SKATOLE - ANOTHER CONTRIBUTOR TO BOAR TAINT

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INTRODUCTION

In Sweden all male pigs used for meat production are castrated in order to prevent boar taint. On the other hand, because of the better production characteristics of uncastrated pigs it would be far better not to castrate (e.g. Hansson et al., 1975).

In order to avoid the marketing of carcasses with pronounced boar taint, procedures for identifying such carcasses must be developed. The identification of tainted carcasses on the slaughter line can be done with the use of the subjective soldering iron method (Jarmoluk et al., 1970), and carcasses classed as non-tainted can probably be sold without restriction. However, objective and simple instrumental methods are preferable.

One compound considered to be the main contributor to boar taint is 5α-androst-16-ene-3-one (androstenone). Correlations between androstenone and boar taint determined by sensory evaluation have been reported to vary from 0.4 to 0.7 (for review, see Malmfors et al., 1978). This magnitude indicates the possible presence of as yet unidentified compounds that might contribute to the taint. In 1970, Vold isolated a strong-smelling compound from boar fat which he proposed to be skatole (3-methyl-indole). The presence of skatole in boar fat has also been demonstrated in other studies (Walstra & Maarse, 1970; Maarse et al., 1972). Both indole and skatole are products of putrefaction, and both are strong-smelling substances. Each of them may thus contribute to the taint.

In the present study a chemical method has been applied for the analysis of skatole and indole in boar fat. The concentrations in fat of these two compounds as well as of androstenone have been correlated to the sensorially determined boar taint.

MATERIAL AND METHODS

Boar taint intensity and the concentrations of 5α-androstenone, indole and skatole were investigated in samples from back fat taken from 84 boars at slaughter. In addition, sensory evaluation and analyses of skatole and indole were performed on fat samples from 16 castrates and 11 gilts. Sensory evaluation only was made of fat samples from a further 38 boars, 7 castrates and 113 gilts. Crosses between Swedish Landrace and Swedish Yorkshire and between Hampshire and the other two breeds were used in the investigation. During rearing, all sexes were kept in the same building but gilts and boars were in separate pens, with or without snout contact.

Chemical analysis

5α-androst-16-ene-3-one (androstenone) in fat was determined according to the extraction and radioimmunological procedure described by Andresen (1975).

Skatole and indole were isolated from fat by steam distillation and extracted simultaneously with *n*-pentane in an apparatus as described by Likens (1964) and also used by Maarse et al. (1972). The extract was further concentrated before submitting it to gas liquid chromatography (GLC). 2-methyl-indole was used as internal standard. A more detailed description of the extraction procedure will be published elsewhere (Hansson et al., 1980).

To make possible calculation of the correlation between independent extractions, fat was distilled and extracted in duplicate in a limited number of samples (n = 36). All samples were analysed in duplicate by GLC. Mean values were used in the statistical analysis, except when precision of the methods was calculated.

Sensory evaluation

The olfactory tests were done by heating the fat samples to 150°C with the tip of a soldering iron (Jarmoluk et al., 1970). The intensity of back fat boar taint was evaluated by a trained panel of 10-12 members. The samples were judged according to a 3-point scale, where 0 = no boar taint, 1 = obvious boar taint, and 2 = strong boar taint.

Statistical analysis

All calculations were done with the Statistical Analysis System (Barr et al., 1976). The difference between the three sexes was tested with sex only in the statistical model. Among boars, the effects of breed cross and

manner of snout contact were evaluated simultaneously. Although the interaction between these effects was non-significant and therefore ignored in the model, separate analyses was also made within each breed cross. The effect of pen nested within manner of contact was tested for the Hampshire breed cross.

RESULTS

Precision of methods

The recovery of skatole was 44-47%. No corrections for procedural losses were made and the skatole and indole concentrations are therefore not to be regarded as absolute values.

The correlation between duplicate extractions or duplicate GLC analyses were used as a measure of the precision of the analysis (Table 1). The results indicate high precision except for the extraction of indole.

Table 1. *Accuracy of the measure of androstenone, skatole and indole, expressed as overall correlations*

Substance	Between duplicate extractions	Between duplicate GLC analyses
Androstenone	0.97	—
Skatole	0.98	0.94
Indole	0.63	0.93

Effect of sex, breed and manner of contact

Among the 269 fat samples analysed sensorially, weak taint was detected in all three sexes, while strong taint was found in boars only. The distribution of the boar taint intensity for the different sexes is shown in Figure 1.

Means and standard deviations for the substances studied as well as the differences between sexes for boar taint, skatole and indole are presented in Table 2. As expected, boars had a higher boar taint intensity than castrates and gilts ($P \leq 0.001$), but for skatole, no difference was found ($P > 0.05$). Castrate samples had a larger indole content than those of boars and gilts ($P \leq 0.01$).

Among boars, no difference in taint intensity or the concentration of androstenone, skatole or indole could be found between the different breed crosses. Boars without snout contact with gilts had a higher concentration of skatole ($P \leq 0.05$) compared to those with snout contact, but showed no difference in androstenone or indole concentration ($P > 0.05$). The effect of manner of contact was analysed further with separate analyses for each breed cross. Only the Hampshire breed crosses had a higher skatole concentration ($P \leq 0.01$) when boars were reared without snout contact with gilts. When a separate analysis was made of the effect of pen, nested within manner of contact, it was found that the skatole concentration differed between pens ($P \leq 0.05$) but not between manner of contact. High concentrations of skatole were found in one pen situated in a corner of the building. Here the mean skatole value was 0.12 µg/g fat compared with the overall mean value for boars of 0.07 µg/g.

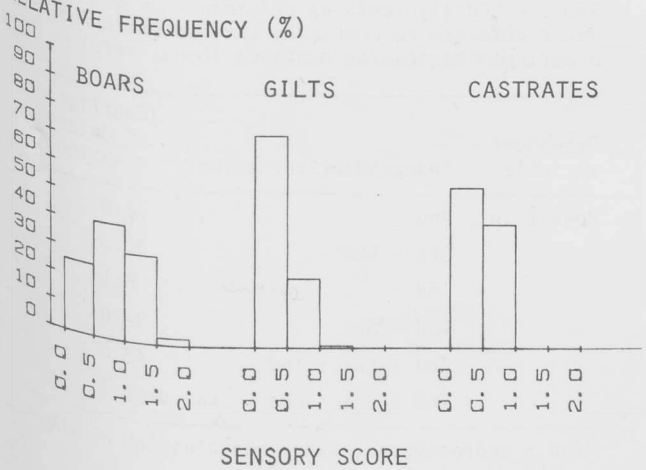

Figure 1. The distribution of boar taint intensity for boars, gilts and castrates.

Relationships between boar taint, androstenone, skatole and indole

Correlations between boar taint, androstenone, skatole and indole are presented in Table 3. Among boars, both linear and quadratic relationships between taint intensity and androstenone, skatole, and indole were calculated. The relationship between taint and androstenone as well as taint and indole was found to be linear, while the relationship between boar taint and skatole was quadratic (Figure 2).

Multiple regression analysis was used to study how much of the variation in boar taint could be accounted for (coefficient of determination) by the various substances, either alone or in different combinations (Table 4). The coefficients of determination between boar taint and androstenone, skatole, and indole were 36%, 33% and 7% respectively. Combining androstenone and skatole increased the coefficient of determination to 43.0%, but the addition of indole did not increase the coefficient any further. The highest coefficient of determination, 49.7%, was found when a combination of the individual components and the product of androstenone and skatole was used.

Table 2. *Means ($\bar{x}$) and standard deviations (S.D.) for boar taint, androstenone[a], skatole, and indole and levels of significance for the effect of sex*

Substance	Sex: Boars (♂, n=83) $\bar{x}$	S.D.	Castrates (⚲, n=16) $\bar{x}$	S.D.	Gilts (♀, n=11) $\bar{x}$	S.D.	Level of significance	Significant differences
Boar taint, points	0.79	0.39	0.41	0.25	0.36	0.30	***	♂-⚲; ♂-♀
Androstenone, µg/g fat	0.63	0.68	—	—	—	—	—	—
Skatole, µg/g fat	0.07	0.12	0.02	0.04	0.01	0.03	n.s.	—
Indole, µg/g fat	0.04	0.01	0.06	0.04	0.04	0.01	*	⚲-♂; ⚲-♀

[a]Androstenone was determined in boars only.
Levels of significance: n.s. = not significant ($P > 0.05$); * = $P \leq 0.05$; *** = $P \leq 0.001$.

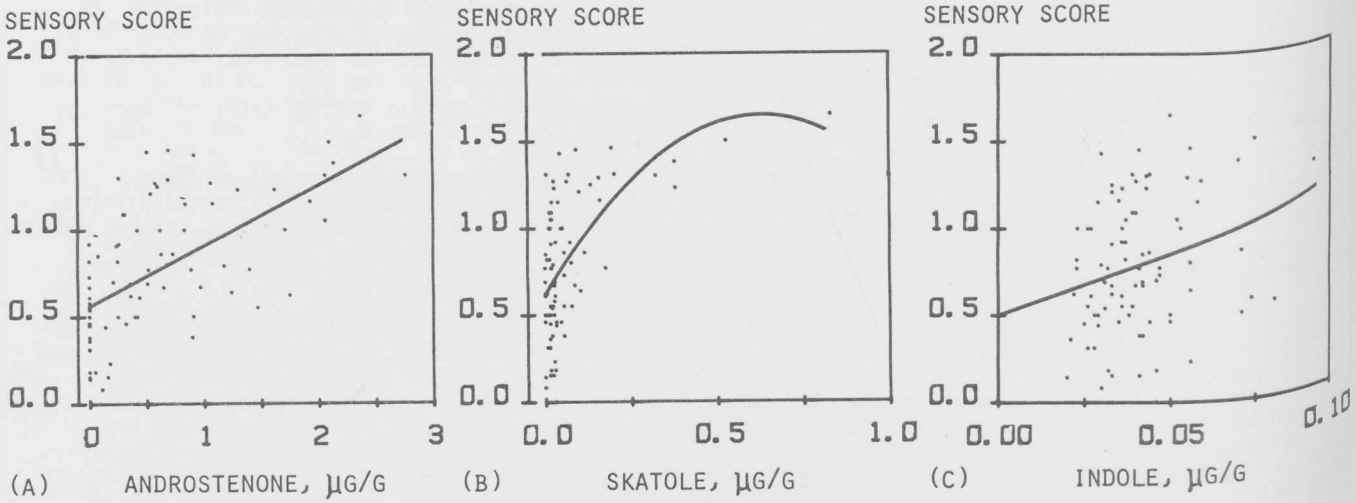

Figure 2. Relationship between boar taint intensity and (a) androstenone, (b) skatole, (c) indole.

Table 3. *Overall correlations between boar taint, androstenone[a], skatole and indole*

	Sex: Boars	Castrates	Gilts
Boar taint			
- androstenone	0.60 ***	—	—
- skatole	0.53 ***	0.10 n.s.	0.29 n.s.
- indole	0.26 *	0.17 n.s.	-0.05 n.s.
Androstenone			
- skatole	0.54 ***	—	—
- indole	0.24 *	—	—
Skatole			
- indole	0.31 **	0.76 ***	0.39 n.s.

[a]Androstenone was determined in boars only.
Levels of significance: n.s. = not significant ($P > 0.05$); * = $P \leq 0.05$; ** = $P \leq 0.01$; *** = $P \leq 0.001$.

Table 4. *Coefficients of determination for boar taint obtained by combining various variables in a multiple regression analysis (boars only)*

Dependent variable	Independent variables[a]	Coefficient of determination, %
Boar taint	And	35.9
	Ska + Ska^2	33.3
	Ind	6.9
	And + Ska	43.0
	And + Ska + Ind	43.0
	And + Ska + And x Ska	49.7

[a]And = androstenone; Ska = skatole; Ind = indole.

DISCUSSION

This study has demonstrated the presence of skatole and indole in fat tissue from boars, castrates and gilts. Skatole has previously been identified in fat from boars by Vold (1970) and Walstra & Maarse (1970) and also quantified by Maarse et al. (1972). Walstra (1974) reports, however, that it was not possible to detect skatole in fat samples from gilts. The importance of skatole and indole for the presence of "off-odour" in fat from castrates and gilts is still not confirmed, as the correlations between taint and both skatole and indole were low ($P > 0.05$) for these two sexes.

Among boars, skatole (but not indole) increased the degree of explanation for the taint. The finding here of a significant interaction between androstenone and skatole is of interest. Skatole probably enhances the sensory impression of boar taint to a higher degree than could be explained by the actual androstenone concentration. Thus the androstenone content alone can probably not be used as an indicator of boar taint, as was also pointed

out by Walstra (1974). Both in our study and in that of Walstra (1974), skatole increased the score given for boar taint intensity. Due to the still very time-consuming method of analysis for skatole and the need for large fat samples (ca 15 g), this substance cannot be used in selection experiments against boar taint, for example. Jonsson & Andresen (1979) have used both androstenone concentration and the intensity of taint when selecting animals. This combination increased the heritability slightly compared with androstenone alone. Willeke and co-workers (1980) used androstenone alone in their selection experiment against boar taint, and have after 3 generations of selection achieved a very high reduction in androstenone concentration. The realized heritability was about 0.4.

As skatole and indole are putrefaction products of tryptophan, formed in the digestive tract, the presence of these substances may be influenced by the environment to a higher degree than endogenous products such as androstenone, as indicated by our results. Even so, the storage of skatole and indole in the body may have a genetic variation.

Crosses between Swedish Landrace and Swedish Yorkshire had the same intensity of boar taint and the same concentrations of androstenone, skatole and indole as crosses between these two breeds and Hampshire. Distinct breed differences were found by Bonneau et al. (1979) who reported that Piétrain boars had higher average concentrations of androstenone than Belgian Landrace boars. Even at 90 kg the frequency of tainted carcasses was high in Piétrain, but not so in Belgian Landrace. Results obtained by Malmfors et al. (1978) indicate that the same concentration of androstenone gave a higher intensity of taint in Swedish Landrace than in Sweidsh Yorkshire boars.

The rearing form when boars are to be used for meat production is still not established. We found no differences when boars had snout contact with gilts, either as regards boar taint intensity or in the concentrations of androstenone and indole. Walker (1979) found a higher incidence of tainted boars in 5 out of 11 replicates when they were reared with gilts in the same pen. As sexual excitement can be supposed to increase androstenone production (Andresen, 1976; Claus & Alsing, 1976) separate buildings for boars may be a matter to reduce this problem. To use the same building but exclude mixed-sex pens or merely to prevent snout contact is probably of little value. The difference in skatole concentration due to pen may be explained by digestive disturbances among the pigs in a specific pen resulting in higher skatole concentrations.

The distribution of boar taint intensity found, with only a few boars showing strong taint, is in agreement with Malmfors & Hansson (1974) and Walstra (1974). Whether or not only the strongly tainted boars must be excluded from the fresh meat market has not been adequately investigated, however.

If boars are used for meat production, but the market requires that no tainted products be sold, a reliable objective analysis for boar taint would be of great help. As far as is known at present, androstenone and skatole both contribute to boar taint. Fatty acid composition too has a certain influence (e.g. Malmfors et al., 1978; Bonneau et al., 1979). Further investigations are needed to establish whether there are other substances of importance for the intensity of the taint. It might then be possible to develop a rapid and instrumental method of analysis.

Our results indicate that skatole contributes to boar taint to a somewhat lesser extent than androstenone. Nevertheless, while in our opinion almost everyone is sensitive to the smell of skatole, it is a fact that not all persons are sensitive to the smell of androstenone. Consequently it is possible that skatole may have a still greater influence on the flavour at the time of consumption of boar meat then these results show.

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REFERENCES

Andresen, Ø. 1975. *Acta Endocr. 76*, 619-624.
Andresen, Ø. 1976. *J. Reprod. Fert. 48*, 51-59.
Barr, A.J., Goodnight, J.H., Sall, J.P. & Helwig, J.I. 1976. *A user's guide to SAS*. Raleigh, N.C.
Bonneau, M., Desmoulin, B & Dumont, B.L. 1979. *Ann. Zootech., 28*, 53-72.
Claus, R. & Alsing, W. 1976. *Berl. Münch. Tierärztl. Wschr. 89*, 354-358.
Hansson, I., Lundström, K. & Malmfors, B. 1975. *Swedish J. Agric. Res. 5*, 69-80.
Hansson, K.-E., Lundström, K., Fjelkner-Modig, S. & Persson, J. 1980. To be submitted for publication in *Swedish J. agric. Res.*
Jarmoluk, L., Martin, A.H. & Fredeen, H.T. 1970. *Can. J. Anim. Sci. 50*, 750-752.
Jonsson, P. & Andresen Ø. 1979. *EAAP, Commission on Pig Production*, Harrogate.
Likens, S.T. & Nickersson, G.B. 1964. *Am. Soc. of Brewing Chemists, Proc. 5*, 5-13.
Maarse, H., Moerman, P.C. & Walstra, P. 1972. *I.V.O. - Rapport C-180 and Rapport No. 3 Researchgroep Vlees en Vleeswaren T.N.O.*, Zeist.
Malmfors, B. & Hansson, I. 1974. *Livestock Prod. Sci. 1*, 411-420.
Malmfors, B., Lundström, K. & Hansson, I. 1978. *Swedish J. agric. Res. 8*, 161-169.
Walker, N. 1978. *Record Agric. Res. Nth. Ireland 26*, 7-10.
Walstra, P. 1974. *Livestock Prod. Sci. 1*, 187-196.
Walstra, P. & Maarse, H. 1970. *I.V.O. - Rapport C-147 and Rapport No. 2 Researchgroep Vlees en Vleeswaren T.N.O.*, Zeist.
Willeke, H., Claus, R., Pirchner, F. & Alsing, W. 1980. *Z. Tierzücht. ZüchtBiol.* In press.
Vold, E. 1970. *Report no. 238*. Institute of animal genetics and breeding, NLH, Vollebekk, Norway.