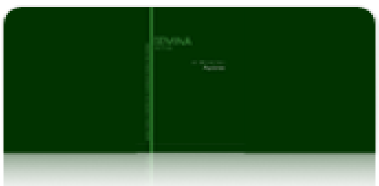

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Immunocastration and its effects on carcass and meat traits of male pigs

Imunocastração e seus efeitos nas características de carcaça e carne de suínos machos

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Abstract

To compose the experiment, 160 male Topgen pigs - 80 surgically castrated (treatment 1) and 80 immunocastrated (treatment 2) - were randomly selected from a commercial swine farm at the moment of slaughter. Surgical castration was performed when the animals were seven days of age and immunocastration was performed by administering two doses (2 mL each) of immunocastration vaccine (analogue of GnRF linked to a carrier protein, development of anti-GnRF antibodies, 200 mg of a GnRF-protein conjugate/mL) when they were 104 and 132 days of age. Animals from both treatments were maintained in masonry stalls, where they received water and *ad libitum* diet (the same feed for both groups). The animals were slaughtered at 160 days of age, and the length and width of the testicles of immunocastrated animals were evaluated, along with the degree and number of carcass lesions, carcass traits and meat quality of both treatments. The means of these measurements were calculated and compared by Student´s t-test. For the immunocastrated treatment, Pearson´s correlation coefficients were also calculated for testicle length and width with backfat thickness. Approximately 80% of the immunocastrated animals had testicle widths of 11 cm or less. Immunocastrated animals showed higher degrees of lesions, pH (initial and 8 hours), hue, muscle depth and loin eye area and lower brightness, redness, chroma and backfat thickness than the surgically castrated animals. The correlation between testicle length and width with backfat thickness was inverse. Immunocastration can be an alternative to improve the proportion of lean meat (*longissimus thoracis*) instead of fat (backfat thickness) leading to better carcass and meat quality, since fat has become undesirable from a nutritional point of view in swine.
Key words: Backfat thickness. Color. Gonadotropin-hormone. Improvac®. Testicle size.

Resumo

Para compor o experimento, 160 suínos machos (Topgen) - 80 castrados cirurgicamente (tratamento 1) e 80 imunocastrados (tratamento 2) - foram selecionados aleatoriamente de uma granja comercial

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de suínos no momento do abate. A castração cirúrgica foi realizada quando os animais tinham sete dias de idade e a imunocastração realizada através da administração de duas doses (2 mL cada) da vacina de imunocastração (análogo do GnRH ligado a uma proteína carreadora, desenvolvimento de anticorpos anti-GnRH, 200 mg de um conjugado de proteína GnRH/mL) quando os animais tinham 104 e 132 dias de idade. Os animais de ambos os tratamentos foram mantidos em baias de alvenaria, onde receberam água e ração *ad libitum* (a mesma dieta para ambos os grupos). Os animais foram abatidos com 160 dias de idade e foram avaliados o comprimento e largura dos testículos dos animais imunocastrados, e o grau e número de lesões na carcaça, características de carcaça e qualidade da carne de ambos os tratamentos. As médias para essas avaliações foram calculadas e comparadas com o teste t. Para o tratamento imunocastrado foi também calculado o coeficiente de correlação de Pearson´s do comprimento e largura dos testículos com a espessura de gordura. Aproximadamente 80% dos animais tiveram largura dos testículos igual ou menor que 11 cm. Os animais imunocastrados mostraram maior grau de lesão, pH (inicial e 8 horas), tonalidade, profundidade de músculo e área de olho de lombo e menor luminosidade, intensidade de vermelho, croma e espessura de gordura do que os animais castrados cirurgicamente. A correlação entre comprimento e largura dos testículos com a espessura de gordura foi negativa. A imunocastração pode ser uma alternativa para aumentar a proporção de carne magra (*longissimus thoracis*) em detrimento de gordura (espessura de gordura), levando a uma carcaça de melhor qualidade desde que a gordura suína se tornou indesejável do ponto de vista nutricional.
Palavras-chave: Cor. Espessura de gordura. Hormônio liberador de gonadotropinas. Vivax®. Tamanho dos testículos.

Introduction

Consumer preferences, behaviour and perception of meat depend not only on the appearance and sensory properties of the meat but also on psychological and marketing aspects (FONT-I-FURNOLS; GUERRERO, 2014). Many factors can affect the quality of meat, including the gender of the animal, which is an important determinant of muscle growth (LAWRIE; LEDWARD, 2006).

Pig production can be impaired by boar taint, which decreases pork quality due to a sensory defect. The sensory defect is caused by two compounds, skatole and androstenone, which are responsible for releasing an unpleasant odour and flavour when the meat or fat of entire male pigs are heated (TUYTTENS et al., 2011; ZAMARATSKAIA; SQUIRES, 2009). For this reason, according to the Inspection Regulations of the Industrial and Sanitary Use of Animal Products, as stated in Article 121 of Decree 30691 of March 29, 1952, in Brazil "It is forbidden to kill non-castrated pigs or animals showing signs of recent castration" (BRASIL, 1952). Because of this, surgical castration of males has been routinely performed to eliminate the possibility of odour in the meat. However, this method is not entirely satisfactory, as it has been associated with endangering pig health and welfare. Therefore, the development of methods that exclude conventional castration is desirable (LUNDSTRÖM; ZAMARATSKAIA, 2006).

Immunocastration is a method that immunizes the male piglet against gonadotropin-releasing hormone (GnRF). GnRF is a neuropeptide that is released from the hypothalamus to stimulate the secretion of luteinizing hormone (LH) and follicle stimulating hormone (FSH), which controls the production of testicular steroids. Immunological blocking of the signal from GnRF decreases the production of LH and testicular steroids (RYDHMER et al., 2010). As a consequence, immunization temporarily suppresses testicular development and function (TUYTTENS et al., 2011), avoiding boar taint, as well as being able to reduce pork eating quality fail rates by approximately 10%, when compared to entire male pigs (MOORE et al., 2017). Immunocastrated pigs, after applying the second dose of the vaccine, become calmer and exhibit significantly fewer aggressive and sexual behaviours (BAUMGARTNER et al., 2010), improving their welfare and carcass quality and reducing the incidence of skin lesions (ŠKRLEP et al., 2014).

As a non-invasive and practically painless method, not only does immunocastration improve animal welfare (DUNSHEA et al., 2005), but it also achieves some productive benefits, such as better growth rate, which is found in entire males before immunocastration, and better feed conversion ratio (FÀBREGA et al., 2010; RYDHMER et al., 2010). In addition to the superior performance, immunocastrated pigs can deposit a higher percentage of muscle and a lower percentage of fat compared to surgically castrated pigs (JANJIC et al., 2017; SANTOS et al., 2012).

However, when using immunocastration, economic factors such as the cost of the immunization vaccine, labour in the application and the possibility of costs in controlling the effectiveness of the vaccine in the slaughter line should be considered (PRUNIER et al., 2006).

The aim of this study was to evaluate carcass traits and pork meat quality of pigs that were submitted to an immunocastration process.

Material and Methods

The work was approved by the Ethics Committee on Animal Use of the State University of Londrina under Case No. 11888.2012.76.

Animals and treatments

To compose the experiment, 160 male Topgen pigs - 80 surgically castrated (treatment 1) and 80 immunocastrated (treatment 2) - were randomly selected from a commercial swine farm at the moment of slaughter. Surgical castration was performed when the animals were seven days of age. The scrotal method was used, in which an incision was made on each testicle, followed by exteriorization and removal. Immunocastration was performed by administering two doses (2 mL each) of an immunocastration vaccine (analogue of GnRF linked to a carrier protein, development of anti-GnRF antibodies, 200 mg of a GnRF-protein conjugate/mL). The first dose was injected at 104 days of age and the second dose at 132 days of age. Animals from both treatments were maintained in masonry stalls at a density of 0.90 m^2 per animal, with nipple-type drinkers and troughs for feed, where they received water and *ad libitum* diet (the same feed for both groups) as recommended by the NRC (1998).

Slaughter

When the animals reached 160 days of age, they were slaughtered in a commercial abattoir under the Federal Inspection Service, in Joaquim Távora, Paraná, Brazil. During pre-slaughter management, the feed was removed 12 hours before shipment. Water was made available until slaughter. The pigs were stunned and exsanguinated according to Humane Slaughter Standards (BRASIL, 2000).

Testicle, carcass and meat analysis

The animals were identified according to treatment. The testicles length and width were measured with a tape measure of immunocastrated animals as required by BRASIL (2007) during their slaughter.

Subsequently, the degree and number of lesions on carcasses were determined for both treatments, wherein the degree of lesion was categorized according to a photographic standard of five categories: (1) not damaged; (2) lightly damaged; (3) slightly damaged; (4) moderately damaged; and (5) severely damaged (MLC, 1985). The number of lesions was quantified at three locations on the carcass: front, dorsal, and rear. These were classified according to the following: (1) lesion found in just one place on the carcass; (2) lesions found in two places on the carcass; (3) lesions found in three places on the carcass.

All carcasses were weighed 45 minutes and 12 hours after the beginning of the slaughter and the hot carcass weight (HCW) and the chilled carcass weight (CCW) were obtained, respectively. The pH of the *longissimus dorsi* muscle was determined on the left halves of the carcasses at 45 minutes (pH initial) and 8 hours (pH 8 h) after the beginning of the slaughter between the penultimate to the last rib, using a digital potentiometer (Testo 205®).

The left halves of the carcasses were sawn between the penultimate and the last rib, and 30 minutes later, using a portable colorimeter (CR-10, Kônica Minolta) the *longissimus dorsi* color components were evaluated: L* (luminosity), a* (redness) and b* (yellowness) by the CIELAB system. Chroma (c*) and hue (h*) were calculated using the values of a* and b* (CIELAB, 1978). In the exposed area, the muscle depth and backfat thickness were also measured using a digital caliper. The loin eye area was also estimated by drawing it on greaseproof paper and the obtained image was used to estimate the area in square centimeters, using a standard point counting method (AMSA, 2001).

Statistical analysis

The experimental design was completely randomized. The means of the treatments (surgically castrated and immunocastrated animals) were calculated and compared by Student´s t-test. For the immunocastrated treatment, Pearson´s correlation coefficients of the testicle length and width with backfat thickness were also calculated, both using the SAEG statistical program.

Results and Discussion

Testicle measurements of immunocastrated pigs

The maximum, minimum and average overall lengths of the testicles of immunocastrated animals were 25.0 cm, 11.0 cm and 15.03 cm, respectively, and the widths were 17.0 cm, 8.0 cm, and 10.36 cm, respectively (Table 1).

Table 1. Testicle lengths and widths of immunocastrated pigs.

Observed values	Testicle length (cm)	Testicle width (cm)
Maximum	25.00	17.00
Minimum	11.00	8.00
General average	15.03	10.36
Coefficient of variation (%)	15.27	16.28

Maximum - maximum value observed; minimum - minimum value observed; general average - overall average presented.

In Brazil, the guidelines set by Decision Nº. 005/2007/CGI/DIPOA determine the procedures adopted by the Federal Inspection Service (FIS) in pig abattoirs regarding the slaughter of immunocastrated male pigs. One of the procedures adopted is the measurement of testicle width because male pigs with testicular widths greater than 11 cm may present a higher risk of boar taint, so these animals must be subjected to a cooking test before being release to commercial marketing, as recommended by Circular Nº. 069/88/DICAR/DIPOA of June 20, 1988 (BRASIL, 2007). However, a new Circular Nº. 001/2017/CGI-DIPOA/DIPOA/DIPOA-SDA/SDA/MAPA was launched in January 27, 2017 that replaces the previous one, and according to the new circular, studies have shown that the immunocastration vaccine has the expect effect, despite the testicle size being superior to 11 cm, which was stipulated in previous law (BRASIL, 2017). An explanation for the substitution of previous law (2007) by the current one (2017) is due to the superior slaughter weight observed now compared to 2007, also leading to superior testicle size because the immunocastration vaccine does not regress testicle size, it only suppresses development, invalidating the previous legislation.

In the current study, 80% of the immunocastrated animals evaluated had testicle widths lower or equal to 11 cm, which indicated that according to BRASIL (2007) these animals were within the standards required for marketing when they were slaughtered. Therefore, 20% of these animals were not within the recommended standards and showed testicles sizes of more than 11 cm. This does not mean that all 20% had boar taint (undesirable for market). However, in order to check the absence of boar taint, they were subjected to a cooking test by the abattoir before marketing; those that did not present boar taint were sent to market and consumers.

It is likely that the differences found between immunocastrated animals in testicle size is due to variation in immunological response to the vaccine, which, according to Einarsson (2006), is because of individual variance to antibody titres between different animals. In other words, it is possible that a few vaccinated male pigs did not respond equally to immunocastration, continuing with high concentrations of steroids, leading to the 20% of animals not meeting recommended standards (greater than 11 cm). The individual variation shown by the animals can be explained by several factors, mainly genetic, but also by the nutritional status, age and stress at the time of vaccination (TIZARD, 2014; GASPAR; SANTOS, 2016).

Carcass lesion degree

Carcass lesion degree was different between the treatments; however, the number of lesions was not different ($P > 0.05$). The lesion degree was higher ($P \leq 0.01$) for the immunocastrated pigs than for the surgically castrated pigs (Table 2). As show in Figure 1, immunocastrated animals had lower percentages of degrees 1 and 2 (13% and 37% of degrees 1 and 2, respectively) than the surgically castrated animals (29% and 50% of degrees 1 and 2, respectively). However, the opposite trend was observed with degrees 3 and 4, where the immunocastrated pigs achieved approximately 45% and 5%, respectively, whereas the surgically castrated animals had values of 18% and 3%. No severely damaged carcasses (degree 5) were observed.

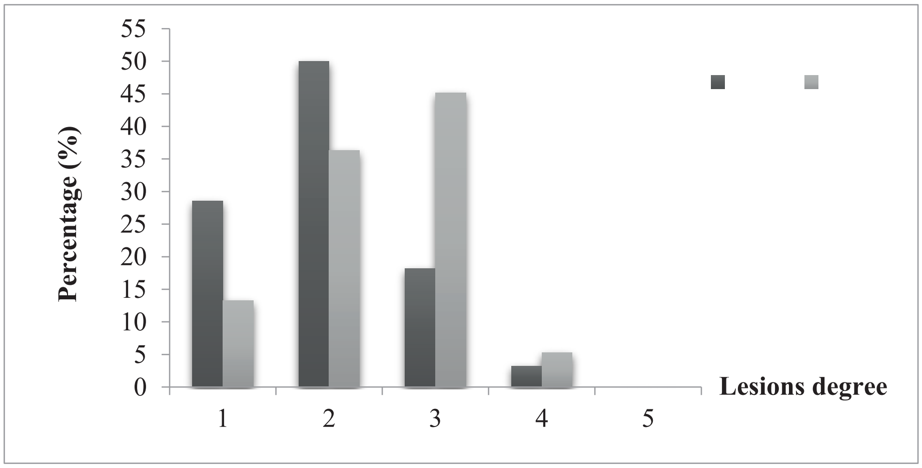
It was expected that the immunocastrated treatment would have higher percentages of lesions on their carcasses than the surgically castrated treatment, since before receiving the second application of the immunocastration vaccine, the pigs are more aggressive than surgically castrated males (ALBRECHT et al., 2012) because they still have an entire male behaviour due to testosterone, leading to a higher number of agonistic interactions and a higher degree of skin lesions (BÜNGER et al., 2015). According to Einarsson (2006), it is only after the second dose of immunocastration vaccine that aggressive and sexual behaviours decrease. Therefore, it is likely that animals from Immunocastrated treatment in the current study behaved as non-castrated males before receiving the second immunization, resulting in injuries that were observed on their skins at slaughter.

Table 2. Averages of carcass traits and meat quality of surgically castrated and immunocastrated treatments.

	Treatments		Significance level	SEM [1]
	Castrated	Immunocastrated		
Degree of lesions	1.96	2.17	**	0.052
Number of lesions	1.78	1.76	NS	0.046
Hot carcass weight (kg)	79.18	81.87	NS	0.744
Chilled carcass weight (kg)	76.22	78.78	NS	0.728
Carcass cooler shrink (%)	3.77	3.78	NS	0.065
pH initial	6.02	6.20	**	0.021
pH 8 hours	5.73	5.80	*	0.018
Lightness (L*)	47.51	46.11	*	0.292
Redness (a*)	7.37	4.28	**	0.244
Yellowness (b*)	8.96	9.16	NS	0.305
Chroma (c*)	12.00	10.16	**	0.313
Hue (h*)	50.51	65.91	**	1.166
Muscle depth (mm)	55.46	57.64	*	0.488
Backfat thickness (mm)	18.94	17.71	*	0.313
Loin eye area (cm^2)	37.02	38.66	*	0.394

**Significant at 1% probability ($P \leq 0.01$); * significant at 5% probability ($P \leq 0.05$); NS - not significant ($P > 0.05$); [1] SEM - standard error of the mean.

Figure 1. Percentage of lesions degree observed in surgically castrated and immunocastrated treatments.



(1) not damaged; (2) lightly damaged; (3) slightly damaged; (4) moderately damaged; (5) severely damaged.

Carcass and meat traits

There were no differences ($P > 0.05$) for hot carcass weight and chilled carcass weight between immunocastrated and surgically castrated animals. However, differences ($P \leq 0.05$) were observed between them for pH initial, pH 8 h and all colour components, except for the yellowness (b*) value (Table 2). *Longissimus thoracis* pH values and hue (h*) were greater, while brightness (L*), redness (a*) and chroma (c*) were lower for immunocastrated animals than surgically castrated animals.

The result showed that hot carcass weight and chilled carcass weight are similar as the values reported by Pauly et al. (2009), who also found no differences between surgically castrated and immunocastrated pigs for these variables. However, the data found in the current study indicates that the meat from surgically castrated animals was clearer (higher L*) than that from immunocastrated animals, this is possibly due to increased extravasations of liquids and pigments, which is a consequence of meat with lower pH values (JONSÄLL et al., 2001). Jeong et al. (2011) also compared surgically castrated and immunocastrated pigs and found clearer meat in the surgically castrated pigs. However, these data are contrary to those observed in previous studies, in which Gispert et al. (2010) and Martinez-Macipe et al. (2016) did not report differences for L*, a* and b* between castrated and immunocastrated pigs.

For muscle depth, backfat thickness and loin eye area, there were differences ($P \leq 0.05$) between immunocastrated and surgically castrated animals (Table 2). Muscle depth and loin eye area were higher and backfat thickness was lower for immunocastrated pigs than for surgically castrated pigs. The lower backfat thickness and the greater muscle depth and loin eye area found for immunocastrated animals can be attributed to the presence of steroids prior to immunization, whereas surgical castration eliminates such a possibility. According to Needham and Hoffman (2015), immunocastrated animals grow similarly to entire males until their booster vaccination, leading to a higher potential for anabolic growth than surgically castrated animals. Therefore, the results found in the current study were expected, because it is known that immunocastrated pigs have better feed conversions and higher potential to develop lean meat (LUNDSTRÖM; ZAMARATSKAIA, 2006), while surgical castration increases fat deposition since the male hormones involved in stimulating muscle growth are no longer present (NEEDHAM, 2014).

The reports of this study differed from those found by Martinez-Macipe et al. (2016), who did not observe differences in fat thickness and loin length between immunocastrated and surgically castrated animals. However, our results are in agreement with those reported by Aluwé et al. (2013) who observed higher ($P < 0.001$) backfat thickness in surgically castrated (17.7 mm) animals than in immunocastrated (14.2 mm) animals.

Correlation

There was moderate inverse correlation ($P \leq 0.01$) between testicle length with backfat thickness and a null inverse correlation between testicle widths with backfat thickness. As the testicle length and width increased there was a decrease in backfat thickness (Table 3).

Table 3. Correlation of testicle length and width with backfat thickness, degree of lesions and number of lesions in immunocastrated pigs.

	Backfat thickness		Degree of lesions		Number of lesions	
	r	Significance level	r	Significance level	r	Significance level
Testicle length	-0.462	**	-0.156	NS	0.254	NS
Testicle width	-0.260	*	-0.165	NS	-0.135	NS

**Significant at 1% probability ($P \leq 0.01$); * significant at 5% probability ($P \leq 0.05$); NS - not significant ($P > 0.05$).

The negative correlations between testicle length and width with backfat thickness in immunocastrated pigs were expected, since the increase in the size of testicles is a consequence of testosterone levels (EINARSSON et al., 2011), which leads to a decrease in fat deposition. Therefore, in the current study, at the point when testicle size increased there was a decrease in backfat thickness.

Conclusion

Immunocastration performed with a vaccine can be an alternative to avoid surgical castration and to provide a leaner carcass, due to an increase of *longissimus thoracis* muscle and a decrease in backfat thickness. This is a relevant result, since fat has lately become undesirable from a nutritional point of view for many consumers. However, immunocastrated pigs lead to carcasses with higher degrees of lesions. Therefore, further research should be conducted to investigate the effect of immunocastration on pig behaviour.

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