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Original Scientific Article

EFFECT OF IMMUNOCASTRATION (IMPROVAC®) IN FATTENING PIGS II: CARCASS TRAITS AND MEAT QUALITY

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Summary: The effect of immunocastration (vaccination against gonadotropin releasing hormone using Improvac® vaccine) on carcass and meat quality traits of Slovenian commercial fatteners was studied. The experimental pigs were selected from 35 litters (2 castrates and 3-4 boars per litter) farrowed within two weeks period and assigned to three treatment groups: boars (n=25), immunocastrated (n=24) and surgically castrated males (n=25). Vaccination of pigs was performed twice; at 10 and 19 weeks of age. Pigs were slaughtered at 24 weeks of age (two slaughter batches in two consecutive weeks) according to the routine abattoir procedure. Various carcass and meat quality traits were assessed. Additionally, an olfactory evaluation of meat for the presence of boar taint was performed using a six member panel. Differences between treatment groups were detected for fat tissue measurements and ratio meat to fat in ham and on the cross-section at the level of last rib or neck. In comparison to the surgically castrated males (the fattest) and boars (the leanest), the immunocastrated males took an intermediate position. However, they were mainly closer to the boars as to the surgically castrated males, except in one case (neck fatness) where immunocastrates were closer to surgical castrates. No significant differences between treatment groups were noted for pH value, colour or drip loss. Regarding intramuscular fat which is important for sensory quality, we noted a significant difference between surgical castrates and boars, whereas the immunocastrates were either intermediate (*biceps femoris* marbling) or closer to boars (*longissimus dorsi* intramuscular fat). The present study provided additional evidence of the benefits of the immunocastration for carcass quality, with no major effect on meat quality.

Key words: pig; immunocastration; carcass traits; meat quality

Introduction

Review of the literature in regard to the prevention of boar taint and the effect of using the Improvac® vaccine has been presented in the first part of the article. Furthermore, the results of the present experiment on pig growth performance, size of the reproductive organs and the level of malodorous compounds responsible for boar taint have also been presented and discussed. This novel method of boar taint prevention is currently intensively tested in many European countries, since the vaccine was approved in the European Union in 2009, some of the tests have already been published (1, 2, 3, 4, 5). Besides its impact on growth, the consequences in terms of carcass leanness seem even more important. According to the published results, the immunocastrated pigs have leaner carcasses compared to the surgical castrates (3, 4, 5, 6), which represents an important advantage for pig producers. Namely, carcass lean meat content is the main criterion for the payment of commercial pig fatteners. However, a better and more complete picture on carcass and meat quality is necessary taking into consideration the demands of retailers and consumers. There is a need for more detailed data on the relative distribution or importance of muscle and fat tissue in valuable meat cuts as well as on the technological and sensory quality of meat. In view of this and to test the vaccine in the local conditions, the objective was to assess the effect of immunocastration on the selected carcass and meat quality traits by comparing three groups of pigs, the entire males, the surgically castrated males

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and the males vaccinated with Improvac®. In addition we performed an olfactory test for the presence of boar taint in all three groups of the pigs.

Material and methods

Olfactory evaluation of boar taint

The intensity of boar taint in pork was performed by a panel of six members of the Veterinary faculty staff selected for their ability to detect this specific odour. Five members were women and one was a man. Women have been shown to be more sensitive to androstenone. Meat samples (15 g) were put in a 250 ml flask, covered by a small amount of water, heated and left boiling for 10 minutes. After the heating, the samples were taken into the separated laboratory, where the intensity of the odour was estimated. Panellists had to choose among the three levels of odour intensity: none, slight or strong. All samples were individually assessed for boar taint by each member of the panel.

Measurements on the slaughter line

The origin and rearing conditions for the experimental pigs have been described in the first part of the present study. Shortly, experimental pigs (50% crosses of Duroc) were selected from 35 litters (2 castrates and 3-4 boars per litter) farrowed within two weeks period, and assigned to three experimental groups: boars (n=25), immunocastrated males (n=24) and surgically castrated males (n=25). The vaccinations with Improvac® were performed at the age of 10 and 19 weeks. During the trial, pigs were lodged individually. Pigs were slaughtered at the age of 24 weeks (in two slaughter batches within two consecutive weeks) according to the routine abattoir procedure *i.e.* CO_2 stunning, vertical exsanguination, vapour scalding, dehairing and evisceration followed by the veterinary inspection and carcass classification. Pigs were transported (app. 1 hour) and left to rest (app. 2 hours) before being slaughtered. At the slaughter line, pigs were classified according to SEUROP by official classification body, using a method approved for Slovenia (7) which consists of taking two measurements at the carcass split line; DM fat (minimal fat thickness over the *gluteus medius* muscle – GM) and DM muscle (shortest distance between cranial end of GM and dorsal edge of vertebral canal). Measurement of pH (pH45) in *longissimus dorsi* muscle (LD) was taken 45 minutes and 24 hours *post mortem* using a MP120 Mettler Toledo pH meter (Mettler-Toledo, GmbH, 8603 Schwarzenbach, Switzerland) fitted with a combined glass electrode (InLab427) and previously calibrated at pH 4.0 and 7.0. The carcasses were cooled overnight by storage at 0-2 °C until the internal carcass temperature dropped below to 7 °C.

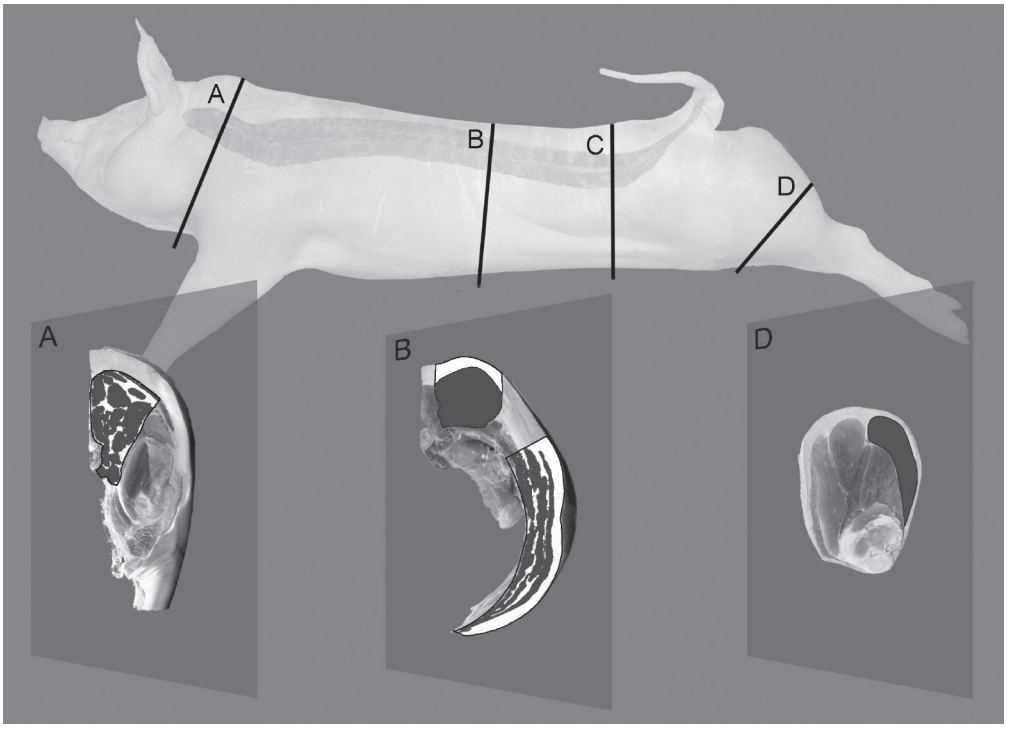

Figure 1: Locations of cross-sections for the evaluation of carcass properties

Carcass properties

A day following slaughter, additional carcass traits were assessed. The carcass was cut at four sites (see Figure 1) which included cutting between 3rd and 4th cervical vertebra (cross-section A), after last rib (cross-section B), between 6th and 7th lumbar vertebra (cross-section C) and through the knee joint (cross-section D). Images of the corresponding carcass cross-sections were taken using a digital photo camera (Canon PowerShot G3, Canon Inc., Tokyo, Japan). LUCIA.NET 1.16.5 software (Laboratory Imaging s.r.o., Prague, Czech Republic) was used for image analysis determining the neck fatness (%) on the cross-section A, loin eye or *longissimus dorsi* area (LD area) and corresponding fat area (fat over LD) on the cross-section B. The ratio between LD meat and corresponding fat (LD meat:fat ratio) was calculated. Additionally, LD marbling, belly leanness (cross-section B) and *biceps femoris* muscle (BF) marbling (cross-section D) were visually assessed using 1-7 point scale (1 denoting the lowest and 7 the highest intensity). The hind leg (portion between cross-section C and D) was weighed prior (ham weight) and after (ham muscle+bone) the removal of the skin and subcutaneous fat and ham leanness % (ham meat) calculated as the ratio between the two weights.

Meat quality measurements

The measurements of the colour and pH were taken on a freshly cut surface of LD (cross section B). Colour of LD was assessed using 1-6 point Japanese colour scale (8). Colour parameter measurements (CIE L*, a*, b*) were taken in triplicate using a Minolta Chroma Meter CR-300 (Minolta Co. Ltd, Osaka, Japan) with an 11 mm aperture, D_{65} illuminant, calibrated against a white tile. Muscle pH (pH_{24}) was determined in two replicates in the central area of LD. Caudally from the level of last rib two 2.5 cm thick slices of LD were removed from the loin for the determination of drip loss, intramuscular fat and olfactory test of boar taint. Drip loss was determined according to the EZ drip loss method (9). Shortly, two cylindrical samples were excised from the central part of LD, weighed and placed in special plastic containers. The samples were reweighed after 24 hours and after 48 hours of storage at 4 °C. Drip loss was expressed as a difference (%) of initial sample weight. Samples of LD muscle were minced and intramuscular fat content (IMF) estimated using NIRS (NIR System model 6500 Spectrometer, Silver Spring, MD, USA) (10).

Statistical analysis

The effect of treatment group (*i.e.* surgically castrated, immunocastrated or boars) was analysed using a GLM procedure of statistical package SAS (SAS Inc., Cary, NC, USA). In the case of meat quality traits (pH_{45}, pH_{24}, colour, Minolta L*, a*, b*, drip24 and drip48) slaughter batch was added to the model as a random effect. Significant differences ($P<0.05$) in means between groups were compared using *Tukey* test.

Results and Discussion

Olfactory evaluation of boar taint

The results of the sensory test (Table 1) revealed that surgically castrated males had the lowest incidence and intensity of the unpleasant odour. A slightly higher incidence and intensity were detected for the immunocastrated males. On the other hand, in the case of boars, all samples were recognized as having an unpleasant odour (99.2 % incidence for a strong boar taint). It is somehow surprising that two samples of immunocastrated males were scored by panellists as having a strong boar taint, despite the fact, that all fat samples of immunocastrated males exhibited levels of androstenone which were below the detection limit of laboratory method and consumer thresholds (see Table 2 of part I of this study). The effectiveness of the immunocastration for the prevention of boar taint has been proven by many studies on the molecular level *i.e.* decreased fat tissue androstenone and skatole levels (5, 11, 12, 13, 14, 15) as well as by the sensory analysis using either consumers (1) or panel tests (2, 16).

Table 1: Incidence of boar taint in surgically castrated, immunocastrated males and boars

Degree of odour	Panel member							
	A	B	C	D	E	F	Average	Incidence, %
SURGICALLY CASTRATED MALES								
None	23	22	22	24	24	22	22.8	95.1
Slight	1	2	2	0	0	2	1.2	4.9
Strong	0	0	0	0	0	0	0.0	0.0
IMMUNOCASTRATED MALES								
None	22	22	22	21	22	21	21.7	90.4
Slight	0	1	0	0	0	1	0.3	1.3
Strong	2	1	2	3	2	2	2.0	8.3
BOARS								
None	0	0	0	0	0	0	0.0	0.0
Slight	0	0	0	0	0	1	0.2	0.8
Strong	25	25	25	25	25	24	24.8	99.2

Carcass properties

There was a significant effect of the treatment group on the majority of the measured carcass traits (Table 2). In the present experiment, boars tended ($P<0.10$) to have heavier carcasses (3.9 kg) as surgically castrated males, while the immunocastrated males were intermediate (1.7 kg lighter than boars and 2.2 kg heavier than surgically castrated males). No differences among treatment groups were found for dressing percentage. Contrary to our result, dressing percentage has sometimes been reported to be lower in immunocastrated males (3, 12). Several studies (3, 12, 17) reported heavier carcass weights for surgically castrated males and immunocastrated males as compared to boars, however, all of the mentioned experiments were conducted on group housed pigs, where growth performance of boars can be affected negatively due to their more aggressive social behaviour (18, 19).

Table 2: Carcass traits (mean ± se) in surgically castrated, immunocastrated males and boars

	SURGICALLY CASTRATED MALES	IMMUNOCASTRATED MALES	BOARS	*P-value*
Number of carcasses	24	24	25	
Carcass weight, kg	91.1 ± 0.85	93.3 ± 1.22	95.0 ± 1.55	0.095
Dressing, %	77.8 ± 0.31	77.1 ± 0.33	77.5 ± 0.39	0.412
Leaf fat, kg	1.3 ± 0.07^{a}	1.1 ± 0.05^{b}	0.9 ± 0.05^{c}	<0.000
DM fat, mm	18.3 ± 0.94^{a}	15.1 ± 0.67^{b}	13.2 ± 0.69^{b}	<0.000
DM muscle, mm	71.4 ± 0.99	73.5 ± 0.90	73.5 ± 0.71	0.167
DM meat, %	56.1 ± 0.72^{a}	58.8 ± 0.48^{b}	60.1 ± 0.52^{b}	0.000
LD area, cm2	47.8 ± 0.80	48.2 ± 0.88	47.5 ± 0.89	0.537
Fat over LD, cm2	17.5 ± 0.69^{a}	15.4 ± 0.49^{ab}	15.0 ± 0.68^{b}	0.014
LD meat : fat ratio	2.77 ± 0.12^{a}	3.20 ± 0.12^{ab}	3.36 ± 0.18^{b}	0.020
Ham, kg	10.9 ± 0.12	11.2 ± 0.18	11.2 ± 0.20	0.471
Ham muscle+bone, kg	8.7 ± 0.15^{a}	9.2 ± 0.17^{ab}	9.4 ± 0.17^{b}	0.014
Ham meat, %	79.7 ± 0.71^{a}	82.1 ± 0.59^{b}	84.1 ± 0.42^{b}	<0.000
Belly leanness (1-7)	4.6 ± 0.19^{a}	5.1 ± 0.12^{b}	5.2 ± 0.12^{b}	0.041
Neck fatness, %	26.0 ± 0.93^{a}	24.6 ± 0.69^{a}	21.6 ± 0.70^{b}	<0.000

LD – muscle *longissimus dorsi*; means with different letters within one row are significantly different ($P<0.05$). DM denotes the name of the Slovenian method for SEUROP classification.

As expected, surgically castrated males were fatter (P<0.05) than boars as demonstrated by several measurements on fat tissue (e.g. leaf fat, DM fat, fat over LD). On several anatomical locations (last rib, neck, ham) they also had significantly lower meat to fat ratio than boars. The immunocastrated males were positioned in between these two control groups. In case of leaf fat, the immunocastrated males were intermediate, differing (P<0.0001) either from surgically castrated males or boars. Such intermediate position of the immunocastrated males has also been demonstrated by Gispert *et al.* (3). For DM fat measurement, the immunocastrated males were closer to boars and they both exhibited lesser subcutaneous fat depot (P<0.0001) and consequently higher carcass meat % (P<0.0001) as surgically castrated males. It is worth mentioning that the difference in carcass meat % between surgically castrated and immunocastrated males was 2.7% points, which is economically important benefit in favour of the later. In the case of fat area over LD and LD meat:fat ratio, the immunocastrated males were also positioned closer to boars, however the difference was insignificant either in relation to boars or surgically castrated males. The immunocastrated males had only slightly lower belly leanness than boars, both groups having leaner belly (P<0.05) as surgically castrated males. The situation was, however different in the case of neck fatness, where the immunocastrated males had (insignificantly) lower fatness as surgically castrated males, whereas they both had fatter neck area as boars. There are several studies reporting on carcass properties of the immunocastrated males compared to the surgically castrated males or boars, however, due to the differences in slaughter weight and other experimental conditions, the results are inconsistent. Whereas one of the early studies (20) showed the immunocastrated males to be fatter from either surgically castrated males or boars, others found no differences between treatment groups (14) or reported the immunocastrated males to be closer to boars than to surgically castrated males (3, 4, 11). Additionally, two recent studies (5, 6) comparing only surgically castrated males against immunocastrated males confirmed the benefits of the later in terms of lower backfat thickness and better lean meat percentage. In summary, we could conclude, that the immunocastrated males are generally reported to be leaner than surgically castrated males and fatter than boars. It is clear that the age at vaccination and especially the timing of second vaccination is the key factor, since it determines the phase during which the animals can profit the anabolic potential of the entire male. It was, for example shown for subcutaneous fat depot (12) that the immunocastrated males, which were vaccinated earlier in life (15^{th} and 19^{th} week), were similar as surgically castrated males, whereas those vaccinated later (18^{th} and 22^{th} week) were closer to boars. Similar result was also obtained by Turkstra *et al.* (13), showing that the immunocastrated males which responded to the vaccination earlier (already after first immunization) had thicker backfat and lower carcass meat % (similar to the control surgically castrated males) as late responders (after second immunization), which were similar to boars. In the present experiment, the immunocastrated males had leaner hams than surgically castrated males and fatter hams (insignificantly) than boars. In regard to ham traits, the literature does not provide uniform data. No advantage of immunocastrated males over surgically castrated males was observed for ham weight (6), while in some cases similar ham weight was reported for immunocastrated males and boars (4, 11). As regards the ratio of fat to muscle tissue in the ham, similarly to our study, an intermediate position of the immunocastrated males has been shown in a recent experiment (3).

Meat quality

The comparison of the tested groups in regard to meat quality (Table 3) revealed significant differences only for intramuscular fat (BF marbling, LD IMF) and Minolta b*, whereas no differences were found for other parameters of meat technological quality. Regarding intramuscular fat content, the immunocastrated males exhibited similar content as boars in the case of low fat muscle like LD, whereas in the case of BF muscle, the immunocastrated males exhibited less marbling as surgically castrated males and more marbling as boars. This result corroborates with the differences observed for body composition. There was however no significant difference in LD marbling score, probably because marbling in that muscle was generally too low to detect a difference.

Table 3: Meat quality traits (mean ± se) in surgical castrates, imunocastrates and boars

	SURGICALLY CASTRATED MALES	IMMUNO-CASTRATED MALES	BOARS	*P-value*
Number of carcasses	24	24	25	
Marbling BF (1-7)	3.4 ± 0.25[a]	2.9 ± 0.15[ab]	2.6 ± 0.17[b]	0.036
Marbling LD (1-7)	1.3 ± 0.08	1.3 ± 0.07	1.2 ± 0.07	0.649
LD intramuscular fat, mg/g	19.8 ± 0.76[a]	15.8 ± 0.83[b]	15.6 ± 0.90[b]	0.001
pH_{45}	6.17 ± 0.05	6.27 ± 0.06	6.27 ± 0.06	0.306
pH_{24}	5.60 ± 0.03	5.62 ± 0.04	5.67 ± 0.04	0.375
Colour (1-6)	3.42 ± 0.10	3.46 ± 0.10	3.50 ± 0.11	0.861
Minolta L*	48.9 ± 0.59	49.2 ± 0.75	48.6 ± 0.76	0.799
Minolta a*	7.3 ± 0.19	6.9 ± 0.22	6.9 ± 0.26	0.405
Minolta b*	2.8 ± 0.23[a]	2.1 ± 0.19[b]	2.4 ± 0.26[ab]	0.049
Drip 24h, %	2.8 ± 0.43	3.7 ± 0.52	2.7 ± 0.53	0.273
Drip 48h, %	4.5 ± 0.52	5.4 ± 0.61	4.2 ± 0.64	0.304

BF – muscle *biceps femoris*; LD – muscle *longissimus dorsi;* pH_{45} – pH measured in LD 45 minutes after slaughter; pH_{24} – pH measured in LD 24 hours after slaughter; Colour (1-6) denotes use of Japanese colour scale; means with different letters within one row are significantly different (P<0.05).

Regarding the marbling score and IMF, an intermediate degree of marbling and intramuscular fat in immunocastrated males compared to leaner boars and fatter surgically castrated males was reported before (3), which is in accordance with the present study for the first, but not for the later trait. In the present study, the IMF of the immunocastrated males is closer to the one of boars. Although it is indicated in the literature, that due to their behaviour (higher level of aggressiveness and physical activity) boars could deplete muscle glycogen resulting in the effect on the ultimate pH and meat quality (18, 21, 22, 23, 24), this was not the case in the present study. In accordance with our results, no differences in pH (3, 4, 25), WHC or colour (4, 25) were reported between immunocastrated males, boars or surgically castrated males**.** However, there are studies, which reported immunocastrated males to have darker meat (L*) than surgically castrated males (26) and lighter meat than entire boars (3) and also lower drip loss than surgically castrated males (27).

Conclusions

The present study (in the local Slovenian conditions) provided additional evidence that the immunisation with Improvac® successfully reduces boar taint, improves carcass quality in comparison to surgically castrated pigs, without any major effect on meat quality.

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UČINEK IMUNOKASTRACIJE (IMPROVAC®) PRI PRAŠIČIH PITANCIH: II. KLAVNE LASTNOSTI IN KAKOVOST MESA

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Povzetek: Preučevali smo vpliv imunokastracije (cepljenja proti gonadotropin sproščajočemu hormonu s cepivom Improvac®) na lastnosti klavnega trupa in kakovost mesa slovenskih prašičev pitancev. Poskusni prašiči (50% križanci pasme durok) so bili izbrani iz 35 gnezd (po 2 kastrata in 3-4 merjasci na gnezdo), rojeni v obdobju dveh tednov. Živali smo razdelili v tri poskusne skupine: merjasce (n=25), imunokastrate (n=24) in kirurške kastrate (n=25). Cepljenje z Improvacom ® smo opravili pri starosti 10 in 19 tednov. S poskusom smo pričeli pri starosti 12 tednov in je trajal do 24. tedna starosti, ko so bili prašiči zaklani (dve seriji zakola v dveh zaporednih tednih) po standardnem klavničnem postopku. Na klavni liniji oziroma na hladnih trupih dan po zakolu smo ocenili različne klavne lastnosti in kakovost mesa. Dodatno smo s pomočjo šestčlanskega panela ocenjevalcev izvedli senzorično ocenjevanje mesa na prisotnost vonja po merjascu. Pomembne razlike med poskusnimi skupinami smo opazili pri meritvah debeline podkožnega maščobnega tkiva, v razmerju med maščobo in mesom na stegnu in prerezu za zadnjim rebrom ter na vratu. V primerjavi s kirurškimi kastrati (najbolj zamaščeni) in merjasci (najbolj mesnati) so bili imunokastrati med obema skupinama, vendar večinoma bližje merjascem, le pri zamaščenosti vratu so bili bolj podobni kirurškim kastratom. Glede vrednosti pH, barve mesa in izceje nismo ugotovili nobenih razlik med poskusnimi skupinami. V primeru intramuskularne maščobe, ki je pomembna za senzorično kakovost mesa, smo ugotovili razlike med kirurškimi kastrati in merjasci. Imunokastrati so bili na sredini med obema skupinama v primeru marmoriranosti mišice *biceps femoris* oziroma bližje merjascem v primeru kemijsko določene intramuskularne maščobe v mišici *longissimus dorsi*. Rezultati naše raziskave so potrdili ugoden učinek imunokastracije na kakovost klavnega trupa brez posledic za kakovost mesa.

Ključne besede: prašiči; imunokastracija; klavne lastnosti; kakovost mesa