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CAUSE AND POSSIBLE WAYS TO ELIMINATE BOAR TAINT IN PORK*

Zamaratskaia Galia

A b s t r a c t: Boar taint, an undesirable odour from meat from some entire male pigs, is caused by the naturally occurring compounds androstenone and skatole. The level of boar taint can be minimized by decreasing the concentrations of these compounds in adipose tissue. Immunocastration substantially reduces the levels of both. Skatole levels can be also reduced by dietary manipulations and improved rearing conditions; however, this approach has no or little effect on androstenone. Genetic selection against high androstenone and skatole levels is an attractive alternative if achieved without negatively affecting reproduction and economic efficiency. If entire male pigs are to be used in pork industry, methods to detect tainted carcasses are needed. Tainted carcasses can be used for processed meat products. Meat processing can probably reduce or mask boar taint; however, more studies are needed to investigate possible processing techniques and consumer attitudes towards final pork product. Thus, in future, surgical castration of male piglets can be avoided and replaced by practical and ethically acceptable alternatives. At the moment, castration using anaesthesia and analgesia, or immunocastration can be used as temporary solutions. This article reviews the development of some alternatives to surgical castration of entire male piglets to control boar taint.

Key words: *boar taint; Surgical castration; Anaesthesia and analgesia; Immunocastration; Use of entire male pigs*

Uzrok i mogućnosti eliminacije polnog mirisa u svinjskom mesu

S a d r ž a j: Polni miris nerastova, neprijatni miris koji potiče od mesa kod muških jedinki, uzrokovan je jedinjenjima androstenon i skatol, koji se prirodno nalaze kod ovih životinja. Intenzitet polnog mirisa može da se umanji smanjenjem koncentracije navedenih jedinjenja u masnom tkivu. Imunokastracija značajno smanjuje nivoe i androstenona i skatola.

Nivo skatola može da se smanji i promenom ishrane kao i poboljšanjem uslova uzgoja. Međutim, ovakav pristup ne utiče na nivo androstenona. Genetska selekcija jedinki sa manjim nivoima adrostenona i skatola je pogodna alternativa ukoliko ne utiče negativno na reprodukciju i ekonomsku isplativost uzgoja. Ukoliko se nerastovi koriste u industriji neophodno je razviti metode detekcije polnog mirisa trupova. Ovakvi trupovi mogu da se iskoriste u preradi. Prerada verovatno može da umanji ili maskira polni miris. Međutim, potrebne su dalje studije koje bi istražile moguće tehnike kao i odnos potrošača prema gotovom proizvodu. Stoga je u budućnosti moguće izbeći hirurško kastraciju prasadi muškog pola i zameniti je praktičnijim i etički prihvatljivijim alternativama. Kastracija pod anestezijom ili analgezijom, kao i imunokastracija su u ovovm trenutku privremena rešenja. Ovaj rad pruža osvrt na razvoj nekih alternativa hirurškoj kastraciji prasadi muškog pola radi kontrolisanja polnog mirisa.

Ključne reči: *polni miris, hirurška kastracija, anestezija I analgezija, imunokastracija, korišćenje nerastova*

Introduction

Surgical castration of entire male piglets not intended for breeding is routinely performed in many European countries to reduce the risk of boar taint, an off-flavour in heated pork products. Boar taint occurs in some entire male pigs at puberty and is primarily caused by high levels of androstenone and/or skatole in pig carcasses. Although surgical castration reduces the levels of both compounds and therefore decreases the risk of boar taint, this approach is not fully satisfactory. Entire male pigs compared to castrates have a superior feed efficiency and higher lean yield of the carcasses. Moreover, surgical castration has been increasingly disparaged because of its negative effects on animal health and welfare. Therefore, to prevent boar taint, methods other than surgical castration are required. Ideally, such methods should be easy for use on farms and effectively reduce taint in entire male pigs. Various factors are known to regulate the levels of skatole and androstenone in pig carcasses and these factors have been regularly reviewed (*Bonneau,* 1982; *Claus et al*., 1994; *Bonneau,* 1998; *Lundström and Zamaratskaia,* 2006; *Zamaratskaia and Squires,* 2009). The purpose of the present short review is to highlight selected aspects of the boar taint problem and to provide a summary of current knowledge on

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AUTHOR: Galia Zamaratskaia, galia.gamaratskaia@lmv.slu.se, Department of Food Science, Swedish University of Agricultural Sciences, Box 7051, SE-750 07, Uppsala, Sweden;

skatole and androstenone. Special focus is given to the potential alternatives to surgical castration.

Cause of boar taint

Skatole (3-methylindole) and androstenone (5α-androst-16-en-3-one) are two major compounds responsible for boar taint (*Dijksterhuis et al*., 2000). Skatole is produced by the microbial degradation of tryptophan in the large intestine of pigs. Androstenone is a steroid produced in the Leydig cells of the testis in mature pigs. Skatole is perceived by most people as a faecal-like odour, whereas ability to detect androstenone is highly variable between people with different genetic background (*Wysocki and Beauchamp,* 1984). Descriptions of androstenone odour vary from sweat- or urine-like to perfume- or flower-like odour. There are indications that other compounds can contribute to boar taint, such as indole (*Garcia-Requeiro and Diaz*, 1989) and androstenol (*Brooks and Pearson,* 1989). Their contribution, however, seems to be of less importance because of relatively weak odour.

Effects of surgical castration

Surgical removal of testicles is an effective method to remove the source of testicular steroids, including the boar taint compound androstenone. Surgical castration also prevents the accumulation of another boar taint compound – skatole – due to enhanced skatole metabolic clearance in the absence of testicular steroids (*Doran et al.,* 2002; *Zamaratskaia et al.,* 2007). Furthermore, surgical castration removes the source of spermatozoa and prevents the male pigs from unplanned breeding. However, surgical castration of piglets negatively affects animal welfare which is a severe drawback of this method. Currently there are no widely accepted alternative to surgical castration.

"Humane" castration

Use of local anaesthesia

Effective local anaesthesia is one option to reduce pain in piglets during surgical castration. Surgical castration with anaesthesia using10 mg of Procaine (Procasel 2%®, Selectavet, Germany) per testis reduces the intensity of pain during castration as assessed by changes in vocalisation and defence behaviour of piglets (*Leidig et al.,* 2009). *Marx et al.* (2003) demonstrated that piglets castrated without anaesthesia produced significantly more screams than piglets castrated with local anaesthesia with lidocain (Ursocain 2%; 0.5 ml per testis). However, piglets during injection are subjected to an additional distress due to prolonged handling and pain due to injection. The use of local anaesthesia improves, although not completely, the welfare status of piglets but increases the costs of the procedure. Additionally, anaesthesia lasts for a short time, and the use of extra analgesic agents is recommended. Finally, the procedure should only be performed by veterinarians in most countries.

Immunocastration

Some progress has recently been made in development of a vaccine for immunization against gonadotrophin releasing factor (GnRF). Considerable experimental evidence supports the notion that this is a reliable non-surgical method to control both boar taint and aggressive behavior of entire male pigs. Blocking the action of GnRF by creating GnRF antibodies stops testicular function, thus producing a temporary castration effect and preventing accumulation of androstenone and skatole in boar's tissues. A potentially promising vaccine, Improvac™, has recently been tested in some countries (*Dunshea et al.,* 2001; *Jaros et al.,* 2005; *Zamaratskaia et al*., 2008a,b; *Font i Furnols et al*., 2008). Immunocastration with Improvac consistently reduced the production of testicular steroids and androstenone along with the size of reproductive organs, as well as skatole levels.

Possibility of use of entire male pigs

Reduction of slaughter weight

Slaughter at a younger age/lower live weight (before puberty) can reduce the risk of increased levels of androstenone and skatole. In some countries, e.g. Ireland and the United Kingdom, male pigs are produced intact. This approach does not negatively affect animal welfare; however, from an economic point of view it is not an attractive option. Additionally, slaughter at lower weight does not entirely eliminate boar taint (*Aldal et al.,* 2005; *Zamaratskaia et al.,* 2005a).

Management strategies (diet and hygienic conditions)

Given that skatole originates from tryptophan in porcine large intestine, it is not surprising that dietary composition is an important factor affecting skatole levels. Reduction of skatole levels by dietary means has been a subject of a considerable research

effort over the past decades (*Lundström et al.,* 1994; *Jensen et al.*, 1995; *Claus et al*., 2003; *Zamaratskaia et al*., 2005a). Non-digestible carbohydrates are known to reduce intestinal production of skatole. For instance, *Jensen et al*. (1995) *and Whittington et al.* (2004) found reduced skatole levels in fat in pigs fed sugar beet pulp. Dietary supplement of raw potato starch reliably reduced skatole levels in porcine tissues in castrated male pigs (*Claus et al.,* 2003), entire male pigs (*Zamaratskaia et al.,* 2005a) and female pigs (*Zamaratskaia et al.,* 2006). This reduction might be due to the inhibition of cell apoptosis in the colon and thus reduced tryptophan availability for skatole production (*Claus et al.,* 2003). Butyrate, which is formed in high quantities when the supply of resistant starch is high, can cause a reduction in apoptosis of epithelial cells and reduces availability of the skatole precursor tryptophan (*Claus et al.,* 2003). Additionally, changes in dietary composition may modify intestinal transit time and the microbial activity in the intestine (*Jensen et al*., 1995).

Environment is also an important factor affecting skatole production in the intestine. Temperature and ventilation in the stable as well as stocking rate were shown to affect skatole levels (*Hansen et al.,* 1994).

Genetic selection for 'low taint' pigs

Some selection experiments have been performed to reduce androstenone levels (*Sellier and Bonneau,* 1988; *Willeke and Pirchner*, 1989; *Sellier at al.,* 2000). However, the selection against androstenone can lead to reduced levels of anabolic hormones as well, which in turn negatively affects growth performance of entire male pigs and onset of puberty in gilts and boars (*Sellier and Bonneau*, 1988; *Willeke and Pirchner,* 1989). To eliminate the undesirable side-effects of selection procedures it is essential to detect pigs that express low androstenone levels at sexual maturity. The development of genetic markers for pigs with low androstenone and skatole levels would allow the selection of taint-free pigs. The subject has been reviewed in more detail elsewhere (*Zamaratskaia and Squires*, 2009).

Detection of boar taint

The use of entire male pigs in pork industry requires identification of pigs with high level of boar taint to insure that no tainted meat reaches the consumers. Rapid, cheap and reliable methods to detect boar taint are needed. There are a number of analytical methods, e.g. HPLC, LC-MS, GC, GC-MS, RIA and ELISA, developed for the measurement of concentrations of skatole, androstenone and both in adipose tissue. However, the application of these methods on the slaughter line is not realistic because of complicated sample preparation and purification steps. The colorimetric method to measure skatole equivalents in adipose tissue (*Mortensen and Sørensen*, 1984) has been used online in Danish slaughterhouses. This method is rapid and simple; however, it does not provide information about the levels of the other important boar taint compound, androstenone. A colorimetric method for total 16-androstenes was also developed (*Squires,* 1990) but never used at slaughterhouses. It was recently suggested that measurements of boar taint levels in carcasses can be performed using an electronic nose based on ion mobility spectrometry (*Vestergaard et al.,* 2006). However, an automatization of an on-line system based on electronic nose technology requires further development. As discussed by *Vestergaard et al.* (2006), "this would not necessarily imply the need for a skatole and androstenone specific sensor array, since also other possible compounds may be involved in the sensory perception of boar taint, but rather a broad-selectivity sensor array that matches the sensory perception of boar taint, which in turn should be calibrated against national consumer thresholds".

Besides, other simple methods to detect pigs with high boar taint levels have been proposed, e.g. measurement of reproductive organ sizes. *Bonneau and Russeil* (1985) suggested that the measurement of bulbourethral glands could be used as an indirect estimation of androstenone levels in fat from entire male pigs. *Zamaratskaia et al.* (2005b) showed that pigs of a crossbred (Swedish Yorkshire dams×Swedish Landrace sires) with testes weight below 565 g and a bulbourethral gland length below 90 mm had low skatole levels; low androstenone levels in this study could not be predicted by the size of reproductive organs. Pigs with reproductive organs above those levels should further be tested for skatole concentrations in fat. Thus, the use of such a method can reduce the number of carcasses for chemical analyses, but cannot be used as the basis on which to reject carcasses. Therefore, further investigations are required to develop a rapid and sensitive method for the systematic analysis of boar carcasses. The tainted meat could then be used for processed meat products.

Camouflage of boar taint

Except for potential presence of boar taint, meat from entire male pigs does not substantially differ from that from female or castrated pigs. The-

refore, tainted meat can be used after diluting with non-tainted meat. Processing of meat from entire male pigs can also neutralize the perception of boar taint. It was suggested that liquid smoke was able to mask the taint perception in sausages from entire male pigs (*Stolzenbach et al.,* 2009). *Wood et al.* (1993) demonstrated the importance of the cooking temperature on the acceptability of meat from entire male pigs. Finally, consumption of cold products from tainted meat does not induce such strong negative reactions among consumers as consumption of products immediately after heating (*Pearson et al.,* 1971). However, development of processing technology to camouflage boar taint needs more research.

Sorting sperm for sex pre-selection

Gender selection has lately been discussed as a promising tool for the pork industry (*Johnson*, 2000). Production of female-only herds through sex pre-selection is an alternative to surgical castration. However, the technique for gender selection is not commercially available at present. Large quantities of sperm are required for such a selection because of sperm losses and cell damage during selection. The other severe drawback of this method is an image of "manipulating nature". However, the technique might become a promising strategy in pork production if it is effective and precise, and costs of sperm separation are low. The current status of sexing technology in the pig and methodological developments is reviewed in *Vazquez et al*. (2009).

Conclusion

Boar taint, an undesirable odour from meat from some entire male pigs, is caused by the naturally occurring compounds androstenone and skatole. The level of boar taint can be minimized by decreasing the concentrations of those compounds in adipose tissue, e.g. via immunocastration, genetic selection, dietary manipulations and improved rearing conditions. Meat processing can probably reduce or mask boar taint; however, more studies are needed to investigate possible processing techniques and consumers attitudes towards final pork product. Genetic selection against high boar taint is probably the most attractive alternative, but is not realistic in the near future. At the moment, the best temporary solutions are "humane" castration using anaesthesia and analgesia, or immunocastration. The advantages and disadvantages of alternative methods should be carefully studied before the final decision is made about how to prevent boar taint without the need of stressful and painful surgical castration. It is generally believed that in future, surgical castration of male piglets can be avoided and replaced by practical and ethically acceptable alternatives.

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