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Evaluating the performance of sensory quality control: The case of boar taint

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ABSTRACT

Detection of malodours referred to as 'boar taint' in entire male pigs is essential for quality control when refraining piglet castration. This study analysed the sensitivity and specificity of sensory evaluation by trained assessors (n = 18) compared to chemical analysis of two marker compounds (androstenone, skatole) in backfat (n = 794). Taking the measurement uncertainty into consideration, several cut-off thresholds for chemical analysis were exemplarily evaluated. Using the panel average score, sensitivity and specificity of sensory analysis ranged from 61 to 69% and 77 to 85%, respectively. Performance of individual assessors varied highly (sensitivity: 47 to 86%; specificity: 45 to 88%) and correlated to olfactory acuity to the compounds. According to receiver operating characteristic-curves, the average panel performed better than single assessors regardless of the sensory criterion shift. Agreement plots illustrate that high skatole levels are better detected than high androstenone levels (useful for assessor feedback). The agreement between sensory and chemical analyses was moderate. Assessors need to be selected carefully.

1. Introduction

If the practice of castrating piglets is given up and boars are raised instead, monitoring malodours referred to as 'boar taint' in carcasses from uncastrated male pigs is essential for quality control. It is widely accepted that androstenone and skatole are mainly responsible for boar taint-related off-flavours in pork, although other compounds were mentioned as contributing to or increasing boar taint perception (Fischer et al., 2014; Rius, Hortós, & García-Regueiro, 2005; Rius Solé & García Regueiro, 2001). To ensure consumer satisfaction, carcasses with elevated levels of androstenone and skatole must be distinguished from carcasses that are free of taint (Lundström, Matthews, & Haugen, 2009). Technical methods for a rapid, reliable and simultaneous detection of both compounds are not yet available for practical application in abattoirs. Industrial quality control, therefore, uses sensory evaluation for at-line or off-line classification of carcasses as 'tainted' or 'untainted'. Usually, subcutaneous fat tissue is heated, e.g., with soldering irons, hot air guns or microwaves, to facilitate odourant release and the odour is assessed by one or more assessors (panel).

Against the background of quality control, it is important to study the diagnostic performance, i.e. accuracy of sensory evaluation in the field of boar taint detection. Recently, various parameters were suggested to quantify the performance of sensory evaluation, i.e., sensitivity, specificity, positive (PPV) and negative predictive values (NPV) as well as the accuracy of classification (Mathur et al., 2012). Evaluating a diagnostic method, however, requires the existence of a true condition that classifies samples as 'negative' (non-tainted) and 'positive' (tainted), preferably without error. Chemical analysis of androstenone and skatole is often considered the true condition (gold standard) although it is known that measurement errors may exist for any given chemical method (Haugen, Brunius, & Zamaratskaia, 2012). Furthermore, the androstenone and skatole thresholds that are relevant for consumer acceptance are set at different levels in various studies, which also affect the observed prevalence of (tentatively) tainted carcasses. Moreover, conflicting results were found for the prevalence of boar tainted carcasses when detected by sensory evaluation (9%) compared to chemical analysis (44%) (Mathur et al., 2012). An earlier study also reported a considerable disagreement between sensory evaluation and the proportion of carcasses that exceed threshold levels for skatole (0.25 ppm) or androstenone (1.5 ppm) (Xue et al., 1996). Beyond that, knowledge about the accuracy of individual assessors is limited while in practice quality control is often based on the evaluation of a single assessor.

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The aims of this paper were thus

i) to study the agreement of chemical analysis and sensory evaluation regarding the discrimination of backfat samples with boar taint vs. samples without boar taint,
ii) to discuss the influence of the uncertainty, i.e., measurement errors, in chemical analysis, and
iii) to assess the performance of trained sensory panellists.

2. Material and methods

In three experiments, a total of 794 backfat samples (626 boars, 121 gilts and 47 castrates) were each evaluated by five assessors from a pool of 18 assessors whose olfactory acuity to the key odourants was assured by standardized smell tests (see Section 2.4). In the first experiment, 214 samples were assessed in July 2012, in the second experiment 285 samples in October 2012 and in the third 295 samples in June 2013. Samples were not preselected, i.e., no assumptions were made regarding any 'usual prevalence of boar taint', but were assessed double-blind. Chemical analysis was carried out afterwards. All sensory evaluations followed a defined protocol under standardized conditions in a sensory laboratory equipped with 10 booths (according to ISO 8589:2010, sensory analysis: general guidance for the design of test rooms). The ventilation system ensured an air exchange with a rate of 6 times per hour.

2.1. Animals and sample preparation for sensory analysis

Backfat samples were derived from the neck of carcasses from a larger study which assessed the influence of dietary effects on growth rate, slaughter performance and meat and fat quality. In experiments 1 and 2 samples were taken from 426 boars and 73 gilts; commercial hybrid gilts (Large White/Yorkshire × Landrace) were crossed with two different sire-lines (Duroc and Piétrain). Animals were allocated to three pig performance testing locations and raised to an average hot carcass weight of 94 kg. Backfat samples in experiment 3 were taken from 295 animals (200 boars; 48 gilts; 47 castrates) raised on three commercial farms and fed to an average hot carcass weight of 94 kg; Piétrain (sire-line) was crossed with hybrid gilts (Large White * Landrace) or Camborough hybrid gilts.

Backfat samples were stored in evacuated plastic bags at −18 °C until assessment; the maximal storage time was 12 weeks until analysis. One day before the sensory evaluation, samples were thawed at room temperature, and rind and meat were removed from the fat. For sensory evaluation, samples of 3 ± 0.5 g fat (if existent all three fat layers were used) were heated in 100 ml beaker glasses covered with watch glasses. Heating was done in a microwave (Samsung, CE1185UB, 32 l) at 450 W for 90 s to a surface temperature of approximately 75 °C and immediately presented to the assessors. Within each serving 10 samples were heated together. Backfat samples were encoded with random three-digit numbers and served in random order to the assessors on each evaluation day.

2.2. Assessment protocol and evaluation procedure of sensory analysis

On each assessment day, 22 (experiment 1) to 30 (experiments 2 and 3) backfat samples were each assessed by five assessors individually (group A) and another 22 or 30 by group B (five assessors). Assessors were randomly allocated to group A or B on every assessment day. After experiments 1 and 2, several assessors left the panel and were replaced by new assessors which resulted in a total of 18 assessors used in all three experiments. Backfat samples were evaluated on a 6 point scale from 0 (=no deviation from standard fat) to 5 (=very strong deviation from standard fat). Assessors were instructed and trained to score a sample as deviant when androstenone or skatole odours were perceivable. They received four reference standards (paper smell strips) with defined amounts of androstenone (~90 and ~360 ng per strip) and skatole (~40 and ~170 ng per strip) for scale points 2 and 4. These references were selected by the panellists according to the range of skatole and androstenone odour intensity in native backfat samples during training; they aimed to illustrate the odour quality of androstenone and skatole at low and high intensities, respectively. Prior to the odour evaluation, each assessor received two to four standard backfat samples (gilt, castrate or boar fat with <0.1 μg/g melted backfat skatole and <0.5 μg/g melted fat androstenone; androstenone was only measured in boar samples) for calibration of the sense of smell and to acquaint with the standard odour of pork fat. Assessors were instructed to open the glasses and wait about 5 s before evaluating the odour by shortly sniffing.

2.3. Selection and olfactory acuity of sensory assessors

Assessors were selected during screening sessions. Due to a known partial anosmia to androstenone (Amoore, 1967; Havlicek, Murray, Saxton, & Roberts, 2010), the selection process focused on drafting only persons able to detect androstenone as well as skatole. Olfactory acuity was determined by triangle tests with paper smell strips described earlier (Meier-Dinkel, Sharifi et al., 2013; Mörlein, Meier-Dinkel, Moritz, Sharifi, & Knorr, 2013). Only assessors who correctly discriminated a very low amount of androstenone (~10 ng; 20 μl of 0.5 μg/g androstenone dissolved in propylene glycol) (Mörlein et al., 2013) and skatole (~20 ng; 20 μl of 1 μg/g dissolved in propylene glycol from the pure solvent) in triplicate triangle tests were selected. The final panel consisted of 18 assessors that were trained on the detection and identification of boar taint compounds in fat. In addition, individual odour detection thresholds to androstenone and skatole were determined for all assessors following a single-staircase, triple-forced choice paradigm described earlier (Fischer et al., 2014; Hummel, Sekinger, Wolf, Pauli, & Kobal, 1997). Thresholds were estimated in two replicates for both odourants.

2.4. Chemical analysis of boar taint compounds in backfat

Chemical analysis of androstenone was carried out by an enzyme linked immunosorbent assay (Claus, Herbert, & Dehnhard, 1997; Weiler, Götz, Schmidt, Otto, & Müller, 2013). Skatole was analysed by liquid chromatography using an Acclaim 120 C18 2.1 ×100 mm 3 μm column (Thermo Scientific, Karlsruhe) followed by fluorescence detection (Ultimate 3000 RS Fluorescence Detector FLD-3400RS) (Dehnhard, Claus, Hillenbrand, & Herzog, 1993). Analyses were performed in duplicate and averaged values are displayed in μg/g melted back fat. The limit of detection was 0.003 μg/g melted fat for androstenone and 0.0037 μg/g melted fat for skatole. The calibration range for androstenone and skatole was 0 to 4.0 μg/g and 0 to 0.25 μg/g melted fat, respectively (standards in different concentrations were added to the acetonitrile phase). For androstenone, an inter-assay variation of 13.1% (n = 9; mean: 1.15 μg/g) and 17.2% (n = 9; mean 0.17 μg/g) was determined; the intra-assay variation was between 7.5% (n = 5; mean 0.32 μg/g) and 8.8% (n = 5; mean: 1.0 μg/g). For skatole, both inter-assay variability and intra-assay variability were on average below 5% (each n = 5; mean 0.165 μg/g and 0.081 μg/g).

2.5. Data analysis

To assess the agreement between chemical (CHEM) and sensory analysis (SENS) the results of both methods were converted into binary variables (0 = no boar taint; 1 = boar tainted/deviant). For chemical analysis, two different threshold scenarios were arbitrarily chosen. For the condition termed CHEM-LOW, a sample was considered tainted when the androstenone value was ≥1.5 μg/g melted fat or the skatole value was ≥0.2 μg/g melted backfat. For the CHEM-HIGH condition, thresholds were higher, i.e., ≥2 μg/g androstenone or ≥0.25 μg/g