Castration or Production of Entire Males – Threats and Possibilities

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Abstract— **Production of entire males with the possibility of boar tainted products reaching the consumer and a lack of international acceptance of pork from intact boars will cause a major threat to the total pork production chain. Advantages of producing entire males will be increased pig welfare, higher production efficiency for producers and a better perception by consumers. This paper summarizes the possibilities to reduce tainted pork reaching the consumer by 1) prevention and reduction of boar taint in the live animal, and 2) detection of tainted carcasses and use of tainted products in further processed meats. Significant reduction is possible through genetic selection, feed and farm management, which should be important future research areas. This will take time and a will not lead to 100% boar taint free products. An international accepted and reliable on-line detection method in the meat processing plants is not yet available, and current detection research only focuses on androstenone and skatole as causative agents of boar taint. There is, however, growing evidence that these two compounds only explain part of the variation in boar taint as experienced by consumer taste panels. A cost-effective on-line detection system has to be developed, which only has a limited number of false positive and false negative carcasses. In the mean time castration with minimal pain is a viable option.**

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V. INTRODUCTION

THE production of entire male pigs for meat has advantages in terms of welfare for the male pig, production efficiency for the farmer, and perception of animal welfare for the consumer [1]. Castration of pigs has traditionally been carried out in most countries across the world to prevent the occurrence of boar taint.

Boar taint is a distinctive and unpleasant taint perceived through a combination of sensory odor, flavor, and taste in pork and pork products during cooking and eating. The incidence of boar taint reported in literature is very variable, ranging from 10 to 75% [2, 3, and 4]. Part of this variation is caused by the cut-off points used for definition of boar taint, which are based on some of the known chemical compounds of boar taint (androstenone and skatole).

Androstenone acts as a male pheromone in pigs and is closely linked to testicular function, while skatole is formed in the gut by microbial degradation of tryptophane [5]. Both androstenone and skatole are highly fat soluble. Although both skatole and androstenone contribute to boar taint, there is evidence that they cannot completely account for the occurrence of boar taint as determined by a taste panel [6].

The first threat from the production of entire males will be consumer rejection of tainted pork. A recent study on boar taint carried out in 7 different European countries showed that overall 6.5% more consumers would be dissatisfied with the odor of entire male pork than with that of gilt meat. The difference between countries ranged from 6.1 to 10.2% for odor and from 2.4 to 6.3% for flavor [1, 7]. Furthermore, there is no international acceptation of pork produced from entire males. This is a second important threat, which is particularly relevant for export oriented countries and companies.

This short paper will focus on the possibilities to produce entire males. There will be several ways to reduce and ultimately prevent occurrence of boar taint at the consumer level. First of all by reducing and preventing boar taint in the live animal. The second way is by detection, canalization, and usage of tainted pork in the production chain.

VI. PREVENTION AND REDUCTION OF BOAR TAINT

A. Castration with minimal pain

In a recent Dutch study the effect of local and systemic analgesia to reduce pain at castration was studied [26]. Local anaesthesia before castration led, compared to castration without anaesthesia, to a significant reduction of pain- and stress response during castration. A drawback is that injecting lidocaine in the testicles might lead to an additional pain response.

Regarding pain after castration, it was concluded that use of local anaesthesia led to an increase in pain related behaviour during the four days following castration. This disadvantage can be overcome by administration of an additional analgesic (meloxicam). Overall, piglets that received meloxicam before castration exhibited less pain related behaviour during the first days after castration.

The same study showed that inhalation anaesthesia with carbon dioxide has advantages over lidocaine administration. Advantages are complete analgesia and loss of consciousness at the time of castration, and a possibility of using this phase to perform other (painful) procedures.

An additional study showed that CO2 could be administered safe, meaning no additional dying of piglets. CO2 is now broadly used in The Netherlands to prevent pain during castration of piglets and to prevent occurrence of boar taint. This is a temporary solution and the different stakeholders from the Dutch pork production chain have agreed to focus research and development on scientifically based boar taint free pork production and to stop castration in 2015.

Immunocastration has been used in some parts of the world as an alternative to surgical castration [28]. This may, however, not be a viable option as it still requires injections and physical impact on pigs, and because of issues with consumer acceptation. A Swiss study showed that the acceptance of consumers to buy meat from immunocastrated pigs was low. Among the proposed alternative methods, the production of entire males, immunocastration and castration with anesthesia, only the last one seems to be acceptable for the Swiss consumer [24].

B. Genetic selection

The level of boar taint is affected by genetic factors, and distinct breed differences have been identified [10]. High heritability of both androstenone (range from 0.25 to 0.87) and skatole (from 0.23 to 0.55) facilitates selection of pigs against boar taint [11, 12].

Selection of boars with low androstenone and skatole levels should be possible provided that fertility or other production characteristics are not negatively affected. Application of traditional breeding schemes in combination with modern genome analysis and DNA marker techniques will be able to reduce levels of androstenone and skatole [10, 29, 30].

This will take at least 3 to 5 years and than there will still be boars in the population with elevated androstenone or skatol levels, because of the natural variation. Nevertheless, the use of low androstenone and skatole boar lines will be able to reduce tainted pork significantly.

C. Feed and farm management

High energy feeding has been shown to increase levels of both androstenone and skatole by acceleration the onset of pubertal development [14]. Skatole is the main component that can be influenced by feeding. Dietary changes may have quantitative and qualitative effects on intestinal microflora and may therefore influence the rate of skatole synthesis. Feed strategies can be used to manipulate the microflora by feeding certain carbohydrates a week before slaughter (inulin, some raw starches) to reduce skatole formation and thus part of the boar taint issue [13].

The processing of entire males at a lower slaughter weight has been considered as a possibility for avoiding boar taint. However, the relationship between taint compounds and carcass weight across the commercial slaughter weight range in the EU is quite small and correlations between skatole and androstenone concentrations on the one hand and carcass weight on the other hand are low [15]. Modern pig breeds are growing fast and recent commercial experiences of some European pig processing companies suggest that age may be a better criterion to use.

D. Raising of only females

The production of only female offspring would solve the issue of castration. While sexed sperm is commercially available for cattle, this is not the case for pigs. A sow needs much more sperm cells (about 2 billion sperms) for insemination than cows due to the anatomy of their reproductive organs. Deep uterine insemination techniques have been developed, which would need only 50 million spermatozoa per dose [8]. The capacity of current sperm sorting technologies in pig semen, however, is still too low and slow for an extended use in pig production [9]. Furthermore, the effect of sperm sorting in cattle is not a 100% female offspring. There are still between 10 and 25% bulls born from sexed cattle semen.

VII. Detection and Use of Boar Taint Carcasses

A. Sensory cut-off levels for boar taint

The incidence of boar taint in literature is very variable, ranging from 10 to 75% [2, 3, and 4]. This variation depends in part on the definition and the cut-off points that are used to define boar taint. Androstenone and skatole are considered largely responsible for boar taint. However, the relative contribution of these substances to boar taint varies in different studies and they do not explain all the variation in boar taint as perceived by consumer panels [6]. Additional components (i.e. indole) have been proposed as causative agents and research should focus on identifying them. A large EU study found that the proportion of carcasses with androstenone and skatole concentrations above the commonly-used thresholds (1.0 ppm androstenone and 0.25 ppm skatole) were 30% and 11% respectively [15].

Another reason for the variation in boar taint levels are the different methods used to determine boar taint, which are often not standardized within method and between labs. Trained sensory panels in general are able to differentiate between levels of boar taint compounds, though substantial differences between panels of seven European countries existed [25]. Consumer panels will also show a large variation in boar taint detection between countries, which are partly, caused by different genetics and farm management used in these countries. Differences in culinary habits between countries and the fact that only a part of the population is sensitive for androstenone based boar taint will further add to the variation. The proportion of very sensitive persons seems to be larger among women than among men [23]. A large EU study showed that on average 6.5 % and 3.0% more consumers would be dissatisfied with odor and flavor of entire male pork, respectively, when compared with gilt meat [1, 7].

Carcass detection systems should be able to detect pork, which is not appreciated by consumers because of taint and off flavor. Detection of boar taint by a human nose is currently the most 'objective' method although subjective, while there is no general recognized on-line method available yet and it represents consumer perception best. A representative and standardized "human-nose-system", which in short term can commercially being used in a pig processing company needs to be developed.

B. On-line assessment of boar taint

Affordable on-line detection of carcasses with unacceptable levels of boar taint components would be one of the solutions to the boar taint problem. However, at the moment there is no working system available in a commercial abattoir, and the heating iron in combination with the human nose is still the best available option. The spectrophotometric method for skatole used in Denmark is the most successful on-line method so far, but it only determines one boar taint component [16]. A recent review on detection methods based on heat generation, electrical polarization, conductivity, electrochemical activity, ionization, optical, dielectric, and magnetic properties has been published by Haugen [17].

Results suggest that gas-sensor technology (electronic nose) may have a potential for future rapid sorting of boars at the slaughter line. However, there is still a need for research and development in this field in order to end up with a successful application. Furthermore, all detection methods that are currently under development are based on determination of androstenone and skatol levels, which may not be the only causative compounds of boar taint. A sub-optimal detection system will create false positive and false negative test outcomes , both of which are detrimental to the pork producing industry.

C. Use of tainted meat in processed meats

Further processing of pork products with tainted pork from entire males should also be subject of further research. It is generally believed that the negative impacted in processed pork is less than in fresh meat. Cooking of meat could reduce the amount of volatile components and thus reducing boar taint [18]. Marinades and spices may mask boar taint but results are not conclusive.

There might be possibilities to mix tainted pork in sausages, which are eaten cold, whereas this is not possible in heated products [21]. In smoked sausage strongly tainted boar meat could only contribute 25% of the total sausage content without causing adverse reactions [19]. Little is known, how much can be mixed into other type of pork products. Recent Swedish research showed the possibilities of masking boar taint in fermented and smoked sausages [27]. The combination of aroma development from starter cultures and the masking affect of smoking could present a possible solution to remove the perception of boar taint in fermented sausage.

Dry curing of ham does not reduce the occurrence and perception of boar taint [20]. Production of cured bacon after salt injection only seems to have minor effect on the perception of boar taint compounds [22]. Development of meat processing technology and ingredients to mask boar taint should be on the research agenda.

VIII. CONCLUSION

The main threats of abandoning castration are that there is no international acceptation of pork produced from entire males, and a reduction in pork consumption as a result of tainted meat. Significant reduction in tainted pork is possible through genetic selection, feed and farm management. It will take at least 3 to 5 years to obtain results that can be used in practice. An international accepted and reliable on-line detection method is not yet available, and most systems focus on androstenone and skatol, which only explain part of the variation. Research efforts should focus on prevention of boar taint in the live animal, development of cost effective and reliable detection systems, and further processing applications for tainted pork. In the mean time castration with minimal pain is a viable option.

REFERENCES

[30] Bonneau, M., Kempster, A. J., Claus, R., Claudi-Magnussen, C., Diestre, A., Tornberg, E., Walstra, P., Chevillon, P., Weiler, U. & G.L. Cook (2000). An international study on the importance of androstenone and skatole for boar taint: I. Presentation of the programme and measurement of boar taint compounds with different analytical procedures. Meat Science, 54, 251-259.

[31] Williams, L. D., Pearson, A. M., & N. B. Webb (1963). Incidence of sex odor in boars, sows, barrows, and gilts. Journal of Animal Science, 22, 116-168

[32] Malmfors, B., & I. Hanson (1974). Incidence of boar taint in Swedish Landrace and Yorkshire boars. Livestock Production Science, 1, 411-420.

[33] Xue, J. L., Dial, G.D., Holton, E.E., Vickers, Z., Squires, E.J., Lou, Y., Gotbout, D., & N. Morel (1996). Breed differences in boar taint: relationship between tissue levels of boar taint compounds and sensory analysis.Journal of Animal Science, 74: 2170-2177.

[34] Claus, R., Weiler, U., & A. Herzog (1994). Physiological aspects of androstenone and skatole formation in the boar: a review with experimental data. Meat science, 38, 289-305.

[35] Babol, J., Squires, E.J., & K. Lunström (1996). Investigation of factors responsible for the development of boar taint. Food Research International 28: 573-581.

[36] Matthews, K. R., Homer, D. B., Punter, P., Beague, M.P., Gispert, M., Kempster, A.J., Agerhem, H., Claudi-Magnussen, C., Fischer, K., Siret, F., Leask, H., Font I Furnols, M. & M. Bonneau (2000). An international study on the importance of androstenonen and skatole for boar taint: III. Consumer survey in seven European countries. Meat Science, 54, 271-283.

[37] Rath, D. (2002). Low dose insemination in the sow – A review. Reproduction in Domestic Animals, 37, 201-205.

[38] Johnson, L.A., Rath, D. Vasques, J.M., Maxwell, & J.R. Dobrinsky (2005). Preselection of sex of offspring in swine for production: current status of the process and its application. Theriogenology, 63, 615-624.

[39] Squires, E.J. (2006). Possibilities for selection against boar taint. Acta Veterinaria Scandinavica, 48 (Suppl 1), S8.

[40] Willeke, H. (1993). Possibilities of breeding for low 5α-androstenone content in pigs. Pig News and Information, 14, 31-33.

[41] Tajet, H., O. Andresen, & T.H.E. Meuwissen (2006). Estimation of genetic parameters of boar taint; skatole and androstenone and their correlations with sexual maturation. Acta Veterinaria Scandinavica, 48 (Suppl 1), S9.

[42] Pauly P., J.V. Spring, O. Doherty, S. Ampuero Kragten, & G. Bee (2008). Performances, meat quality and boar taint of castrates and entire male pigs fed a standard and a raw potato starch-enriched diet. Animal 2:11, 1707-1715.

[43] Claus, R., U. Weiler, & A. Herzog (1994). Physiological aspects of androstenone and skatole formation in the boar: A review. Meat Science, 38, 289-305.

[44] Walstra, P., C. Claudi-Magnussen, P. Chevillon, G. von-Seth, A. Diestre, K.R. matthews, D.B. Homer, & M. Bonneau (1999). An international study on the importance of androstenone and skatole for boar taint: levels of androstenonen and skatole by country and season. Livestock Production Science, 62, 15-28.

[45] Mortensen, A.B. & S.E. Sorensen (1984). Relationship between boar taint and skatole determined with a new analysis method. 30th European meeting of Meat Research Workers, Bristol, United Kingdom.

[46] Haugen, J-E. (2003). Rapid detection of boar taint with chemical sensor technology. The challenge of gas-sensor based methods. European Association of Animal Production Working Group on Production and Utilisation of Meat from Entire Males, 13-14 November, Dublin, Ireland.

[47] Malmfors, B. & K. Lundstrom (1983). Consumer reactions to boar taint, a review. Livestock production Science, 10, 187-196.

[48] Waltstra, P. (1974). Fattening of young boars: quantification of negative and positive aspects. Livestock Production Science, 1, 187-196.

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

[50] McCauley, I., D.P. Hennesey, V. Boghossian, L. Sali, L. Salvatore, J. Reynolds & R. Mawson. (1997). Effects of cooking and processing pork on the perception of boar taint. In Bonneau, M, K. Lundstrom, & B. Malmfors (editors), Boar taint in entire male pigs. E.A.A.P Publication no. 92, Wageningen Pers.

[51] Mottram, D.S., J.D. Wood & R.L.S. Patterson (1982). Comparison of bulls and castrates for bacon production. 3. Composition and eating quality of bacon. Animal Production, 35, 75-80.

[52] Weiler, U. M. Font I Furnols, K. Fischer, H. Kemmer, M.A. Oliver, M. Gispert, A. Dobrowolski, & R. Claus (2000). Influence of differences in sensitivity of Spanish and German consumers to perceive androstenonen on the acceptance of boar meat differing in skatole and androstenone concentrations. Meat Science, 54, 297-304.

[53] Huber-Eicher, B. & P. Spring (2008). Attitudes of Swiss consumers towards meat from entire or immunocastrated boars: A representative survey. Research in Veterinary Science, 85, 626-627.

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

[55] Kluivers-Podt, M. H. Hopster & H.A.M Spoolder (2007). Castration under aneasthesia and/or analgesia in commercial pig production. Report 73, Animal Science Group Lelystad, Wageningen-UR, The Netherlands.

[56] Stolzenbach, S., G. Lindahl, K. Lundstrom, G. Chen & D.V. Byrne (2009). Perceptual masking of boar taint in Swedish fermented sausages. Meat Science, 81, 580-588.

[57] Dunshea, F.R., C. Colantoni, K. Howard, I. McCauley, P. Jackson, K.A. Long, S. Lopaticki, E.A. Nugent, J.A. Simons, J. Walker & D.P. Henessy (2001). Vaccination of boars with GnRH vaccine (Improvac) and eliminates boar taint and increases growth performance. Journal of Animal Science, 79, 2524-2535.

[58] Moe, M., T. Meuwissen, S. Lien, C. Bendixen, X. Wang, L.N. Conley, I. Berget, H. Tajet &E. Grindflek (2007). Gene expression profiles in testis of pigs with extreme high and low levels of androstenone. BMC Genomics 8, doi:10.1186/1471-2164-8-405

[59] Lee, G.J. A.L. Archibald, A.S. Law, S. Lloyd, J. Wood, & C.S. Haley (2005). Detection of quantitative trait loci for androstenonen, skatole and boar taint between large white and Meishan pigs. Animal Genetics 36, 14-22.