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With financial support from:

& European Agricultural Fund for Rural Development

# EFFECT OF 15% DRIED CHICORY ROOT IN FEED FOR MALE PIGS

TRIAL REPORT NO. 876

15% chicory from 2 wks pre-slaughter reduced skatole in intestines and fat tissue, boar taint in fat tissue and meat, and boar flavour in meat, but did not affect androstenone and boar flavour in fat. Chicory alone cannot eliminate boar taint.

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PUBLISHED: SEPTEMBER 8, 2010

Pigs: Finishers

Subject: Nutrition

## Abstract

Results revealed that male pigs fed 15% dried chicory root from two weeks before slaughter had lower skatole levels recorded on the slaughter line. Samples of neck fat and loin from approx. 50 pigs from each group were subject to skatole and androstenone analyses using laboratory equipment (HPLC). Compared with the control group, chicory reduced skatole and boar taint in both meat and fat, and boar flavour in meat.  Analyses showed no differences in androstenone and boar flavour in fat between the control pigs and the trial pigs. Boar flavour in meat was reduced compared with control, but not to the same level as for female pigs.

Dried chicory root is fairly expensive (DKK 6.00-7.50 per kg), which caused feed costs to increase by approx. DKK 40-50 per pig when 15% chicory was added to the feed for two weeks before slaughter making it unprofitable to use chicory in feed for male pigs. To determine the optimum way of reducing boar taint through feeding, dosage-response trials are required and other protein sources need to be investigated.

Increased fermentation of carbohydrates reduces the production of skatole in the pigs' intestines whereby less skatole is embedded in the fatty tissue. Fermentable carbohydrates in pig feed, such as dried chicory root, will affect the fermentation processes in the large intestine, and the bacterial flora that ferment carbohydrates will increase. Tryptophan is used for bacterial growth, and the tryptophan available for production of skatole thereby drops. Tryptophan is a substrate for the production of skatole in pigs' intestine. Results revealed that the male pigs fed chicory had lower levels of skatole in the caecum and the large intestine compared with the male pigs in the control group. These results and the analyses of other metabolites generally indicate that chicory affects the fermentation pattern in the caecum and the large intestine towards increased fermentation of carbohydrates and reduced production of skatole in the large intestine.

Analyses revealed a significantly positive correlation between boar flavour and the level of skatole in the large intestine, and a trend to a positive correlation between boar taint in the meat and the skatole level in the large intestine.

The type of chicory used in this trial contained 54% inulin (fructans). The diet to which 15% chicory was added had an inulin content of 8.8% and the control diet had an inulin content of 0.8%.

FUNDING
The project was financially supported by the Pig Levy Fund and the EU and the Rural Development Programme under the Danish Ministry of Food, Agriculture and Fisheries. Project ID DSP09/10/57 and Journal no. 3663-D-08-00331.

# Background

The addition of dried chicory root to pig feed is expected to affect skatole levels in the carcass as chicory influences the fermentation processes in the caecum and the large intestine where skatole is produced. Extensive research of chicory and lupine conducted at the Danish Faculty of Agricultural Sciences/Aarhus University (FAS/AU) has demonstrated that the addition of chicory to pig feed reduces skatole in blood and fatty tissue, and has a positive effect on the flavour of meat from female and male pigs. This research is based on trials comprising relatively few pigs with low skatole levels in the fatty tissue, wherefore it cannot be concluded if chicory affects the percentage of male pigs that are rejected because of increased skatole levels. FAS/AU recommends 15-25% chicory be added to pig feed to reduce boar taint and for this feeding strategy to be applied for minimum 14 days before slaughter [3], [4], [1].

Chicory or other heavily digestible carbohydrates that do not disintegrate in the small intestine, but ferment in the large intestine, shift the microbial turnover in the intestines, which in turn affects skatole levels. Consequently, an increased fraction of the amino acids originating from the protein fraction of the feed is incorporated as microbial protein. Therefore other heavily digestible carbohydrates, such as raw potato starch, will have the same effect on skatole [7]. Another effect of using fermentable carbohydrates in feed is the production of organic acids in the intestines. Research at Murdoch University, Australia, showed that the addition of 0, 4 or 8% inulin to weaner feed affected the fermentation process in the digestive tract. This research also found more lactic acid and valeric acid in the caecum and less acetic acid in the caecum and the large intestine.

This aim of this trial was to investigate if feeding chicory to male pigs reduces skatole levels, boar taint and boar flavour and the content of metabolites in the intestine. It was furthermore investigated whether - under practical production conditions - chicory affects skatole levels in neck fat and the eating quality of meat from male pigs.

## Hypothesis

The neck fat of male pigs fed chicory from 14 days pre-slaughter has a significantly lower skatole content.

# Materials and method

The trial comprised three groups:

1. Male pigs fed a standard diet (419 male pigs)
2. Male pigs fed 15% dried chicory root for 14 days before slaughter (496 male pigs)
3. Female pigs fed a standard diet (184 female pigs)

The pigs were moved to the finisher facility at 30 kg. The actual trial period started at intermediate weighing, and the pigs switched to the trial diets at an average weight of 52.9 kg. Slaughter weight averaged 78.5 kg. In the first part of the trial period, all the pigs were fed the same diet. Fourteen days before the first pig was delivered for slaughter, the pigs in group 2 switched to a diet containing 15% chicory. The pigs in the other two groups remained on the control diet. All pigs were weighed out for slaughter. Some of the pigs in group 2 were fed the trial feed with chicory for up to 6 weeks before the last pigs in the pen were slaughtered. It was thereby also investigated - under normal production conditions on a farm using dry feed - how to apply a feeding strategy with chicory with the specific aim of reducing boar taint and skatole in neck fat.

The primary parameter was skatole levels in neck fat. Slaughter weight and lean meat percentage were recorded at the slaughterhouse. Daily gain and feed consumption were recorded at pen level, but are shown as a total for all pigs. The trial design comprised too few replicates to be able to make any conclusions regarding productivity.

## Feed

All the pigs in the trial were fed Profil Enhed, which a unity finisher diet. In group 2, 15% chicory was added to the diet, and the diet was formulated with the same nutrient requirements (energy, protein, amino acids etc.) as Profil Enhed. Consequently, the tryptophan content was identical in both diets. Before the diet was formulated, the content of feed units in chicory was determined. The composition of the diets is shown in Appendix 1.

The chicory root used in this trial had an inulin content of 54% (fructans). The diet to which 15% chicory was added had an inulin content of 8.8% and the control diet an inulin content of 0.8%.

## Slaughter, analyses of fat, sensory and intestinal analyses

The pigs were slaughtered at the slaughterhouse in Sæby and samples of neck fat were taken. At the male pig laboratory in Ringsted, these samples were subject to skatole analyses with the calorimetric method [10] used today for on-line analysis of boar taint at one Danish slaughterhouse. Skatole values from these analyses are the sum of skatole and indole. Samples of loins and neck fat were taken from 50 pigs from each group.

At the Danish Meat and Research Institute, Technological Institute, these loin and fat samples were subject to HPLC analysis for skatole, androstenone and indole in neck fat. The loins were cut to chops, cooked and subject to sensory analyses of the meat and fat. The intestines from 20 male pigs in group 1 and 20 in group 2 were ligated and divided. The content of the first part of the small intestine (segment 1), the caecum (segment 5) and the last part of the large intestine (segment 7) were frozen and later analysed for pH, tryptophan, skatole and volatile fatty acids at FAS/AU.

## Statistics

Data were analysed in the SAS programme. Data for pH, metabolites and skatole in the intestines were analysed as repeated recordings within pig with random effect of pig. Group, intestinal segment and the interaction between these were included as systematic effect. The models were successively reduced.

HPLC results (skatole, indole and androstenone), smell and flavour of the chops, and skatole in neck fat (skatole equipment at the slaughterhouse) were subject to a normal two-way analysis of variance with systematic effect of group.

Data were checked for normal distribution and prevalence of outliers. Prior to statistical analysis, skatole was logarithmically transformed to obtain normal distribution. Significant differences are stated at 5 per cent level.

# Results and discussion

## Productivity

All the pigs in the trial had an average daily gain of 937 g/day, and feed conversion ratio averaged 2.61 FUgp/kg gain. Slaughter weight averaged 78.5 kg and lean meat percentage averaged 62.3.

## Effect in intestinal tract

The male pigs fed dried chicory root had a higher pH and higher concentrations of lactic acid and acetic acid in the small intestine than the pigs in the control group, and they had lower levels of acetic acid and skatole in the caecum. No differences were found neither in pH nor in the other parameters. Indole and skatole were not detected in the small intestine (cf. table 1).

In the large intestine, pH was slightly lower; skatole significantly higher; acetic acid, butyric acid, iso-valeric acid lower, but overall the level of organic acids was higher. Lactic acid was not detected in the large intestine.

No differences were found in content of free tryptophan and indole. The analysed content of free tryptophan does not necessarily illustrate the extent of tryptophan fermentation, as protein-bound tryptophan is also present in the intestines and this tryptophan is not covered by this analysis.

**Table 1.** pH, metabolites and skatole in the intestines of male pigs fed diets with and without dried chicory root (LS-means).

| | Small intestine | | Caecum | | Large intestine | |
|---|---|---|---|---|---|---|
| | Control | Chicory | Control | Chicory | Control | Chicory |
| pH | 3.5[a] | 4.1[b] | 5.3 | 5.2 | 5.9[a] | 5.7[b] |
| Sum organic acids (OA), mmol/kg | 7.3 | 20.3 | 189.1 | 186.3 | 191.7 | 185.2 |
| Butyric acid, mmol/kg | 0.02 | 0.30 | 27.2 | 29.8 | 34.3[a] | 29.7[b] |
| Lactic acid, mmol/kg | 3.1[a] | 13.1[b] | 0.1 | 0.0 | 0.0 | 0.0 |
| Acetic acid, mmol/kg | 2.9[a] | 5.7[b] | 104.8[a] | 94.8[b] | 102.3[a] | 96.8[b] |
| Propionic acid, mmol/kg | 0 | 0.1 | 51.7 | 43.6 | 52.7 | 44.6 |
| Sum of isoacids, mmol/kg | 0 | 0 | 1.4 | 1.2 | 4.2[a] | 2.9[b] |
| Isobutyric acid, mmol/kg | 0 | 0 | 2.4[a] | 1.7[b] | 0.8 | 0.7 |
| Isovaleric acid, mmol/kg | 0 | 0 | 0.6 | 0.5 | 1.8[a] | 1.2[b] |
| Free tryptophan, mg/kg | 12.7 | 14.5 | 6.9 | 8.6 | 9.3 | 11.1 |
| Indole, mg/kg | 0.0 | 0.0 | 5.6 | 5.2 | 6.4 | 6.0 |
| Skatole, mg/kg | 0.0 | 0.0 | 2.5[a] | 0.2[b] | 26.3[a] | 6.0[b] |

a,b: Values with different superscripts within row and segment are significantly different ($p<0.05$).

Generally, this indicates that fermentation of chicory in the small and large intestines, in particular, affects the fermentation patterns towards increased carbohydrate fermentation and reduced production of skatole from tryptophan in the intestines (table 1).

The sum of organic acids (OA) was higher in the small intestine of the pigs fed chicory, though pH was higher. pH in the small intestine will increase following the addition of organic acids to the feed or the use of fermented liquid feed with a high concentration of lactic acid bacteria [14]. This is probably attributed to the fact that the acids increase the production of bicarbonate from pancreas.

No differences were observed in the caecum and the large intestine, which was surprising as research has shown that fermentation of chicory increases the concentration of OA in the caecum and the large intestine. This is likely due to a higher percentage of water (less dry matter) in the intestinal material in the pigs fed chicory, which also resulted in a higher total concentration in the entire large intestine of these pigs. The reduced concentration of isoacids in the pigs fed chicory indicates that the fermentation of protein drops when chicory is added to the feed as isoacids form from microbial fermentation of amino acids. Reduced protein fermentation also explains the lower pH in the large intestine of the pigs fed chicory as this reduces the production of ammonia and thereby pH – despite the fact that the concentration of organic acids was unaffected by the type of feed used.

Skatole was not detected in the small intestine, but skatole levels in the caecum and the large intestine were significantly lower among the pigs fed chicory. Generally, for the pigs in the control group, skatole levels were almost ten times higher in the large intestine than in the caecum. When chicory was added to the feed, skatole was reduced by a factor 4 in the caecum as well as in the large intestine.  No differences were observed in indole levels in the caecum and the large intestine between the groups. The lower skatole content in the neck fat of the pigs fed chicory is most likely attributed to a lower production of skatole in the intestines.

## Skatole, androstenone and sensory analyses

Sensory analyses of 50 pigs from each group showed that the male pigs fed chicory had the highest level of indole in neck fat (significant) and the female pigs had lowest level, with the male pigs in the control group in-between. The male pigs in this trial had the highest levels of androstenone regardless of whether they were fed chicory; the female pigs had far lower levels of androstenone (table 2). The sensory analyses revealed that the addition of 15% chicory to pig feed reduced boar taint in the meat and fat significantly to the same level as for the female pigs.

Boar flavour in fat was not significantly reduced when chicory was added to the feed. Boar flavour was significantly lower in the meat from the male pigs fed chicory compared with the male pigs in the control group, but did not reach the same low level as in the meat from the female pigs (table 3). No differences between the three groups were detected for the remaining sensory traits such as tenderness, hardness and juiciness. Compared with the male pigs, the fat of the female pigs had a sweeter taste; the meat tasted more boiled and was less bitter [11], [12], [13] (data are shown in Appendix 3).

The levels of skatole and androstenone in neck fat help explain the variation in boar taint and boar flavour among the male pigs [13]. Indole has very little impact on boar taint and flavour. Combined, the three compounds account for approx. 50% (R2) of the variation in boar taint and flavour. The remaining 50% may be random animal-to-animal variation or be caused by other, unknown compounds. Despite the fact that skatole and androstenone only account for approx. 50% of the variation in boar taint, recordings of skatole and androstenone levels can still be used to reject male pigs with abnormal smell and flavour.

However, with this method, rejection will not be completely accurate. The accuracy in relation to consumer reactions will also depend on how intense the boar taint needs to be before it is deemed unacceptable. A greater accuracy of such a method will require comprehensive representative random sampling of finishers with known levels of skatole and androstenone. With the data material in this trial, it is not possible to detect possible effects of chicory on rejection rates (above 0.25 ppm skatole) as the material is too narrow and skatole figures too low.

There is no exact knowledge on the correlation between sensory traits (taste panel) and consumer reactions to different pork products. It is therefore not possible to determine an acceptance limit for the individual sensory traits. If, at some later point in time, it becomes possible to lay down an acceptance limit, data from this trial can be used to determine rejection limits for skatole and androstenone. The following - hypothetical - example describes the principles of such a calculation in which the assumed acceptance limit for boar taint in fat is 4 on the sensory scale.

Figure 1 illustrates the combination of skatole and androstenone required for boar taint to be above 4. If the levels of skatole and androstenone lead to the sample being above the curve in Figure 1, boar taint in fat will theoretically be above 4 and the pig should – cf. the assumption that the acceptance limit is 4 – be rejected. However, as skatole and androstenone only account for approx. 50% of the variation in boar taint, some pigs will consequently be rejected on an incorrect basis. In this example, it is estimated that 3% of the pigs will be rejected incorrectly and 6% will be incorrectly approved (boar taint above 4). The calculations presuppose that the rejection limit is a combination of skatole and androstenone, and not fixed limits for skatole and androstenone, respectively, that will increase incorrect sorting.

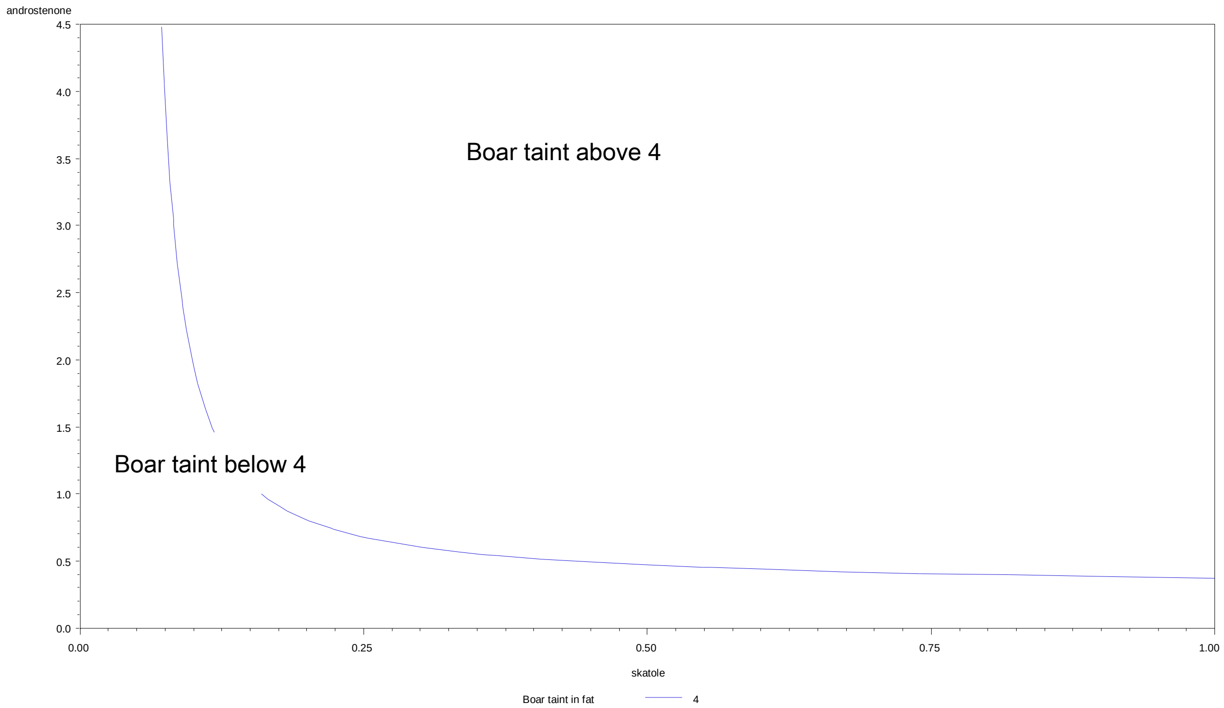


**Figure 1.** Importance of skatole and androstenone to the sensory trait boar taint in fat.

**Table 2.** HPLC analyses of skatole, androstenone and indole in neck fat.

| Group | 1 | 2 | 3 |
|---|---|---|---|
| Gender | Male pigs | Male pigs | Female pigs |
| Diet | Control | Chicory | Control |
| Number of pigs | 50 | 50 | 50 |
| Skatole, ppm | $0.11^{a}$ | $0.04^{b}$ | $0.08^{a}$ |
| Indole, ppm | $0.03^{a}$ | $0.04^{b}$ | $0.02^{c}$ |
| Androstenone, ppm | $1.14^{a}$ | $1.08^{a}$ | $0.13^{b}$ |

a,b,c: Values with different superscripts are significantly different within rows ($p<0.06$).

**Table 3.** Boar taint and boar flavour in fat and meat of chops.

| Group | 1 | 2 | 3 |
|---|---|---|---|
| Gender | Male pigs | Male pigs | Female pigs |
| Diet | Control | Chicory | Control |
| Number of pigs | 50 | 50 | 50 |
| Boar taint – fat | $3.0^{b}$ | $2.3^{a}$ | $2.4^{ab}$ |
| Boar taint – meat | $5.3^{b}$ | $4.6^{a}$ | $4.5^{a}$ |
| Boar flavour – fat | $3.4^{b}$ | $2.8^{ab}$ | $2.5^{a}$ |
| Boar flavour – meat | $6.2^{c}$ | $5.5^{b}$ | $4.5^{a}$ |

a,b,c: Values with different superscripts are significantly different within rows ($p<0.05$).

**Table 4.** Correlation between skatole in large intestine and boar taint and flavour and skatole in neck fat.

| | Skatole in large intestine | Significance |
|---|---|---|
| Skatole in neck fat | 0.23 | - |
| Androstenone in neck fat | 0.23 | - |
| Boar taint - meat (chop) | 0.28 | Tendency p=0.07 |
| Boar taint – fat (chop) | 0.10 | - |
| Boar flavour – meat (chop) | 0.32 | * |
| Boar flavour – fat (chop) | 0.11 | - |

No significant correlations were observed between skatole in the large intestine and skatole, androstenone, boar taint and boar flavour of the meat. A significant, positive correlation was found between boar flavour and skatole in the large intestine, and a trend was found towards a positive correlation between boar taint in meat and skatole in the large intestine. Consequently, the higher the skatole level in the large intestine, the more intense the boar taint and flavour (table 4).

## Effect on skatole in neck fat (slaughter data)

The addition of 15% dried chicory root to feed for male pigs reduced skatole (recorded at the slaughterhouse) compared with the male pigs fed a control diet (table 5). This effect was also found in the pigs selected for sensory evaluation.

**Table 5.** Skatole in neck fat recorded at the slaughterhouse (ppm).

| Group | 1 | 2 | 3 |
|---|---|---|---|
| Gender | Male pigs | Male pigs | Female pigs |
| Diet | Control | Chicory | Control |
| Number | 419 | 496 | 184 |
| Skatole, ppm | 0.14[a] | 0.08[b] | 0.10[b] |

a,b: Values with different superscripts are significantly different within rows (p<0.05).

### Economy

Chicory is a fairly expensive product (DKK 6-7 per kg), and feeding male pigs according to this concept will increase feed costs by DKK 40-50 per pig. The effect found in this trial does not cover these excess costs unless chicory also improves feed conversion and daily gain. Generally, the positive effect on productivity seen in weaners [9] is not expected in finishers as chicory is only used for a very short period up to slaughter.

# Conclusion

The addition of dried chicory root to feed for male pigs significantly reduced the skatole levels in neck fat, and boar taint and flavour of meat and fat compared with the male pigs in the control group. The level of androstenone and boar flavour in fat were unaffected by chicory and were significantly higher than the levels found in female pigs. Apparently, the addition of chicory to feed for male pigs reduces skatole, but not necessarily androstenone. For the consumers, it is therefore no guarantee against abnormal flavour and smell in meat from male pigs.

A significant correlation was found between boar flavour and skatole levels in the large intestine.

Dried chicory root is a fairly expensive product (DKK 6.00-7.50 per kg), and it is not profitable to add chicory to feed for male pigs. In order to determine the economically optimum feeding strategy for reduction of boar taint, dosage-response trials are required and other protein sources need to be investigated.

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## Participants


Technical support: Jens Ove Hansen, Tommy Nielsen and Ib Dahl Jensen

Statistical work: Jens Vinther


Trial no. 986

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# Appendix 1

## Composition of diets, %

| Ingredient | Profil Enhed | Profil Enhed + 15% dried chicory root |
|---|---|---|
| Chicory | 0 | 15.00 |
| Barley | 24.92 | 25.00 |
| Wheat | 44.50 | 26.90 |
| Rapeseed meal | 10.00 | 10.00 |
| Soybean meal | 6.10 | 8.70 |
| Wheat bran | 5.20 | 5.20 |
| Sunflower meal | 5.00 | 5.00 |
| Palm fat | 1.30 | 1.30 |
| Feed lime | 1.18 | 1.18 |
| Molasses | 0.50 | 0.50 |
| Salt | 0.44 | 0.50 |
| Vitalys dry 58 | 0.45 | 0.35 |
| Svinevit 425 | 0.20 | 0.20 |
| Threonine | 0.11 | 0.07 |
| Phytase premix | 0.06 | 0.06 |
| Porzyme 9320 | 0.04 | 0.04 |

## Nutrient content of dried chicory root

Average of six analyses. Glucose, fructose, sucrose and fructan are determined on the basis of an average of two analyses.

| | |
|---|---|
| FUgp per 100 kg | 125.2 |
| Crude protein, % | 5.5 |
| Crude fat, % | 0.4 |
| Water, % | 5.2 |
| Ash, % | 5.0 |
| Enzyme Digestible Organic Matter, ileum | 88.8 |
| Glucose, % | 0.2 |
| Fructose, % | 1.3 |
| Sucrose, % | 14.7 |
| Fructan (inulin), % | 54.4 |

# Appendix 2

Nutrients in diets

| Diet | Control – groups 1 + 3[1] | | Group 2 - +15% chicory[2] | |
|---|---|---|---|---|
| | Analysed | Calculated | Analysed | Calculated |
| **FUgp per 100 kg** | 104 | 100 | 104 | 101 |
| **Crude protein, %** | 16.5 | 17.3 | 16.6 | 17.0 |
| **Lysine, g/kg** | 8.9 | 9.6 | 9.0 | 9.1 |
| **Methionine, g/kg** | 2.7 | 2.8 | 2.7 | 2.7 |
| **Meth. + cyst., g/kg** | - | 6.4 | - | 6.1 |
| **Threonine, g/kg** | - | 6.9 | - | 6.5 |

1) FUgp in the control diet is analysed with eight separate consecutive measurements and the amino acids with four separate consecutive measurements.

2) FUgp in the trial diet is analysed with six separate consecutive measurements and the amino acids with three separate consecutive measurements.

# Appendix 3

Results of sensory evaluations

| Group | 1 – Male pigs | 2 – Male pigs chicory | 3 – Female pigs |
|---|---|---|---|
| Boar taint – fat | $3.0^{b}$ | $2.3^{a}$ | $2.4^{ab}$ |
| Boar taint – meat | $5.3^{b}$ | $4.6^{a}$ | $4.5^{a}$ |
| Boar flavour – fat | $3.4^{b}$ | $2.8^{ab}$ | $2.5^{a}$ |
| Boar flavour – meat | $6.2^{c}$ | $5.5^{b}$ | $4.5^{a}$ |
| Boiled smell - fat | 5.4 | 5.5 | 5.6 |
| Sweet smell – fat | 3.7 | 3.8 | 4.0 |
| Boiled flavour – fat | 6.0 | 5.8 | 6.1 |
| Sweet flavour – fat | $3.8^{a}$ | $3.8^{a}$ | $4.3^{b}$ |
| Sticky flavour – fat | $8.3^{b}$ | $7.8^{ab}$ | $7.6^{a}$ |
| Boiled smell – meat | $4.6^{a}$ | $4.9^{ab}$ | $5.1^{b}$ |
| Acidic smell | 4.3 | 4.3 | 4.5 |
| Boiled flavour – meat | $4.3^{a}$ | $4.4^{a}$ | $4.9^{b}$ |
| Acidic flavour | 6.5 | 6.4 | 6.6 |
| Bitter flavour | $3.8^{b}$ | $3.7^{b}$ | $3.4^{a}$ |
| Metallic flavour | 3.3 | 3.3 | 3.3 |
| Tenderness | 8.6 | 8.7 | 8.6 |
| Hardness at first bite | 4.8 | 5.0 | 5.0 |
| Juiciness | 2.9 | 3.1 | 3.0 |

Scale: 1-15 units. Values with significant difference are marked by different superscripts within row ($p<0.05$)

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