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Sensory emphasis on pork quality related to the diet content of fermentable fibre-rich feedstuffs (chicory and lupine) with special emphasis on the effect on boar taint

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Abstract

Boar taint in entire male pork is caused by skatole and androstenone and other compounds such as indole. However, female pigs also produce skatole and indole. The purpose was to minimise boar taint related to skatole by feeding entire male and female pigs with fibre-rich feedstuffs. An organic, 10% dried chicory or 25% lupine diet was applied for either 7 or 14 days before slaughter. Lupines significantly reduced skatole in backfat for both genders whilst chicory showed no significant differences in this respect. From a sensory perspective, chicory and lupine reduced boar taint since odour and flavour of manure related to skatole and urine associated to androstenone were minimised. The level of boar taint in the entire male pigs was mainly reduced after 14 days by both chicory and lupine while the "boar" taint in female pigs was mainly reduced by lupine.

Keywords: Chicory, lupine, boar taint, sensory profiling, skatole, androstenone

1. Introduction

Boar taint is primarily caused by skatole and androstenone and other compounds such as indole (Mortensen & Sorensen, 1984; Patterson, 1968; EFSA, 2004). Skatole is produced of both male and female pigs from the metabolism of the amino acid tryptophan in the large intestine while androstenone is a male steroid pheromone (EFSA, 2004; Zamaratskaia, 2004; Aldal, Andersen, Egeli, Haugen, Grødum, Fjetland & Eikaas, 2005).

A study has demonstrated that 10% dried chicory or more in the feed significantly reduced skatole in the blood and backfat of entire male pigs after 7, 14 and 21 days of feeding. This resulted in a significant reduction in perceived boar taint, related to skatole, and thus improved the flavour and taste of meat produced from entire male pigs (Byrne & Hansen, 2005; Hansen, 2005). Also, 25% lupine-based diet during the whole fattening period have shown to reduce skatole levels in castrated male and female pigs (Hansen & Claudi-Magnussen, 2004; Claudi-Magnussen & Hansen, 2005).

Sensory profiling is a method in which a panel uses a developed sensory vocabulary to describe perceived sensory characteristics in a sample set. Sensory profiling has previous been applied in the evaluation of the level of boar taint (Dijksterhuis, Engel, Walstra, Font I Furnols, Agerhem, Fischer, Oliver, Claudi-Magnussen, Siret, Béague, Homer & Bonneau,, 2000; Banon, Costa, Gil & Garrido, 2003; Byrne, Thamsborg & Hansen, 2007). Sensory boar taint is perceived during cooking and eating, and is described to have a distinctive and unpleasant characteristic odour and flavour (EFSA, 2004). Skatole is mostly associated with sensory descriptors such as manure and androstenone is mostly related to urine (Dijksterhuis et al., 2000). The results from a sensory profiling can be interpreted alone or in combination with for instance chemical measurements to elucidate possible underlying predictive and causal relationships.

The aim of the study was from a sensory perspective to investigate the potential to reduce boar taint at high and low levels in pork meat by feeding male and female pigs with 10% dried chicory roots or 25% blue lupine seeds for 7 and 14 days prior to slaughter. Thus, it was meant to emphasis the difference between the feeding types and to elucidate the importance of the feeding days prior to slaughter. The focus was on the effect of the non-digestible oligosaccharides in the diet, thus only the skatole concen-

tration in the back fat was included in the data analyis. Androstenone was not measured but sensory descriptors such us urine odour and flavour corresponding to androstenone were included in the sensory profiling to enable tracking of this aspect of taint.

2. Material and Methods

2.1 Dietary treatments

The experiment included 48 pigs (24 entire males and 24 females). At an avg. live weight of 90 kg, the pigs were assigned to one of the three feeding treatments (control (CON), 10% dried chicory (DC), 25% blue lupine (LUP)) according to their live weight, litter and gender (Table 1). The live weight at slaughter day was between 100-108 kg.

Table 1: Experimental design for the feeding period of the three treatments with organic concentrate (CON), 10% dried chicory (DC) and 25% blue lupine (LUP) for 7 or 14 days.

Gender	Feeding type	Feeding days	No. of pigs
Entire male pigs	CON	7	4
		14	4
	DC	7	4
		14	4
	LUP	7	4
		14	4
Female pigs	CON	7	4
		14	4
	DC	7	4
		14	4
	LUP	7	4
		14	4

2.2 Skatole in back fat

Backfat samples from the neck region were taken 45 minutes post mortem for determination of skatole equivalents at the Danish Crown, Ringsted, Denmark. Skatole equivalents in backfat were measured by the automatic spectrophotometric method described by Mortensen & Sorensen (1984) at the abattoir Danish Crown, Ringsted, Denmark.

2.3 *Sensory profiling*

2.3.1 Selection of panellists

The selection of panellists for profiling was carried out in accordance with ISO 1993; 1994a, b. Overall, panellists participated in the sensory profiling were required to display sensitivity to skatole and androstenone, and be able to describe each compound from the perspective of their common unpleasant sensory odour. The potential candidates were recruited from the public and students of University of Copenhagen, Faculty of Life Science, Frederiksberg, Denmark. The sensory panel consisted of one male and nine females in the age range 20-56 years.

2.3.2 Sample preparation for sensory profiling

Muscle *M. Longissimus dorsi* (LD) was used for sensory profiling. All muscles were stored vacuum packed in darkness at –22ºC. Prior to cutting, muscles were held at 4ºC for approximately 12 hours to ease slicing. Muscles were cut into chops of approximately 1 cm thickness. Due to the limited length of the LDs, each chop was halved. Individual chops were subsequently vacuum-packed in oxygen impermeable plastic laminate bags and stored at –22ºC for up to one week before the sensory profiling. Prior to the sensory profiling, the chops were thawed and subsequently removed from their vacuum bags for oven-cooking at 150 ºC 3 minutes a side. The samples were immediately served to the panellists. The average serving temperature was 68ºC.

2.3.3 Descriptive sensory vocabulary development

Prior to the sensory profiling, the sensory panel developed a sensory vocabulary (Table 2) to describe and discriminate the pork samples of sensory characteristics (see Byrne, Bak, Bredie, Bertelsen & Martens, 1999; Byrne, O´Sullivan, Dijksterhuis, Bredie & Martens, 2001).

Table 2: List of the 17 sensory descriptors and an acceptability question with definitions for the sensory profiling of the pork samples of the three treatments with organic concentrate, dried chicory and blue lupine for 1 or 2 weeks prior to slaughter [a]

	Term	Definition with reference materials
	Odour	*Odour associated with*
1	Fresh_cooked_pork_meat-O (frisk stegt svinekød)	Oven-cooked pork meat with no surface browning
2	Boiled_broiler-O (kogt fjerkræ)	Extract from boiled broiler
3	Stable/piggy-O (stald/dyr)	Solution of mixture of skatole and androstenone
4	Urine-O (urin)	Pure androstenone
5	Manure-O (gødning)	Pure skatole
6	Sweat-O (sved)	Cooked pork meat from entire male pigs pre-evaluated to contain a lot of sweat
	Flavour	*Aromatic taste sensation associated with*
7	Fresh_cooked_pork_meat-F (frisk stegt svinekød)	Oven-cooked pork meat with no surface browning
8	Boiled_broiler-F (kogt fjerkræ)	Extract from boiled broiler
9	Fresh_sour-F (frisk syrlig)	Mixture of Greek yoghurt and natural yoghurt 1:1
10	Stable/piggy-F (stald/dyr)	Solution of mixture of skatole and androstenone
11	Urine-F (urin)	Pure androstenone. Reference presented for assessment aim to allow it to evoke `flavour´
12	Manure-F (gødning)	Pure skatole. Reference presented for assessment aim to allow it to evoke `flavour´
13	Sweat-F sved)	Cooked pork meat from entire male pigs pre-evaluated to contain a lot of sweat
	Taste	*Taste associated with*
14	Sweet-T (sød)	Diluted solution of sucrose
15	Bitter-T (bitter)	Diluted solution of quinine chloride
	After taste	Aftertaste sensation associated with:
16	Bitter-AT (bitter)	Bitter aftertaste from bitter solution of quinine chloride
17	Sweet-AT (sød)	Sweet aftertaste from sweet solution of sucrose
	Overall evaluation	*Preference*
18	Overall impression (overordnet indtryk)	The liking of the sample

[a] The Danish term is used in parenthesis; there may be small differences with the English translation. Suffix to sensory terms indicates method of assessment by panellists: -O; odour, -F; flavour, -T; taste, -AT; after taste.

The sensory work was carried out in the sensory laboratory at University of Copenhagen, Faculty of Life Science, Frederiksberg, Denmark, which fulfilled requirements according to the international standards (ASTM, 1986; ISO, 1988). The descriptors were pre-developed from a previous paper by Byrne et al. (2007) and supported by an expert pre-tasting. A 150 mm unstructured line scale anchored on the left by the word 'none' and on the right with 'very much' was used (Meilgaard, Civille & Carr, 2006). The panel performance was evaluated by PanelCheck 1.2.1 (MATFORSK, Norway). The training sessions took place over four days of each two hours.

2.3.4 Descriptive sensory profiling

The sensory descriptive profiling was carried out over four days of each 2 hours. All sessions took place in the sensory laboratory at University of Copenhagen, Faculty of Life Science, Frederiksberg, Denmark. Each sensory profiling was carried out by the same sensory panel as utilised in vocabulary development (section 2.3.3). The sample sets contained all the feeding treatments and were assessed in duplicate by each of the 10 panellists. The sample presentation to the individual panellists on each day of profiling was in randomised order. The quantitative data was collected using the FIZZ Network data acquisition software version 2.20B (BIOSYSTEMS, Couternon, France).

2.4 Data analysis

2.4.1 Univariate data analysis

The skatole concentrations in the back fat were analysed with the Statistical Analysis System version 9.1 (SAS Institute, Cary, NC, USA). The GLM procedure was used to calculate the least-squares means and the standard error of the means.

2.4.2 Multivariate data analysis

Generalised Procrustes Analysis (GPA) (Gower, 1975) was performed on the sensory raw data using Matlab 6.5 (MathWorks Inc., USA) to correct for the panellist effects in line scale usage. Subsequent multivariate analyses were performed using the Unscrambler Software, Version 9.7 (CAMO ASA, Trondheim, Norway). Quantitative ANOVA Partial Least Squares Regression (APLSR) was performed to visualize and determine the descriptive ability of the sensory profiling data sets for the feeding treatments. Data was averaged over panellists and sensory replicates. The Y-matrix containing the level of scale use corrected sensory data and the concentration of skatole was weighted by 1/sdev and full cross-validated. To derive significant indications, regression coefficients were analysed by jackknifing which is based on cross-validation (Martens & Martens, 2001). The sensory data is presented by figures and significant levels are given in the text.

3. Results

3.1 Skatole levels in the backfat

In Table 3, the results of the skatole levels in the backfat is shown.

Table 3: Skatole concentrations in backfat for the three treatments organic concentrate (CON), dried chicory (DC) and blue lupine (LUP)

	CON	**DC**	**LUP**	**s.e.**	**Significance of treatment**
Skatole in backfat (µg/g)					
7 days	0.12^{a}	0.12^{a}	0.04^{b}	0.02	**
14 days	0.14^{c}	0.10^{cd}	0.03^{d}	0.02	**

^{a,b,c,d} Least-squares means that do not share a common superscript letter, within the row, differ significantly (P<0.05). (*), P<0.1, *; P<0.05, **; P<0.01, ***; P<0.001, ns; non-significant. There was no interaction between treatment and gender and treatment and replicate

The control treatment had the highest skatole level in backfat followed by the chicory and lupine group for both genders. There was not significant difference between the control and chicory group in both day 7 and day 14 of feeding. Averaged over genders, the skatole concentration in backfat for the

lupine fed pigs were significantly lower than the control (P<0.01) and the chicory fed (P<0.01). The two genders differed significantly (P<0.05) in skatole levels in backfat as entire male pigs had higher levels than female pigs.

3.2 Sensory boar taint reduction in entire male pigs

The data for the entire male pigs is presented as correlation loadings plot from the APLSR-model (Figure 1). In this case, the correlation loading plot is useful since it visually shows the structure in the data. Terms close together are related and terms far away from each other are different. PC1 is main source of variation and PC2 is the next most important source of variation etc.

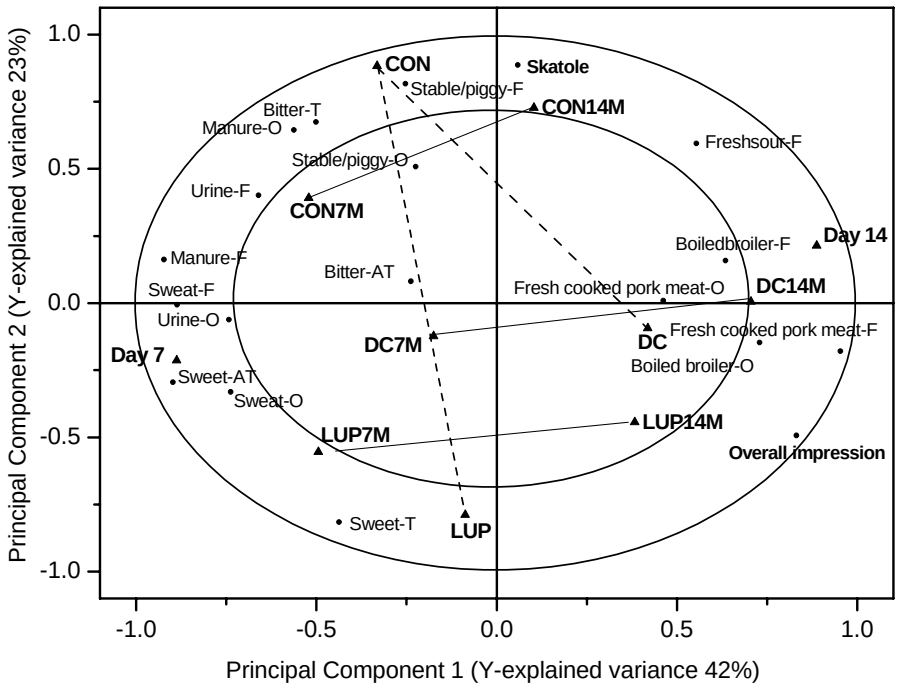

Figure 1: Male; ANOVA Partial Least Squared Regression correlation loadings plot of the two first Principal Components (PCs). The design variables: feeding types; control (CON), chicory (DC) and lupine (LUP), and feeding days prior to slaughtering; 7 and 14 in the X-matrix and the sensory terms and skatole levels in the Y-matrix. -O; odour, -F; flavour, -T; taste, -AT; aftertaste. The horizontal arrows are added to highlight the effect of the feeding period prior to slaughtering. The dashed vertical arrows are added to illustrate the differences in the feeding types in relation to the control feeding.

Both feeding days and feeding types were well-described from a sensory perspective meaning that these both are important in regards to the level of boar taint. However, the feeding days prior to slaughter had relative to the feeding types the greatest importance with respect to the reduction of the level of boar taint. It was revealed since the feeding days prior to slaughter was described across PC1. A systematic effect of the feeding days was observed for all the feeding types moving from the boar taint related sensory terms to fresh_cooked_pork-O/F (odour/flavour), boiled_broiler-O/F, fresh_sour-F and overall impression (Figure 1). The reduction of boar taint was greatest for 14 days of feeding with both chicory and lupine compared to 7 days of feeding. This was clear as 14 days was significantly positively correlated to fresh_cooked_pork_meat-O/F ($P<0.001$), boiled_broiler-O/F ($P<0.001$), fresh_sour-F ($P<0.001$) and significantly negatively correlated to overall_impression ($P<0.001$) while 7 days of feeding was positively correlated to taint descriptors urine-O/F ($P<0.001$), manure-O ($P<0.01$), manure-F ($P<0.001$), sweat-O/F ($P<0.001$) and to sweet-T/AT ($P<0.001$).

Differences between the feeding types were observed. Control feeding was significantly positively correlated to stable/piggy-O/F ($P<0.001$), manure-O ($P<0.001$), fresh_ sour-F ($P<0.01$), bitter-T ($P<0.001$), urine-F ($P<0.001$), manure-F ($P<0.01$) and sweat-F ($P<0.05$). By comparing the chicory feeding and the lupine feeding with the control feeding, it was found that chicory and lupine both were able to reduce the level of boar taint significantly for a number of key descriptors. In that the lupine and chicory samples were moving away from the boar taint related sensory terms. Both chicory and lupine were significantly positively correlated to the overall_impression ($P<0.001$). Further, chicory resulted in significantly positive correlation with fresh_cooked_pork_meat-O ($P<0.01$), boiled_broiler-O ($P<0.001$), fresh_cooked_pork_meat-F ($P<0.001$), and boiled_broiler-F ($P<0.05$) while lupine resulted in significantly positive correlation to sweet-T ($P<0.001$) and sweet-AT ($P<0.05$).

In addition, the chemical measurements of skatole in the backfat were included in the data analysis. High levels of skatole in the pork meat were significantly ($P<0.001$) positively correlated to the control feeding and the sensory descriptor stable/piggy. When feeding with chicory or lupine

this level of skatole in the backfat decreased. However, only lupine was significantly (P<0.001) negatively correlated to skatole.

3.3 Sensory "boar" taint reduction in female pigs

The data based on the female pigs is also presented in a correlation loading plot (Figure 2).

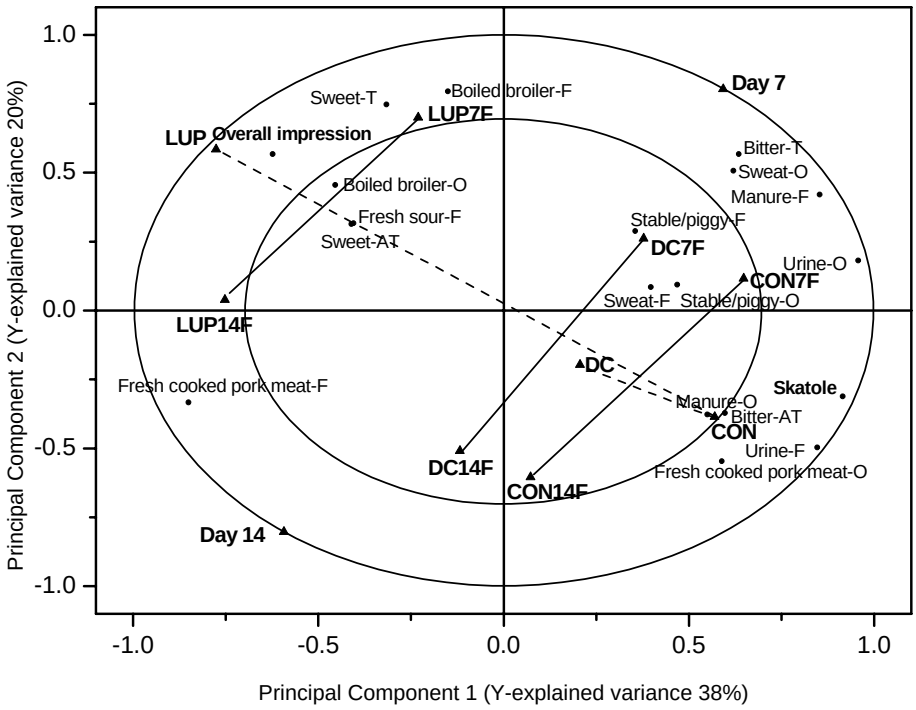

Figure 2: Female; ANOVA Partial Least Squared Regression correlation loadings plot of the two first Principal Components (PCs). The design variables: feeding types; control (CON), chicory (DC) and lupine (LUP), and feeding days prior to slaughtering; 7 and 14 in the X-matrix and the sensory terms and skatole levels in the Y-matrix. -O; odour, -F; flavour, -T; taste, -AT; aftertaste. The arrows are added to highlight the effect of the feeding period prior to slaughtering. The dashed arrows are added to illustrate the differences in the feeding types in relation to the control feeding.

In contrast to the entire male pigs, the main variation among the female pigs was explained by the feeding treatments. The control feeding was significantly positively correlated to the boar taint descriptors urine-O (P<0.01), manure-O (P<0.001), urine-F (P<0.001) and the overall_impression (P<0.001) but the control feeding was also significantly positively correlated to fresh_cooked_pork_meat-O (P<0.001) and bitter-AT

(P<0.001). A reduction of “boar” taint descriptors by both chicory and lupine feeding was observed involving similar sensory changes to those found in the entire male pigs. When feeding the female pigs with lupine or chicory the meat samples moved towards more positive notes such as boiled_broiler-O/F, sweet-T/AT and overall impression. However, the reduction of “boar” taint descriptors was greater when feeding with lupine relative to chicory. Feeding with chicory resulted in significantly positive correlations with manure-O (P<0.05) and bitter-AT (P<0.05) and significantly negative correlation to the overall_impression (P<0.05). Thus, chicory was insufficient for complete elimination of “boar” taint caused by skatole since the female samples were positively correlated to the odour of manure. Further, the chicory resulted in the pork meat with bitter aftertaste. Lupine was significantly positively correlated to boiled_broiler-O, fresh_cooked_pork_meat-F (P<0.01), boiled_broiler-F (P<0.01), sweet-T (P<0.001), sweet-AT (P<0.05) and overall impression (P<0.001). This indicates that lupine resulted in sweet pork meat which was positively correlated to the overall impression.

Only small differences were found between the two different feeding periods. Of note in female pigs the determination was that 14 days had very little additional effect in “boar” taint reduction when compared to 7 days feeding. Thus, 7 days of feeding days was sufficient to reduce the skatole aspect to zero in females and an additional 7 days was not needed.

4. Discussion

4.1 Sensory boar taint reduction

The effect of the feeding types versus the feeding days prior to slaughtering with respect to lowering the level of sensory assessed boar taint differed between the pig genders. Feeding in 14 days was of greatest importance for the entire male pigs while feeding with lupine had greatest influence on the female pigs. Specifically for the entire male pigs, 14 days of chicory or lupine feeding reduced the level of boar taint more efficiently/quantitatively than 7 days of feeding. This was not the case for the female pigs where the “boar” taint levels were reduced already after just 7

days such as additional feeding days appeared not to add to this effect sufficiently. It is most likely explained by the fact that the female pigs were low in taint to begin with and the skatole related reduction was to such a degree that they were undetectable from a sensory perspective after 7 days feeding, i.e. all “boar” taint descriptors were removed after this level of feeding in female pigs. This was in contrast to the entire male pigs where additional days in feeding had a corresponding elevated influence in terms of reduction of boar taint. This being most likely explained by the much higher levels of taint compounds related to skatole and androstenone to begin with in the entire male pigs. To give context to the different sensory effects in entire male and female pigs, androstenone requires discussion even if the main focus of the present work was on the sensory quality in relation to skatole. The influence of androstenone is also illustrated by Figure 1 in which a sensory separation of the sensory terms sweat and urine related to androstenone and the sensory terms manure and stable/piggy related to skatole was found. Since androstenone is a male steroid pheromone, androstenone only gains relevance for entire male pigs. The “boar” taint in the female pigs is therefore only present as a result of skatole production in the GI tract. Chicory and lupine were assumed to mainly affect the skatole aspect due to their effect on the skatole production across the digestive tract since diets with high content of fermentable carbohydrates have been shown to reduce the production of skatole and pCresol (Jensen & Hansen, 2006). Thus, the feeding treatments were not expected to affect the level of androstenone. Lupine significantly reduced the “boar” taint perception in the female pigs while chicory was insufficient for complete elimination of “boar” taint since the female samples were positively correlated to the odour of manure and skatole in backfat at slaughter. A study by Byrne et al. (2007) has previously indicated a reduction of the level of “boar” taint by chicory feeding in female pigs. In the present study with respect to the entire male pigs, the androstenone concentration appeared also possibly to be affected by feeding with chicory or lupine since the urine odour and flavour were significantly reduced after 14 days feeding. Furthermore, chicory was significantly negatively correlated to sweat odour and flavour (Figure 1). This finding is confirmed by Byrne et al. (2007) who state that a significant decrease was found in plasma androstenone with 9 weeks feeding with chicory a corresponding decrease in sweat

odour. Furthermore, it has been reported that dietary fibre is capable of reducing the level of cholesterol in serum (Marlett, Hosig, Vollendorf, Shinnick, Haack & Story, 1994; Byrne et al., 2007). As androstenone and cholesterol follow the same biosynthetic pathway, a prolonged feeding period with a dietary fibre such as chicory and lupine may be postulated as able to affect the androstenone content in plasma in a similar manner to cholesterol (Hansen, Mejer, Thamsborg, Byrne, Roepstorff, Karlsson, Hansen-Møller, Jensen & Tuomola, 2006). As female pigs do not contain androstenone, the results of the lupine female pigs show that skatole is reduced after 7 days of feeding. The sensory results of the entire male pigs indicated that androstenone in interaction with skatole contribute to the perception of boar taint after 7 days of feeding but after 14 days both skatole and androstenone were reduced.

The effect of chicory and lupine did not lead to other off-flavours in the meat. A thought was that the bitter nature of chicory roots was potential to result in an off-flavour. However, it was proved not to be the case since chicory was significantly positively correlated to fresh_cooked_pork_meat-O/F, boiled_broiler-O/F and overall impression. This observation is in accordance to the findings by Byrne et al. (2007). Thus, elevated levels of chicory derived bitter compounds such as sesquiterpene lactones were not determined to cause negative sensory effects (Bais & Ravishankar, 2001). Lupine resulted in meat with sweet taste and after taste. It was observed for both the entire male pigs and female pigs. It is in agreement with a previous study by Claudi-Magnussen & Hansen (2005) who found that lupines resulted in meat with sweet characteristic. Since lupines consists of 7-15% galacto-oligosaccharides (Martínez-Villaluenga, Frías & Vidal-Valverde, 2005), the sweet taste in the pork meat could possible be derived from these compounds.

The overall impression of sensory quality of the different feeding types differed among the gender of the pigs. In regards to the entire male pigs both chicory and lupine were significantly positively correlated to the overall impression at 14 days feeding. However, the chicory was closer correlated to the overall impression than lupine. When observing the female pigs, only lupines were significantly positively correlated to the overall impression. This, indicate that the final decision of using chicory or lupine

may depend on feeding time as well as gender of the pig and the desire of the sensory characteristics of the meat product e.g. as earlier mention lupine was characterised as having a sweet taste and after taste.

4.2 Sensory and chemical compatibility in measuring boar taint

The effects of lupines and chicory in terms of sensory analysis have now been considered. But how predictive/causal comparable are sensory analysis and chemical measurements of the level of skatole in the backfat? The sensory results showed that both chicory and lupine had a reducing effect on boar taint after 14 days feeding time. The finding for lupine was in agreement with the chemical results which confirmed that lupine lowered the skatole concentration in the backfat. However, the skatole concentration was significantly reduced after 7 days but as previous discussed androstenone may have contributed to the perception of boar taint since the sensory boar taint was not lowered after 7 days. The significant reducing effect of boar taint by chicory found in the sensory analysis was not reflected by the chemical analysis of skatole. However, the chemical analysis showed a trend in lower skatole concentration for chicory than the control feeding. However, it was found that chicory reduced boar taint to a greater extent than that determined by chemical analyses of skatole. It could be explained by small differences in flavour active compounds. So even though chemically analyses do not result in significant differences in flavour active compounds, these can be found to be highly significant in their effects evaluated by a trained panel due to high levels of panel sensitivity and potency of compounds. It means that a small increase in concentration can move the perception from below threshold to above threshold. This explanation also may explain the reason for the discrepancy in the importance of the feeding days when comparing the sensory results with the chemical results which showed that no significant differences were found between 7 days and 14 days of feeding. This is a very important distinction to be aware of with respect to sensory and chemical measurements and of note is to say that ultimately boar taint is a sensory phenomenon thus sensory analysis must be considered the benchmark in terms of concluding ultimately on feeding regime effects in relation to taint.

5. Conclusions

From a sensory perspective, chicory and lupine both reduced boar taint since odour and flavour of manure related to skatole and urine associated to androstenone were minimised. Sensory profiling revealed that 14 days of feeding with dried chicory or lupine reduced the level of boar taint in the entire male pigs more efficiently than 7 days of feeding. “Boar” taint reduction in the female pigs was mainly reduced by lupine. Final sensory characteristics of the pork meat differed to a degree with lupine perceived as sweet. However, both lupine and chicory feeding are suitable as a basis for a strategy to control boar taint since 14 days of feeding with either chicory or lupine showed to be suitable to increase the overall sensory quality and decrease boar taint to acceptable levels.

References:

Aldal, I., Andresen, Ø., Egeli, A. N., Haugen, J.- E., Grødum, A., Fjetland, O. & Eikaas, J. L. H. (2005). Levels of androstenone and skatole and the occurrence of boar taint in fat from young boars. Livestock Production Science, 95, 121-129

ASTM (1986). Physical Requirements. Guidelines for Sensory Evaluation Laboratories. STP 913. Pennsylvania: American Society for Testing and Materials.

Bais, H.P. & Ravishankar, G.A. (2001). Cichorium intybus L - cultivation, processing, utility, value addition and biotechnology, with an emphasis on current status and future prospects. Journal of the Science of Food and Agriculture, 81, 467-484

Banon, S., Costa, E., Gil. M.D. & Garrido, M.D. (2003). A comparative study of boar taint in cooked and dry-cured meat. Meat Science, 63, 381-388

Byrne. D. V., Bak. L. S., Bredie. W. L. P., Bertelsen. G., & Martens. M. (1999). Development of a sensory vocabulary for warmed-over flavour: part I. in porcine meat. Journal of Sensory Studies, 14, 47-65

Byrne. D.V., O'Sullivan. M.G., Dijksterhuis, G., Bredie. W. L. P., & Martens. M. (2001). Sensory panel consistency during the development of a vocabulary for warmed-over flavour. Food Quality and Preference, 12, 171-187

Byrne, D.V. & Hansen, L.L. (2005). The effect of feeding different concentration of dried chicory roots (*Cichorium intybus* L.) for 7, 14 or 21 days prior to slaughter on the quality characteristics of meat from entire male pigs. Part II. Sensory boar taint characterisation and chemical predictivity. Project Report: The Royal Veterinary and Agricultural University, Copenhagen, Denmark.

Byrne, D. V, Thamsborg, S. M. & Hansen, L. L. (2007). A defined sensory description of boar taint and the effects of crude and dried chicory roots (*Cichorium intybus* L) and inulin feeding in male and female pork. Meat Science, In Press, Accepted Manuscript

Claudi-Magnussen, C. & Hansen, L. L. (2005). 5310: Svinefodring - næringsstofudnyttelse, produktkvalitet og sundhed (OrganicPigFeed) FØJO-projekt II-7. Work Package 3. Produktkvalitet, Slutrapport. Report no. 01793, Slagteriernes Forskningsinstitut. Organic Eprints 5310

Dijksterhuis, G. B., Engel, B. , Walstra, P. , Font i Furnols, M., Agerhem, H., Fischer, K. Oliver, M. A., Claudi-Magnussen, C., Siret, F., Béague, M. P., Homer, D. B. & Bonneau M. (2000). An international study on the importance of androstenone and skatole for boar taint: II. Sensory evaluation by trained panels in seven European countries. Meat Science, 54 (3), 261-269

EFSA (European Food Safety Authority) (2004). Welfare Aspects of Castration of Piglets; Scientific Report of the Scientific Panel for Animal Health and Welfare ion on a request from the Commission related to welfare aspects of the castration of Piglets, AHAW/04-087. Appected by unanimity by the Panel at the Plenary Meeting held on 12th -13th July 2004

Gower, J. (1975). Generalized Procrustes Analysis. Psychometrica, 40, 31-55

Hansen, L.L. (2005). The effect of feeding different concentration of dried chicory roots (*Cichorium intybus* L.) for 7, 14 or 21 days prior to slaughter on the quality characteristics of meta from entire male pigs. Part I: Animal production and boar taint chemical measurements. Report. Danish Institute of Agriculture Science, Research Centre Foulum, Tjele, Denmark.

Hansen, L. L. & Claudi-Magnussen, C. (2004). Feeding with lupines reduces the amount of skatole in organic pigs. DARCOFenews, Newsletter from Danish Research Centre for Organic Farming (December 2004 No. 4.).

Hansen, L.L., Mejer, H., Thamsborg, S.M., Byrne, D.V., Roepstorff, A, Karlsson, A.H., Hansen-Møller, J., Jensen, M.T. & Tuomola, M. (2006). Influence of chicory roots (Chicorium intybus L.) on boar taint in entire male and female pigs. Animal Science, 82, 359-368

ISO (1988). International Standard 8589. Sensory analysis - general guidance for the design of test rooms. Ref. no. ISO 8589:1988 (E). International Organization for Standardization. Genève

ISO (1993) International Standard 8586-1. Sensory analysis - General guidance for the selection, training and Monitoring of assessors. Part 1: Selected assessors. Ref. no. ISO 8586-2 1994 (E). International Organization for Standardization. Genève.

ISO (1994a). International Standard 11035. Sensory analysis - identification and selection of descriptors for establishing a sensory profile by a multidimensional approach. Ref. no. ISO 11035:1994 (E). International Organization for Standardization. Genève.

ISO (1994b) International Standard 8586-2. Sensory analysis - General guidance for the selection, training and monitoring of assessors. Part 2: Expert. Ref. no. ISO 8586-2 1994 (E). International Organization for Standardization. Genève.

Jensen, M.T. & Hansen, L.L. (2006). Feeding with chicory roots reduces the amount of odorous compounds in colon and rectal contents of pigs. Animal Science, 82, 369-376

Marlett, J.A., Hosig, K.B., Vollendorf, N.W., Shinnick, F.L., Haack, V.S. & Story, J.A. (1994). Mechanism of serum cholesterol reduction by oat bran. Hepatology, 20, 1450-1457

Martens, H. & Martens, M. (2001). Interpretation of many types of data X <=> Y: exploring relationships in interdisciplinary data sets (chapter 8). In Multivariate Analysis of Quality. An Introduction (pp. 139-145). John Wiley & Sons Ltd., London, England.

Martínez-Villaluenga, C., Frías, J. & Vidal-Valverde, C. (2005). Raffinose family oligosaccharides and sucrose contents in 13 Spanish lupin cultivars. Food Chemistry 91, 645-649

Meilgaard. M., Civille. G. V., & Carr. B. T. (2006). Measuring responses. *In* Sensory evaluation techniques 4th ed. (pp. 45-62). Florida: CRC press.

Mortensen, A. B. & Sorensen, S. E. (1984). Relationship between boar taint and skatole determined with a new analysis method. Proc. 30th European Meeting of Meat Research Workers, Bristol, 394-396.

Patterson, R. L. S. (1968). Androstenone: Compound responsible for taint in boar fat. Journal of the Science of Food and Agriculture, 19, 31-38

Zamaratskaia, G. (2004). Factors involved in boar taint; Influence of breed, age, diet and raising conditions. Doctoral Thesis, Swedish University of Agricultural Sciences, Uppsala.