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The effect of skatole and androstenone on consumer response towards fresh pork from *m. longissimus thoracis et lumborum* and *m. semimembranosus*

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ABSTRACT

Consumer liking was assessed for boneless chops (*m. longissimus thoracis et lumborum*) and schnitzels (*m. semimembranosus*) from castrates and entire male pigs with an androstenone content of up to 9.4 ppm and a skatole content of up to 0.92 ppm in the back fat. Skatole affected both odour and flavour as assessed by trained sensory panellists ($P < 0.05$–$P < 0.001$), while androstenone particularly affected flavour ($P < 0.01$–$P < 0.001$). Furthermore, the skatole compound seemed to be more important in explaining the presence of boar taint in the chops, while androstenone seemed to be more important for the schnitzels. For the chops, tenderness was the most important attribute for consumer liking independently of both the androstenone and skatole contents ($P < 0.001$). Furthermore, increasing contents of both androstenone ($P = 0.05$) and skatole ($P = 0.04$) resulted in a decreased liking of the chops. Skatole was the most important factor regarding consumer response towards the schnitzels ($P = 0.03$). The very low liking scores for both chops and schnitzels were mainly attributable to the androstenone content.

1. Introduction

The castration of male piglets has been practised for decades to prevent the development of the unpleasant odour and flavour known as boar taint, which can develop when heating meat and fat from entire males. However, surgical castration has recently been questioned by both the authorities and animal welfare groups, since castration without anaesthesia is potentially painful for the piglets. Before the practice of castration can be effectively discontinued, it is vitally important to obtain knowledge about consumer response towards meat with boar taint in order to reduce the risk of consumer claims. This knowledge, combined with the possibility of sorting the animals on the slaughter line, is essential for the successful production of entire males.

Boar taint was originally described as 'sex odour' or 'undesirable odour' (Patterson, 1968) but is currently defined as 'urine-like', 'sweat', 'pungent' and 'manure-like' (Bonneau, 1992; Byrne, Thamsborg, & Hansen, 2008; Fischer et al., 2011; Tørngren, Kristensen, & Claudi-Magnussen, 2012; Zamaratskaia & Squires, 2009). However, some authors only refer to the flavour as 'boar taint', 'sex odour' or 'tainted' (Lundström & Malmfors, 1988; Rius, Hortos, & Garcia-Regueiro, 2005; Solé & Reguerion, 2001). A more precise definition is necessary if the aim is to describe the correlation between compounds in the fat or meat and the sensory expression, since it is not off-flavour in general but only off-flavour related to the production of entire males, which is of interest.

Two compounds have been identified as being responsible for boar taint: skatole (SKA) (3-methyl-Indole) and androstenone (AND) (5α-androst-16-en-3-one) (Patterson, 1968; Vold, 1970). Other compounds have also been mentioned, such as 3-α-androstenol, 3-β-androstenol, indole (Fischer et al., 2011), 4-phenyl-3-butene-2-one (Solé & Reguerion, 2001), p-cresol and 4-ethylphenol (Patterson, 1967), although so far none of these compounds has proven to have a significant effect on boar taint. Therefore, SKA and AND are the two main compounds of interest when examining consumer response in order to determine potential sorting parameters and thresholds.

It has been shown that boar taint can also be present in low-fat muscles such as *psoas major* (Byrne et al., 2008), even though SKA and AND are mainly fat-soluble (Kock, Heinze, Potgieter, Dijksterhuis, & Minnaar, 2001). SKA is slightly more water-soluble than AND (Kock et al., 2001), and the relative importance of the two compounds for the odour and flavour might therefore depend on the fat content in the muscle — the less fat there is in the muscle, the more important SKA is expected to be relative to AND. While most experiments only focus on a single meat cut per pig (Font-I-Furnols, 2012), it would be advantageous to know the correlation between AND and SKA in the back fat and consumer response towards several muscles and products from the same carcasses.

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In this investigation, a trained sensory panel was used to describe the sensory properties of the meat, not only the boar taint attributes but also texture attributes, while a consumer study was conducted to investigate the effect of the sensory properties on liking. Therefore, to gain a better understanding of the consumer response, a sensory profile would be beneficial, since it gives a more complete picture of the sensory quality rather than merely providing the boar taint-related data from the concentration of AND and SKA.

In order to form a solid basis of knowledge for establishing sorting criteria, entire males with a naturally occurring variation in the content of AND and SKA were selected. A chemical analysis of SKA and AND in the back fat, a sensory profile analysis of different high- and low-fat carcass cuts served warm and cold, and a central location consumer study of the same cuts supplemented with a home-use test for some of the cuts were performed. The overall aim of the study was to understand the correlation between the content of SKA and AND in the back fat of entire males and the response of Danish consumers towards meat from different parts of the carcass. This was done by: i) estimating the linear effect of the concentration of AND and SKA, ii) including uncertainty in the form of confidence intervals and prediction intervals in the interpretation of the linear effect and iii) changing the data from a continuous liking scale to a binary dislike/like variable to understand the effect of AND and SKA on dislike ("do I like it or not?") rather than continuous liking ("how much do I like it?"). Furthermore, we aimed to describe the sensory quality of the same meat and included this in the interpretation of the consumer response. Castrates were included as a control group. This paper covers the results from the *m. longissimus thoracis et lumborum* (boneless loin chops) and *m. semimembranosus* (schnitzels). The results from bacon and pork belly roll are presented in Aaslyng, Broge, Brockhoff, and Christensen (2015).

2. Materials and methods

This study was composed of four parts: collection of the meat, chemical analysis of the back fat, consumer study of chops and schnitzels, and sensory profiling of the same two meat cuts. The animals in this study were the same as in Aaslyng et al. (2015) investigating processed meat, and the set-up in that study using a trained sensory panel, a consumer study partly combined with a central location test and a home use test, but the consumers participating in the three studies (processed meat, chops, schnitzels) were not the same.

A total of 64 entire males and 25 castrates were selected for the study. We aimed to achieve a distribution of both skatole (SKA) and androstenone (AND) between 'below 0.05 ppm' and 'above 2 ppm' (AND) and 'below 0.1 ppm' and 'above 0.4 ppm' (SKA) both measured in the back fat. These thresholds were chosen to gain as large a variation as possible in both compounds reaching from well below and well above the expected odour threshold. The actual AND content was between <LOQ (limit of quantification, 0.2 ppm) and 9.4 ppm, while the actual SKA content was between 0.03 and 0.92 ppm. The distribution is shown in Fig. 1. The actual content of AND and SKA in the back fat was used in the statistical analysis of the consumer and sensory data. No difference between entire males and castrates was seen in ultimate pH in the loin (entire males, average 5.56; castrates, 5.57), the warm carcass weight (entire males, average 85.2 kg; castrates, 82.7 kg) or lean meat percentage (entire males, average 61.0%; castrates, 60.3%). The lean meat content was evaluated by means of online measurements carried out by an AutoFOM equipment based on ultrasound technique and calibrated according to the procedure described in Commission Regulation (EEC) 1249/2008.

2.1. Collection of the meat

Meat from entire males and castrates was collected from a Danish commercial slaughterhouse between January and March 2013. On the day of slaughter, pigs were selected on the basis of the slaughterhouse

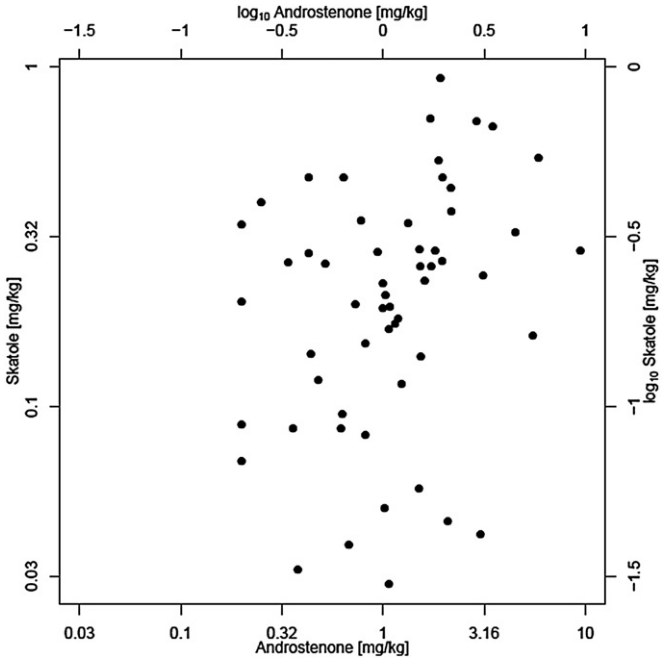

Fig. 1. Content of skatole and androstenone as ppm and log (ppm) in the back fat of entire males used for the consumer study and sensory assessment.

analysis of skatole equivalence (skatole and indole) (Mortensen & Sørensen, 1984) and a human nose test of the back fat (see Section 2.2). The day after slaughter, the ultimate pH was measured in the centre of the left loin between the 4th and 5th lumbar vertebrae using a portable Knick pH-metre (Mettler Toledo, Glostrup, Denmark). If the pH was below 5.5 or above 5.8, the animal was discarded. The loin (*m. longissimus thoracis et lumborum*) and the topside (*m. semimembranosus*) from both sides were excised. The loin was derinded, and the left side was divided into three samples: a sample cut 10 cm from the anterior end and a sample cut 12 cm from the posterior end were used for the central location consumer test, while the middle 12 cm was used for the sensory profiling. The entire right loin was sliced into 16 samples of 2 cm thick chops, which were vacuum-packed with two in each pack for the home use test and labelled with unique ID numbers for each pig. The left topside was used for the sensory analysis, while the right topside was used for the consumer test. All of the meat was vacuum-packed, aged for four days at 5 °C and frozen at −18 °C followed by −40 °C until use maximum 3.5 month later.

2.2. Analysis of back fat

2.2.1. Human nose

The human nose analysis was performed as described by Meinert, Bejerholm, and Støier (2011). Approximately 5 g of back fat was cut into small pieces and added to 75 mL boiling water in a 100 mL conical flask. The flask was sealed with foil and left to stand for two minutes before assessment. Two independent assessors scored the odour on a categorical scale ranging from 0 (no boar taint odour) to 3 (very strong boar taint odour). The samples were assessed in a randomised order. Both assessors were sensitive to AND and SKA.

2.2.2. Androstenone, skatole and indole

The back fat from entire males was analysed for AND, SKA and indole (IND) as described by Hansen-Møller (1994) with minor changes. Androstenone and androstanone were obtained from Steraloids (Malta). Dansylhydrazine was purchased from TCI Europe (Zwijndrecht, Belgium) and recrystallised from methanol. Indole, 2-methylindole, skatole, 20% BF_3 in methanol and 45% KOH solution were purchased from Sigma-Aldrich (Brøndby, Denmark). Methanol, acetonitrile,