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Effect of dietary chicory on boar taint

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ABSTRACT

Following preliminary screening and feeding trials on farms supplying a commercial abattoir, 360 entire male pigs were used to evaluate the effects of different percentages of chicory (*Cichorium intybus* L.) on levels of boar taint compounds and sensory aspects in backfat. Pigs were fed 0, 3, 6 or 9% chicory in the diet, 30 pigs being sampled at 3 different times: initially to measure basal levels of skatole and androstenone and after 1 and 2 weeks on the test diets. Cooked samples of backfat were presented to a trained sensory panel for "sniff" tests. Chicory fed at 9% for 2 weeks reduced skatole levels significantly ($P<0.001$), with 0.55 of pigs below 0.05 μg/g, typical of levels in castrated males. Abnormal odour scores were significantly lower for pigs in this group compared with 0% pigs ($P<0.001$), however, androstenone concentration was significantly higher in this group after the 2 week feeding period ($P<0.005$). Thus, feeding 9% chicory for 2 weeks was effective in reducing backfat skatole concentrations and abnormal odour scores of cooked fat but not androstenone concentration.

1. Introduction

Entire male pigs have superior commercial performance to castrates, due to more efficient food conversion and a higher lean meat percentage in the carcass. In most European countries but not the UK, male pigs are still castrated at a young age to avoid the potential problem of boar taint, an offensive odour/flavour that is mainly manifested when the meat is cooked. It is due to high concentrations of skatole and/or androstenone in the meat which are driven off during cooking. These compounds are derived from different metabolic processes. Skatole (3-methylindole), exhibiting a faecal-like odour, is produced by degradation of the amino acid tryptophan in the hind gut and androstenone (5α-androst-16-ene-3-one), exhibiting a urine-like odour, is a pheromone produced in parallel with testosterone as part of male sex hormone metabolism. Both compounds are metabolised in the liver, showing an interaction that influences their concentrations (Doran, Whittington, Wood, & McGivan, 2002), and, in most pigs, levels in fat are below the thresholds where taint problems can arise. These are 0.2 μg/g of fat for skatole and 1.0 μg/g of fat for androstenone (Bonneau et al., 1992). However in some pigs, with percentages that are variable (Walstra et al., 1999), these compounds reach very high concentrations for reasons which are still not clearly understood.

In the literature several methods have been suggested that could reduce the incidence of boar taint in slaughter weight pigs, but the right solution to the problem has yet to be found. Some methods have significant effects and others seem to have only marginal effects, but the main problem is that androstenone and skatole do not always respond in the same way to the measures. Levels of androstenone in fat are mostly affected by genetic factors controlling its production and excretion as well as by the degree of sexual maturity (Grindflek, Berget, Moe, Oeth, & Lien, 2010). It is commonly accepted that increasing slaughter weight results in animals of greater sexual maturity and consequently having high levels of androstenone, however, the study by Walstra et al. (1999) showed no relationship between body weight and boar taint. Genetic selection seems more effective at lowering androstenone content (Bonneau, 2006; Jensen, 2006); however, even if the patterns of androstenone production and metabolism were better understood (Doran, Whittington, Wood, & McGivan, 2004; Nicolau-Solano et al., 2006) more work is still necessary to identify the right genetic markers for pigs exhibiting low androstenone levels. In contrast, as skatole production is due to the bacterial degradation of tryptophan in the large intestine, its level in the fat can be reduced by modulating management aspects of pig production such as diet, feeding and rearing conditions. Several studies in the last 20 years (Claus, Weiler, & Herzog, 1994; Hansen et al., 2006; Jensen & Jensen, 1998; Kjos, Øverland, Fauske, & Sørum, 2010: Rideout, Fan, Cant, Wagner-Riddle, & Stonehouse, 2004; Whittington et al., 2004; Zamaratskaia, Babol, Andersson, Andersson, & Lundström, 2005) showed how a change in dietary composition, especially in the last weeks before slaughter, possibly through changes in bacterial activity affecting tryptophan (Hansen, Larsen, Jensen, & Hansen-Møller, 1997; Jensen, Jensen, Laue, Agergaard, & Bibby, 1997) has a significant effect on skatole level. Different feed components have been tested; most of the studies have investigated the effects of diets rich in fibre, such as

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sugar beet pulp, or rich in fermentable carbohydrates that escape digestion in the small intestine, such as raw potato starch and chicory. In different studies, the use of chicory (*Cichorium intybus* L.) has reduced skatole levels in faeces, blood and fat (Byrne, Thamsborg, & Hansen, 2008; Claus et al., 1994; Hansen et al., 2006; Jensen & Jensen, 1998; Rideout et al., 2004). Chicory roots are particularly rich in a fructo-oligosaccharide, inulin, which is not digested in the small intestine and is able to alter the patterns of microbial fermentation in the large intestine with a consequent reduction in the production of skatole. In past studies, both chicory roots and pure inulin extracted from chicory, have proved successful in reducing the level of skatole; however, the minimum percentage of dietary inulin required, or the length of feeding period necessary for consistent results in the constraints of commercial pig production is still not clear.

It has been demonstrated that androstenone and skatole are the main contributors to the problem of boar taint but the respective importance of each of them is still not clear. Some studies have underlined the importance of the level of androstenone for tainted pork (Babol, Squires, & Gullett, 1996; Squires, Deng, & Wu, 1992), while others have suggested skatole as the main contributor (Bejerholm & Barton Gade, 1993; Lundström, Malmfors, Malmfors, & Stern, 1987). In a consumer survey carried out in seven countries, Matthews et al. (2000) found that skatole had the biggest impact on consumer acceptability compared to androstenone, a result in agreement with a recent study conducted by our group (Whittington et al., 2011). This study also showed synergism between the compounds affecting the sensory response, with skatole enhancing the odour of androstenone, a result also found by Annor-Frempong, Nute, Whittington, and Wood (1997a). It is possible therefore that reducing skatole alone may be an effective way to control boar taint.

The current project was therefore undertaken to see if a short feeding period with inclusion of chicory before slaughter will be sufficient to significantly reduce the level of skatole and improve the sensory aspects of pork from entire males from British commercial farms.

2. Material and methods

The work was conducted on farms supplying pigs to a major pig processing company in the East of England. The study consisted of two parts, a preliminary study to determine levels of boar taint compounds on the different farms and the effects of using a low level of chicory, followed by the main feeding trial.

2.1. Preliminary studies

Thirty farms supplying a commercial abattoir were screened for levels of androstenone and skatole in the backfat. The farms were all operated in a similar way including the use of common diets and similar genetics. Breeds represented were Large White, Duroc and Pietrain and pigs on each farm were crosses between these, although the exact combination was unknown and likely to differ between farms. For each farm, samples of subcutaneous fat from the dorsal neck region (referred to as backfat) were collected from a minimum of 22 to a maximum of 50 entire male pigs slaughtered on the same day. The sample collected from each pig was an area of skin plus attached fat measuring 15 × 5 cm, taken from the dorsal cervical region close to where the head is removed. After an initial training visit to the abattoir, all samples were taken over several weeks by the staff of the abattoir. Samples per farm were individually labelled, bagged and stored at −20 °C before being sent in batches to University of Bristol (UoB). Each farm was evaluated using a composite sample obtained from fat samples from all the pigs. After removing the skin and underlying sebaceous glands, 2 g of fat, including inner and outer layers, was obtained from each pig. The 100 g of fat tissue obtained for each farm (when 50 pigs were sampled) was then blended together using a Moulinette S food processor (Moulinex®) and sub-sampled for analysis. Skatole and indole concentrations were measured and expressed as microgram compound/g fat tissue (μg/g) using the simultaneous distillation–extraction procedure followed by GC analysis, according to the methodology described by Annor-Frempong et al. (1997a). Androstenone concentrations were measured (and also expressed as μg/g fat tissue) using a modification of the high resolution gas chromatographic procedure of De Brabander and Verbeke (1986). This study provided baseline information on the levels of taint compounds in this farming group.

A preliminary feeding trial was undertaken to study the effects of a low percentage of a dried chicory product, Fibrofos 60 (SOCODE, Cosucra Groupe Warcoing S.A., Belgium) included in the diet. Fibrofos 60 is a powdered product obtained from chicory roots dried at low temperature and containing 60% of inulin on a dry matter basis (DM). In this feeding trial the effects of feeding 5% of Fibrofos 60 in the finishing diet for 2 weeks before slaughter on 7 farms was compared with feeding a non-supplemented feed on 6 control farms. Each farm was represented by 50 pigs and they were sampled and tested using the same methods as described in the previous study. The level of 5% was based on results of previous research on chicory in the literature and views in the project team of the cost effectiveness of using Fibrofos 60, although 10% is the amount recommended by the producing company.

2.2. Main feeding trial

In the main feeding trial only one of the 30 farms from the preliminary study was tested. A total of 360 cross-breed growing-finishing pigs (crosses between Large White, Landrace, white Duroc and Pietrain) all entire males, were fed 4 different levels of Fibrofos 60: 0% (basal diet), 3, 6 and 9% in the finishing diet. The 4 groups were raised in different buildings with a similar layout (90 pigs each), with 18 pigs/pen, on straw covered solid floors which were cleaned out 6 times per week. For each group, 30 entire pigs were sampled at slaughter (as described in the preliminary study) at three different times: a first time (called week 0) to determine the baseline level of skatole and androstenone in all the pigs that had received only the basal diet. Then the supplement of chicory was introduced and the remaining pigs were sampled after 1 and 2 weeks on the test diet. From each pig a sample of backfat was collected, individually labelled and bagged, stored at −20 °C until all 360 pigs were sampled and then sent to UoB for analysis. Hot carcass weight and P2 fat thickness (measured 65 mm from the dorsal mid-line at the level of the last rib) were recorded for each pig. All 360 boars were individually tested for skatole concentration while androstenone was measured individually in 110 pigs (all 9% pigs and 20 pigs of 0% chicory, week 2), using the same procedures as before. All 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; 2 = very weak; 3 = moderately weak; 4 = slightly weak, 5 = slightly strong, 6 = moderately strong, 7 = very strong, 8 = extremely strong). In addition, certain descriptive terms for specific odours, used by Annor-Frempong, Nute, Whittington, and Wood (1997b), were assessed on 0–100 mm line scales. The descriptors for skatole were: mothballs and musty. Those for androstenone were: acrid, stale sweaty, nose feel and piggy; then parsnip, stewed vegetables and sweetness that are typical for low concentrations of androstenone. For cooking, each fat sample was cut into 10 approximately equal cubes, placed in a foil container covered with foil, and cooked in pre-heated ovens set at 200 °C for 15 min to an endpoint temperature of 75 °C. Each cube was then removed and placed in an amber bottle, capped and maintained on a hotplate at 60 °C for at least 3 min before being presented in random order to each member of the panel. Initial panels were set up to test for differences between the 4 pig houses at week zero, i.e. 4 houses × 30 samples. Results were expressed as the means derived from