Fatty acid composition and its association with chemical and sensory analysis of boar taint

Xiaoye Liu a,b, Johanna Trautmann b, Ruth Wigger b, Guanghong Zhou a, Daniel Mörlein b,*

a Key Laboratory of Meat Processing and Quality Control, Ministry of Education, College of Food Science and Technology, Nanjing Agricultural University, Nanjing 210095, PR China
b University of Goettingen, Department of Animal Sciences, Albrecht-Thaer-Weg 3, 37075 Göttingen, Germany

A R T I C L E   I N F O

Article history:
Received 8 December 2016
Received in revised form 9 March 2017
Accepted 21 March 2017
Available online 22 March 2017

Keywords:
Boar taint
Fatty acids
Pork quality
Sensory quality control

A B S T R A C T

A certain level of disagreement between the chemical analysis of androstenone and skatole and the human perception of boar taint has been found in many studies. Here we analyze whether the fatty acid composition can explain such inconsistency between sensory evaluation and chemical analysis of boar taint compounds. Therefore, back fat samples (n = 143) were selected according to their sensory evaluation by a 10-person sensory panel, and the chemical analysis (stable isotope dilution analysis with head-space solid-phase microextraction and gas chromatography–mass spectrometry) of androstenone and skatole. Subsequently a quantification of fatty acids using gas chromatography-flame ionization detection was conducted. The correlation analyses revealed that several fatty acids are significantly correlated with androstenone, skatole, and the sensory rating. However, multivariate analyses (principal component analysis) revealed no explanation of the fatty acid composition with respect to the (dis-)agreement between sensory and chemical analysis.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

Raising boars is one alternative to surgical castration of male piglets. It is, however, widely associated with the risk of reduced consumer acceptance of meat due to the so called boar taint. Mainly androstenone (5α-androst-16-en-3-one) and skatole (3-methylindole) have been brought into relationship with this off-flavor (Bonneau & Chevillon, 2012; Patterson, 1968; Vold, 1970). EU regulations require that meat must be declared unfit for consumption if organoleptic anomalies, especially “pronounced sexual odor” occurs (Regulation EC No 854/2004, 2004). To fulfill this regulation and to ensure consumer acceptance, sensory quality control measures need to be established because, at this point, there is no technical system available to simultaneously detect androstenone and skatole on-line given the time constraints at modern abattoirs. Regardless of whether such a sensory quality control is conducted on-line or at-line, several studies show that often there is a certain lack of agreement between chemical and sensory analysis (Meier-Dinkel, Gertheiss, Müller, Wesoly, & Mörlein, 2015; Trautmann, Meier-Dinkel, Gertheiss, & Mörlein, 2016). A recent analysis of more than 1000 boar fat samples demonstrated that the widely used “safe box” (fixed thresholds for androstenone and skatole) approach to estimate the prevalence of tainted samples has to be expanded by introducing a factor related to the interaction of androstenone and skatole (Mörlein et al., 2016). Another possible explanation of the moderate agreement between chemical analysis and sensory evaluation can be found in other substances contributing to the human perception of boar taint and pork flavor in general, e.g., 2-aminoacetophenone (Fischer et al., 2014), benzylideneacetone (4-phenyl-3-buten-2-one) (Rius Solé & García Regueiro, 2001) or products from lipid oxidation (Rius, Hortós, & García-Regueiro, 2005). Moreover, fatty acids have been documented to affect flavor, e.g., during oxidative processes. Research showed that meat samples with high n-3 PUFA concentrations produced higher concentrations of lipid degradation products, particular aldehydes, alcohols and ketones (Wood et al., 2004). In particular, aldehydes have been described as off-flavors in food (Rius et al., 2005); they have low odor thresholds and contribute, for instance, to flavor changes of cooked beef (Elmore, Mottram, Enser, & Wood, 1999). Moreover, short-chain fatty acids have been proven to contribute to boar taint (Rius et al., 2005). However, little is known about the role of fatty acids on the human perception of boar taint. A recent study indicated that entire male pigs with low androstenone, skatole and indole concentrations had more polyunsaturated fatty acids (PUFA) and less saturated fatty acids (SFA).
2 Materials and methods

2.1 Fat samples

In total, 143 fat samples originating from crossbred boars (Pietrain sire × commercial crossbred dam) were obtained from a larger study aiming to validate genomic selection for reduced boar taint (STRAT-E-GER Project); for more detailed information see Mörlein et al. (2016). The boars were raised at four different performance testing stations (named here A to D) and slaughtered at two commercial abattoirs (Tönnies Lebensmittel GmbH & Co. KG; Long: 8.32240°E; Lat: 51.86262°N; Vion Crailsheim GmbH, Long: 10.058240°E; Lat: 49.149610°N).

To assess whether the fatty acid composition can explain the disagreement between chemical and sensory evaluation, samples were chosen according to their chemical and sensory data as well as availability (some of the samples had already been used up).

2.2 Chemical and sensory analysis of boar taint

Chemical analysis of androstenone and skatole was done using stable isotope dilution analysis with headspace solid-phase microextraction followed by gas chromatography coupled with mass spectrometry (SIDA-HS-SPME-GC/MS) using deuterium labeled internal standards (Fischer et al., 2011; Trautmann et al., 2016); results are given as µg/g (ppm) melted back fat. Androstenone (5α-androst-16-en-3-one) was obtained from Merck, Darmstadt, Germany, and skatole from Sigma-Aldrich (1,2-propanediol) from Carl Roth, Karlsruhe, Germany. The deuterium labeled internal standards H3 and H7 were from Sigma-Aldrich (EC Number 200-838-9; Sigma-Aldrich) to identify individual fatty acids C8:0 to C24:1. Methanol (purity ≥ 99.9%), n-hexane (purity ≥ 95%) and potassium hydroxide (purity ≥ 85%) were utilized. A Supelcowax 10 capillary GC column (30 m, 0.32 mm i.d., 0.25 µm; Sigma-Aldrich) was used. For the analysis 20 g of sample without the rind were homogenized for 5 s at 3000 rpm (Grindomix GM 200; Retsch GmbH, Haan, Germany). Then 200 to 250 mg of the homogenate were mixed with 12 mL of n-hexane and stored for 15 min at room temperature. Thereafter 4 mL of the upper solution and 1.2 mL potassium hydroxide were combined, vortexed for 10 s and then rested for 40 s. The mixture was centrifuged for 60 s at 1000 rpm (Macrofuge 5902, Heraeus Christ). Finally, about 1 mL of the upper layer was transferred to a GC vial. FAMEs were analyzed on an Agilent 7890A GC with a flame ionization detector (FID). Helium was used as the carrier gas at a flow rate of 1 mL/min. The temperature program followed

2.3 Chemical analysis of the fatty acid composition

The analysis of the fatty acid composition by GC–MS is based on the Commission Regulation (EEC) No. 2568/91 Annex X A with slight modifications (EEC No. 2568/91 Commission Regulation No 2568/91 of 11 July 1991 on the characteristics of olive oil and olive-residue oil and on the relevant methods of analysis, 1991). The standard reference material for fatty acid methyl esters standards (FAMEs) mixture was Supelco 37 Component FAME Mix (EC Number 200-838-9; Sigma-Aldrich) to identify individual fatty acids C8:0 to C24:1. Methanol (purity ≥ 99.9%), n-hexane (purity ≥ 95%) and potassium hydroxide (purity ≥ 85%) were utilized. A Supelcowax 10 capillary GC column (30 m, 0.32 mm i.d., 0.25 µm; Sigma-Aldrich) was used. For the analysis 20 g of sample without the rind were homogenized for 5 s at 3000 rpm (Grindomix GM 200; Retsch GmbH, Haan, Germany). Then 200 to 250 mg of the homogenate were mixed with 12 mL of n-hexane and stored for 15 min at room temperature. Thereafter 4 mL of the upper solution and 1.2 mL potassium hydroxide were combined, vortexed for 10 s and then rested for 40 s. The mixture was centrifuged for 60 s at 1000 rpm (Macrofuge 5902, Heraeus Christ). Finally, about 1 mL of the upper layer was transferred to a GC vial. FAMEs were analyzed on an Agilent 7890A GC with a flame ionization detector (FID). Helium was used as the carrier gas at a flow rate of 1 mL/min. The temperature program followed

![Fig. 1. Agreement of binary classification (tainted/untainted) of back fat samples (n = 143) according to sensory analysis compared to chemical analysis using the “curved approach” as suggested in Mörlein et al., 2016 applying thresholds $\theta_{\text{AN}} = 2.0$ ppm, $\theta_{\text{SK}} = 0.2$ ppm and the shape parameter $q = 1.5$.](image-url)