8:11 Relationship between boar taint and skatole determined with a new analysis method

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Introduction

In most countries the majority of male pigs are castrated early and will thus be fattened and slaughtered as castrates. The main reason for this is the well-known problem of boar taint, i.e. the unpleasant odour developed when meat from some boar pigs is cooked.

The actual incidence of boar taint seems, however, to be small as most investigators have reported incidences of less than 10% of boar carcasses (see e.g. Hansson et al. (1980), Otto & Behm (1981)). Of course, the percentages reported depend on methodology and acceptability levels.

The castration of male piglets - in itself a time-consuming process for the farmer and a health risk for the pigs - is also well-known to be disadvantageous in relation to production economy. Especially, the feed conversion ratio, the daily gain and the lean meat content of the carcass are depressed as a result of castration (Allen et al., 1981; Walker, 1978 and Wood and Riley, 1982).

The annual loss due to these factors for the Danish pig producers have been estimated to 300-530 mill. D.Kr. per year (Nyby, 1982, Lønbæk Jensen, 1982, both unpublished). A comparable estimate for the Netherlands of 165 mill. Dfl. per year has been published by Walstra & Mateman, 1982.

Although some disadvantages have been reported with entire male pigs compared to castrates, e.g. smaller killing-out percentages, higher rind contents, lower curing yields (Kempster and Cuthbertson, 1982; Smith et al., 1983; Wood & Riley, 1982) it seems obvious that large savings could result from producing intact male pigs instead of castrates. This would, however, require that methods for sorting out the small number of tainted carcasses were available to the industry, or even better that the formation of boar taint could be prevented.

Identification of compounds responsible for boar taint has been a research object in several countries for some years. Relatively early the compound androstenone (5α-androst-16-en-3-one) was identified as contributor to boar taint (Patterson, 1968), and since then most investigations have concentrated on this and chemically related compounds (reviewed by Bonneau, 1982). It seems now well established that a significant relationship exists between occurrence of boar taint and concentration of androstenone in the carcass.

On the other hand the magnitude of the correlation coefficients reported is very variable and only in few cases exceeds 0.60 (Bonneau, 1982). It should also be noted that in several investigations the organoleptic taste panels have been trained and selected for their ability to detect androstenone (e.g. Cowan & Joseph, 1981; Førland et al., 1980; Walstra, 1981; Walker, 1980; Cliplef & Strain, 1981, Otto & Behm, 1981). Other things being equal this must have contributed to increase the correlations reported. The significance of androstenone for boar taint might thus have been overestimated a little.

Another family of compounds which has been investigated in relation to boar taint is indole and its derivatives, especially skatole (3-methyl-indole) (Vold, 1970). Later investigations by Hansson et al. (1980) confirmed that a significant relationship exists between boar taint and skatole content.

An interesting finding reported by Hansson et al. (1980) was a significant positive correlation between androstenone and skatole content in boars. The methods used so far for skatole determination in meat are based on GLC and require considerable efforts for destillation, extraction etc. (Hansson et al., 1980).

With the aim of obtaining a less complicated and faster method to allow for larger investigations and possibly for industrial applications, a simple method for the determination of skatole in adipose tissue from boars has been developed.

Material and methods

The boars investigated were obtained from two sources:

1. A test production of entire males carried out at two commercial farms in Jutland. A total of 1865 boars were raised to normal bacon weight (90 kg live weight at slaughter) during the period November 1980 - December 1981. In both herds boars and gilts were penned together. All boars were killed at the same slaughterhouse, and a pre-evaluation of carcasses for boar taint was carried out the day after slaughter by heating a fat sample from the belly and judging it for strength of boar taint on a 3-level scale. Based on this evaluation a total of 157 boars were selected for further analysis, so that a test material with higher incidence of boar taint than found in the total material could be used in the experiment.

2. 44 entire males were selected at random from the Danish Pig Breeding Station at Bøggildgård These animals were slaughtered at a live weight of 90 kg. During the fattening period each boar was kept in a pen together with one gilt and one castrate.

The two data sets were combined in the following analysis.

Samples for analysis and taint evaluation were taken from the belly of each carcass. The samples were frozen the day after slaughter and kept at temperatures not higher than -18°C.

Taint evaluation was carried out by a panel consisting of 3-4 laboratory technicians. Belly samples were freed of rind and meat, placed in a conical flask and heated dry on a hot plate. Evaluation was carried out several times during the heating process. Each panel member assessed the taint using a scale from 0 to 3, where:

0 = no boar taint
1/2 = doubtful
1 = slight boar taint
2 = some boar taint
3 = strong boar taint.

The result for each sample was calculated as the arithmetic mean of the judges' scores.

Taste panel evaluation. Samples of belly were cured and sliced. Individual slices were placed in closed petri dishes and heated in an oven until seething, but no browning was achieved. Immediately after this the petri dishes were presented to a taste panel consisting of 9 housewives. The panel members were experienced in organoleptic evaluation of meat and meat products, but were not selected for their taint sensitivity.

Each judge assessed the samples for boar taint, flavour and overall impression. The scale used was in all three cases from -5 to +5, where -5 = very strong taint/bad flavour/bad overall impression, 0 = neither good nor bad, and +5 = excellent smell/flavour /overall impression. The result for each sample was calculated as the arithmetic mean of the judges' scores.

Chemical analysis. The samples were analysed for skatole and skatole-like substances by the following specially developed method:

4 g of fat is taken from the fat layer just beneath the rind. The sample is minced and mixed with 40 ml of a 3:1 mixture of acetone p.a. and 0.1 M Tris (pH 7.5), 0.001 M Na_2SO_3. After thoroughly mixing the sample is filtered through filter paper. Colour reagent is prepared by dissolving 8 g 4-dimethylaminobenzaldehyde in 480 ml 99.9% ethanol p.a., addition of 240 ml conc. H_2SO_4 and 80 ml dist. water. Colour reaction is performed by mixing the filtered extract with colour reagent in the ratio of 0.7:1. After 3 to 5 minutes the absorption at 580 nm is read on a spectrophotometer. The measurements are compared with a standard curve obtained with standard solutions of 0-1 ppm skatole in acetone - tris buffer.

The analysis was further automated by the Technicon II system equipped with a non-standard analytical cartridge, as shown in Figure 1.

As the analysis procedure is not very specific, it cannot be excluded that compounds with similar chemical characteristics interfere with the analysis. For this reason, the results are presented as skatole equivalents (SE-units).

Results

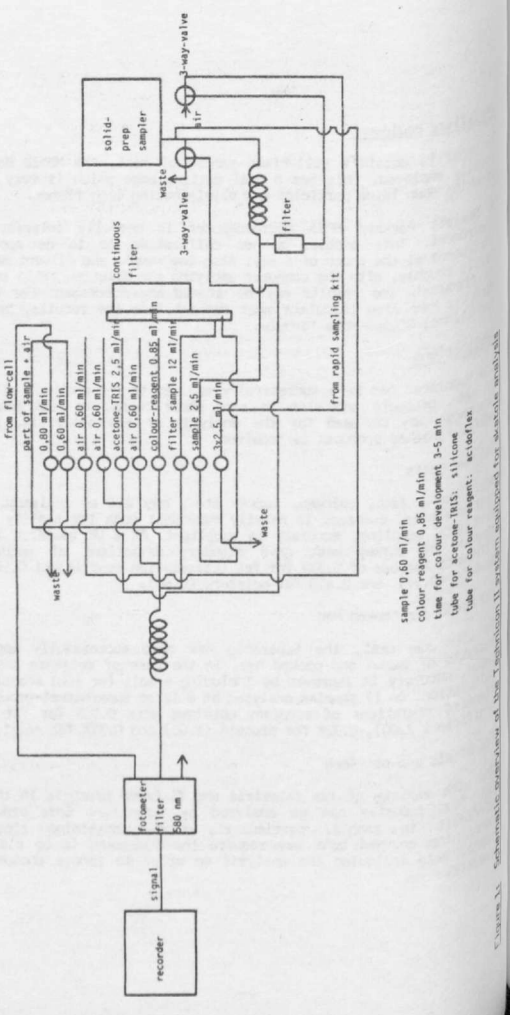
Skatole equivalent analysis

Means and standard deviation for skatole equivalents (SE) for 201 analysed carcasses are shown in table 1, whereas the distribution of the results is presented in Figure 2. It appears that the distribution of the results is very skewed, with a coefficient of skewness of 2.73***.

Table 1: Mean and standard deviation of skatole equivalents (ppm) in fat samples of 201 boar carcasses

	Mean	Standard deviation	Minimum value	Maximum value	Coefficient of skewness
Skatole equivalents (ppm)	0.136	0.168	0.0	1.0	2.73

Whereas the mean and distribution in Table 1 and Figure 2 are based on single determinations, the accuracy of the results was assessed by making double determinations on a subset of 120 fat samples. The two determinations were made within one day for each pig in order to prevent deterioration of the fat samples, but were run in separate analysis series, each consisting of 6 or 12 samples with blanks and liquid skatole standards in between.



Based on this procedure, a coefficient of correlation between repeated single determinations of r = 0.94*** with a residual standard deviation of 0.036 SE-units was calculated. The limit of detection was found to be in the range of 0.02-0.04 SE-units, and recovery of skatole injected into fat samples before emulsification and extraction varied between 95 and 105%.

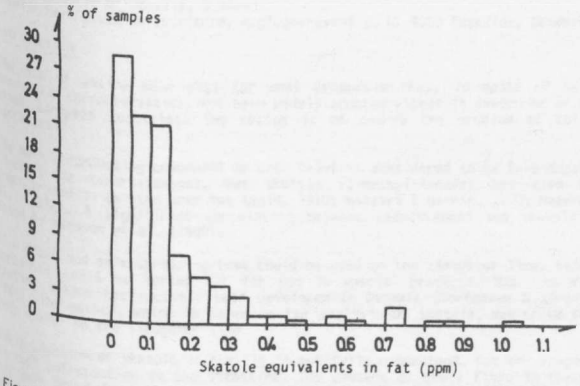


Figure 2: Distribution of the 201 samples of boar fat on content of skatole equivalents

The less than optimal accuracy in the existing analysis set-up is mainly believed to be due to the fact that the Technicon system is operated at close to maximum sensitivity, for measurement of the very small concentrations. Thus, frequent insertions of standards for correction of base line drift and thorough control of temperature and reagents is necessary to obtain acceptable results.

A small part of the residual variation is believed to be due to variation between samples taken within the same carcass.

Organoleptic assessment for boar taint

Organoleptic assessment of meat quality, in this case the level of boar taint, is well known to have severe limitations, being subjective and subject to error and bias in its nature. Nevertheless, the method is inexchangeable as reference for analytical procedures dedicated to describe quality, in this case acceptability of odour and taste.

As earlier described, the assessment of boar taint level was carried out by a trained laboratory panel. To ensure that this system was reproduceable and not biased in favour of the importance of skatole, it was considered important to compare the results from the laboratory panel to an assessment made by a general taste panel without any knowledge of the chemical background for boar taint.

The result of this comparison, which was carried out on 60 boar samples, is shown in Figure 3. The dotted reference lines on the plots represent preliminary acceptance levels, based on discussions with the panel after the test was made.

It can be seen that a good agreement in acceptance/non-acceptance could be demonstrated between the two panels. Although the relationship was not purely linear, a coefficient of correlation of -0.78 was found between the two assessments ($p < 0.0001$).

During the evaluation by the taste panel, 15 of the samples were presented twice in random order and assessed independently. The correlation between the two assessments was calculated to r = 0.80 ($p<0.001$). Thus, it seems that the correlation between the two panels were of the same order of magnitude as the reproducability of one taste panel.

The distribution of the taint level scores in the 201 samples, based on the laboratory panel evaluation, is shown in Figure 4.

The distribution of taint scores is very skewed, as were the skatole analysis results. Approximately 12% of the carcasses had taint scores above the preliminary acceptance level for consumption as roast/cooked pork.

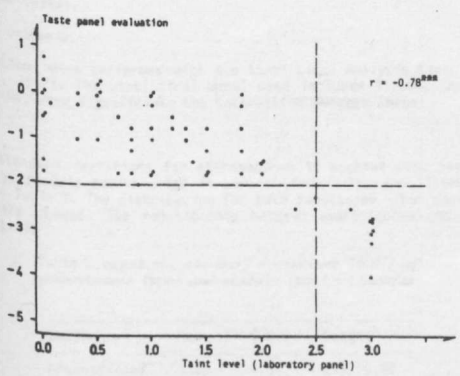


Figure 3: Plot of organoleptic taint evaluation by a standard taste panel against taint levels determined by the ad hoc laboratory panel

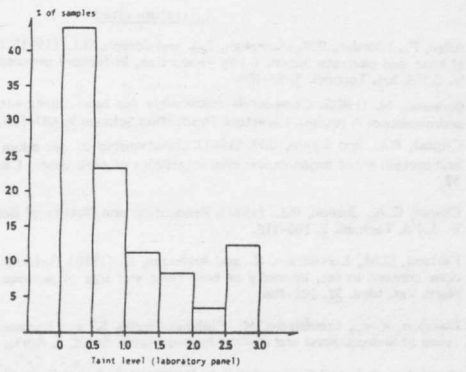


Figure 4: Distribution of the 201 fat samples on taint level assessed by the ad hoc laboratory panel

Relationship between taint and skatole equivalent concentrations

A plot of taint level scores against SE-units in fat samples is shown in Figure 5.

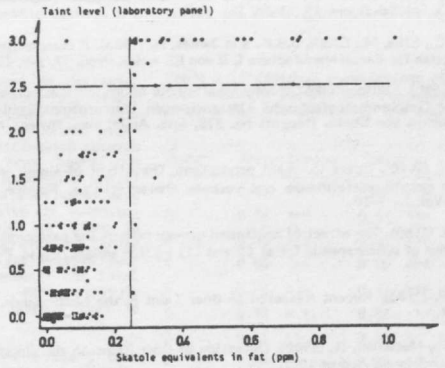


Figure 5: Plot of taint level against content of skatole equivalents in fat

It can be seen in Figure 5 that the relationship is far from linear. This is mainly a result of the taint scale used, as the taint score 3 = "strong boar taint" covers a wide variation in taint, in all cases above the level of acceptability. For statistical purposes, it might have been better to extend the scale to 5 or even higher. From at practical point of view the discrimination between acceptability and non-acceptability is, however, the matter of importance. The coefficient of correlation between taint and chemical analysis - however inadequate to describe the non-linear relationship - was calculated to r = 0.73 ($p < 0.0001$).

By using the preliminary acceptance level of taint score = 2.5, an optimal sorting level of 0.24 ppm skatole equivalents could be found. The two limits are represented as dotted lines in Figure 5.

The taint classification results are summarized in Table 2, using the 0.24 ppm limit.

Thus, a total of 6 samples (3%) have been incorrectly classified by the chemical analysis. Of these, however, only one seriously tainted sample has been classified as not tainted. 5 acceptable samples were classified as tainted by the chemical analysis. These samples were very close to the sorting limit of 0.24 ppm (see Figure 5).

Table 2: Number of acceptable and not acceptable fat samples falling below or above 0.24 ppm skatole equivalents

Organoleptically:	Skatole equivalent content		Total
	< 0.24 ppm	≥ 0.24 ppm	
Acceptable	169	5	174
Not acceptable	1	26	27
Total	170	31	201

Discussion

The results reported here indicate that the relatively simple spectrophotometric analysis for skatole and possibly related compounds is surprisingly well suited as an objective distinction between samples of boar fat with none or little boar taint, and unacceptably tainted samples. Based on the correlations reported, it seems in fact that the correlation between the chemical analysis and organoleptic assessment is of the same magnitude as the reproducability between different organoleptic assessments. The relationship between taint and skatole equivalents seems to be stronger than that reported by Hansson et al. (1980), possibly because of the different method employed. Thus, recovery of skatole with the present method is close to 100%, whereas Hansson et al. using the GLC-method reported a recovery of 47%. Also, the relationship demonstrated here seems to be stronger than the majority of correlations reported between boar taint and androstenone.

We do of course not claim that the relationship between androstenone and boar taint is of no importance, but merely that a screening of samples by the present method seems to give a better security for quality ensurance purposes than is indicated by most of the reported androstenone results. Of course the interrelationship between the two compounds as demonstrated by Hansson et al. (1980) should be borne in mind.

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