HOW TO USE "TAINTED" BOAR MEAT FOR PROCESSED WHOLE MEAT CUTS

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In order to clarify whether processing and application of processed whole meat cuts affect perceived boar taint in Danish flank roll and smoked streaky bacon, carcasses from 28 entire male pigs (four skatole equivalent groups: (1) < 0.10 ppm, (2) 0.20-0.25 ppm, (3) 0.26-0.50 and (4) > 0.65 ppm) and 20 castrates were selected. Androstenone, skatole and indole (ASI) were analysed on neck fat samples using an HPLC method, and sensory profiling was performed by a trained panel. In Danish flank roll, androstenone and skatole have a major effect on perceived boar taint, and, to avoid boar taint, the androstenone content should be below 2.1 ppm (if the skatole < 0.05ppm), and the skatole content should be below 0.3 ppm (if the androstenone < 0.2 ppm). In smoked streaky bacon, androstenone and skatole have a major effect on perceived boar taint, and androstenone is solely responsible for boar taint during cooking and should be below 0.9 ppm to avoid boar taint. It was not possible to eliminate boar taint when serving bacon hot at any skatole or androstenone levels. Serving streaky bacon cold can eliminate unpleasant boar odour, but not the boar flavour. Therefore, bacon served cold should never exceed 0.9 ppm androstenone and 0.8 ppm skatole.

Key Words – Boar taint, streaky bacon, serving temperature, flank roll

I. INTRODUCTION

Castration of male piglets is expected to be prohibited across Europe in the near future. It is therefore important to gain more knowledge about how to process the boar-tainted meat to eliminate the unpleasant odour. Boar taint is caused by the presence of skatole, which is associated with the odour of faeces or naphthalene, and androstenone, which is associated with the odour of urine and sweat. Which of these two compounds is the most important contributor to boar taint is a subject of much debate. Threshold values of 0.2 µg/g skatole and 0.5-1.0 µg/g androstenone in fat tissue are regarded as the concentrations above which consumers are likely to react adversely to the compounds [1]. Androstenone and skatole are volatile compounds, and their concentration is therefore expected to decrease when the meat is heat treated during processing and cooking [2]. More is known about fresh pork than processed meat products, but it has been established that processing makes tainted meat more acceptable [3].

The objective of this study is to clarify the effect of androstenone, skatole and indole levels in the neck fat of entire males on the perceived boar taint in processed whole meat cuts (Danish flank roll and smoked streaky bacon).

II. MATERIALS AND METHODS

At a local slaughterhouse, boars were screened using the Danish skatole method. Twenty-eight carcasses were selected with respect to the following four skatole equivalent groups: (1) < 0.10 ppm, (2) 0.20-0.25 ppm, (3) 0.26-0.50 and (4) > 0.65 ppm plus 20 castrates as a reference. Samples from the neck fat were analysed for skatole, indole and androstenone using an HPLC method.

Processing: Danish flank roll: Flanks (M. *rectus abdominis*) were injected with brine to obtain a 20% weight gain. Flanks were spiced with 5 g spice mixture/kg meat and gelatine, rolled and put in sausage casings and then heat treated at 80°C to 72°C core temperature, after which the rolls were chilled with cold water to 2°C.

Streaky bacon: Pork bellies were derinded and injected with brine to obtain a 10% weight gain. The cured bellies were drained at 5°C (for approx. 18 hours), smoked according to a 9-step smoking program (130 min, 54-60°C) and stored at 3°C (for approx. 18 hours), after which the bacon was sliced, vacuum-packed and stored at 0°C before cooking.

HPLC: The androstenone, skatole and indole contents (ASI) were determined using HPLC on neck fat samples, according to a modified Hansen-Møller method [4]. For the calculation, 0.11 ppm androstenone and 0.0165 ppm skatole and indole (=LOD+(LOQ-LOD/2)) were substituted for values below the limit of quantitation (LOQ).

Sensory analysis: The meat products were evaluated by a professional and trained sensory panel consisting of 8 assessors at the Danish Meat Research Institute (DMRI). All assessors had participated in training in accordance with ISO 8586-1, ASTA STP758 and [5]. Danish flank roll were cut into 2-mm thick slices, and tempered to room-temperature before serving. Whereas bacon were sliced into 2.5-mm thick slices, cooked in an oven (180°C, approx. 10 min) and served as hot samples immediately after cooking, or as cold samples after approx.. 30 minutes of cooling at 5°C.

All sensory attributes were evaluated on a 15-point unstructured scale anchored at the extremes (0 = low intensity and 15 = high intensity). For Danish flank roll, the evaluated odour attributes were: intensity of spices, pepper, acid, urine, manure, pork, piggy. The evaluated flavour and taste attributes were: intensity of spices, pepper, salt, acid, urine, manure, pork, manure. The evaluated after-taste attributes were: intensity of urine, manure, burning. For bacon, the evaluated odour attributes were: intensity of fried pork, smoke, acid, urine, sweaty, chemical and pungent. The evaluated flavour and taste attributes were: intensity of fried pork, smoke, salt, urine, manure, chemical and sweaty.

Modeling: The average sensory scoring for the 8 assessors was calculated and merged with the chemical data (ASI content) of each pig. For the entire male pigs, two types of models for each sensory attribute were calculated using proc mixed in SAS [6]: (1) using androstenone, skatole and indole and the interactions between the three as independent variables and (2) using log10 of androstenone, skatole and indole and the interactions between the three as independent variables. Only significant independent variables ($p < 0.05$) were included in the final models. The two models for each sensory attribute were compared using simple correlation between true and predicted values, and the model with the highest correlation was chosen. The sensory evaluation of the castrates was used as a reference for "acceptable" values of each sensory attribute: if the sensory attribute was higher than *castrate mean + 2 x standard deviation*, then it was considered unacceptable. In this way, 97.5% of the castrate variation is considered acceptable.

III. RESULTS AND DISCUSSION

Boars & castrates: Androstenone levels in the neck fat of entire males varied between 0.37 and 6.25 ppm, and skatole varied between 0.036 and 1.13 ppm. Androstenone levels in castrates were less than the level of quantification (LOQ = 0.2 ppm), and skatole levels were less than 0.12 ppm (LOQ = 0,03ppm) (Table 1).

Table 1. Androstenone, skatole, indole and carcass weight for entire males (n=28) and castrates (n=20)

		Androstenone (ppm)	Skatole (ppm)	Indole (ppm)	Carcass weight (kg)
Entire males	mean	2.03	0.27	0.12	82.6
	min	0.37	0.036	0.015	71.5
	max	6.3	1.1	0.37	97.8
Castrates	mean	0.1	0,058	0.035	80.9
	min	0.1	0.032	0.015	78.2
	max	0.1	0.12	0.083	84.0

As shown in Figure 1, skatole and androstenone levels in the neck fat from entire males were only slightly correlated ($r = 0.46$; $p = 0.02$).

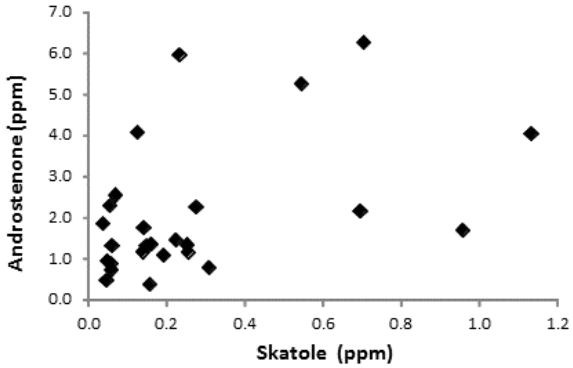

Figure 1. Skatole and androstenone levels (ppm) in the 28 entire male pigs.

Danish flank roll: In contrast to cooked hams [7], both androstenone and skatole have an effect on perceived boar taint in Danish flank roll (not shown). When modelling the intensity of sensory attributes based on androstenone, skatole and indole levels in the neck fat, high determination coefficients (r^2) were obtained for manure after-taste and manure flavour, urine flavour ($r^2 = 0.91$).

Table 2. Model type, determination coefficient (r^2) and acceptance limit when predicting boar taint in Danish flank roll

Sensory attribute	Model type Model (r^2)	Castrate upper limit (mean + 2std)
Manure after-taste	Non-linear 0.91	2.8
Manure odour	Linear 0.88	4.4
Manure flavour	Linear 0.89	4.5
Urine after-taste	Linear 0.87	2.6
Urine odour	Non-linear 0.82	3.4
Urine flavour	Non-linear 0.87	4.3

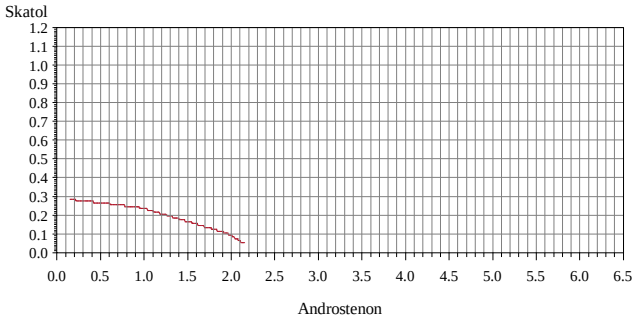

Figure 2. Summarised androstenone and skatole limit (castrate + 2 std) for Danish flank roll.

The sensory profiling showed that manure flavour is the most intense boar taint attribute in Danish flank roll, whereas urine and manure after-taste is the most critical attributes because of the low accept limit (Table 2). When castrate acceptance limits are summarised for all boar taint-related sensory attributes, it is possible to use flanks from male pigs containing skatole and androstenone levels lower than the red line (Figure 2). Therefore, the androstenone content should be below 2.1 ppm (if the skatole < 0.05 ppm), and skatole content should be below 0.3 ppm (if the androstenone < 0.2 ppm).

Smoked streaky bacon: Both androstenone and skatole have an effect on perceived boar taint in cooked bacon (not shown).

Table 3. Model, determination coefficient (r^2) and acceptance limit when predicting boar taint in bacon.

Sensory attribute	Cooking odour	Serving hot bacon	Serving cold bacon
Manure flavour	-	Linear 0.71 (4.4)	Linear 0.74 (6.3)
Pungent odour	Logarithm 0.58 (4.0)	Logarithm 0.76 (5.6)	Linear 0.67 (7.5)
Sweaty odour	Logarithm 0.48 (5.2)	Logarithm 0.78 (6.2)	Logarithm 0.46 (6.5)
Sweaty flavour	-	Logarithm 0.78 (4.7)	Linear 0.64 (5.8)
Urine odour	Logarithm 0.50 (4.0)	Logarithm 0.78 (5.6)	Linear 0.54 (7.5)
Urine flavour	-	Logarithm 0.78 (7.0)	Linear 0.72 (9.9)
Chemical odour	Constant 0.00 (10.2)	Logarithm 0.46 (7.1)	Linear 0.42 (5.8)
Chemical flavour	-	Logarithm 0.51 (7.8)	Logarithm 0.52 (7.4)

When modelling the sensory attributes based on androstenone, skatole and indole levels in the neck fat, lower determination coefficients (r^2) were obtained compared with the Danish flank roll. Nevertheless, attributes related to both skatole and androstenone (urine, manure and sweaty) had the highest determination coefficients among the descriptors (Table 3).

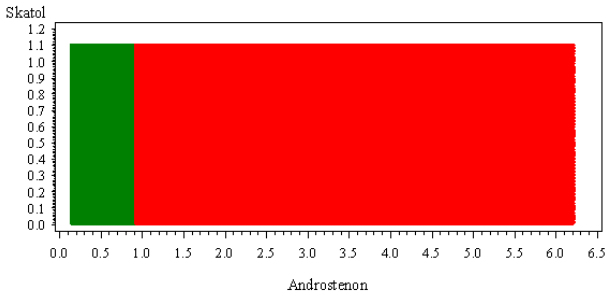

Figure 3. Summarised androstenone and skatole limit (castrate + 2 std) for odour during cooking.

Boar taint-related odour during cooking of bacon is solely correlated with the androstenone level in the neck fat. To avoid unpleasant boar taint, the level of androstenone should be less than 0.9 ppm (Figure 3).

When serving bacon hot to trained panellists, no levels of androstenone and skatole are low enough to result in boar taint intensities lower than the castrate acceptance limit. It is therefore not recommended to serve hot or heated bacon from male pigs.

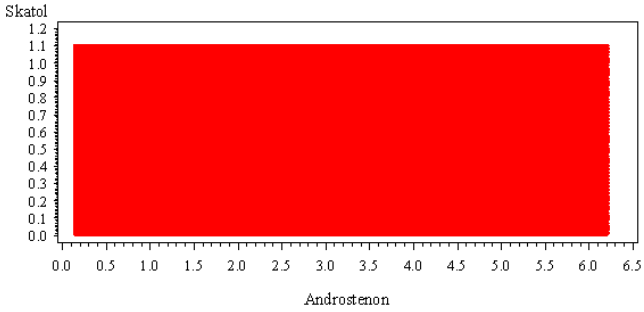

Figure 4. Summarised androstenone and skatole limit (castrate + 2 std) for hot bacon.

When serving bacon cold, unpleasant boar odours are eliminated, but the boar flavours will still be perceptible. Pungent, sweet and urine odours are the most intense attributes in hot bacon, whereas sweet and urine flavours are the most intense in cold bacon.

When processing bacon that is served cold, the bacon should never exceed 0.9 ppm androstenone and 0.8 ppm skatole in the neck fat.

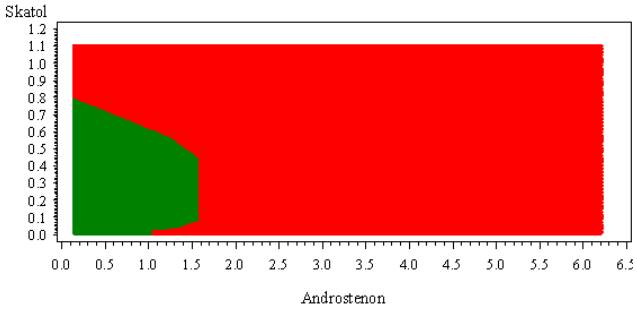

Figure 5. Summarised androstenone and skatole limit (castrate + 2 std) for cold bacon.

IV. CONCLUSION

Danish flank roll: Androstenone and skatole have a major effect on perceived boar taint. Manure flavour is the most intense attribute, whereas manure after-taste is the most critical attribute.

Smoked streaky bacon: Androstenone and skatole have a major effect on perceived boar taint in smoked streaky bacon. Androstenone is solely responsible for boar taint during cooking. Serving bacon hot is not recommended. Serving bacon cold can eliminate unpleasant boar odour, but not the boar flavour.

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