Review on the consequences of using Improvac™ in modern pig production

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Abstract

In Europe growing concerns regarding animal welfare issues in pig production have forced the pig industry to introduce alternative methods to conventional castration procedures. Besides the raising of entire males and castration in combination with analgesia and anaesthesia the vaccination against GnRF (Gonadotropin-releasing factor) seems to be the most promising long-term solution. Immunised male pigs (IM) show higher average daily weight gain than surgically castrated males (CM). Additionally the feed intake in IM is lower than in CM and feed conversion ratio is consequently better. Carcass weight, back fat depth and dressing percentage of IM pigs are intermediate between CM and entire males while meat quality seems not to be influenced by castration technique since CM and IM show comparable results. Steroid hormone concentrations in IM decline to very low levels (below detection line) after the second administration of the anti-GnRF vaccine and boar taint compounds are reliably metabolized. Pigs which received two injections of the anti-GnRF vaccine reduce their sexual and aggressive behaviour to levels of CM pigs which results in low incidents of injury and carcass damages. Surveys analyzing the consumers' attitude to vaccination against boar taint reveal that if profound information on the technique is provided, the acceptance of meat from vaccinated animals is even better than the acceptance of meat from pigs castrated under current farm conditions. Furthermore economic analyses reveal that immunisation against GnRF provides a potential for a return on investment since better feed efficiency compensates for the additional costs of drug and labour time.

Introduction

Over the last couple of years a large variety of alternative methods to surgical castration without anaesthesia has been presented. This development is mainly due to an increase in scientific knowledge on the physiology of pain in young animals, an increase in the public awareness and concerns regarding the castration procedure and as a consequence an increase in the demand for a more animal-friendly castration technique and improved animal welfare. The conventional procedure, *i.e.* surgical castration without anaesthesia and analgesia within the first seven days of life, has been common practice in most European countries over the last centuries. The EU countries alone produce about 250 million slaughter pigs each year.[1] Castration, as a means of preventing boar taint and aggressive behaviour, is performed on 77% of male pigs.[2] Growing public concerns regarding animal welfare and changing legal requirements have forced governments and the pig industry to reconsider the traditional approach and to reinforce the effort to introduce alternative methods. The most recognised approach, besides raising of entire males and surgical castration with analgesia/anaesthesia, is the down-regulation of gonadal hormones by using vaccination against Gonadotropin-releasing factor (GnRF). The product focused on in this review is Improvac™ (Pfizer Animal Health) since immunisation against GnRF is the most favoured among the vaccination techniques and products.

In the interest of completeness it should be mentioned that other ways of down-regulating of gonadal hormone activity exist.

Castration via vaccination can either be directed against the pituitary hormone LH or the hypothalamic hormone GnRF. Both approaches usually use active immunisation, although passive immunisation is also possible, however, it has proven to be less effective.[3] Falvo *et al.*[4] compared the vaccination of boars with LH and GnRF vaccines and came to the conclusion that LH vaccination was less effective when compared with immunisation against GnRF. In the interest of completeness, it should be mentioned that vaccination against 5α-Androstenone is also possible, but has also proven to be less effective.[5] Over the last 30 years a large number of GnRF vaccines has been subjected to various studies as reviewed by Prunier *et al*.[6] In modern production systems only a vaccine with manageable labour costs and good tolerance can prevail. Modern anti-GnRF vaccines use tolerable adjuvants and only two injections. With these vaccines two possible vaccination schedules exist, early and late vaccination. Studies conducted by Turkstra *et al*.[7] and Zeng *et al*.[8] used a vaccine which is administered relatively early during the pig's life. These vaccines hold the advantage of easier detection of successfully vaccinated animals at the slaughter line. The production advantages of entire male boars, however, were diminished in those pigs and the vaccinated animals showed a growth performance and carcass characteristics comparable to those of barrows.

The most recognised late-vaccination technique is the immunisation against GnRF with two injections given at least 4 weeks apart with the second injection given four to six weeks prior to slaughter.

This review in particular focuses on the effects of immunisation against GnRF on growth performance, carcass characteristics and meat quality, blood testosterone concentrations and behaviour. Additionally, short insight is provided into the effects of using immunisation against GnRF on the major boar taint compounds androstenone and skatole, testes size, the consumer's acceptability of meat from vaccinated pigs and the economic implications of using immunisation against GnRF in modern pig production.

In the interests of completeness, it should be mentioned that castration via vaccination is not only used in male pigs but in a large variety of mammals (all species: Ferro *et al.*,[9] Thompson *et al*.;[10] cattle: Ribeiro *et al*.,[11] Bonneau and Enright;[12] ram lambs: Ülker *et al*.;[13,14] goat bucks: Godfrey *et al.*[15] In all of these species, the purposes of vaccination are more or less the same: the improvement of meat and carcass characteristics, a reduction in male aggressive behaviour, reduction in male-associated odour (esp. swine and goat), and in the case of pet species, the neutralisation of fertility.

Immunisation against GnRF has also been tried in females but only plays a tangential role and is not mentioned further.[16,17]

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Effects of using immunisation against Gonadotropin-releasing factor on growth performance

Most authors agree that treatment with anti-GnRF vaccines has no effect on growth performance before the second vaccination (V2) is administered and that these pigs [immunised male (IM) pigs] perform comparable to intact boars during the first part of the fattening period, *i.e.* before V2.[18-21] Body weight and average daily weight gain (ADG) seem to be at comparable levels for IM pigs, boars and barrows [castrated males (CM) pigs] until V2,[18,19,21,22] whereas the feed intake (FI) in CM pigs is higher when compared with the other groups.[18-22] Hemonic *et al*.[22] and Cronin *et al*.[18] report lower average daily feed intake (ADFI) in IM pigs when compared to CM pigs during the first part of the fattening period. From literature it is well known that entire males show lower voluntary ADFI than CM pigs.[18] Cronin *et al*.[18] and Dunshea *et al*.[19] argue that this lower ADFI results from the fact that entire males allocate more of their active time to social behaviour and spend less time feeding. Furthermore, Weiler *et al*.[23] found a negative correlation for voluntary ADFI and testosterone levels in the blood. IM pigs can be regarded as entire males until the second vaccination is given.[19,20] Despite the lower voluntary ADFI in immunisation against GnRF™-treated pigs, average daily gain (ADG) and body weight (BW) are comparable to those of surgical castrates until the time point of the V2.[18-24] This results from the anabolic effect of the male steroid hormones, which are at comparable levels in IM males and intact boars before V2 (see below). After V2, however, IM pigs increase their voluntary ADFI to levels comparable to CM pigs or even higher.[18,19,22,25-27] In contrast, Skrlep *et al*.[21] and Pauly *et al*.[20] found that although ADFI increases after V2, IM pigs do not reach the levels of CM pigs but consume more feed than intact males of the same age. This increase in ADFI results from a change in the hormonal profile of IM pigs as well as a change in the pigs' behaviour.[18,19] Cronin *et al*.[18] found that intact males spend less time feeding than CM and vaccinated pigs after V2. Additionally, IM pigs after V2 alter their behaviour and spend less time on social, especially aggressive and sexual behaviour. As a consequence IM pigs reveal higher ADG. Dunshea *et al*.[19] came to the conclusion that the higher ADG in IM pigs compared to CM pigs is a result of this increase in ADFI in combination with the more barrow-like behaviour rather than a better feed conversion ratio (FCR).

Effects of using immunisation against Gonadotropin-releasing factor on carcass characteristics and meat quality

Intact males are known to have lower carcass weight and dressing percentage than CM pigs.[7,8,28] Most authors found intermediate values for IM pigs for both parameters.[19,28] Gispert *et al*.[28] and Dunshea *et al*.[19] explain these lower values in IM pigs with the higher gut fill and the removal of the testes. Another effect of vaccination against boar taint is the increase in lean meat percentage comparative to CM pigs.[20,24,25,29,30] Along with this increase in lean meat percentage comes a reduction in intramuscular fat content and backfat thickness in IM pigs,[20] which show intermediate values when compared to entire males and CM pigs.[1,20,28,29,31] The proportion of the ham, as analysed by Gispert *et al.*[28] and Pauly *et al*.,[20] and the proportion of the loin revealed higher values for entire males when compared to CM pigs,[20] with IM pigs in between. Meat quality seems not to be affected by vaccination.[20,28,29] The compensatory growth and the reduction in intramuscular fat content were expected to be detrimental to meat quality parameters such as tenderness and juiciness. The study conducted by Pauly *et al*.,[20] however, found no evidence for reduced tenderness and drip loss in pork from IM pigs. Additionally, Dunshea *et al*.[19] found that, independent of the period of time between V2 and slaughter, IM pigs that were slaughtered with 23 weeks of age had dressing percentages comparable to those of intact boars, whereas slaughter at an advanced age (26 weeks) revealed higher values for intact boars compared to IM pigs. Lealiifano *et al*.[32] found that the timing of V2 had a great influence on many carcass characteristics. Those pigs which received the second immunisation four to six weeks prior to slaughter showed carcass values similar to CM pigs, whereas pigs given a late vaccination, *i.e.* two weeks before slaughter maintained many of the performance advantages of intact boars. Rikard-Bell *et al*.[27] state that the increase in ADFI in IM pigs after V2 results in a great deal of that additional energy being converted into fat rather than muscle growth. They further found that combination of immunisation against GnRF-treatment and ractopamine had additive effects not only on growth performance but that carcass composition was positively influenced, since ractopamine is a stimulator of adipose tissue fat mobilisation. IM pigs which received vaccination as well as ractopamine supplementation revealed an increase in carcass weight and lean meat percentage, whereas half carcass fat mass and backfat thickness had decreased. Similar effects were reported by Oliver *et al*.,[26] who analysed the effects of vaccination against boar taint in combination with porcine somatotropin (pST). Porcine somatotropin is a peptide hormone used to alter the partitioning of energy in feed away from fat and towards muscle growth. Both compounds (ractopamine and pST) are not approved as feed additives in the EU.

Effects of using immunisation against Gonadotropin-releasing factor on testosterone levels in the blood

Testosterone levels in the blood seem to follow a similar pattern to androstenone concentrations in the adipose tissue.[32] Until V2, testosterone levels in the blood of IM pigs are comparable to those of entire male pigs,[19,30,33] which show increasing concentrations with age. CM pigs, on the contrary, show testosterone concentrations below the detection limit.[33] IM pigs reveal a significant decrease in the blood testosterone concentration after V2.[19,33] At slaughter, IM pigs regularly display testosterone concentrations comparable with CM, *i.e.* at very low levels or below detection limit.[19,22,30] Only few studies have focused on the long-term effects of immunisation against GnRF. Zamaratskaia *et al*.[33] found that the effects of immunisation against GnRF on hormonal profile lasted until at least 22 weeks after V2, at which time testosterone levels in IM pigs were still at lower levels than in entire boars.

Effects of using immunisation against Gonadotropin-releasing factor on behaviour and animal welfare

The results on the behavioural consequences of vaccination against boar taint are very consistent, although only few studies have so far examined the effects of immunisation against GnRF on behaviour, especially aggressive and sexual behaviour. Most authors agree, that entire males and IM pigs spend more time on social and active behaviour (as indicated by the number of standing, walking or eating pigs) than CM pigs in the period before V2.[18,33-35] After V2, IM pigs alter their behaviour significantly and perform social and active behaviour at comparable levels with CM pigs or females and differ significantly from intact boars.[34,18,25,36] The reduction in active behaviour is also associated with a reduction in aggressive, mounting and sexual behaviour.

Whereas IM pigs before V2 perform aggressive and mounting behaviour at levels comparable with intact males and at much higher levels than CM pigs, the second immunisation against GnRF leads to a significant decrease in these behavioural traits as soon as one week after V2.[18,25,34,36] Additionally, a study conducted by Zamaratskaia *et al*.,[30] examining the long-term effects of vaccination, revealed that these changes last up to 21 weeks after V2.

This reduction in aggressive and mounting behaviour further results in fewer skin lesions in immunised pigs in comparison to intact boars at slaughter.[25,36] Rydhmer *et al*.[36] state that most of the skin lesions found in intact boars at slaughter result from mounting rather than fighting activities.

Aggressive and sexual behaviour are important indicators of animal welfare since high levels of aggression and mounting behaviour impose stress, fear and injury not only on the receiver but on all pigs in the pen.[37] Animal welfare consequences of surgical castration and its alternatives have been reviewed further by Prunier *et al*.[6] and Borrell *et al*.[38] Both authors come to the conclusion that vaccination against boar taint offers a good alternative to surgical castration since not only the pain and discomfort associated with the procedure are avoided but fighting behaviour is reduced after V2.

Effects of using immunisation against Gonadotropin-releasing factor on the boar taint compounds androstenone and skatole, testes size, consumer's acceptability and economic implications

The effects of vaccination against boar taint have been evaluated by many studies since boar taint has been the major reason for castration in the past. Extensive studies as reviewed by Xue *et al*.[39] and Stefan Guizot,[40] have identified androstenone and skatole as major contributors to boar taint. Numerous studies have proven that immunisation against GnRF is very effective in reducing boar taint,[1,18,19,24,30,41] since androstenone and skatole are reliably metabolized in the period after V2. [21,22,24,32] Lealiifano *et al*.[30] further found that even pigs slaughtered only two weeks after V2 show androstenone and skatole levels comparable to barrows and well below threshold limits. Along with the reduction in the concentration of male steroid hormones comes a reduction in the size of the reproductive organs.[21,22,28,42,43] Some authors suggested using the size of the testicles as an indicator of successful vaccination.[19] However, since not only the genetic background and the age at slaughter influence testicle size but also the time between V2 and slaughter a reliable detection of tainted pork by testes size alone seems impossible.[1,20,31,32,44]

The major reason for the close examination of boar taint and the importance of detecting tainted meat at the slaughter line are the potential of such tainted meat to cause taste and smell aberrations in heated pork which most consumers strongly object to.[45,46] Surveys conducted in order to gain knowledge on the acceptance of tainted meat on the one hand, and meat from IM males, on the other, have been carried out in many countries.[45-51] The acceptance of tainted meat is very poor in most European countries although differences exist. These differences in the consumers' acceptability can be due to different cooking and evaluation methodsas well as to the consumers' origins, ages, sex or androstenone sensitivities.[45,52-54] The acceptance of meat from IM pigs differ among the studies. Font I Furnols *et al*.[45] found that there was no significant difference in the evaluation of meat from immunised pigs, surgically castrated pigs and females and came to the conclusion that the products of immunised males were indistinguishable from pork from barrows or females. The study conducted by Huber-Eicher and Spring revealed that most consumers have no clear association with the term *immunocastration*,[46] but that meat from IM pigs would be much less accepted than meat from pigs surgically castrated under anaesthesia. Hofer and Kupper conducted a survey on more informed consumers.[50] The participants were given information on the actual situation of castration and the alternatives. The results of degustation were in line with the findings of Font I Furnols *et al*.[45] More information on vaccination against boar taint, however, seemed to have had positive influence on the consumers' acceptability of meat from immunisation against GnRF-treated pigs, since the majority agreed on vaccination as a feasible alternative to current practice.

For any alternative method to surgical castration it is necessary to evaluate its economic effects, since only methods can prevail which have few financial disadvantages for the stakeholders. Deen *et al*.[55] come to the conclusion that immunisation against GnRF offers potential for a return on investment. However, the financial effects must always be contextualised within the constraints of each production system since the production implications will vary in different systems. De Roest *et al*.[56] came to the conclusion, looking at the EU countries only, that the better feed efficiency of vaccinated pigs can compensate for the costs of vaccination. A lot, however, depends on the costs of the vaccine and the consumers' acceptance of the procedure.

Conclusions

In summary, most authors agree on vaccination against boar taint as a feasible alternative to surgical castration, since its effectiveness in preventing boar taint has been reliably proven in many studies. In addition, vaccination avoids surgical procedures, is effective in decreasing the occurrence of fighting and mounting behaviour and may improve the feed conversion ratio and lean meat percentage without having adverse effects on meat quality parameters.

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