	4.82	4.78	4.75	4.73	4.70	4.67
1.87	5.31	5.22	5.15	5.09	5.04	4.99	4.95	4.91	4.88	4.84	4.81	4.78	4.75	4.73	4.70	4.68
2.07	5.25	5.17	5.11	5.06	5.01	4.97	4.93	4.89	4.86	4.83	4.80	4.78	4.75	4.73	4.71	4.69

Non sensitive
Liking scores

Skatole (ppm)	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
	6.46	6.31	6.18	6.07	5.97	5.88	5.80	5.72	5.66	5.59	5.53	5.48	5.43	5.38	5.33	5.29

Figure 46: Map of liking scores to boar meat patties depending on the levels of androstenone and skatole and the sensitivity of the consumers to androstenone. Variation from green (less differences between boar and castrated) to yellow and red (higher differences between boar and castrated). Liking was scored on a 9 point scale (1=dislike, 9=like).

It is possible to see that the higher the skatole content, the lower the boar liking scores. At low levels of skatole, the higher the androstenone content the lower the boar patties liking scores.

Final model for liking scores to boar meat patties

A global equation has been obtained considering both, sensitive and less sensitive-insensitive consumers to androstenone weighted by the proportion of each type of consumer. In the four EU countries studied there are 65.8% of insensitive consumers and 34.2% of sensitive, thus, the final prediction equation for smell would be:

Boar liking scores= 0.658 * (liking score insensitive consumers) + 0.342*(liking score difference sensitive consumers)

Boar liking scores = 4.318 + 0.177*LnA -0.816*LnS +0.166*LnS*LnA

Where LnA and LnS are the naeperian logarithm of androstenone and skatole content, respectively.

The map of preferences for smell considering both consumers proportionally is presented in Figure 47.

Liking scores — Skatole (ppm)

Androstenone(	0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	6.35	6.18	6.03	5.91	5.80	5.70	5.61	5.53	5.45	5.38	5.32	5.26	5.20	5.15	5.09	5.05
0.67	6.28	6.12	5.98	5.86	5.76	5.67	5.58	5.51	5.44	5.37	5.31	5.25	5.20	5.15	5.10	5.06
0.87	6.22	6.07	5.94	5.83	5.73	5.64	5.56	5.49	5.42	5.36	5.30	5.25	5.20	5.15	5.11	5.06
1.07	6.18	6.04	5.91	5.80	5.71	5.62	5.55	5.48	5.41	5.35	5.30	5.25	5.20	5.15	5.11	5.07
1.27	6.15	6.01	5.89	5.78	5.69	5.61	5.54	5.47	5.41	5.35	5.30	5.24	5.20	5.15	5.11	5.07
1.47	6.12	5.98	5.86	5.76	5.68	5.60	5.52	5.46	5.40	5.34	5.29	5.24	5.20	5.15	5.11	5.08
1.67	6.09	5.96	5.85	5.75	5.66	5.59	5.52	5.45	5.39	5.34	5.29	5.24	5.20	5.16	5.12	5.08
1.87	6.07	5.94	5.83	5.73	5.65	5.58	5.51	5.45	5.39	5.34	5.29	5.24	5.20	5.16	5.12	5.08
2.07	6.05	5.92	5.81	5.72	5.64	5.57	5.50	5.44	5.38	5.33	5.28	5.24	5.20	5.16	5.12	5.08

Figure 47: Map of the liking scores to boar meat patties depending on the levels of androstenone and skatole and considering all the consumers weighted by the proportion of sensitive and non-sensitive to androstenone. Variation from green (less differences between boar and castrated) to yellow and red (higher differences between boar and castrated). Liking was scored on a 9 point scale (1=dislike, 9=like).

The map shows that, as well as with preferences, liking scores are lower when skatole levels are higher. In the case of androstenone, its influence in liking scores is more important when skatole levels are lower.

I.2.6. Dissatisfied consumers by androstenone and skatole content

What it is also of interest is the % of consumers that are dissatisfied with boar meat patties. For that, consumers have been classified in 'dissatisfied with boar meat patties' (liking scores 1 to 4) and 'satisfied with boar meat patties' (liking scores 6 to 9). The percentage dissatisfied consumers according their sensitivity to androstenone is presented in Table 35.

Table 35: Percentage of dissatisfied consumers (liking scores 1 to 4) by sensitivity of consumers to androstenone and type of meat patty evaluated.

Type of pattie	Insensitive	Sensitive	Total
Type 1	25.3	26.1	25.5
Type 2	24.5	50.6	33.5
Type 3	19.9	41.5	28.2
Type 4	16.8	36.9	23.7
Type 5	37.3	37.3	37.3
Type 6	37.7	63.0	46.6
Type 7	46.9	61.0	51.8
Type 8	39.0	50.6	42.9

Analysis of preferences was also performed considering naeperian logarithm of androstenone and skatole levels (average) and its interaction as covariates together with position, country, sensitivity to androstenone, sensitivity to skatole as fixed effects and consumer within country as random effect. Sequence was not included as fixed effect because it was not significant. Results are presented in Table 36.

To construct dissatisfaction maps, a logistic regression analysis has been performed considering only naeperian logarithm of androstenone and skatole, and its interaction as predictors. Consumer and country were considered as random effects. Results are presented in Table 37. Confidence limits of the estimates at 95% level are also provided.

Table 36: Logistic regression results for boar dissatisfaction (liking scores 1 to 4) including levels of androstenone and skatole.

Effect	Num DF	Den DF	F Value	Pr > F
Position (1 or 2)	1	1893	14.36	0.001
Country (DK, FR, IT, PL)	3	423.8	9.12	<.001
Sensitivity to androstenone[1]	2	400.9	13.68	<.001
Sensitivity to skatole[2]	1	435.3	10.81	0.001
Logarithm of androstenone content LnA	1	1893	5.18	0.023
Logarithm of skatole content LnS	1	1893	72.21	<.001
LnA x LnS	1	1893	6	0.014

[1]Sensitivity to androstenone threshold in odorant dilution: very <0.5ppm; 0.5ppm<yes <5ppm; no>5ppm
[2]Sensitivity to skatole threshold in odorant dilution: yes<1.0 ppm; no>1.0ppm

Table 37: Logistic regression results for boar dissatisfaction (liking scores between 1 and 4) over castrates including levels of androstenone and skatole

				Confidence limit	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
Dissatisfied consumers					
Intercept	0.6939	0.2597	0.023	0.5099	0.8779
Logarithm of androstenone	-0.5683	0.2593	0.029	-0.7432	-0.3934
Logarithm of skatole content	0.8877	0.1058	<.001	0.8163	0.959
LnA x LnS	-0.3889	0.1651	0.019	-0.5003	-0.2775

Since sensitivity of the consumers to androstenone has a significant effect on consumer response, the percentage of dissatisfied consumers was studied by logistic regression analysis considering the sensitivity of the consumers in order to develop a map of preferences. For sensitive consumers the model included logarithm of androstenone and skatole content and its interaction, while for non-sensitive consumers ('yes' and 'very' groups together) it included only logarithm of skatole because androstenone was not relevant. In both cases, consumer within country and country were considered as random effects. Results are presented in Table 38. Confidence limits of the estimates at 95% level are also provided.

Table 38: Logistic regression results for boar dissatisfaction (liking scores 1 to 4) including levels of androstenone and skatole, by sensitivity of consumers to androstenone.

Dissatisfied consumers				Confidence limit (95%)	
Effect	Estimate	Std. Error	Pr > |t|	Lower	Upper
Non-sensitive					
Intercept	0.5335	0.3058	0.118	0.3178	0.7492
Logarithm of skatole content	0.9509	0.1318	<.001	0.8620	1.0398
Sensitive					
Intercept	1.042	0.354	0.008	0.799	1.285
Logarithm of androstenone content (LnA)	-0.715	0.453	0.115	-1.021	-0.409
Logarithm of skatole content (LnS)	0.828	0.183	<.001	0.704	0.951
LnA x LnS	-0.735	0.2877	0.011	-0.9288	-0.5405

Sensitivity to androstenone threshold in odorant dilution: sensitive <5ppm, non-sensitive>5ppm

The dissatisfaction map depending on the levels of androstenone and skatole for sensitive consumers and depending on the levels of skatole for less sensitive or insensitive consumers is presented in Figure 48. Higher acceptability values are in green and lower acceptability values are

in red and the change between both colours can be seen gradually depending on the levels of the boar taint compounds. The map includes those levels of skatole (0.10 to 0.40 ppm) and androstenone (0.47 to 2.07 ppm) that were present in the fat of which the boar patties originated.

Dissatisfied (%)

Sensitive Androstenone(	Skatole (ppm) 0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	16.8	20.6	24.3	27.9	31.2	34.5	37.5	40.3	43.0	45.6	47.9	50.2	52.3	54.2	56.1	57.8
0.67	22.2	25.9	29.4	32.6	35.5	38.3	40.8	43.2	45.4	47.5	49.4	51.2	52.9	54.5	56.0	57.4
0.87	26.9	30.4	33.5	36.3	38.9	41.2	43.4	45.4	47.2	48.9	50.5	52.0	53.4	54.8	56.0	57.2
1.07	31.0	34.2	36.9	39.4	41.6	43.6	45.4	47.1	48.6	50.1	51.4	52.7	53.8	54.9	56.0	57.0
1.27	34.7	37.5	39.9	42.0	43.8	45.5	47.1	48.5	49.8	51.0	52.1	53.2	54.2	55.1	56.0	56.8
1.47	38.0	40.4	42.4	44.2	45.8	47.2	48.5	49.7	50.8	51.8	52.8	53.6	54.5	55.2	56.0	56.6
1.67	41.0	43.0	44.7	46.2	47.5	48.7	49.8	50.8	51.7	52.5	53.3	54.0	54.7	55.3	55.9	56.5
1.87	43.7	45.4	46.8	48.0	49.1	50.1	50.9	51.7	52.5	53.1	53.8	54.4	54.9	55.4	55.9	56.4
2.07	46.2	47.5	48.6	49.6	50.5	51.2	51.9	52.6	53.2	53.7	54.2	54.7	55.1	55.5	55.9	56.3

	Skatole (ppm) 0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
Insensitive Dissatisfied (%)	16.0	18.5	20.8	23.0	25.0	27.0	28.8	30.5	32.1	33.7	35.2	36.6	37.9	39.2	40.5	41.6

Figure 48: Map of preferences (%) for dissatisfaction of boar meat patties o depending on the levels of androstenone and skatole and the sensitivity of the consumer to androstenone. Variation from green (higher preference) to yellow and red (lower preference).

It is possible to see that, the higher the skatole content, the lower the preference of smell. Moreover for sensitive consumers higher androstenone content decreases smell preferences mainly when skatole levels are low.

Final model for dissatisfaction with boar meat

A global equation has been obtained considering both, sensitive and very sensitive *vs*. insensitive consumers to androstenone weighted by the proportion of each type of consumer. In the four EU countries studied 65.8% of the consumers were defined as insensitive and 34.2% as sensitive, thus, the final prediction equation for smell would be:

Dissatisfied (%) = 0.658 * (smell preference insensitive consumers) + 0.342*(smell preference sensitive consumers)

Dissatisfied (%) = 0.707 - 0.244*LnA + 0.909*LnS – 0.251*LnS*LnA

Where LnA and LnS are the naeperian logarithm of androstenone and skatole content, respectively. This results have to be transformed to %.

The map of preferences for % of dissatisfied consumers considering both consumers proportionally is presented in Figure 49.

Dissatisfied consumers (%) 34.2% sensitive-65.8% insensitive consumers

Androstenone (ppm)	Skatole (ppm) 0.1	0.12	0.14	0.16	0.18	0.2	0.22	0.24	0.26	0.28	0.3	0.32	0.34	0.36	0.38	0.4
0.47	16.3	19.2	22.0	24.6	27.1	29.4	31.6	33.7	35.7	37.6	39.4	41.1	42.7	44.3	45.7	47.1
0.67	18.0	20.8	23.5	26.0	28.4	30.6	32.7	34.6	36.5	38.2	39.9	41.5	43.0	44.4	45.7	47.0
0.87	19.3	22.1	24.7	27.1	29.4	31.5	33.5	35.3	37.1	38.7	40.3	41.7	43.1	44.5	45.7	46.9
1.07	20.4	23.1	25.7	28.0	30.2	32.2	34.1	35.9	37.5	39.1	40.5	41.9	43.3	44.5	45.7	46.8
1.27	21.3	24.0	26.5	28.8	30.9	32.8	34.6	36.3	37.9	39.4	40.8	42.1	43.4	44.6	45.7	46.8
1.47	22.2	24.8	27.2	29.4	31.4	33.3	35.1	36.7	38.2	39.6	41.0	42.3	43.5	44.6	45.7	46.7
1.67	22.9	25.5	27.9	30.0	32.0	33.8	35.5	37.0	38.5	39.9	41.2	42.4	43.5	44.6	45.7	46.7
1.87	23.6	26.1	28.4	30.5	32.4	34.2	35.8	37.3	38.7	40.1	41.3	42.5	43.6	44.7	45.7	46.6
2.07	24.2	26.7	28.9	31.0	32.8	34.5	36.1	37.6	39.0	40.3	41.5	42.6	43.7	44.7	45.7	46.6

Figure 49: Map of the preferences (%) for dissatisfaction (liking scores between 1 and 4) of boar meat patties depending on the levels of androstenone and skatole and considering all the consumers weighted by the proportion of sensitive and non-sensitive. Variation from green (higher preference) to yellow and red (lower preference).

Again we can observe that the % dissatisfied consumers increases with the increasing skatole content. At low levels of skatole, the higher the androstenone content the higher the % dissatisfied consumers with boar meat patties.

I.2.7. Conclusion

Different type of analysis can be done with these data. Nevertheless, with the analyses that we have done and within the conditions of this experiment with this particular type of meat product, it can be concluded that:

- Patties from castrates were preferred to patties from boars independent of the content of androstenone and skatole.
- The strength of this preference depends on the sensitivity of the consumers to androstenone and skatole, which varied between countries. The higher the sensitivity, the stronger the preference for patties from castrates *vs.* boars. This is independent of androstenone and skatole levels of the boar. Thus, irrespective of the level of androstenone and skatole, sensitive consumers are less satisfied with boar patties compared with insensitive consumers.
- For androstenone-sensitive consumers (34.2% of the total consumer sample), preferences are not affected by androstenone at high skatole levels whereas it has an effect at low skatole levels. Thus, at low skatole levels preferences decrease with increasing androstenone content.
- For androstenone-insensitive consumers (65.8%), preferences are only affected by skatole levels. Preferences decrease with increasing skatole levels.
- Preferences for all the consumers together but weighted for the amount of sensitive and insensitive consumers to androstenone in the population, depended on the amount of androstenone and skatole in the boar patties. The higher the skatole content in the boar patties, the stronger the preference for the castrate patties. At low skatole content, the higher the androstenone content in the boar patties, the stronger the preference for the castrate patties.

It is not possible to establish a single threshold for androstenone and skatole as the decrease in liking is linear and does not accelerate at a certain concentration. The final sorting limit therefore depends on the risk the stakeholders are willing to take. For this reason, a map of preferences depending on the level of androstenone and skatole of the fat of the meat patties is provided to allow stakeholders to choose the threshold for both compounds according to their necessities. These maps are provided for consumers sensitive and insensitive to androstenone but also for the entire population weighted by its sensitivity. It must be emphasised that the uncertainty in the calculations are not visualized in the maps but should still be taken into consideration.

I.3. SENSORY STUDY IN THIRD COUNTRIES

This chapter presents the results of the consumer tests performed in Russia and China (n=120 each). Consumers evaluated three pairs of patties, in which they compared meat from castrated male pigs with 3 different types of boar meat with different androstenone and skatole levels. Consumer preference for smell and flavour was evaluated as well as overall liking for each patty. Results show an interaction between type of boar and country, and between type of boar and consumers' sensitivity to skatole.
Data was analysed considering also the sensitivity of consumers to androstenone and skatole that was obtained by means of several triangular tests. The analysis was performed at three levels: (1) Study the preferences for smell and flavour; (2) Study the difference in liking score between boar and castrated meat; and (3) Study of liking score

I.3.1. Meat evaluated

Consumers evaluated meat from castrated compared with 3 different types of meat from boars. The meat was initially selected according to analytical measurements of skatole (and indole) and sensory evaluation of backfat at slaughter. Characteristics of the meat evaluated in terms of androstenone and skatole in the backfat are presented in Table 39. Each type of meat was originated from one pig and the contents of androstenone and skatole are measured in the backfat of the carcasses used to prepare the patties. Analytical contents for androstenone show that the meat with medium skatole level has also a rather high androstenone content. Thus, main differences between Type 2 and Type 3 are due to skatole content. Nevertheless, type 2 meat has also high indole which makes it even more similar to type 3 meat (assuming that skatole and indole sum up having a similar odour quality).

Table 39: Levels of androstenone, skatole and indole of back fat depending on the type of sample.

	Compound level [mg/kg backfat tissue]		
	Androstenone	**Skatole**	**Indole**
Type 1	**0.84**	**0.043**	**<LOQ**
Type 2	**2.25**	**0.213**	**0.211**
Type 3	**2.43**	**0.497**	**0.059**

LOQ for indole is 0.03 mg/kg

I.3.2. Questionnaire

The questionnaire was divided in 3 parts. The first part is the meat evaluation and its results are reported here. The second part was the sensitivity test and the third part was demographic questions and questions about meat consumption and pork liking.

I.3.3. Consumer characteristics

A total of 240 consumers (women) performed the consumer test in two third countries, Russia (n=120) and China (n=120). The demographics characteristics of the consumers and their responsibility in cooking main meals at home are presented in Table 40. Eighty-five per cent of Russian consumers had university studies being this percentage 30 in China. Regarding the question if consumers like pork meat, their answers are presented in Figure 50.

Table 40: Description of the Russian and Chinese consumers participating in the study.

	Russia	China
Number of consumers	120	120
% of consumers	100.0	100.0
Cold-allergy	26.7	13.3
Age (%)		
<25	13.3	23.3
25-44	35.8	40.0
45-59	36.7	33.3
>60	14.2	3.3
Education level (%)		
Primary	1.7	17.5

Secondary	6.7	15.0
Higher	6.7	37.5
University	85.0	30.0
Cooking main dishes at home (%)		
Mainly me	71.7	46.7
Mainly others	3.3	35.0
Sometimes	25.0	18.3

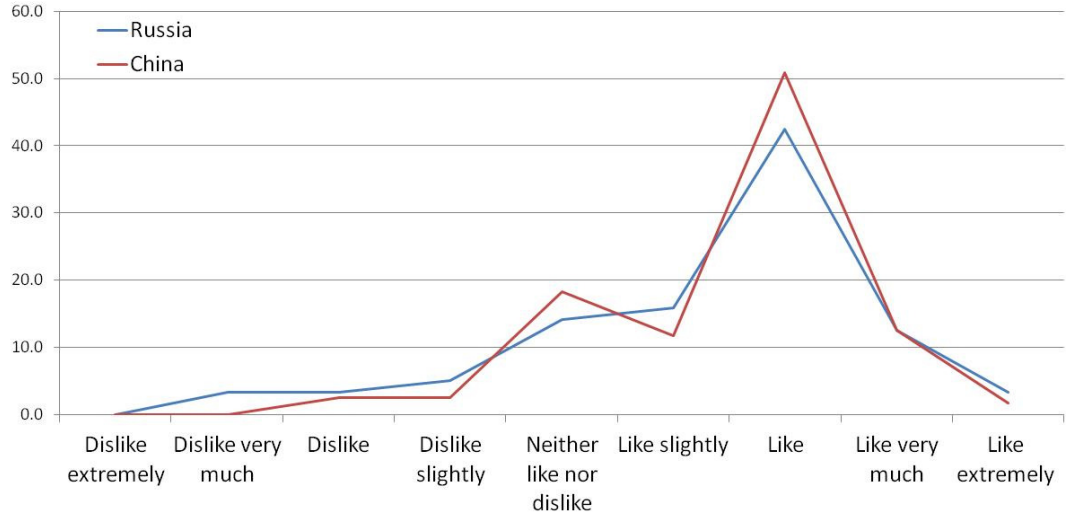


Figure 50: Percentage of scores obtained for each of the pork liking categories in Russia and China.

Meat consumption by Russian and Chinese consumers is presented in Table 41. Also consumers were questioned whether they had a bad experience with pork in the last two months and if the answer was positive they should specify which experience this was. The answers are presented in Table 42.

Table 41: Description of consumers' characteristics regarding their meat consumption.

Russia				
	times/week			
Consume pork in a	*> 4*	*3-4*	*2-3*	*< 1*
Hot dish	2.5	14.2	35.0	48.3
Cold dish	2.5	10.0	25.0	62.5
	Frequency (%)			
Meat consumption	*0-25*	*26-50*	*51-75*	*>75*
Pork	45.0	44.2	10.0	0.8
Beef	50.8	40.8	7.5	0.8
Poultry	24.2	40.8	29.2	5.8
Others	95.7	2.6	1.7	0.0
China				
	times/week			
Consume pork in a	*> 4*	*3-4*	*2-3*	*< 1*
Hot dish	24.2	39.2	33.3	3.3
Cold dish	4.2	11.7	28.3	55.8
	Frequency (%)			
Meat consumption	*0-25*	*26-50*	*51-75*	*>75*
Pork	19.5	29.7	41.5	9.3
Beef	93.2	5.9	0.9	0.0
Poultry	80.5	16.1	3.4	0.0
Others	57.3	26.5	15.4	0.9

Table 42: Consumers' bad experience with pork in the last two months.

	Russia	China
Bad experience with pork (%)		
No	59.2	47.5
Yes	40.8	52.5
Why yes? (%)		
it had a bad taste	28.1	22.8
it had a bad odour	11.2	22.8
it was too fatty	23.6	15.8
high losses when cooking	20.2	5.3
too little fat/ marbling	1.1	7.9
too light/ too dark colour	7.9	5.3
it was rancid	1.1	7.0
it was though	2.2	7.0
it was spoiled	4.5	6.1
n	89	114

I.3.4. Consumers'meat evaluation

Consumer test was carried out in several sessions with different number of consumers:

- In Russia, 15 sessions of 8 consumers each
- In China, 10 sessions of 12 consumers each

Consumers performed 4 paired comparison tests. The first one was on the same type of meat for both samples (castrate) in order to make the consumer familiar with the test procedure. The next 3 paired tests were a comparison of one of the three boar meat types each with a castrate sample. The experiment was designed to balance a) the type of comparison performed, b) the position of both samples (first or second to be evaluated) and c) the sequence of each one (2^{nd} to 4^{th} pair). The cooking of the patties was performed following the protocol of the pilot study (Deliverable 1.2.). For each pair, consumers were asked to indicate which sample they preferred regarding the odour (smell) and the flavour (taste) of the meat. After that they were asked to score the overall liking for each of the samples on a 9-point scale, from 'dislike extremely' (1) to like extremely (9) without the intermediate level 'neither like nor dislike' (5).

I.3.5. Preferences of boar meat

I.3.5.1. Percentages of preference of boar meat

The consumer preference of boar meat in comparison with castrate, for each type of boar, has been calculated by country and presented in Figure 51.

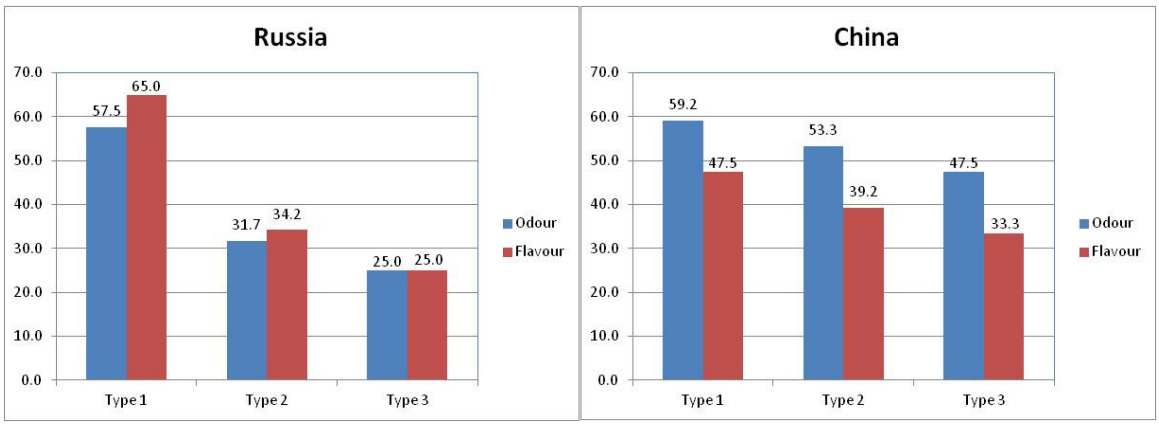


Figure 51: Consumer's preference (in %) for odour and flavour of the different boar over castrate meat evaluated in Russia and China.

This preference of smell and flavour of boar meat over castrate by sensitive and insensitive consumers to androstenone and skatole is presented in Figure 52 for Russia and in Figure 53 for China.

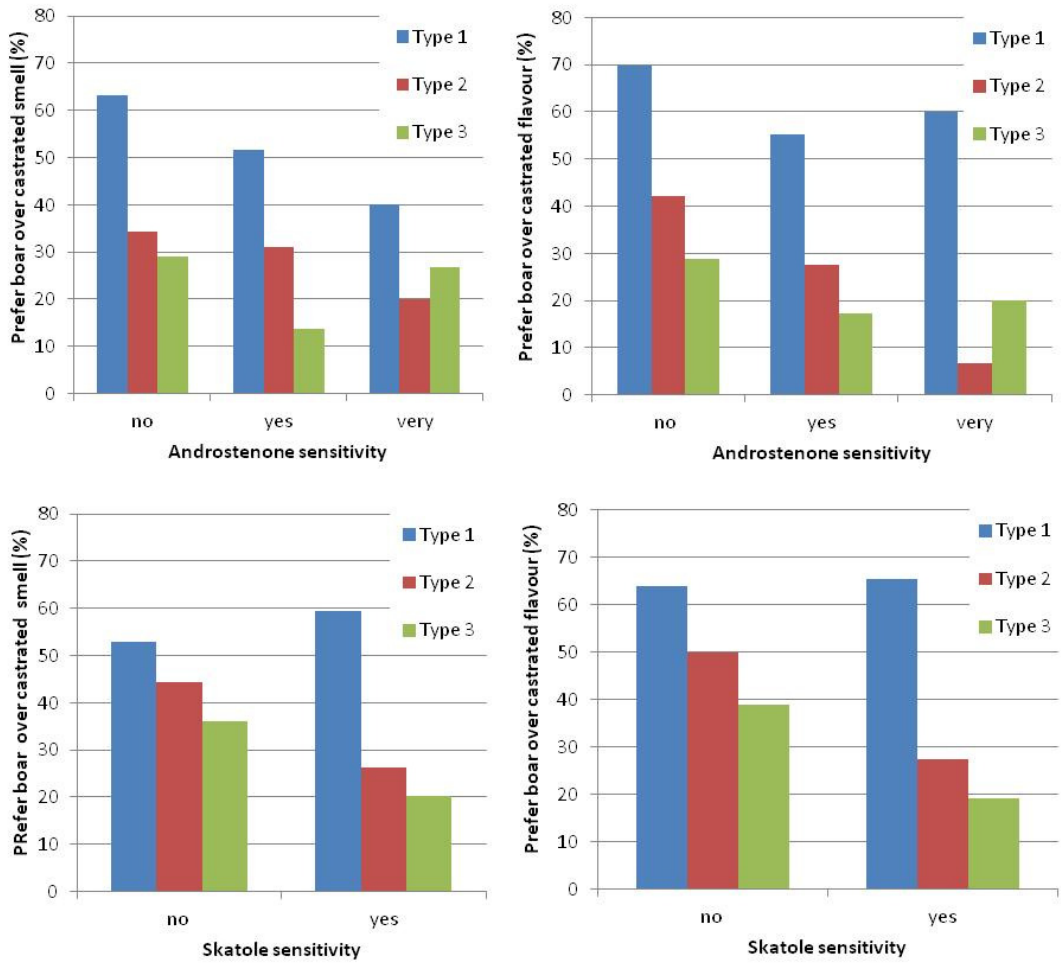


Figure 52: Russian consumer's preference (in %) for smell (left plots) and flavour (right plots) of boar over castrate meat with respect to consumer's sensitivity to androstenone (upper plots; no=63.3%; yes=24.2% or very=12.5%) or to skatole (lower plots; no=30%; yes=70%).

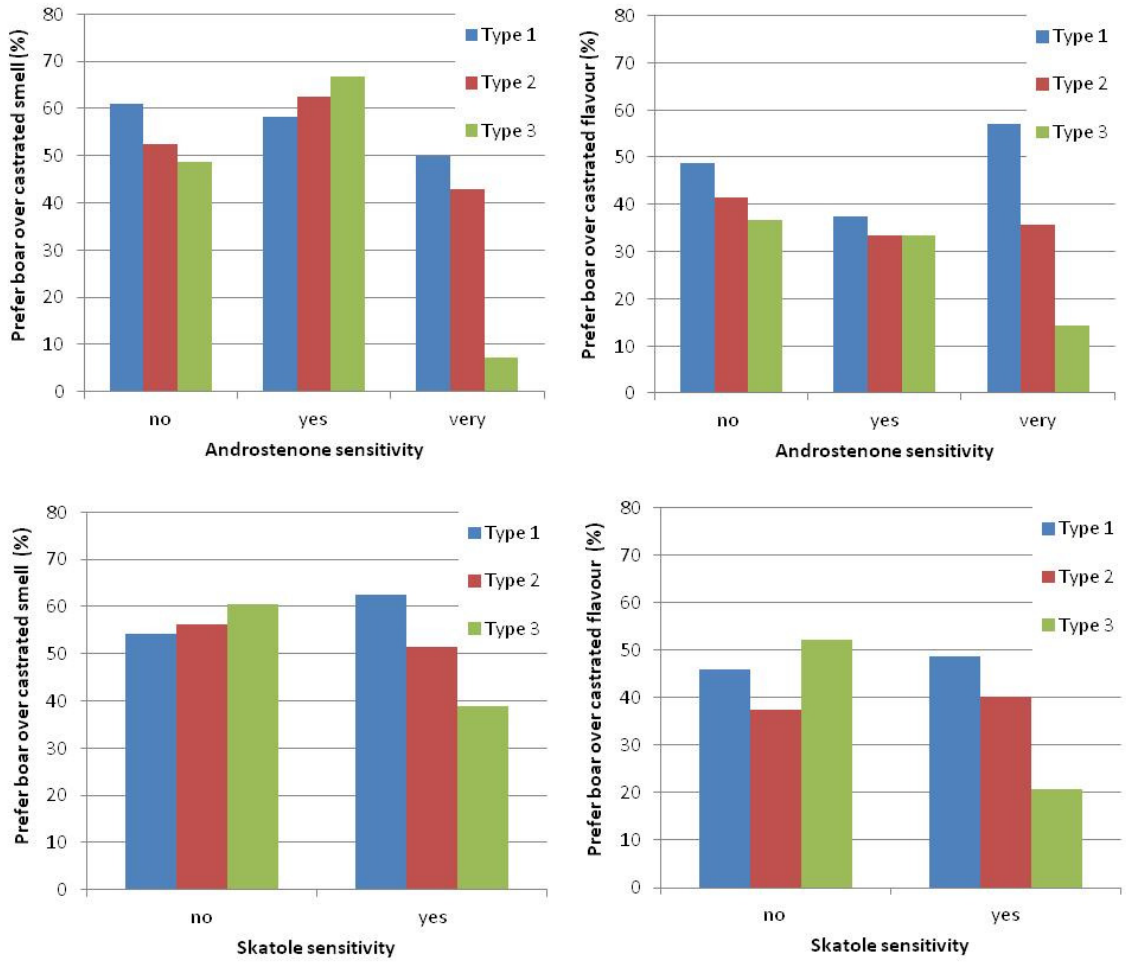


Figure 53: Chinese consumer's preference (in % within each sensitivity group and type of boar) of smell (left plots) and flavour (right plots) of boar meat over castrate by sensitivity of consumer's to androstenone (upper plots; no=68.3%; yes=20%; very=11.7%) or to skatole (lower plots; no=40%; yes=60%).

When consumers are classified according to their liking of androstenone or skatole smell in like (scores 5 to 9 on a scale of 1 to 9; it includes like and neutral scores) and dislike (scores 1 to 4), their preferences for boar over castrate smell or flavour depending on the type of boar is presented in Figure 54 for Russia and in Figure 55 for China.

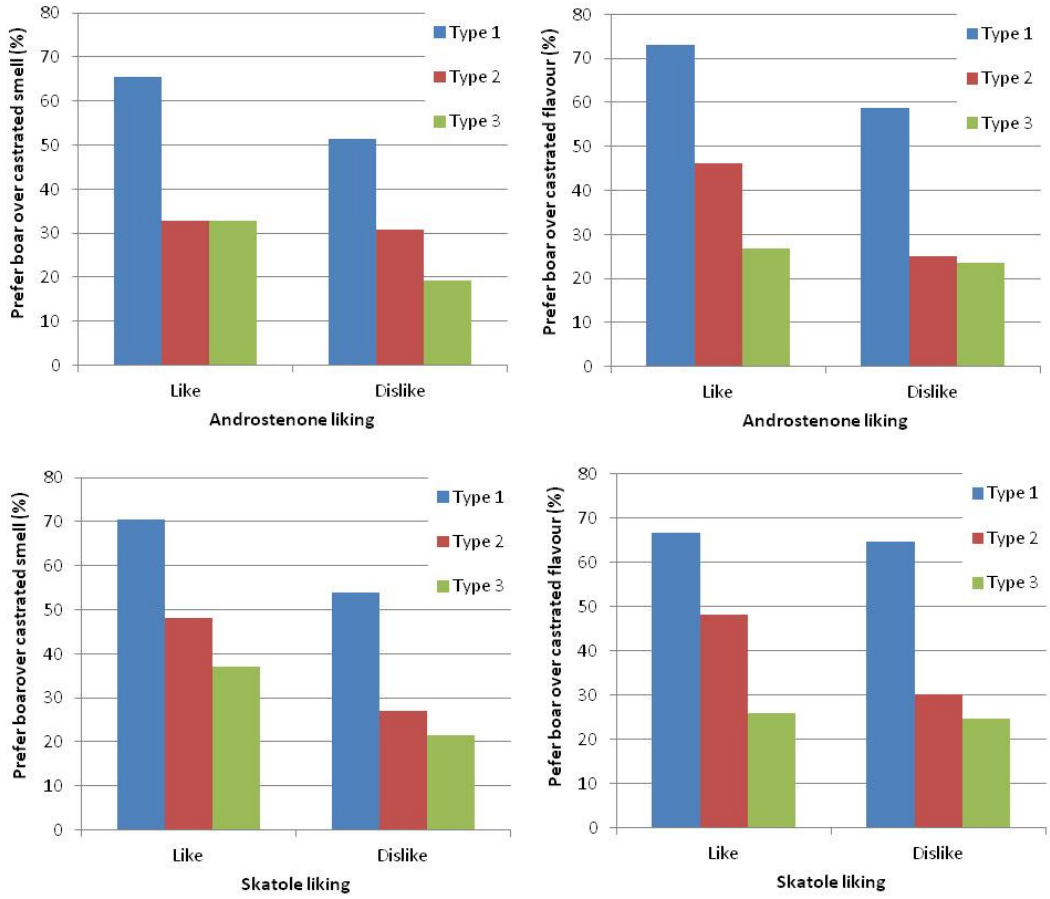


Figure 54: Russian consumer's preference (in % within each liking group and type of boar) of smell (left plots) and flavour (right plots) of boar meat over castrate with respect to androstenone liking (upper plots; like=43.3%; dislike=56.7%) and skatole liking (lower plots; like=65.9%; dislike=34.1%).

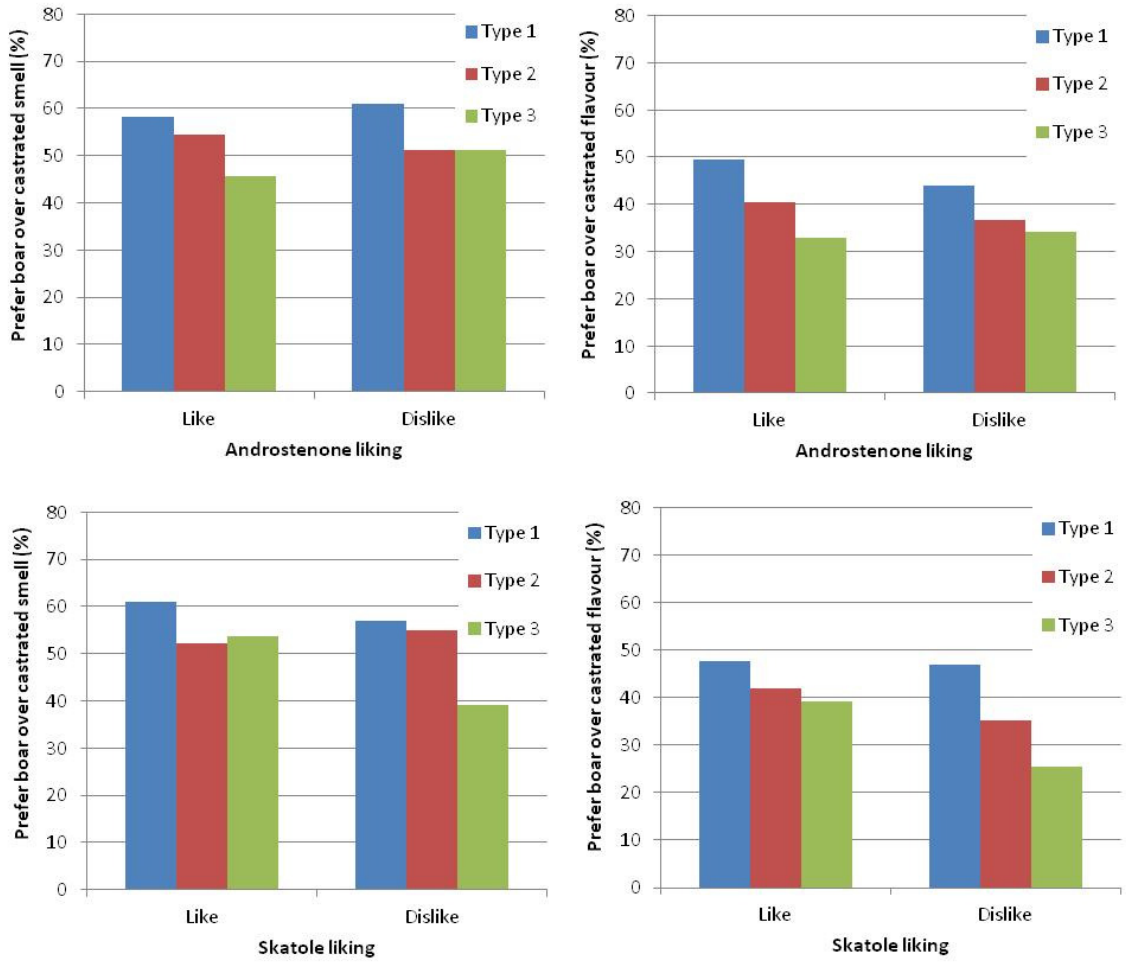


Figure 55: Chinese consumer's preference (in % within each liking group and type of boar) of smell (left plots) and flavour (right plots) of boar meat over castrate with respect to androstenone liking (upper plots; like=22.6%; dislike=77.4%) and skatole liking (lower plots; like=57.5%; dislike 42.5%).

I.3.5.2. Preference of boar meat

Consumers' preference for smell and flavour was analysed using the GLIMMIX procedure of SAS. The model included, as fixed effects, type of boar, country, sensitivity to androstenone, sensitivity to skatole and the double interactions between type of boar and sensitivity to skatole, and type of boar and country. The effects of position, sequence and the other double or triple interactions between sensitivities, country and type of boar were removed because they were not significant. Assessor (consumer within country) was considered as random effect. Results for odour and flavour are presented in Table 43 and Table 44, respectively.
If two levels of sensitivity of androstenone were considered (non-sensitive vs sensitive and very sensitive), this effect was not significant in smell preferences.

Table 43: Logistic regression results for consumers' odour preference of boar over castrate meat.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	2	709	8.47	0.0002
Sensitivity to androstenone	2	245.3	2.97	0.0534
Sensitivity to skatole	1	218.1	1.97	0.1614
Country	1	230.6	13.11	0.0004
Type of boar x country	2	709	3.08	0.0467
Type of boar x sensitivity to skatole	2	709	4.56	0.0108

Table 44: Logistic regression results consumers' flavour preference of boar over castrate meat.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar (1 to 8)	2	709	14.17	<.0001
Sensitivity to androstenone	2	251.8	3.29	0.0389
Sensitivity to skatole	1	219.4	6.4	0.0121
Country	1	233.5	0.29	0.5903
Type of boar x country	2	709	4.24	0.0148
Type of boar x sensitivity to skatole	2	709	5.41	0.0047

Estimates and means of odour and flavour preferences after applying the models presented in previous tables are presented in Table 45. Results show that consumers' preferences for the different type of products are different in Russia and China. In Russia, the proportion of consumers preferring meat from boars over castrates for odour and flavour is significantly higher for boar type 1 (low androstenone and low skatole) compared to boar types 2 and 3 (medium or high levels of both compounds). However, in China, no significant differences for odour and flavour preference were found between boar types. Nevertheless, in both countries, this preference depends also on sensitivity of the consumers to skatole. Consumers who are non-sensitive to skatole did not indicate differences in odour and flavour preferences for boar over castrate when the androstenone and skatole level of the boar meat varied. On the contrary, consumers sensitive to skatole preferred boar type 1 significantly more often than boar type 2 and 3. The triple interaction between country, type of boar and skatole sensitivity was not significant which is probably due to the low number of consumers in this study. The fact that in China there were 60% of consumers classified as sensitive to skatole and in Russia this percentage was 70% might explain part of the differences between countries. Furthermore, although sensitivity of the consumers to androstenone was found to significantly affect flavour preference, when means were compared after applying Bonferroni's test, no differences were found between groups.

Table 45: Estimates and mean of smell and odour preferences for boar over castrate meat using the logistic model.

	Smell				Flavour			
	Estimate	*	Mean	s.e.	Estimate	*	Mean	s.e.
Type of boar								
Type 1	0.127		0.532	0.041	0.089		0.522	0.042
Type 2	-0.433		0.393	0.040	-0.678		0.337	0.038
Type 3	-0.682		0.336	0.039	-0.968		0.275	0.036
Androstenone sensitivity								
NO	-0.065		0.484	0.028	-0.185		0.454	0.028
YES	-0.137		0.466	0.048	-0.702		0.331	0.044
VERY	-0.787		0.313	0.060	-0.670		0.339	0.063
Skatole sensitivity								
NO	-0.197		0.451	0.043	-0.274		0.432	0.043
YES	-0.463		0.386	0.031	-0.764		0.318	0.030
Country								
China	-0.002		0.500	0.037	-0.569		0.362	0.035
Russia	-0.658		0.341	0.035	-0.469		0.385	0.037
Country x Type of boar								
China								
Type 1	0.178		0.545	0.053	-0.291		0.428	0.052
Type 2	0.012		0.503	0.054	-0.596		0.355	0.050
Type 3	-0.195		0.451	0.054	-0.820		0.306	0.049
Russia								
Type 1	0.075	a	0.519	0.054	0.469	a	0.615	0.053
Type 2	-0.879	b	0.293	0.048	-0.760	b	0.319	0.049
Type 3	-1.169	b	0.237	0.044	-1.115	b	0.247	0.046
Skatole sensitivity x Type of boar								
Non-sensitive to skatole								
Type 1	-0.074		0.482	0.063	0.026		0.507	0.064

Type 2	-0.229		0.443	0.063	-0.494		0.379	0.060
Type 3	-0.287		0.429	0.063	-0.353		0.413	0.062
Sensitive to skatole								
Type 1	0.327	a	0.581	0.045	0.152	a	0.538	0.046
Type 2	-0.637	b	0.346	0.043	-0.862	b	0.297	0.041
Type 3	-1.078	b	0.254	0.039	-1.583	c	0.170	0.032

*Different letter after the estimate value indicates significant differences (P<0.05)

Analysis of preferences considering logarithm of androstenone and skatole concentration to develop prediction equations were not performed because there are not enough combinations of both compounds to do it.

I.3.6. Boar scores over castrated scores

Due to the fact that consumers are not trained on the use of liking scale, the difference in liking scores given to boar compared to castrated has been considered for the following calculations.

I.3.6.1. Differences in liking scores between boar and castrated

According to the liking scores given to boar and castrated sample of each pair consumers have been classified as:

- Boar like (boar): score given to boar was higher than that given to castrate.
- Castrate like (cast): score given to boar was lower than that given to castrate.
- Indifferent (none): same score for boar and castrate.

Differences in liking scores were obtained for each type of boar and country. Results (in %) are presented in Figure 56 for Russia and in Figure 57 for China.

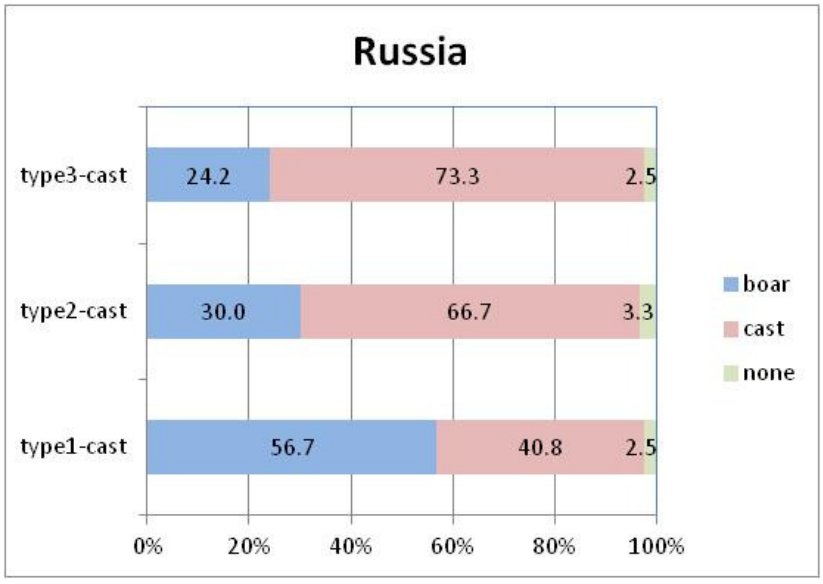


Figure 56: Percentage of Russian consumers that scored higher liking for boar, higher liking for castrate (cast) or scored the same value of liking to both samples (none).

Applying a Chi-squared test for the liking difference in preferences for boar and castrated, these were not significantly different in boars type 1 and there were significant differences in type 2 and type 3 boars. Preferences for boar type 1 were significantly higher than those from boar type 2 and type 3 and they were not significantly different between boar type 2 and type 3.

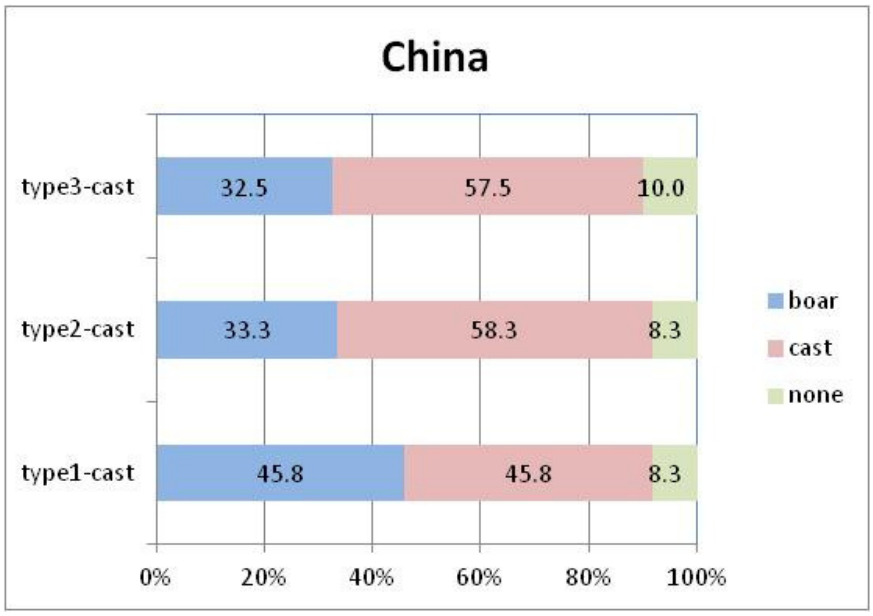


Figure 57: Percentage of Chinese consumers that scored higher liking from boar, higher liking from castrate (cast) or scored the same value of liking to both samples.

Applying a Chi-squared test in preferences for meat from boars and castrates, these were not significantly different for boars type 1 compared to castrates (P=1.000), but there were significant differences in preference for type 2 (P=0.0042) and type 3 boars (P=0.0039) compared to castrates. Preferences for boar type 1 were not significantly different from those for boar type 2 (P=0.1238) or type 3 (P=0.0989).

I.3.6.2. Difference in liking scores as differences between boar and castrates

An evaluation of the difference in overall liking scores (boar – castrated) was performed with the MIXED procedure of SAS including as fixed effects the type of boar, sensitivity to skatole, sensitivity to androstenone, country and interactions between type of boar and sensitivity to skatole and type of boar and country. Sequence, position of the boar sample, and interaction between sensitivity to androstenone and type of boar were excluded because they were not significant. Consumer was considered as random effect.
Significance of each factor is shown in Table 46. The differences between the levels of the different effects, after applying Bonferroni test are presented in Table 47. When differences in liking between meat from boars and castrates were significantly different from zero, they were always negative, i.e., boar meat was scored lower than castrate meat. Differences between boar and castrate were higher for consumers very sensitive to androstenone than for non-sensitive consumers. In Russia, the liking difference to castrate meat is significantly higher for boar types 2 and 3 compared to boar type 1. By trend, this finding is confirmed in China, too. On average, the liking difference between boar and castrate meat is lower in China compared to Russia. In both countries meat from boars type 2 and 3 were scored significantly worse than meat from castrates. Nevertheless, in both countries the higher the skatole content (and androstenone one) of boar meat, the higher the liking differences between boar and castrate meat as indicated by skatole sensitive consumers. This effect cannot be found in consumers classified as non-sensitive to skatole. If two levels of sensitivity of androstenone were considered (non-sensitive vs sensitive and very sensitive), similar results were obtained.

Table 46: ANOVA results for the difference in liking between boars and castrates.

Effect	DF	Den DF	F Value	Pr > F
Type of pair	2	474	18.85	<.0001
Androstenone sensitivity	2	235	5.42	0.005
Skatole sensitivity	1	235	7.01	0.0087
Country	1	235	6.44	0.0118
Type of pair x Country	2	474	7.74	0.0005
Type of pair x Skatole sensitivity	2	474	6.56	0.0015

Table 47: Least square means (LSM) of the different parameters after applying the model presented in Table 4.

	LSM	*	s.e.	Pr > |t|
Type of pair				
Type 1- Castrate	-0.11		0.21	0.6149
Type 2- Castrate	-1.28		0.21	<.0001
Type 3-Castrate	-1.55		0.21	<.0001
Country				
China	-0.69		0.19	0.0003
Russia	-1.27		0.19	<.0001
Androstenone sensitivity				
No	-0.45	a	0.14	0.0019
Yes	-0.94	ab	0.24	0.0001
Very	-1.55	b	0.34	<.0001
Skatole sensitivity				
No	-0.66		0.22	0.0032
Yes	-1.30		0.16	<.0001
Country x Type of pair				
China				
Type 1- Castrate	-0.34		0.27	0.2167
Type 2- Castrate	-0.87		0.27	0.0015
Type 3-Castrate	-0.86		0.27	0.0016
Russia				
Type 1- Castrate	0.13	a	0.28	0.6492
Type 2- Castrate	-1.69	b	0.28	<.0001
Type 3-Castrate	-2.24	b	0.28	<.0001
Skatole sensitivity x Type of pair				
No sensitive to skatole				
Type 1- Castrate	-0.23		0.32	0.4801
Type 2- Castrate	-0.99		0.32	0.0023
Type 3-Castrate	-0.76		0.32	0.0179
Sensitive to skatole				
Type 1- Castrate	0.02	a	0.24	0.9417
Type 2- Castrate	-1.57	b	0.24	<.0001
Type 3-Castrate	-2.34	c	0.24	<.0001

*Different letter after the LSM value indicates significant differences (P<0.05)

I.3.7. Liking scores to boar meat

I.3.7.1. Description of liking scores

The liking scores given by Russian and Chinese consumers to meat of different and to meat of castrate when compared with different types of meat is presented in Figure 58.

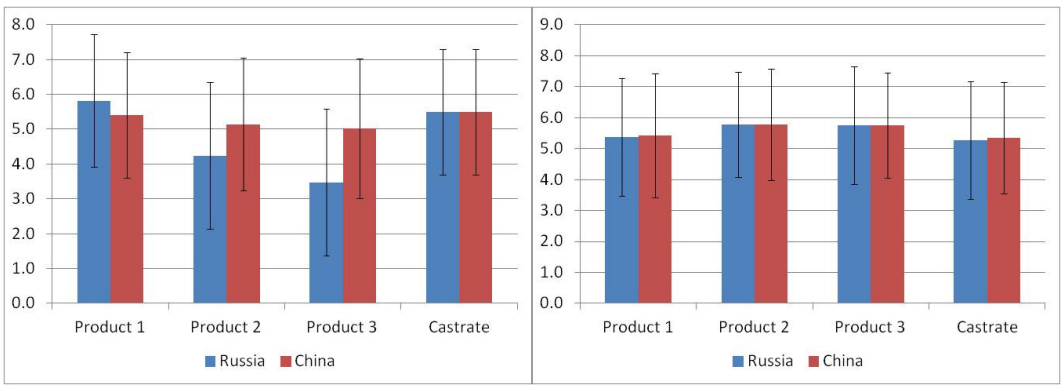


Figure 58: Mean and standard deviation of the scores (from 1: dislike extremely to 9: like extremely without the intermediate level 'neither like nor dislike') given by Russian and Chinese

consumers to meat of different types in overall (left plot) and to meat of castrate when compared with the different types of meat (right plot).

I.3.7.2. Statistics on liking scores

Evaluation of the liking scores (9-point scale) was performed with the MIXED procedure of SAS including, as fixed effects, the type of boar, sensitivity to skatole, country and interactions between product and sensitivity to skatole and between product and country. Sequence, position of the boar sample, sensitivity to androstenone, and its interaction with type of boar were excluded because they were not significant as fixed effects. Consumer was considered as random effect.
Significance of each factor is shown in Table 48. Least squared means were analyses for significant differences using Bonferroni test as presented in Table 49.
In China, no significant difference (P>0.05) in liking scores was observed between boar types. In Russia, boar type 3 was significantly less liked than type 2 and this, lower than type 1.
Nevertheless, these differences depended on skatole sensitivity of consumers in both countries. Skatole sensitive consumers score boar type 1 higher than type 2 and this higher than type 3, whereas non-sensitive consumers score boar type 1 higher than type 3, type 2 being in between.
Triple interaction was not significant, probably because the number of consumers evaluated, and differences between countries might be partly explained by the higher proportion of consumers sensitive to skatole in Russia (+10%) compared to China.
If two levels of androstenone sensitivity were used for the analysis (non-sensitive *vs.* sensitive and very sensitive) the results were the same.

Table 48: ANOVA results (type III) for the difference in liking between boars and castrates.

Effect	Num DF	Den DF	F Value	Pr > F
Type of boar	2	474	35	<.0001
Country	1	237	12	0.0007
Skatole sensitivity	1	237	1	0.2421
Type of pair x country	2	474	22	<.0001
Type of pair x skatole sensitivity	2	474	4	0.0156

Table 49: Least square means (LSM) of the different parameters.

	LSM	*	s.e.
Type of pair			
Type 1	5.58		0.13
Type 2	4.74		0.13
Type 3	4.34		0.13
Country			
China	5.22		0.14
Russia	4.56		0.14
Skatole sensitivity			
No	5.00		0.16
Yes	4.77		0.12
Country x Type of pair			
China			
Type 1	5.38		0.18
Type 2	5.17		0.18
Type 3	5.09		0.18
Russia			
Type 1	5.77	a	0.19
Type 2	4.31	b	0.19
Type 3	3.60	c	0.19
Skatole sensitivity x Type of pair			
Skatole no sensitive			
Type 1	5.46	a	0.21
Type 2	4.90	ab	0.21
Type 3	4.66	b	0.21
Skatole Sensitive			

Type 1	5.70	a	0.16
Type 2	4.58	b	0.16
Type 3	4.03	c	0.16

*Different letter after the LSM value indicate significant differences (P<0.05)

I.3.8. Limitations of the study

- Due to type of boars evaluated, the effect of the androstenone and skatole level cannot be analysed separately. Meat type 2 and 3 had high androstenone levels and medium or high skatole levels and this would allow to see skatole effect, but linked to high levels of androstenone and with varying levels of indole.
- There is only one animal per type and other factors besides the androstenone and skatole level could have influenced consumer preference/liking.
- Due to budget reasons the number of consumers is limited thus limiting the statistical power. Furthermore, they come from one specific region in quite large countries. Moreover in Russia 85% of the consumers have finished university studies, being not representative of the Russian population. Neither in Russia nor in China results can be generalised to the whole country.
- The study was performed in two 3rd countries and results cannot be generalized to other 3rd countries.
- Serving temperature may influence in the results.
- Classification of consumers' olfactory acuity to androstenone and skatole is linked to the method used in the present work.

I.3.9. Sensitivity to androstenone and skatole

Sensitivity to androstenone and skatole has been evaluated in Russia (n=120) and China (n=120) in January 2014. Sensitivity test was performed by means of a battery of 10 triangular tests with smell strips, prepared as reported in Deliverable D.1.2. In brief, one triangular test with D-carbone (1.5%) to train consumers to triangle test evaluation, 3 triangular tests with androstenone low concentration (0.5 µg/g) and 3 triangular tests with androstenone high concentration (5.0 µg/g), 3 triangular tests with skatole (1.0 µg/g). In all the triangular the odd sample was the one with the substance.
According to the two sets of 3 triangular tests with two different concentrations of androstenone (low and high), consumers were classified in:
Very sensitive to androstenone (very): when consumers performed correctly the three triangular with high androstenone levels and the three with low androstenone levels.
Sensitive to androstenone (yes): when consumers performed correctly the three triangular with high androstenone levels and incorrect some or all triangulars with low androstenone levels.
No sensitive to androstenone (no): when consumers performed incorrectly at least one of the three triangular with high androstenone level.

According to the set of 3 triangulars test with skatole consumers were classified in:
Sensitive to skatole (yes): when consumers performed correctly the three triangular with skatole.
Insensitive to skatole (no): when consumers performed incorrectly at least one of the three triangular with skatole.

A total of 95% of Russian consumers performed triangular test of minth correctly. This percentage was 40% in China. This is probably due because in Russia anomalies in the minth strips were detected and strips were painted with a perfume to train consumers with triangular test.
The percentage of non-sensitive to androstenone was 63.3% in Russia and 68.3% in China. Regarding the proportion of sensitive and very sensitive, it was 24.2% and 12.5% in Russia and 20.0% and 11.7% in China. In Russia there were 30% of consumers sensitive to skatole while this percentage was 40% in China.
Demographic questions were also answered by consumers. In Russia most of the consumers had University studies and 40% of the very sensitive consumers to androstenone were younger than 25 years old. Around 72% of the Russian women that participated in the study were mainly responsible for cooking main dishes at home. In China a few number of consumers were older than 60 years and 85% of the very sensitive consumers to androstenone were between 25 and 59 years. Less than half of the women that participated in the study (46.7%) were responsible for cooking main dishes at home.
Regarding their scores of liking of pork in general (without evaluate them, just from previous experiences), Figure 59 for Russia and Figure 60 for China shows the proportion of consumers that selected each liking category depending on their sensitivity to androstenone and skatole. It can be seen than most of the consumers liked pork. Authors would like to highlight the high percentage of

Russian consumers' non sensitive to skatole that selected 'neither like nor dislike' pork and the high percentage of Chinese consumers very sensitive to androstenone that scored 'neither like nor dislike'.

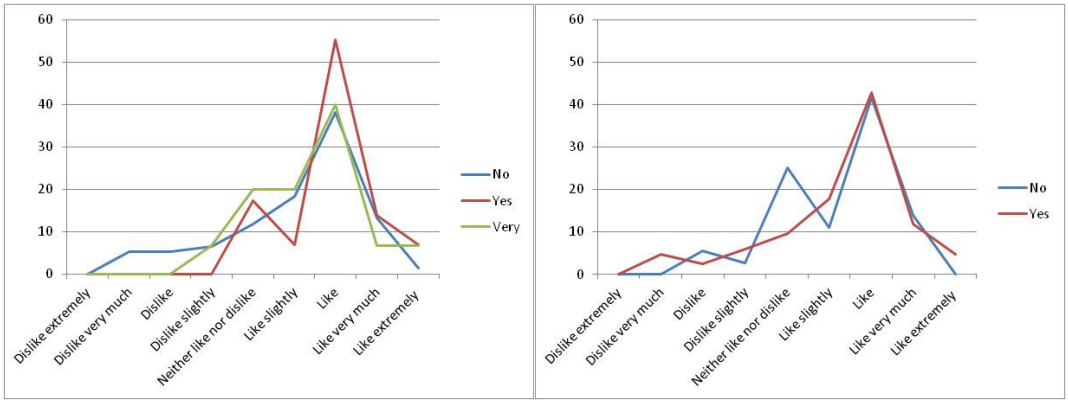


Figure 59: Percentage of pork liking scores depending on the sensitivity to androstenone (left) and skatole (right) by Russian consumers.

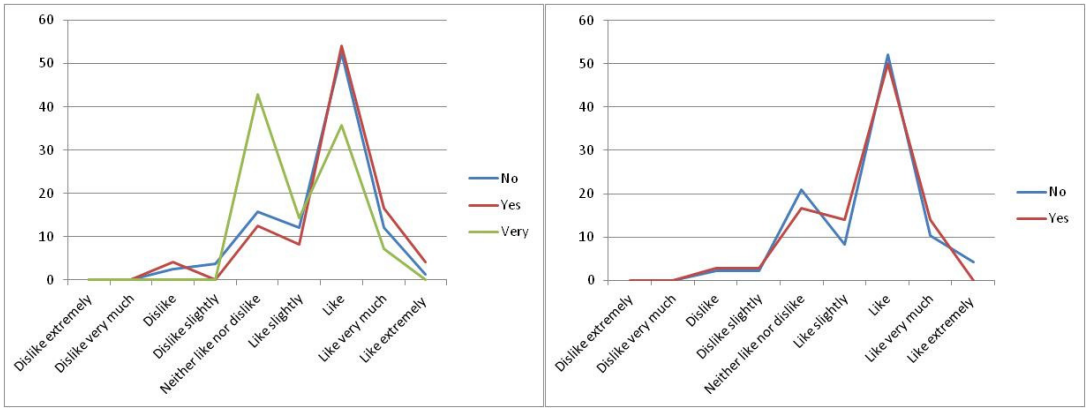


Figure 60: Percentage of pork liking scores depending on the sensitivity to androstenone (left) and skatole (right) by Chinese consumers.

Regarding bad experience with pork, 59% or Russian consumers reported not to have bad experience, this percentage being 47.5% in China. Bad taste was the most important reason for having bad experience with pork. In Russia 2.3% of sensitive and very sensitive consumers (which is only one consumer) liked a lot androstenone, being this percentage 0% in China. In Russia 8.3% of the sensitive and 8.3% of the insensitive consumers liked the smell of skatole. These percentages in China were 36.1% for sensitive and 50% for insensitive consumers.
As explained before, in Russia consumers were also asked to say how strong they perceived smell in strips with androstenone (5.0 µg/g) and skatole (1.0 µg/g). The percentage of consumers depending on their strong or weak perception of androstenone and their sensitivity to this substance is presented in Figure 61. It is possible to see that 66% of very sensitive consumers perceived the odour as 'strong', and 20% as 'neither weak nor strong' and 14% 'weak'. It is important to point out that 32% of non-sensitive consumers to androstenone scored its odour as 'strong' or 'very strong'. This shows that the criterion used to classify consumers into sensitive and non-sensitive would change some consumers' classification.

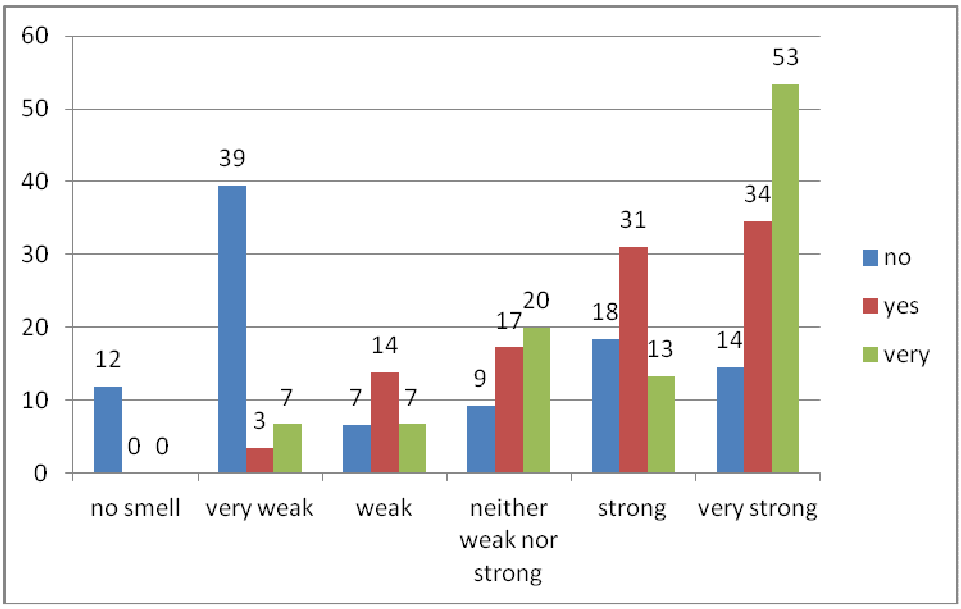


Figure 61: Percentage of consumers according to the strength of their odour perception of androstenone strips (5.0 µg/g) depending on their sensitivity to this substance.

Considering skatole, Figure 62 shows that 60% of Russian consumers sensitive to skatole found its odour strong, and 29% as 'neither weak nor strong' and 12% 'weak'. It is also important to point out that 28% of non-sensitive consumers to skatole found its odour 'strong' or 'very strong'. Again results show that the methodology used to classify consumers into sensitive and non-sensitive would change consumers' classification. And this makes sense since the definition of (in)sensitivity towards skatole or androstenone depends on the methodology, concentrations and criteria used for classification.

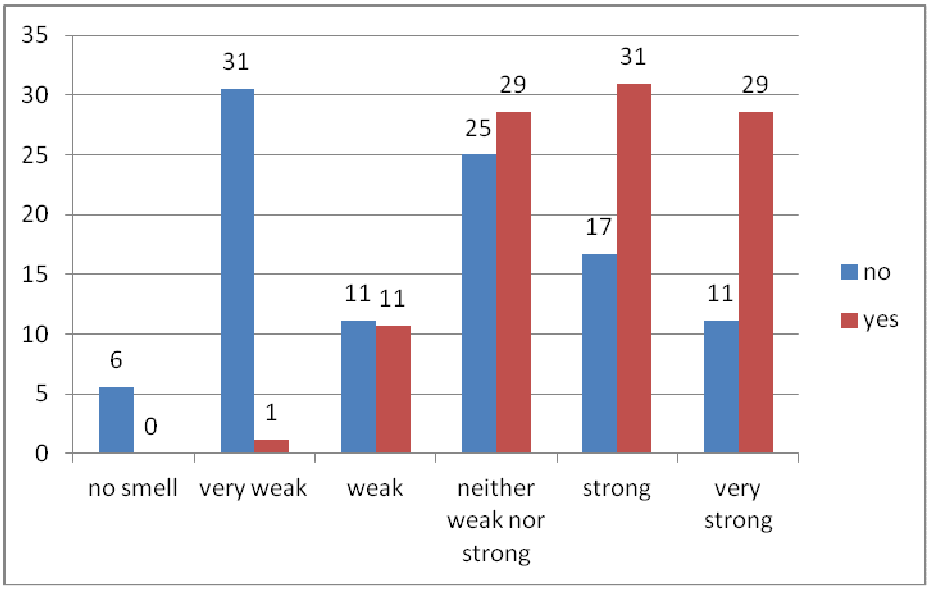


Figure 62: Percentage of consumers according to the strength of their odour perception of skatole strips (1.0 µg/g) depending on their sensitivity to this substance.

The relation between the strength consumers perceiving androstenone and the degree of liking of this compound is presented in Figure 63 and this relation between strength of skatole perception and degree of liking is presented in Figure 64. For androstenone, 61% of consumers that disliked the odour very much score the smell as 'very strong' and 22% as 'strong'. For skatole these percentages were 49% and 27%, respectively.

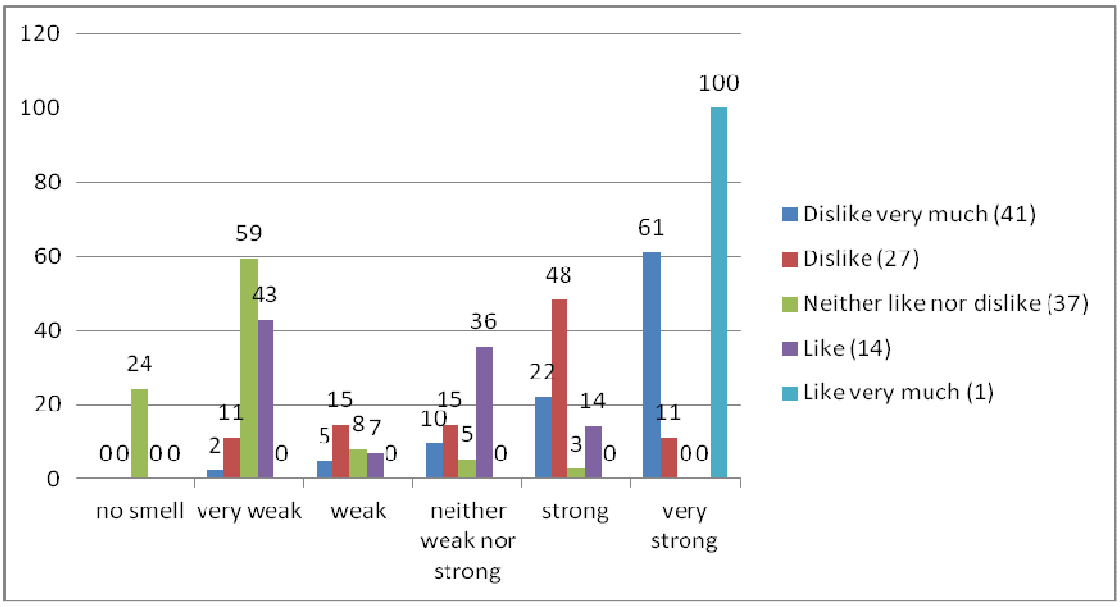


Figure 63: Percentage of consumers according to the strenght of their odour perception of androstenone strips (5.0 µg/g) and their degree of liking of this substance (number of consumers per category is presented between brackets).

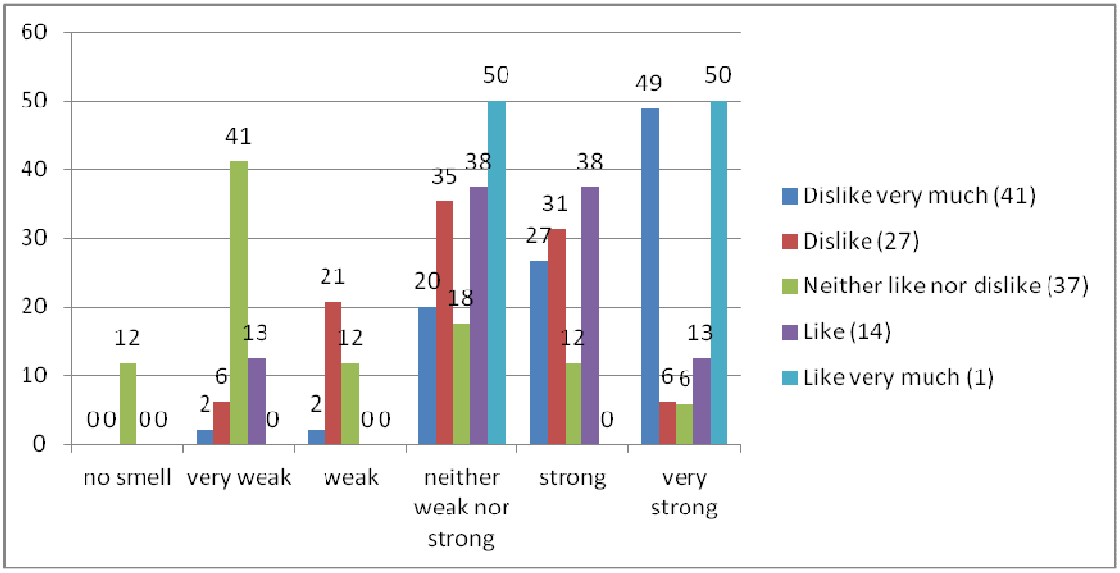


Figure 64: Percentage of consumers according to the strength of their odour perception of skatole strips (1.0 µg/g) and their degree of liking of this substance (nr of consumers per category between brackets).

I.3.10. Conclusions

In the limitations of this experiment it can be concluded that acceptability of boar meat with different levels of androstenone and skatole mainly is related to the sensitivity of consumers to skatole. Skatole sensitive consumers' preferences for boar meat compared with castrated meat decreased with increasing level of androstenone and skatole as measured in the fat used to manufacture the patties. There are differences on preferences for boar meat between countries. Russian consumers are more reluctant to prefer boar with medium or high levels of androstenone and skatole. Nevertheless, because acceptability is linked to sensitivity of consumers to skatole, this difference can be due to the fact that in Russia there are 10% more sensitive consumers than in China.

We also conclude that the percentage of sensitive and anosmic consumers to androstenone and skatole in Russia and China similar is to those obtained in the other 4 European countries (around 65% for androstenone and 35% for skatole). Further studies are needed using boar meat with different levels of androstenone and skatole and a higher number of consumers.

II. SURVEY CONSUMER ATTITUDES AND COUNTRY DIFFERENCES

The evaluation and acceptance of a food product depends on both intrinsic attributes (taste, texture, and other sensory experiences) and extrinsic attributes (price, brands, and credence attributes such as food safety risks, animal welfare, and environmental impact). Perceptions of intrinsic attributes were defined as sensory acceptance, whereas perceptions of extrinsic attributes were defined as consumer acceptance. While both influence product evaluation and acceptance a clear definition is needed to avoid confusion. The objective is to test consumer perception of extrinsic attributes of meat from non-surgically castrated boars by developing a questionnaire that investigates (including the perceptions which influence food choice behaviour and are relevant to) consumer acceptance of alternatives of surgical castration of male pigs. The aim is to measure the importance of the identified factors for consumers in specific regions. An important assumption is that the alternatives to surgical castration (immunovaccination, raising entire males) are too complicated to directly ask consumers their opinion on this. Rather, we addressed the underlying aspects. For this, a combination of approaches was used: (1) Consumer perceptions of motives that are relevant to acceptance of alternatives of surgical castration of male pigs were reported for the different countries and differences were described between the countries; (2) Based on the importance the respondents attach to different pork production related factors, we identified groups of consumers (segments) that are similar in the factors that they find most or least important and thus look at different groups within and across countries, and (3) A choice experiment (only in Italy, Poland, France, and Denmark) was done to determine the importance of the aspects relative to each other.

II.1. Methods

II.1.1. Procedure and respondents

Data collection took place with an online survey in 14 countries. Ten European countries were selected that differ in geographic position, food habits and prevalence of castration. Additional to the ten European countries, 4 countries were selected that are of major interest to Europe in terms of export of pork: Russia, China, South Korea and the US.

Table 50: Countries in the CAMPIG project where the survey of consumer preferences was conducted by geographical region and number of respondents per country (n)

Region	Country		n
North East	1	Poland	800
	2	Baltics: Latvia	800
South East	3	Italy	800
	4	Greece	800
North West	5	Germany	800
	6	Belgium	802
	7	Netherlands	815
	8	Scandinavian country: Denmark	800
South West	9	France	800
	10	Spain	881
3rd countries	11	Russia	800
	12	China	796
	13	South Korea	800
	14	United States of America	800

The draft questionnaire was tested in a qualitative and quantitative pilot. The qualitative pilot was done in The Netherlands. Seven consumers (men and women, different ages) were asked to fill out the questionnaire while thinking aloud. In addition the facilitator questioned how they interpreted questions, if the questions were easy to understand, and how they felt about the questions (e.g. annoying). The quantitative pilot was an online questionnaire with additional evaluation questions on understanding of items and was conducted in Denmark (n=162), France (n=168), Italy (n=166) and Poland (n=161) with 657 respondents in total. Reliability of items were tested with means, standard deviations and factor structures as well as the evaluation questions. Translation of the English master questionnaire was done by professional translators. These translations were

checked by researchers and in two countries by master students from each of the countries on (cultural) appropriateness and understanding of the wording.

For the final survey, a total of 11294 consumers were recruited, roughly 800 in each country not including the respondents in the qualitative pilot. Respondents were recruited by the market research company TNS NIPO (coordination in The Netherlands) from existing consumer panels. A primary selection criterion to be included was a consumption of pork of at least twice a month. For recruiting, quota were set to get a good spread on educational level, sex, age (between 18 and 65), and urbanisation degree. Data collection took place between November 22nd and December 9th 2013 in all countries simultaneously with the minor deviation that Latvia started a few days after the other countries. All respondents from the survey and pilots were paid for their participation. Demographic characteristics of the respondents are presented in Appendix A and B.

II.1.2. Measures

For all scales, items were presented in a random order, unless indicated otherwise.

General food motives
General Food Motives for buying food were measured with the Food Choice Questionnaire (FCQ; Steptoe et al., 1995). Respondents were asked to rate on a seven point scale to what degree (not at all important to very important) they agreed with a list of statements such as "It is important to me that the food I eat on a typical day:" followed by a list of motives. These motives covered a range of dimensions with three items per dimension: health (e.g. keeps me healthy), price (e.g. is cheap), sensory quality (e.g. smells nice), and natural content (e.g. contains natural ingredients). Dimensions of the food choice questionnaire that were deemed irrelevant for the choice between surgical castration and alternatives to castration were deleted: mood (e.g. helps me cope with stress), weight control (e.g. helps me control my weight), religion (e.g. fit within my religion), political values (e.g. comes from a country which is politically approved), convenience (e.g. is easy to prepare), and familiarity (e.g. is what I usually eat). Two items on animal welfare (Has been produced in a way that animals have not experienced pain; has been produced in a way that animal rights have been respected) and one item on environmental protection (Has been prepared in an environmentally friendly way) designed by Lindemann and Vaananen (2000) were added. In the pilots we tested whether "is cheap" (the original item) should be replaced by affordable, since cheap could have a negative connotation. Since the item loaded well on the factor we choose to keep the original item. Based on the pilot, one of the items on environment (has been produced without disturbing the balance of nature) was deleted because respondents did not understand its meaning. The final questionnaire consisted of 15 items with five dimensions (health, price, sensory quality, naturalness, and animal and environmental welfare).

Dimensions of pork production motives as perceived by consumers
Specific motives for buying pork (21 items in final version) were assessed with self-constructed items based on literature and expert meetings. Items were formulated in a similar way as those of the FCQ starting with the phrase: "It is important to me that the pork I eat:" followed by a list of motives. Respondents were asked to rate their agreement with these items on a seven point scale from "not at all important" to "very important". These items cover a range of motives that were considered crucial in the choice between surgical castration and alternatives to castration both in technical terms and for consumers: feed efficiency with benefits in terms of costs and environment, animal welfare (pain and stress), product quality, perceived health risks, natural farming, physical and behavioural integrity, original/identity. For each of these motives at least three items were constructed, discussed with the CAMPIG management team (including the co-authors) and tested in the pilot. We framed the items in such a way that no information was provided to the respondents and all items were presented in a similar, positively framed way to avoid effects of differences in framing. The word "hormones" was avoided since this might cause strong reactions for some respondents. Farmer welfare and transparency are also mentioned in literature. However, since these factors are not in the business to consumer context but in the business to business to society context they were not included. Also, in previous research, farmer welfare was relatively unimportant to consumers. Growth rate and amount of intramuscular fat were also not included since the differences between castrated, immunovaccinated, and non-castrated were considered not to be not large enough to be relevant for consumers. To ensure that all relevant aspects were included in a balanced way, the original list of 30 items was reduced to 21 based on the pilot, with 3 items for each of the 7 dimensions.

Top 3 generic motives for buying and eating meat
Respondents were asked to choose their three most important motives for buying and eating meat from a set of 11 motives. These motives were based on the 21 items of the specific motives, but

described in general terms. Additional items were added after the qualitative pilot in which a larger set of motives was used: *healthy, price, taste, no artificial ingredients, environmental friendly, animal friendly, convenience, safe, appearance, quality, and natural*.

Feelings towards eating meat
Ambivalence towards meat consumption was measured with 3 items on a 7 point scale. This scale has been developed by Priester and Petty's (1996) for any type of product and has been used for meat by Berndsen and van der Pligt (2004). In the original questionnaire, respondents rated their ambivalence on a 11 point or 9 point scale anchored with descriptions at the left and right side. The original items are: *I feel no conflict al all / maximum conflict; I feel no indecision at all / maximum indecision / I have completely one-sided reactions / mixed reactions*. In our case the word "indecision" was considered too strong for the issue of meat consumption and was considered difficult to answer in the pilot study. Therefore we changed this item to *I feel no uneasiness at all / I feel maximum uneasiness*. Also, the phrase "*I have completely one-sided reactions*" was considered difficult in the pilot and could also be interpreted as one-sided negative feelings. Therefore we changed this to "*I have no mixed feeling*". Other adaptions were that we added a description to the question and we used a 7 point scale since this was in line with the other questions in this questionnaire. The description that we added was: "*People who eat meat may at the same time experience negative feelings about this. Could you please indicate to what extend this applies to you? Towards the issue of eating meat:...*". The overall Cronbach's alpha in this study was .953 (>.900 in the separate countries). A Cronbach's alpha higher than .70 can be considered respectable and above .8 very good.

Attitude towards pork production sector
Attitude towards the pork production sector was measured with cognitive and affective attitude statements (Crites et *al*., 1994). Cognitive attitude refers to perception of benefit whereas affective attitude refers to more emotional aspects. Respondents rated their opinion on the "pig farming sector" in their country with 6 items on a 7 point scale anchored with *useless / useful, harmful / beneficial, unacceptable / acceptable* for cognitive attitude. For affective attitude the items were *bad / good, negative / positive, and revolting / gratifying*. In this study, cognitive and affective items loaded on one dimension, the Cronbach's alpha of these combined items was .940.

Knowledge about pork production
A self-estimation of consumers knowledge about pork production methods was measured with a scale developed by Flynn and Goldsmith (1999) which is widely used to measure so called "subjective knowledge" on different topics. Respondents were asked to rate on a seven point scale to what degree ("not at all important" to "very important") they agreed with a list of five statements about "how pork is produced" (e.g. I know a lot about...). In this study the Cronbach's alpha was .741.

Food neophobia
Food neophobia was measured with the Food Neophobia Scale (Pliner and Hobden, 1992) that is used to determine the individual's degree of fear towards new food. Respondents were asked to rate on a seven point scale to what degree ("strongly disagree" to "strongly agree") they agreed with a list of four statements about their feelings towards new or unknown foods (e.g I don't trust new foods). In this study the Cronbach's alpha was .795.

Relative importance of food motives
General food motives based on Steptoes Food Choice Questionnaire as well as on our own work (we added safety which was an important food motive for Dutch consumers). In a previous study (Onwezen et al., 2013 *De Agrofoodmonitor, Maatschappelijke waardering van de Agro & Food sector*) we found that consumers attach different values to animal products compared to plant products; therefore we choose to focus on meat and vegetables. To avoid that respondents will easily choose the same factors for meat and for vegetables we also added snacks as a completely different category of products. We asked about meat rather than pork since otherwise the level of product group would differ from vegetables. Finally, we did not distinguish between environment and animal friendly since the animal friendly option is not relevant for vegetables.

II.1.3. Choice experiment pork motives

Participants were asked to make forced choices from seven two-option choice sets. These sets consisted of two different descriptions of pork starting with "this meat came from a pig that is held in such a way that is …." followed by a combination of pork motives. Seven pork motives were included: animal stress, animal pain, human health risks, taste, natural, costs, and pharmaceutical interventions. These motives were based on the literature and discussions for designing the pork

motives questionnaire and the outcomes of the pilot study. We aimed to include the main issues. In an earlier version we also included "regional meat specialities" and "environment impact" but we deleted these since: this is not that important for most consumers (environment) and the link between pork meat and environmental impact is too complicated for most consumers. Also, "natural behaviour" was deleted since respondents in the pilot had difficulties to interpret this. To generate the choice sets, first a fractional-factorial main-effects design was used to generate the combinations of food motives. Each choice set was presented together with the opposite, so that one set includes stress, pharmaceutical interventions, human health, and taste, whereas the other set includes the other motives (natural, pain and costs). The seven combinations of choice sets were presented to the respondents in a random order and respondents were asked to indicate which one they preferred. The choice experiment was only done in Italy, Denmark, Poland, and France for reasons of budget constraints.

II.1.4. Statistical analyses

Food motives and pork motives: Factor analyses were performed to determine whether the items on motives for food consumption in general and pork production related motives loaded on the intended factors. For general food consumption motives, the items loaded on four factors which was consistent with the original factor structure of the FCQ with the difference that "health" and "natural" loaded on one factor. For the pork production motives, four factors were found. Only the items that had loading above 0.3 on one factor were included. For this reason, "looks tasty" and "Is produced in a natural way" we deleted. Costs were a separate dimension as well as regional identity. Environmental aspects, animal welfare (pain and stress) related aspects, and physical and behavioural integrity of the animals were combined in another factor. The fourth factor included product quality, perceived health risks, and one item from related to natural farming (Is from pigs that had no pharmaceutical treatment without a medical need). The third item related to natural farming "Is produced in a traditional way" surprisingly loaded on the factor regional identity. But after computing the Cronbach's alpha's this item was deleted. Differences between the countries on the four food motives were tested with paired t-tests

Segmentation: For clustering, a so-called finite-mixture model, was applied, using the Latent GOLD 4.0. This type of cluster analysis is based on probability-based classification; subjects are classified into clusters based on membership probabilities that are estimated directly from the model. This enabled us to identify clusters that differ with respect to their scores on dimensions of pork production motives. The analysis are started by a horizontal centring of the segmentation variables, which means that, for each respondent's answers on scales were adjusted by subtracting their overall mean on all non-categorical. A total of 10 clusters were estimated, each model had a different number of clusters (between 1 and 10). Each of these models was fitted 10 times, and for each model the best-fitting estimates from different random starting values were retained to avoid suboptimal solutions. Eventually, the model with the lowest Consistent Akaike Information Criterion (CAIC) value was chosen as the model that had the best trade-off between model fit and parsimony. This model statistically represents the optimal number of consumer segments. Furthermore, the Entropy R^2 is examined. This measures the extent to which the respondents can be uniquely assigned to the clusters and indicates the heterogeneity between clusters and the homogeneity within the clusters. The measure ranges from 0-1 with 1 representing a perfect homogeneity.

Relation between pork motives and consumer characteristics: The associations between dimensions of pork production motives with other consumer characteristics were tested in regression analyses. Four separate regressions were done with costs, environment & animal friendly, quality & health perception, and regional identity as the depending variables. In the first step, demographic variables were included, in the second step general food motives and in the third step ambivalence towards eating meat, food neophobia, attitudes towards pork production in their own country, and subjective (perceived) knowledge on pork production.

Choice experiment: First, the effects of the seven pork motives on consumers' choice were investigated by means of a binary logistic regression analysis. Consumer choice for one of the sets was used as the dependent variable. The independent variables were created by coding the attribute for each choice profile.

II.2. Results

In this chapter we will describe:

- The descriptive results on food motives, pork production motives, experiences with boar castration related topics, and ambivalence
- The segmentation on pork production motives
- The relations between pork motives and consumer characteristics
- And finally the choice experiment with pork production motives

II.2.1. Descriptive results

Experience with castration and related aspects

In the total sample, 61.8% of the consumers indicated that they knew what "castration of pigs" means, roughly 30% knew about boar taint and a similar percentage about immuno vaccination (see Table 51). Immunocastration was less well known than immunovaccination but this might be the result of confusion with vaccination in general. In the pilot study with Dutch consumers' immunovaccination was interpreted as vaccination in general. The results of this question should be considered as preliminary and need validation with regard to the interpretation of the concepts by the consumers. Finally, roughly 30% of the consumers knew none of the above mentioned concepts. Differences were found between the countries. Knowledge of the term "Castration of pigs" ranged from 79.8% in Denmark to 42.5% in South Korea and 48.0% in Italy. Boar taint was better known in Russia (50.9%), Latvia (57.4%), The Netherlands (43.9%), and Poland (41.3%) while it was less known in South Korea (5.5%), Denmark (6.8%), and the USA (8.1%). For immunocastration and immunovaccination large differences were found between the countries but the risks of misinterpretation of these percentages make country comparison even more ambiguous.

Table 51: Familiarity of several terms related to (alternatives of) pig castration

Familiar with concepts (percentage of total):	
Castration of pigs	61.8
Immunocastration of pigs	15.0
Immunovaccination of pigs	29.3
Boar taint	28.5
None of these	28.9

Additionally, 685 (6%) respondents reported that they had a negative experience with pork in the last 2 months which mainly were: Bad taste 2.3% (of total), Bad odour 1.7%, Too fatty 1.7%, Tough 1.6%, Rancid 1.2%, Too little fat / marbling 0.8%, and Too light/dark 0.8%. So, a bad taste and odour were most common together with too tough, however this does not necessarily relate to boar taint. Country differences were found with higher percentages of negative experiences in China and South Korea but not in countries where more boars are raised (such as Spain and The Netherlands).

Ambivalence: One third of the respondents (34.0%) indicated that they perceived no ambivalence towards the issue of eating meat at all. Table 52 lists the percentage of respondents with a score higher than 4 which indicates (on average for the three items) a positive score on ambivalence. Percentages range between 28.5 in China and 12.1 in Russia.

Table 52: Percentage of respondents who experience some degree of ambivalence towards the issue of eating meat ($p < 0.05$)

Country	% score >4*	
China	28.5	a
Italy	27.9	a,b

Greece	25.5	b,c
South Korea	22.4	b
USA	21.3	d,e
France	21.0	c,d
Belgium	20.3	d,e,f
Germany	18.6	d,e
Poland	17.9	e,f
Spain	16.5	d,e,f
Denmark	14.2	g
Netherlands	13.9	f
Latvia	12.6	g,h
Russia	12.1	h

abcdefgh similar letters indicate no significant difference between countries
* on a scale from1 (no ambivalence at all) to 7 (highly ambivalent)

Dimension of general food motives: The general food motive items loaded on four dimensions: "health and natural" related to both nutritional content, natural ingredients and no additives (e.g. keeps me healthy; contains natural ingredients), "price" (e.g. is cheap), "sensory quality" (e.g. smells nice), and "animal welfare" (e.g. has been produced in an animal friendly way).

In most countries, health and natural was considered the most important food motive. In China and Italy health and natural was considered most important, sensory quality second, animal welfare third and price least. Germany and Poland followed the same pattern with the difference that sensory quality (2) and animal welfare (3) were equally important in Germany and in Poland animal welfare (3) and price (4) were equally important. In Greece and South Korea, health and natural was also considered most important but price was second important followed by both sensory quality and animal welfare (equally important for Greece). Also in Russia health and natural was considered most important but sensory quality was rated second, price third en animal welfare least important. In USA, Belgium, France, Latvia, sensory quality was considered most important, health and natural second, price third and animal welfare least important. Denmark, The Netherlands, and Spain showed the same pattern, but with price and animal welfare as equally important.

Table 53: Consumer perception (means) of general food motives per country and ranking of the motives within country.

Country	Health and natural	Sensory quality	Price	Animal welfare
USA	5.08[2]	5.52[1]	4.96[3]	4.74[4]
Belgium	5.48[2]	5.56[1]	4.89[4]	5.18[3]
China	6.02[1]	5.27[2]	4.94[4]	5.12[3]
Denmark	5.05[1]	5.45[2]	4.92[3]	4.92[3]
Germany	5.40[1]	5.21[2]	4.66[4]	5.12[2]
France	5.34[2]	5.62[1]	4.95[4]	5.12[3]
Greece	5.91[1]	5.18[3]	5.36[2]	5.22[3]
Italy	5.91[1]	5.70[2]	5.04[4]	5.60[3]
South Korea	5.60[1]	5.30[3]	5.44[2]	4.84[4]

Latvia	5.35[2]	5.42[1]	5.05[3]	4.14[4]
Netherlands	5.23[2]	5.38[1]	4.75[3]	4.86[3]
Poland	5.91[1]	5.63[2]	5.26[3]	5.29[3]
Russia	6.03[1]	5.57[2]	4.86[3]	3.86[4]
Spain	5.67[2]	5.94[1]	5.19[3]	5.16[3]

[1234] Ranking within the country

Dimensions of pork production motives as perceived by consumers: Pork production motives were scored on 4 dimensions: first the importance of perceived human health risks and quality (*quality & health*), second the importance of low *costs*, third the importance of *environmental & animal friendly (eco)*, and finally the importance of *regional identity*. In all countries *quality & health* was perceived as most important on average (Table 54). This dimension includes both avoiding risks for human health and (sensory) quality. *Animal and environmental friendliness* was rated second in Belgium, Denmark, Germany, France, Greece, Italy, and The Netherlands. Whereas *costs* were second most important in USA, South Korea, Latvia, and Russia. In China and Spain both *costs* and *animal and environmental friendliness* were equally important after *quality & health*.

Regional identity was the least important factor in the USA, Belgium, Denmark, France, Greece, The Netherlands, and Russia as well as in South Korea and Russia where *regional identity* scored lowest together with *animal and environmental friendliness*. In China, Germany, and Italy on the other hand, *cost* was considered the least important of the 4 dimensions of pork production motives.

Table 54: Dimensions of pork production motives (mean) per country and ranking of the motives within the country

Country	Quality & health	Costs	Animal and environment	Regional identity
USA	5,77[1]	5,27[2]	4,79[3]	4,40[4]
Belgium	5,95[1]	5,04[3]	5,27[2]	4,42[4]
China	6,14[1]	5,04[4]	5,27[2]	5,22[2]
Denmark	5,84[1]	4,54[3]	5,07[2]	3,45[4]
Germany	6,02[1]	4,30[4]	5,38[2]	4,64[3]
France	5,99[1]	5,08[3]	5,23[2]	4,59[4]
Greece	6,31[1]	5,11[3]	5,37[2]	4,65[4]
Italy	6.22[1]	5.06[4]	5.62[2]	5.08[3]
South Korea	5,62[1]	5,29[2]	5,05[3]	4,93[3]
Latvia	5,97[1]	4,99[2]	4,61[4]	5,01[2]
Netherlands	5,73[1]	4,76[3]	5,06[2]	3,50[4]
Poland	6.10[1]	4.97[3]	5.27[2]	5.15[3]
Russia	6.46[1]	5.06[2]	4.69[3]	4.97[3]
Spain	6,09[1]	5,24[2]	5,29[2]	4,60[4]

[1234] Ranking within the country

Segmentation analyses: A cluster analyses (segmentation) was done to investigate whether distinct groups of respondents could be identified over the 14 countries that were similar in their combination of pork motives. Several segmentation analyses were ran with the following options as segmentation variables:

- All items of the **pork** motives
- Scores on the 4 factors of **pork** motives

- All items of the **food** motives
- Scores on the 4 factors of **food** motives
- Segmentation with or without different combinations of covariates: country, sex, age, educational level, and degree of urbanisation.

However, none provided a result with less than 10 clusters as the optimal number of segments. Since more than 10 clusters was considered too complicated to describe the analyses were stopped at 10 clusters even when the optimal fit was not yet reached. In a next step, data reductions and therefore simplification was done by:

- Excluding the pork motive items that did not perform well in the factor analyses
- Excluding the pork motive factor "region"
- Conducting the segmentation for each geographical area (e.g. South-East Europe) separately
- Conducting the segmentation per country

Only when the analyses were done within a single country a cluster solution with less than 10 clusters was found. Therefore we decided to run the analyses for the different countries separately. Due to time constraints analyses were done for the countries involved in the sensory studies (Germany, Denmark, Poland, Italy, and Spain), other major EU countries (in terms of number of residents/pork consumers; France), and two 3rd countries with distinct cultures (China and USA). We choose not to include covariates since in general the covariates (sex, age, education, degree of urbanisation) had little effect on the fit index (CAIC) but mainly for reasons of comparability since the once that were relevant were not so in all countries.

In the different countries between 3 (China) and 9 (Italy) clusters were found (see Figure 65 to Figure 73. The cluster analyses show distinct patters of relative and absolute values attached to the four motives. However, in all countries, for all clusters the "*quality & health*" factor was the most important (or almost the most important) pork production motive. This factor includes the items related to perceived human health risks and quality of the pork (including taste).

Since analyses were done per country separately we cannot confirm that some clusters were identical over countries. However, some patterns can be recognised were similar clusters are found over the countries. These patterns and the clusters that are specific for certain countries are described below and summarized in Table 55.

ECO oriented clusters: In all countries except China we found clusters where the environment & animal friendly factor was rated important, next to the "quality and health" factor that was always rated high. Costs and regional identity on the other hand scored low in these clusters. These were the major clusters in Germany, Italy, and the US but smaller in the other countries: cluster 4 in **Denmark** (16.0), cluster 1 in **Germany** (35.5%), cluster 3 in **France** (19.8%), cluster 1 and 2 in **Italy** (29.6% and 25.6% - cluster 2 showed larger differences between the clusters), Cluster 4 in **Poland** (10.9%), cluster 4 in **Spain** (14.0%), cluster 3 in **Russia** (18.8%), and cluster 1 in The **US** (26.0%). Among these clusters was also the cluster that scored extremely low on the importance of region, cluster 4 in Denmark.

PRICE oriented clusters: In several countries we found clusters where cost was rated important, next to the "quality & health" factor that was always rated high. Environment & animal friendly and regional identity on the other hand, were rated low. These clusters were cluster 2 in **Denmark** (18.1%), cluster 4 in **Germany** (10.3%), cluster 2 in **France** (18.3%), cluster 3 in **Spain** (14.6%), and clusters 3 and 4 in The **US** (17.6 and 15.0 %).

Indifferent clusters: In all countries we found one or more clusters of respondents who scored all 4 motives on average approximately at the same level without distinguishing between factors. Usually the clusters were not large (except clusters 2 in China and the US) however, this cluster was most common but the level of the scores differed:

1. All scores were either high, close to the maximum score of 7 which shows that respondents rated all values almost at the highest score. These were cluster 5 in **Denmark** (2.6%), cluster 5 in **Germany** (7.1%), cluster 5 in **France** (9.3%), cluster 7-9 in **Italy** (4.4, 3.6, and 3.9%), cluster 6 and 7 in **Poland** (5.4 and 4.8%), cluster 5 in **Russia** (7.3%), and cluster 5 and 6 in The **US** (8.3 and 5.4%)
2. Or all scores were around the scale medium of 4 suggesting that respondent had difficulties to answer the questions or had no clear opinion. These were cluster 3 in **Denmark** (17.1%), cluster 7 in **Germany** (3.5%), cluster 4 and 6 in **France** (13.8 and 3.9%), cluster 5 in **Italy** (5.5%), cluster 6 in **Spain** (5.6%), and cluster 7 in The **US** (4.6%)
3. Or scores were somewhere around score 5 or 6: Cluster 5 in **Poland** (13.5%), cluster 5 in **Spain** (15.4%), cluster 2 in **China** (39.8%), and cluster 2 in The **US** (23.1%).

Region oriented clusters: Three clusters were similar in the way that regional identity was considered important. Again next to "quality and health" that was always important and additional to importance of environment & animal friendly. Whereas costs were considered less important. These were clusters 3 and 6 in **Germany** (17,8 and 5.8%) cluster 2 in **Poland** (18.6%), and cluster 4 in **Russia** (15.1%).

As long as it is NOT ECO: In these clusters, environment & animal friendly scored low. However, in contrast to cluster 3 where environment & animal friendly was also rated low, these respondents had a clear preference for costs or any other distinct pattern on the other pork motives. These were: cluster 6 in **Italy** (3.3%), cluster 3 in **Poland** (14.0%), cluster 1 in **Spain** (26.4%), cluster 3 in **China** (15.5%), and cluster 1 in **Russia** (33.1%). So, in Spain and Russia this was the largest cluster.

Average Joe: Additionally, in some countries we found a cluster that has scores similar to the average pattern in that country. These clusters were also the largest or second largest in that country: **Denmark** cluster 1 (46.1%), **Poland** cluster 1 (32.9%), **China** cluster 1 (44.7%), and **Russia** cluster 2 (25.8%). Average Joe clusters are often found in segmentation analyses, however since these were different analyses in different countries the clusters have in common that they are average for their country, their patterns however differ since patterns between the countries differ.

Clusters that were unique for a specific country: In Germany cluster 2 (20.1%) environment & animal friendly, costs and regional identity all scored around 4 whereas quality & health scored slightly higher than the others but lower than average. In France the main cluster (cluster 1, 35.1%) showed high scores on environment & animal friendly and similar high scores on cost and quality & health (those scores were comparable to the country average) while regional identity was scored low, similar to the country average. In Italy clusters 3 and 4 (13.4 and 10.8%) showed high scores on quality & health without major differences for the other factors, those were slightly under average. In Spain cluster 7 had very high scores on cost, quality & health and environment & animal friendly, only regional identity was scored low.

Table 55: Description of the clusters on the segmentation variables: The importance of four pork production motives

	Denmark (n=800)	**Germany (n=800)**	**France (n=800)**	**Italy (n=800)**	**Poland (n=800)**	**Spain (n=881)**
1	46.1% average cluster: quality & health> eco > costs > region	35.5% quality & health and eco high; region and costs low	35.1% eco high just like quality & health and cost; region low	29.6% eco high just like quality & health; costs and region low	32.9% Average cluster: quality & health > eco and costs > region	26.4% Eco low; others average
2	18.1% eco low; costs and quality & health high	20.1% All scores just above 4 except quality & health which is higher but lower than average	18.3% costs high just like quality & health; eco and region low	25.6% Region high, others average but little differences between scores	18.6% region important, just like eco and quality & health; costs low	19.1% eco high, just like quality & health; cost and region average
3	17.1% All values around 4	17.8% region high; quality & health and eco as well; but not costs	19.8% eco high just like quality & health; cost and region low	13.4% quality & health high; eco low; cost and region average	14.0% eco very low; others average	14.6% eco low, region also; cost and quality & health average
4	16.0% Region low; quality & health and eco high; costs somewhat lower	10.3% quality & health and costs high; eco and region low	13.8% All values around 5	10.8% quality & health high; others slightly lower than average	10.9% eco high just like quality & health; region low; cost average to low	14.0% eco high, just like quality & health; cost and region low
5	2.6% All values around 6	7.1% All values around 5½	9.3% All values around 6½	5.5% All values around 4	13.5% All values around 5	15.4% All values around 6
6		5.8% region high, like cluster 3 but with higher values	3.9% All values around 4	3.3% eco low; quality & health lower than average similar to cost region	5.4% All values around 6½	5.6% All values around 4
7		3.5% All values around 4		4.4% All values close to 7	4.8% Similar to 6	4.9% All high except region
8				3.6% Similar to 7		
9				3.9% Similar to 7		

NB. quality: human health risk perception and pork quality related items; eco includes animal welfare and environment; region the importance one's own regional identity, and costs the importance of low product costs and price.

Table 56: Description of the clusters on the segmentation variables in non EU countries: The importance of four dimensions of pork production motives

	China **(n=796)**	USA **(n=800)**	Russia **(n =800)**
1	44.7% Average group: quality & health > eco > region > costs	26.0% eco high just like quality & health; cost and region low	33.1% Low on eco; other scores are average
2	39.8% All values around 5½	23.1% Little differences, all around 5	25.8% Average group: quality & health > costs > eco > region
3	15.5% quality & health high; region and eco low	17.6% Cost high, just like quality & health; eco and region low	18.8% Eco and quality & health high; region low; costs average
4		15.0% Similar to cluster 3 but lower scores, especially for eco	15.1% Region and quality & health high; other scores are average
5		8.3% All values around 6½	7.3% All values are around 6½
6		5.4% Similar to cluster 6	
7		4.6% All values around 4	

NB. quality: human health risk perception and pork quality related items; eco includes animal welfare and environment; region the importance one's own regional identity, and costs the importance of low product costs and price.

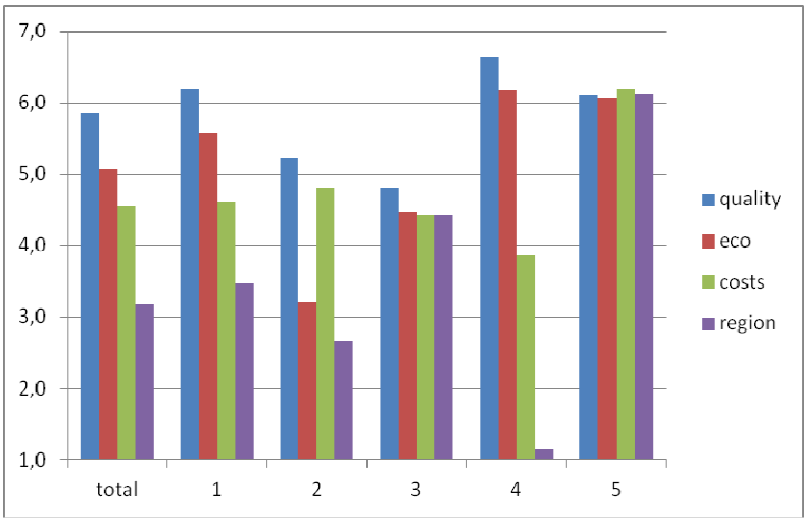


Figure 65: Average scores (scale 1-7) on the dimensions of pork production motives in the 5 clusters in Denmark (n=800)[7]

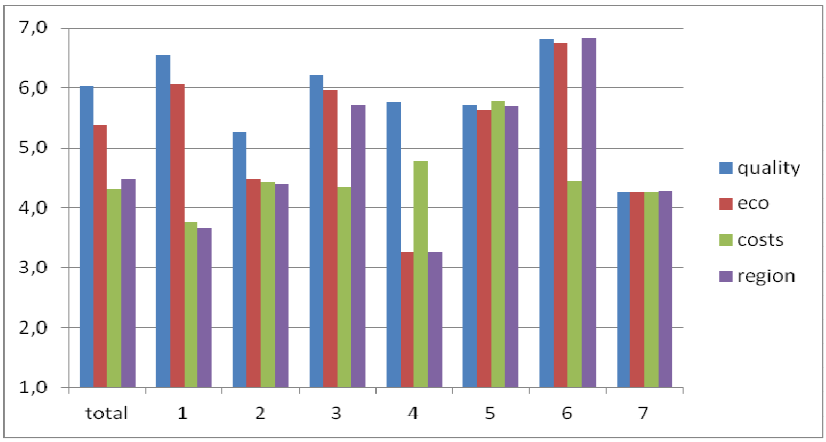


Figure 66: Average score on the dimensions of pork production motives in the 7 clusters in Germany (n=800)

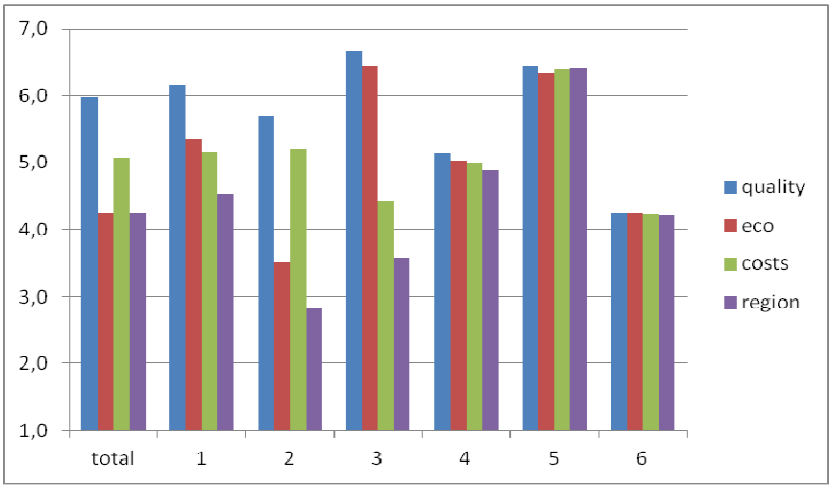


Figure 67: Average scores on the dimensions of pork production motives in the 6 clusters in France (n=800)

[7] Quality includes human health risk perceptions and pork quality related items; eco includes animal welfare and environment; region the importance one's own region, and costs the importance of low product costs and price.

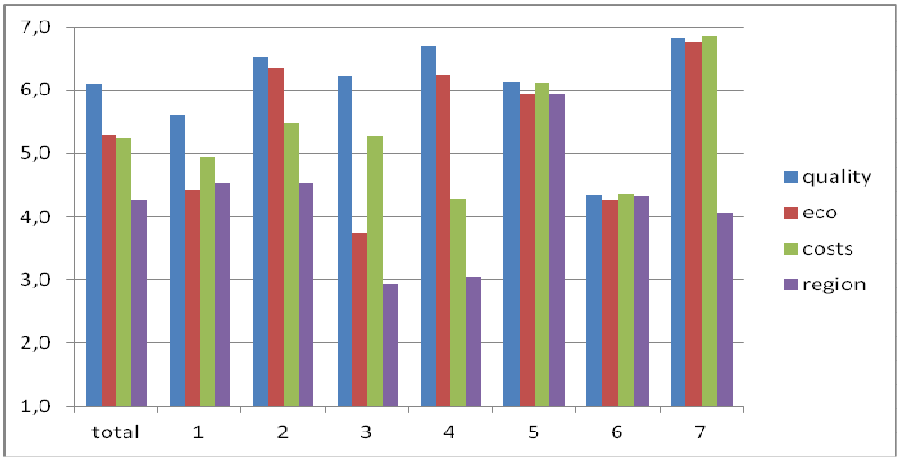


Figure 68: Average scores on the dimensions of pork production motives in the 7 clusters in Spain (n=800)

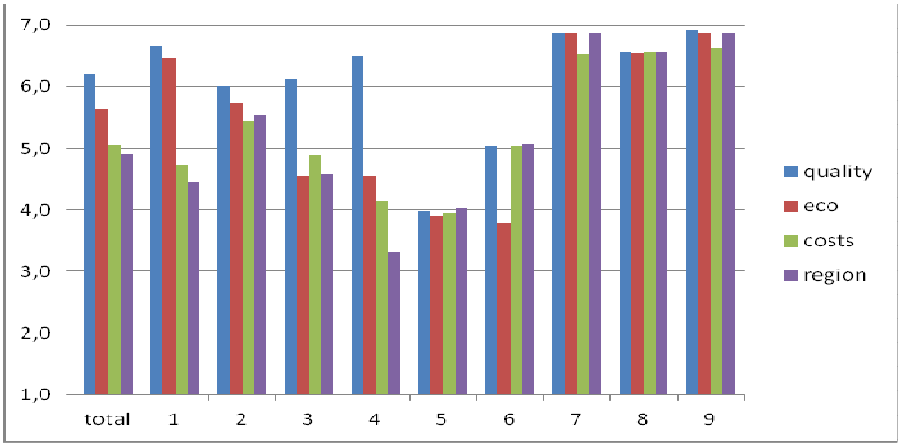


Figure 69: Average scores on the dimensions of pork production motives in the 9 clusters in Italy (n=800)

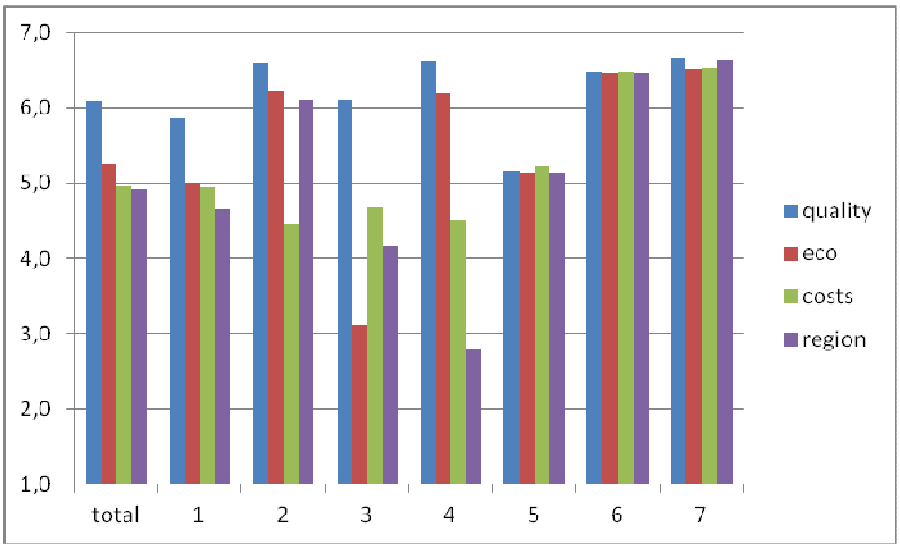


Figure 70: Average scores on the dimensions of pork production motives in the 7 clusters in Poland (n=800)

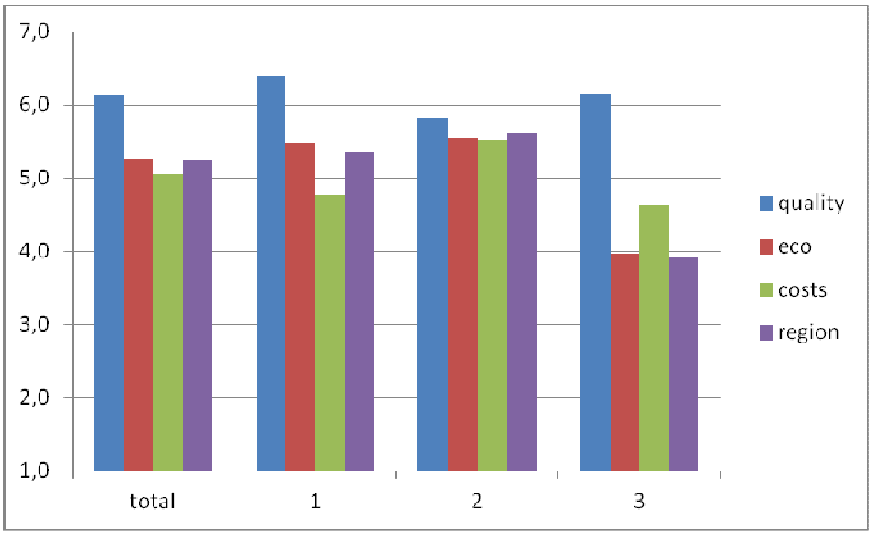


Figure 71: Average scores on the dimensions of pork production motives in the 3 clusters in China (n=800)

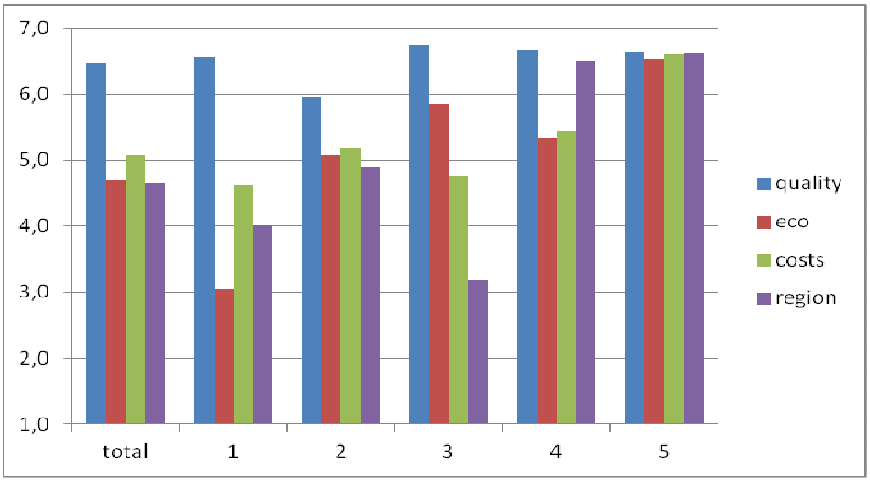


Figure 72: Average scores on the dimensions of pork production motives in the 5 clusters in Russia (n=800)

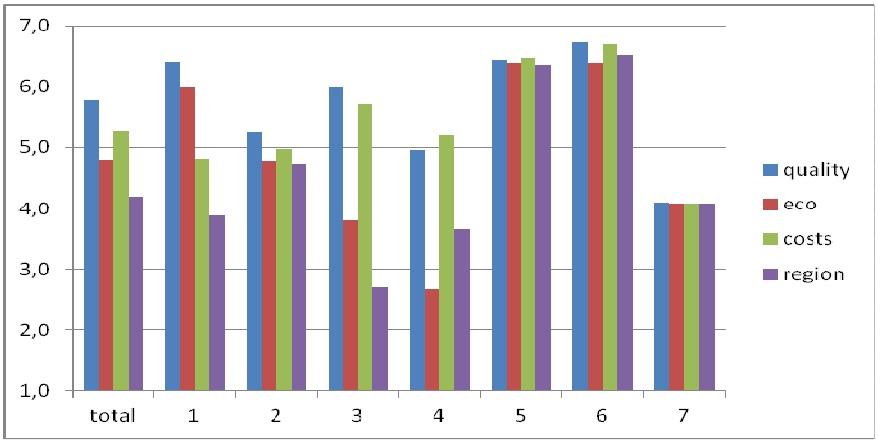


Figure 73: Average scores on the dimensions of pork production motives in the 7 clusters in the USA (n=800)

II.2.3. Top three generic motives for buying and eating meat

When respondents were asked to choose three main motives for buying and eating meat from a set of 11 generic formulated motives; quality, price and taste were most often selected, and no artificial ingredients, animal welfare, environmental friendly, and convenience least often selected (Table 57). In Greece healthy was chosen more often than taste as a main motive and for China where healthy and safe each were mentioned as one of the top 3 motives by more than half of the respondents. Healthy was also an important motive for a large proportion of respondents in the other countries, expect in Russia. For safety on the other hand large differences between the countries were found. Direct comparison between countries should be done with caution due to country differences in interpretation of the words. However, the percentage of respondents that chose safety as a main motive gives an indication that in some countries this was considered a main motive (as earlier mentioned in China, but also in Italy, South Korea, Greece, USA) whereas in others it seems not that important (Denmark, Germany, Belgium, Latvia, Poland, Spain, and France). Some other remarkable findings between the countries were seen. In Russia, natural was most often chosen as a main motive. Animal friendly was considered relatively more important (rank order 4 or 5) in Denmark, Germany, Belgium, and The Netherlands compared to the other countries. No artificial ingredients were often considered a top 3 motive in Italy and Poland.

II.2.4. Relation between pork motives and consumer characteristics

The associations between dimensions of pork production motives with other consumer characteristics were tested in four separate analyses with *costs*, *environment & animal friendly*, *quality & health perception*, and *regional identity* as the outcome variables.

Costs: For the importance of the dimension of pork production motives costs, differences between countries were found, in line with the results described earlier in the descriptive results sections. Additionally, women and older respondents rated costs as more important. For each of the four FCQ dimensions, those respondents who scored higher on the dimensions, especially the importance of costs also scored higher on the importance of costs for the production of pork. Ambivalence towards eating meat was unrelated to the importance of costs for the production of pork. Higher food neophobia, more positive attitudes towards the pork production and less subjective knowledge about pork production were related to a higher perceived importance of costs (see Table 58).

Table 58: Regression analyses on the importance of costs for production of pork

Variable	Standardized	t-test	Significance
Step 1			
Country	.04	3.72	.000
Sex	.07	6.98	.000
Age	.05	5.16	.000
Degree of urbanisation[1]	-.01	-1.28	.200
Step 2 (general food motives)			
Health and natural	.07	6.89	.000
Price	.50	62.30	.000
Sensory quality	.12	12.27	.000
Animal welfare	.02	1.82	.069
Step 3			
Ambivalence	.01	1.55	.122
Food Neophobia	.10	12.2	.000
Attitudes pork production	.11	14.3	.000
Subjective knowledge pork production	-.04	-5.85	.000

[1] A low score means a higher degree of urbanization

Table 57: Percentage of consumers that choose a specific motive as being in their top 3 of most important for buying and eating meat, for the total sample (including 3rd countries) and per country

Motive	Total sample	Belgium	Denmark	Germany	France	Greece	Italy	Latvia	NL	Poland	Spain	USA	China	South Korea	Russia
Quality	63.1[1]	64.5[1]	64.3[1]	71.0[1]	69.4[1]	70.6[1]	68.4[1]	64.6[1]	58.4[2]	60.1[1]	66.5[1]	53.5[1]	53.0[3]	62.0[1]	57.3[1]
Price	48.0[2]	53.1[2]	59.3[1]	47.0[3]	53.1[2]	53.0[2]	31.3[2]	56.0[2]	55.0[2]	50.7[2]	48.2[2]	57.1[1]	22.9[4]	48.8[3]	36.9[3]
Taste	47.2[2]	57.4[2]	62.7[1]	56.8[2]	45.9[3]	33.3[4]	34.3[2]	49.0[3]	63.7[1]	45.6[3]	40.3[3]	54.1[1]	23.6[4]	56.9[2]	37.1[3]
Healthy	30.0[4]	29.7[4]	21.6[4]	18.9[6]	24.8[5]	52.4[2]	19.9[6]	25.9[5]	32.4[4]	23.8[6]	33.5[4]	27.4[5]	61.6[1]	33.6[5]	14.0[8]
Safe	22.9[5]	12.6[9]	3.6[10]	10.1[9]	13.4[8]	30.8[4]	35.5[2]	11.0[8]	16.8[6]	13.0[8]	13.5[7]	32.8[4]	62.2[1]	45.4[3]	21.0[7]
Natural	21.7[6]	17.5[5]	12.1[7]	15.5[6]	18.5[6]	16.1[6]	19.5[6]	38.9[4]	8.2[8]	23.6[6]	26.4[6]	15.6[7]	23.4[4]	9.5[7]	58.4[1]
Appearance	20.9[7]	17.6[5]	23.9[4]	26.4[4]	30.5[4]	10.3[8]	18.1[6]	26.6[5]	14.6[6]	30.6[5]	31.7[4]	23.4[5]	5.0[10]	2.8[10]	29.9[5]
No artificial ingredients	19.3[8]	19.0[5]	14.2[7]	19.0[6]	16.3[8]	18.3[6]	30.9[2]	22.9[5]	10.4[8]	36.8[4]	16.5[7]	11.8[8]	18.6[7]	9.0[7]	26.9[5]
Animal friendly	15.0[9]	20.3[5]	23.3[4]	28.2[4]	20.3[6]	9.6[8]	20.5[6]	2.1[9]	22.8[5]	9.4[9]	14.8[7]	11.9[8]	12.4[8]	11.5[7]	3.0[10]
Environmental friendly	7.6[10]	6.1[10]	10.6[7]	6.0[10]	6.3[10]	3.6[10]	8.0[11]	1.5[9]	6.7[11]	3.1[10]	6.0[10]	4.3[11]	14.2[8]	16.3[6]	13.9[8]
Convenience	4.4[11]	2.4[11]	4.4[10]	1.1[11]	1.8[11]	2.1[10]	13.8[10]	1.5[9]	10.9[8]	3.3[10]	2.6[11]	8.3[10]	3.1[10]	4.4[10]	1.8[10]

[1234] Ranking within the country (different superscripts indicate significant differences *at* $p < 0.05$)

Environment and animal welfare: For the importance of the environment & animal welfare, women and older respondents rated this as more important than younger respondents and males. No differences were found between the countries or for respondents from more urban versus more rural areas. Those respondents who scored lower on FCQ price and those who scored higher on each of the other three FCQ dimensions, especially the importance of animal welfare, also scored higher on the importance of costs for the production of pork. Ambivalence towards eating meat and a higher food neophobia were related to a higher perception of the importance of environment and animal welfare for the production of pork. Attitudes towards pork production and subjective knowledge were unrelated to perceived importance of environment and animal welfare (see table 59).

Table 59: Regression analyses on the importance of environment and animal welfare for production of pork

Variable	Standardized	t-test	Significance
Step 1			
Country	-.02	-1.58	.114
Sex	.21	22.67	.000
Age	.14	14.67	.000
Degree of urbanisation[1]	.01	1.43	.154
Step 2 (general food motives)			
Health and natural	.15	20.27	.000
Price	-.02	-3.82	.000
Sensory quality	.04	5.35	.000
Animal welfare	.68	97.55	.000
Step 3			
Ambivalence	.05	8.28	.000
Food Neophobia	.05	8.62	.000
Attitudes pork production	-.00	-.17	.866
Subjective knowledge pork production	.01	1.78	.076

[1] A low score mean a higher degree of urbanization

Regional identity: For the importance of the dimension of pork production motives regional identity, differences between countries were found, in line with the results described earlier in the descriptive results sections. Additionally, women and older respondents rated regional identity as more important than men and younger respondents as well as respondents from more urban areas compared to those from more rural areas. For each of the four FCQ dimensions, those respondents who scored higher on the dimensions, especially the importance of health and natural content also scored higher on the importance of region for the production of pork. Ambivalence towards eating meat, food neophobia, positive attitudes towards pork productions, and higher subjective knowledge were related to a higher perceive the importance of origin / region for the production of pork (see Table 60).

Table 60: Regression analyses on the importance of regional identity for production of pork

Variable	Standardized	t-test	Significance
Step 1			
Country	.03	3.24	.001
Sex	.03	3.21	.001
Age	.07	7.59	.000
Degree of urbanisation[1]	-.08	-8.46	.000
Step 2 (general food motives)			
Health and natural	.28	23.75	.000
Price	.05	5.20	.000
Sensory quality	.03	3.07	.002
Animal welfare	.08	7.30	.000
Step 3			
Ambivalence	.08	8.98	.000
Food Neophobia	.26	29.10	.000
Attitudes pork production	.08	9.27	.000
Subjective knowledge pork production	.09	10.72	.000

[1] A low score mean a higher degree of urbanization

Quality and health perception: For the importance of the dimension of pork production motives perceive quality & health, differences between countries were found, in line with the results described earlier in the descriptive results sections. Additionally, men and older respondents rated quality & health as more important. No differences were found between respondents from more urban versus

more rural areas. Those respondents who scored lower on price and those who scored higher on each of the other three FCQ dimensions, especially the importance of health and natural, also scored higher on the importance of safe & quality for the production of pork. A lower ambivalence towards eating meat, a higher food neophobia, positive attitudes towards pork productions, and lower subjective knowledge were related to a higher perceive the importance of safe & origin for the production of pork (see Table 61).

Table 61: Regression analyses on importance of quality and health perception for production of pork

Variable	Standardized beta	t-test	Significance
Step 1			
Country	.07	7.88	.000
Sex	.16	17.19	.000
Age	.18	19.59	.000
Degree of urbanisation[1]	-.01	-.63	.529
Step 2 (general food motives)			
Health and natural	.51	56.26	.000
Price	-.03	-4.78	.000
Sensory quality	.21	25.38	.000
Animal welfare	.07	7.69	.000
Step 3			
Ambivalence	-.11	-14.78	.000
Food Neophobia	.01	1.91	.000
Attitudes pork production	.05	7.76	.000
Subjective knowledge pork production	-.05	-6.69	.000

[1] A low score mean a higher degree of urbanization

II.2.5. Choice experiment pork motives

Respondents were presented for seven pork motives that could influence product choice. These were: *this pork came from a pig that was held in such a way that… pain for the animal was avoided/ stress for the animal is avoided/ is most natural / pharmaceutical interventions were done only in case of a medical need / risks for human health were avoided / it is done at low cost / it ensures the best taste.* The pork motives distributed over 2 sets and the respondents had to choose between the sets. The including of each of the motives in the set increased the chance that respondents choose that option. In other words, all motives were relevant. "Natural" seems to be most important for the choice, followed by health, taste, and stress and pain for animals. Costs and especially pharmaceutical interventions scored lowest. The odds ratios are presented in Table 62. These can be interpreted as the chance that a set of motives was chosen when the specific motive was included in that set. So for all countries together, the chance that a set of motives was chosen was 3.6 times larger when "natural" was included in the set compared to not in that set. In Italy including "no pharmaceutical interventions" in the set reduced the chance that this set of motives was chosen.

Table 62: The importance of pork motives in an choice experiment, odds ratio's per motive. For the total sample and per country.

	Total sample	Denmark	France	Italy	Poland
Natural	3,59	3,13	3,98	4,01	3,39
Health	2,80	2,74	3,21	2,77	2,58
Taste	2,73	3,19	2,80	2,43	2,59
Pain	2,55	2,73	2,51	2,76	2,25
Stress	2,17	2,52	1,93	2,50	1,87
Costs	1,62	1,71	1,43	1,61	1,79
Pharma	1,25	1,22	1,65	0,82	1,47

II.3. Discussion and conclusion

In this chapter we summarise the main results of this study, discuss the strengths and limitations of the methods and describe the final conclusions given the limitations.

II.3.1. Summary of the main Results

The importance of several aspects related to the consumption of food in general and pork in specific were determined in several ways. First, using questionnaires addressing specific aspects (e.g. pain and stress for animal; smells nice) for both food in general and pork in specific. Additionally, based on these scores, consumer segments were identified, that have a clear patterns of motives which they find important and that differ from the country average. For example, even though on average within a country animal welfare is scored lower than other motives, one group of consumers might score high on this and lower on for example costs. Motives related to pork production were also questioned in a more general way (e.g. animal welfare, sensory quality). Consumers were asked to choose their three most important motives and additionally in a price experiment respondents were forced to make choices between sets of motives and make trade-offs between several important motives. This makes it possible to determine the relative importance of specific motives compared with other motives. Finally, the last paragraph of this section describes how attitudes towards the pork production sector in the respondents' own country, subjective (perceived) knowledge, ambivalence towards eating meat, and food neophobia relate to the four dimensions of pork production motives.
For aspects that consumers find important for their food consumption, four different dimensions of motives were identified. The dimension that included both nutritional content, natural ingredients and no additives (e.g. keeps me healthy, contains natural ingredients; labelled *health and natural*) was considered most important or second most important in all countries compared with *price*, *sensory quality*, and *animal welfare*. *Sensory quality* was considered most important in USA, Belgium, France, Latvia, The Netherlands, and Spain. *Animal welfare* was considered least important or third most important, except in Germany where it was second most important along with sensory appeal.

For aspects related to the production of pork, four dimensions of motives were identified that determine the attitude of consumers. Consumers in all countries rated their perceived *"food safety and quality"* on average as most important. *"Animal and environmental friendliness"* was rated second in Belgium, China, Denmark, Germany, France, Greece, Italy, The Netherlands, Poland and Spain; third in South Korea and Russia, and fourth in Latvia. *"Costs"* and *"regional identity"* were the other two dimensions of pork-production related motives for consumers.

In all countries except China we found groups of consumers (population clusters) who rated *animal friendliness* as important, next to *food safety and quality* that was always rated high in all clusters in all countries. Large population clusters for whom *animal and environmental friendliness* was rated important were identified in Germany (35.5%), Italy (29.6%) and the US (26.0%). In several countries we identified population clusters for whom production *costs* were rated important (next to perceived *safety and quality*) while *animal and environmental friendliness* and *regional identity* were rated low in these clusters in Denmark (18.1%), Germany (10.3%), France (18.3%), Spain (14.6%), and the US (32.6%). Three population clusters were similar in the way that *regional identity* was considered important, whereas production *costs* were considered less important in Germany (23.6%) and in Poland (18.6%). Finally, a substantial share of the studied populations does not have a clear opinion on pig production aspects.

When respondents were asked to choose three main motives for buying and eating meat from a set of 11 generic formulated motives; *Quality, price* and *taste* were most often selected, and *no artificial ingredients, animal welfare,* and *convenience* least often selected. *Safety* was chosen more often as a main motive in China, Italy, Korea, Greece, and USA and less often in Denmark, Germany, Belgium, Latvia, Poland, and France. *Animal friendly* was considered relatively more important (rank 4 or 5) in Denmark, Germany, Belgium, and The Netherlands.

In a choice experiment on the importance of production aspects respondents ranked *produced in a natural way* as the most important, followed by *avoiding human health risks, ensuring the best taste*, and *avoiding stress* and *avoiding pain*. *Produced at low costs* and *pharmaceutical interventions only in case of medical need* scored lowest.

Motives for food consumption in general and for production of pork in specific were related as expected (e.g. higher importance of price in general was related to a higher perceived importance of costs in pork production). A positive attitude towards the pork production sector in the respondents' own country was related to a higher perceived importance of *costs*, *regional identity*, and *quality and health* whereas it was unrelated to the importance of *animal welfare* in pork production. A higher subjective (perceived) knowledge about pork production was related to a lower perception of the importance of *costs* and *quality and health*, a higher perceived importance of *regional identity*, whereas it was unrelated to the importance of *animal welfare* in pork production. Ambivalence towards eating meat was related to a higher perceived importance of *animal welfare* and *regional identity*, a lower

perceived importance of *quality and health* whereas it was unrelated to the importance of *costs* in pork production. Finally, a higher food neophobia was related to a higher perceived importance of all dimensions of pork production motives but especially *regional identity*.

II.3.2. Strengths and limitations

Any food hazard in the period of data collection would have influenced the comparability of the results. It is therefore a strength of the design that the data collection in all different countries was done within the same time frame. In addition the methodology was similar in the different countries. One main strength of this study is the large sample of 11.294 respondents (n=800 per country) in a wide range of different countries, 10 EU and 4 outside the EU. It should be noted however that differences between the countries can exist in interpretation of the items due to both culture and language. The used terminology (e.g. animal friendly) might for example be more commonly known in certain countries or have slightly different meaning. Therefore, direct comparison of countries was done with caution. Rather, we compared relative importance of motives within the country.. The comparison between countries is further complicated by the fact that the representativeness of the respondents differed between countries. The study had an overrepresentation of highly educated people in Asian samples (South Korea, China) which was the results collecting the data through an online survey. Results should be verified in the underrepresented groups. Apps or face-to-face interviews might be helpful to reach groups of consumers who do not or to a less degree has the access or ability to work on a computer (e.g. elderly people).

A limitation that is important for the interpretation of the results is that we did not observe real behaviour but collected self-reported attitudes which are often divergent from real life situations. The results on which motives are considered as more important than others therefore need validation for behaviour. Scores on motives might be subject of social desirable answers (e.g. animal welfare) and therefore differ from actual behaviour. Also, food purchase is influenced by the broader social and physical environment such as group norms, price promotions, convenience, etc. Consumer attitudes and perception are important to consider also beyond their impact on buying behaviour for the possible impact on public opinions and debates. For example, respondents who value animal welfare as more important may or may not in their actual food purchase choice more animal welfare friendly products and may or may not have a strong negative opinion against pig castration in public debates.

Another main strength of this study is the combination of methods and type of questioning. We questioned a range of aspects that were combined in an integral evaluation. Consumer attitudes were measured with different techniques: both questionnaire and choice experiment, with types of framing of the questions (more specific and more general) and with a combination of validated scales and self-constructed scales. A questionnaire to access what aspects consumers find important for the production of pork, did not exist and was designed, piloted and applied in a large and diverse sample of respondents. Finally, the measurement of ambivalence needs more validation. The largest group of respondents (34.0%) indicated that they perceived no ambivalence towards the issue of eating meat at all, with an average score of 1.0 over 3 items (scored between 1-7). Another 13.6% of the respondents scored on average 4.0 which is due to 3 times a score of 4, which is the average of the scale, the question is not relevant for them or difficult to answer.

II.3.3. Discussion and conclusion

Implications for the alternatives: The term boar taint is known by quite a substantial proportion of the respondents but unknown by the majority. On average 28% of the respondents were familiar with the term "boar taint" with large differences between countries ranging from over 50% in Russia and Latvia to less than 10% in South Korea, Denmark, and the USA. A negative experience with pork in the past 2 months in the sense of a bad taste or a bad odour on the other hand was reported by respectively 2.3 and 1.7% of the respondents and this does not necessary have to imply boar taint. So, it seems that boar taint is not experienced in large percentages of the population, also not in the countries where meat from entire males is consumed at a larger scale.

In this study we chose not to ask respondents about their preference for the different alternatives to castration without anaesthesia directly. This was based on two assumptions. First, that most respondents do not have a thorough knowledge on the pros and cons and implication of the different methods. This was confirmed by the self-reported knowledge of the concepts. Second, that real life situations do not allow for educating consumers on these topics, especially not for consumers who have a low level of involvement with food production. In addition, providing information is always subject to bias since the formulation of pros and cons will influence the way there are weighted and therefore the attitudes of consumers. Instead, we addressed the important aspect that relate to the

alternatives. This allows us to determine which aspects are most important to consumers and how important they are compared to the other motives.

For keeping entire males an important aspect is the sensory quality. In this study (sensory) quality was a main important motive in food consumption in general and pork consumption in specific both when asked in a more general or more specific way and in questionnaires as well as the choice experiment. Keeping entire males also has benefits in terms of a better food conversion and therefore lower costs and less environmental impact. Environmental impact however was generally considered as less important when considered separately from animal welfare. For costs, the importance depended on the framing, when asked in a more general way (e.g. costs) it was considered important while it was not when asked in a more specific way (e.g. is not expensive). For animal welfare this was also the case, for food in general and when framed more generally it was considered less important than most other motives. However, when framed in a more specific way and for pork instead of food, including the word animal and referring to pain, stress, respect, etc. it was the second most important dimension (including also environmental friendliness) in most countries. For this aspect we also found differences between countries while in South Korea, Russia and Latvia it was considered less important. Also, we found distinct groups of respondents for whom animal welfare was an important aspect. In Germany, Italy and the USA these were large population clusters.

In the total sample roughly 30% of the respondents indicated that they were familiar with the term immuno vaccination but this high percentage might be the result of confusion with vaccination in general. This is supported by the finding that immunocastration was less well known than immunovaccination and the experiences in the pilot study. Consumer perception on immunovaccination was not studied directly but based on the results of the motives it is expected to depend on how this will be related to pork production aspects. In the choice experiment "pharmaceutical interventions were done only in a case of a medical need" was between the least important motives. In contrary, the dimension "health and natural" was the most important dimension for food consumption in general and "food safety and quality" the most important one for pork production; this includes human health (risks) but not naturalness. At a more generally formulated level "natural" was a motive of average importance. If consumers would relate immunovaccination to human health risks or to naturalness this would probably decrease the acceptance since these aspects, especially health, are of high importance to consumers. Interestingly, in the perception of the respondents, quality and health related aspects of pork production were correlated since these loaded on one dimension.
Finally, the questionnaire in this study did not include the word hormone. Immunovaccination is not a hormone but it has effects on the hormonal system, which is also the case for castration. Based on this study we cannot conclude on how the consumers' interpretation, understanding and possible reactions to these hormonal aspects will be. It is an important aspect to study in further research.

Third countries: Differences in consumer attitudes between EU and Asian countries were smaller than the differences within the EU countries. This is found with the limitation that the degree the samples were representative for their country differed per country and replication is needed in groups of respondents that were underrepresented in this study.

Implications for research: The results of this study show that framing of the questions is crucial. When asked for food in general, animal welfare was considered less important than when asked for pork production. Also, when asked in a more general way price was considered more important and animal welfare less than when asked in a more specific way. In future research these questionnaires should be validated for behaviour. In this study, we measured consumer motives and their (relative) importance to consumers. However, in real life situations the social and physical environment also influences food purchase and consumption behaviour.