Asian-Aust. J. Anim. Sci.
Vol. 20, No. 10 : 1618 - 1623
October 2007
www.ajas.info

# Effects of Dehairing Methods and Sex on Pork Quality and Boar Taint Compound Levels in Tissues

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**ABSTRACT :** The objective of this study was to investigate the effects of dehairing methods and sex on various traits of pork quality, as well as on tissue levels of the boar taint compounds androstenone and skatole. At the early postmortem period, dehided pigs showed higher muscle pH levels ($p<0.05$), lower temperatures ($p<0.05$) and lower drip loss ($p<0.001$) than scalded pigs. Thus, the dehairing method can affect the early postmortem glycolytic rate and water-holding capacity. Moreover, the differences in meat quality traits between the genders were small, and not considered to have practical importance. The scalding method had only a limited effect on the androstenone content. On the other hand, the scalded entire males exhibited a lower content of skatole than the dehided entire males ($p<0.01$). These results appear to indicate that the heating treatment from the scalding process influenced the reduction of skatole content for the scalded entire males. (**Key Words :** Dehairing Methods, Sex, Pork Quality, Boar Taint, Androstenone, Skatole)

## INTRODUCTION

Pale, soft, and exudative (PSE) pork usually develops as the result of rapid muscle metabolism during the early postmortem period (<1 h) (Ryu et al., 2005; Choi et al., 2007). Rapid postmortem glycolysis induces an accumulation of lactate, which results in a rapid decline in muscle pH while the carcass temperature is still high (Briskey and Wismer-Pedersen, 1961). This combination of low muscle pH and high muscle temperature can affect the ultimate meat quality by causing excessive denaturation of the muscle protein (Offer, 1991; Choi et al., 2006). Also, the muscle pH, temperature (Homer and Matthews, 1998), and final pork quality can vary between processing plants (Van der Wal et al., 1999; Hambrecht et al., 2003; Lee et al., 2005; Gardner et al., 2006; Park et al., 2007).

In processing, after stunning and bleeding, dehairing is performed. The scalding process is the most commonly used surface treatment during slaughter. In the scalding process, energy is added to the carcass by immersion into scalding water at 60 to 65°C for 3 to 6 min, and then singeing at 1,200°C for 10 s. As a result, scalding and singeing increase the muscle temperature (Maribo et al., 1998). An alternative to surface treatment is hide removal where the carcasses are not subjected to heat on the slaughter line. The muscle temperature of dehided carcasses does not increase since metabolic heat is presumably removed faster by equalization to a cooler surface and the environment (Troeger and Woltersdorf, 1987; Maribo, 1996; Maribo et al., 1998).

Raising entire male pigs instead of castrated pigs for pork production has several advantages. For example, entire pigs have a higher feed efficiency, faster growth, and a higher lean to fat ratio compared to other genders (Kumer and Barsaul, 1991; Babol and Squires, 1995; Renaudeau et al., 2006). Moreover, the adipose tissue of entire pigs is softer due to higher levels of unsaturated fatty acids (Babol and Squires, 1995). However, the primary problem with boar production is the occurrence of boar taint, an unpleasant meat odor that occurs with entire male pigs (Patterson, 1968). Boar taint is distinctive and perceived as unpleasant during the cooking and eating of pork and pork products through a combination of sensory qualities like odor, flavor, and taste (Vestergaard et al., 2006). Boar taint is mainly caused by high levels of 5α-androst-16-en-3-one (androstenone) and 3-methylindole (skatole) in the fat (Vestergaard et al., 2006). Androstenone is synthesized in

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Received January 17, 2007; Accepted May 21, 2007

the testes, and skatole is produced by bacteria in the hind gut of pigs (Bonneau et al., 1992; Claus et al., 1994).

The levels of androstenone and skatole in fat are affected by various factors such as genetics and the environment (Zamaratskaia et al., 2004). Moreover, the levels are affected by cooking (De Kock et al., 2001; Banon et al., 2003). All these factors affect the formation and loss of volatile compounds (Bonneau et al., 1992). Therefore, the primary objective of this study was to compare the effects of dehairing methods and sex on pork quality traits, as well as on the reduction of the boar taint compound androstenone and skatole in tissues.

## MATERIALS AND METHODS

### Animals and samples

A total of 60 crossbred (Yorkshire×Landrace×Duroc) pigs were used in this study. All the pigs were raised together on the same farm and slaughtered in the same slaughter house during the winter period at 172.2±3.3 days. The treatment conditions for the animals before and after slaughter (such as feeding system and environmental conditions) were the same, with the exception of the dehairing method. One half (n = 30) of each pig was dehaired by scalding, and the other half (n = 30) dehaired by dehiding. Each treatment contained 10 gilts, 10 castrated males, and 10 entire male pigs. The scalding was performed in a scalding-singeing combination by scalding for 3 min at 60°C, and then singeing via passage of the bodies through gas burners for 10 s at 1,200°C. The other half of each pig was dehided by suspending the carcass in the head-up position, freeing the hide from around the neck and head, and then pulling downward on the upper end of the hide whereby the hide was removed from the carcass. And then all carcasses get chilled within 20 min after slaughter. The carcass weight was obtained at slaughter. Back fat thickness at the 10th rib was also measured. At 45 min postmortem, a total of 60 muscle samples were collected from the *longissimus dorsi* muscle (at the 8th *thoracic vertebra*), and were analyzed for muscle pH and temperature. After 24 h of chilling, the pork loins (9th-13th) were collected to evaluate meat quality traits. Samples of subcutaneous fat were taken from the back fat area and kept at -80°C until chemical analysis.

### Meat quality traits

The muscle pH was measured directly from the carcasses using a spear type electrode (290A, Orion Research Inc., USA) at 45 min ($pH_{45\ min}$) and 24 h ($pH_{24\ h}$) postmortem. The muscle temperature was also measured directly at 45 min postmortem using a portable thermometer (TES-1300, TES Electrical Electronic Co., Taiwan). The

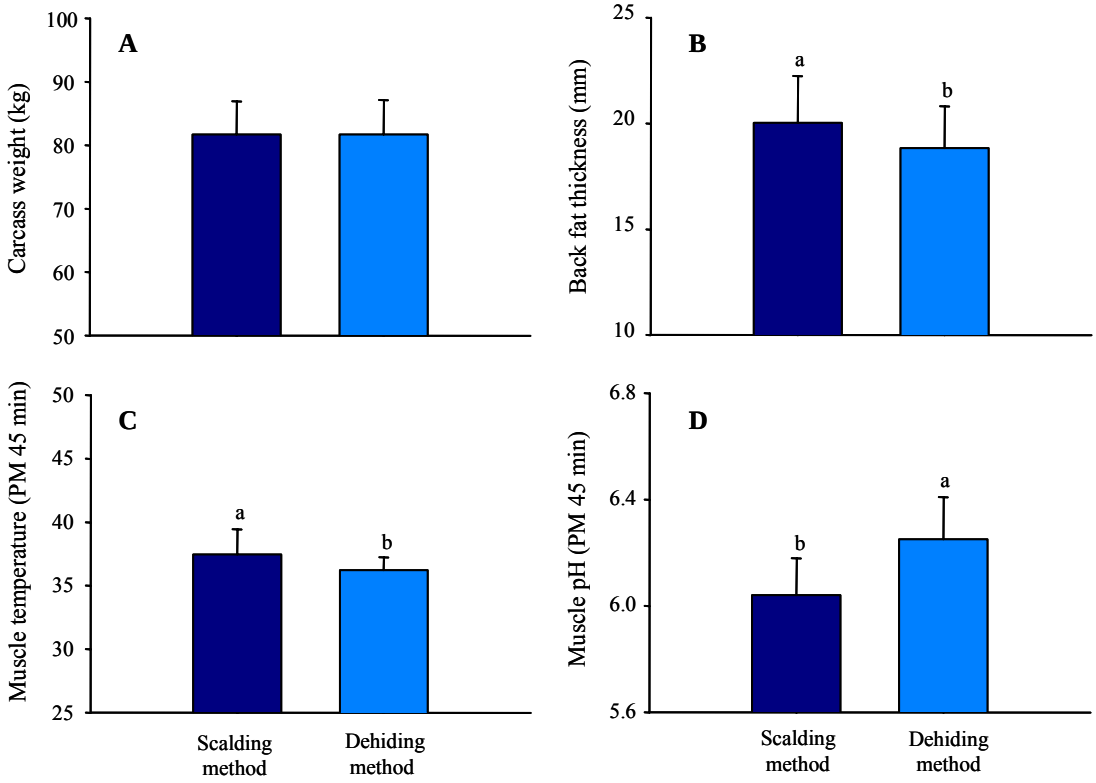


**Figure 1.** Effects of dehairing methods on carcass characteristics (A-B) and muscle temperature (C), and pH (D). Bar indicates SD. Different letters on the bars denote significant differences ($p<0.05$) Abbreviation: PM, postmortem.

**Table 1.** Interactions between the dehairing methods (DM) and sex on the meat quality traits in the porcine *longissimus dorsi* muscle

| | DM | Sex | | | Level of significance | | |
|---|---|---|---|---|---|---|---|
| | | Gilt | Castrated male | Entire male | DM | Sex | DM×Sex |
| Muscle $pH_{24\ h}$ | Scalding | 5.57±0.11[b] | 5.57±0.18[b] | 5.73±0.11[a] | NS | *** | NS |
| | Dehiding | 5.56±0.11[b] | 5.53±0.06[b] | 5.71±0.07[a] | | | |
| Lightness ($L^*$) | Scalding | 48.76±1.60[a] | 47.56±2.51[a] | 42.09±2.63[b] | NS | *** | NS |
| | Dehiding | 48.58±3.47[a] | 48.23±1.27[a] | 40.70±3.08[b] | | | |
| Redness ($a^*$) | Scalding | 6.47±0.63[ab] | 7.15±0.95[a] | 6.03±0.94[b] | ** | *** | * |
| | Dehiding | 6.61±1.45[ab] | 6.43±1.06[ab] | 4.67±1.01[c] | | | |
| Yellowness ($b^*$) | Scalding | 3.73±0.77[a] | 3.87±0.59[a] | 3.10±0.86[ab] | NS | *** | NS |
| | Dehiding | 3.91±1.34[a] | 3.65±0.77[a] | 2.34±0.95[b] | | | |
| Drip loss (%) | Scalding | 4.90±2.04[a] | 3.99±1.57[a] | 3.82±1.57[a] | *** | NS | NS |
| | Dehiding | 1.27±1.39[b] | 1.97±1.54[b] | 2.25±2.06[b] | | | |
| Filter-paper fluid uptake (mg) | Scalding | 34.98±18.64[b] | 33.58±22.80[b] | 64.76±25.66[a] | *** | ** | * |
| | Dehiding | 16.02±5.93[c] | 22.65±15.11[bc] | 27.64±13.49[bc] | | | |

Results are expressed in mean value±SD.
Level of significance: NS, not significant; * p<0.05; ** p<0.01; *** p<0.001.
[a-c] Means with different superscripts within a row and column are significantly different (p<0.05).

meat color was determined at 24 h postmortem with a Minolta chromameter (CR-300, Minolta Camera Co., Japan) after exposing the surface to the air for 30 min at 4°C. The average of three measurements was recorded, and the results are expressed as the CIE (Commission International de l'Eclairage) lightness ($L^*$), redness ($a^*$), and yellowness ($b^*$). The drip loss was determined by suspending the muscle samples, which were standardized for surface area, in an inflated plastic bag at 4°C for 48 h (Honikel, 1987). The filter paper fluid uptake (FFU) was measured using the method reported by Kauffman et al. (1986).

**Analysis of androstenone and skatole**

The fat tissue samples (2 g) were taken from the neck region of the left carcass side for the analysis of androstenone and skatole content. For androstenone, rapid analysis was based on an enzyme immunoassay method (Claus et al., 1997) and was carried out according to the technical bulletin included with the commercial test kits (Riedel-deHaen, Seelze, Germany). The skatole levels in the fat were measured by a spectrophometric method developed by Mortensen and Sorensen (1984).

**Statistical analysis**

All data were analyzed using ANOVA in the SAS package (2001), and significance is reported at the p<0.05 level.

## RESULTS AND DISCUSSION

**Carcass characteristics, muscle temperature, and pH**

The scalded pigs had a higher back fat thickness than the dehided pigs at 20.03 and 18.83 mm, respectively (p<0.05) (Figure 1). Similarly, in an earlier study scalded pigs had a higher back fat thicknesses, lean meat percentages, and carcass weights than dehided pigs (Maribo et al., 1998). In this study, however, there were no significant differences in the carcasses weights (81.67 vs. 81.77 kg, p>0.05). This result was not due to the different dehairing methods, and the difference between the treatments might originate from the fact that the dehided pigs had higher live weights than the scalded pigs. According to Maribo et al. (1998), dehided carcasses had a pH in the *longissimus dorsi* muscle that was 0.1 to 0.2 units higher than that of the scalded carcasses at 1 h postmortem. They also had a higher ultimate pH. In our study, compared to the scalded pigs, the dehided pigs had a higher muscle $pH_{45\ min}$ (6.25 vs. 6.03, p<0.05) and a lower muscle temperature (36.22 vs. 37.45°C, p<0.05) at the early postmortem period.

**Meat quality traits**

Table 1 shows the interactions between the dehairing methods and sex on the meat quality traits in the porcine *longissimus dorsi* muscle. The entire male pigs had a higher muscle $pH_{24\ h}$ (p<0.001) and lower lightness (p<0.001) than the gilt and castrated male pigs. Compared to the gilt and castrated males, the dehided entire males had lower redness (p<0.05) measurement. A similar result was reported by Sather et al. (1991) where entire male meat had a slower postmortem glycolytic rate, darker surface, and lower drip loss than the other genders. Conversely, in another study a slightly paler color was observed in entire males than in gilts (Kempster et al., 1986). However, the differences in the meat quality traits were small and not considered to have practical importance. Thus, the processing characteristics of entire male meat differ very little from those of other genders (Babol and Squires, 1995).

According to a report by Troeger and Woltersdorf

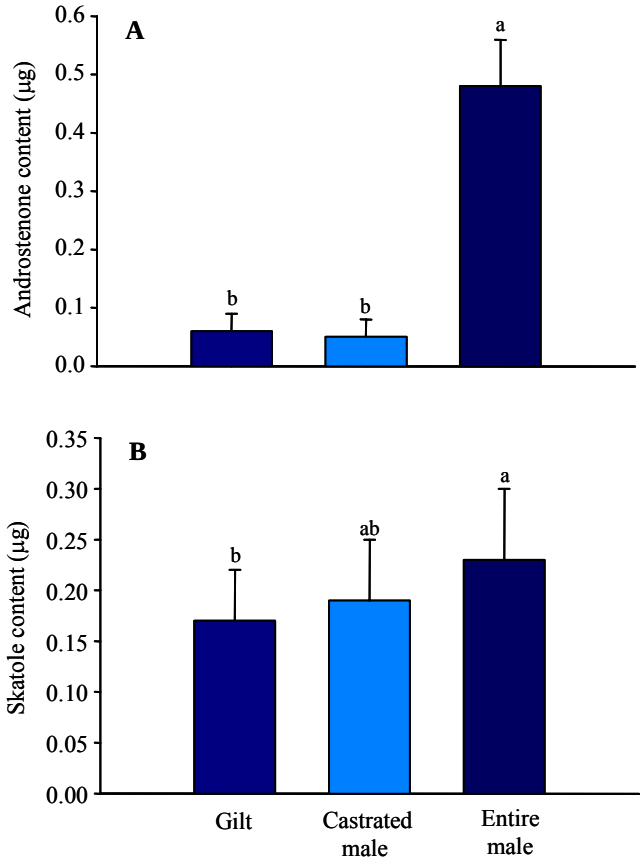


**Figure 2.** Effect of sex on the androstenone (A) and skatole (B) contents in back fat. Bar indicates SD. Different letters on the bars denote significant differences ($p<0.05$).

(1987), dehided carcasses had a higher early postmortem pH than scalded carcasses. However, no difference was observed for the ultimate pH. Malmfors and Nilson (1978) found a higher water holding capacity (WHC) in the meat of entire males than from the meat of gilts and castrated males, but Lundstrom et al. (1987) found no differences between the genders. In this study, the muscle $pH_{24\,h}$ in the dehided and scalded carcasses were similar within the sexes. However, the scalded carcasses, including those of gilts, castrated, and entire males, exhibited a higher drip loss ($p<0.001$) and FFU ($p<0.001$) than the dehided carcasses. After comparisons of Figure 1 and Table 1, we determined that the dehairing method can affect the early postmortem glycolytic rate, such as the muscle pH, thus also affecting the WHC.

**Levels of androstenone and skatole**

Figure 2A shows the effect of sex on the androstenone content of fat. Entire males exhibited a higher level of androstenone than gilts and castrated males (0.48 vs. 0.06 vs. 0.05 μg/g, respectively). The levels of androstenone in the fat of entire males ranged from 0.00 to 5.00 μg/g, however, in some entire males the level may reach 8.50 μg/g, approximately (Walstra et al., 1999). Moreover, the threshold level of androstenone measured by immunoassay is proposed to be in a range of 0.5 to 1.00 μg/g (Zamaratskaia et al., 2004). Cooking conditions can reduce the androstenone and skatole contents (Bonneau et al., 1992; Banon et al., 2003), however, in this study the androstenone levels in the dehided and scalded entire males were similar (Table 2). Thus, the condition of heat from scalding was found to have only a limited effect on the androstenone content.

Dijksterhuis et al. (2000) reported that androstenone was related mostly to urine, while skatole related mostly to manure or naphthalene, which causes the consumer, particularly women, to reject the product (Banon et al., 2003). It is not clear whether androstenone or skatole is more important in causing boar taint. Some studies indicate that skatole (Andresen et al., 1993) is more important, and others indicate androstenone (Bonneau et al., 1993). Still others suggest it is a combination of the two (Babol and Squires, 1995). Therefore, it is unclear which compound is a better estimate of boar taint. Thus, the best way to evaluate boar taint objectively is to measure the levels of both compounds (Babol and Squires, 1995). The levels of skatole in fat from entire males can range from 0.00 to 0.80

**Table 2.** Interactions between the dehairing methods (DM) and sex on androstenone content in back fat

| | DM | Sex | | | Level of significance | | |
|---|---|---|---|---|---|---|---|
| | | Gilt | Castrated male | Entire male | DM | Sex | DM×Sex |
| Androstenone (μg/g) | Scalding | $0.04\pm0.03^{b}$ | $0.07\pm0.05^{b}$ | $0.45\pm0.09^{a}$ | NS | *** | NS |
| | Dehiding | $0.09\pm0.06^{b}$ | $0.06\pm0.05^{b}$ | $0.51\pm0.17^{a}$ | | | |

Results are expressed in mean value±SD. Level of significance: NS, not significant; *** $p<0.001$.
[a, b] Means with different superscripts within a row and column are significantly different ($p<0.05$).

**Table 3.** Interactions between the dehairing methods (DM) and sex on skatole content in back fat

| | DM | Sex | | | Level of significance | | |
|---|---|---|---|---|---|---|---|
| | | Gilt | Castrated male | Entire male | DM | Sex | DM×Sex |
| Skatole (μg/g) | Scalding | $0.16\pm0.05^{c}$ | $0.20\pm0.05^{b}$ | $0.19\pm0.06^{bc}$ | * | ** | ** |
| | Dehiding | $0.14\pm0.06^{c}$ | $0.17\pm0.07^{bc}$ | $0.26\pm0.07^{a}$ | | | |

Results are expressed in mean value±SD. Level of significance: * $p<0.05$; ** $p<0.01$.
[a-c] Means with different superscripts within a row and column are significantly different ($p<0.05$).

μg/g, although in some entire males levels can reach approximately 1.50 μg/g. In addition, some castrated males and gilts may exhibit skatole levels in fat of up to 0.30 μg/g (Babol and Squires, 1995). However, the threshold level for skatole in fat is more or less established and ranges between 0.20 to 0.25 μg/g (Babol and Squires, 1995). In the present study, the entire males exhibited a higher content of skatole than the gilts (0.23 vs. 0.15 μg/g, $p<0.05$) (Figure 2B), and the scalded entire males exhibited a lower content of skatole than the dehided entire males (0.19 vs. 0.26 μg/g, $p<0.01$) (Table 3).

De Kock et al. (2001) has asserted that factors influencing the volatilization of androstenone and skatole should be considered when predicting the sensory responses of boar taint. Moreover, they reported that the heating temperature can influence the contents of androstenone and skatole (De Kock et al., 2001). Skatole is less lipophilic than androstenone, has a lower molecular weight (131.18 vs. 272.4 g/mol), and lower melting (95-97°C vs. 142-143°C) and boiling points (Windholz et al., 1983). Thus, skatole has a higher volatility than androstenone. The results from this study support these findings, where the heat treatment from the scalding process influenced the reduction of skatole content for the scalded entire males.

## ACKNOWLEDGEMENT

This work was supported by the Agricultural R&D Promotion center (Korea).

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