Concentrations of androstenone and skatole in neck fat and meat cuts: Are these concentrations correlated to sensory attributes?

L. Meinert, C. Bejerholm, B.W. Lund, M.D. Aaslyng and S. Støier

Danish Meat Research Institute, Meat Quality, Taastrup, Denmark

Boar taint is an unpleasant and unwanted flavour/odour that develops in some entire male pigs. The presence of the compounds skatole and androstenone are mainly responsible for the development of boar taint. In order to perform reliable sorting of the carcasses as well as optimizing the use of meat from entire male pigs it is of the outmost importance to know the distribution of flavour compounds in the carcass. In the present study, it was shown that the concentrations of skatole in both shoulder and loin were highly correlated to the content of skatole in the neck fat. The concentrations of skatole in the neck fat had furthermore a significant effect on the boar taint related sensory attributes in both the shoulder and loin. With regard to androstenone, there was a significant effect of the concentration on the boar taint related sensory attributes in shoulder and loin. However, the correlations between concentrations in the neck fat and in the cuts were not as clear for androstenone as for skatole.

I. INTRODUCTION

In Europe, the potential stop for surgical castration by 2018 is an area of focus. Many issues related to male pig production are therefore in centre of research. One of these issues is to fully understand the significance of different concentration levels of especially skatole and androstenone in neck fat of entire males in relation to the sorting out of tainted carcasses. It is highly important to establish the relationship between concentrations of skatole and androstenone in the neck fat and in the meat, and furthermore to relate these chemical analyses to the perceived eating quality. The establishment of correlations between chemically measured concentrations of boar taint compounds and the perceived eating quality is of the outmost importance in order to establish both reliable sorting criteria and to optimize the use of the carcass.

The aim of this study was to measure the concentrations of skatole and androstenone in neck fat and in the two cuts shoulder and loin, and to investigate a possible correlation. Furthermore, a goal was to link these concentrations of boar taint compounds to the sensory characteristic of the cooked meat.

II. MATERIALS AND METHODS

Pigs and meat. Selection of entire male pigs was based on the content of both androstenone and skatole in the neck fat. Fourteen male pigs and one castrate were used in the experiment. The selection was focused on obtaining a variation in skatole and androstenone levels, in order to cover both the "normal area" and some higher concentration levels. From each of the 15 pigs, neck fat and the two meat cuts shoulder and loin were collected for analysis. The samples were frozen at -20 °C until analysis.

Chemical analysis. Analysis of skatole and androstenone in both neck fat and meat cuts was performed at DMRI according to the HPLC-FD method described by Hansen-Møller [1]. However, sample preparation for the analysis of meat cuts was slightly modified. The shoulder was minced, and a subsample was analysed. From the loin, a slice of approx. 100 g was cut from one end of the muscle followed by homogenisation.

Sensory profiling. The loin was cut into 2 cm chops and fried in the pan until a core temperature of approx. 72 °C. The minced shoulder was formed into patties (100 g) and fried in a pan for a total time of 12 min. A trained panel of nine assessors performed the accredited quantitative sensory evaluation of the meat. The two cuts were evaluated

in separate sessions with prior training, in which the sensory attributes were selected.

Statistical analysis

The importance of the concentrations of androstenone and skatole in relation to the sensory attributes was analysed (SAS Institute, Cary, USA) using the model:

$$\text{Attribute} = \mu + \beta\log(A) + \beta\log(S) + \beta\log(A)*\log(S) + \varepsilon$$

Where A = androstenone and S = skatole in either neck fat or pork cut.

The effects of $\log(A)^2$ or $\log(S)^2$ were also tested, though no significant effects were seen.

III. RESULTS AND DISCUSSION

The two cuts, shoulder and loin, represent different parts of the pig: fore end and middle part. Furthermore, the cuts also represent a variation in fat content as the shoulder contained an average of 14 % and the loin approx. 1 % fat.

Table 1. Concentrations of skatole (mg/kg) in neck fat, shoulder and loin. LOQ, limit of quantification [1]

Pig no.	Fat	Loin	Shoulder
Castrate	< LOQ	< LOQ	< LOQ
11	0.04	< LOQ	< LOQ
19	0.04	< LOQ	< LOQ
22	0.05	< LOQ	< LOQ
4	0.06	< LOQ	< LOQ
10	0.09	< LOQ	0.01
30	0.12	0.01	0.03
15	0.15	< LOQ	0.02
52	0.26	0.01	0.02
51	0.26	0.01	0.03
14	0.35	0.01	0.06
38	0.37	0.02	0.06
48	0.40	0.02	0.07
47	0.47	0.02	0.07
50	0.70	0.02	0.14

Pearson's correlation coefficients for skatole in lard and in the cuts were 0.97 ($P<0.0001$) for minced shoulder and 0.91 ($P<0.0001$) for the loin.

Table 2. Concentrations of androstenone (mg/kg) in neck fat, shoulder and loin. LOQ, limit of quantification [1]. nd, not detected.

Pig no.	Fat	Loin	Shoulder
Castrate	nd	<LOQ	<LOQ
48	0.25	<LOQ	0.13
51	0.34	< LOQ	0.13
10	0.36	< LOQ	0.14
47	0.43	<LOQ	0.12
30	0.48	<LOQ	0.14
11	0.68	<LOQ	0.11
14	0.78	0.07	0.11
15	0.82	<LOQ	0.13
4	1.51	<LOQ	0.22
50	1.72	< LOQ	0.16
52	1.73	< LOQ	0.11
22	2.09	0.08	0.25
38	2.18	0.07	0.27
19	3.03	< LOQ	0.29

Pearson's correlation coefficient between the concentration of androstenone in the neck fat and in the minced shoulder was 0.67 ($P=0.009$). The coefficient was not calculated for the loin due to very few data.

From Table 1 and 2 it is readily seen that the content of both skatole and androstenone was lower in loins compared with the shoulders. In the loins, there were very few samples with a quantified content of androstenone.

The sensory profiles confirmed the presence of boar taint related flavours and odours in both patties and chops. Figure 1 shows the bi-plot of the sensory evaluation of loins.

It is seen from Figure 1 that the sensory attributes related to boar taint is highly correlated. The castrate is placed opposite the boar taint attributes, and the male pigs are distributed between the castrate (and pig no. 30) and pig no. 50 and no. 38, which had the highest intensities of boar taint. Comparing with Table 1 and 2, these two pigs are among those with the highest contents of skatole and/or androstenone.

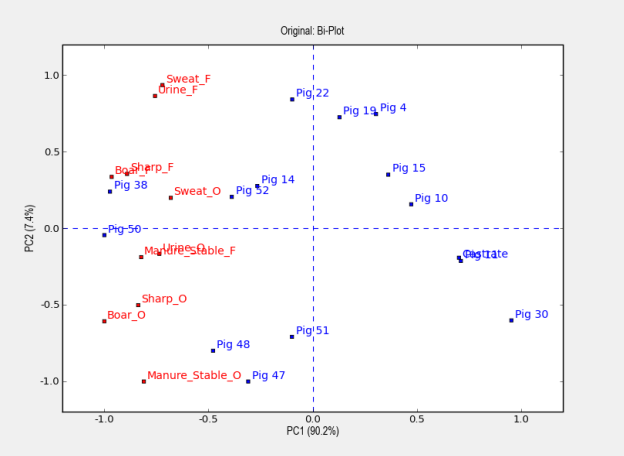

Figure 1. Bi-plot of the sensory data for loin (assessed as pan-fried pork chops). F = Flavour and O = odour.

The perceived flavours and odours were correlated to the measured concentrations of skatole and androstenone. The regression coefficients are shown in Table 3 and 4.

Table 3. Regression coefficients (β) related to the logarithm of the content of androstenone and skatole in the shoulder. Only significant coefficients (P<0.05) are shown.

	Neck fat		**Shoulder**	
	Log(A)	Log(S)	Log (A)	Log(S)
Flavour				
Boar	1.1	1.8	0.9	1.6
Sweat	1.4	1.8	4.1	1.5
Manure/Stable		1.9		1.7
Sharp	1.0	1.9	4.0	1.7
Urine/Urinal	1.4	1.9	4.8	1.7
Odour				
Boar		1.6	4.7	1.5
Sweat		1.3	1.3	3.6
Manure/Stable		1.8	3.3	1.7
Sharp		1.7	3.9	1.6
Urine/Urinal		1.6	4.5	1.5

From Table 3 it is seen that skatole in the neck fat had a significant effect on all boar taint related attributes perceived in patties. Androstenone had only an effect on boar taint flavours but not odours. However, looking at the concentrations determined in the shoulder, both androstenone and skatole had a significant effect on the boar taint attributes.

Table 4. Regression coefficients (β) related to the logarithm of the content of skatole in the loin. Log (A) was not included in the model due to a low number of samples with a content above the quantification level.

	Neck fat		Loin
	Log(A)	Log(S)	Log(S)
Flavour			
Boar	2.1	2.3	
Sweat	2.3	1.4	
Manure/Stable	1.2	2.2	
Sharp	2.0	2.1	
Urine/Urinal	2.3	1.6	
Odour			
Boar	1.4	2.9	2.9
Sweat	1.6	1.8	
Manure/Stable		2.4	2.6
Sharp	1.0	2.4	2.2
Urine/Urinal	1.3	2.0	1.8

From Table 4 it is seen that the concentrations of both androstenone and skatole in the neck fat had a significant effect on the boar taint attributes in chops. However, the skatole content in the meat had only an effect on the boar taint odour.

IV. CONCLUSION

It can be concluded that the concentrations of skatole in both shoulder and loin were highly correlated to the content of skatole in the neck fat. The concentrations of skatole in the neck fat had furthermore a significant effect on the boar taint related sensory attributes in both shoulder and loin. With regard to androstenone, there was a significant effect of the concentration on the boar taint attributes. Though not odour in the shoulder.

However, the correlations between concentrations in the neck fat and in the cuts regarding androstenone were not as clear as for skatole.

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