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BOAR TAINT: ANDROSTENONES OR SKATOLE? A REVIEW

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INTRODUCTION

Craig and Pearson (1959) and Craig et al. (1962) demonstrated that the urine- or perspiration-like odor emanating from heated boar fat was localized in the unsaponifiable fraction, although their attempts to identify the responsible components were unsuccessful. Patterson (1968) isolated and identified 5α-androst-16-en-3-one as the cause of boar taint. Later it was shown by Claus et al. (1971), Beery and Sink (1971), Beery et al. (1971) and Thompson et al. (1972) that this compound, which has been called androstenone, and several others C_{19}-Δ^{16}-steroids possess the same or similar odors and also contribute to boar taint or odor. Brooks and Pearson (1986) have reviewed the metabolic pathways involved in formation of the C_{19}-Δ^{16}-steroids and shown that these compounds all possess urine- or perspiration-like odors, although their threshold levels vary by tenfold (Brooks and Pearson, 1989).

Swedish and Danish researchers (Hansson et al., 1980; Lundström et al., 1980, 1988) reported that skatole, a bacterial breakdown product of tryptophan in the gut, also contributes to boar taint. The role of skatole as a predictor of boar taint has been widely accepted in northern Europe, in fact, on-line measurement of skatole has been adopted by Danish factories to screen carcasses for taint. Nevertheless, the relative importance of the androstenones and skatole in detection of carcasses with boar taint is still confusing and stimulated this review.

OBJECTIVES

The present review was undertaken to determine whether skatole or the androstenones is/are responsible for boar taint. Further, it was deemed to be important to ascertain if both compounds may play a role in the objectionable odor(s) in the meat of the intact male pig.

METHODS

The literature on boar taint and other objectionable odors in pork will be reviewed. First, we will examine the metabolic pathways, chemical structures and properties of the androstenones and skatole. Then we will review the odor and flavor characteristics of the androstenones and skatole and their relationships to boar taint or off odors in pigmeat and/or fat. Finally we will consider procedures for eliminating problems from skatole and the androstenones from the meat and/or fat of sexually mature intact male pigs.

RESULTS AND DISCUSSION

The review will discuss off-odors and flavors in pigmeat and/or fat as outlined above.

METABOLIC PATHWAYS, CHEMICAL STRUCTURES AND PROPERTIES OF SKATOLE AND THE ANDROSTENONES

Skatole (3-methyl-indole) and indole are produced in the digestive tract by microbial breakdown of tryptophan. Both of these compounds are lipophilic and hydrophilic, but are preferentially deposited in the fatty tissues (Claus et al., 1994). Although the concentration of indole is higher than that of skatole in the tissues of intact male pigs, Lundström et al. (1988) concluded that skatole is responsible for most of the objectionable odors and/or flavor (taste) in boar meat.

The androstenones are steroids belonging to the family of C_{19}-Δ^{16}-steroids. They are synthesized from cholesterol, as are all of the steroids, but are formed from pregnenolone and are not in the direct pathway of the sex hormones, testosterone and estradiol (Brooks and Pearson, 1986). The androstenones are lipophilic and hydrophobic, so in contrast to skatole are found only in the fat (Claus et al., 1994). Androstenone is a pheromone and causes the female pig in estrus to assume the mating stance according to Melrose et al. (1971). Thus, it serves as a sexually functional hormone in contrast to skatole.

ODOR AND FLAVOR CHARACTERISTICS OF SKATOLE AND THE ANDROSTENONES

Skatole and indole have a fecal odor, with the odor of skatole being more potent and objectionable than that of indole (Lundström et al., 1988). The presence of skatole in both the fatty and lean tissues led Lundström et al. (1988) to conclude that skatole is a better indicator of boar taint than androstenone. Claus et al. (1994) reported that the threshold for detection of skatole was 0.25 μg/g compared to 0.5 μg/g for androstenone. The latter value does not take into account the fact that other C_{19}-Δ^{16}-steroids can contribute to boar taint (Brooks and Pearson, 1989).

The androstenones have a urine-like or perspiration-like odor, which was described as being the objectionable odor emanating from heated boar tissue by Lerche (1936). The same or similar odor characteristics have been associated with boar taint by a number of workers (Patterson, 1968; Beery and Sink, 1971; Beery et al., 1971; Thompson et al., 1972; Brooks and Pearson, 1986, 1989; Claus et al., 1994). Some persons can not smell the androstenones (Griffith and Patterson, 1970), apparently having no olfactory receptors for these compounds (Claus et al., 1994), which is apparently not the case for skatole. This suggests that panelists lacking the receptors for androstenone recognized the objectionable odor of skatole and considered it to be responsible for boar taint as Claus et al. (1994) suggested. The latter viewpoint is supported by Pearson et al. (1994), who stated that heated pig fat has many other odors—both objectionable and pleasant. Unpublished observations (A. M. Pearson and colleagues) have identified one of the objectionable odors as having a "piggy" or "pigpen" odor, that appears to be identical to that of skatole and is quite different from that of androstenone.

The relationship between skatole and androstenone(s) concentrations is low. Lundström et al. (1988) reported a correlation of r=0.32 and found only seven out of 143 boars weighing 110 kg had skatole levels above the threshold. Claus et al. (1994) confirmed the low relationship by reporting a large scale study in Germany found that 36% of market weight boars had androstenone concentrations exceeding its threshold but only 8% exceeded the threshold for skatole.

ELIMINATION OF SKATOLE AND THE ANDROSTENONES

Claus et al. (1994) stated that elimination of androstenones from the tissues can be achieved by castration, but requires three to six weeks. However, the operation is difficult, time-consuming and results in some risk from infection in mature boars. Selection for low androstenone concentrations was highly effective, but simply led to delayed puberty, which postponed development of the anabolic steroids and was thus unsuccessful in reducing androstenone levels in market weight boars (Willeke et al., 1987). The use of immunization against the C_{19}-Δ^{16}-steroids has been shown to suppress androstenone levels with varying degrees of success (Shenoy et al., 1982; Williamson and Patterson, 1982; Williamson et al., 1985). Brooks et al. (1986) and Bonneau et al. (1994) were somewhat more successful at immunization, but a few animals still had objectionable concentrations of androstenone(s).

Skatole production, on the other hand, can be easily suppressed by feeding the nondigestible fructooligosaccharide, inulin, and bicarbonate according to Claus et al. (1994). On this type of diet, none of 16 boars exceeded the threshold level of 0.25 µg/g of fat for skatole. Thus, climination of skatole as an undesirable aroma/flavor component in pigmeat should be feasible.

SUMMARY

Two entirely different types of compounds have been identified and equated as being responsible for boar taint, the undesirable odor emanating from the heated meat of sexually mature uncastrated male (boar) pigs, namely, the androstenones (C_{19}-Δ^{16}-steroids) and skatole. The androstenones are testicular steroids and possess a penetrating perspiration- or urine-like odor. Skatole, on the other hand, is produced by microbial breakdown of tryptophan in the gut and has a strong fecal or pigpen odor. Although both compounds are present in the fat of boars at higher concentrations than in that from barrows, gilts or sows, the levels of the two compounds are not closely related. The androstenones appear to be responsible for boar taint per se. In contrast to the androstenones, which about 25% of all persons can not smell due to the absence of odor receptors, skatole appears to be almost universally recognizable as being objectionable. Although skatole production can be prevented by feeding inulin and bicarbonate, the androstenones present a more formidable problem.

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