Growth performance and carcass traits of boars raised in Germany and either surgically castrated or vaccinated against gonadotropin-releasing hormone

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Summary

Objectives: To test the effect on male growth performance and carcass traits in a typical German production operation comparing vaccination against gonadotropin-releasing hormone (GnRH) with surgical castration early in life to control boar taint.

Material and methods: Boars were either surgically castrated within the first week of life (G1; n = 91), vaccinated against GnRH (Improvac; Pfizer Animal Health, Louvain-la-Neuve, Belgium) twice at 10 and 21 weeks of age (G2; n = 89), or not treated (G3; n = 12). Animals were slaughtered at 25 to 26 weeks of age. Growth performance (overall daily weight gain; G1 and G2) and carcass traits (% lean muscle, loin muscle, and backfat thickness; G1 and G2) were recorded, and intensity of boar taint was organoleptically assessed (G2 and G3).

Results: Boar taint was observed in intact boars (G3) but not in vaccinated boars (G2) at slaughter 4 to 5 weeks after the second vaccination. The carcasses of G2 boars were significantly leaner and had less backfat than those of surgical castrates (G1). There was a tendency of G2 boars to have greater weight gain than G1 pigs during growing-finishing.

Implications: Vaccination of boars against GnRH, as performed in this study, reliably controls boar taint and yields superior carcass traits when compared with surgical castration.

Keywords: swine, boar, castration, gonadotropin-releasing hormone vaccination, Improvac

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Resumen - Desempeño de crecimiento y características de la canal de machos criados en Alemania castrados quirúrgicamente o vacunados contra la hormona liberadora de gonadotropina

Objetivos: Probar el efecto en el desempeño de crecimiento de machos y las características de la canal en cerdos en una operación alemana típica comparando la vacunación contra la hormona liberadora de gonadotropina (GnRH por sus siglas en inglés) contra la castración quirúrgica a temprana edad para controlar el olor de los machos.

Materiales y métodos: Los machos fueron ya sea castrados quirúrgicamente en la primera semana de vida (G1; n = 91), vacunados contra la GnRH (Improvac; Pfizer Animal Health, Louvain-la-Neuve, Belgium) dos veces a las 10 y 21 semanas de edad (G2; n = 89), ó no tratados (G3; n = 12). Los animales fueron sacrificados a las 25 ó 26 semanas de vida. El desempeño del crecimiento (ganancia de peso diaria total; G1 y G2) y rasgos de la canal (porcentaje de músculo magro, músculo de lomo, y grosor de grasa del lomo; G1 y G2) se registraron, y la intensidad del olor a machos se evaluó organolépticamente (G2 y G3).

Resultados: Se observó el olor en machos intactos (G3) pero no en machos sacrificados (G2) 4 a 5 semanas después de la segunda vacunación. Las canales de machos G2 fueron significativamente más magras y tuvieron menos grasa en el lomo que los animales castrados quirúrgicamente (G1). Hubo una tendencia de los machos G2 a tener una ganancia de peso mayor que los cerdos G1 durante el crecimiento-finalización.

Implicaciones: La vacunación de machos contra la GnRH, según el protocolo de este estudio, controla confiablemente el olor en machos intactos y produce características de canal superiores cuando se comparó con la castración quirúrgica.

Résumé - Performance de croissance et caractéristiques de carcasse de verrats élevés en Allemagne et castrés chirurgicalement ou vaccinés contre la gonadolibérine

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Objectifs: Vérifier, chez des verrats élevés dans une unité de production allemande typique, les effets sur les performances de croissance et les caractéristiques des carcasses d'une vaccination contre la gonadolibérine (GnRH) ou une castration chirurgicale tôt dans leur développement afin de contrôler l'odeur de verrat.

Matériels et méthodes: Les verrats ont été soit castrés chirurgicalement au cours de leur première semaine de vie (G1; n = 91), vaccinés contre la GnRH (Improvac; Pfizer Santé Animale; Louvain-la-Neuve, Belgique) deux fois à 10 et 21 semaines d'âge (G2; n = 89), ou non traités (G3; n = 12). Les animaux ont été abattus à l'âge de 25 à 26 semaines d'âge. Les performances de croissance (gain de poids quotidien global; G1 et G2) et les caractéristiques des carcasses (pourcentage de muscle maigre, épaisseur de la longe, et du gras dorsal; G1 et G2) ont été notées, et l'intensité de l'odeur de verrat a été évaluée de manière organoleptique (G2 et G3).

Résultats: L'odeur de verrat a été notée chez les verrats entiers (G3), mais non chez les verrats vaccinés (G2) au moment de l'abattage, 4 à 5 semaines après la seconde vaccination. Les carcasses des verrats G2 étaient significativement plus maigres et avaient moins de gras dorsal que celles des animaux castrés chirurgicalement (G1). Les verrats G2 montraient une tendance à avoir un gain de poids plus élevé que les porcs G1 durant la période de croissance-finition.

Implications: La vaccination des verrats contre GnRH, telle qu'effectuée dans la présente étude, a permis de contrôler de manière fiable l'odeur de verrat et d'obtenir des caractéristique de carcasses supérieures comparativement à la castration chirurgicale.

Male piglets intended for growing-finishing are usually surgically castrated without anesthesia within the first week of life. Removal of the testes prevents the boar from synthesizing androstenone or accumulating skatole, the two main substances that cause boar taint.[1,2] Pork from boars with boar taint is usually rejected for human consumption. On the basis of studies demonstrating that surgical castration may be associated with stress and pain,[3] this procedure has generated increasing ethical concerns in many countries. Several European countries have addressed these concerns by changing their policies on castration towards a mandatory requirement for anesthesia, analgesia, or both in association with castration (eg, Norway and in the future, Switzerland).[4]

A vaccine against gonadotropin-releasing hormone (GnRH) (Improvac; Pfizer Animal Health, Louvain-la-Neuve, Belgium) for control of boar taint has been introduced to the global market as an animal-welfare-friendly alternative to surgical castration. The vaccine is already licensed in a number of countries, including Australia, Brazil, Korea, Mexico, South Africa, and Switzerland.[5] Vaccination is directed towards endogenous GnRH,[6] reducing synthesis of gonadotropins and subsequently of testicular steroids, including those responsible for boar taint. Vaccination may also cause atrophy of the testes.[7] The vaccine must be administered twice and reliably elicits an anamnestic immune response after the second vaccination, which should be given close to the boar's market age.[8] Since intact boars have less backfat and leaner carcasses than surgical castrates and need less feed for the same growth rates due to better feed efficiency,[9] late immunization also promises to have positive effects on productivity. Although this has been addressed previously,[7,8] these studies are both unique, as they consider national production standards and thus results may not be extrapolated to the global swine industry. For instance, in Australia, where initial studies have been conducted, the market live weight for pigs is usually below 100 kg.[10] Although some studies[8,11] included heavier pigs, they did not reach the 120 to 130 kg common in Germany and the United States. Also, androstenone levels increase dramatically during puberty, particularly during the late 100- to 130-kg growth period, with a concomitant increase in taint intensity.[12] This study was conducted to test the effects of vaccination and surgical castration on growth performance and carcass traits of boars raised to market weights typical of a German production operation.

Methods and materials

All experiments reported in this study were approved by the Animal Welfare and Care authorities of the Land of Saxony-Anhalt, Germany.

Production facilities and health status

The experiments were performed in a swine operation located in Saxony-Anhalt, Germany, between August 2007 and February 2008. The operation comprised a 600-sow farrow-to-wean unit and a nursery-grower-finisher unit 6 km apart from one another. There were no apparent health problems in either unit. The operation was considered stable for porcine reproductive and respiratory syndrome (PRRS), ie, no clinical disease, and was positive for porcine circovirus type 2 (PCV2). However, porcine circovirus associated disease (PCVAD) had not been observed. *Lawsonia intracellularis* had been detected and diarrhea observed occasionally in some grower-finishers. Sows were vaccinated for PRRS twice a year using a vaccine containing a live EU strain (Porcilis PRRS; Intervet GmbH, Unterschleissheim, Germany). Sows were also vaccinated against parvovirus and erysipelas (Porcilis Ery + Parvo; Intervet GmbH), against *Clostridium perfringens* types A and C, and against *Escherchia coli* (using an autogenous vaccine). Piglets were vaccinated against *Mycoplasma hyopneumoniae* using a one-dose vaccine (Stellamune; Pfizer Animal Health, Karlsruhe, Germany).

Experimental animals, housing, and slaughter

A total of 230 crossbred male piglets (EUROC Hybrid × Pietrain) from 55 litters (one to seven male piglets per litter) were initially enrolled in the study. As assessed by a veterinarian, all piglets were in good general health. Piglets were randomly selected within litters to avoid litter effects and assigned to two treatment groups (n = 115 in each group) at the age of 5.07 ± 0.80 days (range 3 to 7 days; group G1) and 5.07 ± 0.87 days (range 2 to 6 days; group G2). The same day, piglets were ear-tagged with three different tags for unambiguous identification: one tag with the number coding for the farm, and two red (G1) or green (G2) tags, one on each ear, for identifying group and animal ID. Lactating sows were housed in farrowing crates with partially slatted floors and red-light heat lamps in the piglet area. Piglets had ad libitum access to water, and between day 7 and weaning, were fed a commercially available starter feed with 15.5 MJ metabolic energy (ME) per kg dry matter (DM) and 1.25% lysine per kg DM (Denkapig Mini Start; Denkavit Futtermittel GmbH, Warendorf, Germany). A total of six piglets died during lactation (two in G1 and four in G2), and 113 and 111

piglets in G1 and G2, respectively, were weaned and moved to the nursery at the age of 27.1 ± 0.80 days.

In the nursery, all pigs were housed in six pens in one room. Subgroups of pigs of each group (ie, 52, 31, and 30; and 50, 31, and 30 pigs per pen for G1 and G2, respectively) were randomly assigned to a pen, ie, subgroups of a treatment group were not necessarily in adjacent pens. Pens had fully slatted floors and multi-space feeders for dry feed. On the day of relocation to the nursery, pigs were continued on piglet starter feed and then switched to a phase 1 nursery diet containing 14.6 MJ ME and 1.45% lysine per kg DM (Optistart; Denkavit Futtermittel GmbH) given ad libitum between day 2 and day 14 of the nursery period. From day 15 until the end of nursery period at 10 weeks of age, pigs were fed ad libitum a phase 2 nursery diet containing 13.6 MJ ME and 1.25% lysine per kg DM (FA I-Super; Denkavit Futtermittel GmbH). During the nursery phase, two G1 and three G2 pigs died or were euthanized. A total of 111 and 108 pigs in G1 and G2, respectively, were moved into the grower-finisher unit at the age of 10 weeks. Of these pigs, 96 per group were randomly selected for further consideration. The remaining twelve G2 pigs were assigned to group G3. The remaining fifteen G1 pigs were excluded from further investigation.

The grower-finisher unit had a total of 36 pens, with 18 pens on each side separated by an aisle. Pens measured 2.0 × 5.2 m, housing 12 pigs with a space allowance of 0.87 m^2 per pig. Floors were partially slatted with a solid area (2.0 × 0.5 m). The wall separating alternate pens accommodated a 4.5-m long trough, split longitudinally to feed animals of adjacent pens. All 192 pigs in groups G1 and G2 were confined in a total of 16 pens on one side of the unit. Pens were randomly assigned to treatment groups, and then pigs in a nursery group were randomly assigned to these pens. Animals from different nursery groups were not mixed in grower-finisher pens to avoid disturbing the social order and subsequent fighting. Twelve of 15 remaining G1 pigs and the 12 remaining G2 pigs (ie, the new group G3) were housed in the remaining two pens. Pens on the opposite side of the aisle were filled with nonexperimental pigs, including the last three animals from G1. Experimental and nonexperimental pigs were never mixed and did not share the same feeders. Natural light was provided equally to all pigs. Pigs were fed three times a day (7:30 AM, 1:00 PM, and 4:00 PM). Between days 1 and 39 in the finisher, pigs were fed a diet containing 13.56 MJ ME and 1.12% lysine per kg DM, followed by a diet that contained 13.37 MJ ME and 0.95% lysine per kg DM. Each pen was equipped with an iron chain providing some stimulation and exercise. During the growing-finishing phase, five pigs from G1 and five from G2 died or were euthanized. A sixth pig in G2 was detected as being mistakenly surgically castrated and was consequently withdrawn from the study. A seventh pig in G2 could not be transported to the slaughter plant due to serious lameness and was euthanized. There were no pig losses in G3.

A total of 91 (G1), 89 (G2), and 12 (G3) pigs were sent to slaughter at 25 weeks of age (G1: n = 46; G2: n = 45; G3: n = 6) and at 26 weeks of age (G1: n = 45; G2: n = 44; G3: n = 6). The abattoir was accredited according to the European Union and was located 25 km from the farm. Pigs were transported by truck to the abattoir, with no mixing of groups during transport. Time between loading and arrival at the abattoir was 1 hour, with slaughter approximately 2 hours after arrival using low-voltage electric stunning and exsanguination.

Surgical castration and vaccination

Immediately after being randomly allocated to the group (ie, at the age of 5.07 ± 0.80 days), G1 piglets were surgically castrated without anesthesia by a skilled farm employee according to an on-farm standard operating procedure (piglets were restrained by another employee, the scrotal surface was disinfected, and the testes were removed using a disposable sterile scalpel and an emasculator within 20 to 30 seconds). The G2 piglets were not surgically castrated, but were later immunized using Improvac, an injectable vaccine containing modified synthetic GnRH coupled to a carrier protein in an aqueous adjuvant.[6] Two doses of vaccine were administered, with the first given at 10 weeks of age, immediately after relocation into the grower-finisher unit. The second injection was given at 21 weeks of age, 4 to 5 weeks prior to slaughter. For each injection, 2 mL of Improvac was administered subcutaneously in the neck immediately behind the base of the ear using a disposable 2-mL syringe and an 18-gauge needle. The G3 animals received neither treatment, but remained intact and served as controls in order to verify the effectiveness of vaccination on size of the testes and epididymides and boar taint of G2 animals.

Weighing of pigs and assessment of carcasses

All G1 and G2 animals were individually weighed when they were relocated to the grower-finisher unit.

At slaughter, the testes and epididymides of all G2 and G3 animals were collected. The organs were cut free from all connective tissue and the testes were then measured (maximum length and width) using a caliper, first including the epididymides and then after the epididymides were removed.

Carcasses of G1 and G2 animals were assessed according to European and national regulations.[13,14] The carcass was defined as the body of a slaughtered pig, exsanguinated and eviscerated, split down the mid-line (body half), without flare fat, kidneys, and diaphragm. The following parameters were recorded: carcass weight (kg), the weight of the carcass 30 to 45 minutes after slaughter; backfat, the thickness of backfat including rind (F) in millimeters (mm), measured by ultrasound using a US-Porkitron unit (ZTS Zimmermann Tier Service, Bahlingen, Germany) between the second- and the third-last rib 7 cm off the midline of the split carcass; loin muscle, the thickness of the muscle (M) in mm measured at the same location as backfat and using the same equipment; and lean meat content (LM), defined as the relationship between the weight of the red striated muscles obtained by total dissection of the carcass, provided that they are separable by knife, and the total weight of the carcass. Lean meat content was expressed as a percentage (%) and calculated using the equation LM (%) = 58.6688 – (0.82809 × F) + (0.18306 × M).

To test the effect of vaccination against boar taint, carcasses of G2 animals were organoleptically assessed and compared to intact G3 boar carcasses. Briefly, a belly sample was collected from each boar within 20 minutes after slaughter and immediately refrigerated. Two trained assessors, working independently and in a blinded fashion, tested the samples within 20 hours. Assessment started with the "cooking test." Approximately 60 g of the belly sample was put in a beaker, 90

mL of cold drinking water was added, and the beaker was covered with aluminum foil and heated until boiling. Samples were then tested while hot for the odor of the released steam, as well as for odor and taste of the extract. Testing was repeated after the samples were cooled. Samples were then graded as follows: no boar taint (no odor in any of the tests); moderate boar taint (no odor when tested cold, but slight to moderate odor when tested hot by smelling, tasting, or both); strong boar taint (slight to moderate odor when tested cold by smelling, tasting, or both, and moderate to strong odor when tested hot by smelling, tasting, or both). If both assessors detected no boar taint, the carcass was judged to be free of boar taint. If one assessor did not detect boar taint of any intensity but the other did, the test was repeated, and the result of the repeated test was then used for final assessment. Any assessment of "strong boar taint" either as the result of the initial or of a repeated testing resulted in discarding the carcass from being introduced into the food chain. Any assessment of "moderate boar taint" either as the result of the initial or of a repeated testing resulted in a second test, the "melting test." For the melting test, approximately 150 g of the belly sample was finely cubed, put in a beaker, covered with aluminum foil, heated on a cooking plate, and then presented hot to the two assessors who were asked to check for odor in the steam immediately after removal of the aluminum foil. Intensity of boar taint was determined using the same grading system as for the cooking test. If the result of the melting test confirmed moderate boar taint as determined by the cooking test, the carcass was discarded because of boar taint. If the result of the cooking test was not confirmed, ie, the melting test was negative, the carcass was judged to be free of boar taint.

Statistical analysis

Only data from animals with complete data sets were included in the statistical analysis (G1: n = 91; G2: n = 89; G3: n = 12). Body weight at slaughter and subsequently overall and average daily weight gain were determined by multiplying the carcass weight by 1.266.[15] Statistical analysis of data were performed using SPSS for Windows 14.0 (SPSS Inc, Chicago, Illinois). Arithmetic means (± SD) for the size of testes and epididymides were compared between groups using the *t*-test. For all parameters related to growth performance and carcass traits, least squares means values (± SEM) were calculated per group and analyzed using a linear mixed model with treatment as a fixed effect and random effects for nursery pen and finishing pen. A difference with $P < .05$ was considered statistically significant.

Results

Testes with and without adjacent epididymides of G2 (vaccinated) animals were smaller than those of the G3 control boars (Table 1). However, some individual vaccinated boars had genital organs that were nearly as big as those of G3 boars in both length and width (Table 1).

None of the carcasses from vaccinated animals had boar taint. In contrast, carcasses of three of the 12 intact G3 boars (25%) did have strong boar taint and were therefore discarded. Vaccinated animals markedly differed from surgically castrated animals in their growth performance and carcass quality, ie, vaccinated animals grew better and had leaner carcasses (Table 2).

Discussion

The results of this study confirm that vaccination of boars using the anti-GnRH vaccine Improvac leads to a shrinkage of the testes and epididymides, when their sizes are compared to those of intact control boars.[7] Reproductive organs from a few vaccinated boars were as large as those from the control boars. While a sound explanation for this phenomenon is still pending, it has been observed in previous studies[7,16] and again indicates that size of testes alone cannot be used as a reliable indicator of the effectiveness of vaccination. Skatole and androstenone are the major contributors to the odor of boars.[17] When boars are housed on partially solid floors, it is suspected that body skatole levels increase because of over-exposure to manure and urine, by absorption either from the skin or from the lung, especially during the summer months when ventilation may be inadequate.[18] However, even under the conditions of this study, where boars were housed on partially solid flooring, boar taint, as determined by an organoleptic assessment, was abolished in vaccinated boars compared to intact control boars. Results of the study also suggest that, concomitant with reduction in their size, the testes had ceased production of sexual steroids, in agreement with a recent Swedish study.[8] Moreover, the present study shows that a 4- to 5-week period after the second vaccination is long enough to allow for sufficient elimination of tainting substances from the bodies of 21-week-old EUROC Hybrid × Pietrain male finisher pigs.[8] Only some boars (ie, 18% to 42%) have androstenone levels above 1.0 μg per g of fat.[19,20] It is thus this percentage of boars that potentially are affected by boar taint, which was confirmed in this study. Although approximately 19.0% of women and 27.0% of men cannot smell boar taint,[18] pork must be completely devoid of boar taint as the ultimate organoleptic prerequisite for acceptance for human consumption in most parts of the world.[11] Vaccination against GnRH is therefore a promising alternative to conventional methodology for boar-taint control, ie,

Table 1: Mean measurements of the testes with and without epididymides in boars vaccinated with Improvac* (G2) and in intact (non-castrated) boars (G3)

	Testes with epididymides		Testes without epididymides	
	G2	G3	G2	G3
Length (cm)				
Mean ± SD	11.8 ± 1.0[a]	13.4 ± 1.3[b]	8.5 ± 1.1[a]	9.8 ± 0.8[b]
Range	8.9-15.3	10.1-15.3	5.0-12.3	8.4-11.1
Width (cm)				
Mean ± SD	5.3 ± 0.7[a]	6.5 ± 0.6[b]	4.9 ± 0.6[a]	6.1 ± 0.5[b]
Range	2.6-7.0	5.4-7.9	2.6-6.5	5.2-7.0

* An injectable vaccine containing modified synthetic gonadotrophin-releasing hormone coupled to a carrier protein in an aqueous adjuvant (Pfizer Animal Health, Louvain-la-Neuve, Belgium).

[ab] Values with different superscripts within a row and within a measurement type differ (*t*-test; $P < .05$)

Table 2: Least squares means (± SEM) of parameters for growth performance and carcass traits of boars either surgically castrated (G1) or vaccinated against gonadotropin-releasing hormone (G2)*

Parameter	Group		P¶
	G1 (n = 91)	G2 (n = 89)	
BW growing-finishing (kg)†	27.57 ± 0.65	28.97 ± 0.60	< .01
BW slaughter (kg)‡	120.03 ± 1.12	123.65 ± 1.14	< .05
Overall weight gain (kg)	90.40 ± 1.14	92.88 ± 1.11	< .10
Average daily gain (kg)	0.82 ± 0.01	0.87 ± 0.01	< .10
Carcass weight (kg)	94.81 ± 0.89	97.67 ± 0.90	< .05
Lean meat (%)	54.06 ± 0.38	56.41 ± 0.36	< .001
Loin muscle (mm)	56.93 ± 0.67	58.70 ± 0.64	< .01
Backfat (mm)	18.25 ± 0.44	15.77 ± 0.42	< .001

* G2 pigs were vaccinated with two doses of Improvac (Pfizer Animal Health, Louvain-la-Neuve, Belgium) given at 10 weeks of age and at 21 weeks of age, 4 to 5 weeks prior to slaughter.

† Pigs were weighed when they entered the grower-finisher.

‡ Slaughter weight was calculated as carcass weight × 1.266,[15] and overall weight gain and average daily gain calculations were based on this value.

¶ Linear mixed model.

BW = body weight.

surgical castration.

In this study, the live weight of pigs before slaughter was not recorded and was calculated by multiplying the carcass weight by the factor 1.266. While this procedure may have provided only an estimate of live weight, the factor is specific for breed and the animal's weight, and was derived from performance testing published by the Association of German Pig Industry.[15] On the basis of that calculation and under the conditions of this study, boars vaccinated against GnRH tended to have a higher overall and daily weight gain than surgically castrated pigs during the growing-finishing phase. Results on weight gain of animals reared in a system utilizing vaccination against GnRH versus surgery for castration are inconsistent among published studies. While there was no difference in a recent Swedish study,[8] Dunshea et al[7] reported superior growth rates when animals were vaccinated against GnRH. It has been suggested that this superiority is the result of anabolic effects mediated by testicular steroids, particularly testosterone. Similar but lesser effects have been observed in intact boars, but not in surgically castrated boars nor in boars that are immunocastrated long before being marketed.[8,21]

In this study, carcasses of boars vaccinated against GnRH were leaner and had less backfat than surgically castrated pigs. These effects seem to be well substantiated and have been almost uniformly reported throughout studies where boars were vaccinated against GnRH [5,7,22] or when boars were treated with a GnRH agonist for GnRH down-regulation.[23] Such effects are most likely due to the action of testosterone, which remains at high levels until shortly after the second vaccination. Testosterone can promote muscle growth either directly or indirectly via the somatotropin axis[23-25] and has a clear negative correlation to body-fat mass. Testosterone is markedly lower in obese men,[26] and testosterone treatment of men with testicular malfunctions leads to changes in body composition toward muscle growth and decrease in body fat.[27]

This study indicates that vaccination of boars against GnRH may be a good alternative to surgical castration, not only from a perspective of the control of boar taint, but also from a productivity standpoint. Consumers' perception of meat quality in terms of meat composition is different around the world. In Germany, as in the United States, there is a clear trend towards leaner meat. As of February 9, 2009, basis payment was 1.3 Euro per kg for a carcass in the range of 86 to 105 kg with 56% LM, with penalties for lighter or heavier carcasses. Also, there was a penalty of 0.04 Euro per kg for LM < 56% to 52%, with a bonus of 0.02 Euro per kg for LM > 56% to 58% and no bonus for LM > 58% to 60%. On the basis of the German market prices at the time this study was conducted, carcasses of the boars vaccinated against GnRH yielded approximately 13 Euros more than surgically castrated pigs, with approximately 4 Euros for higher carcass weight and 9 Euros for higher LM content.

Although it was not specifically addressed in this study, it seems worth mentioning in this context that feed conversion was better in vaccinated boars, which means significant savings due to less feed consumption,[5,9,28] thus also contributing to the overall economic benefit of vaccination over surgical castration. Considering the increasing worldwide concerns about surgical castration and the millions of pigs that are annually castrated, usually without anesthesia,[11] control of boar taint using vaccine against GnRH represents a significant step forward in terms of animal welfare.[3]

Implications

- Under the conditions of this study, vaccination of boars against GnRH at 10 and 21 weeks of age reliably abolishes boar taint 4 to 5 weeks after the second vaccination, enabling production of odor-free pork from male pigs.
- Vaccination against GnRH as performed in this study leads to a carcass composition of leaner meat and less backfat than in surgical castrates.
- In areas where the consumer's perception of quality pork is lean meat, returns from vaccinated male pigs may be higher than from surgically castrated animals.
- Vaccination as a means to abolish testicular function and control boar taint is an animal-welfare-friendly alternative to surgical castration.

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