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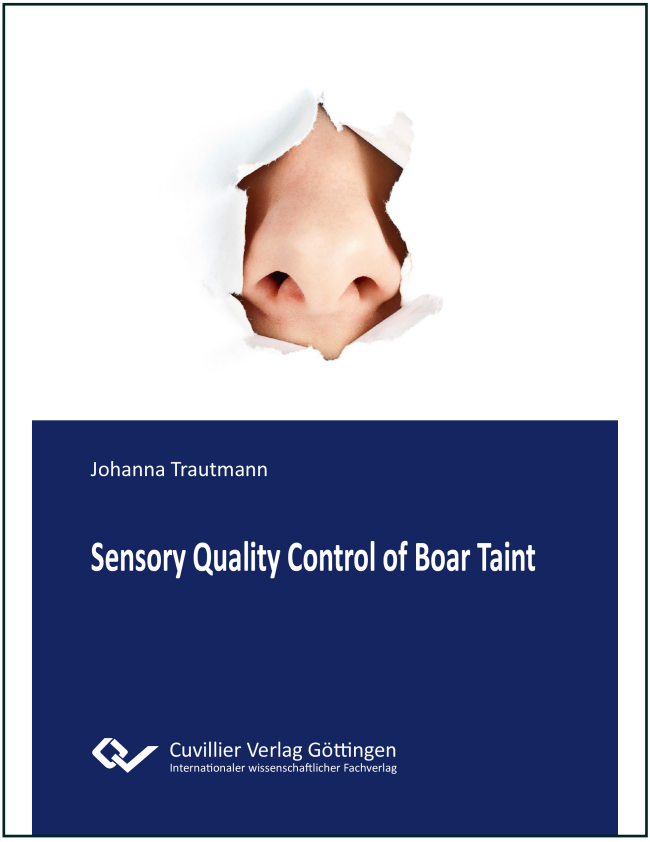
Sensory Quality Control of Boar Taint



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1. Introduction

The concern about the widespread castration of non-anaesthetized pigs is one of the main questions in European agriculture with regard to animal welfare. The misgivings of the public have led to changes in European law and will most certainly have lasting effects on the production chain of pork. Consumer and scientific concerns about animal welfare with respect to painful routine practices in animal husbandry have been growing in the recent past, and as a result such invasive operations as tail-docking, beak-trimming or castration - which are not done as a curative treatment of diseases but as preventive measures to adapt pigs to the production systems - have come under increased scrutiny (WBA, 2015). Consumers are concerned about such practices because contemporary intensive farming systems entail conditions that prevent animals from their natural behavior and imply body adaptation to these raising conditions (Phoenix & Walter, 2009). Scientifically there is no doubt about pain during castration without anesthesia. Several studies have documented physiological reactions including increased adrenocorticotropic hormones or cortisol levels, acute and chronic pain and behavioral reactions such as stress as well as a reduction in weight gain following castration (Baumgartner, Laister, Koller, Pfützner, Grodzycki, Andrews, & Schmoll, 2010; Llamas Moya, Boyle, Lynch, & Arkins, 2008). Moreover, the castration procedure itself is a time-consuming task for the farmer. In addition, castrated pigs are less productive from an economic, sustainability and world food supply perspective due to lower daily feed intake, reduced feed conversion and a lower percentage of lean meat (e.g.: Batorek, Čandek-Potokar, Bonneau, & Van Milgen, 2012; Field, 1971; Pauly, Luginbühl, Ampuero, & Bee, 2012). In 2013 the German Federal Council passed a law prohibiting surgical castration without anesthesia by 2019 (Bundesregierung, 2013). Castration is only one aspect and might be regarded as less important than free range husbandry, nevertheless studying an alternative is one puzzle piece of improving pig welfare.

These facts shed light on why there is now growing interest in the fattening of entire male pigs. In fact, due to national farm assurances 90% of the intensive pig production in the UK is carried out without castration (House of Commons Environment Food and Rural Affairs Committee, 2009). The occurrence of an off-odor in the fatty tissue of male pigs continues to hinder a wide-spread realization in Germany. This so-called boar taint has been the focus of various sensory research projects. Between 1971 and 2012 at least

57 studies had been conducted (Font-i-Furnols, 2012). Boar taint is a complex olfactory perception that can arise when pork is heated and it has been associated with two major compounds in pork: androstenone and skatole (e.g.: Claus, Weiler, & Herzog, 1994; Lundström, Matthews, & Haugen, 2009). Several chemical methods are currently available for their analytical quantification. Of these only the Danish on-line colorimetric method for skatole and its equivalents is utilized in modern abattoirs with their high speed work pace (Hagdrup, 2009). An equivalent analytical method for androstenone with regard to speed and costs does not exist. Although there are methods available giving concentration information about androstenone and skatole in the ppm/ppb range, human assessors are the best instrument to reflect consumer perception. If screened and trained assessors cannot detect androstenone and skatole in fat samples under controlled conditions, it becomes unlikely that a naïve consumer will detect a difference in a less controlled and more variable world.

The control of boar taint is crucial to convince members of the production chain that raising entire males for meat production is viable. From the primary (e.g., farmers) to the secondary production (e.g., abattoir) and final stage of production (e.g., retailers), each member of the production chain needs the guarantee that boar carcasses can effectively be screened to ensure consumer acceptance of this alternative. The basis for any fast and efficient method for detecting boar taint is sensory quality control. One routine function of sensory science is quality control testing (Lawless & Heymann, 2010). The primary objective for using a sensory quality control for boar taint is to acquire analytical information. Of course human assessors, as a measuring instrument, have limits, just as any other chemical analysis has limits. As for chemical analysis, there are instruments to minimize and handle such challenges for human assessors. Apart from the specific use of sensory quality control, the use of sensory science in general is irreplaceable interpreting the results obtained through chemical analysis.

2. Research Project and Objectives of the Thesis

The studies presented in this thesis were conducted within the framework of the STRAT-E-GER[1] (FKZ: 2816802511). In this project genetic, chemical and olfactory data have been connected to establish a) a viable selection program for reducing boar taint ante mortem and b) evaluation criteria for a human sensory quality control system. The project was carried out in cooperation between the *University of Bonn*, the *University of Göttingen*, the *Genossenschaft zur Förderung der Schweinehaltung eG (GFS) Ascheberg*, the *Schweinezuchtverband Baden-Württemberg e.V. (SZV)*, the *Besamungsverein Neustadt an der Aisch e.V. (BVN)*, *B.&C.Tönnies Fleischwerk GmbH & Co. KG (Tönnies)*, *VION GmbH (VION*) and *NHDyeAGNOSTICS GmbH (NHD).* In total 2831 boars where slaughtered. The first work package aimed at identifying DNA variants for androstenone and skatole concentrations to establish a selection program (University of Bonn). The second work package targeted the phenotypic characterization of the samples through sensory analysis in addition to chemical analysis (University of Göttingen). A sensory quality control method was developed to provide recommendations for the sensory evaluation of boar taint. The subsequent research is the basis of this PhD-thesis.

Chapter 3.1 contradicts the widespread opinion which maintains that pig castration has always been used to prevent off-odors. A closer look at the history and genesis of castration provides a better understanding of past needs and demonstrates that these differ from the needs and practices of current livestock systems. **Chapter 3.2** addresses the issue of animal welfare with regard to pig castration as well as other welfare issues, all of which have led to changes in the consumption behavior of consumers. **Chapter 3.3** is a comprehensive summary of current understanding of the so-called boar taint. **Subchapter 3.3.1** presents the related compounds androstenone and skatole, while **subchapter 3.3.2** summarizes their human olfactory perception. **Subchapter 3.3.3** condenses the available chemical analysis. And finally, **subchapter 3.3.4** explains the difficulties to determine consumer acceptance. **Chapter 3.4** examines the sensory

[1] The project is entiteld *Strategien zur Vermeidung von Geruchsabweichungen bei der Mast unkastrierter männlicher Schweine – Innovationen zur Verbesserung der Fleischqualität* (STRAT-E-GER), which can be translated into *Strategies to avoid odor deviations in the meat of uncastrated male pigs – Innovations to improve meat quality*. It was financed by the Federal Ministry of Food and Agriculture (BMEL) under the auspices of the Parliament of the Federal Republic of Germany and administered via the Federal Office for Agriculture and Food (BLE) through the innovation support program.

quality control as a tool for evaluating boar taint. **Subchapter 3.4.1** states the difference between legal specifications and voluntary/optional sensory quality control. **Subchapter 3.4.2** states practical implications for a sensory quality control system of boar taint.

The objectives of this thesis are:

1. To develop methods which allow an objective characterization of the olfactory acuity of human assessors in terms of the major boar taint compounds.
2. To assess methodological aspects of a sensory quality control of boar fat regarding the sample preparation and the test environment.
3. To re-assess the relationship between chemical boar taint analysis and sensory evaluation in a large scale study.
4. To establish a framework for evaluating the performance of sensory quality control.

In detail, **Chapter 4** (Paper I: How olfactory acuity affects the sensory assessment of boar fat: A proposal for quantification) addresses the importance of standardized sensory practices to obtain consistent data. Humans are known to be difficult measuring instruments to work with because of general varying olfactory abilities and anosmias. Thus Paper I describes and evaluates how an objective selection process for assessors could be carried out utilizing routine medical psychophysical tests. Such psychophysical tests were devised and applied to objectively judge the assessors' ability to correctly discriminate, detect and identify androstenone and skatole. During the study fat samples were rated by the assessors, and their accuracy of detection for boar taint was evaluated. The considerable variation of olfactory performance demonstrates the need for objective criteria in the selection process of assessors.

Chapter 5 (Paper II: Boar taint detection: A comparison of three sensory protocols) presents a comparison of common heating methods because heating is necessary for sample preparation to release androstenone and skatole for sensory evaluation. In this study the microwave (MW), the hot-iron (HI) and the hot-water (HW) method were compared. A sensory panel consisting of 10 assessors according to ISO 8586 was used. The comparison was carried out on 72 boar fat samples. The heating method

significantly affected the probability of a deviant rating. To analyze the performance, sensitivity and specificity were calculated using chemical analysis as an assumed gold standard for comparison. The performance was best for HI when both sensitivity and specificity were considered. The results show the superiority of the panel result compared to individual assessors. However, the consistency of the individual sensory ratings was not significantly different between MW, HW, and HI.

Chapter 6 (Paper III: Noise does not affect olfactory performance regardless of whether assessors are accustomed to abattoir noise or not) analyzes a wide-spread recommendation that sensory tests should be carried out in an environment without extraneous noise. While recent studies suggest an influence of noise on olfactory performance, it is unclear to which extent this influence varies between subjects who are accustomed to noise and those who are not. In this study two groups of panelists were selected: a University panel usually working under silent conditions and an abattoir panel usually working at the slaughter line with abattoir noise. Odor discrimination, odor identification, and odor detection thresholds were studied. Furthermore, a sensory quality control task using 40 boar samples was performed. All tests were accomplished both with and without extraneous noise recorded at an abattoir (70 dB) using headphones. Contrary to the researchers' expectations, abattoir noise hardly affected the olfactory tests. Neither was the quality control task impaired: abattoir noise did not influence the perceived intensity of boar taint and the classification results of the testers, regardless of whether they were accustomed to such noise or not. The results indicate that sensory quality control can be conducted in the manufacturing environment with constant noise without diminishing assessors' performance.

Chapter 7 (Paper IV: Human olfactory perception of taint in pork) analyzes odor-odor interactions of androstenone and skatole and its interaction with the human sensory evaluation. Therefore, fat samples were collected from 1043 entire male pig carcasses for sensory evaluation and quantification of boar taint compounds using gas chromatography mass spectrometry (GC-MS). Each sample was sniffed by 10 trained assessors resulting in 11,000+ individual ratings which were subjected to statistical analysis. Pearson correlations of chemical traits and sensory traits (panel average) were significantly higher for skatole than for androstenone. Linear terms of androstenone and

skatole as well as their interaction significantly contributed to perception of deviant smell. Standardized regression coefficients illustrate the higher importance of skatole than androstenone.

Chapter 8 purposes to present additional discussion points while considering all four papers simultaneously.

Finally, **Chapter 9** draws conclusions from the presented results by providing information for a sensory quality control system of boar taint detection.

3. Framework and Theory

3.1. History and Genesis of Pig Castration

When discussing male pig castration it is often said that castration has always been done to prevent deviant odors. While it is true that castration of male animals is an old tradition, the motives for castration have varied. In this chapter an attempt is made to give insights into ancient literature about castration and its motives from the time before the birth of Christ (B.C.) to former German regulation from the 1930s.

The Fertile Crescent not only represents the earliest evidence of domesticated grains such as einkorn wheat (*Triticum monococcum*) around 10 000 B.C. (Doebley, Gaut, & Smith, 2006), but was also where domestication of the wild boar (*Sus scrofa)* took place, which may have occurred as early as 10 500–10 000 B.C. (Zeder, 2008). There is evidence that there were other centers of pig domestication in Southeast Asia (Kittawornrat & Zimmerman, 2011) and China around 10 000 B.C. and in southern Sweden around 2400 B.C. (Falkenberg & Hammer, 2007). Zooarcheological findings of upper canines from pigs in Uppåkra (Sweden) reveal evidence of castration during the European Iron Age 500 B.C. Based on the malformation of canines in male pigs and how canines continued to follow further developmental pathways in entire boars and sows, the assumption has been made that these differences could have resulted from castration (Magnell, Boethius, & Thilderqvist, 2012). This possibility is supported by the fact that the teeth of male pigs comprise a part of their secondary sexual characteristics, whose development, of course, can be affected by castration due to changes in the synthesis of hormones. Although castration implies a health risk, there seemed to be reasons for taking this risk.

Irrespective of any doubts surrounding Homer, his text (to be dated around 1102 and 800 B.C.) remains an early witness to castration of pigs. Hoesch offers a quote from Homer´s text: "*Castration of boars must be restricted to the spring and fall and should only be done by a waning moon*" (Hoesch, 1911). The ancient Roman scholar and writer Varro (116 B.C. to 27 B.C.) wrote three books concerning agriculture entitled *Rerum Rusticarum Libri Tres*. The second of these books is entitled *De re pecuaria* and deals with breeding and livestock management. In *De re pecuaria* Varro describes the age of castration as follows: "*The best time for castrating boars is when they are one year old. No*