

MASKING STRATEGIES TO AVOID THE BOAR TAINT IN MEAT PRODUCTS

STRATEGIJE MASKIRANJA POLNOG MIRISA NERASTA U PROIZVODIMA OD MESA

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ABSTRACT

Surgery to castrate male pigs can be substituted by the manufacture of “entire males”. However, the meat of whole male animals may have an unpleasant sexual odor, i.e. - boar taint. The purpose of this paper was to demonstrate how to use masking techniques on meat that has a noticeable boar taint during the processing stage. Smoke has frequently been implicated as a method for hiding boar taint in many types of meat products. Meat items may be smoked naturally using a traditional method or artificially using liquid smoke. Another method for hiding the boar taint in meat products is the addition of spices. Strong-smelling spices, such as paprika, chili, oregano, thyme, rosemary, mint, and cinnamon, can help to mask the stench of swine taint. Also, the use of essential oils in conjunction with spices and herbal extracts helps to mask the boar taint in meat products. Moreover, some of the recent publications focused on the investigation of yeast inoculation as a method for hiding boar taint.

Keywords: boar taint, masking, smoke, spices, essential oils, yeast.

REZIME

Hirurška kastracija muške prasadi može se zameniti proizvodnjom i preradom svinjskog mesa od nekastriranih mužjaka (nerasta). Međutim, meso od nerasta može imati neprijatan polni miris. Svrha ovog rada je da prikaže upotrebu tehnika maskiranja prilikom prerade mesa kod koga je detektovan polni miris. Dim se često koristi kao jedna od metoda za prikriivanje polnog mirisa u mnogim proizvodima od mesa. Proizvodi od mesa se mogu dimiti na tradicionalni način ili upotrebom tečnog dima. Još jedna od metoda maskiranja polnog mirisa u proizvodima od mesa jeste i upotreba začina. Jako aromatični začini, poput paprike, čilija, origana, timijana, ruzmarina, mente i cimeta, mogu pomoći u maskiranju neprijatnog mirisa nerasta. Takođe, upotreba eteričnih ulja u kombinaciji sa začinama i biljnim ekstraktima pomaže da se prikrije polni miris u proizvodima od mesa. Dodatno, neke novije publikacije su fokusirane na istraživanje mogućnosti inokulacije kvasaca kao tehnike za maskiranje polnog mirisa.

Ključne reči: polni miris, maskiranje, dim, začini, eterična ulja, kvasci.

INTRODUCTION

Boar taint is an offensive smell found in male pork meat that is mostly brought on by androstenone, skatole, and indole accumulation in fat tissue (Duarte et al., 2021). Most experts agree that androstenone and skatole are the main chemicals to blame for swine taint (Meinert et al., 2017). Skatole, a volatile substance with a naphthalene-like odor that results from the intestinal tract's microbial breakdown of the amino acid tryptophan, is produced. The sexual pheromone androstenone, which is made in the Leydig cells of the testes, has a smell that is similar to that of urine or perspiration. While androstenone can be prevented by castration, high levels of skatole in pork can be efficiently decreased by diet and increasing the conditions of stable hygiene (Peñaranda et al., 2020). When cooking or eating pork or pork products, there may be an odor or flavor that some people find repulsive (Martínez et al., 2016). Boar taint may be perceived as having a feces- or urine-like smell. The smell was also described as sweat, rancid, stable, soap and naphthalene (Fig. 1). Consumer sensitivity can vary, and some consumers may not be able to smell the odor. Along with other steroid hormones, androstenone is produced in the testes, and it is broken down in the liver. Starting with tryptophan, skatole and indole are created in the intestine and further are broken down in the liver. At sexual maturity, androstenone, skatole, and indole are accumulated in fat tissue (Duarte et al., 2021). The sensory perception thresholds for androstenone and skatole, chemicals that cause boar taint, are typically between 0.20 and 0.25 ppm and 0.5 to 1.0 ppm, respectively (Lundstrom et al., 2009). Boar taint is influenced by things like breed, which affects the

genetics of the animals, age, nutrition, and rearing conditions upbringing (Duarte et al., 2021).

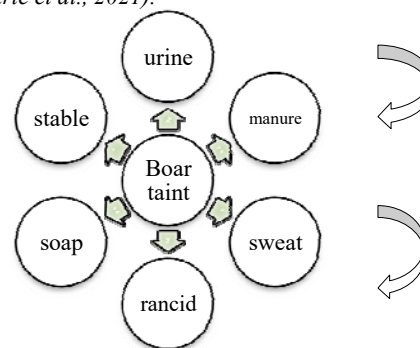


Fig. 1. Boar taint compounds
(Bilić-Šobot, 2016; Čandek-Potokar, 2017)

Historically, surgical castration of male piglets has been used to prevent the appearance of boar taint. However, castration is likely to be forbidden in the coming years because of worries about animal welfare (Duarte et al., 2021). For moving away from surgical castration, there are primarily two methods. Raising entire male pigs, or boars is one option. The second involves administering a vaccination that inhibits the hormone (GnRH) that triggers the release of gonadotropins and reduces testicular activity (Final report, 2019). To combat the notion of boar taint, processing meat from intact male pigs might be an alternative to castration (Stellenbosch et al., 2009).

A range of processing techniques can be applied to the meat that has a recognizable boar taint. Many of these techniques

could be used in combination one with another. Boar taint is most prominent when meat is heated or cooked, hence it is common practice to use tainted meat for goods meant to be served cold. For items that are not made from a single cut of meat, dilution or mixing with non-tainted meat is used. Pig meat can be processed or cooked in a variety of techniques that can assist to lessen the sense of boar taint, including dry curing, fermentation, smoking, and thermal treatment. Another strategy to lessen the sense of boar taint is to add spices to sausages or marinated meats (Final report, 2019).

Because of the lowering and disguising properties of seasoning, cooking, curing, fermenting, and smoking, processed meat products have a greater possibility for marketing infected pig meat (Peñaranda et al., 2020). Depending on the makeup of the raw materials, the specifics of the processing procedures, and the masking techniques employed, there are numerous ways to reduce the presence of boar taint in meat products (Škrlep et al., 2020; Hemeryck et al., 2020). This paper tends to provide a comprehensive review of masking techniques to handle meat that has a detectable boar taint during the processing phase.

METHODOLOGY

The search for the relevant literature for the present review was done methodically. By using this method, a large amount of literature data has been collected on how to deal with meat with detectable „boar taint”. In fact, typical reviews frequently start with studies that the writers are already familiar with and then focus on those findings, according to Hagen-Zanker & Mallett (2013). There is a chance that some research may be overcited as a result, while many important publications will be accidentally omitted. This approach leads to studies with a widespread bias, which has an impact on the validity of the reviews' conclusions (Hagen-Zanker & Mallett, 2013; Mallett, Hagen-Zanker, Slater, & Duvendack, 2012).

To lessen the probability of such bias, the current study utilized the PRISMA technique (Preferred Reporting Items for Systematic Reviews and MetaAnalyses), along with the suggestions offered by Hagen-Zanker and Mallett (2013). PRISMA is an open, exacting, and reproducible method for finding relevant papers in a scientific database and synthesizing their findings. Top academic databases used by the study team include Scopus®, Web of Science Core Collection®, ScienceDirect and ResearchGate. The search strings, listed in Table 1, were tailored to each specific database by using Boolean operators and other elements in line with the particular language required. The phrases "boar taint" OR "tainted meat" OR "boar meat" OR "entire male* meat" AND meat AND processing AND masking" were explicitly used to find the applicable papers for the present review.

Table 1. Search strings used for selected databases.

| Database | Search string | Results |
|--------------------------------|---|---------|
| Scopus | ("boar taint" OR "tainted meat" OR "boar meat" OR "entire male meat") AND meat AND processing | 78 |
| Web of Science Core Collection | ("boar taint" OR "tainted meat" OR "boar meat" OR "entire male meat") AND meat AND processing | 120 |
| ScienceDirect | boar taint, entire male meat, processing, masking strategies, smoke, spice | 19 |
| ResearchGate | ("boar taint" OR "tainted meat" OR "boar meat" OR "entire male meat") AND meat AND processing | 55 |

The inclusion and exclusion criteria were chosen by the study team and are presented in Table 2.

The analysis excluded relevant material that is usually referred to as "gray literature" and is located outside of peer-reviewed sources by limiting it to peer-reviewed English-language papers. There is no need for ethical approval of this article. Three members of the research team independently read the 272 papers in full. Following a collaborative debate among the members of the study team, 34 papers were finally included in the review.

The final pool of papers consists of 34 papers. Appendix A lists their contents in detail. Despite the fact that 85% of the papers are dated after 2010, the publishing period really runs from 1995 to 2022, which seems to confirm the growing interest in this topic among academics.

Table 2. Inclusion and exclusion criteria for papers' selection.

| Criteria | Inclusion | Exclusion |
|-------------------|--|-----------|
| Publication Years | All | None |
| Language | English | Other |
| Focus | deal with meat with detectable boar taint, meat processing, masking processing techniques that can be used on meat that has a discernible boar taint | Other |
| Publication type | Full-text paper published in a peer-reviewed journal, dissertation, research studies (conference papers and abstracts, opinions) | Other |

MASKING

The use of smoke has commonly been revealed as a strategy for masking boar taint in different types of meat products (Aaslyng, Broge, Brockhoff, & Christensen, 2015; Aaslyng and Koch, 2018; Kallas et al., 2016; Engesser et al., 2017; Marro et al., 2018; Martínez et al., 2016; Stolzenbach et al., 2009; Schnäckel et al., 2014; Bejerholm et al., 2018). Smoke can mask boar taint, especially the odor. The more intensive the smoke the better results are achieved (Bejerholm et al., 2018). Meat products can be subjected to smoke using a traditional natural smoking process or using liquid smoke. The natural smoking process (in a smoking chamber) can be divided into cold, warm and hot smoking. Liquid smoke is manufactured using different types of wood and is manufactured during several cleaning steps (Aaslyng and Koch, 2018).

Stolzenbach et al. (2009) evaluated the use of smoking to eliminate the perception of boar taint in meat products in the type of fermented sausages. The same authors indicated that the smoking process may present a potential solution to remove or decrease the perception of boar taint in fermented sausages, but they asserted the necessity of its optimization.

Marro et al. (2018) assessed the effect of processing on the level of main boar taint compounds (skatole and androstenone) in different types of sausages. They concluded that the reduction of skatole in raw fermented sausages and pasteurized sausages might be the consequence of the smoking process. The relatively high reduction of skatole in raw fermented sausage (26%) and pasteurized sausage (44%) might be due to the presence of formaldehyde, which can be attributed to the process of smoking. Similar results were observed by Bonneau et al. (1980). Authors detected that high temperature and smoking process affected skatole reduction in pasteurized sausages. Also, Kallas et al. (2016) and Martínez et al. (2016) indicated that the

smoking process had an effect on masking the odor of androstenone in cooked sausages (frankfurters) produced from entire male pigs.

Aaslyng and Koch (2018) investigated different smoking times and different types of liquid smoke in the production of bacon and sausage. In the production of streaky bacon from entire male pigs, three smoking times (10, 30 and 60 minutes) were used. The same authors concluded that longer smoking time contributed to a better masking effect. In the case of sausage, 40 and 80 minutes of smoking contributed to fully masked boar taint.

Few studies have been conducted in order to investigate the effect of liquid smoke as an alternative to masking boar taint in meat processing (Aaslyng and Koch, 2018; Lunde et al., 2013; Stolzenbach et al., 2009). Lunde et al. (2008) determined that the addition of liquid smoke into meat chops from entire male pigs with high to medium concentrations of skatole and androstenone (0.43 µg/g skatole and 1.61 µg/g androstenone) had an effect on masking boar taint. Also, Lunde et al. (2013) have shown that the addition of liquid smoke added to the surface of bacon affected the masking of the skatole flavor. It was contrary to previously published results by Stolzenbach et al. (2009), who have shown that liquid smoke applied on the sausage surface had no effect on masking boar taint of fermented sausages.

In the same study, Stolzenbach et al. (2009) reported that the addition of 0.05% liquid smoke had an effect on masking boar taint in fermented sausages produced using medium tainted meat (up to 1.8 µg/g androstenone, 0.08 µg/g skatole). However, Aaslyng and Koch (2018) determined that the addition of liquid smoke at concentrations of 0.1% did not mask boar taint in sausages produced using meat from entire male pigs with medium concentrations of androstenone and skatole.

Due to the fact that the smoking process of sausages in the Mediterranean area is less common, the attention of some researchers was focused on the study of yeast inoculation as a strategy for masking boar taint in fermented sausages (Corral et al., 2017a; Corral et al., 2017b). Corral et al. (2017a) and Corral et al. (2017b) pointed out that *Debaryomyces hansenii* yeast and long ripening time were appropriate strategies to limit the perception of boar taint in dry fermented sausages.

Regardless of fat content, any product can be utilized. The masking effect improves with increasing smoke flavor intensity. The flavor and of boar taint cannot be totally hidden in whole muscle products. Wiener sausages may totally conceal the taste and taint of the pig. The use of smoke is advised in conjunction with other tactics (Aaslyng, 2018).

The addition of spices is one of the alternatives for masking boar taint in meat products. Spices with a strong aroma help to cover up the smell of pig taint. It is possible to suggest rosemary, oregano, thyme, and cinnamon as appropriate spices (Bejerholm et al., 2018). Recommendation made by Catalogue of applications of meat from entire male pigs with boar taint: Make use of dishes that contain a lot of spices. You can use spices like paprika, chile, oregano, thyme, rosemary, mint, and cinnamon. Babol and Squires (1995) investigated the effect of fennel addition on the sensory acceptability of cooked sausages produced from entire male pigs. The authors reported that the addition of fennel at a concentration of 0.015% significantly increased the acceptability of cooked sausage bologna sausage. Lunde et al. (2008) evaluated the effect of the use of oregano extracts and liquid smoke on masking boar taint of marinated meat. The authors pointed out that the addition of oregano extracts in combination with the use of liquid smoke contributed to masking boar taint in marinated pork chops (Lunde et al., 2008).

Martínez et al. (2016) evaluated the effect of spices and smoking on masking boar taint in cooked sausages. Authors indicated that the use of spices contributed to fully masking the androstenone odor. The same authors observed that only the combined use of spices and smoking was able to remove the perception of androstenone. Also, Aaslyng et al. (2015), Egea et al., (2018) and Kallas et al. (2016) observed that spices increased the sensory acceptability of meat products produced from entire male pigs.

The percentage of boar meat (skatole concentrations up to 0.3 µg/g, androstenone up to 3.8 µg/g in melted backfat), the length of conventional smoking, the concentrations of two spices, and the percentage of melted backfat were all elements that Mörlein et al. (2019) found to be important for the development of emulsion-type sausages. Frankfurter variations were created in two separate experiments and evaluated by 211 consumers in total. Increased quantities of boar-tainted meat dramatically decreased consumer approval, according to a linear mixed effects model, which was unaffected by higher degrees of smoke or spice. To find the mixture that is equally regarded as the reference created without boar-infected meat, a non-inferiority test was provided. Inferring a like decline of 0.5 on a 9-point liking scale as the benchmark for an inferior product, it is suggested that up to 33% of the meat may be boar meat (Mörlein et al., 2019).

Šojić et al. (2018a; 2018b) evaluated the application of caraway essential oil and *Satureja montana* L. essential oil on reducing the boar taint in meat products (model sausages), produced with two levels of skatole (0.2 ppm and 0.4 ppm). The data from these studies showed that the addition of essential oils and plant extracts in sausages may be an alternative solution for commercializing the meat of entire male pigs.

Besides spices and herbal extracts, Sheard et al. (1999) reported that the addition of polyphosphates affected to masking boar taint of cooked pork steaks.

Pearama et al. (2020) used a Check-All-That-Apply questionnaire to examine the acceptability and sensory qualities of chorizo that had been prepared with three different levels of androstenone (castrated 0-0.3 mg/kg, medium 0.4-0.9 mg/kg, and high 1-2.75 mg/kg) and two masking strategies (rosemary, and rosemary plus smoking). The analysis of the results revealed that rosemary combined with smoked chorizo was the most successful (3.7% selection rate for animal flavor) of all the employed masking techniques. Also, a high androstenone level combined with rosemary chorizo came closest to the ideal product as described by consumers.

Different strategies for the valorization of tainted pork, such as combining it with gilt basic ingredients in patties, processing it to make Frankfurters, or processing it to make restructured ham, appeared to be quite promising. Therefore, the following conclusion can be drawn: fine-tuning manufacturing procedures (use of cooking and/or smoke condensates) and mixing with non-boar taint meat (targeted dilution) might greatly minimize (the perception of) boar taint and therefore potentially lessen consumer rejection (Hemeryck et al., 2020).

Egea et al. (2020) use fat replacement by vegetable fibers to improve the quality of sausages made with non-castrated male pork. In the beginning, Frankfurt sausages were perceived as having less of a boar taint than Spanish sausages. Although there was a slight loss in the sausage flavor, the R2 method (3% inulin, 1% β-glucan, and 0.5% grape skin) produced stronger masking properties in both items. Thus, reducing the amount of fat in Spanish and Frankfurt sausages made from non-castrated male pig meat and replacing it with plant fibers (inulin, β-glucan, and grape skin) may be a good tactic to cover up boar

taint and create a texture that is comparable to commercial sausages.

Reducing the salting period significantly decreased the salt concentration and had an impact on other dry-cured ham characteristics, but not always favorably. Interesting correlations between boar taint levels and proteolytic activity highlighted a potential problem for dry-cured hams made from EM meat, especially when combined with lower salt content (Kaltnekar et al., 2016).

CONCLUSIONS

Effective and practical alternatives to surgical castration are required to tackle the multifaceted problem of boar taint. There are several established techniques that can lessen the buildup of androstenone or skatole in the fat. Because processing in various ways may disguise the effects of skatole and androstenone, boar taint is less obvious in processed products than in raw meat. Most meat products can efficiently manage low to medium levels of boar taint by employing techniques like masking, such as the usage of microbial starter cultures, the addition of distinct-flavored spices (paprika, chili, oregano, thyme, rosemary, mint, and cinnamon), essential oils, herbal extracts and smoking. A longer smoking process could improve the masking effect. Polyphosphates were added in addition to spices and herbal extracts to help hide the boar taint.

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Primljeno: 12.01.2022.

Prihvaćeno: 17.02.2023..