Effect of dietary chicory on boar taint and its impact on Salmonella counts in the pig intestine

Final report to BPEX

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Summary

This report describes research to demonstrate and understand the effects of dried chicory on boar taint and Salmonella colonisation of the gut in pigs. There were 3 trials. In the first, levels of the 2 boar taint compounds were measured in 50 entire male pigs from 30 company farms supplying a major meat processing company. Skatole and androstenone concentrations in backfat were typical of published research describing the UK pig herd. In the second trial, 5% chicory fed for 2 weeks was effective in 5 out of 7 farms in reducing skatole, known to be the most potent boar taint compound. In the third trial, 0, 3, 6 and 9% chicory were compared at 1 and 2 weeks after feeding. Pigs given 9% chicory for 2 weeks had very low skatole concentrations, characteristic of castrates. Only 1 pig out of 30 had a value of skatole above the 'threshold' of 0.2µg/g. However, there was no reduction in the 'abnormal odour' score from the taste panel, possibly because these pigs had an unusually high level of androstenone which prevented the lower skatole concentration being expressed. Measurements of bacterial colonisation of the hind gut were made which suggested that chicory discourages the proliferation of harmful bacteria including Salmonella. Very few samples were positive for Salmonella.

The results show that chicory has some beneficial effects when fed for a short time before slaughter but is not a reliable universal method for reducing boar taint or Salmonella infections in pigs.

Introduction

Male pigs are not castrated in Britain and boar taint, an offensive odour/flavour, is a potential problem when the meat is cooked. It is due to high concentrations of skatole and androstenone in the meat which are driven off during cooking. These compounds are derived from different metabolic processes. Skatole is produced by fermentation in the hind gut and androstenone is produced along with testosterone as part of male sex hormone metabolism. Both compounds are metabolised in the liver and in most pigs levels in fat are below the 'thresholds' where taint problems can arise. These are 0.2µg/g skatole and 1.0µg/g androstenone (Bonneau et al, 1992).However in some pigs, around 10% of the total, these compounds reach very high concentrations for reasons which are not clearly understood. Correlations between the 'abnormal odours' of boar taint have been shown to be higher for skatole than androstenone (Whittington et al, 2010) and therefore it is possible that reducing skatole production in the hind gut will also reduce boar taint. Diet is a major factor in skatole production, with non starch polysaccharides such as inulin changing fermentation patterns and reducing skatole. In Danish research, feeding whole chicory roots reduced skatole significantly (Hansen et al, 2006). This study investigated the effects of a commercially available dried chicory product (Fibrofos 60) fed for a short time before slaughter on concentrations of boar taint compounds in backfat and on the sensory response to cooked fat. The aim was to establish dietary levels and feeding periods that could reliably reduce boar taint.Since inulin changes the bacterial population in the gut and has been shown to encourage the proliferation of 'friendly' bacteria at the expense of harmful bacteria such as Salmonella, the impact of feeding Fibrofos on gut bacteria has also been measured.

Materials and Methods

The work was conducted on farms supplying pigs to a major pig processing company in the East of England. There were 3 trials. In the first, levels of skatole and androstenone in backfat were measured in pigs from 30 farms supplying the abattoir. The aim was to establish a boar taint benchmark for the company. In the second trial, the effects of feeding 5% Fibrofos 60 for 2 weeks before slaughter on 7 farms was compared with feeding a non-supplemented feed on 6 control farms. The level of 5% was based on previous Danish research and views of the cost effectiveness of using Fibrofos. In these first 2 trials, each farm was represented by 50 pigs, with samples of equal size being minced together and analysed as 1 sample. In the 3rd trial, diets containing 3, 6 or 9% Fibrofos were fed for 2 weeks before slaughter on one farm and backfat samples were removed at 0, 1 and 2 weeks from groups of 30 pigs for analysis of boar taint compounds. Samples of backfat from all 360 pigs in the 3rd trial were also taken for sensory analysis. Sections of the hind gut were removed in the abattoir and returned to Bristol University for the measurement of bacterial populations.

In the backfat samples, skatole concentrations were measured using the simultaneous distillation-extraction procedure followed by GC analysis described by Annor-Frempong, et al. (1997). Androstenone concentrations were measured using a modification of the high resolution gas chromatographic procedure of De Brabander et al. (1985).

For sensory testing, the samples were presented to a 10 - member taste panel (all female) for "sniff" tests to determine pork odour intensity and abnormal odour intensity using 8 point category scales (1 = extremely weak, 8 = extremely strong). In addition, certain descriptive terms for specific odours were assessed on 0-100 scales. For cooking, each fat sample was cut into 10 approximately equal sized cubes, placed in a foil container covered with foil, and cooked in pre-heated ovens set at 200^0C for 15 minutes. Each cube was then removed and placed in a bottle set at 60^0 C and presented to each member of the panel.

For the assessment of gut bacteria, 180 pigs from the different treatments were identified in the abattoir and their intestines were coded using coloured strings. Distal colon sections, 5mm long containing faeces, were removed in the gut room and placed in sterile bags for transport to Langford. Faeces were removed and placed in stomacher bags with diluents. Diluted material was spread onto agar plates and incubated. Enterobacteriaceae, the bacterial group to which Salmonella belongs, and Lactic acid bacteria, the 'healthy' bacterial group, were identified and counted. Salmonella were identified and enumerated separately using an enrichment procedure.

Data were statistically analysed using general linear models (GLM), comparing the different levels of chicory in the diet and the duration of feeding.

Results

The results from trial 1 involving pigs from 30 farms are shown in Figure 1. Each bar represents 50 pigs whose backfat samples have been minced together. There was wide variability between farms, as shown in other work on boar taint. Three farms had

androstenone concentrations above the 'threshold' value of 1.0 µg/g and 9 farms had skatole concentrations above the 'threshold' of 0.2µg/g fat. There were different genetics and production systems on the different farms which must explain these variations. The overall means were 0.71µg/g for androstenone and 0.2µg/g for skatole.

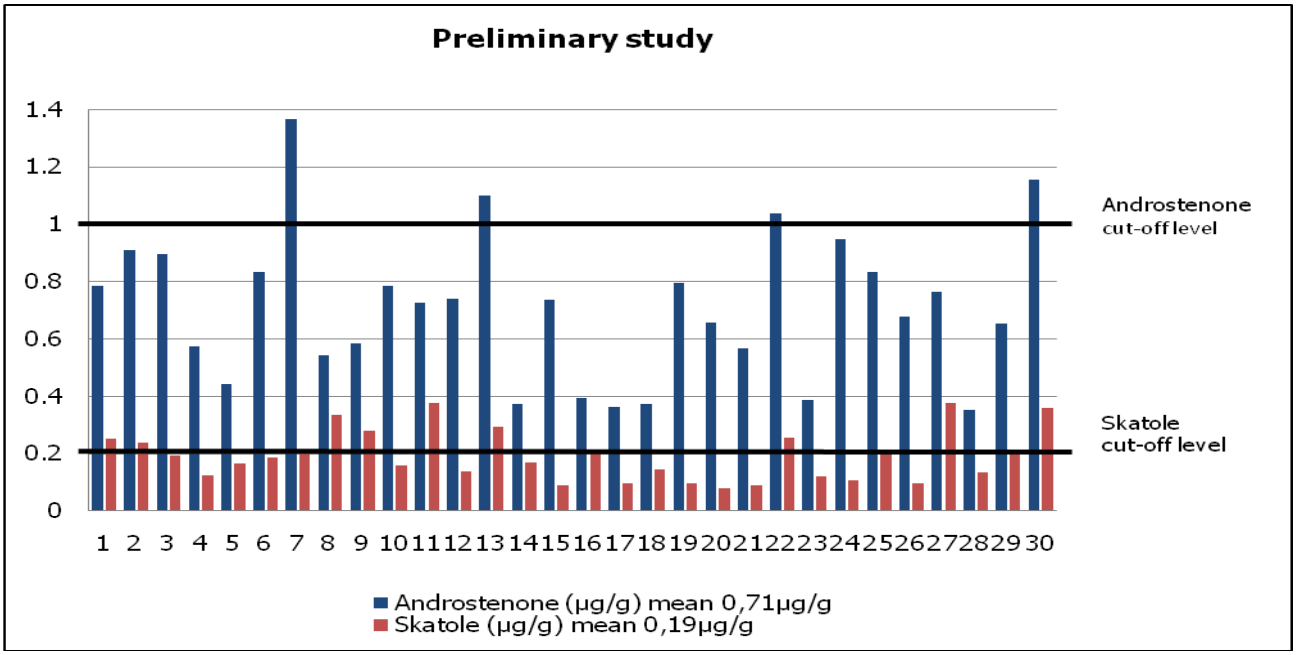


Figure 1. Concentrations of skatole and androstenone in the 30 farms involved in trial 1.

The results for the pigs on the 13 farms involved in trial 2 are in Table 1. Dried chicory fed at 5% of the finishing diet for 2 weeks before slaughter reduced skatole concentrations below the level of control farms in 5 out of the 7 treatment farms. There was one farm (no 9) with a very high skatole level and no explanation for this could be found. Genetics and husbandry methods were similar to other treatment farms. On the basis of these mainly promising results it was decided to proceed to trial 3 and to compare levels of chicory below and above the level used in trial 2.

Concentrations of skatole in the backfat of the 12 groups of 30 pigs (3 weeks x 4 levels of chicory, 360 pigs in total) in the main trial, trial 3, are shown in Table 2. The levels of skatole in the different groups were variable even though this trial took place on one farm with similar genetics and feeding systems in the different houses where the pigs were reared. After 2 weeks of feeding the 9% chicory diet, the level of skatole was significantly lower than in all the other groups and typical of values seen in castrates. There was no evidence that 3 or 6% chicory was effective. The distribution of skatole values in the pigs fed different levels of chicory at 2 weeks is shown in Figure 2. The % of pigs exceeding the threshold value of 0.2µg/g skatole was 63, 37, 43 and 3 for the 0, 3, 6 and 9% chicory groups respectively. Only 1 pig, representing 3% of the 9% group, had a value greater than 0.2µg/g.

Table 1. Concentrations of skatole in trial 2.

Farm	UOB number	Date sampled	Box number	Samples received	Group	Skatole(µg/g)
Brooks	2	12/05/2008	NX0847	50	Control	0.155
Webster	5	15/05/2008	NX0768	50	Control	0.124
Wingfield	6	14/05/2008	SL0336	50	Control	0.226
Waters	11	14/05/2008	NX0893	50	Control	0.139
Brand	12	13/05/2008	NQ0056	50	Control	0.159
Alexander	13	13/05/2008	NX0985	50	Control	0.088
Green	1	12/05/2008	NX0556	50	Trial	0.040
D.Miller	3	16/05/2008	SL0630	50	Trial	0.087
Fen Farm	4	15/05/2008	NX4181	38	Trial	0.069
Cole	7	16/05/2008	LR2308	50	Trial	0.062
Stanford	8	16/05/2008	SL0967	39	Trial	0.151
Hadingham	9	15/05/2008	SM1702	50	Trial	0.238
Barker	10	14/12/2007	SL0249	42	Trial	0.085

Table 2. Backfat skatole concentrations in groups of pigs given 0, 3, 6 or 9% dried chicory for 0, 1 or 2 weeks (trial 3).

Week	Chicory level				Sig
	0g/kg	30g/kg	60g/kg	90g/kg	
0	0.149[a]	0.226[b]	0.131[a]	0.137[a]	*
1	0.111	0.085	0.080	0.108	ns
2	0.237[b]	0.129[b]	0.124[b]	0.047[a]	***

[ab]Means in a row with different superscripts are significantly different (P<0.05).

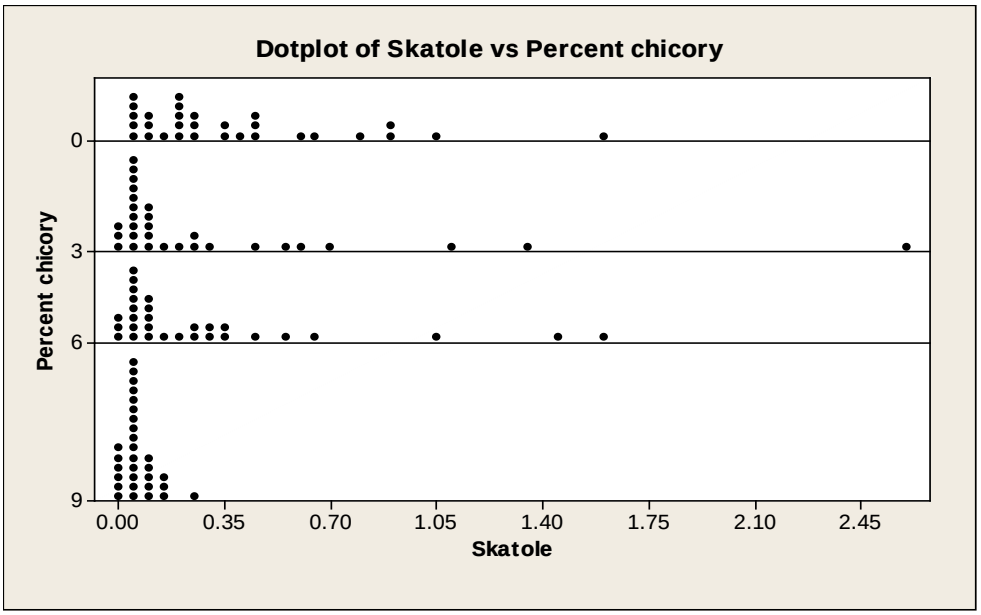


Figure 2. Distribution of skatole concentrations in the pigs fed different levels of chicory at 2 weeks.

The results of the 'sniff' tests on heated backfat from pigs fed the different levels of chicory for 2 weeks are in Table 3. There was no trend in the pork odour scores. Abnormal odour score was numerically lower in the 9% group than in the 0% controls but the difference was marginal. 'Mothballs' is a descriptor for skatole and this was lower in the 9% group than in controls. 'Parsnip', which is a descriptor for androstenone, was not different between the groups and was numerically higher in the 9% group. A possible explanation for this result is given in Figure 3. The concentration of androstenone in the 9% group after 2 weeks was higher than in most farms in trial 1.

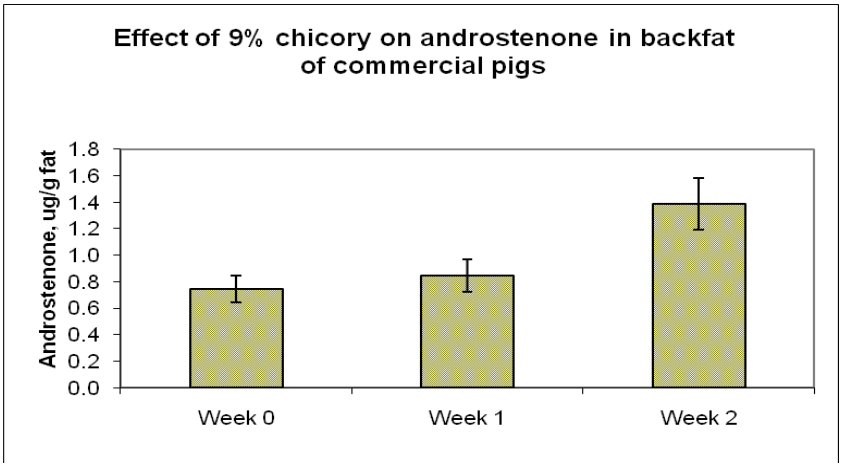


Figure 3. Concentrations of androstenone in the groups fed 9% chicory for 0, 1 and 2 weeks.

Table 3. Results from the sensory tests in trial 2. [x]1-8 scales, [y]0-100 scales

	Chicory levels				Sig
	0 g/kg	30 g/kg	60 g/kg	90 g/kg	
Pork odour[x]	3.53	3.72	3.58	3.70	NS
Abnormal[x]	4.30[a]	3.90[c]	4.22[ab]	4.04[bc]	***
Mothballs[y]	11.2[a]	8.2[b]	9.2[ab]	7.4[b]	*
Parsnip[y]	16.3	17.7	18.4	19.6	NS

The results for levels of Enterobacteriaceae bacteria are in Table 4 and Figure 4. Numbers of bacteria were different between the groups at the outset. Feeding 9% chicory reduced the bacterial population after 1 and 2 weeks of feeding. Levels of Lactic acid bacteria are shown in Figure 5. There was a decline in numbers after 2 weeks in all groups, including the 0% group, which is difficult to explain. However, both the 3% and 9% groups showed reductions after 2 weeks. From the 180 samples after enrichment, only 8 were found to be positive for Salmonella species. There was no pattern between the treatment groups.

Table 4. Mean Log_{10} $CFUg^{-1}$ ± SEM of Enterobacteriaceae from distal porcine gut samples after slaughter

	Before feeding	After 1 week	After 2 weeks
0%	6.22 ± 0.12 [a,1]	6.50 ± 0.14 [b,2]	5.86 ± 0.22 [ab,1]
3%	6.01 ± 0.30 [a,1]	6.25 ± 0.18 [b,1]	6.21 ± 0.21 [b,1]
9%	6.60 ± 0.16 [a,1]	5.46 ± 0.37 [a,1]	5.58 ± 0.15 [a,1]

*superscript letters within the same column and numbers within the same row which are different, indicate a significant difference ($P<0.05$)

Fig 4. Mean Log_{10} $CFUg^{-1}$ of Enterobacteriaceae from distal porcine gut samples after slaughter

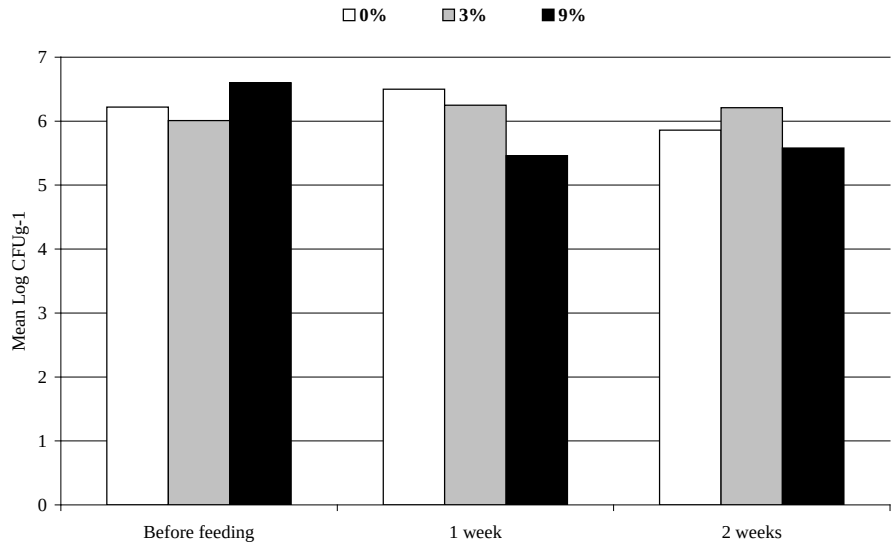
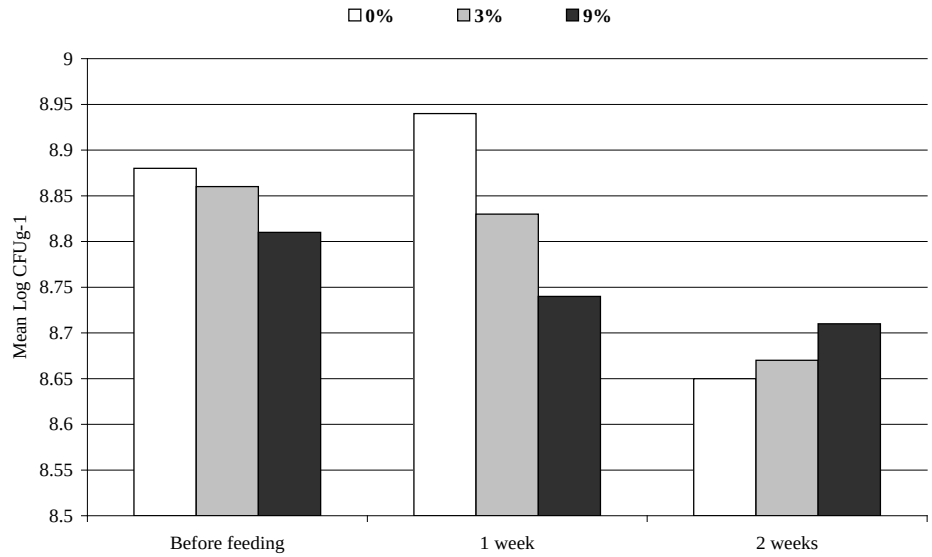


Fig 5. Mean Log_{10} $CFUg^{-1}$ of Lactic acid bacteria from distal porcine gut samples after slaughter



Discussion

The average values for skatole and androstenone in backfat, 0.2 and 0.71µg/g respectively, are similar to values for the UK in a Europe-wide study reported by Walstra et al. (1999). UK was about average for the 6 countries represented. The values are higher than reported recently by us in Large White cross pigs reared at the University of Leeds (the growth rate trial). There were different genotypes involved in the present study including Duroc and Hampshire and these are known to have higher values of boar taint compounds than Large White.

The large variation found between farms in trial 1 has been seen by us in a recent study (Whittington et al., 2010) and is thought to be due to genotype and husbandry differences between farms. Nine of the farms exceeded the threshold value for skatole taken to indicate tainted pork (0.2µg/g) and 4 exceeded the threshold for androstenone (1.0µg/g). Of the 4 farms high in androstenone, 3 also exceeded the threshold for skatole. The fourth was at the limit (0.2µg/g).

A value of 5% dried chicory as the commercial product Fibrofos 60 was decided on for a preliminary investigation (trial 2). The level was based on Danish research and our own views on the cost effectiveness of chicory. Fed for 2 weeks, this reduced skatole concentrations in 5 out of 7 treated farms to levels below all 6 control farms. Only 1 farm in the treated group had a skatole level higher than the threshold, 0.238µg/g. These were considered promising results so we proceeded to trial 3.

The results of the main trial showed the same wide variation between groups observed in trials 1 and 2. However, there was a clear effect of 9% chicory in reducing skatole to extremely low levels. After 2 weeks, the skatole concentration was on average 0.047µg/g in the 9% group. Only 1 pig out of 30 had a value greater than the threshold of 0.2µg/g compared with 19 given the 0% diet, 11 given the 3% diet and 13 given the 6% diet. This was very good evidence that chicory at 9% of the finishing diet was effective in reducing skatole.

The sensory tests on heated backfat samples showed that the panellists did not detect a difference in abnormal odour, a reliable indicator of boar taint, between the 9% group and the rest. Pork odour was also not different. The scores for ‘mothballs’, a term used to describe the essential odour of skatole, was lower in the pigs given chicory than in 0% controls and was lowest in the 9% group. However the scores for ‘parsnip’, a term used to describe androstenone, tended to increase as chicory inclusion increased, although not significantly. These results suggest that although skatole was reduced, androstenone was not and was actually perceived at a higher level in the 9% group. Results for androstenone showed that the level in the pigs given chicory for 2 weeks was very high, 1.4µg/g. This is a level only reached by 1 of the 30 farms in trial 1. It is unlikely that androstenone increased as a direct result of low skatole concentrations. The result is attributed to the use of different pigs in the treatment groups, with the 9% chicory group at 2 weeks being an outlier in terms of androstenone.

Overall the results show that under the conditions of this trial, chicory was effective in reducing skatole but not boar taint. It is surprising that the sensory perception of boar taint was not reduced because most data shows that skatole is the taint compound most closely associated with boar taint (eg Whittington et al., 2010). In other pigs, with lower concentrations of androstenone, the result may have been more positive for pork odour and flavour.

The estimated cost of Fibrofos 60 is around £3 per pig. It seems difficult to justify this cost based on the current results.

The microbiological results showed a tendency for chicory to reduce levels of the bacterial group Enterobacteriaceae which includes Salmonella, E coli and other pathogenic bacteria. Low levels of Enterobacteriaceae are indicative of a healthy gut as are high levels of Lactic acid bacteria, this group showing a trend to increase when chicory was fed.

Acknowledgements

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