Maj-Britt Haastrup ERK

Fra: Elise S. Hansen [ESH@da.dk] på vegne af Dansk Arbejdsgiverforening [DA@da.dk]
Sendt: 1. juli 2008 17:26
Til: Justitsministeriet
Emne: SV: Høring over Dyreværnsrådets udtalelse om kastration af pattegrise - 2008-5440-0017

Under henvisning til det til DA fremsendte høringsbrev af 1. juli 2007 vedrørende Høring over Dyreværnsrådets udtalelse om kastration af pattegrise - 2008-5440-0017 skal vi oplyse, at sagen falder uden for DA's virkefelt, og at vi under henvisning hertil ikke ønsker at afgive bemærkninger.

Med venlig hilsen

Nils Trampe, sekretariatschef

Fra: Justitsministeriet Departementet - Justitsministeriet Departementet [mailto:jm@jm.dk]
Sendt: 1. juli 2008 16:29
Til: rigsadvokaten@ankl.dk; Dansk Arbejdsgiverforening; post@dyrefondet.dk; ddd@ddd.dk; info@dansksvineproduktion.dk; dmri@danishmeat.dk; db@dyrenes-beskyttelse.dk; lo@lo.dk; fvst@fvst.dk; peter_mollerup@post9.tele.dk; jvp@danishmeat.dk; jvp@danishmeat.dk; kl@kl.dk; dl@dansklandbrug.dk; info@anima.dk; mim@mim.dk; oem@oem.dk; alledyrsret@mail.dk; info@wspa.dk; sns@sns.dk; Info@danskesvineproducenter.dk; landbrugsraadet@landbrug.dk; politi@politi.dk; sbc@life.ku.dk; detvs@fvst.dk; fvm@fvm.dk; info@sala.dk; kf@meatboard.dk; 3f@3f.dk; info@okologi.dk; lyngdalgaard@mail.dk; regioner@regioner.dk; dma@danishmeat.dk; peter.munster@bm.com; transport@di.dk; di@di.dk; mirja@oasa-dk.dk; itd@itd.dk; ylva@get2net.dk; life@life.ku.dk; hoeringssager@danskerhverv.dk; djf@agrsci.dk
Cc: £JOURDyrevelfærdskontoret (951s35)
Emne: Høring over Dyreværnsrådets udtalelse om kastration af pattegrise - 2008-5440-0017

Justitsministeriet fremsender hermed høring vedrørende Dyreværnsrådets udtalelse om kastration af pattegrise.

Fristen for afgivelse af bemærkninger er **senest fredag den 22 august 2008 kl. 12.00.**

Se venligst vedhæftede filer.

Med venlig hilsen

JUSTITSMINISTERIET

Maj-Britt Haastrup
Kontorfuldmægtig

Tlf.: 7226 8546
Mail: mbh@jm.dk

Slotsholmsgade 10
1216 København K
7226 8400
www.justitsministeriet.dk
jm@jm.dk

Justitsministeriet
Dyrevelfærdskontoret 2008 NR. 5440-0017
Akt.nr. 3

RIGSPOLITIET

Jmt. Mdt.
14 JULI 2008

POLITI

11 JULI 2008 hj

Justitsministeriet

JURIDISK AFDELING

J.nr.: 2008-005-160
/ OA

Polititorvet 14
1780 København V

Telefon: 3314 8888

E-mail: rpchc@politi.dk
Web: www.politi.dk

Vedr. Justitsministeriets sagsnr. 2008-5440-0017

Ved brev af 1. juli 2008 har Justitsministeriet anmodet om eventuelle bemærkninger til Dyreværnsrådets udtalelse om kastration af pattegrise og den dermed forbundne smerteforelse.

Det kan i den anledning oplyses, at Rigspolitiet ikke har bemærkninger til udtalelsen.

Med venlig hilsen

Erik Justesen
vicerigspolitichef

...uskontoret 2008 NR. 5440-0017

...kt.nr. 4

Modtaget i 7/7-08
Dyrevelfærdskontoret

Justitsministeriet
Slotsholmsgade 10
1216 København K

7. juli 2008
Eksp.nr. 554867
/meo-dep

Høring over Dyreværnsrådets udtalelse om kastration af pattegrise

Økonomi- og Erhvervsministeriet har modtaget ovenstående høring fra Justitsministeriet. Økonomi- og Erhvervsministeriet har sendt materialet i høring hos Erhvervs- og Selskabsstyrelsen.

Økonomi- og Erhvervsministeriet har på denne baggrund ingen bemærkninger til denne høring.

Med venlig hilsen

Mette Olsen
Kontorfuldmægtig

ØKONOMI- OG ERHVERVSMINISTERIET
Slotsholmsgade 10-12
1216 København K

Tlf. 33 92 33 50
Fax 33 12 37 78
CVR-nr. 10 09 24 85
oem@oem.dk
www.oem.dk

Maj-Britt Haastrup

Fra:	Munster, Peter [Peter.Munster@bm.com]
Sendt:	21. august 2008 13:48
Til:	Eddie Omar Rosenberg Khawaja
Cc:	Jensen, Jens Christian Eskjear
Emne:	Høringssvar fra Pfizer Animal Health
Prioritet:	Høj
Vedhæftede filer:	Høringssvar fra Pfizer Animal Health.pdf; 01_Improvac_Food Safety_Clarke_2008_IJARVM.pdf; 02_Hennessy and Newbold. IPVS 2004.pdf; 03_Hennessy et al. Eating Quality. IPVS 2006..pdf; 04_Jeong et al Eating Quality and Sensory IPVS 2008.pdf; 05_Boghossian et al_Immunocastration_A Strategy to Produce Taint Free Pork.pdf; 06-Lagerkvist_Swedish consumer preferences.pdf; 07_Hennesey_Consumer attitudes_APVS 2007.pdf; 08_Giffin et al Consumer Acceptance IPVS 2008.pdf; 09_Allison_Improvac Consumer Acceptance_IPVS Proceedings 2008.pdf; 10_Cronin behavior of IC EM and CM.pdf; 11a_MacKinnon Pearce_The Pig Journal 2007 59_29-67.pdf; 11b_MacKinnon Pearce_The Pig Journal 2007 59_68-90.pdf

Kære Eddie Khawaja,

Denne henvendelse sker på vegne af Pfizer Animal Health.

Jeg fremsender hermed et høringssvar vedr. Dyreværnsrådets udtalelse til Justitsministeren ang. kastration af pattegrise. Jeg har desuden vedhæftet det kildemateriale, som svaret henviser til.

Skulle der være problemer med en fil eller lignende, må du meget gerne kontakte mig, så skal jeg sørge for at I får en ny udgave.

Har I spørgsmål til selve substansen, kan I kontakte Jens Christian Eskjær Jensen, der er teknisk direktør for Pfizers arbejde med svin.
Jens kan træffes telefonisk på +33 (60) 80 57 431 eller på mail jens.chr.jensen@pfizer.com.

Venlig hilsen/Kind regards

Peter Andreas Münster
Konsulent for Pfizer Animal Health

Client Executive
Burson-Marsteller A/S
peter.munster@bm.com

Mobile:+45 3056 7535
Phone:+45 3332 7878
Fax: +45 3332 7879

Crisis hotline: +45 2092 6911

Høringssvar

vedr.

Udtalelse om kastration af pattegrise og den dermed forbundne smerteføelse

Fra

Pfizer Animal Health
23-25 Avenue du Dr Lannelongue
F-75668 Paris cedex 14

Erklæring fra Dyreværnsrådet om kastration af pattegrise og den dermed forbundne smerte

Den 14. marts 2008 bad Justitsministeriet Dyreværnsrådet om en udtalelse vedrørende kastration af pattegrise og den smerte, de følte i forbindelse med denne procedure. Justitsministeriet bad også Rådet om at overveje mulige alternativer til kastration af pattegrise i sin gennemgang. I forbindelse med undersøgelsen overvejede Dyreværnsrådet kastration under bedøvelse og modtog også information fra Pfizer Animal Health om brugen af vaccination mod ornelugt som et alternativ til kirurgisk kastration.

Udtalelsen fra Dyreværnsrådet blev afleveret til justitsminister Lene Espersen i juni, hvorefter ministeren sendte udtalelsen i høring hos relevante myndigheder og organisationer.

Kommentarer fra Pfizer Animal Health

Pfizer er glad for det initiativ, Justitsministeriet har taget med hensyn til at undersøge de velfærdsmæssige aspekter af kirurgisk kastration af pattegrise og at overveje dyrevenlige alternativer til kirurgisk kastration.

Dyreværnsrådet bemærker helt korrekt, at der ikke umiddelbart kan gives nogen anbefalinger om alternativer til kirurgisk kastration, fordi der ikke findes nogen i øjeblikket. Men vi mener, at anbefalingen om at forskningen fortsætter, og at spørgsmålet om kastration af pattegrise tages op igen inden for maks. fem år, er en noget konservativ tidshorisont.

I Rådets erklæring står der endvidere, at Improvac, Pfizers vaccine mod ornelugt, endnu ikke er godkendt til brug i Danmark (og i EU), og det rejser en række spørgsmål, som skal afklares, "før det kan vurderes, om denne metode kan bruges som et alternativ til kirurgisk kastration". Disse spørgsmål handler om sikkerheden for den person, som vaccinerer grisene, forbrugernes holdning og også omfanget af aggressiv adfærd hos ikke kastrerede, men vaccinerede grise og konsekvenserne med hensyn til dyrevelfærd og håndtering af grisene. Vi vil gerne benytte denne lejlighed til at formidle yderligere information til behandling af disse vigtige spørgsmål.

1. Sikkerhed for den person, der vaccinerer grisene

Der er i 2007 blevet indsendt en anmodning til Det Europæiske Lægemiddelagentur (EMEA) under EUs centraliserede procedure om tilladelse til markedsføring i EU af Improvac. Udvalget for Veterinærlægemidler (CVMP) fortager den videnskabelige evaluering. Forudsat at CVMP er tilfreds med de fremlagte data, forventes en godkendelse af Improvac som et immuniserende lægemiddel til dyr inden midten af 2009. Et kritisk aspekt af denne gennemgang er sikkerheden for den person, der vaccinerer grisene, og det skal sikres tilstrækkeligt, før godkendelse af produktet kan overvejes.

Risikoen for denne person består i sandsynligheden for uforsætlig selvinjektion, faremomenter (helbredsmæssige konsekvenser, behandlingsmuligheder og

helbredelse) og i hvilken grad disse kan afhjælpes ved passende forholdsregler for at mindske risikoen.

Muligheden for uforsætlig selvinjektion minimeres ved at sikre, at produktet indgives af en kvalificeret person med en sikkerhedssprøjte (med en nål, der kan trækkes tilbage og låses). Den foreslåede produktmærkning giver råd til lægerne i tilfælde af uforsætlig selvinjektion og anbefaler, at når en person har været udsat for selvinjektion, skal denne ikke længere anvende produktet for at undgå risikoen for yderligere eksponering.

Improvac er allerede godkendt og i brug i flere lande i hele verden, og over 3,5 mio. grise er blevet vaccineret til dato, og antallet stiger hastigt. Tre tilfælde af hudkontakt med nåle eller mistanke om selvinjektion er rapporteret, og de var alle enten helt symptomfri eller medførte i et tilfælde forbigående hormonale ændringer uden klinisk manifestering, som normaliseredes igen uden behandling.

Alle aspekter af sikkerhed for de personer, der indgiver vaccinen vil blive gennemgået i detaljer og blive taget med i betragtning i den endelige vurdering af risiko/fordel, der foretages af CVMP, når de skal afgøre, om Improvac kan anbefales til godkendelse i EU.

2. Forbrugernes holdning

Ud fra et videnskabeligt synspunkt er fødevaresikkerheden ved brug af Improvac klar. Improvac indeholder et proteinantigen, som ikke har nogen hormonel eller farmakologisk aktivitet og ikke er aktivt, når det indtages gennem munden (1). Det efterlader ingen rester i kødet, som kan påvirke mennesker, og ligesom de fleste andre vacciner er Improvac tildelt en tilbageholdelsestid på 0 (nul) dage i de 18 lande, hvor den er godkendt i øjeblikket, hvilket afspejler fødevaresikkerheden ved brug af Improvac.

Med hensyn til kødkvaliteten har flere sensoriske undersøgelser i en række lande klart vist, at svinekød fra orner, der har fået Improvac, er af samme sensoriske kvalitet (lugt, smag, saftighed, mørhed og generel kvalitet) som svinekød fra hungrise eller kastrerede grise (2-5).

Ud fra et forbrugerpsykologisk perspektiv er de videnskabelige data alene imidlertid ikke altid tilstrækkelige til at dæmpe bekymringer. Med Improvac kan forbrugerbekymringer eller usikkerhed afklares ikke blot med videnskabelige fakta, men også ved at pege på de positive fordele for en række interessenter, herunder fordelene for de behandlede grise. Man har fået bevis for dette gennem forbrugerundersøgelser foretaget i Australien, Korea, Schweiz og også i fire EU-medlemslande: Sverige, Holland, Tyskland og Frankrig (1, 6-9).

Undersøgelserne bad forbrugerne give udtryk for deres holdning med hensyn til fjernelse af ornelugt ved brug af vaccination eller fysisk kastration. Resultaterne fra alle landene angav klart forbrugernes præference med en overvældende majoritet for brug af en vaccine til at forhindre ornelugt fra de over 5300 deltagere, så længe kødsmagen var den samme, som den man fik ved kastration. Denne tendens forstærkes jo mere information omkring mulighederne for kontrol af ornelugt

forbrugerne har til rådighed. Bekymring om dyrevelfærd var den primære faktor, der fik forbrugerne til at foretrække vaccination mod ornelugt frem for kastration. Resultaterne viste, at vaccination mod ornelugt ikke blot er acceptabel for forbrugerne, men foretrækkes frem for kastration. Respondenterne i Frankrig, Tyskland og Holland blev oven i købet spurgt specifikt til deres holdning til vaccination versus kastration *med* bedøvelse og i disse lande var holdningen den samme, nemlig at vaccination var den foretrukne metode til at bekæmpe ornelugt.

3. De vaccinerede hangrises adfærd

Selvom det er muligt at opdrætte intakte hangrise til slagtevægt uden adfærds-problemer, og man har nogen erfaring hermed i Danmark, er der ingen tvivl om, at problemer med aggressiv og seksuel adfærd blandt orner somme tider kan opstå, og at disse kan udgøre et velfærdsproblem i den sene opvækstfase. Det kan også være et problem, hvis grisene flyttes og blandes, når de skal slagtes.

Improvacs virkning taget i betragtning kan kontrol af hangrisenes adfærd forventes efter vaccinationen, hvilket er blevet bekræftet. I forbindelse med undersøgelser af hangrises adfærd, der sammenlignede virkningerne af vaccination med Improvac mod kirurgisk kastration på hangrisene, når de opstaldes i grupper, udviste vaccinerede grise de samme lave niveauer af aggressiv adfærd som kirurgisk kastrerede hanner (begge væsentligt lavere end intakte hanner) ved 21 uger (10).

Da vaccinationen foretages i den sene opvækstfase, er en af de potentielle fordele ved Improvac, at det giver svineproducenten mulighed for at udnytte den økonomiske fordel ved hangrisenes naturlige tilvækst, lavere foderforbrug og mere kødholdige slagtekrop, samtidig med at hangrisenes adfærd når de er omkring puberteten er kontrolleret fordi vaccinens effekt er indtrådt på dette tidspunkt. Herved forbedres velfærden for grisene, de bliver nemmere at håndtere (som var de kirurgisk kastrerede), risikoen for skader reduceres (som følge af slagsmål og bedækningsadfærd) og dermed forbedres også slagtekroppens kvalitet. (11).

Afsluttende bemærkninger

Vi er glade for at Dyreværnsrådet er blevet bedt om at gennemgå dette emne og sætter stor pris på muligheden for at kommentere indholdet af rådets udtalelse. Vi håber, at ovennævnte punkter og de oplysninger, der er givet, kan bidrage til at belyse nogle vigtige aspekter og fordele ved vaccination mod ornelugt som et alternativ til kirurgisk kastration. EMEAs behandling af ansøgningen om tilladelse til markedsføring i EU er igangværende og skulle være afsluttet i starten af 2009. Forudsat at resultatet af denne behandling er positivt, forventer vi, at vaccination mod ornelugt vil være en mulighed for svineproducenterne i hele EU næste år, og det vil således være et praktisk alternativ til den nuværende kirurgiske kastration med positive resultater og fordele for producenter, for dyrevelfærden og af forbrugernes accept samt præference.

Vi håber, afhængig af EU-myndighedernes godkendelse af vaccination mod ornelugt, at Dyreværnsrådet vil genoptage dette emne på et passende tidspunkt og endnu engang overveje anbefalingerne med hensyn til alternative metoder til kirurgisk kastration.

Referencer

1. Clarke I, et al, Inherent Food Safety of a Synthetic Gonadotropin Releasing Factor (GnRF) Vaccine for the Control of Boar Taint in Entire Male Pigs. Int J App Res Vet Med 2008; 6:7-14

2. Henessey D, Newbold R, Consumer Attitudes to a Boar Taint Vaccine Improvac® A Qualitative Study, Proc Int Pig Vet Soc 2004; Germany. Vol 2, pg 612

3. Hennessy DP, et al, Eating Quality and Acceptability of Pork from Improvac Immunized boars, Proc Int Pig Vet Soc 2006; Denmark, pg 291

4. Jeong J, et al, The effect of immunocastration on meat quality and sensory properties of pork loins. Proc Int Pig Vet Soc 2008; South Africa. Vol 2, pg 588

5. Boghossian V, et al, Immunocastration – A Strategy to Produce "Taint Free" High Quality Pork from Entire Males. Proc 41st Int Cong Meat Sci Tech 1995.

6. Lagerkvist C, et al. Swedish Consumer Preferences for Animal Welfare and Biotech: A Choice Experiment. AgBioForum 2006; 9(1):51-58.

7. Hennessey D, Consumer Attitudes to Boar Taint & Immunocastration. Proc 2nd Asian Pig Vet Soc 2007; Wuhan, China.

8. Giffin B, et al. Consumer acceptance of the use of vaccination to control boar taint. Proc Int Pig Vet Soc 2008; South Africa. Vol 1, pg 267

9. Allison J, Pfizer Symposium Proceedings. Int Pig Vet Soc 2008; South Africa

10. Cronin G, et al , The effects of immuno- and surgical-castration on the behaviour and consequently growth of group-housed male finisher pigs. Applied Animal Behaviour Science 2003; 81: 111-126.

11. MacKinnon J, Pearce M, Improvac® (Pfizer Animal Health): An immunological product for the control of boar taint in male pigs. The Pig Journal 2007; 59: 29-67 and 68-90.

Inherent Food Safety of a Synthetic Gonadotropin-Releasing Factor (GnRF) Vaccine for the Control of Boar Taint in Entire Male Pigs

Iain Clarke, PhD[1]
John Walker, PhD[2]
David Hennessy, PhD[2]
John Kreeger, DVM, PhD[3]
John Nappier, PhD[4]
John Crane[4]

[1]*Department of Physiology*
Monash University
VIC, Australia
[2]*Pfizer Australia Pty Ltd*
Melbourne
VIC, Australia
[3]*Pfizer Inc*
Groton, Connecticut, USA
[4]*Pfizer Animal Health*
Kalamazoo, Michigan, USA

KEY WORDS: pigs, swine, gonadotropin releasing factor, vaccine, boar taint, immunocastration, food safety

ABSTRACT

Compared to compounds with a pharmacological mode of action, where the possible presence of drug residues in food is a public health concern, vaccines are generally considered safe from a food quality perspective. This is due to the intrinsic lability of these complex biological molecules, both in the body of the vaccinated animal and, if they should ever get so far, in the cooking process and/or intestinal tract of a consumer. The inherent food safety of a novel gonadotropin-releasing factor (GnRF) vaccine, intended to be administered by injection to male pigs for the control of boar taint, was confirmed using several animal models. In addition to conventional oral bioavailability studies, an experiment was also performed to check for the presence of a direct hormonal effect of the vaccine antigen. The vaccine antigen comprises a synthetic analogue of mammalian GnRF covalently coupled to a carrier protein. Intravenous administration of this antigen in sheep had no effect on luteinizing hormone secretion from the pituitary gland, demonstrating that the vaccine itself has no hormonal activity. Repeated oral dosing of the vaccine to pigs failed to stimulate production of detectable circulating antibodies against GnRF and did not affect serum testosterone levels. This lack of oral activity was further confirmed by the oral administration to laboratory rats of graduated doses of the vaccine up to 70 times (on a weight for weight basis) the recommended injectable dose in pigs. There were no quantifiable vaccine antigen levels or anti-GnRF antibodies detectable in the sera of these rats at any dosage level, or any secondary effects on sex hormone levels, indicating that vaccine given orally is neither systemically bioavailable nor immunogenic. These studies confirm that there is no risk to human health from the consumption of pork from pigs administered this boar taint vaccine.

INTRODUCTION

Boar taint, caused principally by accumulation of androstenone and skatole in fatty tissue, is a significant food quality problem in sexually maturing male pigs. Androstenone is a pheromone steroid produced in the testes, and skatole is a by-product of the bacterial degradation of tryptophan in the large intestine. Both substances are highly lipophilic and are sequestered in the adipose tissue of the pig. Due to relatively high volatility, both compounds are readily released upon heating and cooking of pork and can give rise to an offensive odour (boar taint).[1-4]

There are 2 traditional management approaches to this meat quality problem: slaughter prior to sexual maturity and, much more commonly, surgical castration prior to weaning. Both practices have significant drawbacks however. Slaughter of pigs at relatively light weights results in significant production losses. Castration of very young pigs prevents endogenous production of male steroids that give rise to androstenone and skatole accumulation but causes increased fat deposition in the carcass, less lean meat yield, and statistically significant reductions in growth efficiency.[5,6] Because of poorer feed conversion efficiency, castrated pigs are significantly more expensive to raise than intact pigs. Aside from direct production losses, castration is also associated with increased mortality from post-castration complications such as infections and hernias. Anecdotally, this increase in mortality can be as high as 0.5 to 1.5 percentage points. Additionally, castration is criticised by animal welfare groups because it is generally practised without anaesthesia and is associated with pain-related behavior[7] and significant increases in serum cortisol concentrations indicative of stress.[4,8]

The economic and welfare drawbacks of surgical castration prompted the development of a parenteral vaccine (Improvac®/ Vivax®; Pfizer Animal Health) that stimulates neutralizing antibodies directed against endogenous gonadotropin-releasing factor (GnRF).[6,9] Endogenous GnRF stimulates the pituitary-gonadal axis, which, in the boar, results in the synthesis of testicular steroids, including testosterone and androstenone. Suppressing testicular steroid synthesis not only prevents androstenone production but also accelerates hepatic clearance of skatole.[4,10] Thus, the net effect of inducing antibodies against circulating GnRF is the inhibition of testicular function and the consistent reduction of both androstenone and skatole to levels below consumer detection.

The immunizing antigen in the commercial vaccine comprises a synthetic analogue of endogenous mammalian GnRF conjugated to a carrier protein. Instead of having 10 amino acids like endogenous GnRF, the synthetic GnRF peptide lacks 1 amino acid and is thus foreign to the GnRF gonadotrope receptors in the pituitary gland. Covalent linkage of the GnRF analogue to the carrier protein results in an antigen that is even more foreign to the pituitary GnRF receptors but, together with the aqueous adjuvant in the vaccine formulation, allows stimulation of the immune system to transiently produce high levels of circulating antibodies to GnRF.

The studies described in this paper were conducted, firstly, to determine if the synthetic GnRF analogue or the vaccine antigen have any hormonal activity (Study 1) and, secondly, to see if orally administered vaccine antigen is systemically bioavailable or immunogenic (Studies 2 and 3). Negative results would confirm that there are no immunologic or endocrinologic safety hazards for humans consuming meat from vaccinated pigs.

MATERIALS AND METHODS

All experiments involving animals were carried out in compliance with national legislation and subject to local ethical review.

Study 1. Evaluation of Hormone Activity of the GnRF Analogue and Antigen Conjugate

A controlled experiment was performed to determine if either the GnRF analogue or the protein conjugate (vaccine antigen) have any direct hormonal activity when administered parenterally. As GnRF is highly conserved across mammalian species,[11] and because of extensive experience with a sheep model, the sheep was used as the test animal. Twelve post-pubertal female crossbred sheep were randomly assigned to 1 of 4 groups (n = 3 each). The jugular vein was cannulated for blood sampling and intravenous (IV) injection of the test articles. On Day 8 of their respective oestrus cycles, when luteinizing hormone (LH) pulse frequency was low, sheep were given 3 IV injections of 20 mg of morphine at half-hour intervals to suppress synthesis of endogenous GnRF.[12] After the third morphine injection, the respective test groups were given either a single IV injection of saline, natural GnRF peptide (1 µg), synthetic GnRF peptide analogue (50 µg), or sufficient vaccine antigen to provide the equivalent amount of 50 µg of covalently bound GnRF peptide analogue. The 50-fold larger dose of GnRF peptide analogue compared with natural GnRF was estimated from the sequence of the analogue peptide and potency comparisons with other characterized peptide analogues. Baseline blood samples were obtained prior to treatment and at 10 intervals up to 240 minutes after injection (Figure 1). Plasma concentrations of LH were assayed using a standard radioimmunoassay previously described[13] with a detection limit of 0.11 ng/mL.

Study 2. Systemic Effects of Oral Administration of Vaccine in Pigs

To evaluate the effects of oral ingestion of the vaccine, a controlled experiment was performed to determine the antibody and hormonal response in pigs following multiple vaccine doses given orally.

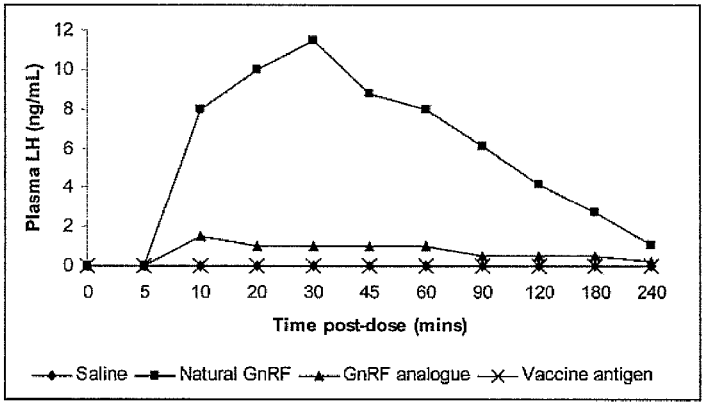
Pigs were chosen as the test animal for this study since the gastrointestinal tract of the pig is similar to that of humans and their size allows simple administration of a full dose of the vaccine.

Twelve 12- to 13-week-old male pigs were randomly assigned to a treatment group or untreated control group (n = 6 each). Commercial vaccine was given to the treated group as a 2-mL oral dose by mixing with a small amount of pelleted feed, prior to normal feeding. This was similarly followed by a second oral dose 28 days later. Blood samples were obtained at 14, 28 and 42 days after the first oral treatment and assayed for serum testosterone and antibodies against GnRF. The sample taken 28 days after the first dose was obtained just prior to administration of the second dose. The sample taken 42 days after the first dose was obtained 14 days after the second dose: an interval that would normally allow an anamnestic immune response to be detected if it occurred. Samples were taken between 10 AM and noon to minimize diurnal variation in testosterone concentrations. Serum testosterone was measured using a commercial radioimmunoassay kit (Direct Testosterone Kit, Cat No. 135; Pantex, Santa Monica, CA, USA), expressed as ng/mL, and analysis of variance (ANOVA) used to compare results. Titers of antibody against GnRF were measured by a validated in-house radioimmunoassay, with titers expressed as reciprocals of the dilution that bound 30% of a commercial tritium-labeled GnRF tracer available from Amersham Inc (Piscataway, NJ, USA). Separation of bound from free GnRF was achieved with precipitation using bovine gamma globulin and 18% polyethylene glycol. The limit of quantification (LOQ) of this assay was 20 titer units.

Study 3. Oral Bioavailability and Systemic Effects of Vaccine in Rats

A controlled study was conducted to evaluate systemic bioavailability, immunogenicity, and any indirect hormonal effects of the vaccine following oral and parenteral administration to Sprague-Dawley rats (a well-characterized laboratory animal model routinely used in toxicology studies). Table 1 summarizes the test groups, vaccine dos-

Figure 1. Mean plasma luteinizing-hormone (LH) concentrations following IV injection of sheep with either saline, 1 µg natural gonadotropin releasing factor (GnRF), 50 µg synthetic GnRF analogue, or vaccine conjugate antigen (sufficient to provide the equivalent amount of 50 µg of covalently bound GnRF peptide analogue). Limit of LH quantification = 0.11 ng/mL.



ages, and toxicological/immunological and other outcome parameters. Serum anti-GnRF antibody levels and systemic bioavailability of the antigen were determined by electrochemiluminescent immunoassays (ECLIA) with an LOQ of 4.7 pmol/mL for anti-GnRF antibodies and 1.4 pmol/mL or 0.098 µg/mL for vaccine antigen.

Commercial vaccine was administered orally by gavage once on Day 1 and on Day 29 to 5/sex/group male and female Sprague-Dawley rats at doses of 11.4 µg/kg, 272 µg/kg, and 462 µg/kg. These doses represented approximations of 1.7×, 41.2×, and 70×, respectively, of hypothetical oral consumption of a full 2-mL vaccine dose by a 60-kg human. An additional 2 groups of 5 males and 5 females were given either saline or formulation vehicle at the same dosing volume and dosing interval. A positive control group was also included that consisted of 5 males and 5 females given 27.5 µg/kg subcutaneously also on Day 1 and Day 29. Parameters for evaluation included daily clinical observations, weekly body weight, weekly food consumption, and terminal hematology, coagulation, clinical chemistry, and hormone analysis. Hormone analysis included LH (all animals), progesterone (females only), estradiol-17β (females only), and testosterone (males only). Rats in the oral groups and in the SC injection positive control groups (Table 1) were necropsied on Day 58 of the study (ie, 29 days after the second dose). Organ weights on heart, liver, kidneys, adrenal glands, pituitary, and brain were obtained and representative sections of 47 tissues were collected for histological evaluation. Hormone data were analyzed using a mixed model ANOVA.

Systemic exposure and antibody response were assessed in toxicokinetic (TK) satellite groups in which 3/sex/group were dosed with 462 and 27.5 µg/kg for the high-dose oral dose and positive control SC dose groups, respectively, on Day 1 and Day 29. Blood samples were taken at 0 (pre-treatment), 1, 4, 8, 12, and 24 hours and 2, 7,14, and 21 days after the first dose and at 0 (pre-treatment), 1, 4, 8, 12, and 24 hours and 2, 7,14, and 21 days after the second dose from all animals in both TK treatment groups. The blood samples were processed into serum and were assayed for the vaccine antigen and anti-GnRF antibodies. The vaccine antigen and logarithm transformed anti-GnRF

Table 1. Rat Bioavailability Study Test Groups.

Test Group	Antigen Dose	Dosing Regimen	Toxicity Parameters
Sterile water control (n = 5/sex)	0 µg/kg	PO, day 1 and 29	1, 2
Vehicle control (n = 5/sex)	0 µg/kg	PO, day 1 and 29	1, 2
Oral-toxicity low dose (n = 5/sex)	11.4 µg/kg	PO, day 1 and 29	1, 2
Oral-toxicity mid dose (n = 5/sex)	272 µg/kg	PO, day 1 and 29	1, 2
Oral-toxicity high dose (n = 5/sex)	462 µg/kg	PO, day 1 and 29	1, 2
Positive control (n = 5/sex)	27.5 mg/kg	SC, day 1 and 29	1, 2
TK (n = 3/sex)	462 mg/kg	PO, day 1 and 29	2, 3, 4
TK positive control (n = 3/sex)	27.5 mg/kg	SC, day 1 and 29	2, 3, 4

PO = per os; SC = subcutaneous injection; TK = toxicokinetic.

Toxicity parameter key: (1) mortality, food consumption, body weight, terminal hematology and coagulation, clinical chemistry, gross necropsy, Day 58 histopathology; (2) hormone response; (3) anti-GnRF antibody; (4) GnRF analogue protein conjugate bioavailability.

values were analyzed with a mixed model ANOVA for repeated measures.

RESULTS

Study 1. Evaluation of Hormone Activity of the GnRF Analogue and Antigen Conjugate

The mean temporal responses for the 4 treatment groups are shown in Figure 1. Luteinizing hormone was not detectable in any of the 12 sheep prior to administration of their respective treatments, indicating that morphine effectively blocked LH secretion. All 3 sheep given 1 µg of natural GnRF had a rapid, marked increase in LH with a mean peak value of 11.63 ± 5.03 ng/mL. The 3 sheep given unconjugated GnRF peptide analogue at a dosage 50 times greater than that for natural GnRF had a relatively small increase in LH, with a mean value approximately 10-fold less than that for sheep given natural GnRF at a 50 times lower dose. Sheep given either the GnRF analogue-protein conjugate (vaccine antigen) or saline produced no quantifiable LH response. The test determined that the GnRF peptide analogue had a relative activity of only 0.2% compared to natural GnRF (mean GnRF analogue response ÷ mean GnRF response ÷ 50 × 100%), while the vaccine conjugate antigen had no LH stimulating activity.

Study 2. Systemic Effects of Oral Administration of Vaccine in Pigs

The serum anti-GnRF antibody titer for all samples was <20, the minimum detectable level, following both the first and second oral vaccine doses. Mean serum testosterone levels at the 3 sampling intervals are shown in Table 2. All pigs had measurable testosterone levels that were within normal reference ranges for animals of that age. There were no significant differences in testosterone levels between orally dosed pigs and untreated control pigs at any sampling interval. Throughout the trial, daily observations of the test animals revealed no abnormal clinical signs or adverse events in any of the pigs.

Table 2. Mean Serum Testosterone Concentration in Pigs Given Oral GnRF Analogue Protein Conjugate Vaccine.

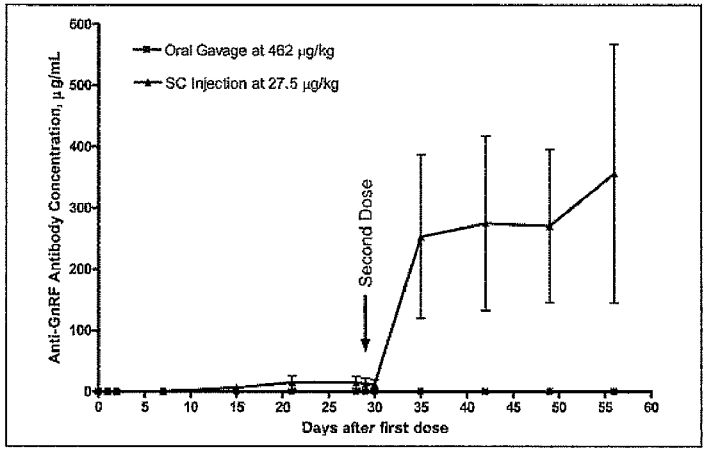
Test Group (n = 6 each)	Mean Serum Testosterone (ng/mL) ± SD		
	Day 14	Day 28	Day 42
Untreated controls	0.69 (± 0.35)	1.04 (± 0.35)	1.18 (± 0.49)
Vaccine treated	1.33 (± 0.84)	1.15 (± 0.49)	0.92 (± 0.26)
P-value	0.44	0.59	0.57

Study 3. Oral Bioavailability and Systemic Effects of Vaccine in Rats

All vaccine dose levels and routes of administration were clinically well tolerated. All rats survived to termination of the study and there were no significant differences in body weight or food consumption. Post-treatment haematology, coagulation, and clinical chemistry values were not affected by treatment. Occasional individual variations in these parameters were random, generally small, and were not associated with vaccination route, dosage size, or other parameters or with histological findings. Orally treated rats had no test article-related histopathological effects. There were no quantifiable anti-GnRF antibody responses in any of the rats in the TK group given vaccine orally. There were also no quantifiable antigen levels in the serum of any rat in the TK groups at any of the sampling times, whether the vaccine was administered orally or by SC injection. Unfortunately, because of instability of the GnRF conjugate in frozen serum, the effective LOQ of the assay was estimated to be ~1 µg/mL rather than the 0.098 µg/mL determined during method validation.

As expected, parenterally vaccinated (positive control) rats had significant anti-GnRF antibody responses as compared to the orally treated rats (Figure 2, $P = 0.033$) and significant decreases in serum hormones, testosterone in male and progesterone in female rats (Table 3) relative to the control and the orally treated rats. Serum levels of LH and estradiol-17β in the parenterally vaccinated rats were not significantly different from the serum levels of these hormones in the control and orally treated rats. At necropsy, the parenterally vaccinated rats had undersized sex glands/reproductive organs, ie, testes, seminal vesicles, prostate glands, or uteri.

Figure 2. Antibody response after oral and subcutaneous administration of vaccine in rats.



Based on these results, an oral no-observed-effect level (NOEL) for the GnRF analogue conjugate (vaccine antigen) was considered to be 462 µg/kg, the highest oral dosage level given. On a weight-for-weight basis, this oral NOEL is approximately 70-fold greater than the recommended 2 mL injectable vaccine dose in pigs.

DISCUSSION

Intravenous administration to sheep of the GnRF conjugate antigen used in the commercial vaccine demonstrated that this antigen has no innate hormonal activity. The minor LH-stimulating effect of the unconjugated GnRF analogue (approximately 0.2% the effect of natural GnRF) was completely

Table 3. Rat Bioavailability Study Mean Serum Hormone Assay Results.

Test Group	Antigen Dose (Route)	Testosterone (Male) ng/mL	Progesterone (Female) ng/mL
Sterile water control	0 µg/kg (PO)	76.0 ± 27.0	6.10 ± 1.65
Vehicle control	0 µg/kg (PO)	67.3 ± 23.9	8.67 ± 2.24
Oral-toxicity low dose	11.4 µg/kg (PO)	74.2 ± 26.4	10.3 ± 2.63
Oral-toxicity mid dose	272 µg/kg (PO)	103 ± 36.5	11.4 ± 2.88
Oral-toxicity high dose	462 µg/kg (PO)	53.3 ± 19.1	7.20 ± 1.90
Positive control	27.5 mg/kg (SC)	13.5 ± 5.1*	2.34 ± 0.77*
TK high dose	462 mg/kg (PO)	120 ± 40.1	5.00 ± 1.34
TK positive control	27.5 mg/kg (SC)	16.2 ± 5.7†	1.45 ± 0.55†

PO = per os; SC = subcutaneous injection; TK = toxicokinetic.
*$P < 0.05$ vs all other main study treatment groups.
†$P < 0.05$ vs oral TK treatment group.

eliminated after conjugation with the carrier protein. This experiment was designed to test an extreme challenge in the test animal, by direct injection into the blood stream of a high dose of peptide, and of the equivalent amount of peptide presented as conjugate. The complete lack of hormonal activity of the antigen provides compelling evidence that no direct hormonal effect could occur from the hypothetical human consumption of antigen in the meat from a vaccinated animal.

Pigs that were administered the vaccine orally had no detectable antibody response or interference with normal testosterone levels (Table 2). As may be expected with a protein, these results demonstrate an absence of bioavailability following oral ingestion of the GnRF analogue-protein conjugate (vaccine antigen). Negative serum antibody results 14 days after the second oral vaccine dose were noteworthy because an anamnestic response would have occurred within that time period if oral administration were capable of eliciting a systemic immune response. In terms of human food safety, this feeding experiment, which was designed to be sensitive for the detection of an immune response, provides strong evidence that hypothetical human consumption of vaccine residues would not induce antibodies to GnRF or have any secondary endocrinological effect.

As evidenced by the contrasting serologic response of laboratory rats given the vaccine orally or by SC injection, an immune response occurs only when the vaccine is given by injection (Figure 2). Oral administration of the vaccine to rats failed to stimulate anti-GnRF antibodies, corroborating the results of the pig oral administration experiment. Furthermore, oral administration was toxicologically innocuous even when vaccine was given at a relative dose of 70 times that recommended by SC injection for pigs. Administration of vaccine by SC injection had no toxicological effect in rats, either clinically or by objective biochemical parameters. Quantifiable levels of the antigen (LOQ = 1 µg/mL) could not be found in any of the rats in either the orally dosed groups or the subcutaneously dosed group. In summary, the experiments in laboratory animals indicate that the vaccine administered orally is neither toxic nor systemically available nor immunogenic.

As far as we are aware, oral absorption of active residues in meat from any protein subunit vaccine given parenterally to food-producing animals has never been demonstrated. Given the protein composition of vaccine antigens, expected rapid metabolism in the animal host after injection, the fact that slaughter almost always occurs weeks or even months after vaccination, and that meat is usually cooked prior to eating, consumption of intact vaccine antigens is highly unlikely. Nevertheless, consumer insistence on food safety for any product that is used in livestock is rightfully placed. These considerations justify the safety studies described in this report. The results, demonstrating that the antigen in this boar taint vaccine has no intrinsic hormonal activity and is neither systemically available nor immunogenic by the oral route, affirm the food safety of a product concept that has been safely and effectively used in the field for nearly a decade.[14,15]

ACKNOWLEDGEMENTS

The authors thank Mark Dana of Scientific Communications Services for assistance in preparing this report.

REFERENCES

1. Bonneau M: Compounds responsible for boar taint with special emphasis on androstenone: a review. *Livest Prod Sci* 1982;9:687-705.
2. Agergaard N, Knarreborg A, Beck J, Laue A, Jensen MT, Jensen BB: Absorption of skatole to the portal vein blood following tryptophan infusion to the hind gut. In Proceedings of the EAAP Working Group on Production and Utilisation of Meat From Entire Male Pigs, Milton-Keynes, U.K., 27-29 September 1995.
3. MacKinnon JD, Pearce MC: Improvac™ (Pfizer Animal Health): An immunological product for the control of boar taint in male pigs. (1) Boar taint and its control and the mode of action, safety and efficacy of Improvac™. *Pig J* 2007;59:29-67.
4. EFSA report: Welfare aspects of the castration of piglets. *The EFSA Journal* 2004;91:1-18.
5. Bonneau M, Dufour R, Chouvet C, et al: The effects of immunization against luteinizing hormone-releasing hormone on performance, sexual development, and levels of boar taint-related compounds in intact male pigs. *J Anim Sci* 1994;72:14-20.
6. Dunshea FR, Colatoni C, Howard K, et al: Vaccination of boars with a GnRF vaccine (Improvac) eliminates boar taint and increases growth performance. *J Anim Sci* 2001;79:2524-2535.
7. McGlone JJ, Nicholson RI, Hellman JM, et al: The development of pain in young pigs associated with castration and attempts to prevent castration-induced behavioral changes. *J Anim Sci* 1993;71:1441-1446.
8. Carroll JA, Berg EL, Strauch TA, et al: Hormonal profiles, behavioral responses, and short-term growth performance after castration of pigs at three, six, nine, or twelve days of age. *J Anim Sci* 2006;84:1271-1278.
9. McCauley I, Cronin GM, Barnett KL, et al: An immunocastration vaccine (Improvac) increases growth in individually and group-housed boars. *J Anim Sci* 2000;78(suppl 1):138.
10. Babol J, Squires EJ, Lundström K: Relationship between metabolism of androstenone and skatole in intact male pigs. *J Anim Sci* 1999;77:84-92.
11. Schneider F, Tomek W, Grundker C: Gonadotropin-releasing hormone (GnRF) and its natural analogues: A review. *Theriogenology* 2006;66:691-709.
12. Horton RJ, Li JY, Cummins JT, et al: Morphine decreases LH secretion in ovariectomized ewes only after steroid priming and not by direct pituitary action. *Neuroendocrinology* 1990;52:612-617.
13. Lee VW, Cumming IA, de Kretser DM, et al: Regulation of gonadotrophin secretion in rams from birth to sexual maturity. I. Plasma LH, FSH and testosterone levels. *J Reprod Fertil* 1976;46:1-6.
14. Cronin GM, Dunshea FR, Butler KL: The effects of immuno- and surgical-castration on the behaviour and consequently growth of group-housed, male finisher pigs. *Appl Anim Behav Sci* 2003;81:111-126.
15. Oliver WT, McCauley I, Harrell RJ, et al: A gonadotropin-releasing factor vaccine (Improvac) and porcine somatotropin have synergistic and additive effects on growth performance in group-housed boars and gilts. *J Anim Sci* 2003;81:1959-1966.

CONSUMER ATTITUDES TO A BOAR TAINT VACCINE, IMPROVAC® - A QUALITATIVE STUDY

D. Hennessy and R. Newbold

CSL Animal Health 45 Poplar Rd, Parkville, Victoria 3052 Australia

Introduction and Objectives

If, as a society, we are to continue raising animals for food we must becoming more energy efficient, producing less effluent and continue to improve animal welfare.

The first commercial boar taint vaccine, Improvac, gives pig producers a powerful new tool to achieve those goals without jeopardising eating quality. Improvac is a vaccine against the animal's own gonadotropin releasing factor (GnRF) it stimulates specific antibodies which inhibit natural GnRF activity, temporarily inhibiting testes function. As a consequence the accumulation of ***all*** boar taint compounds is suppressed and; any taint already present at the time of vaccination is eliminated. This paper reports the key findings from market research on consumer attitudes to boar taint and immunocastration.

Material and Methods

Four separate in-depth focus group sessions were conducted by an independent market research company. Each session of around 2 hours involved 12 participants. All participants were female aged between 30 to 55 years and were the main grocery buyer in the household. The broad aim was to gain an understanding of consumers reaction to the issue of boar taint and the use of Improvac to control it; and to understand how knowledge of Improvac may affect consumers attitude to pork.

The demographics of the 4 focus groups was as follows:

1. An Asian background and a regular pork consumers
2. A non-Asian background and regular pork consumers
3. A non-Asian background, occasional pork consumers
4. A non-Asian background, lapsed pork consumers

Regular pork consumption was a frequency of at least once every 2 weeks. Occasional pork consumption was at least once per month; and lapsed pork consumption was about once per 3 months but less than previously because of bad experiences with flavour and smell. At the conclusion each participant was offered a small (~1 kg) loin sample to cook for friends or family. They were fully aware the pork was from Improvac vaccinated pigs. They were given a questionnaire to assess their attitudes to the quality of the pork compared to the pork they usually purchased. All participants willingly volunteered to serve Improvac pork to their family, in total about 80 people provided feedback.

Results and Discussion

Remembering that most male pigs in Australia are not castrated and thus the participants had at least a 50% chance that pork purchased in most supermarket stores was male. The key findings from the focus groups were:

- Consumers in Australia had no recognition of the term "boar taint".
- All participants had experienced pork with "off" odour and flavour – this was often attributed to pork being a "bit funny".
- Many participants blamed the retailer for selling old spoiled pork.
- The Asian group had less bad experiences with odour and flavour because they purchased their pork mainly from Asian butchers who sold only female pigs.
- The explanation of "boar taint" as the cause of the odour/flavour problems was understood and did not alter the participants overall perception of pork.
- Vaccination was seen as a natural process, a highly acceptable part of animal production.
- The concept of vaccination to control boar taint intuitively made sense to the groups.
- When it was explained that Improvac was not a hormone, not a chemical and contained no genetically modified organisms or process but was rather a natural vaccine working with the pigs immune system all participants were undeterred by it use.
- The use of Improvac was seen as a favourable alternative to surgical castration.
- All participants volunteered to serve Improvac pork to their families.
- 86% of respondents rated the Improvac pork as having an excellent flavour and cooking odour compared to the pork they normally purchased.
- The results clearly showed that the Improvac pork was highly preferred to boar pork.
- No consumers had any concern over the use of Improvac for the routine control of boar taint – it was preferred to surgical castration.

Summary

Improvac is a natural, non-hormonal vaccine that works in harmony with the pig's immune system to block the compounds that cause boar taint in certain male pigs. The result is the delivery of a consistently fresh full flavoured pork which is totally safe for human consumption. Improvac is also an animal welfare friendly and environmentally friendly alternative to surgical castration.

® Improvac is a registered trade mark of CSL Limited.

Abstract No: O.62-03

EATING QUALITY AND ACCEPTABILITY OF PORK FROM IMPROVAC IMMUNIZED BOARS

DP Hennessy[1], J Singayan-Fajardo[2], M Quizon[2], D Hennessy[1]

[1]Pfizer, MELBOURNE, Australia

[2]Pfizer Animal Health, 23/F AYALA LIFE CENTRE, MAKATI CITY 1200, Philippines

Introduction and Objectives

Global population growth and continued demand for pig meat will continue to place pressure on the world's pork supply. To meet demand the pig industry must become more efficient. One way to increase production efficiency significantly (1) is to raise boars rather than castrates.

However, pork from some boars can have an offensive smell and taste, known as 'boar taint'. Thus, most of the world's male pigs are surgically castrated. However, there are problems with castration that make it undesirable. Compared to boars, castrates are less feed efficient, often grow slower, are less lean, and produce more effluent. There are also growing animal welfare concerns with castration (2). If society is to continue raising animals for food we must become more energy efficient, produce less effluent and continue to improve animal welfare.

Improvac®, a vaccine to control boar taint, gives pig producers a powerful new tool. By providing an animal welfare and environmentally friendly alternative to castration, Improvac allows producers to benefit from the natural growth and carcass quality advantages associated with non-castrated male pigs while controlling boar taint.

The aim of this study was to compare the sensory attributes and consumer acceptability of pork from Improvac boars compared to pork from female and castrated male pigs.

Material and Methods

Twenty boars were immunized with Improvac at 12 and 18 weeks of age and slaughtered at 23 weeks of age. Twenty surgical castrates and 20 female pigs (randomly selected, age matched) served as controls. Approximate carcass weight at slaughter for all groups was 70-75 kg. The left loin (*Longissimus dorsi)* from each pig was removed 24 hours after slaughter, deskinned, boned, sliced into 12-15 mm steaks and individually packed and frozen at -20°C until required for the sensory evaluation.

Loin steaks from each treatment were provided in a random, blind manner to 122 female and 43 male randomly selected consumers from the Manila area. Steaks were cooked on a double sided hot-plate for 2-3 minutes until they were cooked but still a little pink in the middle. Using a 100-point line scale, each consumer assessed in random sequence six separate samples of pork for aroma, flavour, aftertaste, tenderness, and juiciness. Overall acceptability and intent to purchase were also evaluated. Depending on the measured parameter, the data were analysed using either a balanced ANOVA, regression analysis, Friedman's Rank Correlation Test or Wilcoxan Signed Rank Tests.

Results

The key results are summarised in Tables 1 and 2. For the key sensory attributes (Table 1), there were no significant differences between the three types of pork (P>0.05). Pork from Improvac boars was rated as the same high quality as pork from female or castrate pigs.

Table 1 Key sensory attributes ranked on a 100-point line scale (the higher the score the better the liking).

	Improvac	Castrate	Female
Aroma	72.0	71.3	74.5
Flavour	65.5	64.5	66.3
After taste	64.6	64.4	65.7
Tenderness	72.9	71.3	70.5
Juiciness	69.4	68.6	66.8
Overall liking	68.8	67.5	68.5

Consumers were forced to rank the samples (1-best to 3-least) and were asked to state if they would be likely to purchase that quality of pork (Table 2). Consistent with the results for the key sensory attributes (Table 1), there were no appreciable differences between the three types of pork for overall preference or intent to purchase.

Table 2 Mean forced ranking preference and percent intent to purchase.

	Improvac	Castrate	Female
Overall rank preference	1.94	2.08	1.94
Intent to purchase (%)	82.1	79.7	80.0

Summary: In this randomly selected group of Filipinos there was no demonstrated difference in the sensory quality of pork from Improvac boars compared to pork from either female or castrated male pigs.

The ability to use Improvac immunization to control boar taint by the international pig industry will result in improved efficiency of pork production, lower pollution pressures on the environment and improve animal welfare. As shown, these goals can now be achieved without jeopardising eating quality and consumer acceptability.

® Improvac is a registered trade mark of Pfizer Pty Ltd.

References

1. Dunshea et al J. Anim. Sci. 2001. 79:2524–2535
2. EFSA report "Welfare Aspects of the Castration of Piglets". EFSA Journal. 2004. 91:1-18.

OR.12.04

The effects of immunocastration on meat quality and sensory properties of pork loins

J. Y. Jeong*, J. H. Choi**, D. J. Han**, D. H. Lee***, D. Hennessy****, and C. J. Kim**

*Department of Animal Science, University of Wisconsin, Madison, WI 53706, United States; **Department of Food Science and Biotechnology of Animal Resources, Konkuk University, Seoul 143-701, Republic of Korea; ***Pfizer Korea, Seoul, Korea 143-811; ****Pfizer Australia, 45 Poplar Rd Parkville, Vic Australia 3052.

Introduction and Objectives

Boar taint is a sensory defect of pork and occurs mainly in pork from non-castrated male pigs. It is predominantly caused by two compounds, skatole and androstenone. Because the elimination of boar taint is critical to consumer acceptance of pork, surgical castration of the young male pig is generally practiced. An emerging new alternative method of boar taint control is vaccination or immunocastration. Studies have demonstrated that pork from boars vaccinated to control boar taint was of the same quality as pork from female or surgically castrated pigs (1). According to Dikeman (2)[2], immunocastration showed very good potential for preventing boar taint and improving marbling as well as being able to capitalize on the growth, feed efficiency and carcass leanness of boars. The aim of this study was to compare the meat quality and sensory characteristics of pork loins from immunocastrated boars with loins from surgically castrated boars, non-castrated boars and gilts.

Material and Methods

A total of 99 pigs, from the same farm and genetic origin, were systematically divided into four groups (39 surgically castrated pigs, 40 immunocastrated pigs (Improvac®, Pfizer Animal Health Korea Ltd), 10 non-castrated intact boars, and 10 gilts). Improvac was administered subcutaneously as 2 x 2 mL doses; the first dose at about 9 weeks of age and the second dose at about 20 weeks of age. Pigs were slaughtered at 26 weeks of age and processed using normal practices for the commercial slaughterhouse. After overnight chilling, pork loins were removed from left side of each carcass, vacuum-packed and transported to the Meat Science Laboratory, Konkuk University. The area between the 5th though 7th ribs from all pigs was cut from the whole loin to determine the meat quality traits while samples from between the 8th and 9th ribs of the immunocastrated and surgically castrated groups were used for the sensory evaluation. The cooked loins were assessed by trained-selected panelists for smell (boar odor), visual appearance, color, taste, tenderness, juiciness, overall appeal. Smell was scored on follows; 10= extremely intense and 1= extremely bland. Other traits were scored on follows; 10= extremely acceptable and 1 = extremely unacceptable. Data were analyzed using SAS program. Analysis of variance was performed using the PROC GLM procedure with treatment groups as the main effect ($P < 0.05$).

Results and Discussion

The results are summarised in Table 1 and 2. The pH of the four treatments ranged between 5.62-5.71 and no significant differences were observed between the treatments. Similarly there were no differences in photographic color, CIE L*(lightness) and b*(yellowness) measured using the color standard (NPPC). However, the non-castrated boars showed higher a*(redness) value than the surgically castrated boars and gilts. For water holding capacity (WHC) and drip loss, immunocastrated boars did not show any significant difference from the other treatments. In shear-force only the gilts showed a significant difference compared with non-castrated boars. Marbling score was not significantly different among the groups.

In the sensory evaluation, loins from the immunocastrated boars were judged to be the same as loins from surgically castrated boars for boar odor, appearance, color, taste, tenderness, juiciness and overall palatability.

Table 1: Meat quality assessments. Attributes in the same row with different superscripts are statistically different ($P<0.05$).

Traits		Surgically castrated	Immuno castrated	Non-castrated	Gilts
pH		5.66	5.62	5.68	5.71
Color	L*	55.93	55.47	54.95	55.20
	a*	13.70^{B}	13.84^{AB}	14.19^{A}	13.73^{B}
	b*	3.22	2.88	3.20	2.87
Photographic color		2.04	1.95	1.96	2.21
WHC (%)		41.24	40.48	42.97	42.21
Cooking loss (%)		33.14	32.723	32.82	32.51
Shear force (kg)		4.30^{AB}	4.48^{AB}	5.02^{A}	3.93^{B}

Table 2: Visual and sensory evaluations. Attributes in the same row with different superscripts are statistically different ($P<0.05$).

Traits	Surgically castrated	Immuno castrated
Smell (boar odor)	2.07	2.03
Visual appearance	7.64	7.57
Color	7.60	7.56
Taste	7.50	7.43
Tenderness	7.44	7.52
Juiciness	7.34	7.30
Overall appeal	7.53	7.54

Conclusion

This study demonstrated that using vaccination to control boar taint in non-castrated male pigs (immunocastration) can be used without any negative effects on either the objective meat quality or the sensory properties of pork loins. Utilization of this technology will enable the Korean swine industry to increase its competitiveness by the raising of more efficient boars, rather than surgical castrates, with no negative effect on pork quality.

References

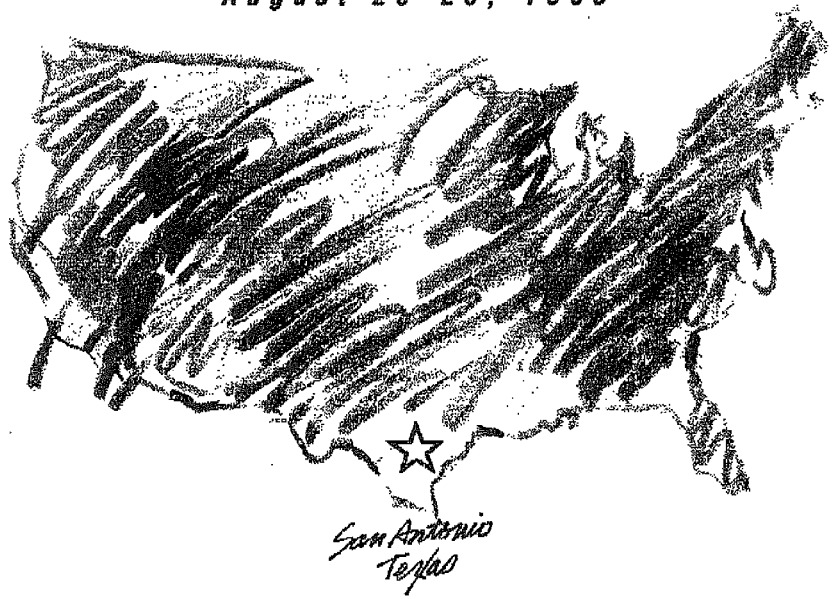
1. Hennessy, D. P. et al. 2006. Proc. 19th IPVS, Copenhagen, Denmark.
2. Dikeman, M. E. 2007. Meat Sci. 77, 121-135

Improvac® is a registered trade mark of Pfizer Pty Ltd

PROCEEDINGS VOLUME II

41ST ANNUAL INTERNATIONAL CONGRESS OF MEAT SCIENCE AND TECHNOLOGY

San Antonio, Texas, U.S.A.
August 20-25, 1995



LINKING SCIENCE AND TECHNOLOGY TO SOCIETAL BENEFITS

A31

IMMUNOCASTRATION - A STRATEGY TO PRODUCE "TAINT-FREE" HIGH QUALITY PORK FROM INTACT BOARS.

V. BOSHOSSIAN, D. HENNESSY[a], J. MOSBEY[b], L. SALVATORE[c], L. SALI[a], P. JACKSON[a], J. REYNOLDS and R. MAWSON.

Australian Food Research Institute, Sneydes Rd, Werribee, Victoria 3030; [b] Victorian Institute of Animal Science, Mickleham Rd, Attwood, Victoria 3049; and [c] CSL Ltd Poplar Rd, Parkville, Victoria, 3052. For further information please contact Dr D Hennessy.

Keywords: meat quality, boar taint, intact boars, immunocastration, sensory evaluation

WHAT IS BOAR TAINT AND HOW DOES IT REDUCE MEAT QUALITY ?

Boar taint presents as a distinct unpleasant perspiration-like, faecal-like, or urine-like smell, when fat or meat from some entire mature boars is cooked. Taint is rarely detected in meat from gilts, castrated boars, or sexually immature boars. However, not all boars of the same age and weight will exhibit "taint". Furthermore, not all people are able to detect the compounds reported to cause taint. Thus not all "tainted" carcasses will be offensive to all consumers.

Two major compounds are thought to be responsible for the reduced meat quality associated with boar taint, androstenone and skatole. The concentration of both of these is higher in the fat of boars than in either castrates or gilts (Bonneau et al., 1991). The most common method of controlling taint is castration. However, animal welfare concerns about castration and the substantial production advantages of intact boars versus castrates are driving many countries to find alternative methods to control boar taint.

A PROMISING NEW STRATEGY FOR ENSURING HIGH MEAT QUALITY AND IMPROVING PRODUCTION EFFICIENCY

One method of improving production efficiency, whilst maintaining high meat quality by controlling boar taint, is to raise intact boars and to vaccinate against LHRH. We have previously reported on the development of a "user-friendly" vaccine which allows boars to be raised as functionally intact males for the majority of their life. When the vaccine is administered a few weeks prior to slaughter testicular function is rapidly and totally inhibited. The consequences of stopping testes function is that boar taint is eliminated (Hennessy et al., 1994). We report here the effects of vaccination of heavy boars on the chemical and sensory evaluation of taint.

METHODS

A synthetic LHRH peptide was conjugated to a carrier protein and mixed with an adjuvant, approved for use in food producing animals. At approximately 20 weeks of age, 16 intact Large White, Landrace crossbred boars were allocated to vaccinated or non-vaccinated control groups. The vaccinate group received two doses of vaccine (2 ml) given subcutaneously high on the neck, at 6 weeks and 3 weeks prior to slaughter. No adverse reactions to either vaccination were noted in any pig throughout the trial. The pigs were slaughtered at about 115 kg and the loins were collected and frozen at -20 ^{o}C until used for the sensory evaluation. Fat from the belly region from each pig was collected at slaughter for the analysis of taint, by measuring the fat concentration of androstenone; using a the method of Brabander and Verbeke, (1986); and of skatole using method of Hansen-Moeller (1992).

Sensory Evaluation

An untrained consumer-type panel consisting of 30 individuals was used to evaluate both cooked and raw samples of pork. Meat from vaccinated boars, non-vaccinated boars (control) and sows was included. The samples for each group were derived from eight animals. Graphic rating scales were used in the questionnaire.

Cooking and Presentation of Pork

The pork was cooked in a fan-forced electric oven at 260 ^{o}C for 8 minutes and cut into 2.5 cm square pieces. Each panellist assessed samples from six animals (two animals from each treatment group) and each animal was assessed by either six or nine panellists. A randomized incomplete block design was used to allocate samples to panellists. In addition, the six corresponding raw samples were evaluated by each panellist, however, different blinding codes were used for the raw samples. It was ensured that all samples were hot during the evaluations so that the boar odour and flavour could be easily detected.

REML analysis (Patterson and Thompson, 1971) was carried out on the response scores to determine any significant differences between treatments. Bartlett's test for homogeneity of variance was used to compare the variation in animals within each treatment group. All comparisons were at the 5% level.

RESULTS and DISCUSSION

The results of this experiment are in agreement with our other demonstrations (Hennessy et al., 1994) that vaccination against LHRH was highly effective in stopping testicular steroidogenesis and in subsequently reducing the fat concentration of both androstenone and skatole. In this trial testosterone in the vaccinates was almost non-detectable (see Table 1). Further evidence of a suppression of testes function can be seen in the significant reduction in mean testes weight ($P<0.01$, see Table 1).

A fat androstenone concentration of greater than 0.5 μg/g is associated with offensive odour, in people sensitive to androstenone. In the non-vaccinated controls androstenone was well above the sensory threshold in 6 of the 8 boars. In contrast, all of the vaccinates had androstenone concentrations well below the sensory threshold (see Table 1 for summary of data). Similarly, skatole in the vaccinates was consistently below the sensory threshold for skatole of 0.20 μg/g. A skatole concentration of greater than 0.2 μg/g fat is associated with offensive odour in people who are sensitive to skatole. In the control boars, skatole was generally higher and in 2 individuals was above 0.2 μg/g (see Table 1 for summary of data).

Consistent with our previous experiments there were no effects of vaccination on live-weight at slaughter or back-fat thickness in the current trial. On these parameters the growth of vaccinated boars was the same as non-vaccinated controls (see Table 1)

Table 1. Mean and standard deviation of live weight, paired testes weight, serum testosterone concentration and fat tissue concentration of skatole and androstenone in control and vaccinated intact boars.

	Live weight (kg)	Testes weight (gm)	Testosterone (nmol/L)	Skatole (μg/g)	Androstenone (μg/g)
Vaccinates	118.7 ± 5.1	315.1 ± 63.7	0.39 ± 0.13	0.044 ± 0.047	0.22 ± 0.05
Controls	113.5 ± 9.3	486.5 ± 62.5	8.7 ± 3.45	0.146 ± 0.286	0.87 ± 0.45

In the sensory evaluation of the meat panellists detected a significantly stronger unpleasant/boar odour and unpleasant/boar flavour in the samples from non-vaccinated boars than in those from the vaccinated boars and sows. There were no significant differences between the three groups in the acceptability of meat flavour however, the non-vaccinated boar meat had the lowest mean (A low score indicates lower acceptability). For acceptability of odour, the control boar group had a significantly lower mean score than the sows, but the mean score of the vaccinated boars was not significantly different from the non-vaccinated boars or the sows.

The evaluations of the raw meat showed that panellists did not perceive any significant differences in odour and colour between the three groups.

The variance of the vaccinates was significantly lower than that of the non-vaccinated boars for strength of meat flavour. With respect to unpleasant/boar flavour, the variance of the sows was significantly lower than the other two groups. It should be noted that although the difference between the vaccinated and non-vaccinated boars was not significant for unpleasant/boar flavour, the variance of the vaccinated boars was lower than that of the non-vaccinated control boars.

Although the test for homogeneity of animal treatment group variances was not significant ($p>0.15$), for either the acceptability of odour of raw meat or the intensity of unpleasant/boar odour of raw meat, when pairwise comparisons of the variances were completed (using the variance ratio (F^2) test), the variance of the vaccinated boars was found to be significantly lower than that of the non-vaccinated boars for both these attributes ($p<0.05$).

CONCLUSIONS and INDUSTRY SIGNIFICANCE

Our studies have shown that the meat quality of intact boars can be substantially improved by using anti-LHRH vaccines to eliminate boar taint. We have developed a user friendly, experimental vaccine, against LHRH, which is highly effective in reducing the fat concentration of androstenone and skatole to well below their respective sensory thresholds. When meat from vaccinated boars was assessed for taint, by sensory evaluation, it was found to be indistinguishable from meat from female pigs.

This vaccine promises to be a very useful management tool, which when used at strategic stages of production will enable producers to substantially increase production efficiency by marketing intact boars, of any weight, with confidence that they will be "taint-free". Further work is under way to determine whether such a vaccine can be produced on a commercially viable basis.

REFERENCES

Brabander, H.F. and Verbeke, R. (1986). *J. Chromatog.* **363**:293-302.
Bonneau, M., Le Denmat, M., Vaudelet, J.C. and Veloso Nunes, J.N. (1991). *J. Revh. Porc* 23:325-336.
Hansen-Moeller, J. (1992). *J. Chromatog.* 624:479-490.
Hennessy, D.P., McColl, M., McNamara, M., Mosbey, J., Wan, S.S., Salvatore, L., Sali, L. and Waldron, D. (1994). *Proc 13th Int Pig Vet Soc* , Bangkok, June 1994, p 487
Patterson, H.D. and Thompson, R. (1971). *Biometrika* **58**:545-554

ACKNOWLEDGMENTS

The authors generously acknowledge the technical assistance of Donna Waldron, Helen Read and Margaret Misselbrook.

AgBioForum, 9(1): 51-58. ©2006 AgBioForum.

Swedish Consumer Preferences for Animal Welfare and Biotech: A Choice Experiment

Carl Johan Lagerkvist
Swedish University of Agricultural Sciences

Fredrik Carlsson
Göteborg University

Diana Viske
Swedish Animal Welfare Agency

This paper compares consumer preferences for immunocastration versus surgical castration and no castration using willingness-to-pay estimates from a choice experiment. Results suggest that consumers place a higher value on pork from immunocastrated pigs than pork from surgically castrated pigs. In contrast, consumers reveal negative valuations of pork from intact boars as compared to pork from surgical castrates. We also show how a binary heteroskedastic logit model can be used to accommodate a larger variance for later choice sets within a choice experiment.

Key words: animal welfare, boar taint, choice experiment, consumer, hormone, immunocastration, surgical castration.

Introduction

Means-end chain theory (e.g., Gutman, 1982) and the theory of planned behavior (e.g., Ajzen, 1991) suggest that an implicative relation between product attributes and physiological or psychological consequences and between these consequences and values governs consumer behavior. A product is regarded as a bundle of attributes; people select products that involve desired consequences while trading off with any undesirable consequences.

Product differentiation strategies are increasingly used in food marketing to attract the interest of consumers for various product characteristics. Product differentiation is achieved through distinct product attributes and is often communicated through product labels or other marketing activities. Long-run competitiveness of food products requires that consumers attribute a value to the product. The attributed value may originate from a plethora of product attributes and/or from conditions in the production process. These attributes and conditions, however, may differ with respect to consumer desirability.

This study investigates the consumer tradeoff for pork meat between consequences related to product attributes characterized by various levels of animal welfare, taste quality, and use of biotechnology in production of pork. Evaluated by personal values, these tradeoffs will reflect which consequences consumers try to achieve in a consumption situation. The specific focus in this study is on castration of male pigs.

Castration of male pigs is routinely performed worldwide in order to prevent the occurrence of the objectionable odor or flavor of boar taint in pig carcasses. Boar taint is caused mainly by androstenone, a testicular steroid, and skatole (3-methylindole from tryptophan by swine intestinal bacteria; Zeng et al., 2001). The latter, however, is easily suppressed by dietary means (Claus, Weiler, & Herzog, 1994). Consumer tolerance of tainted meat is low, as it involves an unpleasant experience of cooking and eating. Large importers of pork (e.g., Japan and Singapore) do not import meat from entire male pigs. There are currently no practical and valid techniques to detect boar taint on the slaughter line (Federation of Veterinarians of Europe [FVE], 2001). Early slaughter to prevent male pigs from reaching sexual maturity is uneconomical in most cases.

The most common castration technique is surgical castration, where the testicles are physically removed. Anesthesia is generally not used due to practical problems and high costs. There is substantial evidence that surgical castration is labor cost intensive, painful, and highly aversive to pigs. Consequently, today's surgical castration can be seen as an ethical issue—given that we see animals as sentient beings—and can also give rise to humans concerns about the animals welfare (FVE, 2001).

Immunocastration by active immunization against gonadotropin-releasing hormone (GnRH) using a synthetic peptide vaccine to suppress the production of male hormones has recently been recognized as a potential mean of castration. The interest in immunocastration is likely due to both a concern for prevention of boar taint and a concern for the welfare of the animals. The vaccine stimulates the male pig's immune system to make antibodies; when these antibodies are attached to the animal's natural GnRH, the hormone cannot initiate reproductive processes. Recent research work shows better growth performance for immunocastrates compared to surgical castrates for Western as well as for Chinese breeds (Zeng et al., 2001, 2002), as immunocastration makes it possible to exploit the growth potential of male pigs for most of their productive life. These studies also found that the meat percentage was higher for boars and immunocastrates than for surgical castrates. For immunocastrates, the energy conversion ratio was lower than that of boars but higher than that of surgical castrates (Zeng et al., 2002). Vaccine for immunocastration is currently approved in Australia and pending approval in Taiwan and China. It is not, however, currently approved in the EU or in the United States. Several new vaccines are also under development (e.g., Wang & Walfield, 2005).

The role of public acceptance of immunocastration as an alternative to surgical castration is largely unexplored. Such an acceptance likely involves tradeoffs between animal welfare concerns, food safety risks through use of biotechnology, and food (e.g., taste) quality. Potential food safety risks include possible residues in meat (European Food Safety Authority, 2004). A recent study of the use of biotechnology in food production found consumer preferences for food produced without biotechnology. Use of recombinant growth hormone was found to constitute an undesirable characteristic (Kiesel, Buschena, & Smith, 2005). In light of this, this paper investigates consumers' preferences for immunocastration by comparing willingness-to-pay (WTP) estimates obtained from a choice experiment (CE). The primary finding is that people seems to accept potential food safety risks to alleviate animal welfare problems related to surgical castration. Hence, biotechnology is found to be a "good" rather than a "bad" when consumers choose between product attributes (immunocastration compared to surgical castration) that are equal with respect to taste quality. On the other hand, people prefer pork from surgical castrates over pork from intact boars. This suggests that taste quality dominates animal welfare concerns as product attributes. Our findings are indicative of a Pareto criterion that extends to include the well-being of the animals in production agriculture.

The Choice Experiment

Market data for sales of pork where male pigs were either not castrated or immunocastrated are not available in Sweden, because there is no market for boars and immunocastration is not yet approved there. Primary data for the evaluation of alternatives for surgical castration were instead collected through a mail survey developed and mailed to consumers in Sweden. The survey contained a CE in which consumers were asked to make choices between pork chops with varying levels of price, type of housing system, castration, tailing, and fixation. The use of a CE in this analysis is motivated as the method allows for a multiattribute valuation and allows estimation of marginal rates of substitution between different attributes and levels of given attributes. CEs have recently been extensively used to assess consumer's choices among food product attributes including food safety (e.g., growth hormones and fed genetic corn in beef) and animal welfare (e.g., Alfnes, 2004; Alfnes & Rickertsen, 2003; Baker & Burnham, 2001; Carlsson, Frykblom, & Lagerkvist, 2005a; Lusk, Roosen, & Fox, 2003). Attributes and levels used in the CE (besides castration) were selected due to policy relevance and results from previous Swedish studies on factors important in consumer valuation of pork meat (Carlsson et al., 2005a; Liljenstolpe, 2003). Table 1 reports attributes and levels in the CE.

Survey Design

The questionnaire used for the CE was devised together with veterinarians at the Swedish Animal Welfare Agency. The definitive questionnaire was preceded by a pretest using two focus groups (each comprising five individuals). The resulting questionnaire consisted of three parts. The first part included questions about the respondent's and the household's buying habits for pork. The CE constituted the second part. In the introduction to the CE, the purpose of the survey was explained briefly, followed by a "cheap-talk" script suggested by Carlsson, Frykblom, and Lagerkvist (2005b) to reduce the probability of hypothetical bias. Furthermore, an information sheet was included in the questionnaire to describe the process quality variables and provide a short explanation of the choices offered (see Appendix). The third part of the questionnaire contained questions regarding the respondent's socioeconomic and demographic status.

Consumers were asked to make binary choices between various pork chop alternatives. Each alternative was described by four quality attributes and one price variable in a set of six choices. Table 2 provides an example of a choice situation. The choice sets were created using a cyclical design principle (Bunch, Louviere, & Andersson, 1996).[1] One potential criticism of the experiment is a potential lack of realism, in that a food manufacturer or retailer may not label products with, say, "no castration of pigs" or "no fixation." However, even though this might be true, the use of a CE here is motivated, as it closely resembles an actual purchase situation—specifically, the tradeoffs between attributes

Table 1. Attributes and levels in the choice experiment.

Attribute	Levels
1. Type of housing system	1.1 Pigs kept indoors in boxes with little straw.
	1.2 Pigs kept indoors in boxes with plenty of straw.
	1.3 Possibilities for pigs to be outdoors.
2. Castration	2.1 Surgically castrated pigs (no risk for boar taint; suffering for the piglet).
	2.2 No castration of the pigs (more meaty; lower fat content but risk for boar taint).
	2.3 Immunocastration of pigs (more meaty; less fat content but a low risk for boar taint).
3. Tail docking	3.1 The pig has been tail docked.
	3.2 The pig has not been tail docked but tail biting can occur.
	3.3 The pig has not been tail docked. The pig has been raised in a more expensive way to prevent tail biting.
4. Fixation	4.1 Keeping sows permanently fixated is allowed.
	4.2 Keeping sows fixated at delivery is allowed.
	4.3 Fixation of sows is banned.
5. Price[a] (SEK/kg)	0 (75); +4 (79); +8 (83); +12 (87); +24 (99)

[a] *At the time the survey was carried out, 1 Swedish Krona (SEK) ≈ $0.13.*

where a product is chosen from several competing options. This mimicking will be an advantage in reducing problems of incentive compatibility. In addition, even if not labelled, any product or process characteristics can still be communicated through means other than a label.

The CE did not include an opt-out alternative. However, each respondent was instructed to answer the CE only if he or she actually consumes the product. Furthermore, for all attributes, the current level was included when designing the choice sets (see Table 1). The comparison between the levels of the attributes in a CE does not require an outside option or an opt-out alternative. This is because we are primarily interested in the comparison between different clearly defined alternatives, such as if the pig has been castrated or not. If we want to compare these it is, from a welfare theory point of view, not necessary to include an opt-out. There could be other arguments for and against including an opt-out alternative. For example, an opt-out alternative could make the choice situation more realistic in providing a no-purchase option, but some respondents could also use it as a simple choice heuristic.

Table 2. Example of choice set.

Attributes	Pork chop 1	Pork chop 2
Type of housing system	Indoors, little straw	Indoors, plenty of straw
Castration	Immunocastrated pigs	Pigs surgically castrated
Tail docking	No tail docking; tail biting prevented	The pig is tail docked
Fixation	Permanently fixated	Allowed at delivery and around the time of covering
Price surcharge (SEK/kg)	+ 8 SEK	+ 12 SEK
Total cost	83 SEK	87 SEK
Your choice		

As with other valuation methods, there are several potential disadvantages associated with CEs; see for example Lusk and Hudson (2004) for a comparison of valuation methods. The hypothetical nature of the experiments may induce respondents to exaggerate their stated WTP; see for example Carlsson and Martinsson (2001) and Lusk and Schroeder (2004). In order to reduce the potential problem of hypothetical bias, we therefore included the above-mentioned cheap-talk script in the survey.

1. *A cyclical design is a straightforward extension of the orthogonal approach. Strictly dominant choice sets were deleted from the possible set of choices. Moreover, we wanted to avoid too-dominant choice sets. This was done by calculating so-called code sums for each option (Wiley, 1978). In order to calculate the code sum, we arranged the levels of the attributes from worst to best, the lowest attribute level being assigned the value 0; the next, 1; the next, 2; and so on. Thus, for a three-level attribute, the highest value is 2. The code sum is the sum of all these values for each option. By comparing the code sums, one can get a simple indication of which alternatives are particularly dominant. This is obviously a crude approach, and in order for it to work reasonably well, the utility difference between two levels should not differ too greatly across attributes. In our case, we deleted all design alternatives with a code sum difference exceeding 4; there were altogether 64 such alternatives.*

Model

The households' choices can be described using a random utility model framework. We assume a linear random utility function; in particular, utility is a linear function of money. This means that we assume that the utility of a particular alternative I can be described as

$$U_i = v_i + \varepsilon_i = \beta a_i - \gamma c_i + \varepsilon_{ij}, \quad (1)$$

where a_i is a vector of the attributes in alternative I, β is the corresponding parameter, c_i is the cost associated with alternative I, γ is the marginal utility of money, and ε_i is an error term. If the error terms are extreme value distributed, then the probability that a particular alternative is chosen can be formulated as the standard logit probability. Thus, the probability that alternative A is chosen when there is a choice between A and B can be expressed as

$$P[\mathrm{A}] = 1 / (1 + \exp[-\beta(a_\mathrm{A} - a_\mathrm{B}) + \gamma(c_\mathrm{A} - c_\mathrm{B})]). \quad (2)$$

In the literature there is an increasing concern about the role of the scale parameter in discrete choice models and also increasing empirical evidence of the importance of modeling the scale parameter in an appropriate way. In particular, attributes may have effects both on the behavior in terms of affecting the level of the utility but also in terms of affecting the variance of the utility. In order to assess the potential effect on the level of utility (e.g., for a welfare analysis), it is important to make sure that one is not capturing effects on the variance instead; see for example Louviere, Hensher, and Swait (2000), Swait and Adamowicz (2001), and Islam and Louviere (2004). We therefore use a binary heteroskedastic logit model, where the error term has a logistic distribution with mean zero and variance $\exp(\delta z_i)^2$, where z_i is vector of choice set specific characteristics and δ is the corresponding parameter vector. The question remains what to include in the variance function. One obvious candidate is of course the attribute levels. However, note that the variance function is exponential, and because the discrete choice model depends on difference in attribute levels, it is not advisable to directly include the attribute levels directly in the variance function.[2] Therefore, we include two other characteristics in the variance function. The first one is the value of the difference in cost; the second is a dummy variable for the second half of the total number of choice sets.

Because the utility function is linear in money, the marginal willingness to pay for an attribute is the ratio between the parameter of the attribute and the cost parameter, such that

$$MWTP = \beta / \gamma. \quad (3)$$

In order to allow for heterogeneity in preferences regarding the attribute levels, we will interact the attribute levels with a set of socioeconomic characteristics.

Results

In the autumn of 2005, 700 surveys were mailed to a random sample of Swedish citizens and legal aliens, drawn from the Swedish census registry, between 20 and 75 years of age. Two reminders were sent out within a three-week period to those who had not replied. Altogether 347 (49.6 %) individuals returned the questionnaire, of whom 285 were available for analysis because of nonresponse to various questions. Although not all of these respondents answered all six choice sets, we still chose to include them in the analysis. Table 3 presents demographic and socioeconomic statistics of the sample.

The primary results of this paper are reported in Tables 4 and 5. Table 4 reports the estimated model. All attribute coefficients are found significant. As expected, the cost coefficient is negative, suggesting that a price increase would reduce the probability that respondents choose the improved attributes in question. The coefficient of the variance function of the absolute cost difference is negative but insignificant. The positive sign of the coefficient of the second half of the experiment implies that the variance is higher for the second half of the experiment. A plausible explanation of this is that respondent gets fatigued and loses interest by the end of the experiment. It is therefore important to control for this effect, because it otherwise could affect the reliability of estimated marginal WTPs.

A number of socioeconomic characteristics were interacted with the various attributes. The socioeconomic variables were income, age, educational level, shopping experience, own consumption frequency (of

2. *For example, we would believe that the effect on the variance is the same for a choice set where the cost of alternative A is 200 Swedish Krona (SEK) and the cost of B is 250 SEK as it is for a choice set where the cost for A is 250 SEK and the cost for B is 200 SEK. However, because only the difference in attribute levels matters, the exponential variance function will not treat them as the same unless we use the absolute difference between them.*

Table 3. Descriptive statistics of respondents.

Variable	Definition	Mean	SD
Experience	1 = responsible for most food purchases; 0 = otherwise	0.45	0.50
Sex	1 = female; 0 = male	0.5467	0.498
Age	Age (years)	48.04	15.06
Members	No. of persons in household	2.54	1.25
Children	No. of dependants < 20 years	0.77	1.32
Highest standard of education	1 = University or college; 0 = other	0.37	0.48
	1 = High school; 0 = other	0.42	0.49
Income	Household income net of taxes (SEK) per month	24,454	10,381

Note. According to Statistics Sweden on December 31, 2003, there were 50.24% men and 49.76% women in the population of people between 20 and 75 years old, and with this part of the population the mean age was 45.8 years (standard deviation 15.08). The official statistics (available only for December 31, 2001) report an average of 2.69 individuals per household (standard deviation 1.34). Official statistics report that 27.7% has university or college education, and 48.6% to have no more than high school. The average disposable income (net of taxes and social transfers) for all households in Sweden in 2004 was 17,742 SEK/month, while the average disposable income for cohabitants with one child amounted to 30,525 SEK/month.

Table 4. Estimated binary heteroskedastic logit model.

Attribute	Level[a]	Coefficient	P-value
Type of housing system (base= indoors, little straw)	Indoors, plenty of straw	0.555	0.0001
	Outdoors	0.821	0.0000
	Indoors, plenty of straw * female	0.472	0.0102
	Outdoors * female	0.553	0.0027
	Indoors, plenty of straw * experience	-0.373	0.0289
	Outdoors * experience	-0.496	0.0056
Castration (base = surgical castration)	No castration	-0.297	0.0008
	Immunocastration	0.295	0.0020
Tailing docking (base = tail docked)	No tail docking, tail-biting can occur	-0.200	0.0514
	No tail docking, tail-biting prevented	0.148	0.0833
Fixation (base = permanent)	At delivery	0.754	0.0000
	Banned	0.711	0.0000
	At delivery * female	0.292	0.0641
	Banned * female	0.572	0.0033
Cost		-0.019	0.0000
Variance function			
Abs (difference in cost)		-0.020	0.1380
Second half of the experiment		0.571	0.0002
Log likelihood	983		
Restricted log likelihood	1138		
No. of observations	1642		

[a] *Female and experience (do the shopping by themselves) represent socioeconomic interaction variables.*

pork), household consumption frequency (of pork), farming background, household size by number of family members, and number of dependants under the age of 20 years. Due to space limitations, the final model includes only those socioeconomic interaction variables that had a significant effect at the 10% level. The only characteristics that had a significant effect, for type of husbandry and fixation, were female and experienced consumers (those who are mainly responsible for food purchase in the household). Females were on average found to derive lower levels of utility than men for use of more straw in an indoor housing system, for allowing pigs to be outdoors, and for forms of fixation more animal-friendly than permanent fixation. Interestingly,

Table 5. Mean marginal WTP, Swedish Krona (SEK) per kg.

Attribute	Level	Mean marginal WTP (SE)
Type of housing system (base= indoors, little straw)	Indoors, plenty of straw	34.4 (8.4)
	Outdoors	47.9 (9.6)
Castration (base = surgical castration)	No castration	-15.9 (5.34)
	Immunocastration	15.7 (5.3)
Tail docking (base = tail docked)	No tail docking; tail biting can occur	-10.6 (5.9)
	No tail docking; tail biting prevented	7.9 (4.4)
Fixation (base = permanent)	At delivery	48.6 (10.8)
	Banned	54.3 (10.8)

Note. the base price was set at 75 SEK/kg. Standard errors are shown in parentheses.

respondents classified as experienced were found to derive negative utilities from indoor housing systems with plenty of straw as well as for outdoor production systems. The disparity in utility levels between experienced and inexperienced respondents is substantial for these attribute levels.

Table 5 reports estimates and standard errors for the mean marginal WTP for the various attribute levels, standard errors are calculated using the Delta method (Greene, 2000). Mean marginal WTP is estimated according to Equation 3. Note that these are WTP measures compared to the base case for each attribute. The hypotheses H_0: $WTP^{surgical\ castration} = WTP^{immunocastration}$ and H_0: $WTP^{surgical\ castration} = WTP^{no\ castration}$ can be rejected at any conventional level. The hypotheses were tested using two-sided tests, because both positive and negative price premiums are possible a priori. Hence, a significant positive WTP for immunocastration and a significant negative WTP for no castration was found. This implies that consumers associate a positive utility from consumption of immunocastrated pork compared to pork originating from surgical castrates and negative utility from pork originating from intact boars compared to pork from surgical castrates. The negative WTP for the no-castration alternative is similar to the results presented by Liljenstolpe (2003). The latter study included castration with anesthesia and no castration together with six other attributes in a CE directed to Swedish consumers, in which pork fillets of various characteristics were evaluated. Using a mixed logit estimation, Liljenstolpe reported a price discount of 13.8% for no castration and a price premium of 39% for castration with anesthesia.

The estimates in Table 5 are also instructive for comparing the ranking of attributes and levels. Consumers associated higher WTP for fixation of sows and type of housing system for fattening pigs than for castration. Interestingly, when comparing mean WTP for ban on fixation with fixation at delivery, the hypothesis that they are equal cannot be rejected at any conventional levels. However, there is a significant difference between the WTP for outdoor production and indoor production with plenty of straw.

Tail docking of fattening pigs was regarded as the least important attribute among those included in the study. Note that the results related to the various levels of the tail-docking alternative are similar to the results for the castration attribute. In relation to the base case (where tail docking is performed), respondents associated a negative WTP for the alternative with no tail docking but where tail biting can occur. This implies that tail biting, which induces pain, suffering, and possible infections to animals, is viewed as a more important animal welfare problem than tail docking. This is a reasonable result, as tail biting is an indicator of a poor environment or other types of stress. We interpret this result as indicating that consumers prefer pork from pigs that have been tail docked if there are chances that tail biting can occur. Consistently, a positive WTP is found for the alternative with no tail docking but where tail biting is prevented.

Conclusions

Europeans are in general more reluctant to the combination of biotechnology and food. It is debatable whether this is due to recent food scares (such as bovine spongiform encephalopathy), successful campaigns by environmental lobbyists, or the central role of food and cooking in European culture. Swedes have been shown to be relatively more averse towards genetically modified organisms (for example) than many other Europeans (Hoban, 1997).

Using a choice experiment, we estimated the WTP for several process attributes for pork meat. Included attributes related to potential animal welfare enhancing measures in pork production. Our results confirm the results from studies of Carlsson et al. (2005a) and Liljenstolpe (2003) in finding that consumers placed high values in allowing fattening pigs to be outdoors. In addition, consumers strongly opposed fixation of sows. Based on our results, however, we cannot say that a ban of fixation would reduce negative external effects from pork production.

Our results also indicate that consumers associate a benefit from the consumption of pork from immunocastrated pigs compared with pork from surgically castrated pigs. In contrast, consumers reveal negative valuations of pork from intact boars. These findings imply that animal welfare concerns are more emphasized than biotechnology aversion or food safety risk when consumers compare immunocastration and surgical castration. With a low risk for boar taint, these alternatives are identical with respect to taste quality. In addition, consumers place higher values on pork from surgically castrated pigs than on pork from intact boars. Hence, food quality concerns apparently dominate animal welfare concerns in avoiding boar taint. Taken together, our findings suggest that immunocastration of male pigs represents a Pareto-efficient improvement in pork production. Consumers will be able to maintain taste quality while improving the well-being of pigs and avoiding the problems related to surgical castration. The use of biotechnology in this setting, therefore, is regarded as a desired production attribute.

If consumers in other countries share the same type of values, there are important policy implications to be drawn from this study. Under current legislation in many countries surgical castration has been accepted, lacking reasonable alternatives, as many markets for pork do not accept boar meat, even though surgical castration impedes the well-being of animals. Immunocastration provides several potential public as well as agribusiness advantages over surgical castration, including animal welfare improvements, potential cost savings in procedures, and gains from higher growth rates for pigs. Our findings suggest that immunocastration is a socially viable alternative. Therefore, the abolition of surgical castration of pigs should be supported.

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*, 179-211.

Alfnes, F. (2004). Stated preferences for imported and hormone-treated beef: Application of a mixed logit model. *European Review of Agricultural Economics, 31*, 19-37.

Alfnes, F., & Rickertsen, K. (2003). European consumer's willingness to pay for U.S. beef in experimental auction markets. *American Journal of Agricultural Economics, 85*, 396-405.

Baker, G.A., & Burnham, T.A. (2001). Consumer response to genetically modified foods: Market segment analysis and implications for producers and policy makers. *Journal of Agriculture and Resource Economics, 26*, 387-403.

Bunch, D., Louviere, J., & Anderssen, D. (1996). *A comparision of experimental design strategies for choice-based conjoint analysis with generic-attribute multinominal logit models* (working paper). Davis, CA: University of California Graduate School of Management.

Carlsson, F., Frykblom, P., & Lagerkvist, C.J. (2005a). Consumer preferences for food product quality attributes from Swedish agriculture. *Ambio, 34*, 366-370.

Carlsson, F., Frykblom, P., & Lagerkvist, C.J. (2005b). Using cheap-talk as a test of validity in choice experiments. *Economics Letters, 89*, 147-152.

Carlsson, F., & Martinsson, P. (2001). Do hypothetical and actual marginal willingness to pay differ in choice experiments? *Journal of Environmental Economics and Management, 41*, 179-192.

Claus, R., Weiler, U., & Herzog, A. (1994). Physiological aspects of androstenone and skatol formation in the boar: A review with experimental data. *Meat Science, 38*, 289-305.

European Food Safety Authority. (2004). Opinion of the scientific panel on animal welfare on a request from the commission related to welfare aspects of the castration of piglets. *The EFSA Journal, 91*, 1-18.

Federation of Veterinarians of Europe. (2001). *Pig castration* (FVE position paper FVE/01/083). Brussels: FVE.

Greene, W. (2000). *Econometric analysis*. Upper Saddle River, NJ: Prentice-Hall.

Gutman, J. (1982). A means-end chain model based on consumer categorization processes. *Journal of Marketing, 46*, 60-72.

Hoban, T.J. (1997). Consumer acceptance of biotechnology: An international perspective. *Nature Biotechnology, 15*, 232-234.

Islam, T., & Louviere, J. (2004). *Modelling the effect of including/excluding attributes in choice experiments on systematic and random components* (unpublished working paper).

Kiesel, K., Buschena, D., & Smith, V. (2005). Do voluntary biotechnology labels matter to the consumer? Evidence from the fluid milk market. *American Journal of Agricultural Economics, 87*, 378-392.

Liljenstolpe, C. (2003). *Valuing farm animal welfare: Measuring consumer response with choice experiments* (working paper 2003:3). Uppsala: Swedish University of Agricultural Sciences Department of Economics.

Louviere, J., Hensher D., & Swait, J. (2000). *Stated choice methods*. Cambridge: University Press.

Lusk, J.L., & Hudson, D. (2004). Willingness-to-pay estimates and their relevance to agribusiness decision making. *Review of Agricultural Economics, 26*, 152-169.

Lusk, J.L., Roosen, J., & Fox, J.A. (2003). Demand for beef with growth hormones and fed genetic corn. *American Journal of Agricultural Economics, 85*, 16-29.

Lusk, J.L, & Schroeder, T.C. (2004). Are choice experiments incentive compatible? A test with quality differentiated beefsteaks. *American Journal of Agricultural Economics, 85*, 840-856.

Swait, J., & Adamowicz, W. (2001). The influence of task complexity on consumer choice: A latent class model of decision strategy switching. *Journal of Consumer Research, 28*, 135-48.

Wang, C.Y., & Walfield, A.M. (2005). Site-specific peptide vaccines for immunotherapy and immunization against chronic diseases, cancer, infectious diseases, and for veterinary applications. *Vaccine, 23*, 2049-2056.

Wiley, J.B. (1978). Selecting Pareto optimal subsets from multiattribute alternatives. *Advances in Consumer Research, 5*, 171-174.

Zeng, X.Y., Turkstra, J.A., Jongbloed, A.W., vanDiepen, J.T.M., Meloen, R.H., Oonk, H.B., et al. (2002). Performance and hormone levels of immunocastrated, surgically castrated and intact male pigs fed ad libitum high- and low-energy diets. *Livestock Production Science, 77*, 1-11.

Zeng, X.Y., Turkstra, J.A., van de Wiel, D.F.M., Gou, D.Z., Meloen, R.H., Schapper, W.M.M., et al. (2001). Active immunization against gonadotrophin-realising hormone in Chinese male pigs. *Reproduction in Domestic Animals, 36*, 101-105.

Appendix: Information Sheet—Pork Meat

To facilitate your choices, this sheet provides short presentations of product attributes of pork.

1. Type of Housing System

Fattening pigs that have the opportunity to be outdoors or are kept outdoors usually have a larger chance of satisfying their natural behavior compared to pigs kept indoors. This is especially the case for pigs in indoor production systems that allow for only a minimum level of straw. Outdoor production as well as handling of straw is related to greater costs for the producer.

Possible alternatives are:

- pigs kept indoors in boxes with little straw;
- pigs kept indoors in boxes with plenty of straw; or
- possibilities for pigs to be outdoors.

2. Castration

Pork from uncastrated male pigs can have a strong boar taint, which will appear as an odor mainly during heating. Different people have different sensibilities towards boar taint.

In Sweden, almost all male pigs are castrated in order to avoid boar taint. Castration is done without anesthesia during the first week; the piglet suffers from castration. In several countries, research is going on to develop alternatives to surgical castration. One method that is used in Australia (for example) is that pigs are vaccinated against an endogenous substance that affects hormone development. This is called *immunocastration*. The sexual development of the pigs will thus be delayed and boar taint can be avoided. Uncastrated pigs grow faster and develop more muscles and lower fat content in the meat.

Possible alternatives are:

- surgical castration of pigs (no risk of boar taint, suffering for the piglet);
- no castration of pigs (meatier, lower fat content, risk of boar taint); or
- immunocastration of pigs (meatier, lower fat content, low risk of boar taint).

3. Tail Docking

Fattening pigs can develop a type of behavioral disorder called *tail biting*, in which the pigs bite on and finally bite off each other's tails. Tail biting can be caused by a poor environment, inferior fodder, or other types of stress. It causes pain, suffering, and infections. Tail biting is prevented in other countries by docking the piglets' tails. Tail docking is currently banned in Sweden.

Possible alternatives are:

- the pig has been tail docked;
- the pig has not been tail docked and tail biting can occur; or
- the pig has not been tail docked but has been raised in a more expensive way to prevent tail biting.

4. Fixation

During delivery there is a risk that the sow may by mistake lie down on her piglets, causing their deaths. This is especially a problem if the barn is noisy and the sow has difficulty hearing her piglets. This problem is prevented in many countries by keeping the sow *fixated*, which prevents her from turning around. Sows are usually fixated during their entire life. Fixation causes suffering, because sows have a strong natural behavior to move around and to settle before delivery. In Sweden, sows are allowed to be fixated during one week around the time of delivery and also around the time of covering.

Possible alternatives are:

- sows are permanently fixated;
- sows are allowed to be fixated at delivery and around the time of covering; or
- fixation of sows is banned.

Presented at 2nd Asian Pig Veterinary Society Conference, Wuhan, China 2007

CONSUMER ATTITUDES TO BOAR TAINT & IMMUNOCASTRATION

D. Hennessy
Pfizer Animal Health 45 Poplar Rd, Parkville, Vic 3052 Australia

Keywords: Improvac, Vivax®, immunological castration, boar taint, consumer acceptability.

Introduction

External pressures on pig production, from a variety of sources, are leading to pig producers having to be ever more economically efficient whilst improving both environmental performance and animal welfare. The introduction of Improvac® (Pfizer Animal Health), the first commercial vaccine to control boar taint, gives pig producers a powerful new tool. This paper reports the key findings of Australian market research to examine consumer attitudes to the problem of boar taint and its control with the immunocastration vaccine, Improvac.

Material and Methods

Four separate in-depth focus groups were conducted by an independent market research company. Each session lasted around 2 hours and involved 12 participants. All participants were female aged between 30 to 55 years and were the main grocery buyer in the household. The broad objective was to gain an understanding of the consumer's reaction to the issue of boar taint and the use of Improvac to control it; and to examine how knowledge of Improvac may affect consumer's attitude to pork.

The demographics of the 4 focus groups were as follows:

1. An Asian background, regular pork consumers
2. A non-Asian background, regular pork consumers
3. A non-Asian background, occasional pork consumers
4. A non-Asian background, lapsed pork consumers

Regular pork consumption was a frequency of at least once every 2 weeks. Occasional pork consumption was at least once per month; and lapsed pork consumption was about once per 3 months but less than previously because of bad experiences with flavour and smell. At the conclusion each participant was offered a small (~1 kg) loin sample to cook for friends or family. They were fully aware the pork was from Improvac vaccinated pigs. They were given a questionnaire to assess their attitudes to the quality of the pork compared to the pork they usually purchased. All participants volunteered to serve the pork from immunocastrated boars to their family, in total about 80 people (participants, family or friends) provided feedback.

Results and Discussion

In Australia most male pigs are not castrated and thus the participants had at least a 50% chance that pork purchased in retail stores was from a male pig and thus may have high levels of boar taint.

The key findings from the focus groups were:

- Australian consumers even those of Asian background were unaware of the term "boar taint".
- All participants acknowledged that they had experienced pork with "off" odour and flavour – this was often attributed to pork being a "bit odd" or a "bit strong".
- The Asian group had less bad experiences with odour and flavour primarily because they purchased their pork mainly from Asian butchers who sold only female pigs.
- The explanation of "boar taint" as the cause of the odour/flavour problems they had experienced was understood by the participants as a plausible explanation.
- Vaccination in general was seen as a natural process, a highly acceptable part of animal production and was ranked highly compared to other invasive animal husbandry procedures such as castration, and tail docking. The concept of vaccination to control boar taint intuitively made sense to all participants.
- After explaining that Improvac was not a hormone or a chemical and contained no genetically modified organisms, but that it was simply a vaccine working with the pig's immune system, all the participants were comfortable with its use and importantly all volunteered to feed pork from Improvac vaccinated pigs to their families.
- The use of Improvac was seen as a favourable alternative to surgical castration.
- The results clearly showed that the pork from Improvac vaccinated pigs was highly preferred to boar pork.

Summary

Improvac is a proven efficacious and safe vaccine that works in harmony with the pig's immune system to block the compounds that cause boar taint in male pigs. The use of Improvac to produce pork free from boar taint was readily accepted as a favourable alternative to surgical castration by the Australian consumers polled in this survey. Pork from Improvac vaccinated pigs was also highly preferred to boar pork.

ELSEVIER

Available online at www.sciencedirect.com
SCIENCE DIRECT®

APPLIED ANIMAL BEHAVIOUR SCIENCE

Applied Animal Behaviour Science 81 (2003) 111–126
www.elsevier.com/locate/applanim

The effects of immuno- and surgical-castration on the behaviour and consequently growth of group-housed, male finisher pigs

G.M. Cronin[a,*], F.R. Dunshea[b], K.L. Butler[c], I. McCauley[b], J.L. Barnett[a], P.H. Hemsworth[d]

[a]*Animal Welfare Centre, Department of Natural Resources and Environment, Victorian Institute of Animal Science, 600 Sneydes Road, Werribee, Vic. 3030, Australia*
[b]*Department of Growth and Development, DNRE, VIAS, Werribee, Vic. 3030, Australia*
[c]*Biometrics Unit, DNRE, VIAS, Werribee, Vic. 3030, Australia*
[d]*Animal Welfare Centre, DNRE and University of Melbourne, VIAS, Werribee, Vic. 3030, Australia*

Accepted 22 November 2002

Abstract

An experiment was conducted to compare behaviour, in particular social and feeding behaviour, and consequently growth performance of group-housed entire and castrated male pigs during the finisher stage of production. Three treatments: (1) entire males, (2) immuno-castrated males, treated with Improvac® at 14 and 18 weeks of age, and (3) surgically-castrated males, castrated at 14-days old, were compared to assess whether castration affected feeding and social behaviours. Twelve groups of 15 male pigs were formed at 14 weeks of age (47.1 ± 5.50 kg). Pigs had ad libitum access to pelleted, commercial feed from two single space feeders per pen. Pig behaviour and feeder utilisation were compared during 24-h periods at 17 and 21 weeks of age, using time-lapse video recording. At 17 weeks, entire males and immuno-castrated males were more active ($P < 0.05$) than surgical-castrated males (21.9, 19.8 and 16.1% of 24 h), but at 21 weeks there were no differences among the treatments (pooled mean 16.4% of 24 h). As expected, social behaviour at 17 weeks was greater ($P < 0.01$) for entire males and immuno-castrated than surgical-castrated males (3.8, 1.8 and 0.1% of 24 h), but not at 21 weeks, when it was greater ($P < 0.01$) for entire males than immuno- and surgical-castrated males (1.8, 0.5 and 0.4% of 24 h). While the mean time pigs spent in the feeders at 17 weeks did not differ among the treatments (100 min/pig/24 h), at 21 weeks entire males spent less time ($P < 0.05$) in the feeders (76 min/pig/24 h) than immuno- and surgical-castrated males (110 and 107 min, respectively). On both the observation occasions, the "sexually-active" treatments (entire males and immuno-castrated males at 17 weeks and entire males at 21 weeks of age) on average allocated about one-third of active time to feeding, whereas castrated males spent almost one-half of

* Corresponding author. Tel.: +61-3-9742-0450; fax +61-3-9742-0400.
E-mail address: greg.cronin@nre.vic.gov.au (G.M. Cronin).

0168-1591/02/$ – see front matter
doi:10.1016/S0168-1591(02)00256-3

active time in the feeder, assumed to represent feeding behaviour ($P < 0.05$). At 23 weeks, there was a trend for entire males to be lighter ($P = 0.061$) than immuno-castrated males, with surgical-castrated males in between (102.3, 108.9 and 103.9 kg). Thus, castration reduced social behaviour and increased feeding behaviour in group-housed finisher pigs. The results of the experiment also suggest that the social and feeding behaviours of immuno-castrated males at 21 weeks were similar to surgically-castrated males.

Keywords: Finisher pigs; Feeding; Aggression; Mounting behaviour; Time budgets; Castration; Immuno-castration; Growth; Improvac®

1. Introduction

Until recently, Australia was one of only a few pork-producing countries that did not routinely castrate male grower or finisher pigs (Moore, 2001). Indeed, the Australian Model Code of Practice for the Welfare of Pigs reflects this situation and currently recommends that (surgical) castration should be avoided wherever possible (Anon., 1998). However, with the increase in exports of Australian pork to the Asian region, to markets that have a strong preference for meat from gilts and barrows (surgically-castrated male pigs), some Australian farmers have reverted to surgical castration of male pigs (Higgins and Cutler, 1999). Surgical castration of male pigs typically occurs when pigs are about 14-days old. A consequence of the procedure is increased body fat content and reduced growth performance (Campbell and Taverner, 1988; Dunshea et al., 1993). A relatively new technology, immuno-castration, has been developed and involves using a vaccine (Improvac®, CSL Ltd., Parkville, Vic., Australia) against gonadotrophin-releasing hormone (GnRH) to chemically "castrate" male pigs in the latter stage of the finisher phase of production, thereby eliminating the need for surgical removal of the testes (Dunshea et al., 2001). Blocking GnRH release from the hypothalamus with a vaccine inhibits production of luteinising hormone (LH) and follicle stimulating hormone (FSH) by the pituitary gland and prevents testicular development; this effectively castrates the pigs at around 18 weeks of age, after they have had the benefit of growing as entire males to that point.

The nutritional requirements for efficient growth, and the characteristics of feeding behaviour, of individually-housed surgical castrates and entire males are quite well understood (see Campbell and Taverner, 1988; Quiniou et al., 1999). Commercial growing pigs, however, are housed in groups and do not grow as fast and, or as efficiently as expected, compared to their individually-housed counterparts. Clearly, group housing introduces additional variables including stocking density/space allowance, group size and social behaviour. Further, towards the end of the finisher phase of growth, entire males in groups often grow slower than castrates (Patterson, 1985; De Haer and Merks, 1992; De Haer and de Vries, 1993), possibly due to increased sexual activity (courting behaviour and mounting events) and aggression between males; these behaviours are controlled by endocrine factors (Gray, 1971). Thus, the use of a non-surgical method for castration of males late in the growth phase of production may improve the efficiency of growth by reducing undesirable male characteristics that limit growth.

The objectives of this experiment were to record the behaviour of group-housed, male pigs over 24-h periods towards the end of the growth phase of production to examine whether castration per se affected: (1) the animal's time budget in relation to feeding behaviour and activity, and (2) social behaviour. The hypothesis tested was that castration decreases the time group-housed, male pigs allocate to social behaviour and increases the time allocated to feeding behaviour. Two alternative methods of castration were compared: traditional surgical castration and the new technology of immuno-castration.

2. Materials and methods

The experiment was conducted at a large commercial pig farm near Corowa, New South Wales (longitude 146.4°E, latitude 36.0°S, altitude 143 m) in south-east Australia. For each of the two replicates in time, a pool of 150 male piglets was selected. About one-third of the pigs, chosen on an ad hoc basis, were surgically castrated at 14 days of age. At 14 weeks of age, 12 groups of 15 male pigs (Large White × Landrace commercial line) were formed. Average pig weight was 47.1 ± 5.50 kg. Each time replicate involved six pens of pigs (two pens of each of the three treatments) located in the same shed with natural lighting; time replicates were conducted in November–December and March–April, respectively. Mean minimum and maximum ambient temperatures during these periods were approximately 12–28 and 11–25 °C, respectively.

Pig behaviour and feeder utilisation were compared among groups of entire males, immuno-castrated males (entire males treated with Improvac® at 14 and 18 weeks of age, i.e. the recommended ages when pigs should be treated) and surgically-castrated males (castrated at 14-days old). Each pen measured 5.7 m wide × 3.5 m deep and contained two electronic, single space feeders that provided a pelleted, commercial diet ad libitum. The two feeders, which were developed and constructed in-house by QAF Meat Industries Ltd., were located at the front of the pen as shown in Fig. 1. Pigs fed from the individual feed troughs while standing in a 0.4 m wide × 0.9 m long feeder race which had solid side walls. A bar placed 0.15 m above floor level, mid-way along the race, prevented pigs from lying in the race and only one pig could occupy a feeder race at a time. All pigs were fitted with a uniquely coded ear-tag transponder that allowed individual identification whilst at the feeder, i.e. inside the feeder race. A computer registered the feed allocated to each pig (and assumed eaten by that pig) per 24 h period commencing at midnight each day. Pelleted feed was delivered at a rate of about 1 g/s. The computer provided a print out each morning detailing any pig that either: (i) did not register as eating, or (ii) registered eating <0.5 kg, in the previous 24 h, which assisted in identifying any transponders that failed or pigs that may have been ill. Transponders that failed were immediately replaced by 08:00 h each day.

Fifteen of the 18.1 m^2 available to the pigs for lying was concrete slats (100 mm wide solid surface to 20 mm void). The remainder of the floor surface available for lying was solid concrete and was predominantly the space between the entrances to the two feeder races. Each pen contained three bite drinkers attached to the pen walls (panels of horizontal metal bars) and situated over slatted floor. Water was not provided in the feeder. A 24-h time-lapse video record was made for each pen of pigs at 17 and 21 weeks of age. Video-recording of the six pens of pigs per time replicate occurred over two consecutive days each

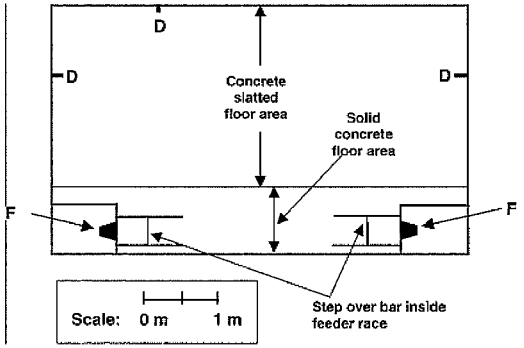


Fig. 1. Pen lay out. D indicates position of drinkers; F indicates feed trough within the electronic single space feeder.

week with the use of three time-lapse video cassette recorders (Panasonic AG-6124). The order of video-recording of pens was randomised in the experiment. Each pig was weighed weekly, at which time it was also spray-painted on its back with a numeral from 1 to 15 for individual identification on the video record. A low-light, colour video camera with wide-angle, auto-iris lens was mounted above each pen. Night time video recording was assisted by a 20 W fluorescent light attached to the roof, between 3.5 and 5 m above each feeder.

Behaviour data were transcribed from the video records using The Observer behaviour recording program, supplemented with the Support Package for Video Analysis (version 4.0 for Windows; Noldus Information Technology, 1997). A Panasonic AG-7355 video cassette recorder with jog and shuttle control which enabled frame by frame analysis of the video record, was linked directly to a computer which could then read the time track on the video tape record. To transcribe the video-recorded data, an observer replayed the video tape, commencing at the pre-determined start time for the 24-h period, and followed the image of each pig individually on the video monitor for the entire 24-h period.

A continuous record (duration and frequency) of each pig's location in the pen and behaviour was obtained according to the list shown in Table 1. As indicated in Table 1, pigs were recorded as being "idle" if they occupied a sitting or lying posture. The complement of "idle" was "active", which was recorded when pigs occupied a standing posture. The major activities of interest in this experiment were "feeding behaviour" and "social behaviour". Feeding behaviour was assumed when the focal pig was standing in the feeder race and defined by the pig having its head and front legs within the feeder race. Social behaviour was the combination of aggressive behaviour, which included aspects of courtship behaviour but which were difficult to distinguish on the time-lapse video record from aggression per se, and mounting events, while "other behaviour" constituted the remaining time that pigs stood. In addition, the circumstances at the time the focal pig entered or exited a feeder were also recorded as a modifier to feeding behaviour (Table 1).

Table 1
List of locations and behaviours recorded from the time-lapse video records

Classes	Elements	Modifiers
Location in pen	Left feeder	Entry/exit circumstance[†]
	Right feeder	Entry/exit circumstance[†]
	Front area of pen between the feeders	
	Mid-pen	
	Rear-pen	
General behaviour	Idle: sitting and lying postures—including resting/sleeping (duration).	
	Mounting events: the focal pig is mounted on the back of another pig with one front leg on either side of the other pig's back enabling the focal pig to hold onto the other pig should it move about (frequency and duration).	
	Attempted mount: the focal pig mounts another pig but is unable to achieve a stable mount position, as described above (frequency).	
	Aggressive behaviour: including root, nose, lever, bite another pig, parallel pressing against another pig (frequency and duration).	
	Other activity: none of the above-listed general behaviours (frequency and duration).	

[†] Modifiers—subjective evaluation of circumstance at: (A) entry to a feeder: (i) was the feeder vacant? (ii) was a pig leaving the feeder? (iii) did the pig displace another pig from the feeder? (B) exit from a feeder: (i) was the exit voluntary with (a) no other pig nearby or (b) another pig waiting to enter? (ii) was the focal pig displaced?

The experimental unit was the pen of pigs and differences due to the treatments (entire males, immuno- and surgical-castrated males) were determined using analysis of variance with time considered as a blocking effect (GenStat, 2000). This gave 8 d.f. for residual error. The pen means for the different variates subjected to statistical analysis were computed for the number of pigs per pen. Data were transformed using either the angular transformation of percentage values or $\log_e$ transformation when appropriate. When comparing situational factors around the feeders, the analysis was modified to a split–plot analysis with a situational × pen mean as the experimental unit. As the 24 h periods for measuring feed intake and behaviour had different start times (midnight compared to 08:00–09:00 h, respectively), the 24 h feed intake data did not align with the full 24 h of behaviour recording. For the statistical analysis, the feed intake data were averaged over 3 days—the date of the behaviour observation plus 1 day either side of that date.

3. Results

A total of six pigs were removed during the course of the experiment: one from each of the entire male and immuno-castrated male treatments and four from the surgical-castrated male treatment; two pigs were withdrawn from each of the two pens. The removal of all but

one surgical-castrated male pig occurred prior to the week 17 video recordings. The transponders of two surgical-castrated pigs failed the day prior to video recording; there was one occurrence in each time replicate. The respective transponders were replaced prior to the start of video observations and the subsequent daily feed intakes of the pigs appeared to be normal. No transponders were reported to fail on the days when pigs were video recorded nor on the day of post-observation.

3.1. Growth and feed intake

Although mean pig live weights at 14 weeks were not significantly different due to the treatments, surgical-castrated males on average were 1 kg lighter than entire males and immuno-castrated males (49.4, 49.5 and 48.3 kg, respectively, for entire, immuno- and surgical-castrated males; $P > 0.05$).

Differences due to treatment in the 3-day average feed intake of pigs around the days of video recording were found. At 17 weeks, the 3-day average feed intake tended to be lower for entire and immuno-castrated males compared to surgical-castrated males (2.31, 2.29 and 2.61 kg/24 h, respectively; $P = 0.055$, sed = 0.121), but at 21 weeks was higher for immuno-castrated than either entire or surgical-castrated males (2.69, 3.32 and 2.90 kg/24 h, for entire, immuno- and surgical-castrated males, respectively; $P < 0.02$, sed = 0.171). While there were no effects of treatment ($P > 0.05$) on the mean live weight of pigs (based on pen means) at 17 weeks (64.1, 64.8 and 64.5 kg, respectively, for entire, immuno- and surgical-castrated males) or 21 weeks (89.6, 93.9 and 91.5 kg, respectively, for entire, immuno- and surgical-castrated males), by 23 weeks entire males tended to be lighter ($P = 0.061$) than immuno-castrated males, with surgical-castrated males in between (101.9, 108.3 and 104.9 kg, respectively, for entire, immuno- and surgical-castrated males; sed = 2.44). Similarly, live weight gain was not affected by treatment in week 17 (average daily gains were 943, 947 and 935 g, respectively, for entire, immuno- and surgical-castrated males; $P > 0.05$, sed = 44.6), but there was a tendency in week 21 for immuno-castrated males to gain more weight than the other treatments (average daily gains were 932, 1177 and 954 g, respectively, for entire, immuno- and surgical-castrated males; $P = 0.10$, sed = 107.8).

3.2. Behaviour

The predominant behaviour of pigs was "idle", which accounted for 80.7 and 83.6% of pigs' time per 24 h, respectively, in weeks 17 and 21. During the remaining time pigs were considered "active". The entire and immuno-castrated males treatments were more active than the surgical-castrated male treatment at 17 weeks ($P < 0.05$, Table 2). At 21 weeks, however, there were no differences in activity due to the treatments ($P > 0.05$). The diurnal pattern of activity by pigs in the different treatments at the two observation ages is presented in Fig. 2.

3.3. Social behaviour

Entire and immuno-castrated males at 17 weeks performed more social behaviour than surgical-castrated males ($P < 0.01$, Table 2). Expressed in terms of the animals' time

Table 2
The effects of treatment on pig behaviour at 17 and 21 weeks of age

Age class		17 weeks					21 weeks				
Behaviour variables	Unit	Entire males	Immuno-castrated males	Surgical-castrated males	sed	*P*-value	Entire males	Immuno-castrated males	Surgical-castrated males	sed	*P*-value
Activity (time spent standing)	Percentage of time	21.9a	19.8a	16.1b	1.87	0.04	17.6	16.2	15.3	0.98	0.12
Feeding behaviour											
Time spent in feeders	Percentage of time	7.0	6.7	7.4	0.67	0.54	5.3a	7.7b	7.2b	0.72	0.03
Visits to the feeders	Frequency	16.4	15.3	17.7	3.23	0.76	13.6	12.4	17.5	3.55	0.36
Social behaviour											
Duration (untransformed)	Percentage of time	3.8	1.8	0.1			1.8x	0.5y	0.4y	0.25	<0.001
Duration (after angular transformation)	Degrees	10.69x	7.40x	1.90y	2.094	0.009					
Aggressive behaviour	Frequency	27.4x	28.6x	4.5y	6.23	0.008	27.9x	9.5y	9.5y	4.66	0.006
Mounting events	Frequency	9.4x	5.3xy	0.1y	1.71	0.002	7.2x	0.6y	0.1y	1.47	0.002
Attempted mounts	Frequency	5.8a	7.8a	0.1b	1.98	0.012	15.2	3.0	0.5		
Attempted mounts (after log$_e$ transformation)							1.77a	0.20ab	−1.05b	0.880	0.04

Values shown are means per pig per pen over 24 h period; within age classes, a,b: $P < 0.05$; x,y: $P < 0.01$, using least significant differences; sed: standard error of difference between the means, $P = 0.05$.

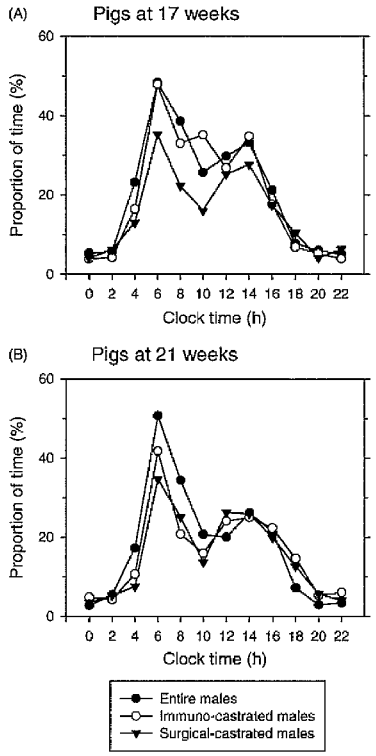


Fig. 2. Changes in the proportion of time (per 2 h period) that pigs in the different treatments stood (assumed to estimate activity). Graphs A and B, respectively, are for pens of pigs at 17 and 21 weeks of age. Values shown are the means of four pens per treatment.

budget allocation, pigs in the entire male treatment allocated more ($P < 0.05$) of their active time to social behaviour than surgical-castrated males, with the immuno-castrated males intermediate between these two treatments (16.6, 9.0 and 0.8% of active time, respectively, for entire, immuno- and surgical-castrated males; $P < 0.05$, sed = 3.60). In week 21, pigs in the entire male treatment performed significantly more social behaviour than the immuno- and surgical-castrated males treatments, both in absolute terms

($P < 0.001$, Table 2) and as a proportion of active time (10.6, 3.2 and 2.4% of active time, respectively; $P < 0.01$, sed = 1.64).

3.4. Aggressive behaviour

Aggressive behaviour was the predominant behaviour class contributing to social behaviour (~90% based on pooled means) and the effects of the treatments on time spent in aggressive behaviour were, therefore, similar to those shown in Table 2 for social behaviour. Table 2 also indicates the frequency of aggressive behaviour. At 17 weeks, entire and immuno-castrated males compared to surgical-castrated males and, at 21 weeks, entire males compared to immuno- and surgical-castrated males, had a higher frequency of aggressive behaviour ($P < 0.01$) during the 24 h observation period (Table 2).

3.5. Mounting events

While mounting events accounted for about 10% of social behaviour across treatments, there were effects of treatment on the incidence of mounting. The mean number of mounts per pig was greater at 17 weeks for entire and immuno-castrated males than surgical-castrated males ($P < 0.01$), whereas at 21 weeks, entire males performed the greatest incidence of mounts and immuno-castrated males were similar to surgical-castrated males ($P < 0.01$; Table 2).

Behaviour variables describing mounting events captured from the observation records were the average duration of mounts, the number of mounts by individuals within groups and the occurrence of attempted mounts. The mean duration of individual mounts by pigs in the different treatments at 17 weeks were 30, 27 and 8 s, and 21 weeks were 42, 25 and 20 s, respectively, for the entire, immuno- and surgical-castrated males. Fig. 3 shows for each treatment at the two observation times, the mean proportion of pigs that were: (i) not observed to mount, or mounted between (ii) 1 and 5 times, (iii) 6 and 10 times, or (iv) more than 10 times, during the 24-h observation period. As suggested in Fig. 3, the distributions of pigs in the entire and surgical-castrated males treatments across the different mounting frequency classes were similar within-treatments at 17 compared to 21 weeks of age. In the immuno-castrated male treatment, however, a shift in the distribution pattern occurred between 17 and 21 weeks of age. A similar pattern was recorded for attempted mounts. At 17 weeks, more attempted mounts were performed by entire and immuno-castrated than surgical-castrated males ($P < 0.05$, Table 2), whereas at 21 weeks entire males performed more attempted mounts than immuno- and surgical-castrated males ($P < 0.05$, Table 2).

3.6. Feeding behaviour

The average number of visits to and the proportion of time spent in feeders by pigs in the different treatments per 24 h period, are shown in Table 2. The pooled mean frequency of visiting feeders per 24 h was 16.4 and 14.5 times, respectively, at 17 and 21 weeks and there were no differences due to the treatments in this parameter. The number of visits to feeders by individual pigs ranged from 4 to 82 visits per pig over 24 h. Although there was no difference ($P > 0.05$) due to treatments at 17 weeks in the time pigs spent in feeders (mean

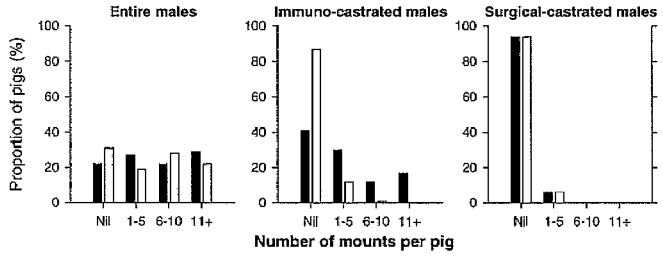


Fig. 3. The proportion of pigs in each treatment that (1) did not mount another pig in the pen, or that mounted between (2) 1 to 5 times or (3) 6 to 10 times or (4) more than 10 times in 24 h. Solid columns signify pigs aged 17 weeks and open columns represent pigs at 21 weeks of age. Values shown are the means of four pens per treatment.

values: 101, 96 and 107 min/pig/24 h), at 21 weeks, entire males spent less time in the feeders compared to immuno- and surgical-castrated males (77, 110 and 103 min/24 h, respectively; $P < 0.05$, sed = 10.4). Overall, the time individual pigs spent in the feeders per day ranged from 11.7 to 171.4 min; individual duration of occupying the feeder (the pig was assumed to be feeding) ranged from 1 s to 53 min. The proportion of active time that pigs allocated to feeding behaviour was affected by treatment at both 17 weeks, when the entire and immuno-castrated males compared to surgical-castrated males spent a lower proportion of their active time in feeding behaviour (32.2, 33.3 and 46.8% of active time for entire, immuno- and surgical-castrated males, respectively; $P < 0.05$, sed = 4.12) and, at 21 weeks, when the entire males compared to immuno- and surgical-castrated males spent a lower proportion of active time in feeding behaviour (30.1, 47.7 and 46.7% of active time, respectively; $P < 0.01$, sed = 4.56).

3.7. Feeder occupancy

Feeder occupancy was calculated from the mean proportion of time pigs spent in the feeder multiplied by the number of pigs per pen, divided by 2 (the number of feeders per pen). While there was no effect of treatment on feeder occupancy by pens of pigs at 17 weeks (51.4, 49.3 and 52.7% of 24 h, respectively, for entire, immuno- and surgical-castrated males; $P > 0.05$, sed = 3.44), there was a difference at 21 weeks. Feeders were used less ($P = 0.05$) in the entire male than immuno- and surgical-castrated males treatments at 21 weeks (39.5, 56.4 and 50.0% of 24 h, respectively; sed = 5.72). The diurnal patterns in the use of feeders by pens of pigs at 17 and 21 weeks of age are shown in Fig. 4.

3.8. Situational factors at entry to feeders

The mean numbers of visits by pigs to feeders are shown in Table 3 for the different treatments at the two video-recording ages. For the majority of visits (~70–80% of visits

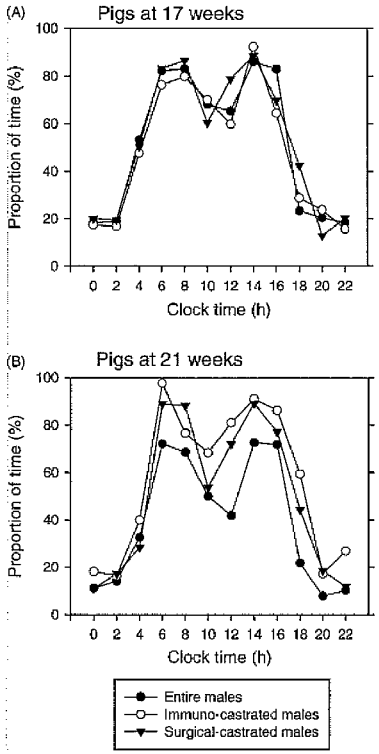


Fig. 4. Changes in the proportion of time (per 2 h period) that pigs in the different treatments utilised the feeders in their pens. Graphs A and B, respectively, are for pens of pigs at 17 and 21 weeks of age. Values shown are the means of four pens per treatment.

by pigs to feeders), pigs entered a feeder that was unoccupied when the pig approached the entrance to the feeder. Less frequently, pigs would "queue" at an occupied feeder and enter the feeder once the occupant exited, or alternatively in a minority of cases, forcibly displaced the occupant. For pigs at 21-weeks old, entire males were more likely ($P < 0.001$) to enter a vacant feeder than pigs in the other treatments (81 versus 69% of feeder visits, respectively; Table 3). Conversely, entire males were less likely ($P < 0.01$)

Table 3
Situational differences at the time of entry to the feeder by entire, immuno- and surgical-castrated male pigs at 17 and 21 weeks of age

Treatments	Entire males	Immuno-castrated males	Surgical-castrated males	sed	*P*-value
17-weeks old					
Number of visits represented	16.5	15.3	17.6	3.29	0.79
Situation prior to pig entering:					
(1) Feeder was vacant (%)	78.9	76.7	71.0	5.59	0.39
(2) A pig was leaving feeder (%)	18.6	19.6	27.4	5.76	0.31
(3) Occupant was displaced (%)	2.5	3.7	1.6	1.23	0.29
Total (%)	100.0	100.0	100.0		
21-weeks old					
Number of visits represented	13.6	12.3	17.5	3.56	0.37
Situation prior to pig entering:					
(1) Feeder was vacant (%)	81.1q	69.6p	68.1p	1.89	<0.001
(2) A pig was leaving feeder (%)	16.4y	25.7x	24.6x	2.29	0.007
(3) Occupant was displaced (%)	2.5	4.7	7.3	2.9†	0.32
Total (%)	100.0	100.0	100.0		

Values shown are the total number of visits per 24 h to the feeder and the proportion of entries to the feeder in which: (1) the feeder was vacant when the focal pig arrived, (2) a pig was leaving the feeder and the focal pig then entered, and (3) the focal pig displaced the occupant from the feeder. Data for focal pigs that were in the feeder at the commencement of the observation period were excluded. Within age classes, x,y: $P < 0.01$; p,q: $P < 0.001$, using least significant difference; sed: standard error of difference between the means.

to "queue" for access to a feeder, based on the proportion of visits to the feeder in which pigs entered the feeder shortly after the occupant left the feeder, and not including situations in which pigs were displaced from the feeder by a pen mate.

An interesting observation was that pigs stayed longer in the feeder on the occasions they entered a feeder that had been recently vacated by another pig. While there were no differences due to treatment in the time pigs spent in the feeder per visit at either 17 or 21 weeks of age, there were significant differences due to the circumstance existing prior to the pig entering the feeder ($\log_e$ means with untransformed mean values shown in parentheses were: 17 weeks, 5.793 (343 s) and 6.267 (565 s), respectively, for feeder vacant compared to feeder occupied; sed = 0.0314, $P < 0.05$; 21 weeks, 5.881 (395 s) and 6.324 (612 s), respectively, for feeder vacant compared to feeder occupied; sed = 0.0242, $P < 0.05$).

3.9. Situational factors at exit from feeders

There were no differences between the treatments in the proportion of times that pigs exited from the feeders under the three different circumstances that were recognised—pig exited "voluntarily" and either (i) no other pig was located nearby (pooled means for weeks 17 and 21, respectively, were 68 and 74% of occasions) or (ii) pig nearby (28 and 21%), or (iii) the pig was displaced from the feeder (4 and 5%). At 17 weeks, the average duration of visits to a feeder was shorter ($P < 0.05$) in situations in which pigs voluntarily exited from the feeder and no other pig was waiting to enter (423 s) or the pig was displaced from the feeder (369 s) compared to the situation in which another pig was waiting to enter the feeder (566 s; sed = 31.4). At 21 weeks, there were no differences (499, 682 and 656 s, respectively; $P > 0.05$).

4. Discussion

This experiment showed that castration reduced social behaviour and increased feeding behaviour in group-housed finisher pigs. While immuno-castration had a similar effect on behaviour to surgical castration, there were clear benefits to production such as increased feed intake and a trend for faster growth. Immuno-castrates were effectively castrated at 18 weeks of age, after they had had the benefit of growing as entire males to that point and had increased feed intakes beyond this age when feed intakes of entire males declined. Entire males in the latter part of the finisher stage of production, however, appeared more easily distracted from feeding, reducing feed intake, and spent more time in social behaviour including aggressive behaviour and mounting. Despite the relatively large differences in feeding behaviour parameters, treatment effects on growth were less pronounced, possibly due to the limited number of replicates.

Time spent in a feeder, assumed to represent feeding behaviour, was not affected by treatment at 17 weeks of age. However, surgical-castrated males at 17 weeks had 13% higher daily feed intake compared to entire and immuno-castrated males. While it is possible that the surgical castrates could eat faster and thus increase feed intake without increased time in the feeder (De Haer and Merks, 1992), this was unlikely as the rate of feed supply in the electronic feeders in the present experiment was restricted (1 g/s). The discrepancy between time in the feeder and feed intake may be associated with entire males and immuno-castrates using the feeder race as a hide area to avoid aggression, which has been reported previously by McGlone and Curtis (1985). Treatment differences were found in the time pigs spent in the feeder at 21 weeks of age. Entire males spent less time in the feeder than immuno-castrates and surgical castrates, which was reflected in reduced feed intake. For example, entire males spent least amount of time per 24 h in the feeder (5.3%) and ate least (2.68 kg), whereas the immuno-castrates spent most time feeding (7.7%) and ate most per day (3.33 kg). Surgical-castrates were intermediate to the other treatments (7.2% of time and 2.90 kg feed intake per day). Surgical castration (at 14 days of age) resulted in an increase of 8.1% in feed intake in week 21 compared to entire males. Immuno-castrates on the other hand, increased feed intakes in week 21 by 14.1% compared to surgical-castrates and 23.4% compared to entire males. Thus, immuno-castration offers pork producers a means to significantly improve feed intakes of group-housed male finisher pigs. As reported in the results, live weights of immuno-castrates were correspondingly heavier than entire males. Presumably as a consequence of the removal of endogenous hormones influencing aggression and sexual activity, more time was spent feeding.

The time spent in feeding behaviour and feed intake in the present experiment for group-housed entire males were higher than those reported by Nielsen and Lawrence (1993) for

groups of 15 entire males with one feeder space (3.7% of time and 1.42 kg per day), Nielsen et al. (1995) for groups of nine entire males (4.1% of time and 1.96 kg per day) and Labroue et al. (1999) for groups of 8–13 Large White entire males (3.9% of time and 2.12 kg/day). For castrates, however, our data were intermediate between other results. For example, Gonyou et al. (1992) reported that surgical castrates and gilts in groups of five at the end of the finisher phase spent 8.8% of time feeding per 24 h and consumed 3.16 kg feed per day, whereas De Haer and Merks (1992) reported 4.4% of time feeding and 2.04 kg intake per day. Differences between the results of experiments may be due to breed, genotype, group size, feeder design (the feeders used in this experiment were designed and made by the piggery), method of providing feed (e.g. availability or rate of delivery of feed was limited to 1 g/s in this experiment) which could affect rate of eating and method of recording data.

Interestingly, on average, groups of entire males at 17 and 21 weeks and immuno-castrated males at 17 weeks allocated about one-third of their active time to feeding behaviour. These classes/ages of boars had a high incidence of mounting. In contrast, the groups of immuno-castrates at 21 weeks and surgical-castrates at 17 and 21 weeks allocated about 46% of their activity to feeding behaviour. The only other report in the literature of time budgets of finisher pigs is by Gonyou et al. (1992). Gilts and surgical-castrates housed in groups of five spent about 55% of their active time feeding. The finding in the present experiment that entire males had a different time-budget allotment for feeding than castrated males has not been previously reported. Further, that feeding behaviour by entire males decreased between 17 and 21 weeks of age may have been at least partly attributable, therefore, to a general reduction in activity levels by entire males, as feeding motivation may have been regulated by the time budget.

A characteristic of feeding behaviour in pigs is the high degree of variability in parameters such as the number of visits to feeders per 24 h, the average duration of visits to feeders and total time spent feeding per day (De Haer and de Vries, 1993; Young and Lawrence, 1994; Gonyou, 1999). Based on the raw data from this experiment, we found the number of visits to feeders per pig ranged from 4 to 82 per day. The total time spent feeding per 24-h period ranged from 11.7 to 171.4 min and the duration of individual visits to a feeder ranged from 1 s to 53 min. While access to the feeders did not seem to be a limiting factor to feed intake compared to other experiments (e.g. Nielsen and Lawrence, 1993; Gonyou and Stricklin, 1998; Gonyou, 1999), a related issue that requires further investigation is the variability of feeder use by individual pigs and impact on feed intake.

In the present experiment, there was a clear diurnal pattern of utilisation of the feeders by the groups of pigs in all treatments and at both ages (see Fig. 4). This result supports earlier findings by De Haer and Merks (1992), Nielsen and Lawrence (1993) and Young and Lawrence (1994) that pigs display an early morning and a late afternoon peak in feeding behaviour. Deviations from this pattern could occur if access to the feeders became limiting, which may have occurred, for example had there been more pigs, only one feeder or restricted access to feed in each pen. The average activity pattern of pigs, as presented in Fig. 2, indicated pigs were highly active between 06:00 and 08:00 h, which corresponded to a period of high feeder use. A second, lower peak of activity occurred between 14:00 and 16:00 h. Another finding indicative that feeder space was not limiting was that on about 80% of occasions when pigs entered a feeder, the feeder was vacant as the pig approached

to enter the feeder race. The results of the experiment also suggest that some pigs "queued" for access to a feeder. These pigs tended to remain longer in the feeder and may have been hungrier. Also, the longer a pig remained in the feeder, the more likely other pigs were to "queue" for the feeder, unless the "queuing" pig was able to reduce the waiting period by displacing the occupant from the feeder. This only occurred in a minority of cases (2.7 and 4.8% of occasions at 17 and 21 weeks of age, respectively).

The finding that entire males at 21 weeks of age were less likely to "queue" for a feeder than immuno- and surgical-castrates may have been a consequence of the feeders being more often vacant in the entire male treatment compared to the other treatments. Entire males at 21 weeks of age performed more aggressive and sexual activity than castrated males. On average, in this experiment, entire males spent 10% of their active time (time budget) in sexual and aggressive behaviour compared to only 3% by castrates. Castrates, on the other hand, spent more time feeding. Thus, the increase in social behaviour displayed by entire males may have been at the expense of feeding behaviour.

By increasing the rate of flow of feed pellets in the feeder or alternatively by increasing the amount of feed available in the feed receptacle, feed intake in entire males may be increased. Other possible strategies to encourage group-housed entire boars to visit the feeder more often may be the provision of more feeder spaces compared to castrates, the positioning of visual barriers in the pen and around the entrance to the feeder race or the relocation of the feeder to the centre of the pen rather than at the periphery. The rationale for the latter ideas is to increase feeding behaviour in entire boars by reducing opportunity for social interaction.

Thus, immuno-castration had a similar effect to surgical castration on reducing the incidence of social behaviour in group-housed male pigs. Castration resulted in an increase in feeding. While the decrease in social behaviour following castration had a clear benefit to production parameters (feed intake and growth rate), there are also potential welfare and meat quality benefits from a reduction in aggression and mounting events, through reduced injury, less carcass bruising and DFD meat.

5. Conclusion

Castration reduced social behaviour and increased feeding behaviour in group-housed male finisher pigs and altered the time-budget allocations for these activities. The 21-week-old entire male pigs that were administered Improvac® at 14 and 18 weeks of age performed social and feeding behaviours in similar proportions to males surgically castrated at 14-day-old. Immuno-castrated males had higher feed intakes and tended to grow faster to slaughter weight than entire males.

Acknowledgements

We gratefully acknowledge QAF Meat Industries Ltd. for their generous assistance in providing the facilities for the research, the co-operation of Rob Smits, David Harrison, Pete Rich and piggery staff at Corowa and Dr. David Hennessy and CSL Ltd. for provision

of the Improvac®. The technical support provided by Elaine Leeson and Dr. Rebecca Morrison with the video equipment, Maurie Miles with the computer software and hardware and Dr. D. Suster, Dr. K. Breuer, A. Cassar, T. Chamberlain and T. Moyes for video read-outs are also acknowledged. The experiment was co-funded by grants from the Department of Natural Resources and Environment and the Pig Research and Development Corporation (now Australian Pork Limited).

References

Anon., 1998. Standing Committee on Agriculture and Resource Management. Model Code of Practice for the Welfare of Animals—Pigs, second ed. SCARM Report no. 66. CSIRO Publishing, Collingwood.

Campbell, R.G., Taverner, M.R., 1988. Genotype and sex effects on the relationship between energy intake and protein deposition in growing pigs. J. Anim. Sci. 66, 676–686.

De Haer, L.C.M., Merks, J.W.M., 1992. Patterns of daily food intake in growing pigs. Anim. Prod. 54, 95–104.

De Haer, L.C.M., de Vries, A.G., 1993. Feed intake patterns of and feed digestibility in growing pigs housed individually or in groups. Livest. Prod. Sci. 33, 277–292.

Dunshea, F.R., Colantoni, C., Howard, K., McCauley, I., Jackson, P., Long, K.A., Lopaticki, S., Nugent, E.A., Simons, J.A., Walker, J., Hennessy, D.P., 2001. Vaccination of boars with a GnRH vaccine (Improvac®) eliminates boar taint and increases growth performance. J. Anim. Sci. 79, 2524–2535.

Dunshea, F.R., King, R.H., Campbell, R.G., Sainz, R.D., Kim, Y.S., 1993. Interrelationships between sex and Ractopamine on protein and lipid deposition in rapidly growing pigs. J. Anim. Sci. 71, 2919–2930.

GenStat, 2000. The Guide to GenStat®, Part 2: Statistics. Payne, R.W. (Ed.), Lawes Agricultural Trust, Rothamsted Experimental Station, VSN International Ltd., Oxford.

Gonyou, H.W., 1999. Feeder and pen design to increase efficiency. Adv. Pork Prod. 10, 103–113.

Gonyou, H.W., Chapple, R.P., Frank, G.R., 1992. Productivity, time budgets and social aspects of eating in pigs penned in groups of five or individually. Appl. Anim. Behav. Sci. 34, 291–301.

Gonyou, H.W., Stricklin, W.R., 1998. Effects of floor area allowance and group size on the productivity of growing/finishing pigs. J. Anim. Sci. 76, 1326–1330.

Gray, J.A., 1971. Sex differences in emotional behaviour in mammals including man: endocrine bases. Acta Psychol. 35, 29–46.

Higgins, P., Cutler, R., 1999. Barrow production. PRDC Notes Pig Research and Development Corporation, Canberra.

Labroue, F., Guéblez, R., Meunier-Salaün, M.-C., Sellier, P., 1999. Feed intake behaviour of group-housed Piétrain and Large White growing pigs. Ann. Zootech. 48, 247–261.

McGlone, J.J., Curtis, S.E., 1985. Behavior and performance of weanling pigs in pens equipped with hide areas. J. Anim. Sci. 60, 20–24.

Moore, M., 2001. Entire males not popular. Pork News 1 (3), 26–27.

Nielsen, B.L., Lawrence, A.B., 1993. The effect of group size on the behaviour and performance of growing pigs using computerised single-space feeders. Pig News Information 14 (3), 127N–129N.

Nielsen, B.L., Lawrence, A.B., Whittemore, C.T., 1995. Effects of single-space feeder design on feeding behaviour and performance of growing pigs. Anim. Sci. 61, 575–579.

Noldus Information Technology, 1997. The Observer, Support Package for Video Analysis. Reference manual, Version 4.0 for Windows Edition. Wageningen, The Netherlands.

Patterson, D.C., 1985. A note of the effect of individual penning on the performance of fattening pigs. Anim. Prod. 40, 185–188.

Quiniou, N., Dubois, S., Le Cozler, Y., Bernier, J.-F., Noblet, J., 1999. Effect of growth potential (body weight and breed/castration combination) on the feeding behaviour of individually kept growing pigs. Livest. Prod. Sci. 61, 13–22.

Young, R.J., Lawrence, A.B., 1994. Feeding behaviour of pigs in groups monitored by a computerised feeding system. Anim. Prod. 58, 145–152.

IMPROVAC™ (PFIZER ANIMAL HEALTH): AN IMMUNOLOGICAL PRODUCT FOR THE CONTROL OF BOAR TAINT IN MALE PIGS

(I) BOAR TAINT AND ITS CONTROL AND THE MODE OF ACTION, SAFETY AND EFFICACY OF IMPROVAC™

J.D. MACKINNON — Pig Health and Production Consultancy, Cheneys Cottage, East Green, Kelsale, Saxmundham, Suffolk IP17 2PH

M.C. PEARCE — Pfizer Animal Health, Ramsgate Road, Sandwich, Kent CT13 9NJ

The Pig Journal (2007) 59, 29-67.

Summary

Boar taint is caused primarily by the male steroid androstenone, and skatole – a bacterial metabolite of tryptophan. Potentially, taint is a major limiting factor to the marketing of pig meat derived from carcases of entire male pigs. Androstenone can only be detected by sensitive subjects who generally find the smell highly offensive, whilst skatole can probably be detected by nearly everyone. The occurrence of boar taint shows national, regional and seasonal differences which can be influenced, but not eliminated, by feeding and management practices. The most effective and widely practised method of controlling boar taint currently is the painful and undesirable procedure of surgical castration. However, the new technology of immunocastration, utilising the product Improvac™, offers a real and welfare friendly alternative.

Introduction

In recent years, the global consumption of pig meat has increased at the rate of 1.3 per cent per annum (Roppa, 2006), which in turn places increasing pressure on the pig industry for greater efficiency of pig production. By the year 2015 it is predicted that the annual average consumption of pig meat per head worldwide will be 17.9 kg - almost twice that of 1970. Global production of pig meat in 2004 was estimated to be 100,907 million tonnes, 56 per cent of which was produced in Asia; 25.8 per cent in Europe and 17.1 per cent in the Americas. The medium to long term outlook for pig meat consumption in Europe is generally positive (Anon, 2005), but there is strong and increasing competition from the poultry sector. In 2004, European consumers ate an average of 43.5 kg of pig meat and 23 kg of poultry meat per person, which represented 50 and 26 per cent respectively of their total average annual meat consumption of 87.4 kg. Although slow growth in pig meat consumption until

at least 2012 is expected, the increase in consumption of poultry meat is expected to rise more steeply as consumers begin to show greater preference for it. Greater efficiency and competitiveness could be achieved by finishing entire male pigs but, unless controlled, the presence of compounds in the fat of such animals, primarily androstenone and skatole which are released upon heating or cooking, could limit the development of pig meat production as consumers change to meat from other species in which the equivalent of boar taint does not exist.

The rearing of entire male pigs for meat is strongly resisted in most pig-producing countries because there is very low consumer tolerance of boar taint. However, future welfare legislation may prohibit surgical castration without anaesthesia, particularly in Europe. As routine use of anaesthesia would pose severe practical difficulties, other means of controlling boar taint must be found. Slaughter of male pigs before they reach sexual maturity has proven an acceptable solution in some markets, but this reduces production efficiency. Adoption of this practice in other countries would necessitate a substantial increase in the number of pigs reared to maintain pork production at current levels, and would prevent producers from supplying the types and quality of pig meat currently demanded by their markets. There are husbandry and processing techniques that can reduce the intensity of boar taint and these provide a possible solution if carcases that are still affected can be easily identified on the slaughter line and diverted to an acceptable use (Babol and Squires, 1995; Bonneau and Squires, 2000). It is possible to dilute tainted meat in certain products such as sausages and salami (Williams *et al*, 1963; Walstra, 1974), providing a commercial outlet for a limited number of tainted carcases. Nevertheless, husbandry and processing alone cannot provide a high level of boar taint control and occasions will arise when consumers are exposed to its undesirable odour and, as a result, will not readily purchase pig meat products again. Until recently, the only means of controlling boar taint was by the surgical removal of at least the testicular parenchyma (Rhodes and Patterson, 1971), but the advent of vaccination against gonadotrophin-releasing factor (GnRF) has provided the pig industry with a welfare friendly and effective alternative to surgical castration (Falvo *et al.*, 1986; Caraty and Bonneau, 1986; Bonneau *et al.*, 1994; Oonk *et al.*, 1998; Beekman *et al.*, 1999; Dunshea *et al.*, 2001; Zeng *et al.*, 2001; Metz *et al*, 2002; Jaros *et al.*, 2005).

This review describes the problem of boar taint and the rationale behind the use of a new technology for effective control of taint in entire male pigs which would obviate the need for surgical castration. This in turn would allow pig producers to achieve the growth efficiencies necessary for pig production to remain competitive.

CAUSE OF BOAR TAINT

Several chemical substances are thought to be responsible for causing boar taint of which androstenone and skatole are regarded as the most important (Hansson *et al.*, 1980; Dijksterhuis *et al.*, 2000). Other chemicals thought to contribute to taint include androstenol (Brennan *et al.*, 1986; Brooks and Pearson, 1989) and indole (García-Regueiro and Diaz 1989; Moss *et al.*, 1993; Annor-Frempong *et al.*, 1997; Rius and García-Regueiro, 2001), but they seem to be of lesser importance because of their relatively weak odour and different lipophilic properties.

Androstenone

Gonadotrophin releasing factor (GnRF), which is produced in the hypothalamus, stimulates the secretion of luteinising hormone (LH) and follicle stimulating hormone (FSH) from the anterior pituitary gland. In turn, LH stimulates the Leydig cells in the interstitial tissue of the testes to produce androgens including testosterone and androstenone (5α-androst-16-en-3-one) (Garner and Hafez, 1987). The testis of the boar has a high number of LH-binding sites: each Leydig cell in the adult has about 35,000 binding sites (Peyrat *et al.*, 1981). In contrast with other mammals, the boar possesses a relatively large amount of testicular interstitial tissue (Fawcett *et al.*, 1973) of which 70 per cent is composed of Leydig cells (Peyrat *et al.*, 1981). This explains the high output of steroid hormones in the boar. Androstenone is one of the main causes of boar taint (Patterson, 1968) and is perceived as a characteristic and unpleasant smell of urine or sweat by those individuals who are sensitive to it. Other descriptions include odour that is onion-like, ammonia-like, faecal, musk-like or animal-like. The boar is unique among mammals in that it specifically produces high quantities of androstenone, the output of the mature testes being some ten times that of testosterone (Claus *et al.*, 1971).

In addition to androstenone, other steroids and non-steroids have been identified in pig fat (Bonneau, 1982; Rius Solé and García-Regueiro, 2001; Rius *et al.*, 2005). These include androstenol (5α-androst-16-en-3-ol), various short-chain aldehydes and fatty acids, and phenolic compounds such as 4-phenyl-3-buten-2-one. The latter is thought to be derived from phenylalanine, and may account for the description of fruity, perfumed or "mothballs" (naphthalene) given by some individuals to boar taint. Three-α-androstenol has a musk-like or floral odour (Labows and Wysocki, 1984).

Skatole

Skatole (3-methyl-indole) has been identified as a cause of faecal odour that may be associated with pig fat (Vold, 1970). Skatole is produced in the large intestine by microbial breakdown of the amino-acid tryptophan (Yokoyama and

Carlson, 1979). The concentration of skatole in pig fat varies considerably from pig to pig and is related not only to production in the gut, but also to factors that influence skatole absorption and elimination from the body. Skatole can be influenced, but not reliably eliminated by diet (Jensen *et al.*, 1995). The addition of fibre, such as pectin or sugar-beet pulp to the diet, tends to reduce levels formed in the gut (Gill *et al.*, 1993; Wood *et al.*, 1994).

Relationship between Androstenone and Skatole

Androstenone may be found in low concentrations in females (Claus, 1976) but is only significant in entire males. In contrast, skatole may occur in significant concentrations in both males and females, although it has a much lower tendency to accumulate in the latter (Williams *et al.*, 1963; Claus *et al.*, 1996). In male pigs, levels of androstenone and skatole are often correlated with each other (Bonneau *et al.*, 1992; Annor-Frempong *et al.*, 1997) and high levels of both are found in fat from some boars aged around 110 days and weighing around 75 kg or more (Whittington *et al.*, 2004; Aldal *et al.*, 2005). A peak in steroid hormones also occurs in male piglets aged 2–4 weeks, but not in female or castrated piglets. However, skatole peaks occur in all three groups at this age, suggesting a relationship to increased microbial action associated with changes in the gut flora when pigs are weaned (Lanthier *et al.*, 2006).

Increased levels of androstenone in older, post-pubertal boars can be attributed to the increased synthesis of steroids in the increasing mass of testicular interstitial tissue (Bonneau, 1982; Claus *et al.*, 1994). Skatole levels vary substantially with age (Babol *et al.*, 2004). Beyond around 140 days of age, levels increase markedly in some males to very high levels, which are maintained until at least 240–260 days of age. Although skatole levels are to some extent correlated with anatomical and endocrinological indicators of sexual maturity, Babol *et al.* (2004) concluded that the increase is temporary and after reaching a maximum, levels tend to decline with age. Nevertheless, the time at which high levels tend to be present coincides with the average age of slaughter. Because high levels of skatole tend not to be found in gilts and castrated males, it is logical to assume that they are related to puberty in the entire male.

Skatole levels in fat are related to its metabolism in the liver (Friis, 1995; Squires and Lundström, 1997; Babol *et al.*, 1998a; Babol *et al.*, 1998b). Elevated levels of sex steroids reduce the hepatic metabolism of skatole and subsequent clearance from the body, resulting in increased accumulation of skatole in the fat (Babol *et al.*, 1999).

HUMAN SENSITIVITY TO BOAR TAINT

A major European study sampling 4,313 entire male carcases and 223 gilt carcases from pigs reared under normal commercial conditions showed that,

despite significant national differences in liking for meat from entire males, the degree of dislike increases as levels of both androstenone and skatole increase (Bonneau *et al.*, 2000; Matthews *et al.*, 2000). Skatole and androstenone levels in fat are, respectively, significantly correlated with scores produced by sensory taste panels for skatole odour, but not with scores for androstenone odour. Fat content of androstenone will not necessarily predict the odour of boar taint (Cameron *et al.*, 2000) probably because some people are unable to detect it (Wysocki and Beauchamp, 1984) or have become desensitised to it by frequent exposure and therefore do not find it unpleasant (Font i Furnols, 2003). Responses to different combinations of androstenone and skatole can sometimes be similar (Annor-Frempong *et al.*, 1997).

A taste panel composed entirely of women detected androstenone in 100 per cent of samples taken from 49 boars and none in samples from gilts of the same slaughter weight; the odour intensity was found to increase as the slaughter weight increased from 100 kg to 130 kg (Brennan *et al.*, 1986). Female consumers are known to be more critical than their male counterparts (Matthews *et al.*, 2000), and the ratio of men to women who are unable to smell androstenone is relatively uniform throughout the world (Table 1) (Gilbert and Wysocki, 1987).

Table 1 - Percentage of people who cannot smell androstenone, by region (adapted from Gilbert and Wysocki, 1987)

Region	Men	Women	Men : Women
Asia	25.5	17.2	1.48
Africa	21.6	14.7	1.47
Europe	24.1	15.8	1.53
U.K.	30.0	20.9	1.44
Latin America	24.6	17.7	1.39
Caribbean	29.2	17.5	1.67
USA	37.2	29.5	1.26

In a major study of large populations of people, around 27.46% of men and 19.04% of women could not smell androstenone: a ratio of around 1.44 men for every woman. However, when detected, the proportion of men and women who correctly identified the smell as "sweat" was roughly equal. A male bias for the inability to detect androstenone has also been reported by Baydar *et al.* (1993) but a recent study (Bremner *et al.*, 2003) suggests that true androstenone anosmia in the human population may be significantly lower than previously

estimated. Complete, specific androstenone anosmia was found to occur in 1.8 to 5.96 per cent of young, healthy adults. In assessing boar taint, it is important to realise that results of sensory panel studies are only valid if panellists are known to be able to detect androstenone. Weiler *et al.* (2000) found that individuals highly sensitive to androstenone reacted to both androstenone and skatole, whereas individuals with mild sensitivity for androstenone reacted to skatole only. Without differentiation according to individual sensitivity, the importance of androstenone might therefore be underestimated using this technique.

Detection Thresholds of Androstenone and Skatole

It has been proposed that levels above which meat can be considered to be tainted should be 1 ppm for androstenone and 250 ng/g for skatole (Mortensen *et al.*, 1986), although some national legislation has adopted a threshold of 500 ng/g for androstenone, as measured by heating salivary glands (German Meat Hygiene Ordinance, Annexe 1, Chapter 4, 2–3). For skatole, it is now generally accepted that the threshold should be 200 ng/g (Babol *et al.*, 2004).

TAINT DETECTION AT SLAUGHTER

There is clear potential value in a simple, objective slaughter-side screening test to identify tainted carcases rapidly (Babol and Squires, 1995). Sorting of carcases on the basis of androstenone and skatole can reduce, but not eliminate the problem, given current technology (Bonneau *et al.*, 2000). Tests based on human perception do not necessarily detect androstenone accurately and they would certainly be unable to keep pace with slaughter lines and carcass distribution. Laboratory analytical methods such as photospectrometry, high-pressure liquid chromatography and gas chromatography are all highly effective in detecting both androstenone and skatole, but do not have a slaughter-side application. Photospectrometry has been specifically assessed as a potential means of screening (Mortensen and Sorensen, 1984). Initially it was considered to be too slow, too expensive and was able to detect only one compound at a time. The system has been adapted in Denmark for the routine detection of skatole on-line in one slaughterhouse only, since most male pigs produced there are castrated (F. Andersen, personal communication, 2007). Squires (1990) described a similar system for the detection of androstenone, but to date this has not been validated in slaughterhouses.

A monoclonal antibody-based ELISA has been developed for the rapid detection of androstenone in boar sera (Abouzied *et al.*, 1990) and good correlation has been demonstrated between serum levels and fat levels (Tuomola *et al.*, 1997). Good correlation has also been demonstrated between serum and fat levels of skatole (Tuomola *et al.*, 1996) so routine slaughter-side serum ELISA screening for boar taint is a distinct possibility.

Perhaps the most promising means of slaughter-side boar taint detection is the development of an electronic nose based on gas sensor array technology that can discriminate between different levels of taint (Annor-Frempong *et al.*, 1998).

If identified quickly on the slaughter line, carcases could either be rejected or handled and processed differently. Results from taste panels reported by Williams *et al.* (1963) indicate that it may be possible to use meat with boar taint in highly spiced comminuted preparations such as salami, but these should be for consumption without heating, or in preparations that contain pork liver since the smell of liver tends to mask the smell of boar taint. If any control system is eventually developed based on management changes to reduce the incidence of boar taint and testing to identify any remaining affected carcases, its economic viability will depend on the proportion of rejected carcases and whether any commercial use can be found for them.

CONTROL OF BOAR TAINT

Apart from surgical castration, most of the world has, until now, had no effective method by which boar taint can be controlled in post-pubertal pigs. Some management practices can reduce its presence, but not eliminate it. The new technology of vaccination against GnRF has been used for some time in Australia and New Zealand and is now becoming more widely available. It provides a highly effective alternative to surgical castration.

Management and Husbandry

Improved standards of piggery hygiene aimed at reducing the overall contact of pigs with faecal material, particularly in summer months, would be expected to reduce skatole levels in carcases of both males and females by reducing transcutaneous absorption. It is thought that, in high temperatures, skatole may pass through the skin as pigs wallow or it may be absorbed in gaseous form through the lungs. Pigs allowed to lie in pens with solid floors that were heavily soiled with faeces and urine and that were kept at high stocking densities (0.6 m^2 per pig) for a week or more, had higher levels of skatole in their subcutaneous fat than pigs from clean pens with low stocking densities (1.2 m^2 per pig). Within a week of slaughter, it was possible to increase or lower skatole levels by reversing the conditions (Hansen *et al.*, 1994). The findings of Walstra *et al.* (1999) confirmed these results on a wider scale. Attention to stocking rates, ventilation and hygiene, particularly in summer, is therefore potentially important in mitigating skatole levels, as is the keeping of pigs on slatted floors (Kjeldsen, 1993).

By reducing the slaughter weight of pigs, it may be possible to avoid high levels of boar taint. This is done in some countries such as the U.K. and Ireland, but it is unlikely to be viable commercially for most other countries.

Androstenone levels rise at puberty in the male pig, commencing at around 100 days of age. At approximately 120 days of age, the development of the Leydig cells is maximal (Colenbrander *et al.*, 1982) but the liveweight of the pig would be about 75 kg and therefore too light for the majority of markets. Maintaining current levels of pork production, but with lighter slaughter weights, would require a substantial increase in the number of pigs slaughtered with increased production costs and additional physical resource input.

Social interactions may influence levels of androstenone in groups of pigs. Fredriksen *et al.* (2006) raised 1,353 entire males in stable social groups and compared the effects of keeping pigs in the same litter from birth to slaughter, mixing pigs at 25 kg bodyweight. At slaughter, the mean levels of androstenone in fat were 820 and 1,000 ng/g respectively, but although androstenone was lower in the unmixed group, 45 per cent of pigs still had concentrations above the threshold value of 1,000 ng/g.

From 107 days of age, plasma androstenone levels were shown to increase in individually housed boars (Narendran *et al.*, 1982). When sows in oestrus were introduced into the boar pens, plasma androstenone increased by 247 ± 27 per cent in the ensuing 24 hours. A control boar showed an increase of similar magnitude (221%), probably because of auditory and olfactory stimulation. It is therefore possible that in mixed-sex rearing, androstenone levels may rise in males as females in the group come into oestrus. Patterson and Lightfoot (1984) demonstrated that some boars indeed had high androstenone levels when reared with gilts when slaughtered at weights above 100 kg. Thus the rearing of stable groups of the same sex is to be advocated when attempting to reduce the potential for boar taint in entire males.

Nutrition

High skatole levels can be induced by the feeding of brewers' yeast, presumed to be as a result of poor ileal digestibility and therefore a higher level of fermentation of protein in the hindgut (Jensen *et al.*, 1995). The incorporation of fibre in the diet as either wheat-bran or sugar-beet pulp, or the replacement of yeast with casein, reduced the backfat levels of skatole. It was concluded that skatole production depended on the amount of protein entering the hindgut and the preferential proteolytic activity of the intestinal flora.

Feeding a wet feed with whey as the liquid fraction rather than water reduced backfat skatole levels in comparison with the feeding of dry feed (Andersson *et al.*, 1997). There were no effects from differing levels of lysine in this study, presumably because of its high ileal digestibility, but Lundström *et al.* (1994) found that entire male pigs fed a low protein diet and slaughtered at 103 kg had lower skatole levels than either those fed on a high protein diet or females on both diets.

Antibiotics

Since skatole is primarily a product of microbial proteolysis in the hindgut, it is possible that the addition of antibiotics to the feed of finishing pigs might suppress production (Mackinnon, 1985), but there would be no anticipated effect on androstenone. Using low levels of tylosin and virginiamycin (20 ppm in each case), Hansen and Larsen (1994) were unable to demonstrate a significant reduction in the skatole concentration in the neck fat of entire male pigs. However, Allen *et al.* (2001) reported lower skatole levels in entire boars fed wet feed containing virginiamycin. The addition of zinc bacitracin to fermented liquid feed has also been shown to be effective in reducing skatole levels (Hansen *et al.*, 1997). In Europe, the routine use of antibiotics in feed for purposes other than the treatment and control of disease under veterinary supervision is not permitted and it would therefore not be an option for the control of boar taint.

Breeding and genetic selection

The heritability of androstenone levels in the carcase ranges from 0.25 to 0.82 (Willeke, 1993) and selection of boars has shown that it is possible to reduce the levels of androstenone below accepted thresholds (Willeke *et al.*, 1987). The main influencing factor is likely to be the age at which the males reach puberty, there being differences between breeds in the levels of androstenone in carcase fat by the time pigs reach slaughter weight. The Duroc breed has much higher levels of androstenone than the Yorkshire, Landrace or Hampshire breeds (Xue *et al.*, 1996) and the Large White has higher levels than the Landrace (Willeke, 1993). Genetics also influence the accumulation of skatole in boar fat. Lundström *et al.* (1994) have suggested that a recessive gene is responsible for high skatole levels, especially when intestinal levels are high. A distinct age-related distribution of plasma skatole levels has been found in Yorkshire, Landrace, Hampshire and Duroc boars (Babol *et al.*, 2004). Maximum levels were observed at approximately 180–200 days of age in all boars. Levels decreased in the Yorkshire and Landrace at approximately 240–260 days, but persisted in the Hampshire and Duroc until 310–360 days. It is possible that age-related levels are determined by the activity of specific enzymes responsible for hepatic metabolism (Whittington *et al.*, 2004).

Lee *et al.* (2005) have detected quantitative trait loci for androstenone and skatole in Large White x Meishan pigs. Thus far, genetic selection specifically for the reduction of boar taint has not been a practical option, perhaps because high androstenone levels could reflect libido and male fertility. However, simulation studies based on assumptions about the heritability of boar taint indicate that significant reductions could be made over five years (Ducro-Steverink, 2006). Boar taint is highly heritable and a number of candidate genes for it have been identified (Squires, 2006). Work is currently in progress on genetic markers for low boar taint based on these genes.

Artificial Insemination Using Sexed Semen

For elimination of androstenone and reduction of skatole levels alone, there would be enormous advantages in breeding female slaughter pigs only. Flow cytometry has successfully led to the birth of normal offspring from sexed sperm of at least seven mammalian species, the sperm of the ox and the pig being particularly well suited to such separation techniques (Garner, 2006). In one study, the mean pregnancy rate in multiparous sows using sexed semen was only 33.3 per cent, but all but one piglet born were of the predicted sex (Grossfield *et al.*, 2005). Sexed semen has the potential for increasing the rate of genetic progress, especially when insemination technology can capitalise on methods using low sperm numbers (Gerrits *et al.*, 2005). There is, however, some way to go before sexed semen for the production of slaughter pigs becomes a commercial reality (Johnson *et al.*, 2005; Heinritzi *et al.*, 2006), although recent commercial announcements have been made in the farming press. Flow cytometry allows the sorting of approximately 15 million sperm per hour, which does not compare favourably with the typical sperm concentration of a single commercial semen dose which contains between two and three billion viable sperm. Speed of separation and viability of sorted sperm need to be improved and equipment costs must be reduced for semen sexing to become a viable economic consideration. Furthermore, the disadvantage of rearing predominantly female pigs is that production efficiency will be reduced.

Suppression of Male Characteristics

Surgical Castration

Until recently, surgical castration was the only way of eliminating androstenone and reducing skatole in carcases of post-pubertal male pigs that was sufficiently reliable for routine use. It should be noted, however, that even surgical castration is not completely effective in practice. A recent US field survey reported a 1–2 per cent prevalence of significant androstenone concentrations in apparently castrated pigs and, occasionally, in gilts. Possible explanations are cryptorchidism, intersex pigs and adrenal malfunction (Nederveld *et al.*, 2006). Additionally, in environments heavily contaminated with faeces, skatole can accumulate to levels above taint thresholds in both castrated males and female pigs. In practical terms though, surgical castration offers an effective solution to the problem of boar taint. Unfortunately, there are serious welfare concerns related to this procedure and disadvantages related to growth performance and lean meat content of castrated males when compared with entire males.

Pain-related vocalisation during castration has been analysed by Marx *et al.* (2003). Castration compared with simple restraint resulted in comprehensive changes in vocalisations: vocalisations were more extended and powerful,

indicating that pain-related changes in calls of piglets can be identified. It is important to distinguish the differences between "honest" signalling and other vocalisations because piglets tend to respond to handling with high frequency calls at maximum levels. The stress characteristics of vocalisations in terms of pureness and entropy are most pronounced during the surgical period of the process of handling and castration (Puppe *et al.*, 2005); the way in which pigs are restrained does not affect the pain caused by castration (Weary *et al.*, 1998). Taylor *et al.* (2001) concluded that the assumption that neo-natal animals are less sensitive to pain than older animals is incorrect.

Physiological responses are also potential indicators of pain. White *et al.* (1995) found, when comparing responses of pigs during castration with and without local anaesthesia, that the highest heart rates and energy of vocalisations came from pigs castrated without local anaesthesia. Incision of the scrotum and severing of the spermatic cord elicited a greater increase in heart rate than removal of the testicles and ligation of the cord. McGlone *et al.* (1993) and Taylor *et al.* (2001) found no differences in behaviour and perception of pain when piglets were castrated at different ages from one to 20 days, but 14 days was optimum for subsequent growth and weaning weight (McGlone *et al.*, 1993). Under EU legislation (Anon, 2001a), the administration of local anaesthesia would be required beyond the age of seven days.

Local anaesthesia can mitigate pain-induced behaviour in young pigs from two to four weeks of age, but apparently not in older pigs at seven weeks of age (McGlone and Hellmann, 1988; Horn *et al.*, 1999; Haga and Ranheim, 2005). There is no demonstrable difference in effect between injection of the local anaesthetic into testicular tissue or into the spermatic cord (Haga and Ranheim, 2005), or with sub-cutaneous infiltration prior to injection into the testicular tissue. Mean arterial blood pressure, electroencephalogram readings and pulse rate all showed significantly smaller responses to castration with local anaesthetic compared with the administration of the anaesthetic itself (Haga and Ranheim, 2005), suggesting physiological stress in addition to pain. Significant increases in adrenocorticotrophic hormone (ACTH), cortisol and lactate induced by castration (Prunier *et al.*, 2005) indicates potential for tissue damage as well as stress.

General anaesthesia during castration has been attempted, but it has been associated with high mortality and subsequent suppression of nursing behaviour (McGlone and Hellmann, 1988). Castration of piglets using CO_2 anaesthesia has also been reported. (Svendsen, 2006).

In addition to castration being a painful mutilation, the open wounds that are usually left to heal by second intention under typical farm conditions may become infected by pyogenic bacteria leading to chronic inflammation (de Kruijf and Welling, 1988).

Surgical castration of piglets is performed routinely in most pig producing countries in the world. In the UK, whilst not illegal, the practice is considered undesirable on welfare grounds so quality assurance schemes do not permit the procedure as routine. The European Commission Directive 2001/93/EC (Anon, 2001a) sets out minimum standards for the protection of pigs, stating that any procedure carried out other than for reasons of treatment, diagnosis or identification that results in the loss of a sensitive part of the body or alteration of bone structure shall be prohibited. Castration, by means other than tearing of tissues, is listed as an exception, but after the age of seven days it should only be performed by a veterinary surgeon with anaesthesia and additional prolonged analgesia. An earlier scientific report prepared for the European Commission considered the procedure acceptable if it did not cause pain (Anon, 1997).

The European Commission will review welfare legislation again in 2009 and it is possible that routine castration will be banned and allowed only in exceptional circumstances with local anaesthesia and under veterinary supervision. In Norway, this approach has been mandatory since 2002. The views expressed by the European Commission (Anon, 1997) are supported by the Federation of Veterinarians of Europe (Anon, 2001b) who concluded that, in the future, the need to castrate male piglets surgically should be reduced by developing realistic ethical and practical alternatives.

CONTROL OF BOAR TAINT: IMMUNOCASTRATION

There are many opportunities for the use of immune modulation techniques in livestock that offer the potential to reduce use of chemicals and for the need for surgical procedures to be carried out (Lofthouse and Kemp, 2002). Vaccination against GnRF is a very attractive means of simulating surgical castration in farm animals (Bonneau and Enwright, 1995), particularly in pigs, because their relatively short growth period limits the time for which efficacy is required. In addition to control of boar taint, the technology of immunocastration offers possibilities to reduce aggressive behaviour in males, to act as a contraceptive in domestic pets and wild-life and to treat steroid-related cancers such as cancer of the prostate (Thompson, 2000). Avoidance of surgical castration at a young age and its replacement with immunological castration closer to slaughter also offers potential production efficiency benefits in cattle, sheep, goats and pigs, with improved carcase characteristics compared with surgical castrates.

Vaccination of entire male pigs against GnRF reduces plasma gonadotrophins and androgen levels and either inhibits the development or causes the regression of testicular parenchyma and the secondary male sex organs (Caraty and Bonneau, 1986; Falvo *et al.*, 1986; Oonk *et al.*, 1998; Beekman *et al.*, 1999; McCauley *et al.*, 2000; Dunshea *et al.* 2001; Metz *et al.*, 2002; Zeng *et al.*, 2001; Jaros *et al.*, 2005). It suppresses sexual development in gilts as well as boars (Oliver *et al.*, 2003).

Concept, Formulation and Administration of Improvac™

GnRF is a peptide neurohormone produced in the preoptic area of the hypothalamus (Schaison, 1990); it is secreted into the hypophyseal portal bloodstream then carried to the pituitary gland. The gonatrope cell membranes contain GnRF receptors which, when activated, trigger the release of luteinising hormone (LH) and follicle-stimulating hormone (FSH) (McCann and Ojeda, 1996). LH is also known as interstitial cell-stimulating hormone because it stimulates the Leydig cells of the testis to produce steroid hormones such as androstenone and testosterone.

Immunocastration is achieved by successfully raising antibodies to endogenous GnRF, thereby blocking the above chain of events and removing the stimulus for testicular activity. For it to be a real alternative to surgical castration, an anti-GnRF vaccine must be reliable and safe to use. Meloen *et al.* (1994) described problems with the development of vaccination against GnRF because GnRF derived antigens may be recognised as "self," even after multiple vaccinations. They developed a 20-amino-acid tandem repeat of the GnRF peptide sequence to act as the antigen, which totally abolished the development and endocrinological function of the testes. To achieve successful vaccination against GnRF, it was found necessary to use Freund's complete adjuvant and to administer the vaccine in repeated high doses. Further modifications were developed in which the peptide sequence was conjugated with other components to enhance antigenicity and lower the frequency of administration (Oonk *et al.*, 1998; Beekman *et al.*, 1999). Improvac™, the only commercially available GnRF vaccine, contains a synthetic, incomplete analogue of GnRF conjugated to an inert carrier protein to make up the complete antigen. This is then combined with an aqueous-based synthetic adjuvant to increase the level and duration of the immune response whilst avoiding excessive tissue reaction at the site of injection (Improvac™, Australian Product Information).

A dose titration study carried out with Improvac™ (Study G102: Pfizer Animal Health) compared the effects of increasing the dose of GnRF conjugate from 200µg to 2,000µg, with a saline control. Within this range, there were no significant differences between the different potencies on testis growth and function. To allow a margin for error, the commercial product contains 200µg/ml of the conjugate and thus provides 400µg of antigen per 2 ml dose, which is administered sub-cutaneously behind the ear. Two separate doses are required at least four weeks apart to achieve immunocastration. The timing of dosing is discussed further later in this review.

Efficacy of Improvac™

The effect of immunocastration can be measured by monitoring plasma androgen levels and the dimensions of the testicles (Oonk *et al.*, 1995), although there is a high degree of natural variation in the testicular dimensions,

especially during puberty when testicular growth is rapid. At slaughter, efficacy of immunocastration can be assessed by measuring testosterone and the weights and dimensions of the testes and the bulbo-urethral glands. Direct evidence of successful prevention of boar taint can be obtained by measuring androstenone and skatole concentrations in fat.

Effect of Improvac™ on Testes and Bulbo-urethral Glands

The priming dose of Improvac™ has no physiological effect on the size of the testes or serum testosterone level by the time of administration of the second dose four weeks later (Dunshea *et al.*, 2001). However, within two weeks of administration of the second dose, suppression of testes growth and secretion of testosterone is evident and, at slaughter approximately four weeks after the second dose, the weight of the testes and the bulbo-urethral glands, trimmed of connective tissue, are approximately half that of unvaccinated entire males. Figures 1 and 2 show the impact of immunocastration on the testes and bulbo-urethral glands. The effect of vaccination against GnRF on the testes and bulbo-urethral glands following the administration of two doses of Improvac™ has been clearly demonstrated in several studies, which are summarised in Table 2.

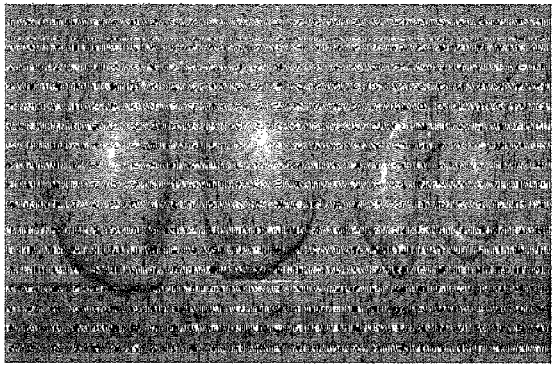


Fig. 1 - Comparison of testes from a male pig vaccinated with Improvac™ (left) with the testes from a unvaccinated male pig (right)
(Photo courtesy of Pfizer Animal Health).

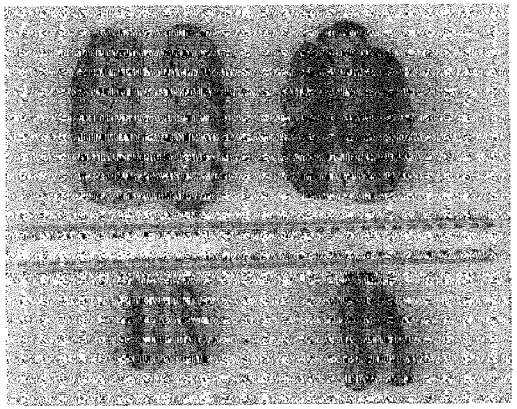


Fig. 2 - Comparison of bulbo-urethral glands from entire male pigs vaccinated with Improvac™ (bottom) with bulbo-urethral glands from un-vaccinated pigs (top)
(Photo courtesy of Pfizer Animal Health).

Table 2 - Weight and dimensions of the testes and bulbo-urethral glands of entire male pigs vaccinated against GnRF with Improvac™ and un-vaccinated entire males

Study	Nº boars per group		Testes				Bulbo-urethral glands			
	Not Vaccinated	Improvac	Mean weight (g)		Mean width (mm)[1]		Mean weight (g)		Mean length (mm)	
			Not Vaccinated	Improvac	Not Vaccinated	Improvac	Not Vaccinated	Improvac	Not Vaccinated	Improvac
Dunshea *et al.* (2001) Light slaughter[2]	50	50	421.6	182.6***	124.0	93.9***	137.4	52.9***	120.5	86.5***
Dunshea *et al.* (2001) Heavy slaughter[3]	50	50	509.6	254.4***	133.0	102.6***	148.0	75.1***	117.2	93.8***
Jaros *et al.* (2005)	77	270	761.9	230.9***	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Study G104[4]	40	32	344.0	198.7***	111.0	95.9***	110.3	51.3***	108.4	79.0***
Study G105[5]	17	19[6]	351.1	157.2***	116.6	85.3***	117.0	48.2***	106.8	81.6***

Key:

1 Scrotal width measured *in vivo* with engineering calipers 4 weeks after second dose of Improvac.

2 Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

3 Improvac given at 18 and 22 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

4 Study G104: Pfizer Animal Health, Improvac given at weaning and at 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

5 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

6 Eighteen animals for bulbo-urethral gland measurements.

Table 2 contd. - Weight and dimensions of the testes and bulbo-urethral glands of entire male pigs vaccinated against GnRF with Improvac™ and un-vaccinated entire males

Study	Nº boars per group		Testes				Bulbo-urethral glands			
	Not Vaccinated	Improvac	Mean weight (g)		Mean width (mm)[1]		Mean weight (g)		Mean length (mm)	
			Not Vaccinated	Improvac	Not Vaccinated	Improvac	Not Vaccinated	Improvac	Not Vaccinated	Improvac
Study G105[7]	20[8]	20	443.1	210.4***	120.9	92.6***	120.0	56.1***	114.6	90.9***
Study G106 (site 1)[9]	46	50	450.8	198.5***	125.9	91.0***	n.a.	n.a.	n.a.	n.a.
Study G106 (site 2)[9]	47	48	380.3	222.4***	115.0	94.9***	n.a.	n.a.	n.a.	n.a.
Study G106 (site 3)[9]	45	43	452.5	265.9***	118.2	96.7***	n.a.	n.a.	n.a.	n.a.

Key contd. -

7 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, six weeks after second vaccination.

8 18 animals for bulbo-urethral gland measurements.

9 Study G106: Pfizer Animal Health, Improvac given at age 15 and 19 weeks. Measurements taken at slaughter, four weeks after second vaccination.

n.a. not recorded or not tested.

*** Significantly different from un-vaccinated pigs, $P<0.001$

Dunshea *et al.* (2001) vaccinated commercial Large White × Landrace pigs in Australia at either 15 and 19 weeks of age or 18 and 22 weeks of age to determine whether there were any differences in effect between light and heavy slaughter weights four weeks later at 23 (around 98 kg liveweight) and 26 weeks (around 120 kg liveweight) of age. The width of the testes was measured using engineering calipers prior to slaughter and, after slaughter, the testes and bulbo-urethral glands were dissected out, trimmed of connective tissue, weighed and measured. In both age groups, Improvac™ significantly reduced weights and dimensions.

Jaros *et al.* (2005) vaccinated commercial Large White × Landrace crosses and Duroc crosses on two farms in Switzerland with two doses of Improvac™ at an interval of 4–5 weeks between doses, the second dose being given 4–6 weeks prior to slaughter. Pigs weighed approximately 48 and 77 kg at the time of vaccination on the first farm and 37 and 64 kg on the second. The slaughter weights ranged from 100 to 110 kg and vaccination was timed to take into account the growth rate of the pigs. After slaughter, the testes of the vaccinated pigs were compared with un-vaccinated controls and were found to be significantly lighter. Similar, highly significant, results were found in a study in Australia of pigs that were slaughtered either 4 or 6 weeks after the second dose (Study G105: Pfizer Animal Health).

In a further study in Australia (Study G104: Pfizer Animal Health), it was demonstrated that an anti-GnRF effect on the development of the testes and bulbo-urethral glands was achieved if pigs were vaccinated at weaning and again at 19 weeks of age. In a field study conducted at three different locations (one in New Zealand and two in Australia) (Study G106, sites 1–3: Pfizer Animal Health) using commercial crosses, highly significant suppression of the testicular growth was confirmed.

In effect, vaccination of entire males against endogenous GnRF appears to mimic experimental hypophysectomy, which has been shown to either halt the development or cause the regression of the male sex organs depending on age (Anderson, 1987).

Effect of Improvac™ on Boar Taint Compounds

The testis of the boar has a high number of LH-binding sites (Peyrat *et al.*, 1981) and because of the relatively large testicular mass in this species (Fawcett *et al.*, 1973), the output of steroid hormones is potentially very high, especially of androstenone (Claus *et al.*, 1971). There is a correlation between the levels of androstenone and skatole in boars (Bonneau *et al.*, 1992), with high levels of both occurring naturally from around 110 days of age onwards (Whittington *et al.*, 2004; Aldal *et al.* 2005). Studies with Improvac™ have demonstrated that the anti-GnRF effect significantly diminishes the size of the testes and, as might be expected, brings about a concomitant suppression of testosterone and androstenone (Table 3).

Table 3 - Serum testosterone and androstenone and skatole levels in the fat of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males

Study	Mean serum testosterone (ng/ml)			Mean fat androstenone (ng/g)			Mean fat skatole (ng/g)		
	Not Vaccinated, Entire	Castrates	Improvac	Not Vaccinated, Entire	Castrates	Improvac	Not Vaccinated, Entire	Castrates	Improvac
Dunshea *et al.* (2001) (Light slaughter)	10.5	0.28***	1.16***	1,210	106***	160***	133	48***	68***
Dunshea *et al.* (2001) (Heavy slaughter)	8.26	0.27***	0.62***	1,050	103***	126***	95	46***	56***
Jaros *et al.* (2005)	n.a.	n.a.	n.a.	n.a.	42	58	n.a.	n.a.	n.a.
Study G104 [1]	7.20	n.a.	1.30***	730	n.a.	120***	66	n.a.	42
Study G105 [2]	8.20	n.a.	1.33***	715	n.a.	166**	94	n.a.	36*

Key:

1 Study G104: Pfizer Animal Health, Improvac given at weaning and at 19 weeks of age. Measurements taken four weeks after second vaccination.

2 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

Table 3 contd. on next page

Table 3 contd. - Serum testosterone, and androstenone and skatole levels in the fat of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males

Study	Mean serum testosterone (ng/ml)			Mean fat androstenone (ng/g)			Mean fat skatole (ng/g)		
	Not Vaccinated, Entire	Castrates	Improvac	Not Vaccinated, Entire	Castrates	Improvac	Not Vaccinated, Entire	Castrates	Improvac
Study G105 [3]	11.44	n.a.	2.21***	611	n.a.	173**	131	n.a.	69*
Study G106 (site 1) [4]	19.2	n.a.	0.66***	1,358	n.a.	111***	119	n.a.	36**
Study G106 (site 2) [4]	8.7	n.a.	0.97***	445	n.a.	120***	227	n.a.	131***
Study G106 (site 3) [4]	7.9	n.a.	0.87***	707	n.a.	100***	215	n.a.	130***

Key contd. -

3 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, six weeks after second vaccination.

4 Study G106: Pfizer Animal Health, Improvac given at age 15 and 19 weeks. Measurements taken at slaughter, four weeks after second vaccination.

n.a. Not recorded or tested.

*, **, *** Significantly different from un-vaccinated entire male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

Serum testosterone levels in vaccinated entire male pigs were compared with un-vaccinated and surgically castrated males (Dunshea *et al.*, 2001) slaughtered at either 23 or 26 weeks of age. Significantly less testosterone was found in castrated males: the amount detected was less than one-thirtieth of that detected in un-vaccinated entire males. Improvac™ vaccination suppressed testosterone levels to almost the same degree with no significant difference between the vaccinated entire males and the surgically castrated males. Significant reductions in circulating testosterone were also found in pigs given the first vaccination at weaning (Study G104: Pfizer Animal Health), pigs slaughtered at either 4 or 6 weeks after the second dose (Study G105: Pfizer Animal Health) and in a commercial field study at three locations (Study G106 sites 1–3: Pfizer Animal Health).

Dunshea *et al.* (2001) recorded significant reductions in the levels of androstenone in fat from vaccinated entire males to below the accepted threshold of 1,000 ng/g compared with unvaccinated controls, and there were no significant differences between the androstenone levels found in the vaccinated entire pigs and surgically castrated pigs. This effect on androstenone was confirmed by Jaros *et al.* (2005) who measured the level of androstenone in the salivary glands. A significant reduction of androstenone in the fat of vaccinated entire males has also been confirmed in field studies (Studies G104, G105 and G106: Pfizer Animal Health) in which comparisons were drawn with un-vaccinated entire males, regardless of whether the first dose was given at weaning, as in study G104, or later. These studies carried out by Dunshea *et al.* (2001) and Pfizer Animal Health showed that there was also a highly significant reduction in skatole levels in the fat. Tables 4 and 5 show the numbers of pigs in controlled studies that were above and below the accepted thresholds for androstenone and skatole. Nearly 35 per cent of pigs in the un-vaccinated entire male groups were above the threshold of 1,000 ng/g for androstenone, with figures ranging from 10 to 59 per cent, depending on the study. A further 24 per cent of entire pigs had androstenone concentrations between 500 and 1,000 ng/g, leaving only 41.5 per cent below 500 ng/g. Among male pigs vaccinated with Improvac™, only one pig was above the 1,000 ng/g limit for androstenone, giving 99.8 per cent below this figure, and 98.3 per cent were below the lower androstenone threshold of 500 ng/g. Just over 80 per cent of entire male pigs had concentrations of skatole below the 200 ng/g threshold, with figures ranging from 57 per cent to 100 per cent, depending on the study. In contrast, 97.4 per cent of vaccinated pigs were below the threshold for skatole. No pigs vaccinated with Improvac™ were identified with high concentrations of both compounds - a situation that represents the highest risk for detectable taint.

Table 4 - Percentage and number of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males with androstenone levels above the thresholds of 500 ng/g fat and 1,000 ng/g fat

Study	Fat Androstenone Concentration								
	< 500 ng/g			500–1,000 ng/g			> 1,000 ng/g		
	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)
Dunshea *et al.* (2001) (Light slaughter)	27 (12)	100 (47)	94 (45)	22 (10)	0 (0)	6 (3)	51 (23)	0 (0)	0 (0)
Dunshea *et al.* (2001) (Heavy slaughter)	27 (13)	100 (48)	100 (46)	25 (12)	0 (0)	0 (0)	48 (23)	0 (0)	0 (0)
Jaros *et al.* (2005)	n.a.	100 (263)	99.3 (268)	n.a.	0 (0)	0.4 (1)	n.a.	0 (0)	0.4 (1)
Study G104 [1]	37 (14)	n.a.	100 (32)	37 (14)	n.a.	0 (0)	26 (10)	n.a.	0 (0)
Study G105 [2]	53 (9)	n.a.	89 (17)	18 (3)	n.a.	11 (2)	29 (5)	n.a.	0 (0)

Key:

1 Study G104: Pfizer Animal Health, Improvac given at weaning and at 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

2 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

Table 4 contd. - Percentage and number of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males with androstenone levels above the thresholds of 500 ng/g fat and 1,000 ng/g fat

Study	Fat Androstenone Concentration								
	< 500 ng/g			500–1,000 ng/g			> 1,000 ng/g		
	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)
Study G105 [3]	60 (12)	n.a.	95 (19)	20 (4)	n.a.	5 (1)	20 (4)	n.a.	0 (0)
Study G106 (site 1) [4]	25 (11)	n.a.	98 (47)	16 (7)	n.a.	2 (1)	59 (26)	n.a.	0 (0)
Study G106 (site 2) [4]	69 (34)	n.a.	98 (48)	21 (10)	n.a.	2 (1)	10 (5)	n.a.	0 (0)
Study G106 (site3) [4]	48 (25)	n.a.	100 (42)	29 (15)	n.a.	0 (0)	23 (12)	n.a.	0 (0)
Overall	41.5 (130)	100 (358)	98.3 (564)	24 (75)	0 (0)	1.6 (9)	34.5 (108)	0 (0)	0.2 (1)

Key contd. -

3 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, six weeks after second vaccination.

4 Study G106: Pfizer Animal Health, Improvac given at age 15 and 19 weeks. Measurements taken at slaughter, four weeks after second vaccination.

n.a. not recorded or not tested.

Table 5 - Percentage and number of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males with skatole levels above the threshold of 200 ng/g.

Study	Fat Skatole Concentration					
	< 200 ng/g			≥ 200 ng/g		
	Per Cent Not Vaccinated, Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated, Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)
Dunshea *et al.* (2001) (Light slaughter)	84 (38)	100 (47)	98 (47)	16 (7)	0 (0)	2 (1)
Dunshea *et al.* (2001) (Heavy slaughter)	94 (45)	100 (48)	100 (46)	6 (3)	0 (0)	0 (0)
Pfizer G104 [1]	100 (39)	n.a.	100 (32)	0 (0)	n.a.	0 (0)
Study G105 [2]	88 (15)	n.a.	100 (19)	12 (2)	n.a.	0 (0)

Key:

1 Study G104: Pfizer Animal Health, Improvac given at weaning and at 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

2 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, four weeks after second vaccination.

Table 5 contd. - Percentage and number of entire male pigs vaccinated against GnRF with Improvac™, un-vaccinated entire males and surgically castrated males with skatole levels above the threshold of 200 ng/g.

Study	Fat Skatole Concentration					
	< 200 ng/g			≥ 200 ng/g		
	Per Cent Not Vaccinated, Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)	Per Cent Not Vaccinated, Entire (Number)	Per Cent Castrated (Number)	Per Cent Improvac (Number)
Study G105 [3]	90 (18)	n.a.	100 (20)	10 (2)	n.a.	0 (0)
Study G106(site 1) [4]	86 (38)	n.a.	100 (48)	14 (6)	n.a.	0 (0)
Study G106(site 2) [4]	57 (28)	n.a.	92 (45)	43 (21)	n.a.	8 (4)
Study G106(site3) [4]	62 (32)	n.a.	93 (39)	38 (20)	n.a.	7 (3)
Overall	80.6 (253)	100 (95)	97.4 (296)	19.4 (61)	0 (0)	2.6 (8)

Key contd. -

3 Study G105: Pfizer Animal Health, Improvac given at 15 and 19 weeks of age. Measurements taken at slaughter, six weeks after second vaccination.

4 Study G106: Pfizer Animal Health, Improvac given at age 15 and 19 weeks. Measurements taken at slaughter, four weeks after second vaccination.

n.a. not recorded or not tested.

It should be noted that clinical trial protocols inevitably create some artificiality. Greater attention to detail means that pigs are less likely to escape treatment than in a commercial setting, potentially improving results. Countering this bias, however, is the fact that none of the trials included the on-farm quality assurance procedures that are routinely associated with the commercial use of Improvac™. Re-vaccination is normally recommended for any pig suspected of having an incomplete response to the second vaccination, based on visible assessment of testicle size and observation of male sexual behaviour. In surgical castration groups, cryptorchid pigs are more likely to be identified and removed, eliminating the most common cause of failure to control boar taint with surgical castration.

Sensory Assessment of Meat from Improvac™ Vaccinated Pigs

In addition to chemical assay of androstenone and skatole concentrations, the presence or absence of boar taint can also be assessed in sensory tests, relying on human subjects to detect the taste and/or smell of boar taint in meat. Several of the studies already mentioned included this component. As would be expected, surgical castration effectively eliminated detectable boar taint in the studies carried out by Dunshea *et al.* (2001) and Jaros *et al.* (2005) and the results for the pigs vaccinated with Improvac™ compared favourably.

D'Souza *et al.* (2000) reported results of a consumer taste panel assessment of boar odour and flavour of cooked loin steaks from entire males, surgically castrated males and entire males vaccinated with Improvac™, of two genotypes (A = fast growing lean type and B = a type with the propensity for increased fat deposition). The taste panel was balanced for age and gender and ten individuals tasted each sample. From genotype A, the surgical castrates had the most acceptable odour and taste, whilst in genotype B, the immunocastrates were rated most acceptable. In a comparison of the acceptability of odour of meat from vaccinated and un-vaccinated entire males, Hennessy and Walker (2004) found that no samples from the Improvac™ vaccinated group were found to be unacceptable.

In a global assessment of human sensitivity to androstenone (Gilbert and Wysocki, 1987) people of Asian origin were found to be the most sensitive (Table 1). Hennessy and Newbold (2004) found that an Asian group of consumers had fewer bad experiences of undesirable sensory attributes of pork because they tend to source meat only from female carcases. With this fact in mind, a further study assessing the sensory attributes of cooked loin steaks was carried out in The Philippines (Hennessy *et al.*, 2006) where comparisons were made between meat from female, castrated male and Improvac™ vaccinated entire male pigs. The assessment was made by 122 female and 43 male consumers chosen at random and they found that there were no sensory differences in odour and flavour between the three categories of meat.

These sensory studies confirm the chemical results that Improvac™ can effectively and consistently eliminate boar taint from meat from entire male pigs.

SAFETY OF IMPROVAC™

Injection Site Reactions

Improvac™ contains an aqueous adjuvant that is non-depot forming and rapidly clears from the injection site. In studies described earlier, carried out under commercial conditions, injection site reactions were closely monitored. Some reactions were detectable but there were no significant differences between groups given Improvac™ or a saline placebo (Dunshea *et al.*, 2001). Occasional abscesses were detected at slaughter in other studies, indicating that the standard advice given for the use of all vaccines on maintenance of hygienic conditions by the operator during administration should be followed (Data on file, Pfizer Animal Health). In the field studies, approximately 90 per cent of pigs had no detectable injection site reactions following either of the two doses, whilst the remaining 10 per cent had small but visible reactions that resolved within 7–10 days. Only two of 400 carcases required trimming. Clinically, all pigs tolerated vaccination well.

Operator Safety

GnRF is common to all mammalian species, including humans. Therefore accidental injection of both male and female operators is to be avoided. A first accidental injection is unlikely to cause significant systemic effects, but it is likely to act as a priming dose, just as it does in pigs. A second accidental injection could then induce inhibition of testicular or ovarian function. Data from studies with pigs vaccinated with Improvac™ (Mackinnon and Pearce, 2007) and other studies of immunocastration cited in this review suggest that the effect is temporary. However, time to recovery would be difficult to predict. For this reason, the following precautions should be taken when using Improvac™ in the field, viz.

1. Operators should use a safety vaccinator.
2. Operators should be fully trained on the correct procedures for handling and restraining pigs and injecting them.
3. Women who may be pregnant should not use Improvac™.
4. In the event of accidental self-injection, immediate medical advice should be sought and the operator should not handle or use Improvac™.

Tissue Residues and Consumer Safety

Improvac™ has no intrinsic hormonal or pharmacological activity and, as would be expected from its protein nature, has no immunological activity when

given orally. Using the pig as a model for human gastric physiology, repeated oral doses of Improvac™ had no detectable effects. Similar studies in both rats and rabbits using repeated and/or single high oral doses confirmed this inherent safety (safety studies, Pfizer Animal Health). In common with most vaccines, Improvac™ has no withdrawal period in the markets where it is currently approved: there are national licences in Australia, Brazil, Chile, Korea, Mexico, New Zealand, Philippines, South Africa and Switzerland. Under normal circumstances, Improvac™ would be administered at least four weeks prior to slaughter.

SUMMARY ASSESSMENT OF DIFFERENT MEANS TO CONTROL BOAR TAINT

The authors' personal assessment of the potential relative values of the means by which boar taint can be controlled in current commercial circumstances is summarised in Table 6.

Table 6 - Potential relative value and current practicality of some production factors for the control of boar taint in entire male pigs

Reducing Factor	Androstenone	Skatole
Reduction in stocking density	–	+
Improvement in hygiene	–	++
Lighter slaughter weights (where currently not practised)	+	–
Stable social groups	+	–
Separate sex rearing	++	–
Increased fibre levels	–	++
Reduced protein levels	–	+
Feeding wet (whey) feed	–	++
Use of feed antibiotics	–	+
Genetic selection	+++	+++
Different breeds	+++	+
Slaughter detection and sorting	+++	+++
Dilution of tainted meat	++	+
Sexed semen	+	+
Surgical castration	+++++	++++
Immunocastration	+++++	++++

– No effect
\+ Currently low value practical value
+++++ Currently high value practical value

There is no demand for pig meat with boar taint. Thus, to preserve current markets or indeed expand them, effective control of taint is a pre-requisite. Manipulation of diet, management factors and adjustment of slaughter weights help to control boar taint, but are not always commercially viable. Genetic selection and developments in semen sexing techniques have future potential, but are commercially some way off. The feeding of antibiotics to finishing pigs as a routine is heavily resisted in Europe and would potentially only affect skatole levels anyway. The sorting of carcases on the basis of androstenone and skatole is not entirely effective. It is clear that surgical castration is currently the most effective practical method of control, but there are serious welfare concerns about the technique. In Australia, immunocastration has been widely used in commercial pig production since the launch of Improvac™ in 1998, and it is estimated that several million pigs have been routinely and successfully vaccinated against GnRF. The practical considerations of the use of Improvac™ are the subjects of a further review in this volume (Mackinnon and Pearce, 2007).

Acknowledgements

The authors would like to thank Jim Allison, John Crane and Tony Simon for their substantial input into the preparation of this review, and Julie Lennox for her assistance in the preparation of the manuscript, which is gratefully acknowledged. This review was prepared with the financial support of Pfizer Animal Health.

References

Abouzied, M.M., Asghar, A., Pearson, A.M., Gray, J.I., Miller, E.R. and Pestka, J.J. (1990). Monoclonal antibody-based enzyme-linked immunosorbent assay for C_{19}-Δ^{16}-steroids in sera of boars. Journal of Agricultural and Food Chemistry, **38**, 331–335.

Aldal, I., Andresen, Ø., Egeli, A.K., Haugen, J-E., Grødum, A., Fjetland, O. and Eikaas, J.L.H. (2005). Levels of androstenone and skatole and the occurrence of boar taint in fat from young boars. Livestock Production Science, **95**, 121–129.

Allen, P., Joseph, R. and Lynch, B. (2001). Reducing the incidence of boar taint in Irish pigs. Final Report, Project ARMIS No. 4404. Dublin: Teagasc.

Anderson, L.L. (1987). In: Reproduction in Farm Animals 5th Edition. Ed. Hafez, H.S.E. Lea and Febiger, Philadelphia, p. 330.

Andersson, K., Schaub, A., Andersson, K., Lundström, K., Thomke, S. and Hansson, I. (1997). The effects of feeding system, lysine level and gilt contact on performance, skatole levels and economy of entire male pigs. Livestock Production Science, **51**, 131–140.

Annor-Frempong, I.E., Nute, G.R., Whittington, F.W. and Wood, J.D. (1997). The problem of taint in pork: II. The influence of skatole, androstenone and indole, presented individually and in combination in a model lipid base, on odour perception. Meat Science, **47**, 49–61.

Annor-Frempong, I.E., Nute, G.R., Whittington, F.W. and Wood, J.D. (1997). The problem of taint in pork: III. Odour profile of pork fat and the inter-relationship between androstenone, skatole and indole concentrations. Meat Science, **47**, 63–76.

Annor-Frempong, I.E., Nute, G.R., Wood, J.D., Whittington, F.W. and West, A. (1998). The measurement of the responses to different odour intensities of 'boar taint' using a sensory panel and an electronic nose. Meat Science, **50**, 139–151.

Anon (1997). Welfare of Intensively Kept Pigs. Report of the Scientific Veterinary Committee of the European Commission. Brussels: European Commission, (XXIV/B3/ScVC/0005/1997). Available from: http://ec.europa.eu/food/animal/welfare/farm/out17_en.pdf [accessed 03 March 2007]

Anon. (2001a). Commission Directive 2001/93/EC amending Directive 91/630/EEC laying down minimum standards for the protection of pigs. Brussels: European Commission, (Official Journal L316). Available from: http://eur-lex.europa.eu/LexUriServ/site/en/oj/2001/l_316/l_31620011201en00360038.pdf [Accessed 03 March 2007]

Anon. (2001b). Pig Castration. FVE Position Paper. Brussels: Federation of Veterinarians of Europe, (FVE/01/083). Available from: http://www.fve.org/papers/pdf/aw/position_papers/01_083.pdf [Accessed 03 March 2007]

Anon. (2005). Prospects for agricultural markets and income 2005–2012. Report of the Directorate-General for Agriculture. Brussels: European Commission. Available from: http://ec.europa.eu/agriculture/publi/caprep/prospects2005/fullrep.pdf [Accessed 03 March 2007]

Babol, J. and Squires, E.J. (1995). Quality of meat from entire male pigs. Food Research International, **28**, 201–212.

Babol, J., Squires, E.J. and Lundström, K. (1998a). Hepatic metabolism of skatole in pigs by cytochrome P4502E1. Journal of Animal Science, **76**, 822–828.

Babol, J., Squires, E.J. and Lundström, K. (1998b). Relationship between oxidation and conjugation metabolism of skatole in pig liver and concentrations of skatole in fat. Journal of Animal Science, **76**, 829–838.

Babol, J., Squires, E.J. and Lundström, K. (1999). Relationship between metabolism of androstenone and skatole in intact male pigs. Journal of Animal Science, **77**, 84–92

Babol, J. Zamaratskaia, G., Juneja, R.K. and Lundström, K. (2004). The effect of age on distribution of skatole and indole levels in entire male pigs in four breeds: Yorkshire, Landrace, Hampshire and Duroc. Meat Science, **67**, 351–358.

Baydar, A., Petrzilka, M. and Schott, M.-P. (1993). Olfactory thresholds for androstenone and galaxolide: sensitivity, insensitivity and specific anosmia. Chemical Senses, **18**, 661–668.

Beekman, N.J.C.M., Schaaper, W.M.M., Turkstra, J.A. and Meloen, R.H. (1999). Highly immunogenic and fully synthetic peptide-carrier constructs targetting GnRH. Vaccine, **17**, 2043–2050.

Bonneau, M. (1982). Compounds responsible for boar taint, with special emphasis on androstenone: a review. Livestock Production Science, **9**, 687–705.

Bonneau, M. Dufour, R., Chouvet, C., Roulet, C., Meadus, W. and Squires, E.J. (1994). The effects of immunisation against luteinizing hormone-releasing hormone on performance, sexual development and levels of boar taint-related compounds in intact male pigs. Journal of Animal Science, **72**, 14–20.

Bonneau, M. and Enwright, W.J. (1995). Immunocastration in cattle and pigs. Livestock Production Science, **42**, 193–200.

Bonneau, M., Le Denmat, M., Vaudelet, J.C., Veloso Nunes, I.R., Mortensen, A.B. and Mortensen, H.P. (1992). Contribution of fat androstenone and skatole to boar taint: II. Eating quality of cooked ham. Livestock Production Science, **32**, 81–88.

Bonneau, M. and Squires, E.J. (2000). Use of entire males for pig production. Conferência virtual internacional sobre qualidade de carne suína. Available from: http://www.cnpsa.embrapa.br/sgc/sgc_publicacoes/anais00cv_portugues.pdf [Accessed 03 March 2007].

Bonneau, M., Walstra, P., Claudi-Magnussen, C., Kempster, A.J., Tornberg, E., Fischer, K., Diestre, A., Siret, F., Chevillon, P., Claus, R., Dijksterhuis, G., Punter, P., Matthews, K.R., Agerhem, H., Béague, M.P., Oliver, M.A., Gispert, M., Weiler, U., von Seth, G., Leask, H., Font i Furnols, M., Homer, D.B. and Cook, G.L. (2000). An international study on the importance of androstenone and skatole for boar taint: IV. Simulation studies on customer dissatisfaction with entire male pork and the effect of sorting carcases on the slaughterline, main conclusions and recommendations. Meat Science, **54**, 285–295.

Bremner, E.A., Mainland, J.D., Khan, R.M. and Sobel, N. (2003). The prevalence of androstenone anosmia. Chemical Senses, **28**, 423–432.

Brennan, J.J., Shand, P.J., Fenton, M., Nicholls, L.L. and Aherne, F.X. (1986). Androstenone, androstenol and odour intensity in backfat of 100- and 130-kg boars and gilts. Canadian Journal of Animal Science, **66**, 615–624.

Brooks, R.I. and Pearson, A.M. (1989) Odour thresholds of the C19-Δ16-steroids responsible for boar odour in pork. Meat Science, **25**, 11–19.

Cameron, N.D., Penman, J.C., Fisken, A.C., Nute, G.R., Perry, A.M. and Whittington, F.W. (2000). Boar taint in pigs selected for components of efficient lean growth rate. Meat Science, **54**, 147–153.

Caraty, A. and Bonneau, M. (1986). Immunisation active du porc mâle contre la gonadorlibérine: effets sur la sécrétion d'hormones gonadotropes et sur la teneur en 5 alpha-androst-16-ène-3-one du tissu adipeux. Comptes Rendus de l'Académie des Sciences III (Sciences de la Vie), 1986, **303**, 673–676.

Claus, R. (1976). Messung des ebergeruchsstoffes im fett von schweinen mittels eines radioimmunotests. 2. Zeitlicher verlauf des geruchsdepotabbaues nach der kastration. Sonderdruck aus Zeitschrift für Tierzüchtung und Züchtungsbiologie, **93**, 38–47

Claus, R., Hoffman, B. and Karg, H. (1971). Determination of 5α-androst-16-en-3-one, a boar taint steroid in pigs with reference to relationships to testosterone. Journal of Animal Science, **33**, 1293–1297.

Claus, R., Raab, S. and Röckle, S. (1996). Skatole concentrations in blood plasma of pigs as influenced by the effects of dietary factors on gut mucosa proliferation. Journal of Animal Physiology and Animal Nutrition, **76**, 170–179.

Claus, R., Weiler, U. and Herzog, A. (1994). Physiological aspects of androstenone and skatole formation in the boar—a review with experimental data. Meat Science, **38**, 289–305.

Colenbrander, B., Frankenhuis, M.T. and Wensing, C.J.G. (1982). Male sexual development. In: Control of Pig Reproduction. Eds. Cole D.J.A. and Foxcroft G.R. Butterworth Scientific, London, pp. 3–24

de Kruijf, J.M. and Welling A.A.W.M. (1988). Het voorkomen van chronische ontstekingen bij gelten en borgen. Tijdschrift voor diergeneeskunde, **113**, 415–417.

Dijksterhuis, G.B., Engel, B., Walstra, P., Font i Furnols, M., Agerhem, H., Fischer, K., Oliver, M.A., Claudi-Magnussen, C., Siret, F., Béague, M.P., Homer, D.B. and Bonneau, M. (2000). An international study on the importance of androstenone and skatole for boar taint: II. Sensory evaluation by trained panels in seven European countries. Meat Science, **54**, 261–269.

D'Souza, D.N., Hennessy, D., Danby, M., McCauley, I. and Mullan, B.P. (2000). The effect of Improvac™ on pork quality. Journal of Animal Science, **78** (Supplement 1), 158.

Ducro-Steverink, D. (2006). Selection against boar taint: a simulation study. Acta Veterinaria Scandinavica, **48**, (Suppl. 1), P.6.

Dunshea, F.R., Colantoni, C., Howard, K., McCauley, I., Jackson, P., Long, K.A., Lopaticki, S., Nugent, E.A., Simons, J.A., Walker, J. and Hennessy, D.P. (2001). Vaccination of boars with a GnRH Vaccine (Improvac™) eliminates boar taint and increases growth performance. Journal of Animal Science, **79**, 2524–2535.

Falvo, R.E., Chandrashekar, V., Arthur, R.D., Kuenstler, A.R., Hasson, T., Awoniyi, C. and Schanbacher, B.D. (1986). Effect of active immunization against LHRH or LH in boars: reproductive consequences and performance traits. Journal of Animal Science, **63**, 986–994.

Fawcett, D.W., Neaves, W.B. and Flores, M.N. (1973). Comparative observations on intertubular lymphatics and the organization of the interstitial tissue of the mammalian testis. Biology of Reproduction, **9**, 500–532.

Font i Furnols, M., Gispert, M., Diestre, A. and Oliver, M.A. (2003). Acceptability of boar meat by consumers depending on their age, gender, culinary habits and sensitivity and appreciation of androstenone odour. Meat Science, **64**, 433–440.

Fredriksen, B., Lium, B.M., Marka, C.H., Heier, B.T., Dahl, E., Choinski, J.U. and Nafstad, O. (2006). Entire male pigs in a farrow-to-finish system. Effects on androstenone and skatole. Livestock Science, **102**, 146–154.

Friis, C. (1995). Is boar taint related to sex differences or polymorphism of skatole metabolism? Proceedings of EAAP Working Group on Production and Utilisation of Meat from Entire Male Pigs, 28–29 September 1995, Milton Keynes, UK.

García-Regueiro, J.A. and Díaz, I. (1989). Evaluation of the contribution of skatole, indole, androstenone and androstenols to boar-taint in back fat of pigs by HPLC and capillary gas chromatography (CGC). Meat Science, **25**, 307–316.

Garner, D.L. (2006). Flow cytometric sexing of mammalian sperm. Theriogenology, **65**, 943–957,

Garner, D.L. and Hafez, E.S.E. (1987). In: Reproduction in Farm Animals 5th Edition. Ed. Hafez, E.S.E. Lea and Febiger, Philadelphia, pp. 189-209.

Gerrits, R.J., Lunney, J.K., Johnson, L.A., Pursel, V.G., Kraeling, R.R. Rohrer, G.A. and Dobrinsky, J.R. (2005). Perspectives for artificial insemination and genomics to improve global swine populations. Theriogenology, **63**, 283–299.

Gilbert, A.N. and Wysocki, C. J. (1987). The smell survey results. National Geographic, **172**, 514–525.

Gill, B.P., Hardy, B., Perrott, J.G., Wood, J.D. and Hamilty, M. (1993). The effect of dietary fibre on the meat eating and fat quality of finishing pigs fed *ad libitum* [abstract]. Animal Production, **56**, 421–422.

Grossfield, R., Kline, P., Sieg, B. and Rath, D. (2005). Production of piglets with sexed semen employing a non-surgical insemination technique. Theriogenology, 63, 2269–2277.

Haga, H.A. and Ranheim, B. (2005). Castration of piglets: The analgesic effects of intra-testicular and intra-funicular lidocaine injection. Veterinary Anaesthesia and Analgesia, **32**, 1–9.

Hansen, L.L. and Larsen, A.E. (1994). Effect of antibiotic feed additives on the level of skatole in fat of male pigs. Livestock Production Science, **39**, 269–274.

Hansen, L.L., Larsen, A.E., Jensen, B.B., Hansen-Møller, J. and Barton-Gade, P. (1994). Influence of stocking rate and faeces deposition in the pen at different temperatures on skatole concentration (boar taint) in subcutaneous fat. Animal Production, **59**, 99–110.

Hansen, L.L., Mikkersen, L.L., Agerhem, H., Laue, A., Jensen, M.T. and Jensen, B.B. (1997). Effect of fermented liquid feed and zinc bacitracin on microbial metabolism in the gut and sensoric profile of *m. longissimus dorsi* from entire male and female pigs. In: Boar Taint in Entire Male Pigs. Eds. Bonneau, M., Lundström, K., and Malmfors, B. European Association for Animal Production Publication No. 92. Wageningen Pers, Wageningen, The Netherlands, pp. 92–96.

Hansson K., Lundström, K., Fjelkner-Modig, S. and Persson, J. (1980). The importance of androstenone and skatole for boar taint. Swedish Journal of Agricultural Research, **10**, 167–183.

Heinritzi, K., Ritzmann, M. and Otten, W. (2006). Alternativen zur Kastration von Saugferkeln, Bestimmung von Katecholaminen sowie Wundheilung nach Kastration von Saugferkeln zu unterschiedlichen Zeitpunkten. Deutsche Tierärztliche Wochenschrift, **113**, 94–97.

Hennessy, D. and Newbold, R. (2004). Consumer attitudes to a boar taint vaccine, Improvac™ - a qualitative study. Proceedings of the 18th IPVS Congress, 27 June1- July 2004, Hamburg, Germany, p. 612.

Hennessy, D. and Walker, J. (2004). Effect of a boar taint vaccine, Improvac™, on pork quality. Proceedings of the 18th IPVS Congress, 27 June–1 July, 2004, Hamburg, Germany, p. 611.

Hennessy, D.P., Singayan-Fajardo, J. and Quizon, M. (2006). Eating quality and acceptability of pork from Improvac™ immunised boars. Proceedings of the 19th IPVS Congress, 16–19 July 2006, Copenhagen, Denmark, p. 291.

Horn, T., Marx, G. and von Borell, E. (1999). Behaviour of piglets during castration with and without local anaesthesia. Deutsche Tierarztliche Wochenschrift, **106**, 271–274.

Jaros, P., Bürgi, E., Stärk, K.D.C., Claus, R., Hennessy, D. and Thun, R. (2005). Effect of active immunization against GnRH on androstenone concentration, growth performance and carcass quality in intact male pigs. Livestock Production Science, **92**, 31–38.

Jensen, M.T., Cox, R.P. and Jensen, B.B. (1995). Microbial production of skatole in the hind gut of pigs given different diets and its relation to skatole deposition in backfat. Animal Science, **61**, 293–304.

Johnson, L.A., Rath, D., Vazquez, J.M., Maxwell, W.M.C. and Dobrinsky, J.R. (2005). Pre-selection of sex of offspring in swine for production: Current status of the process and its application. Theriogenology, **63**, 615–624.

Kjeldsen, N. (1993). Practical experience with the production and slaughter of entire male pigs. In: Measurement and Prevention of Boar Taint in Entire Male Pigs. Ed. Bonneau, M. INRA, Paris, pp. 137–144.

Labows, J.N. and Wysocki, C. (1984). Individual differences in odour perception. Perfumer and Flavorist, **9**, 21–26.

Lanthier, F., Lou, Y., Terner, M.A. and Squires, E.J. (2006). Characterizing developmental changes in plasma and tissue skatole concentrations in the prepubescent intact male pig. Journal of Animal Science, **84**, 1699–1708.

Lee, G.J., Archibald, A.L., Law, A.S., Lloyd, S., Wood, J. and Haley, C.S. (2005). Detection of quantitative trait loci for androstenone, skatole and boar taint in a cross between Large White and Meishan pigs. Animal Genetics, **36**, 14–22.

Lofthouse, S. and Kemp, J. (2002). Manipulating the immune response; applications in livestock breeding. Journal of Reproductive Immunology, **57**, 239–253.

Lundström, K., Malmfors, B., Stern, S., Rydhmer, L., Eliasson-Selling, L., Mortensen, A.B. and Mortensen, H.P. (1994). Skatole levels in pigs selected for high lean tissue growth rate on different dietary protein levels. Livestock Production Science, **38**, 125–132.

Mackinnon, J.D. (1985). Growth improvements with antimicrobial substances - an *a priori* consideration. Proceedings of The Pig Veterinary Society, **13**, 55–75.

Mackinnon, J.D. and Pearce, M.C. (2007). Improvac™ (Pfizer Animal Health): an immunological product for the control of boar taint in male pigs. The Pig Journal, **59**, (I) Boar taint and its control and the mode of action, safety and efficacy of Improvac™, 29-67. (II) Practical application in pig production and potential production benefits, 68-91.

Marx, G., Horn, T., Thielebein, J., Knubel, B. and von Borell, E. (2003). Analysis of pain-related vocalization in young pigs. Journal of Sound and Vibration, **266**, 687–698.

Matthews, K.R., Homer, D.B., Punter, P., Béague, M-P., Gispert, M., Kempster, A.J., Agerhem, H., Claudi-Magnussen, C., Fisher, K., Siret, F., Leask, H., Font i Furnols, M. and Bonneau, M. (2000). An international study on the importance of androstenone and skatole for boar taint: III. Consumer survey in seven European Countries. Meat Science, **54**, 271–283.

McCann, S.M. and Ojeda, S.R. (1996). The anterior pituitary and hypothalamus. In: Textbook of Endocrine Physiology. Eds. Griffin, J.E. and Ojeda, S.R. Oxford University Press, Oxford, p. 203.

McCauley, I., Cronin, G.M., Barnett, J.L., Butler, K.L., Hennessy, D.P., Campbell, R.G., Luxford, B., Smits, R.J., Tilbrook, A.J. and Dunshea, F.R. (2000). An immunocastration vaccine (Improvac™) increases growth in individually and group-housed boars [abstract]. Journal of Animal Science, **78** (Supplement 1), 138.

McGlone, J.J. and Hellmann, J.M. (1988). Local and general anaesthetic effects on behaviour and performance of two- and seven-week-old castrated and uncastrated piglets. Journal of Animal Science, **66**, 3049–3058.

McGlone, J.J., Nicholson, R.I., Hellmann, J.M. and Herzog, D.N. (1993). The development of pain in young pigs associated with castration and attempts to prevent castration-induced behavioural changes. Journal of Animal Science, **71**, 1441–1446.

Meloen, R.H., Turkstra, J.A., Lankhof, H., Puijk, W.C., Schaaper, W.M.M., Dijkstra, G., Wensing C.J.G. and Oonk, R.B. (1994). Efficient immunocastration of male piglets by immunoneutralization of GnRH using a new GnRH-like peptide. Vaccine, **12**, 741–746.

Metz, C., Hohl, K., Waidelich, S., Drochner, W. and Claus, R. (2002). Active immunization of boars against GnRH at an early age: consequences for testicular function, boar taint accumulation and N-retention. Livestock Production Science, **74**, 147–157.

Mortensen, A.B., Bejerholm, C. and Pedersen, J.K. (1986). Consumer test of meat from entire males in relation to skatole in backfat. Proceedings of 32nd European Meeting of Meat Research Workers, 1986, Ghent, Belgium. pp. 23–26.

Mortensen, A.B. and Sorensen, S.E. (1984). Relationship between boar taint and skatole determined with a new analysis method. Proceedings of 30th European Meeting of Meat Research Workers, 1984, Bristol, UK. pp. 394–396.

Moss, B.W., Hawe, S.M. and Walker, N. (1993). Sensory thresholds for skatole and indole. In: Measurement and Prevention of Boar Taint in Entire Male Pigs. Ed. Bonneau, M., INRA, Paris, pp. 63–68.

Narendran, R., Etches, R.J., Hacker, R.R. and Bowman, G.H. (1982). Effect of sexual stimulation on concentrations of 5α-antrosteone and testosterone in the peripheral plasma of boars reared individually. Animal Reproduction Science, **4**, 227–235.

Nederveldt, H.R., Crane, J.P., Hart, F.J., Runnels, P.L., Li, R., Pruse, K.J. (2006). Occurrence of boar taint and taint compounds in backfat from pork carcases in the U.S. Proceedings of the 19th IPVS Congress, 16–19 July 2006, Copenhagen, Denmark, p. 596.

Oliver, W. T., McCauley, I., Harrell, R.J., Suster, D., Kerton, D.J. and Dunshea, F.R. (2003). A gonadotropin-releasing factor vaccine (Improvac™) and porcine somatotropin have synergistic and additive effects on growth performance in group-housed boars and gilts. Journal of Animal Science, **81**, 1959–1966.

Oonk, H.B., Turkstra, J.A., Lankhof, H., Schaaper, W.M.M., Verheijden, J.H.M. and Meloen, R.H. (1995). Testis size after immunocastration as a parameter for the absence of boar taint. Livestock Production Science, **42**, 63–71.

Oonk, H.B., Turkstra, J.A., Schaaper, W.M.M., Erkens, J.H.F., Schuitemaker-de Weerd, M.H., van Nes, A., Verheijden, J.H.M. and Meloen, R.H. (1998). New GnRH-like peptide construct to optimize efficient immunocastration of male pigs by immunoneutralization of GnRH. Vaccine, **16**, 1074–1082.

Patterson, R.L.S. (1968). 5α-androst-16-en-3-one: compound responsible for taint in boar fat. Journal of the Science of Food and Agriculture, **19**, 31–38.

Patterson, R.L.S. and Lightfoot, A.L. (1984). Effect of sex grouping during growth on 5α-androstenone development in boars at three commercial slaughter weights. Meat Science, **10**, 253–263.

Peyrat, J.P., Meusy-Dessolle, N. and Garnier, J. (1981). Changes in Leydig cells and luteinizing hormone receptors in porcine testis during post-natal development. Endocrinology, **108**, 625–631.

Prunier, A., Mounier, A.M. and Hay, M. (2005). Effects of castration, tooth resection or tail-docking on plasma metabolites and stress hormones in young pigs. Journal of Animal Science, **83**, 216–222.

Puppe, B., Schön, P.C., Tuchscherer, A. and Manteuffel, G. (2005). Castration-induced vocalisation in domestic piglets, *Sus scrofa*: complex and specific alterations of the vocal quality. Applied Animal Behaviour Science, **95**, 67–78.

Rhodes, D.N. and Patterson, R.L.S. (1971). Effects of partial castration on growth and the incidence of boar taint in the pig. Journal of the Science of Food and Agriculture, **22**, 320–324.

Rius, M.A. and García-Regueiro, J.A. (2001). Skatole and indole concentration in Longissimus dorsi and fat samples of pigs. Meat Science, **59**, 285–291.

Rius, M.A., Hortós, M. and García Regueiro, J.A. (2005). Influence of volatile compounds on the development of off-flavours in pig back fat samples classified with boar taint by a test panel. Meat Science, **71**, 595–602.

Rius Solé, M.A. and García-Regueiro, J.A.G. (2001). Role of 4-phenyl-3-buten-2-one in boar taint: identification of new compounds related to sensorial descriptors in pig fat. Journal of Agricultural and Food Chemistry, **49**, 5303–5309.

Roppa, L. (2006). Global meat production. Summary of presentation given at Banff Pork Seminar, Banff, Canada, 2005. Alberta Pork Industry Report, Volume 3, Issue 1, February 2006.

Schaison, G. (1990). Gonadotropin-releasing hormone (GnRH) generalities. Proceedings of International Symposium: Recent Progress on GnRH and Gonadal Peptides, 16–17 September 1989 Paris,. Eds. P. Bouchard, F. Haour, P. Franchimont and B. Schatz. Elsevier, Paris, p.15.

Schneider, F., Falkenberg, H., Kuhn, G., Nürnberg, K. Rehfeldt, C. and Kanitz, W. (1998). Effects of treating young boars with a GnRH depot formulation on endocrine functions, testis size, boar taint, carcass composition and muscular structure. Animal Reproduction Science, **50**, 69–80.

Squires, E.J. (1990). Studies on the suitability of a colorimetric test for androst-16-ene steroids in the sub-maxillary gland and fat of pigs as a simple chemical test for boar taint. Canadian Journal of Animal Science, **70**, 1029–1040

Squires, E.J. (2006). Possibilities for selection against boar taint. Acta Veterinaria Scandinavica, **48**, (Suppl. 1), S8.

Squires, E.J. and Lundström, K. (1997). Relationship between cytochrome P450IIE1 in liver and levels of skatole and its metabolites in intact male pigs. Journal of Animal Science, **75**, 2506–2511.

Svendsen, O. (2006). Castration of piglets under carbon dioxide anaesthesia. Acta Pharmacologica Sinica, **27** (Supplement 1), 112.

Taylor, A.A., Weary, D.M., Lessard, M. and Braithwaite, L. (2001). Behavioural responses of piglets to castration: The effect of piglet age. Applied Animal Behaviour Science, **73**, 35–43.
Thompson, D.L. (2000). Immunization against GnRH in male species (comparative aspects). Animal Reproduction Science, **60-61**, 459–469.
Tuomola, M., Harpio, R., Knuuttila, P., Mikola, H. and Lövgren, T. (1997). Time-resolved fluoroimmunassay for the measurement of androstenone in porcine serum and fat samples. Journal of Agricultural and Food Chemistry, **45**, 3529–3534.
Tuomola, M., Vahva, M. and Kallio, H. (1996). High performance liquid chromatography determination of skatole and indole levels in pig serum, sub-cutaneous fat, and sub-maxillary salivary glands. Journal of Agricultural and Food Chemistry, **44**, 1265–1270.
Vold, E. (1970). Fleisch produktion seigen schaften bei ebern und kastraten. IV. Organoleptische und gaschromatografische Untersuchungen Wasserdampfflüchtiger Stoffe des Rückenspeckes von Ebern. Scientific Reports of the Agricultural College of Norway, **49**, 1–25.
Walstra, P. (1974). Fattening of young boars: Quantification of negative and positive aspects. Livestock Production Science, **1**, 187–196.
Walstra, P., Claudi-Magnussen, C., Chevillon, P., von Seth, G., Diestre, A., Matthews, K.R., Homer, D.B and Bonneau, M. (1999). An international study on the importance of androstenone and skatole for boar taint: Levels of androstenone and skatole by country and season. Livestock Production Science, **62**, 15–28.
Weary, D.M, Braithwaite, L.A. and Fraser, D. (1998). Vocal response to pain in piglets. Applied Animal Behaviour Science, **56**, 161–172.
Weiler, U., Font i Furnols, M., Fischer, K., Kemmer, H., Oliver, M.A., Gispert, M., Dobrowolski, A. and Claus, R. (2000). Influence of differences in sensitivity of Spanish and German consumers to perceive androstenone on the acceptance of boar meat differing in skatole and androstenone concentrations. Meat Science, **54**, 297–304.
White, R.G., DeShazer, J.A., Tressler, C.J., Borcher, G.M., Davey, S., Waninge, A., Parkhurst, A.M., Milanuk, M.J. and Clemens, E.T. (1995). Vocalization and physiological response of pigs during castration with or without a local anaesthetic. Journal of Animal Science, **73**, 381–386.
Whittington, F.M., Nute, G.R., Hughes, S.I., McGivan, J.D., Lean, I.J., Wood, J.D. and Doran, E. (2004). Relationships between skatole and androstenone accumulation, and cytochrome P4502EI expression in Meishan x Large White pigs. Meat Science, **67**, 569–576.
Willeke, H. (1993). Possibilities of breeding for low 5α-androstenone content in pigs. Pig News and Information, **14**, 1, 31N–33N.
Willeke, H., Claus, R., Müller, E., Pirchner, F. and Karg, H. (1987). Selection for high and low levels of 5α-androst-16-en-3-one in boars. I. Direct and correlated response of endocrinological traits. Journal of Animal Breeding and Genetics, **104**, 64–73.

Williams, L.D., Pearson, A.M. and Webb, N.B. (1963). Incidence of sex odour in boars, sows, barrows and gilts. Journal of Animal Science, **22**, 166–168.
Wood, J.D., Nute, G.R., Whittington, F.M., Kay, R.M. and Perrott, J.G. (1984). Effect of molassed sugar-beet feed on pig meat quality (abstract). Animal Production, **58**, 471- 472.
Wysocki, C.J. and Beauchamp, G.K. (1984). Ability to smell androstenone is genetically determined. Proceedings of the National Academy of Science of the USA, **81**, 4899–4902.
Xue, J., Dial, G.D., Holton, E.E. Vickers, Z., Squires, E.J., Lou, Y., Godbout, D. and Morel, N. (1996). Breed differences in boar taint: Relationship between tissue levels of boar taint compounds and sensory analysis of taint. Journal of Animal Science, **74**, 2170–2177.
Yokoyama, M.T. and Carlson, J.R. (1979). Microbial metabolites of tryptophan in the intestinal tract with special reference to skatole. The American Journal of Clinical Nutrition, **32**, 173–178.
Zeng, X.Y., Turkstra, J.A., Van de Wiel, D.F.M., Guo, D.Z., Liu, X.Y., Meloen, R.H., Schaaper, W.M.M., Chen, F.Q., Oonk, H.B. and Zhang, X. (2001). Active immunization against gonadotrophin-releasing hormone in Chinese male pigs [abstract]. Reproduction in Domestic Animals, **36**, 101–105.

IMPROVAC™ (PFIZER ANIMAL HEALTH): AN IMMUNOLOGICAL PRODUCT FOR THE CONTROL OF BOAR TAINT IN MALE PIGS

II. PRACTICAL APPLICATION IN PIG PRODUCTION AND POTENTIAL PRODUCTION BENEFITS

J.D. MACKINNON — Pig Health and Production Consultancy, Cheneys Cottage, East Green, Kelsale, Saxmundham, Suffolk IP17 2PH

M.C. PEARCE — Pfizer Animal Health, Ramsgate Road, Sandwich, Kent CT13 9NJ

The Pig Journal (2007) 59, 68-90.

Summary

This review examines the practical application and production benefits of Improvac™ (Pfizer Animal Health) - an anti-GnRF immunological product containing a GnRF peptide conjugate in an aqueous-based adjuvant. Vaccination of entire male pigs against naturally occurring gonadotrophin releasing factor (GnRF) provides a highly effective and welfare friendly alternative to surgical castration for the control of boar taint, with substantial additional benefits to pig producers. Because vaccination can be timed to occur close to slaughter, the use of this new technology enables the producer to capitalise on the natural growth and carcase characteristics of entire male pigs. Compared with surgically castrated males, pigs managed with Improvac™ utilise feed more efficiently and produce a leaner carcase. The suppression of characteristic peripubertal male behaviour improves terminal growth performance, enhances welfare, and reduces the risk of injury and compromised carcase quality.

Introduction

Boar taint is potentially the main limiting factor to the marketing of pig meat derived from entire male pigs (Bonneau, 1998). The smell of boar taint can be highly offensive to sensitive individuals. It is caused mainly by the presence of androstenone, a lipophilic sex steroid produced in the testes (Patterson, 1968) and skatole, a lipophilic indole produced by bacterial metabolism of tryptophane in the intestine (Vold, 1970). Both compounds are volatile and released during heating and cooking. Skatole may be present in carcases of female pigs and both entire and castrated male pigs, but significant levels of androstenone are confined to the carcases of entire males, cryptorchids and intersex pigs with functional testes (Xue and Dial, 1997; Bonneau and Squires, 2000). Current approaches to the control of boar taint

have been summarised in an earlier review in this volume (Mackinnon and Pearce, 2007).

Not only is the presence of boar taint in meat a disadvantage when rearing entire male pigs; aggressive and sexual behaviour is an additional problem that can limit growth performance and affect meat quality. Such behaviour is particularly relevant when males are mixed before slaughter because of their stress-related predisposition to the development of dry, firm and dark (DFD) meat (Sather *et al.*, 1995; D'Souza *et al.*, 1999).

The advantages of rearing entire males for slaughter are well known and have been widely reviewed (Walstra and Kroeske, 1968; Xue *et al.*, 1997). When compared with castrated males, entire boars have lower feed intake, better feed efficiency, higher nitrogen retention and produce leaner carcases with less backfat. When the level of dietary amino acids is not limiting, entire boars will usually grow faster than castrated males. Indeed, the efficiency of entire males was recognised by Sir Anthony Fitzherbert when in 1523 he advocated the cessation of castration (Sir Anthony Fitzherbert, 1470–1538. The Book of Husbandry, believed to be the first published work on agriculture in the English language). However, because of consumer sensitivity to boar taint, surgical castration has been widely practised for centuries, wherever pigs have been reared.

Surgical castration of piglets without anaesthesia is undoubtedly a painful procedure (Taylor *et al.*, 2001), and a serious welfare issue subject to increasing attention as society becomes more concerned about many aspects of livestock production. Recently, the subject of surgical castration has been reviewed (Prunier *et al.*, 2006) and it was concluded that although castration can be legally performed without anaesthesia or analgesia in the first seven days of life, available evidence shows that castration at any age is painful and may have a detrimental influence on health. Few anaesthetics or analgesics are licensed for use in piglets in Europe. Standard methods for general and epidural anaesthesia cannot be applied easily on commercial farms for practical, regulatory and economic reasons, and compliance would be very difficult to police. Although local anaesthesia is relatively straightforward, similar constraints exist. Immunocastration, which achieves castration by active vaccination against naturally occurring gonadotrophin releasing factor (GnRF), is an effective alternative to surgical castration.

In Europe it has been recommended that the practice of surgical castration should be reviewed and, if possible, alternative means of controlling secondary male sexual characteristics found (Anon, 1997; Anon, 2001). Vaccination against GnRF is highly effective in suppressing boar taint and aggression, and represents an attractive alternative to surgical castration for the pig industry (Caraty and Bonneau, 1986; Falvo *et al*, 1986; Oonk *et al.*, 1998; Beekman *et al.*, 1999; McCauley *et al.*, 2000; Dunshea *et al*, 2001, Metz *et al.*,

2002; Zeng *et al.*, 2001; Zeng *et al*, 2002; Jaros *et al.*, 2005). Currently, Improvac™ is the only anti-GnRF product licenced for immunocastration. Improvac™ was developed for commercial use in Australia and New Zealand (Dunshea et al., 2001) where it has been used in more than 4 million finishing boars since 1998. The efficacy of Improvac™ for suppression of secondary male sex characteristics including boar taint boar taint was the subject of a previous review in this volume (Mackinnon and Pearce, 2007). This review explores the practical application of Improvac™ in the pig industry and potential production benefits.

EFFICACY OF IMPROVAC™ IN COMMERCIAL PIG PRODUCTION

Growth Performance

In their extensive reviews of the literature from the years 1942 to 1995, Walstra and Kroeske (1968) and Xue *et al.* (1997) found that entire males usually grow faster and more efficiently than surgically castrated males due to natural androgen driven growth which is absent in castrated males; and castrated males, in turn, tend to grow faster than females albeit with lower feed efficiency (Henry *et al.*, 1992; Whittemore, 1998; Latorre *et al.*, 2004). There are production advantages to growing entire males compared with castrates, but the occurrence of boar taint in meat and the effects of sexual and aggressive behaviour on growth rate are important disadvantages. It has already been shown (Mackinnon and Pearce, 2007) that Improvac™ successfully controls boar taint. By reducing sexual behaviour and aggression late in the fattening period, immunocastration with Improvac™ may improve growth performance. However, if immunocastration is to be acceptable economically, it must allow a rate and efficiency of growth that is at least equal to that of surgically castrated pigs.

In contrast to the comparison between Improvac™ vaccinated pigs and surgically castrated pigs, any differences between Improvac™ vaccinated pigs and entire males will arise only during the period between administration of the second dose of Improvac™ and slaughter. This is because before the second dose of Improvac™, there is no substantive physiological difference between vaccinated and un-vaccinated boars.

Improvac™ Vaccinated Pigs Compared with Surgically Castrated Pigs

Growth performance data comparing pigs vaccinated with Improvac™ with surgically castrated pigs are summarised in Table 1. In the Australian studies conducted by Dunshea *et al.* (2001), only performance during the four-week period following the second dose of Improvac™ when pigs were transitioning to immuno-castrates was examined. These results may therefore reflect residual male activity and possible compensatory effects following the onset of immunocastration. Dunshea *et al.* (2001) compared results for pigs slaughtered

at 100 kg and 120 kg with surgically castrated pigs. Pigs slaughtered at the heavier weight of around 120 kg - and therefore given Improvac™ later in the growth cycle - grew significantly faster than castrates during the four weeks prior to slaughter. In pigs slaughtered at 120 kg, average daily feed intake was higher in vaccinated pigs than surgically castrated pigs albeit not significantly, but the feed conversion ratio was significantly lower in vaccinated pigs. Conversely, in pigs slaughtered at 100 kg, average daily feed intake was marginally lower in vaccinated pigs than surgically castrated pigs although not significantly; however, the feed conversion ratio was also significantly lower in vaccinated pigs.

Table 1 - Comparison of growth performance between entire male pigs vaccinated with Improvac™ and surgically castrated males

Study	Approximate Slaughter Weight (kg)	Average Daily Gain (g)		Average Daily Feed Intake (kg)		Feed Conversion Ratio	
		Surgically Castrated	Improvac Vaccinated	Surgically Castrated	Improvac Vaccinated	Surgically Castrated	Improvac Vaccinated
Dunshea *et al.* (2001) Light slaughter weight.	98–100	809 [1]	868 [1]*	2.91	2.81	3.39	3.05*
Dunshea *et al.* (2001) Heavy slaughter weight.	117–121	847 [1]	1,119 [1]***	3.13	3.40	3.73	3.10*
Jaros *et al.* (2005)	100–110	817	827	n.r.	n.r.	n.r.	n.r.
Hennessy *et al.* (2006a)	124–138	851	944**	n.r.	n.r.	2.47	2.24***
Hennessy *et al.* (2006b)	n.r.	770	760	1.89	1.74***	2.47	2.28***

1 Average daily gain calculated from 2nd Improvac vaccination to slaughter
n.r. Not recorded or not tested.
*, **, *** Significantly different from surgically castrated male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

In contrast, a study by Jaros *et al.* (2005) examined performance from 25 kg bodyweight to slaughter and studies by Hennessy *et al.* (2006a, 2006b) considered performance from weaning to slaughter. Thus, the studies by Jaros *et al.* (2005) and Hennessy *et al.* (2006a, 2006b) included a period during which pigs were functional boars before Improvac™ treatment, so results from these studies are more indicative of the total difference in performance likely to be seen in practice. Jaros *et al.* (2005) in Switzerland demonstrated a trend towards better average daily gain in vaccinated pigs, while in Brazil, Hennessey *et al.* (2006b) showed that vaccinated pigs slaughtered at around 108 kg grew significantly faster than castrated males and had significantly improved mean feed efficiency. In Mexico, Hennessy *et al.* (2006a) found no difference in average daily gain but showed a significant reduction in average daily feed intake and, consequently, improved mean feed efficiency in vaccinated males compared with castrated males.

These data confirm that the growth of entire males vaccinated with Improvac™ can outperform the growth of surgically castrated males. The benefit of improved feed conversion efficiency appears to be a consistent finding, with a significant improvement in growth rate only apparent in some studies. This latter finding may be dependent on feeding practices especially in the late fattening period after the onset of immunocastration. An expected corollary of improved feed efficiency is reduced waste output per pig produced. This is an increasingly important environmental consideration.

Improvac™ Vaccinated Pigs Compared with Entire Male Pigs

Growth performance data comparing pigs vaccinated with Improvac with entire male pigs are summarised in Table 2. In the Australian studies conducted by Dunshea *et al.* (2001), only performance during the four-week period following the second dose of Improvac™ when pigs were transitioning to immuno-castrates was examined. Dunshea *et al.* (2001) found that vaccinated pigs slaughtered at the heavier weight of around 120 kg compared with around 100kg - and thus given Improvac™ later in the growth cycle - grew significantly faster than the un-vaccinated entire pigs. In a multi-centre field study conducted in Australia and New Zealand (Study G106, Pfizer Animal Health) pigs vaccinated with Improvac™ grew faster than entire boars during the four weeks from the time of second vaccination to slaughter: in two of the three sites this difference was statistically significant. In a window of slaughter study in Australia (Study G105, Pfizer Animal Health) using small groups of animals the same trend towards better average daily gain was seen in the groups slaughtered four weeks and six weeks after the second Improvac™ vaccination. These data show that the vaccination of entire males with Improvac™ can enhance growth performance during the late fattening period compared with un-vaccinated entire males; this is thought to be a consequence of the suppression of male sexual behaviour and aggression that follows the second vaccination with Improvac™.

Table 2 – Comparison of growth performance between entire male pigs vaccinated with Improvac™ and un-vaccinated entire males

Study	Approximate Slaughter Weight (kg)	Average Daily Gain (g)		Average Daily Feed Intake (kg)		Feed Conversion Ratio	
		Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated
Dunshea *et al.* (2001) Light slaughter weight.	96–98	786 [1]	868 [1]	2.44	2.81**	3.03	3.05
Dunshea *et al.* (2001) Heavy slaughter weight.	113–121	858 [1]	1,119 [1]***	2.79	3.40	3.30	3.10
Pfizer G105 (4 weeks)[2]. Data on file.	91–93	947 [1]	1,042 [1]	n.r.	n.r.	n.r.	n.r.
Pfizer G105 (6 weeks)[2]. Data on file.	96–101	574 [1]	691 [1]	n.r.	n.r.	n.r.	n.r.
Pfizer G106 (Site 1). Data on file.	103–107	752	917**	n.r.	n.r.	n.r.	n.r.
Pfizer G106 (Site 2). Data on file.	92–92	796	831	n.r.	n.r.	n.r.	n.r.
Pfizer G106 (Site 3). Data on file.	103–106	776	916**	n.r.	n.r.	n.r.	n.r.

1 Average daily gain calculated from 2nd Improvac vaccination to slaughter
2 Weeks between second Improvac vaccination and slaughter
n.r. Not recorded or not tested.
*, **, *** Significantly different from surgically castrated male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

Carcase Characteristics

Walstra and Kroeske (1968) and Xue *et al.* (1997) concluded that the lean meat content of entire male carcases is greater than that of castrates and the back-fat thickness is less. The back-fat thickness of gilts is usually less than that of castrated males (Henry *et al.*, 1992; Ellis *et al.*, 1996; Whittemore, 1998). Data from three previously cited Improvac™ studies in which carcase weight, dressing percentage and back-fat thickness of immunocastrated pigs were compared with surgically castrated pigs are shown in Table 3. Male pigs immunocastrated with Improvac™ had a significantly lower dressing percentage than surgically castrated male pigs slaughtered at 23 and 26 weeks of age (Dunshea *et al.*, 2001), and in studies conducted by Dunshea *et al.* (2001) and Hennessey *et al.* (2006a), back fat thickness of immunocastrated males was significantly lower than in surgically castrated pigs. Hennessy *et al.* (2006b) described increases in the amount of meat in some commercially important cuts including leg, tenderloin, shoulder, belly and ventral part of the belly in immunocastrated pigs compared with surgically castrated pigs, and in some of these cuts the difference was significant. Jaros *et al.* (2005) and Hennessy *et al.* (2006a) reported that significant increases in the percentage lean meat yield were found in immunocastrated males compared with surgically castrated pigs (54.5 compared with 53.8 per cent and 52.5 compared with 47.9 per cent, respectively).

Table 3 – Comparison of carcase weights, dressing percentages and back-fat thicknesses between entire male pigs vaccinated with Improvac™ and surgically castrated males

Study	Hot Carcase Weight (kg)		Dressing Percentage		Backfat Thickness (mm)	
	Surgically Castrated	Improvac Vaccinated	Surgically Castrated	Improvac Vaccinated	Surgically Castrated	Improvac Vaccinated
Dunshea *et al.* (2001). Light slaughter weight.	77.1	74.4	77.1	75.7**	14.4	11.9**
Dunshea *et al.* (2001). Heavy slaughter weight.	93.0	92.7	79.3	76.8**	17.1	15.1***
Hennessy *et al.* (2006a)	103.8	108.9	n.r.	n.r.	n.r.	n.r.
Hennessy *et al.* (2006b)	87.5	87.5	n.r.	n.r.	20.1	15.5*

n.r. Not recorded or not tested.
*, **, *** Significantly different from surgically castrated male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

Data comparing pigs immunocastrated with Improvac™ with entire males in which carcase weight, dressing percentage and back fat thickness were measured are shown in Table 4. Dunshea *et al.* (2001) reported that male pigs immunocastrated with Improvac™ had a significantly lower dressing percentage compared with un-vaccinated entire males slaughtered at 26 weeks of age. Pfizer field study G106 (Pfizer Animal Health) reported that average dressing percentage was 1–1.5 per cent lower in immunocastrated males compared with entire males. Dunshea *et al.* (2001) also reported that in heavy pigs, back fat thickness was significantly higher in immunocastrated males compared with entire males. Likewise, in Pfizer study G106, immunocastrated males had significantly higher back fat than entire males at one site but, at another site, although back fat was higher in immunocastrated pigs compared with entire males it was not significantly so.

Table 4 – Comparisons of carcase weights, dressing percentages and back-fat thicknesses of entire male pigs vaccinated with Improvac™ with un-vaccinated entire and surgically castrated males

Study	Carcase weight (kg)		Dressing percentage (%)		Backfat thickness (mm)	
	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated
Dunshea *et al.* (2001). Light slaughter weight.	72.9	74.4	75.8	75.7	11.1	11.9
Dunshea *et al.* (2001). Heavy slaughter weight.	88.6	92.7	78.1	76.8**	12.6	15.1***
Pfizer G105 (4 weeks). Data on file.	70.8	68.4	75.8	74.8	10.9	12.0
Pfizer G105 (6 weeks). Data on file.	73.6	79.5	76.8	78.7	11.3	11.5
Pfizer G106 (Site 1). Data on file.	70.5	73.1	69.2	68.2*	10.9	12.6**
Pfizer G106 (Site 2). Data on file.	72.2	71.2	78.3	77.8	13.0	13.9

*, **, *** Significantly different from surgically castrated male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

The authors conclude that the back-fat thickness of male pigs immunocastrated with Improvac™ will typically lie between that of un-vaccinated males and castrated males and gilts. Figure 1 shows differences in the back-fat thickness between an entire male, a male immunocastrated with Improvac™ and a surgically castrated male pig.

Fig. 1 - Thickness of fat over the loin of an entire male (left), an entire male vaccinated with Improvac™ (Pfizer Animal Health) (centre) and a surgically castrated male (right). (Photo courtesy Pfizer Animal Health).

ANTI-GnRF TITRES AND TIMING OF VACCINATION

A primary indicator of vaccination efficacy is demonstration of antibodies against the target antigen. Difficulties encountered with vaccination against endogenous GnRF, such as the need for repeated high doses (Meloen *et al.*, 1994), have been overcome with the development of Improvac™. Relatively high titres of antibodies against GnRF (anti-GnRF) in response to immunocastration with Improvac™, measured using non-competitive radio-immunoassay, have been demonstrated in studies conducted by Pfizer Animal Health. Median anti-GnRF titres measured two and four weeks after the second dose of Improvac™ are shown in Table 5. In all groups tested, titres declined by approximately 50-60 per cent in this two-week period. There were no anti-GnRF titres recorded in un-vaccinated controls.

Table 5 - Median titres of antibody against GnRF in 12 groups of entire male pigs two and four weeks after a second booster dose of Improvac™

Study Number	No. of pigs	Median anti-GnRH titres	
		2 Weeks After 2nd Improvac Dose	4 Weeks After 2nd Improvac Dose
Dunshea *et al.* (2001). Light slaughter weight.	50	1,208	613
Dunshea *et al.* (2001). Heavy slaughter weight.	50	1,126	487
Pfizer G104	50	789	412
Pfizer G106 (Site 1). Data on file.	50	1,029	478
Pfizer G106 (Site 2). Data on file.	50	1,018	495
Pfizer G106 (Site 3). Data on file.	50	1,048	459

In Pfizer study G105 (Pfizer Animal Health), anti-GnRF titres and testosterone were measured one, two, four, six and eight weeks after the administration of the second dose of Improvac™ and, at each interval, twenty pigs were slaughtered. The width of the testes was measured prior to slaughter using engineering calipers. After slaughter, the testes were removed and weighed; the bulbo-urethral glands were dissected out, weighed and measured; and androstenone and skatole concentrations in sub-cutaneous fat samples determined. The results are shown in Table 6. As the interval between second vaccination and slaughter increased, the median anti-GnRF titre fell. Four weeks after the second dose of Improvac™ and beyond, the number of pigs with testosterone >2nM increased, and there was a concomitant increase in the weight and dimensions of the testes and bulbo-urethral glands. Nevertheless, compared with un-vaccinated controls, the weight and dimensions of the testes and bulbo-urethral glands remained lighter and smaller throughout. Four weeks after the second dose of Improvac™ and beyond, no vaccinated pigs had levels of androstenone >1,000 ng/g or skatole >200 ng/g in sub-cutaneous fat. These limited data suggest that the optimum timing of the second dose of Improvac™ is likely to be around 4–6 weeks before slaughter. Although androstenone and skatole levels were still low 8 weeks after the second dose of Improvac™, there was evidence of rising testosterone, suggesting that boar taint more than eight weeks after the second dose of Improvac™ could not be predicted with certainty.

Table 6 - Effect of time interval between a second dose of Improvac™ and slaughter on titre of antibody against GnRF and the weight and dimensions of testes and bulbo-urethral glands (Study G105; Pfizer Animal Health).

Measurement	Interval from 2nd Improvac Dose											
	1 week		2 weeks		4 weeks		6 weeks		8 weeks			
	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated	Un-vaccinated Entire Male	Improvac Vaccinated
Median *anti-GnRF titre*	1135	n.a.	665–1,164	n.a.	252–405	n.a.	117–122	n.a.	n.a.	66	n.a.	
Percent pigs with serum testosterone concentration > 2nM	20	90	8	71	17	91	34	79	39	89		
Mean testes weight (g)	219.8**	275	206.9*	274.3	157.2***	351.1	210.4***	443.1	220.6***	531.9		
Mean testis width (mm)[1]	100.8*	108.4	92.6*	101.9	85.3***	116.6	92.6***	120.9	94.1***	128.9		
Mean bulbo-urethral gland weight (g)	66.1	72.8	49.6**	79.1	48.2***	117	56.1***	120	56.5***	175.3		
Mean bulbo-urethral gland length (mm)	90.7	92.3	82.4**	95.4	81.6***	106.8	90.9***	114.6	80.2***	128.1		
Per cent pigs with fat androstenone concentration >1,000 ng/g	5	15	0	5	0	29	0	20	0	42		
Per cent pigs fat skatole concentration > 200 ng/g	0	0	26	15	0	12	0	10	0	11		

[1] Width measured *in vivo* with engineering calipers.
n.a. Not applicable.
*, **, *** Significantly different from surgically castrated male pigs, $P<0.05$, $P<0.01$ and $P<0.001$ respectively.

It has been suggested that vaccination against GnRF should be delayed because early blocking of GnRF does not decrease boar taint in maturity (Ziecik *et al.*, 1989), and the advantages conferred by anabolic effects on early male growth should be exercised before suppression of GnRF to control boar taint (Bonneau *et al.*, 1994). The authors conclude from the data reviewed that the impact of Improvac™ administration would be optimised by giving the second dose 4–6 weeks before slaughter and the first dose at least 4 weeks earlier (Dunshea *et al.*, 2001; Jaros *et al.*, 2005).

EFFECT ON BEHAVIOUR AND MEAT QUALITY

Behaviour

The growth potential of entire boars may be compromised by aggressive behaviour or excessive sexual activity expressed in the form of mounting and riding of other pigs which can lead to injury, especially if post-pubertal gilts are present in the same pen. In addition, aggressive behaviour of males prior to slaughter can affect meat quality (Sather *et al.*, 1995; D'Souza *et al.*, 1999). The administration of dietary narcoleptics (bromide and tryptophane) has been shown to improve average daily gain and daily feed intake without affecting food conversion ratio in heavy, group-housed boars (McCauley *et al.*, 2004). Immuno-castration gave greater control of sexual behaviour and better growth performance than narcoleptics, supporting the view that sexually related or aggressive behaviour can limit growth potential. Comparisons of behaviour between entire males immunocastrated with Improvac™ at age 14 and 18 weeks, un-vaccinated entire males and surgically castrated males suggest that castration reduces undesirable behaviour and increases feeding behaviour and, by 21 weeks of age, the behaviour of immunocastrated pigs is similar to surgical castrates (Cronin *et al.*, 2003).

Fighting induced physical activity in response to aggressive interactions in pigs depletes muscle glycogen which, in turn, can affect muscle pH (D'Souza *et al.*, 1999). Dunshea *et al* (2001) found that of 30 pigs exhibiting fight lesions prior to slaughter, 26 were un-vaccinated entire males and four were vaccinated with Improvac™. Although there were no lesions recorded amongst surgically castrated pigs, there were no statistically significant differences between the immunocastrates and the surgical castrates.

Meat quality

D'Souza *et al.* (2000) and Hennessy and Walker (2004) reported reduced drip loss from carcases of entire males vaccinated with Improvac™ compared with female carcases. Muscle pH at and after slaughter influences the colour and texture of pig meat: dark, firm and dry meat (DFD) may result when the muscle pH stays above 5.8 after 24 hours, and pale, soft, exudative meat (PSE) may develop if pH does not fall below 6.0 within 45 minutes of slaughter (Anon,

2004). Although D'Souza *et al.* (2000) found that meat from entire males and females had lower pH than meat from immunocastrated males - possibly due to behavioural differences - all samples tested were below pH 5.8 by 48 hours after slaughter, regardless of sex or immunocastration. Therefore, the use of Improvac™ does not adversely affect meat quality.

SAFETY AND USE OF IMPROVAC™ ON THE FARM

Occasional injection site reactions were detected at slaughter in some of the studies described (Data on file, Pfizer Animal Health). This highlights the need for standard advice to be given on the need to maintain hygienic conditions and proper injection technique. In the field studies reviewed, approximately 90 per cent of pigs had no detectable injection site reactions following either of the two Improvac™ doses; the remaining 10 per cent had small but visible reactions that resolved within 7–10 days. Only two of 400 carcases required trimming. Clinically, all pigs tolerated vaccination well. The correct method of administering Improvac™ is shown in Figure 2.

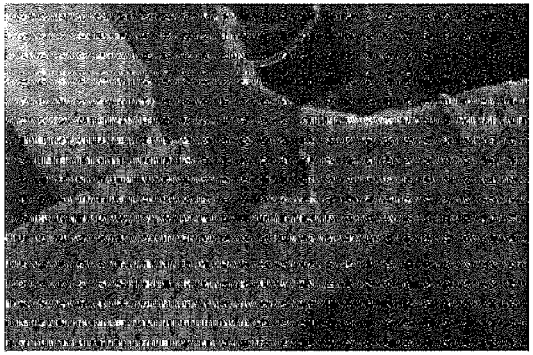


Fig. 2 – Improvac™ should be administered sub-cutaneously in the neck just behind the ear. The vaccinator should be held perpendicular to the skin on the opposite side of the pig to the operator. *(Photo courtesy of Pfizer Animal Health).*

Because GnRF is common to all mammalian species, including humans, accidental injection of both male and female operators is to be avoided. A single injection is unlikely to have any untoward effect, but a subsequent injection could cause suppression of sex hormones and regression of sex organs in both males and females. Therefore, precautions should always be taken when using Improvac™. A specifically designed safety vaccinator should be used such as that shown in Figure 2, which is manufactured by N. J. Phillips Pty Ltd, Australia. This example has a spring-loaded retractable safety shield that covers the needle and a dose guard that prevents product injection except when the shield is fully retracted and the needle is fully inserted into the pig. All operators should be fully trained in administering Improvac™.

When used correctly, Improvac™ is highly effective at eliminating boar taint, but it is important that all males receive two doses at least four weeks apart and that the second dose is given at least 4 weeks before slaughter. Careful planning and selection of pigs for vaccination is necessary. Cryptorchid and overtly hermaphrodite pigs should also be vaccinated, since retained testicles will produce androstenone.

Experience in the commercial use of Improvac™ gained over the last seven years in Australia suggests that the process of vaccination should not be rushed and each pig should be clearly marked as it is injected. Post-vaccination inspections should be conducted 2–3 weeks after the second dose has been given to identify any pigs that may not have received two doses. Continuing sexual behaviour and large, reddened testicles are signs that one dose may have been missed. Since inadvertent double doses do not have adverse effects (Data on file, Pfizer Animal Health), it is better to re-vaccinate if it is suspected that either the first or second dose has not been given.

IMPLICATIONS OF IMPROVAC™ USE FOR THE PIG INDUSTRY

Immunocastration offers substantial potential benefits for the pig industry, by improving pig welfare, increasing production efficiency, and guaranteeing high quality meat.

Animal Welfare

Use of Improvac™ obviates the need for painful and stressful surgical castration and eliminates the risk of post-surgical infection, hernias and other complications. It therefore reduces the amount of time that piglets must be handled. In finishing pigs, the suppression of aggressive and sexual male behaviour reduces the incidence of injuries such as skin abrasions and lameness which result from fighting and mounting.

Acceptability of Pig Meat to Consumers

By consistent elimination of both androstenone and skatole from pigs vaccinated with Improvac™, meat from entire male pigs can be made entirely acceptable to consumers. It should be noted that surgical castration is not completely effective at controlling boar taint because cryptorchids and inter-sex pigs may not have one or both testes removed. Elimination of taint should remove some of the conditioned resistance to pig meat following unpleasant experience of boar taint. The potential for improved meat quality from vaccinated pigs by reduction of drip loss and DFD meat can further improve the acceptability of pig meat in general.

Acceptability of Carcases to Meat Processors

Effective vaccination with Improvac™ should produce meat at least as free of boar taint as either surgical castration or slaughter of intact boars at a lower weight. However, it will still be advisable to identify hermaphrodite or cryptorchid pigs on the slaughter line because if, inadvertently, they are not vaccinated they may have androstenone and skatole in their carcases. True inter-sex pigs can possess a single testicle in place of an ovary but have female genitalia of normal appearance externally. Such pigs are rare, but they may present a problem in the slaughterhouse.

Less fat will need to be trimmed from carcases derived from immunocastrated males than from surgically castrated males in markets where surgical castration is routine.

Immunocastration is likely to reduce the incidence of skin damage arising from tusk wounds inflicted during fighting. This will, in turn, reducing carcase trimming at slaughter and losses arising from such trimming.

BENEFITS FOR PIG PRODUCERS

Pig producers who currently do not surgically castrate will benefit from being able to take entire male pigs to much heavier slaughter weights than currently practised in many places. This is particularly relevant for the rearing and fattening of heavy pigs destined for the production of processed meat products such as bacon, ham and sausages.

Unlike surgical castration, immunocastration will allow producers to capitalise on the natural anabolic potential of entire males. Increased financial rewards should be obtained in markets where incentives are paid for reduction in carcase fat content when vaccinated entire males are reared instead of surgically castrated males. These benefits can be achieved without making changes to dietary protein. A recent study conducted in the USA (Study 3322E-60-04-305, Pfizer Animal Health) compared the growth performance

and carcase characteristics of surgically castrated pigs with pigs vaccinated with Improvac™ slaughtered at around 135 kg bodyweight. Both groups of pigs were fed either a low lysine diet (0.95–0.65 per cent) or a high lysine diet (1.15–0.78 per cent) *ad libitum*. There were no significant differences between treatment groups related to diet. This implies that the growth potential of males immunocastrated with Improvac™ can be realised - and not compromised - without increasing the specification of the diet.

In systems where finishing pigs are not separated by sex, suppression of characteristic male aggression and sexual behaviour will make management of pigs easier and may result in lower numbers of casualty pigs that fail reach the slaughterhouse. It is not uncommon for heavy pigs to sustain limb fractures during bouts of excessive riding and mounting amongst entire males. Suppression of aggressive sexual behaviour has been observed consistently in studies with Improvac™ and these observations are born out by stockmen who have managed pigs immunocastrated with Improvac™ (S. Davies, personal communication, 2006). The improved growth performance seen in immuno-castrated males after administration of the second dose of Improvac™ can probably be explained, at least in part, by the suppression of aggressive and sexual behaviour. Stressful interactions during loading and in lairage can lead to further skin damage and trauma and additionally have adverse effects on meat quality. Finally, the chances of pregnancy occurring in post-pubertal gilts penned with entire males should be virtually eliminated.

Acknowledgements

The authors would like to thank Jim Allison, John Crane and Tony Simon for their substantial input into the preparation of this review, and gratefully acknowledge Julie Lennox for her assistance in the preparation of the manuscript. This review was prepared with the financial support of Pfizer Animal Health.

References

Anon (1997). Welfare of Intensively Kept Pigs. Report of the Scientific Veterinary Committee of the European Commission. Brussels: European Commission, (XXIV/B3/ScVC/0005/1997). Available from: http://ec.europa.eu/food/animal/welfare/farm/out17_en.pdf [accessed 03 March 2007]

Anon. (2001). Pig Castration. FVE Position Paper. Brussels: Federation of Veterinarians of Europe, (FVE/01/083). Available from: http://www.fve.org/papers/pdf/aw/position_papers/01_083.pdf [Accessed 03 March 2007]

Anon (2004). Meat eating quality—a whole chain approach. Factors affecting pig meat eating quality. Final Report, 12 July 2004, SEERAD, Edinburgh, Scotland. Available from: http://www.scotland.gov.uk/Resource/Doc/47060/0017442.pdf [Accessed 04 March 2007]

Beekman, N.J.C.M., Schaaper, W.M.M., Turkstra, J.A. and Meloen, R.H. (1999). Highly immunogenic and fully synthetic peptide constructs targeting GnRH. Vaccine, **17**, 2043–2050.

Bonneau, M. (1998). Use of entire males for pig meat in the European Union. Meat Science, **49**, (Supplement 1) S257–S272.

Bonneau, M. Dufour, R., Chouvet, C., Roulet, C., Meadus, W. and Squires, E.J. (1994). The effects of immunisation against luteinizing hormone-releasing hormone on performance, sexual development and levels of boar taint-related compounds in intact male pigs. Journal of Animal Science, **72**, 14–20.

Bonneau, M. and Squires, E.J. (2000). Use of entire males for pig production. Conferência virtual internacional sobre qualidade de carne suína. Available from: http://www.cnpsa.embrapa.br/sgc/sgc_publicacoes/anais00cv_portugues.pdf [Accessed 03 March 2007].

Caraty, A. and Bonneau, M. (1986). Immunisation active du porc mâle contre la gonadorlibérine: effets sur la sécrétion d'hormones gonadotropes et sur la teneur en 5 alpha-androst-16-ène-3-one du tissu adipeux. Comptes Rendus de l'Académie des Sciences III (Sciences de la Vie), 1986, **303**, 673–676.

Cronin, G.M., Dunshea, F.R., Butler, K.L., McCauley, I., Barnett, J.L. and Hemsworth, P.H. (2003). The effects of immuno- and surgical- castration on the behaviour and consequently growth of group-housed, male finisher pigs. Applied Animal Behaviour Science, **81**, 111–126.

D'Souza, D.N., Dunshea, F.R., Leury, B.J. and Warner, R.D. (1999). Effect of mixing boars during lairage and pre-slaughter handling on pork quality. Australian Journal of Agricultural Research, **50**, 109–113.

D'Souza, D.N., Hennessy, D., Danby, M., McCauley, I. and Mullan, B.P. (2000). The effect of Improvac™ on pork quality. Journal of Animal Science, **78** (Supplement 1), 158.

Dunshea, F.R., Colantoni, C., Howard, K., McCauley, I., Jackson, P., Long, K.A., Lopaticki, S., Nugent, E.A., Simons, J.A., Walker, J. and Hennessy, D.P. (2001). Vaccination of boars with a GnRH Vaccine (Improvac™) eliminates boar taint and increases growth performance. Journal of Animal Science, **79**, 2524–2535.

Ellis, M., Webb, A.J., Avery, P.J. and Brown, I. (1996). The influence of terminal sire genotype, sex, slaughter weight, feeding regime and slaughter-house on growth performance and carcass and meat quality in pigs and on the organoleptic properties of fresh pork. Animal Science, **62**, 521–530.

Falvo, R.E., Chandrashekar, V., Arthur, R.D., Kuenstler, A.R., Hasson, T., Awoniyi, C. and Schanbacher, B.D. (1986). Effect of active immunization against LHRH or LH in boars: reproductive consequences and performance traits. Journal of Animal Science, **63**, 986–994.

Hennessy, D. and Walker, J. (2004). Effect of a boar taint vaccine, Improvac™, on pork quality. Proceedings of the 18th IPVS Congress, 27 June–1 July 2004, Hamburg, Germany, p. 611.

Hennessy, D., Bernal, G. and Hodge, A. (2006a). Growth performance and carcass quality in male pigs given the boar taint vaccine Improvacò [Improvac™] compared to surgical castrates. Proceedings of the 19th IPVS Congress, 16–19 July 2006, Copenhagen, Denmark. Volume 1, p. 292.

Hennessy, D.H., Silveira, E.T.F.S., Poleze, E.P. and Umehara, O.U. (2006b). Improvacò immunized boars compared to surgical castrates: control of boar taint and growth performance. Proceedings of the 19th IPVS Congress, 16–19 July 2006, Copenhagen, Denmark, p. 597.

Henry, Y., Sève, B., Colléaux, Y., Ganier, P., Saligaut, C. and Jégo, P. (1992). Interactive effects of dietary levels of tryptophan and protein on voluntary feed intake and growth performance in pigs in relation to plasma free amino acids and hypothalamic serotonin. Journal of Animal Science, **70**, 1873–1887.

Jaros, P., Bürgi, E., Stärk, K.D.C., Claus, R., Hennessy, D. and Thun, R. (2005). Effect of active immunization against GnRH on androstenone concentration, growth performance and carcass quality in intact male pigs. Livestock Production Science, **92**, 31–38.

Latorre, M.A., Lázaro, R., Valencia, D.G., Medel, P. and Mateos, G.G. (2004). The effects of gender and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs. Journal of Animal Science, **82**, 526–533.

Mackinnon, J.D. and Pearce, M.C. (2007). Improvac™ (Pfizer Animal Health): an immunological product for the control of boar taint in male pigs. The Pig Journal, **59**. (I). Boar taint and its control and the mode of action, safety and efficacy of Improvac™, 29-67. (II) Practical application in pig production and potential production benefits, 68-90.

McCauley, I., Cronin, G.M., Barnett, J.L., Butler, K.L., Hennessy, D.P., Campbell, R.G., Luxford, B., Smits, R.J., Tilbrook, A.J. and Dunshea, F.R. (2000). An immunocastration vaccine (Improvac™) increases growth in individually and group-housed boars [abstract]. Journal of Animal Science, **78** (Supplement 1), 138.

McCauley, I., Cronin, G.M., King, R.H., Hemsworth, P.H., Barnett, J.L., Luxford, B., Smits, R.J., Hennessy, D.P., Campbell, R.G. and Dunshea, F.R. (2004). Dietary narcoleptics and immunocastration improve growth in group-housed boars. Asia Pacific Journal of Clinical Nutrition, **13** (Supplement), S89.

Meloen, R.H., Turkstra, J.A., Lankhof, H., Puijk, W.C., Schaaper, W.M.M., Dijkstra, G., Wensing C.J.G. and Oonk, R.B. (1994). Efficient immunocastration of male piglets by immunoneutralization of GnRH using a new GnRH-like peptide. Vaccine, **12**, 741–746.

Metz, C., Hohl, K., Waidelich, S., Drochner, W. and Claus, R. (2002). Active immunization of boars against GnRH at an early age: consequences for testicular function, boar taint accumulation and N-retention. Livestock Production Science, **74**, 147–157.

Oonk, H.B., Turkstra, J.A., Schaaper, W.M.M., Erkens, J.H.F., Schuitemaker-de Weerd, M.H., van Nes, A., Verheijden, J.H.M. and Meloen, R.H. (1998). New GnRH-like peptide construct to optimize efficient immunocastration of male pigs by immunoneutralization of GnRH. Vaccine, **16**, 1074–1082.

Patterson, R.L.S. (1968). 5α-androst-16-en-3-one: compound responsible for taint in boar fat. Journal of the Science of Food and Agriculture, **19**, 31–38.

Prunier, A., Bonneau, M., Von Borell, E. H., Cinotti, S., Gunn, M., Fredriksen, B., Giersing, M., Morton, D. B., Tuyttens, F. A. M. & Velarde, A. (2006). A review of the welfare consequences of surgical castration in piglets and the evaluation of non-surgical methods. Animal Welfare, **15**, 277–289

Sather, A.P., Jones, S.D.M., Squires, E.J., Schaefer, A.L., Robertson, W.M., Tong, A.K.W. and Zawadski, S. (1995). Ante-mortem handling effects on the behaviour, carcass yield and meat quality of market weight entire male pigs. Canadian Journal of Animal Science, **75**, 45–56.

Taylor, A.A., Weary, D.M., Lessard, M. and Braithwaite, L. (2001). Behavioural responses of piglets to castration: The effect of piglet age. Applied Animal Behaviour Science, **73**, 35–43.

Vold, E. (1970). Fleisch produktion seigen schaften bei ebern und kastraten. IV. Organoleptische und gaschromatografische Untersuchungen Wasserdampfflüchtiger Stoffe des Rückenspeckes von Ebern. Scientific Reports of the Agricultural College of Norway, **49**, 1–25.

Walstra, P. and Kroeske, D. (1968). The effect of castration on meat production in male pigs. World Review of Animal Production, **4**, 59 – 64.

Whittemore, C.T. (1998). In: The Science and Practice of Pig Production 2nd Edition. Blackwell Science Ltd, Oxford, UK, p. 51.

Xue, J.L. and Dial, G.D. (1997). Raising intact male pigs for meat: detecting and preventing boar taint. Swine Health and Production, **5**, 151–158.

Xue, J.L., Dial, G.D. and Pettigrew, J.E. (1997). Performance, carcass, and meat quality advantages of boars over barrows: A literature review. Swine Health and Production, **5**, 21–28.

Ziecik, A.J., Esbenshade, K.L. and Britt, J.H. (1989). Effects of a gonadotrophin-releasing hormone antagonist on gonadotrophin secretion and gonadal development in neonatal pigs. Journal of Reproduction and Fertility, **87**, 281–289.

Zeng, X.Y., Turkstra, J.A., Van de Wiel, D.F.M., Guo, D.Z., Liu, X.Y., Meloen, R.H., Schaaper, W.M.M., Chen, F.Q., Oonk, H.B. and Zhang, X. (2001). Active immunization against gonadotrophin-releasing hormone in Chinese male pigs [abstract]. Reproduction in Domestic Animals, **36**, 101–105.

Zeng, X.Y., Turkstra, J.A., Meloen, R.H., Liu, X.Y., Chen, F.Q., Schaaper, W.M.M., Oonk, H.B., Guo, D.Z. and van de Wiel, D.F.M. (2002). Active immunization against gonadotrophin-releasing hormone in Chinese male pigs: effects of dose on antibody titre, hormone levels and sexual development. Animal Reproduction Science, **70**, 223–233.

A A R H U S U N I V E R S I T E T

Justitsministeriet
Dyrevelfærdskontoret

DET JORDBRUGSVIDENSKABELIGE FAKULTET (DJF)

Susanne Elmholt

Dato: 22. august 2008

Journalnr:
Reference:

Direkte tlf: 8999 1858
Direkte fax: 8999 1819
Mobiltlf:
E-post:
Susanne.Elmholt@agrsci.dk
Web: www.agrsci.dk

CVR-nr: 57607556
EAN-nr: 5798000877412

Høringssvar vedrørende Dyreværnsrådets "Udtalelse om kastration af pattegrise og den dermed forbundne smertefølelse"

Udtalelsen omhandler de dyrevelfærdsmæssige problemstillinger vedr. kastration med vurdering af, hvorvidt kastration af pattegrise i praksis fortsat er den eneste egnede metode til at undgå ornelugt i svinekød, om indgrebet i så fald bør ledsages af bedøvelse eller smertelindring samt om tidspunktet for indgrebet bør ændres.

Det Jordbrugsvidenskabelig Fakultet (DJF) ved Aarhus Universitet finder, at udtalelsen som helhed giver en god beskrivelse af problemstillingen omkring kastration. Vi kan tilslutte os den langsigtede målsætning om, at kastration bør undgås, så snart en alternativ metode kan sikre, at forbrugerne kan købe svinekød uden risiko for ornelugt. Ligeledes ville det være ønskværdigt at kunne iværksætte midlertidige foranstaltninger for at lindre grisenes smerter, indtil kastration helt kan ophøre.

Vi er dog tvivlende over for, om usikkerhederne omkring dosering, virkningsgrad og bivirkninger af smertelindrende produkter vil kunne være afklaret i tide til at kunne godkende produktet til brug i svinebesætninger pr. 1/1/2010, som er det starttidspunkt, der foreslås i udtalelsen. Vi skal bemærke, at afhængig af indgiftsform kan smertelindringen i sig selv være forbundet med ubehag. Endelig bør et sådant tiltag ledsages af initiativer, der modvirker, at fokus på det langsigtede mål - at undgå kastration – slækkes. Sådanne initiativer kan eksempelvis bestå af opfølgende status og iværksættelse af forskning og udvikling, der sigter mod at undgå kastration

Set i lyset af, at der i de senere år er sket betydelige landvindinger bl.a. i forståelsen af, hvordan man fodringsmæssigt kan påvirke skatol-induceret ornelugt hos hangrise, bør der i denne forbindelse fokuseres på udvikling af teknikker til måling af ornelugtskomponenter på slagtegangen. Sådant udstyr kombineret med videreudvikling af fodringsbaserede og/eller andre metoder til nedsættelse af ornelugtsproblemet burde give mulighed for efterfølgende afbalanceret og differentieret forarbejdning af kødet, hvor kød med ornelugt kan anvendes i produkter, hvor lugten almindeligvis

Det Jordbrugsvidenskablige Fakultet (DJF)
Aarhus Universitet
Blichers Allé 20, Postboks 50
8830 Tjele
Tlf: 8999 1900
Fax: 8999 1919
E-post: djf@agrsci.dk
Web: www.agrsci.dk

DET
JORDBRUGSVIDENSKABEL
IGE FAKULTET (DJF)

ikke kan detekteres. Ud fra en velfærdsmæssig synsvinkel vil denne løsning være at foretrække frem for smertelindring. Som nævnt i udtalelsen kan der dog opstå problemer ved undladelse af kastration på grund af ornegrisenes øgede tilbøjelighed til aggressiv adfærd. Der bør derfor sideløbende etableres et dansk erfaringsgrundlag vedrørende sådanne produktionsformer.

Vores kommentarer er uddybet nedenfor.

Smertelindring

På det foreliggende grundlag er det vanskeligt at vurdere den konkrete effekt af forslaget om intervention i form af smertebehandling, idet en behandlingsstrategi – det vil sige hvilke midler, der tænkes anvendt, indgiftsform, behandlingshyppighed og deres dosering – ikke fremgår af udtalelsen.

I udtalelsen skriver rådet: 'Det skal endvidere sikres, at indgivelsen af det smertelindrende middel ikke fører til at grisene håndteres flere gange end det i dag er tilfældet'. I de undersøgelser, vi er bekendt med, er behandling med smertestillende middel sket ved injektion 15-20 minutter før selve kastrationen for at sikre, at smertereaktionen i det beskadige væv på langt sigt reduceres, idet det aktive middel skal være fordelt i kropsvævet inden operationen påbegyndes. Andre, mindre lidelsesvoldende indgiftsformer, er ikke umiddelbart realistiske til smågrise, der er yngre end en uge, idet grise i denne alder ikke viser interesse for oral indtagelse af andet end somælk. Indgift gennem somælk kan måske være en mulighed, men indebærer, at soen udsættes for behandling. Metoden vil derfor sandsynligvis indebære forøget håndtering i forhold til det, der er tilfældet i dag. En anden strategi for smertebehandling er at lindre smerten gennem hele perioden, indtil såret er lægt. Hvis dette skal kunne ske uden hyppige håndteringer, vil også dette formodentlig forudsætte, at indgiften kan ske gennem soen og somælk, hvilket måske har bivirkninger for andre velfærdsproblemer i svineproduktionen, f.eks. udvikling af skuldersår, da indgiften formodentlig også vil nedsætte soens smerteføIsomhed. Smertelindring vil således sandsynligvis indebære hyppigere håndtering. Derfor mener vi, at udviklingsarbejdet omkring smertelindring bør vurderes i forhold til lokalbedøvelse.

De smertestillende midler, der forskes i til svin, anvendes også til smertebehandling hos mennesker. Os bekendt er der imidlertid betydelig usikkerhed om dosering og effekter af smertestillede medicin til svin, specielt i den meget unge alder. For visse af de mulige midler har svin en markant højere udskillelsesrate (6-10 gange højere halveringstid i plasma end for eksempel mennesker og kvæg), hvilket gør det svært at overføre erfaringer fra andre dyrearter. På humanside er der for flere produkter veldokumenteret risiko for bivirkninger, hvorfor man ved anvendelse til nyfødte er specielt forsigtig. Midlerne kan forventes at medføre tilsvarende

DET
JORDBRUGSVIDENSKABEL
IGE FAKULTET (DJF)

bivirkninger ved brug til nyfødte grise. Os bekendt er der ingen undersøgelser på svin, der specifikt har fulgt risikoen for disse bivirkninger. Da behandlingen blandt andet sker på et tidspunkt, hvor der er stor risiko for, at grisen skades af soen, såfremt dens vitalitet forringes, er det væsentligt både ud fra et økonomisk og et velfærdsmæssigt synspunkt at undgå disse bivirkninger, hvorfor en væsentlig forskningsindsats må være nødvendig.

Rent forsøgsteknisk ser vi også problemer, når fastlæggelse af dosis og tidspunkt for indgift skal fastlægges. For eksempel er der kun begrænset viden om svins smertereaktioner, og det er derfor ikke oplagt, hvad der er tilstrækkelig smertelindring, og hvordan det konstateres, om den er opnået. Her er behov for yderligere forskning i svins smertereaktioner.

Et andet forhold, der ikke berøres i udtalelsen, er i hvilken udstrækning, det er muligt at sikre, at besætningerne anvender smertelindring ved kastration. Idet flere sygdomskomplekser i svineproduktionen vurderes at være forbundet med større, og især længerevarende, smerte end kastration, kan den ansvarsbevidste landmand fristes til at anvende den til kastration beregnede smertestillende medicin til dyr med større behov. Et yderligere problem ved dette er, at der her ofte vil være tale om ældre dyr, hvorfor der kan opstå problemer med tilbageholdelsestid i forhold til slagtning. Denne problemstilling bør overvejes og taler desuden for, at problemer omkring smertelindring og behov herfor i svineproduktionen behandles samlet, såvel lovmæssigt som forskningsmæssigt.

Endelig vil der med omkring 15 millioner doser om året ske en betydelig øgning af udledning af midlerne og deres nedbrydningsprodukter. Hvis midlerne tages i anvendelse i svineproduktionen, bør der foretages en vurdering af eventuelle miljømæssige risici.

Frasortering

I afsnit 1 i udtalelsen gennemgås en række tiltag med henblik på at reducere hyppigheden af forekomsten af ornelugt blandt de slagtede grise. Disse tiltag omfatter fodring med brug af cikorie, inddragelse af ornelugt i avlsmålet og nedsættelse af alder ved slagtning. Selvom disse tiltag ikke kan fjerne problemet med ornelugt fuldstændigt, vil de kunne reducere forekomsten til et niveau, hvor kød med ornelugt kan anvendes til forarbejdede kødprodukter, hvor ornelugten ikke generer. Brugen af tiltagene er dog betinget af, at der kan foretages en frasortering af ornelugtsgrise på slagtelinjen.

Ornelugtsproblemet er knyttet til forskellige lugtkomponenter og er ikke 100 procent specifikt for ukastrerede hangrise. Også blandt sogrise og kastrerede hangrise forekommer der afvigende lugt, omend i væsentlig mindre udstrækning end blandt ikke kastrerede hangrise. Oprindeligt blev ornelugten tilskrevet indhold af androstenon, mens det nu er alment

DET
JORDBRUGSVIDENSKABEL
IGE FAKULTET (DJF)

accepteret, at også skatol har mindst ligeså stor betydning for problemets opståen. Populært sagt skyldes ornelugtproblemet, at androstenon og skatol ikke udskilles hurtigt nok fra kroppen. De to stoffer trækker på samme nedbrydningsmekanisme, og når nedbrydningen er begrænset, vil der ske en stigning, både i skatol og androstenon. Skatol produceres væsentligst af bakterier i tarmen, mens produktion af androstenon er tæt knyttet til kønshormonet testosteron.

Problemstillingen kompliceres af, at der er markante forskelle på, hvordan forbrugere reagerer på de forskellige komponenter af ornelugt. For eksempel menes der at være genetiske forskelle hos forbrugere, der giver forskellig reaktion på lugtkomponenterne. Disse markante forskelle menes primært at være knyttet til reaktionen på androstenon. Det er også væsentligt, at kød med ornelugt kan anvendes i visse forarbejdede produkter uden at give anledning til reaktion hos mennesker.
Som det nævnes i udtalelsen, er der tidligere udviklet udstyr til sortering ud fra ornelugtsmålinger på slagtelinjen med henblik på at kunne sortere kødet til forskellig anvendelse i den senere forarbejdning. Det nævnes i udtalelsen, at udstyret kun er i stand til at udpege nogle af de grise, der har ornelugt. Dette er korrekt, men er imidlertid et spørgsmål om design af det specifikke udstyr, snarere end et spørgsmål om teknologiske muligheder. I forbindelse med udviklingen af udstyret blev det påvist, at både skatol og androstenon var væsentlige for opfattelsen af ornelugt, men at indholdet af skatol havde den største sammenhæng med ornelugt. Man formodede derfor, at man ved at frasortere grise med højt skatol indhold samtidig undgik forhøjet androstenon. Derfor er det eksisterende udstyr kun baseret på skatol målinger. Det har siden vist sig, at denne sortering ikke var tilstrækkelig til skabe accept blandt aftagerne af kødet.

Der er dog intet, der tyder på, at det ikke skulle være muligt at udvikle tilsvarende udstyr, der kombinerer skatol og androstenon målinger. Teknologien er til stede, og udviklingen i sensorteknologier har væsentligt forbedret mulighederne. Der er også udenlandske udviklingsprojekter i gang med henblik på at udvikle et sådant udstyr.

Der skal dog bemærkes, at der stadig kan være usikkerhed om, hvorvidt yderligere 'ornelugts'-komponenter skal identificeres og benyttes. Derfor kan en nøjere kortlægning af forbrugerreaktioner på lugt-komponenter være påkrævet.

Udviklingen af et sorteringsudstyr, der omfatter flere væsentlige ornelugtskomponenter, vil kunne sikre, at tilstrækkeligt effektive, forebyggende metoder til begrænsning af forekomsten vil kunne anvendes rentabelt, hvis de i tilstrækkeligt omfang nedsætter risikoen for ornelugt og derved overflødiggør kastration ved en mere hensigtsmæssig og differentieret efterbehandling af kødet.

På vegne af Det Jordbrugsvidenskabelige Fakultet

Med venlig hilsen
Susanne Elmholt
Seniorforsker, koordinator for DJF's myndighedsbetjening

DET
JORDBRUGSVIDENSKABEL
IGE FAKULTET (DJF)

Til Justitsministeriet
fra Aktive Dyrerettigheder
www.aktivedyrerettigheder.dk

22.08.08

Høringssvar om kastration uden bedøvelse

Det er forbudt at kastrere dyr uden bedøvelse, men grise er som det eneste dyr undtaget fra reglen og kan kastreres uden forudgående bedøvelse, hvis det sker inden for dyrets 2. til 7. levedøgn. Reglen gælder både for konventionelle og økologiske pattegrise.

Dyreværnslovens § 1 foreskriver: *"Dyr skal behandles forsvarligt og beskyttes bedst muligt mod smerte, lidelse, angst, varigt men og væsentlig ulempe".*

Ca. 13 millioner grise kastreres hvert år for at forhindre, at nogle af dyrene udvikler ornelugt. Lugten findes i kødet fra 5-10 procent af ukastrerede grise, når de bliver kønsmodne i en alder af ca. 6 måneder, det vil sige omkring slagtetidspunktet. Lugten skyldes især lugtstofferne androstenon og skatol. Danske slagterier har udviklet apparatur til at spore ornelugt i grisekød, men har forsømt at videreudvikle metoden.

Flere eksperter og dyrlæger mener, at de omtalte kastrationer er smertevoldende, fordi der skæres i dyr, som er ved fuld bevidsthed, fordi der ved indgrebet trækkes i testiklerne og især fordi der trækkes i sædstrengen, som sidder fast i bughulen. Ifølge Det Jordbrugsvidenskabelige Fakultet (DJF) ses der desuden smerter efter operationen og det ser ud til, at grise er påvirket i op til fem dage efter indgrebet.

Dyreværnsrådet om kastrationerne

Dyreværnsrådet udtalte i juli 2008 om kastration af grise uden bedøvelse:

- Kastration af pattegrise er forbundet med smerte og stress uanset på hvilken måde kastrationen foretages. Rådet mener, at det fremtidige mål bør være at undgå kastration.

- Pt er der ikke alternativer til kastration, skriver Rådet og anbefaler yderligere forskning, så der inden for en kortere årrække kan findes alternativer til kastration.

- Forudgående bedøvelse (lokalbedøvelse eller fuld bedøvelse) er ikke egnet til at forhindre smerte hos grise under kastration, mener Rådet.

- Rådet antager, at efterfølgende smertebehandling kan indføres inden for en kortere periode, og anbefaler, at dette krav indføres fra den 1. januar 2010.

- De personer, der foretager kastration, skal altid gøre det korrekt og så skånsomt som muligt, skriver Rådet.

Rådet mener, at der ikke på nuværende tidspunkt bør foretages andre ændringer i loven end indførelsen af efterfølgende smertebehandling og at spørgsmålet tages op igen om senest 5 år.

Ifølge Rådet kan følgende reducere ornelugt: 1) tidligere slagtning (før dyrene bliver kønsmodne), 2) bedre hygiejne i staldene, 3) fodring med planten cikorie, 4) kønssortering af sæd, så der ikke avles hangrise, 5) at grise, som arveligt betinget udvikler ornelugt, ikke

bruges til avl og 6) at standse hangrisenes kønsmodning ved at vaccinere dyrene (er ikke lovligt i EU).

Det Jordbrugsvidenskabelige Fakultet om kastrationerne

DJF skrev om kastration af grise i rapporten "Smerter og lindring heraf under og efter kastration af pattegrise", som blev offentliggjort i juni 2008:

"Kastration af grise gør ondt. Det gør ondt på grisen at blive kastreret og bedøvelse kan kun løse noget af problemet. Det er smertefuldt for grisen at blive kastreret, selvom den kun er få dage gammel.", fastslog seniorforsker Mette S. Herskin, DJF.

DJF skrev blandt andet: *"En meget iørefaldende reaktion på kastration er grisens skrig. Analyser af skrigets frekvenser viser, at der er forskel afhængig af, om grisen bliver skåret i huden eller om sædstrengen bliver hevet ud og skåret over.*

Det kan gøre ondt på grisen, når man hiver i sædstrengen, selvom grisen er lokalbedøvet i testiklerne, fordi sædstrengen sidder fast helt op i bughulen. Det gør i øvrigt også ondt at blive stukket i testiklerne for at blive bedøvet, og det virker ikke 100 procent på alle grise, forklarer Mette Herskin.

Der er også smerter efter operationen. Selvom der kun er få undersøgelser af smerter i perioden efter kastration, er der noget der tyder på, at grise er påvirket i op til fem dage efter. Blandt andet gnubber de med enden, slår med halen og leger mindre".

Alder ser ikke ud til at have indflydelse på smerten. Man mener dog, at der hos de helt små er øget risiko for øget smerteføIsomhed efter en operation på grund af ændringer og beskadigelser af nerve-enderne, skrev DJF. Mette Herskin udtalte: *"Nogle af reaktionerne vil formodentlig kunne afhjælpes ved at give grisen et smertebedøvende middel inden operationen og et smertestillende middel efter kastrationen."*

KVL, DJF og DFVF om cikorie

Forskere ved flere forskningsinstitutioner (KVL, DJF og DFVF) oplyste i juni 2005, at rødder fra planten cikorie forbedrer smag og lugt i kød fra ukastrerede grise. Forskerne fandt, at en uges fodring med 10% cikorie af den daglige fodermængde kan reducere dannelsen af skatol. Forskerne påviste desuden, at grise, som blev smittet med svinedystenteri, ikke fik symptomer og ikke udskilte dysenteribakterier i gødningen. Dermed kan der spares på brugen af antibiotika. Forskerne fandt også, at dyrene fik færre sygdomsfremkaldende indvoldsorm, når de fik cikorie i foderet.

Senere forsøg har bekræftet forskningen. Så sent som i juni 2008 offentliggjorde DJF nye, positive resultater fra fodringsforsøg med tørret cikorierod. Rødderne har en gavnlig effekt på tilvæksten hos økologiske smågrise i tiden lige efter fravænningen, viste disse forsøg.

Aktive Dyrerettigheders konklusion og anbefaling

Dyreværnsrådet anbefaler, at grise i modsætning til andre dyr fortsat skal kunne kastreres ved fuld bevidsthed, men med efterfølgende smertebehandling.

Dyreværnslovens § 1 foreskriver, at dyr behandles forsvarligt og beskyttes bedst muligt mod smerte, lidelse, angst og væsentlig ulempe.

Aktive Dyrerettigheder ser følgende muligheder for at undgå kastration uden bedøvelse: 1) kastration ved fuld bedøvelse, 2) fodring med cikorie (cikorie styrker desuden dyrenes sundhed og reducerer medicinforbruget), 3) tidligere slagtning (før kønsmodning) og 4) sporing på slagterierne af kød med ornelugt.

Kastration uden bedøvelse er i modstrid med Dyreværnsloven. Aktive Dyrerettigheder ønsker, at grise får samme rettigheder og samme beskyttelse ifølge Dyreværnsloven som andre dyrearter. Det betyder blandt andet, at hvis grise skal kastreres, skal det ske på samme måde, som andre dyrearter kastreres.

Nogle dyr udvikler en lugt, som generer mennesker. Selvom kastration uden bedøvelse kan undgås, bøjer lovgiverne desværre Dyreværnsloven med en særlov. Aktive Dyrerettigheder henstiller, at gældende lovgivning indrettes på en måde, så særlove og bekendtgørelser ikke er i modstrid med Dyreværnsloven, men bringes i overensstemmelse med Dyreværnslovens ord. Også regler om kastration af dyr. Dyr skal have lige ret for loven.

Med baggrund i ovenstående overvejelser anbefaler Aktive Dyrerettigheder et forbud mod kastration af grise.

LANDBRUGSRAADET

Justitsministeriet
Att. Dyrevelfærdskontoret
Slotsholmsgade 10
1216 København K

22. august 2008
POL
Tlf 33 39 42 81
Fax 33 39 41 50
pol@landbrug.dk

Vedr.: Høring over Dyreværnsrådets udtalelse om kastration af pattegrise

Med henvisning til høring over Dyreværnsrådets udtalelse om kastration af pattegrise, jf. henvendelse af 1. juli 2008, sagsnr. 2008-5440-0017, skal Landbrugsraadet hermed på vegne Dansk Svineproduktion, Danske Slagterier, Dansk Landbrug og Landsforeningen af Danske Svineproducenter fremsende følgende bemærkninger.

Vi skal indledningsvis bemærke, at Dyreværnsrådets udtalelse på udmærket vis beskriver problemstillingerne og de mulige løsningsmodeller i forhold til kastration af grise.

Vi er enige i, at det langsigtede mål er, at undgå kastration af grise. Dette kan imidlertid ikke lade sig gøre på kort sigt, og udtalelsen beskriver de fleste af de udfordringer der er, inden det er muligt at stoppe med rutinemæssig kastration. Ud over de i udtalelsen fremførte forhold, så er det også helt afgørende, at der internationalt er accept fra både myndigheder og forbrugere af de metoder, der skal anvendes alternativt til kastration uden forudgående bedøvelse.

Dyreværnsrådet anbefaler afslutningsvis, at der allerede fra den 1. januar 2010 bør indføres et krav om behandling af den smerte og ubehag, som kastrationsindgrebet bevirker. Det anerkendes, at mulighederne for smertebehandling med henblik på lindring af smerterne i perioden efter kastration bør undersøges nøje. I den forbindelse er udfordringen, at der inden ovennævnte skæringsdato dels skal findes en praktisk løsning og dels ske valg og godkendelse af det mest hensigtsmæssige middel hertil. Med henblik på afklaring af de praktiske forhold er Dansk Svineproduktion parat til at iværksætte initiativer med henblik på at finde løsninger inden for den givne tidshorisont. I forhold til godkendelse af middel afhænger muligheden for ikrafttræden til den foreslåede dato endvidere af lægemiddelproducenter og godkendelsesmyndigheder.

Dyreværnsrådet har afdækket fordele og ulemper ved anvendelse af bedøvelse forud for kastration, og er nået frem til, at det ikke kan anbefales at kastration kun kan foretages med anvendelse af lokal bedøvelse eller fuld bedøvelse. Vi kan fuldt ud støtte konklusionen på baggrund af de fremførte betragtninger.

Dyreværnsrådet peger på, at der under alle omstændigheder er behov for, at kunne identificere hangrise, som udvikler ornelugt. Metoder til identifikation af ornelugt er et helt centralt område, hvor der skal videreudvikles metoder. Der skal formentlig udvikles en ny fælles metode i EU, hvis produkter fra ukastrerede hangrise skal kunne afsættes, og dette kræver endvidere, at der sker en ophævelse af det tyske de facto forbud mod kød fra ukastrerede hangrise.

Dyreværnsrådet peger på, at der skal fokus på potentielle velfærdsmæssige problemer i besætningerne, hvis kastration undlades. Når dette undersøges nærmere bør det ske med udgangspunkt i de erfaringer, som er i de besætninger, som i en årrække har praktiseret hangriseproduktion.

Endelig peges på, at det skal sikres, at personalet er uddannet og har rutine i kastration af grise indtil vi kommer i en situation, hvor kastration kan undlades. I den forbindelse skal vi gøre opmærksom på, at der i forbindelse med udmøntning af det politisk vedtagne krav om egenkontrol for dyrevelfærd i svinebesætninger er lagt op til, at kastration er et af fokusområderne. Dette bør kunne opfylde behovet for løbende opfølgning af, at der er ajourført erfaring hos personer, som skal kastrere grise.

Med venlig hilsen

Per Olsen

Sondrup den 12.08.08

Til Justitsministeriet
Civil- og Politiafdelingen
Dyrevelfærdskontoret
Slotsholmsgade 10
1216 København K

Høringssvar på: Dyreværnsrådets udtalelse om kastration af grise.

På baggrund af den offentlige debat, har justitsministeriet anmodet Dyreværnsrådet om en udtalelse om kastration og dyrenes smerter. Dyreværnsrådet blev bedt om at gennemgå de nyeste forskningsresultater og give en vurdering af, hvorvidt lovgivningen om kastration af grise skal revideres.

Rådet anbefaler, at det fortsat skal være tilladt at kastrere grise med kniv uden bedøvelse. Rådet anbefaler, at der tages skridt til at indføre krav om smertebehandling efter indgrebet med virkning fra 2010.

- Vi er helt uenige i Dyreværnsrådets anbefaling til ministeren.

Vi er uenige i Rådets vurdering, at der ikke findes alternativer til kirurgisk indgreb uden bedøvelse. Vi er af den klare opfattelse, at operativ kastration af grise kan og skal forbydes øjeblikkeligt. Vi er opmærksomme på de overgangsvanskeligheder der for branchen er forbundet med et forbud, men fordelene ved et forbud mod kirurgisk kastration overvejer langt ulemperne.

- Anima opfordrer til at lovgiverne øjeblikkeligt ophører med negativ særstilling af dyrene i landbruget. Vi finder det uetisk, at myndighederne ved udarbejdelse af tilladelser og forbud tager udgangspunkt i dyrenes brugsværdi. Vi mener, at alene hensynet til dyret skal bestemme arten og graden af tilladelser og forbud.

Bestemmelser til beskyttelse af dyr i *bekendtgørelse om halekupering og kastration af dyr* undtager grise, blot indgrebet foretages mellem den 2. og 7. levedag. Selv landbruget anerkender dyrenes smerter ved kastration. Hverken forskning eller sund fornuft støtter påstanden om, at kastration er forbundet med mindre smerte hos grise eller at smerten er aftagende med grisens alder sådan at forstå, at jo yngre jo mindre smerte. Alligevel er det tilladt at kastrere pattegrise uden forudgående bedøvelse, hvis det sker så tidligt som muligt inden for dyrets 2. til 7. levedøgn. Hvis kastration foretages efter dette tidspunkt, skal dyret bedøves og gives længerevarende efterfølgende smertebehandling.

- Anima opfordrer til øjeblikkelig forbud mod operativ kastration af grise med mindre kastrationen udføres i behandlingsøjemed, under bedøvelse og med efterfølgende smertebehandling. Den indlysende årsag er de smerter, som kastration påfører dyrene:

'Forskellige smerter

En meget iørefaldende reaktion på kastration er grisens skrig. Analyser af skrigets frekvenser viser, at der er forskel afhængig af, om grisen bliver skåret i huden eller om sædstrengen bliver hevet ud og skåret over.

- Det kan gøre ondt på grisen, når man hiver i sædstrengen, selvom grisen er lokalbedøvet i testiklerne, fordi sædstrengen sidder fast helt op i buhghulen. Det gør i øvrigt også ondt at blive stukket i testiklerne for at blive bedøvet, og det virker ikke 100 procent på alle grise, forklarer Mette Herskin.

Der er også smerter efter operationen. Selvom der kun er få undersøgelser af smerter i perioden efter kastration, er der noget der tyder på, at grise er påvirket i op til fem dage efter. Blandt andet gnubber de med enden, slår med halen og leger mindre.

Ungdom hjælper ikke

Man har tidligere ment, at det er bedst at kastrere grise i en tidlig alder, blandt andet fordi der er en bedre sårheling. Der er dog ikke noget der tyder på, at alder har indflydelse på smerten. Tværtimod mener man, at der hos babyer er øget risiko for øget smerteføIsomhed efter en operation på grund af ændringer og beskadigelser af nerve-enderne.

- Nogle af reaktionerne vil formodentlig kunne afhjælpes ved at give grisen et smertebedøvende middel inden operationen og et smertestillende middel efter kastrationen, siger Mette Herskin.

Rapporten "Smerter og lindring heraf under og efter kastration af pattegrise", Intern rapport, DJF Husdyrbrug nr. 9, juni 2008'

Cikorie kan erstatte kirurgisk kastration:
'Både i praksis og i forsøg er det påvist, at tilsætning af cikorie til svinefoder har flere gavnlige egenskaber, eksempelvis færre problemer med farefeber og mavesår hos søer, mindre ornelugt fra slagtesvin, mindre udledning af ammoniak og endda gavnlig effekt over for alvorlige sygdomme som lawsonia og dysenteri.

Cikorierødder indeholder sukkerstoffet inulin. Inulin ændrer tarmfloraen så de bakterier, der danner skatol, holdes ned. Resultaterne fra forsøgene viser, at kun få dages fodring med cikorierødder i tiden umiddelbart inden slagtning kan fjerne ornelugten.

Den ændrede tarmflora bevirker også, at grisene får færre indvoldsorm. Samtidig forebygger cikorierødder forekomsten af dysenteri.'

Lavere slagtevægt
- altså slagtning før grisene begynder at blive kønsmodne med forekomst af androsteron og skatol til følge - kan enten alene eller i kombination med mere hensigtsmæssigt foder og med foder iblandet cikorie erstatte den smertefulde operative kastration.

'For ikke så længe siden afhornede vi (landmænd) kalve uden bedøvelse. Den metode blev der heldigvis sat spørgsmålstegn ved, og i dag forstår vi ikke længere, at vi engang synes, det var helt naturligt. Med smågrisene kan det gå ligesådan. Om nogle år er det måske sat i system, at hangrisene slagtes ved en lavere vægt for at undgå ornelugten.'

Bedre staldmiljø
Nyere forskning har desuden vist, at bedre hygiejne i stalden har en gavnlig virkning på ornelugten. Ved tæt kontakt med fæces øges ornelugten/-smagen i kødet.

Vaccination (kemisk kastration) kan inden længe repræsentere endnu et alternativ til kniven. Med den viden vi har samlet om metoden – i litteraturen og hos producenten – ser vi med forhåbning frem til en EU godkendelse af endnu en mulig vej væk fra de smertefulde kirurgiske indgreb.

EU
Danske landmænd er ikke alene om at blive mødt med krav om at stoppe mishandlingen af grise. I EU er der heldigvis kommet fokus på de smertefulde indgreb og en række lande: Schweiz, Norge, Belgien og Holland har besluttet at stoppe kastration uden bedøvelse.

Anima opfordrer ministeren til at udforme dansk lovgivning om dyrebeskyttelse sådan, at dyrenes velfærd altid prioriteres højere end økonomiske argumenter.

Med venlig hilsen.
Bente Tolley

Ministeriet for Fødevarer, Landbrug og Fiskeri
Fødevarestyrelsen

Justitsministeriet
Dyrevelfærdskontoret
Slotsholmsgade 10
1216 København K.

KONTOR FOR
KEMISK FØDEVARESIKKERHED,
DYREVELFÆRD
OG VETERINÆRE LÆGEMIDLER

Att.: Eddie Khawaja

J.nr.: 2008-20-24-05256/PFJO
15.08.2008

Høringssvar til Dyreværnsrådets udtalelse om kastration af pattegrise

Fødevarestyrelsen har følgende bemærkninger til Dyreværnsrådets udtalelse om kastration af pattegrise:

Helt overordnet er Fødevarestyrelsen enig i, at det bør være målet helt at undgå kastration af pattegrise, da det, uanset hvordan indgrebet gennemføres, ikke kan undgås, at kastration af pattegrise vil være forbundet med smerte og stress for grisen. Der er senest redegjort for dette i en intern rapport fra juni 2008 "Smerte og lindring heraf under og efter kastration af pattegrise" fra Det Jordbrugsvidenskabelige Fakultet, Århus universitet.

Fødevarestyrelsen er enig i, at der ikke på nuværende tidspunkt findes en brugbar metode til at kastrere pattegrise uden smerte og stress, som umiddelbart kan implementeres i praksis. Det er behov for yderligere forskning og udvikling på området, og den baggrund støtter Styrelsen at der fra 2010 indføres krav om smertebehandling i forbindelse med kastration af pattegrise.

Med venlig hilsen

Pernille Fraas Johnsen

Fødevarestyrelsen
5. kontor
Mørkhøj Bygade 19
2860 Søborg
Tel 33 95 60 00
Fax 33 95 60 01
fvst@fvst.dk
www.fvst.dk

Eddie Omar Rosenberg Khawaja

Fra: Wieke Huizing Edinger (FVST) [WIHE@fvst.dk]
Sendt: 20. august 2008 09:24
Til: Eddie Omar Rosenberg Khawaja
Cc: Asger Lundorff Jensen (E-mail); 'Carl Kortbæk Svendsen' (E-mail); 'Eiliv Svalastoga (E-mail) ' (E-mail); 'Susanne Nautrup Olsen (E-mail) ' (E-mail); 'Svend Kargo Jensen (E-mail) ' (E-mail); Malene Sthyr (FVST); Lissi Vestergaard Karlsen (FVST); Gunnar Mylius Pedersen (FVST)
Emne: Høring om Dyreværnsrådets udtalelse om kastration af pattegrise

Kære Eddie Khawaja

Det Veterinære Sundhedsråd kan underskrive Dyreværnsrådets udtalelse om kastration af pattegrise.

Rådet er enig med Dyreværnsrådet i, at kastration af grise ER forbundet med smerte og derfor bør afløses af noget andet og bedre. Rådet er også enig i, at de kendte metoder til lokal- eller fuld bedøvelse inden kastration ikke er egnede til at forhindre smerte ved kastration, og at det bedste alternativ ville være helt at undlade kastration. Da sidstnævnte løsning ikke er brugbar i dag, støttes, at der bliver foretaget yderligere forskning på flere alternativer til kastration (kønssortering af sæd, "vaccination" af hangrisene, som det allerede sker i Australien, fodring med fodermidler, der fjerner ornelugten fra kødet, o.a.), hvorefter spørgsmålet skal genoptages senest om 5 år.

Det Veterinære Sundhedsråd er også enighed med Dyreværnsrådet i, at der for nuværende ikke er grund til at ændre på kravene til uddannelse af de grisepassere, der står for kastrationerne. Rådet er tryg ved det håndelag og den måde kastrationerne rent teknisk udføres i stort set alle sobesætninger.

Med venlig hilsen

Wieke Huizing Edinger / Juridisk sekretær

-----Oprindelig meddelelse-----
Fra: Wieke Huizing Edinger (FVST) [mailto:WIHE@fvst.dk]
Sendt: 7. juli 2008 09:28
Til: Asger Lundorff Jensen (E-mail); 'Carl Kortbæk Svendsen' (E-mail); 'Eiliv Svalastoga (E-mail) ' (E-mail); 'Susanne Nautrup Olsen (E-mail) ' (E-mail); 'Svend Kargo Jensen (E-mail) ' (E-mail)
Cc: Lissi Vestergaard Karlsen (FVST); Malene Sthyr (FVST); Gunnar Mylius Pedersen (FVST)
Emne: 2008-20-08-00132 Høring over Dyreværnsrådets udtalelse om kastration af pattegrise. FRIST den 15. august

<<DVR-udtalelse om kastration 010708_pdf.PDF>> <<Høringsbrev_pdf.pdf>>

Kære alle

Hermed sendes i høring i Rådet Dyreværnsrådets udtalelse om kastration af pattegrise.

Jeg skal anmode om at modtage Jeres bemærkninger senest den 15. august. Jeg vil derefter - afhængig af længden af Jeres evt. bidrag - udarbejde et fælles høringssvar, som jeg vil sende rundt inden fremsendelse til JM.

Mvh. Wieke

DYREVÆRNS-ORGANISATIONERNES SAMARBEJDS-ORGANISATION

DOSO
RØRHOLMSVEJ 5
HØSTERKØB
2970 HØRSHOLM
Tlf. 4970 7371
E-mail. doso@doso.dk

Justitsministeriet
Att.: Christina A. Gulisano
Slotsholmsgade 10
1216 København K

18. august 2008

Vedr.: Dyreværnsrådets udtalelse om kastration af pattegrise

DOSO har modtaget henvendelse fra Justitsministeriet af 1. juli 2008 (sagsnr. 2008-5440-0017), hvori man opfordres til at kommentere Dyreværnsrådets udtalelse om kastration af pattegrise. I den forbindelse skal DOSO komme med følgende bemærkninger:

DOSO kan tilslutte sig Dyreværnsrådets synspunkt om, at det fremtidige mål må være, at kastration af pattegrise helt undgås. Vi er også enige i, at det vil tage nogen tid, før alternative løsninger er udviklet. På den anden side mener vi, at man på dette område er så langt fremme, at spørgsmålet skal tages op igen om 3 år - og ikke om 5 år, som Rådet foreslår. I den forbindelse skal det nævnes, at medicinalfirmaet Pfizer er meget langt fremme med en godkendelse af vaccinen Improvac, således at kemisk "kastration" bliver muligt, og dermed forhindrer grisene i at udvikle de frygtede lugt- og smagsdannende stoffer.

DOSO kan ikke acceptere, at det fortsat skal være tilladt at påføre grise smerte gennem et operativt indgreb. Så længe kastration er nødvendigt, skal denne udføres, uden at grisen mærker smerte. Det gælder både under selve indgrebet og i tiden efter. Vi er bekendt med, at dette vil give nogle praktiske problemer, men vi mener, at disse kan reduceres, hvis bedøvelse, smertebehandling og operativt indgreb tilrettelægges optimalt. Således kan lokalbedøvelse (som sker direkte i testiklerne, og som ikke fuldt ud forhindrer smerte ved træk i sædstrengen) helt undgås, hvis man smertebehandler i god tid, inden grisen skal kastreres. Selv om dette betyder, at grisen skal håndteres to gange, er fordelen, at grisen under hele processen slet ikke udsætte for smerte, og at injektionen kan gives i et mindre følsomt område.

DOSO erkender, at der i dag ikke er tilstrækkelig veterinærfaglig viden om optimal smertebehandling og kan derfor tilslutte sig Rådets forslag om, at krav om smertebehandling først indføres 1. januar 2010.

DOSO
RØRHOLMSVEJ 5
HØSTERKØB
2970 HØRSHOLM
Tlf. 1970 7371
E-mail. doso@doso.dk

DOSO mener endvidere, at kastration af pattegrise fortsat kun må foretages inden for grisens 2., og 7. levedøgn, og at personen som udfører indgrebet ikke kun skal være uddannet til opgaven, men også har pligt til fortsat at vedligeholde denne kompetence i forbindelse med udvikling af nye og bedre metoder.

Til sidst skal det bemærkes, at WSPA-Danmark støtter denne udtalelse, og at dyreværns-foreningen ANIMA sender sit eget høringssvar.

Med venlig hilsen
DOSO

Peter Mollerup
Formand

Det Dyreetiske Råd

Grønnegårdsvej 8
1870 Frederiksberg C

Telefon: 3533 3075
Fax: 3533 3022
e-mail: sbc@life.ku.dk

22. august 2008

Att.: Cristina A. Gulisano
Justitsministeriet
Dyrevelfærdskontoret
Slotsholmsgade 10
1216 København K

Vedr. høring over Dyreværnsrådets udtalelse om kastration af pattegrise.

Det Dyreetiske Råd har modtaget en henvendelse fra Justitsministeriet af 1. juli 2008 (Sagsnr.: 2008-5440-0017) vedr. høring over Dyreværnsrådets udtalelse om kastration af pattegrise. Rådet anmodes om at komme med bemærkninger til udtalelsen.

Afsnit 1
Det Dyreetiske Råd kan tilslutte sig Dyreværnsrådets indledende betragtning om, at endemålet bør være, at kastration af pattegrise undgås. Det Dyreetiske Råd kan ligeledes tilslutte sig Dyreværnsrådets vurdering af, at det er for tidligt helt at forbyde kastration, men at forskningen i relation til alternative løsninger skal intensiveres, og at spørgsmålet skal tages op igen senest om 5 år.

Afsnit 2.1-2.2
I relation til spørgsmålet om brug af bedøvelse/smertebehandling er Det Dyreetiske Råd enig i, at de skitserede muligheder rummer visse problemer, både i relation til optimal smertedækning og i relation til en række praktiske forhold. Det Dyreetiske Råd finder det dog påvist med rimelig sikkerhed, at brug af fuld narkose eller lokalbedøvelse forud for kastrationen reducerer smertereaktionerne ved indgrebet. Det Dyreetiske Råd er samtidig enig med Dyreværnsrådet i, at det er relevant at behandle grisene for de smerter, der opstår efter indgrebet.

Set alene fra en dyrevelfærdsmæssig synsvinkel finder Det Dyreetiske Råd, at det optimale vil være, at grisene er smertedækket både under og efter kastrationen. Alene ud fra denne betragtning vil Det Dyreetiske Råd foretrække, at der stilles krav om både bedøvelse og smertedækning.

Det Dyreetiske Råd har dog forståelse for, at der kan være store praktiske problemer forbundet med både at skulle smertedække og bedøve grisene; og vil derfor kunne se det som et fornuftig kompromis, at der alene blev stillet krav om en effektiv smertedækning, som muligvis kan tage toppen af de akutte smerter, og som kan beskytte grisene mod smerter efter indgrebet.

Det Dyreetiske Råd stiller dog spørgsmålstegn ved Dyreværnsrådets forestilling om, at "at indgivelsen af det smertelindrende middel ikke fører til, at grisene håndteres flere gange end det i dag er tilfældet". Efter Det Dyreetiske Råds opfattelse, er det nemlig tvivlsomt, om der kan sikres en effektiv smertedækning, med mindre smertebehandlingen foretages *inden* kastrationen.

Så vidt Det Dyreetiske Råd er orienteret, tilsiger principper for god smertedækning, at smertebehandlingen skal iværksættes *inden* smertepåvirkningen for at have den optimale effekt. Det Dyreetiske Råd finder det derfor afgørende, at smertebehandlingen gives, inden kastrationen

foretages, og at den gives tilstrækkelig tid til at virke. Smertebehandlingen vil dermed betyde, at grisene skal håndteres 2 gange, men i modsætning til ved anvendelse af lokalbedøvelse kan midlet til smertebehandling indgives mere skånsomt (enten som blot en enkelt injektion og i et mindre følsomt område, eller via en mundsprøjte). Såfremt smertebehandlingen gives forud for kastrationen, er det endvidere muligt, at denne metode samlet set kunne give en bedre smertedækning, end der kan opnås ved anvendelse af lokalbedøvelse alene, da der formodentlig vil være en smertestillende effekt både under og efter kastrationen.

Det Dyreetiske Råd medgiver Dyreværnsrådet, at der udestår en del veterinærfaglig forskning og udredningsarbejde for at nå frem til en sikker viden om, hvordan grisene smertedækkes optimalt. På baggrund af den eksisterende veterinærfaglige viden er der dog efter Det Dyreetiske Råds opfattelse ingen grund til at udsætte et krav om anvendelse af smertedækning, idet der allerede findes smertestillende midler, der er godkendt til anvendelse på svin (Flunixin og Meloxicam). Ét af disse (Meloxicam) er det tilladt at give oralt (dvs. via munden) hos heste, hunde og katte – en mulighed, der også kan tænkes anvendt på svin. Det Dyreetiske Råd finder derfor, at krav om smertedækning bør stilles, så snart det er muligt i forhold til at få etableret nogle praktisk anvendelige procedurer, og anser 1. januar 2010, som foreslået af Dyreværnsrådet, for at være en rigeligt lang frist.

Det Dyreetiske Råd påpeger videre, at reguleringen af området løbende bør justeres i forhold til udvikling af viden om forebyggelse og lindring af smerter hos grise og i forhold til udviklingen af smertestillende midler og metoder til indgivelse af disse.

Afsnit 2.3
Såfremt kastration foretages, er Det Dyreetiske Råd enig i, at det – af de anførte grunde – er formålstjenligt, at grise i almindelighed kastreres inden for deres 2.-7. levedøgn.

Afsnit 2.4
Det Dyreetiske Råd er endvidere enig i, at det er vigtig at sikre, at kastrationen udføres så korrekt og skånsomt som muligt, men at det, set i lyset af at disse indgreb må formodes at ophøre inden for en overskuelig årrække, er unødvendigt at skærpe kravene til den relevante uddannelse.

Det Dyreetiske Råd tilslutter sig dog samtidig opfordringen til på anden måde at sikre, at de personer, der udfører kastrationerne, gør det på den mest hensigtsmæssige måde. Det Dyreetiske Råd finder i den forbindelse ikke, at det er tilstrækkeligt at vedligeholde den kompetence, der oprindelig er opnået, men også at disse personers viden skal opdateres. Såfremt praktiserende dyrlæger, som foreslået af Dyreværnsrådet, skal involveres i dette initiativ, påhviler der dem således et stort ansvar, ikke blot for selv at holde sig ajour med relevant viden, men også for at formidle denne viden videre til de personer, som kommer til at håndtere dyrene i forbindelse med kastrationen.

Endelig vil Det Dyreetiske Råd gerne opfordre til, at der i de videre overvejelser skelnes mellem, hvad der er veterinærfagligt muligt, hvad der samlet set er dyrevelfærdsmæssigt mest hensigtsmæssigt, og hvad der er håndterbart ud fra praktiske og økonomiske synsvinkler. Efter Rådets opfattelse vil en sådan skelnen bidrage til at synliggøre, hvilke muligheder og begrænsninger der er i forhold til at reducere grisenes smerteoplevelse ved kastration eller i forhold til helt at undgå indgrebet.

Med venlig hilsen

Stine B. Christiansen
Faglig sekretær

Justitsministeriet
Civil – og Politiafdelingen
Dyrevelfærdskontoret
Slotholmsgade 10
1216 Kbh. K

22. august 2008

Høring over Dyreværnsrådets udtalelse om kastration

Økologisk Landsforening skal hermed fremsætte sine kommentarer til Dyreværnsrådets udtalelse om kastration af pattegrise, som er modtaget i høring den 1. juli 2008.

Økologisk Landsforening bakker op om Dyreværnsrådets opfattelse, at det fremtidige mål bør være, at kastration af smågrise undgås. Foreningen er samtidig enig i Dyreværnsrådets sammenfatning, at der ikke på nuværende tidspunkt findes alternativer til kastration og at lokalbedøvelse eller fuld bedøvelse på nuværende tidspunkt ikke er egnet med henblik på at forhindre smerte.

Vi opfordrer ligeledes til at forskningen på området intensiveres, således at det overordnede mål om kastration af smågrise kan undgås så hurtig som muligt.

Venlig hilsen

Peder Bligaard
Konsulent
LEDELSESSEKRETARIATET
ØKOLOGISK LANDSFORENING

Fra: Johanne Østerbye [mailto:JO@emdrupvej28a.dk]
Sendt: 23. august 2008 16:37
Til: Eddie Omar Rosenberg Khawaja
Cc: Marianne Jensen
Emne: Høring over Dyreværnsrådets udtalelse om kastr ation af pattegrise - 2008-5440-0017

Emne: Høring over Dyreværnsrådets udtalelse om kastr ation af pattegrise - 2008-5440-0017

Til:
Justitsministeriet
Att. Eddie Omar Rosenberg Khawaja
Sagsnr. 2008-5440-007

Justitsministeriet har d.1. juli 2008 sendt ovenstående udtalelse til høring.

Den Danske Dyrlægeforening har følgende bemærkninger til det fremsendte materiale:

Det er med stor tilfredshed, at DDD kan konstatere, at der er sammenfald mellem Dyreværnsrådet og foreningens anbefalinger på området.

Med venlig hilsen

Johanne Østerbye/sagsnr. 0801939

cand.med.vet & fagkonsulent
jo@ddd.dk
Mobil: 2943 4084

Den Danske Dyrlægeforening
Emdrupvej 28A, DK-2100 København Ø.
Tlf. 3871 0888 - Fax 3871 0322.
www.ddd.dk - ddd@ddd.dk
Åbningstid: Mandag-torsdag kl. 8:30-16.00, fredag kl. 8.30-15.30

Eddie Omar Rosenberg Khawaja

Fra: lillian.christensen@3f.dk på vegne af jll@3f.dk
Sendt: 5. august 2008 08:37
Til: Eddie Omar Rosenberg Khawaja; jll@3f.dk
Emne: VS: Høring over Dyreværnsrådets udtalelse om kastration af pattegrise - 2008-5440-0017

3f har modtaget ovennævnte udtalelse om kastration af pattegrise.

Rådet udtaler at det bør overvejes, om der skal stille skærpede krav til personalet, der skal foretage kastrationen.

I den forbindelse finder 3F det vigtigt at personalet løbende efteruddannes, således at det sikres at kastrationen foretages på den mest skånsomme måde. Ligeledes finder vi, at det skal sikres, at der i den eksisterende landbrugs- og dyrlægeuddannelse indgår, at dyrene skal lide mindst muligt ved kastration.

Venlig hilsen
Jesper Lund-Larsen
Miljø- og Arbejdsmiljøkonsulent

Fagpolitisk Center for Arbejdsliv
Kampmannsgade 4
DK 1790 København V

Tlf. +45 88 92 10 12
Mobil +45 21 45 74 32

E-mail: jll@3f.dk
Web: www.3f.dk