Impact of using vaccination with Improvac® on boar taint, carcass composition and meat quality

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Abstract

Boar taint is traditionally controlled by physical castration early in life, but animal welfare concerns are likely to lead to an end to the practice in Europe by 2018, and even apart from the welfare consideration there are major disadvantages in terms of animal health and productivity. Improvac represents an alternative to physical castration and the concept is attractive due to potential benefits in on-farm growth performance and carcass characteristics, as well as major improvements in animal welfare and a reduction in the carbon footprint of pig production. Pigs vaccinated with Improvac showed in different studies less fat, more meat and higher weight of key individual primal cuts than physical castrates.

Boar taint, immunological castration, carcass quality, primal cut yields, Improvac

Boar taint is an unpleasant odour and taste predominantly associated with the cooking and eating of pork from some sexually maturing male pigs. Two main compounds are responsible for boar taint, androstenone and skatole.

Androstenone is a steroid hormone produced directly by the testicles of male pigs. It serves as a pheromone and accumulates in the salivary glands. Being highly lipophilic, it also accumulates in fat where it can contribute to boar taint.

Skatole is produced in boars, castrates and female pigs by bacterial digestion of the amino acid tryptophan in the pig's hind gut, from where it is absorbed and, if not cleared by the liver, accumulates in fatty tissues. In intact male pigs the liver is less efficient at metabolizing skatole than in females or castrated males, leading to an accumulation of boar taint (EFSA 2004). Occasionally, taint caused by skatole is detected in pork from female pigs and physically castrated males, particularly when the pigs have been heavily exposed to faecal matter before slaughter as skatole present in faeces can be absorbed through the skin (EFSA 2004).

Although either compound can cause objectionable taint on its own, the highest risk is from pork with elevated concentrations of both compounds (EFSA, 2004). At commercial slaughter weights, the incidence of boar taint is very variable, ranging from 10 to 75% according to different studies (EFSA 2004). Some recent news magazine reports have suggested rates of less than 10%. The reason for this great variation is that there is no standardized definition of boar taint or agreement on how to detect it. Typically the results quoted are from sensory tests, where individuals are asked to make a subjective judgement about the odour and taste of different samples. Differences in methodology can make a big difference, in particular whether the tests are performed by consumers or people trained to evaluate meat and detect taint.

The variation between test results highlights a common misperception about boar taint. We often discuss it as though it is a yes or no phenomenon; a pig either has boar taint and is terrible or doesn't have boar taint and is OK. In fact, as can be seen from the scattergram below (Fig. 1), the concentrations of taint compounds in samples from entire male pigs form a continuous variable. In reality there is a continuum from normal to mildly tainted through to severely tainted. The risk to the industry from failing to control taint is not only that of individual consumers being so annoyed that they complain, which is actually quite rare, but of a long-term decline in the reputation and consumption of pork as consumers have disappointing experiences. There are also differences between consumers in their sensitivity to taint, some of which may be genetically determined. If the most sensitive

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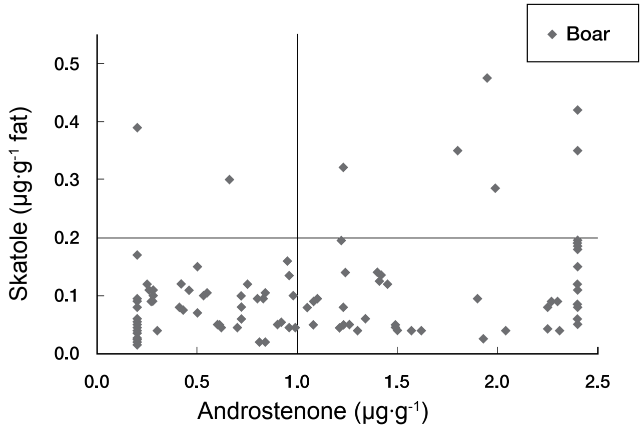

Fig. 1. Androstenone and skatole concentrations in the fat of 100 boars slaughtered at either 23 or 26 weeks of age (Dunshea et al. 2001)

individuals in the population begin to reject pork, even if others still find it acceptable, there will be a long-term impact on sales.

Following from the above, defining cut-off concentrations for the taint compounds, below which pork can be considered taint free, is inevitably an arbitrary judgment. Nevertheless, it is useful to have such benchmarks and it is conventional to use sensory thresholds of 1.0 $\mu g.g^{-1}$ and 0.2 $\mu g.g^{-1}$ for androstenone and skatole respectively, although a lower limit of 0.5 $\mu g.g^{-1}$ is sometimes proposed for the former. Table 1 below shows androstenone and skatole results for 1036 boars at typical EU slaughter weights, distributed using these benchmarks (Allison et al. 2011a). In all 40.9% were considered to have at least a moderate risk of taint (with either androstenone above 1.0 $\mu g.g^{-1}$ or skatole above 0.2 $\mu g.g^{-1}$) and 18.5% fell into the high risk category (shaded area) with significant presence of both taint compounds.

Boar taint is traditionally controlled by physical castration early in life but animal welfare concerns are likely to lead to an end to the practice in Europe by 2018, and even apart from the welfare consideration there are major disadvantages in terms of animal health and productivity. Physical castration raises the pre-weaning mortality rate in male piglets (Allison et al. 2010) and physical castrates are less efficient than entire males at converting feed into weight gain. They are fatter, have less lean meat in the carcass, require more feed and, as a consequence, have a greater environmental impact.

All partners in the pork chain are under external pressure to improve economic efficiency as well as meet societal objectives on animal welfare and environmental sustainability.

Table 1. Distribution of androstenone and skatole in fat tissue of 1036 entire boars sampled during 15 clinical studies in 8 European countries (data presented as the percentage of the total)

Skatole concentration ($\mu g \cdot g^{-1}$)	Androstenone concentration ($\mu g \cdot g^{-1}$)		
	< 0.50	0.50 - 1.00	> 1.00
< 0.100	32.8	18.2	20.9
0.100 - 0.200	4.6	3.3	7.6
> 0.200	1.5	1.8	9.1

Improvac provides the pork industry with a tool to help meet these demands. It represents an alternative to physical castration (Plate I, Fig. 2-3, Plate II, Fig. 4) and the concept is attractive due to potential benefits in on-farm growth performance and carcass characteristics, as well as major improvements in animal welfare and a reduction in the carbon footprint of pig production.

During the development of Improvac 57 studies have been conducted around the world, involving chemical assay for androstenone and skatole. The results are summarized below for Improvac vaccinates, physical castrates and boars, but note that these aggregated figures are for general information and are not suitable for a scientific comparison across the groups. Although individual studies were designed for statistical evaluation, the combined figures are unbalanced and contain likely biases - for example the farms with the highest skatole contamination did not include physical castrate control groups. They also differ from commercial practice in that cryptorchids and other pigs with visible sexual abnormalities were excluded, and no compliance check was conducted 2 weeks after the second dose of Improvac to identify and treat possibly missed animals. Even given these design limitations, however, the results confirm the exceptionally high level of reliability in boar taint reduction.

Table 2. Summary of androstenone and skatole data from 57 global studies where Improvac was used to control boar taint (Crane et al. 2011)

Group	No. of Studies	Total No. Pigs	% Pigs Androstenone < 1.0 $\mu g \cdot g^{-1}$	Total No. Pigs	% Pigs Skatole < 0.2 $\mu g \cdot g^{-1}$
Physical castrates	39	2544	99.9%	3077	99.8%
Improvac	57	4941	99.5%	5875	99.4%
Entire males (boars)	35	2212	59.7%	2220	84.6%

In addition to the analytical characterization of boar taint presented above there have been at least 35 sensory studies throughout the world, using either trained assessors or consumer panels (Crane et al. 2011). Except for one trained panel which found Improvac pigs to be slightly worse than physical castrates, and one consumer panel that found them to be slightly better, all studies found equivalence between samples from Improvac vaccinated males, physically castrated males and females (when included).

Carcass Quality

A key economic indicator in the overall efficiency of meat production is lean meat yield which is often reflected in the “Carcass grading” applied post slaughter. In Pfizer Animal Health’s European trials carcass grading was recorded in 19 studies. Thirteen of those studies, from 10 countries, recorded carcass grading using the SEUROP standardised system. When the data from the 13 studies were pooled a shift in distribution of grading

Table 3. Distribution of carcass grading against the SEUROP system pooled from 13 Pfizer studies in Europe from 10 countries

Sex	Grade (lean meat %)					
	S	E	U	R	O	P
(No of pigs)	(60+)	(55-59)	(50-54)	(45-49)	(40-44)	(< 39)
Castrates (1345 pigs)	8.1%	42.5%	30.3%	11.1%	5.9%	2.2%
Improvac (1234 pigs)	16.5%	58.8%	12.7%	7.8%	2.5%	1.6%

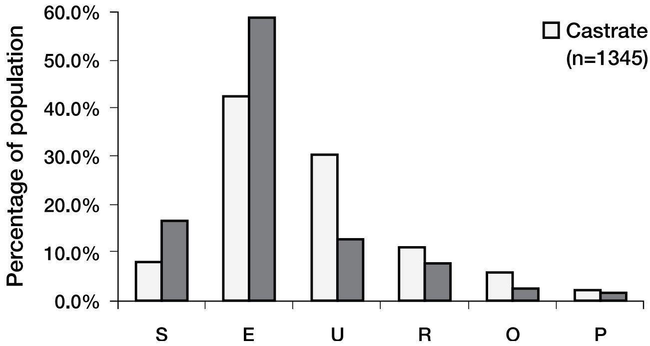

Fig. 5. Distribution of carcass grading against the SEUROP system pooled from 13 Pfizer studies in Europe from 10 countries

to more superior grades was found for the Improvac vaccinated pigs (Allison et al. 2011b). The shift in distribution is highly significant when tested with a Chi-Squared test ($P < 0.001$). The results are shown in Table 3 and Figure 5.

The impact on carcass grading is not surprising if we consider what is happening to the pig. Improvac works by causing a temporary immunological suppression of testicular function. After the second dose of vaccine, given 4 to 6 weeks prior to slaughter, the physiology of the pig becomes like that of a castrate. Up until this point, however, it is a boar, with the higher lean, lower fat carcass typical of an entire male animal. Although some fat deposition will occur in the final weeks, the body composition at slaughter will still be more like that of a boar than that of a physical castrate, with trials consistently showing more lean and less fat. The extent to which changes occur can be manipulated through diet and adjusting the time between full vaccination and slaughter, making the Improvac vaccinated pig a flexible animal in terms of meeting desired slaughter characteristics.

As well as total lean meat yield an important commercial parameter is the weight of primal cuts. Several studies have investigated this area of commercial significance and a recent trial in the USA also examined the interaction with diet, particularly lysine concentration. Table 4 below shows the cutting yields for Improvac vaccinated animals on different diets compared to control groups of physical castrates and entire males. Compared to physical castrates the Improvac pigs had higher cutting yields, with the improvement becoming more marked with better nutrition. The results fit with other work showing that it may be necessary to adjust feeding to fully optimizing the performance of vaccinated pigs, in

Table 4. The effect of using Improvac on cutting yields of finishing male pigs (Boler et al. 2011)

	Sex						SEM
	Physical castrate	Immunological castrate				Entire	
Lysine level	Low	Low	Low/Med	Med/High	High	High	
Left side chilled wt, kg	44.65^{ab}	43.84^{a}	45.46^{bc}	46.70^{c}	44.50^{ab}	44.09^{ab}	0.24
[1]Lean cutting yield, %	61.51^{a}	62.73^{ab}	62.88^{ab}	64.08^{b}	64.01^{b}	66.09^{c}	0.26
[2]Carcass cutting yield, %	73.70^{a}	74.28^{a}	74.83^{ab}	76.12^{b}	76.33^{b}	77.87^{c}	0.27

Means within a row for experimental treatments without a common superscript differ ($P < 0.05$)
[1]Bone-in lean cutting yield = (trimmed ham + trimmed loin + Boston + picnic) / left chilled side wt)*100
[2]Bone-in carcass cutting yield = (lean cutting yield components + trimmed belly) / left chilled side wt)*100

particularly by ensuring adequate lysine during the phase before the second dose of vaccine when the animal is an entire male.

Meat Quality

Objective meat quality measurements, such as pH and drip loss, may be problematic in entire males due to their increased excitability and susceptibility to stress during transport and slaughter. Reflecting the fall in testosterone the behaviour of Improvac vaccinated animals is typically castrate-like from 1 to 2 weeks after the second dose so such problems would not be anticipated. Meta-analyses on multiple studies confirm that there is no difference between physical castrates and Improvac vaccinated pigs for most objective meat quality parameters. The possible exception, as might be expected, is intra-muscular fat, which was not significantly different in the analysis but did have a tendency to be slightly lower, often similar to that of gilts when these were available for comparison.

Table 5. Impact of Improvac use compared to physical castration on objective meat quality parameters; meta-analyses from comparative studies using group housed pigs

	Effect	Sed	95 % CI	P - value	Number of studies
Shear force (kg)	-0.14	0.13	(-0.46, 0.18)	0.32	5
Drip loss (%)	0.25	0.22	(-0.22, 0.71)	0.27	13
pH	-0.03	0.03	(-0.09, 0.02)	0.25	17
Objective color					
L*	-1.36	0.94	(-0.65, 3.37)	0.17	13
a*	-0.24	0.48	(-1.47, 1.00)	0.65	5
b*	0.18	0.34	(-0.69, 1.04)	0.62	5
NPPC subjective color	0.36	0.36	(-0.57, 1.28)	0.37	5
Intra-muscular fat (%)	-0.27	0.15	(-0.58, 0.04)	0.09	13

Conclusions

Effective control of boar taint is essential for the long term success of the pork industry. The traditional, and highly effective, way to reduce boar taint is physical castration, but this practice is increasingly unsustainable because of animal welfare concerns. The use of Improvac provides the industry with a welfare-friendly alternative that has a similar high level of effectiveness in reducing boar taint. In addition, by replacing early physical castration with a temporary suppression of testicular function close to the time of slaughter, pigs are allowed to spend most of their lives as boars, allowing producers to capture the natural growth efficiency and carcass advantages of entire males, without sacrificing meat quality.

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Fig. 2. The boars after the first dose of Improvac

Fig. 3. The boars after the second dose of Improvac

Plate II

Fig. 4 . The boar scrotum with atrophy of testicles (slaughter line)