BOAR TAINT COMPOUND LEVELS IN BACK FAT VERSUS MEAT PRODUCTS: DO THEY CORRELATE?

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Abstract – Surgical castration of male pigs will soon be abandoned, turning one of the best-acknowledged advantages of this practice (the elimination of boar taint) into the biggest challenge for pig industry when raising intact males becomes common practice. The occasional occurrence of boar taint in consumable pig products may lead to disapproval of the affected end products by consumers, possibly permanently altering their commercial meat preferences.

In an attempt to contribute to map the (economical) consequences in relation to boar-taint consumer acceptance, as well as, offer a strategy to the stockholders, the current study investigated not only carcass (back fat) boar taint levels, but additionally generated information on the levels of boar taint compounds recovered after the production of several commercially relevant meat products using highly specific UHPLC-HRMS laboratory analysis. Our results demonstrate that levels of androstenone, skatole and indole in back fat and meat products tend to correlate strongly, particularly in fatty meat products. Concentration values in the edible meat fraction were much lower compared to back fat and meat-derived body fat.

Key Words – androstenone, indole, skatole.

I. INTRODUCTION

Within the time frame of a few years, pig industry will have to deal with major changes, triggered by the ban on castration of male piglets in 2018. Rearing intact males will probably gain popularity, as costs for immunological castration do not have to be spent. Moreover, lower food conversion together with decreased nitrogen excretions in feces and urine, will lead to additional economical and ecological advantages in comparison with the production of castrated pigs [1]. Additionally, the leaner meat with a higher fraction of polyunsaturated fatty acids may lead to an increased consumer interest in a world of healthy lifestyles [1, 2]. However, a major issue, strongly reducing the valorisation potential of boar meat, needs to be tackled, before all stockholders will be fully convinced about the introduction of boar meat on the national and international market. As castration was merely introduced to prevent boar taint, an adverse odor and flavor, abandoning this practice evidently comes with the reoccurrence of this organoleptic disadvantage. Specific research is conducted to reduce boar taint, but none of the current approaches guarantees complete elimination [1,3-5]. Consequently, a fraction of the slaughtered intact male pigs will still be responsible for tainted carcasses and consuming fresh or processed meat derived from these carcasses may lead to adverse consumer-reactions affecting the commercial status of pork meat.

To estimate and interfere with any compromising effects of boar taint on pig industry, it is mandatory to gain information on acceptable boar taint thresholds in the tainted carcass and its derived meat products. While most studies consistently report analytical outcomes for neck or back fat levels, little is known about boar taint levels in fresh or processed meat, despite potential differences between several meat products, likely influencing the respective consumer acceptance [6-8]. In this study, however, we investigated the correlation between several fresh and processed meat products and their respective back fat levels, as a first step towards the evaluation of tainted-meat consumer acceptance.

II. MATERIALS AND METHODS

Three hundred carcasses of intact male pigs were screened at the slaugherline (Debra Meat slaughterhouse, Tielt, Belgium) on the occurrence of (intense) boar taint by an expert, based on olfactory evaluation using the soldering iron

method (RDS 80, Kurtz Ersa, Wertheim, Germany) [9]. Forty-five carcasses were retained for analytical determination of the three most relevant boar taint compounds androstenone, skatole and indole. Analysis was performed on back fat samples by UHPLC-HRMS [10]. Nine tainted carcasses were ranked either based on the highest concentration of (only) androstenone (3 carcasses; group 1), on the highest concentration of (only) indolic (i.e. skatole and indole) compounds (3 carcasses, group 2), or on the combination of high concentrations of both androstenone and indolic compounds (3 carcasses; group 3). Subdivision into 3 groups was only relevant for extended research (including taste-panel-testing (data not shown)). Boar taint compound levels were also determined in fresh and processed meat products (cutlets, bacon, blade loins, tenderloins, minced meat, salami sausage, cooked ham and uncooked ham) derived from these carcasses. For minced meat and salami sausage, a fraction of non-tainted (blank) fat was added to the recipe. All meat was stored at -20°C until analysis. With the exception of tenderloin, minced meat and salami sausage, both the fatty tissue (=meat fat) and the muscle tissue (= meat lean) were subjected to the analysis of the three boar taint compounds [10, 11]. For salami and minced meat, muscle tissue was replaced by the (mixed) product.
Correlations between boar taint compound levels in back fat, meat fat and meat were evaluated by the Pearson's correlation coefficient (r). Results were considered significant if $p < 0.05$.

III. RESULTS AND DISCUSSION

For the nine selected carcasses, back fat levels of androstenone, skatole and indole varied from 131 to 3131 µg/kg, 16 to 521 µg/kg and 49 to 340 µg/kg (Table 1).

In general, correlation between back fat and the fat fraction of the meat product strongly correlated for androstenone, with $r > 0.90$ ($p < 0.05$) for all meat products (Table 2).
For indole and skatole similar conclusions could be drawn for most meat products, except for cutlet ($r_{skatole} = 0.83$; $p < 0.05$) and bacon ($r_{skatole} = 0.55$; n.s.). Correlations between back fat and the lean meat part of the meat products were also observed with $r > 0.90$ ($p < 0.05$) for salami and minced meat (both represented by a mixture of fat and meat), blade loin, cutlet and bacon for three or two compounds. This can probably be explained by the high intrinsic fat fraction of these particular meat products.

Table 1 Concentration of androstenone, skatole and indole in back fat of nine selected boar carcasses.

Category	Androstenone (µg/kg)	Skatole (µg/kg)	Indole (µg/kg)
Group 1.1	1613	63	75
Group 1.2	1969	21	85
Group 1.3	3131	16	49
Group 2.1	131	199	98
Group 2.2	147	279	106
Group 2.3	182	320	101
Group 3.1	1187	521	340
Group 3.2	458	59	114
Group 3.3	444	157	182

Table 2 Pearson's correlation coefficients between back fat and the meat and fat fraction of the meat product.

	Back fat		
	Androstenone	Skatole	Indole
Cooked ham meat	0.47	0.76^{b}	0.82^{b}
Cooked ham fat	0.98^{a}	0.94^{a}	0.91^{a}
Uncooked ham meat	0.81^{b}	0.89^{a}	0.87^{b}
Uncooked ham fat	0.97^{a}	0.99^{a}	0.91^{a}
Salami sausage meat	0.97^{a}	0.98^{a}	0.93^{a}
Blade loin meat	0.96^{a}	0.97^{a}	0.90^{a}
Blade loin fat	0.91^{a}	0.97^{a}	0.95^{a}
Cutlet meat	0.99^{a}	0.85^{b}	0.95^{a}
Cutlet fat	0.94^{a}	0.97^{a}	0.83^{b}
Bacon meat	0.94^{a}	0.96^{a}	0.87^{b}
Bacon fat	0.92^{a}	1.00^{a}	0.55
Tenderloin meat	0.88^{a}	0.90^{a}	0.89^{b}
Minced meat	0.85^{a}	0.96^{a}	0.95^{a}

[a]: $p < 0.01$
[b]: $p < 0.05$

A rather strong correlation is also observed in leaner meat products such as ham and tenderloin. The remarkably low and non-significant correlation for androstenone in cooked ham may be attributed to the production process for which cooking under sealed conditions is expected to result in the redistribution of androstenone (and to a lesser degree also of skatole and indole) from intermuscular fat towards subcutaneous (or intramuscular) fat tissue (see also Table 4). Since no heating is applied in the manufacturing of uncooked ham, this resulted in correlation coefficients exceeding 0.80.

Table 3 Mean (standard deviation, s.d.) and range of boar taint compounds in back fat, cutlet meat fat and cutlet meat.

Cutlet	Group 1	Group 2	Group 3
µg/kg	(mean (s.d.) - range)		
	Indole		
Back fat	70 (15)	101 (4)	212 (96)
	49-85	97-106	114-340
Meat fat	93 (61)	148 (19)	200 (111)
	34-176	121-163	53-316
Meat	18 (6)	21 (3)	46 (35)
	13-26	17-24	15-94
	Skatole		
Back fat	33 (22)	265 (51)	246 (201)
	15-63	199-319	59-521
Meat fat	59 (37)	323 (59)	241 (159)
	33-110	244-383	74-451
Meat	2 (0)	16 (13)	41 (51)
	-	5-33	2-112
	Androstenone		
Back fat	2238 (657)	153 (21)	696 (352)
	1613-3131	131-182	443-1187
Meat fat	1693 (238)	286 (77)	683 (442)
	1405-1981	206-388	245-1278
Meat	508 (191)	45 (17)	138 (104)
	364-774	34-68	38-278

An additional finding of this study concerns the successful retrieval of boar taint in the respective fat fraction of the meat products, but the obvious reduction of the boar taint compounds levels in the (edible) meat tissue of the meat products (presented for cutlet and cooked ham in Tables 3 and 4). This reduction may be related to the intrinsic fat percentage of each respective meat product, as boar taint compounds are lipophilic compounds [7].

Table 4 Mean (standard deviation, s.d.) and range of boar taint compounds in back fat, meat fat and meat of cooked ham.

Cooked ham	Group 1	Group 2	Group 3
µg/kg	(mean (s.d.) - range)		
	Indole		
Back fat	70 (15)	101 (4)	212 (96)
	49-85	97-106	114-340
Meat fat	2 (0)	2 (0)	97 (107)
	-	-	2-245
Meat	4 (4)	8 (6)	15 (9)
	1-9	1-13	6-28
	Skatole		
Back fat	33 (22)	265 (50)	246 (201)
	16-63	199-319	59-521
Meat fat	5 (5)	135 (67)	201 (222)
	2-12	41-183	45-511
Meat	2 (0)	2 (0)	14 (17)
	-	-	2-38
	Androstenone		
Back fat	2238 (657)	153 (21)	696 (352)
	1613-3131	131-182	443-1187
Meat fat	3756 (1795)	111 (69)	947 (486)
	1955-6176	21-188	328-1501
Meat	51 (12)	30 (5)	35 (21)
	34-62	23-36	19-65

IV. CONCLUSION

Strong correlations of boar taint compound levels between back fat and the meat and fat fraction of the meat products were observed for several pork meat products. While similar concentrations are found in back fat and the fat fraction of the meat product, remarkable low levels are reported for edible (lean) meat tissue. The low(er) boar taint levels in the lean meat fraction of several meat products, together with the observed variation between the individual meat products, may eventually lead to a successful market-launch of specific processed or fresh meat products, (partly) derived from strongly tainted carcasses. Therefore, an expert taste-panel is currently subjected to evaluate boar taint odor and flavor in each of the selected meat products, to ultimately allow us to propose valorisation guidelines for consumer acceptance of (tainted) boar meat.

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