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Physical meat quality and chemical composition of the *Longissimus thoracis* of entire and immunocastrated pigs fed varying dietary protein levels with and without ractopamine hydrochloride

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ABSTRACT

Physical and chemical attributes of the *Longissimus thoracis* (LT) of 96 PIC© entire (E) and immunocastrated (C) pigs were evaluated. The study followed a 2 × 2 × 3 factorial design where three diets of low, medium and high proteins (7.50, 9.79 and 12.07 g digestible lysine/kg) were fed either with (10 mg/kg) or without ractopamine (RAC) for the last 28 days of growth. Vaccination of C occurred at 16 and 20 weeks and slaughtering at 24 weeks of age. The LTs were analysed for moisture, protein, fat and ash contents as well as CIE L*, a*, b* colour, drip loss, cooking loss and Warner–Bratzler shear force (WBSF). Various sex and protein interactions were observed for LT protein content, L* values and WBSF. Cooking loss was decreased in C and by the medium protein diet. Feeding RAC increased WBSF values, whilst decreasing a* and b* values. However, the differences observed are minor and might be considered negligible when evaluated by a consumer.

1. Introduction

Surgical castration has traditionally been practised as a means to decrease aggressive and sexual behaviour as well as to improve the meat quality of various male livestock species. However, surgical castration has raised various ethical and welfare issues (Tuyttens, Vanhonacker, Verhille, De Brabander, & Verbeke, 2012). In response, many European countries are considering implementing legislation which limits the application of surgical castration. Although the production of entire, or uncastrated, male pigs is preferred over castrated animals due to the favourable anabolic influences of their male steroid hormones, castrates are often produced to prevent boar taint. Boar taint is an offensive smell and taste in the meat of entire male pigs and is caused by androstenone, skatole and indole which accumulate in the adipose tissue and decrease the eating quality of the pork (Bonneau, 1982). Due to the fact that surgical castration is becoming a more unacceptable means of controlling boar taint and the behaviour of male pigs, alternative methods need to be investigated, of which immunological castration is an attractive solution.

Immunocastration involves the vaccination of entire male pigs with a gonadotropin-releasing hormone (GnRH) analogue so that antibodies are produced against GnRH and thus the hypothalamic–pituitary–gonadal axis is blocked, ceasing testicular steroid hormone production. Vaccination protocol involves the administration of two subcutaneous doses into the neck with at least 4 weeks between them and the last being 4 to 6 weeks prior to slaughter. Following the standard vaccination schedule, the second, or booster, vaccination initiates the production of GnRH antibodies within 3 to 5 days (Claus, Lacorn, Danowski, Pearce, & Bauer, 2007), thus immediately inhibiting luteinizing hormone (LH) and follicle-stimulating hormone (FSH) secretion causing testosterone and androstenone to drop to levels seen in surgical castrates within 2 weeks (Brunius et al., 2011) without a significant increase until slaughter (Claus et al., 2007). However, Brunius et al. (2011) found that growth hormone (GH) levels are not affected by standard immunisation and insulin-like growth factor 1 (IGF-1) levels were intermediate in immunocastrates, with surgical castrates having the lowest levels and entire males having the highest. Thus immunocastrates may have a higher potential for anabolic growth than surgical castrates due to the unique changes in their hormone production.

Immunocastrates grow similarly to entire males until their booster vaccination after which their lean growth seems to be sacrificed in lieu of fat deposition. Thus immunocastrates were fatter than entire males when backfat thickness and carcass dissection were investigated (Boler et al., 2011; Gispert et al., 2010; Metz, Hohl, Waidelich, Drochner, & Claus, 2002). Therefore, in order to counteract such an increase in fat gain, products such as Paylean® (Elanco™, USA) can be used in order to promote protein synthesis through the action of a β-adrenergic agonist known as ractopamine hydrochloride (RAC). Since the performance of

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immunocastrates seems to be intermediate to that of entire males and surgical castrates, their nutrient requirements are likely to differ. Boler et al. (2011) found that immunocastrates should be fed at a higher lysine level than surgical castrates in order to improve their cutting yields. When adding RAC to the diets of immunocastrates, protein synthesis should increase and thus so too should the protein requirements. Andretta et al. (2012) performed a meta-analysis of the relationship between lysine and RAC and found that from the 29 articles analysed, pigs fed higher lysine levels had a higher loin area and lower backfat depth than those untreated. Although RAC has been thoroughly researched over the past 20 years, few studies have focused on the protein requirements of immunocastrates and the effects on the chemical composition and quality of the resultant meat. Likewise, research into the effects of varied protein levels fed with RAC on immunocastrates is lacking; this includes investigations into how chemical composition of the meat, as well as the meat quality is affected.

The aim of this research is thus to quantify the impact of varied protein levels fed to entire males and immunocastrates with and without RAC on the chemical composition and meat quality of the *Longissimus thoracis* muscle (LT).

2. Materials and methods

The various procedures used in this study were approved by Stellenbosch University's Research Ethics Committee: Animal Care and Use (SU-ACUM13-00022). All experimental procedures conform to the accepted standards for the use of animals in research and teaching under the South African National Standards 10386: 2008.

2.1. Animals, housing and feeding

The animals used for the study formed part of a growth and slaughter trial conducted at Elsenburg in the Western Cape Province, South Africa. The growth trial consisted of 120 entire PIC© male pigs which were individually penned and allocated one of 12 treatment combinations. Immunocastrated animals received their Improvac® (Zoetis™ Animal Health) vaccinations at 16 and 20 weeks of age. Until 20 weeks of age, all pigs received a commercial grower diet after which they received either a low, medium or high (7.50, 9.79 and 12.07 g digestible lysine/kg respectively) protein diet (Table 1). Paylean® (RAC) was added to the applicable diets at 10 mg/kg for the last 28 days of growth after which the pigs were slaughtered at 24 weeks of age without feed or RAC withdrawal. Thus the treatment combinations were: E Low, E Medium and E High; E Low RAC, E Medium RAC and E High RAC; C Low, C Medium and C High; and C Low RAC, C Medium RAC and C High RAC.

2.2. Slaughtering and sampling

All of the pigs were slaughtered at 24 weeks of age at a commercial abattoir 45 min away from the research facility in the Western Cape Province, South Africa. Slaughtering followed commercial practises using electrical stunning followed by exsanguination by thoracic stick. The LT pH and temperature were recorded 45 min *post mortem* (pH_{45} and $temp_{45}$) between the 2nd and 3rd last ribs, 45 mm from the dorsal midline using a calibrated portable Crison PH25 pH metre, (Allela, Barcelona). The carcasses were placed in a cold room at 4 °C for 24 h, after which the pH and temperature was measured again in the same manner as before (pH_{24} and $temp_{24}$). From the 120 carcasses, 96 were selected for analysis by selecting eight of the mid-weight pigs from each treatment in terms of their live mass at slaughter. At the time of deboning 24 h *post mortem*, the LT from the right-hand side of the carcass was sampled from each of these 96 pigs. Results for the slaughter trial including the hot carcass weight (HCW), backfat thickness and cutting yields are presented and discussed by Needham and Hoffman (in press). This includes the average HCW of 101.4 ± 0.89 kg for E and 101.8 ± 1.14 kg for C which was not significantly influenced by any treatment effects.

At 48 h *post mortem*, the pH and temperature (pH_{48} and $temp_{48}$) was taken within the LT. Four 2 cm thick steaks (A, B, C and D) were then cut perpendicular to the long axis of the muscle fibres from the distal end towards the cranial end of the LT and trimmed of all fat and excess tissue. The first steak, A, was used for colour measurements on the freshly cut surface, steak B was used for cooking and then shear force measurements, steak C was used for drip loss and steak D was used for chemical composition analyses.

Table 1
Ingredient and nutrient composition of the low and high balanced dietary protein experimental finisher diets fed to the pigs from 20 to 24 weeks of age; all values are on as as-is basis and all amino acid values shown are digestible values.

	Diet	
	Low	High
Ingredient composition, g/kg		
Maize	326.77	205.67
Wheat bran	294.67	124.33
Barley meal	150.00	150.00
Soya oil cake (470 g CP/kg)	126.67	300.17
Sunflower oil cake (360 g CP/kg)	50.00	150.00
Canola oil	25.00	30.00
Limestone	14.17	12.67
Salt	4.30	4.42
L-lysine HCL	2.00	1.80
Vitamin and mineral premix	2.00	2.00
Monocalcium phosphate	1.90	0.00
Mycotoxin binder	1.00	1.00
L-threonine	0.53	0.18
Phytase enzyme	0.50	0.50
DL-methionine	0.27	0.37
Choline chloride liquid	0.13	0.13
Xylanase and β-glucanase enzyme combination	0.10	0.10
Maize gluten meal (600 g CP/kg)	0.00	16.67
Calculated nutrient composition		
NE pig, MJ/kg	9.20	9.20
DE pig, MJ/kg	13.29	13.83
Crude protein, g/kg	161.16	255.80
Crude starch, g/kg	359.20	271.02
Crude fibre, g/kg	60.76	68.07
Crude fat, g/kg	49.12	47.40
Ash, g/kg	59.31	71.02
Amino acids, g/kg		
Lysine	7.50	12.07
Methionine	2.47	4.09
TSAA	4.74	7.48
Tryptophan	1.59	2.66
Threonine	4.88	7.85
Arginine	9.24	16.12
Isoleucine	5.08	9.09
Leucine	10.33	17.24
Valine	6.11	10.12
Histidine	3.48	5.61
Calcium, g/kg	7.51	7.49
Total phosphorus, g/kg	6.86	7.42
Available phosphorus, g/kg	2.50	2.53
Sodium, g/kg	2.00	2.00
Potassium, g/kg	9.86	12.94

CP: crude protein.
Vitamin and mineral premix: Vitamin A: 5489.5 IU/kg, Vitamin D: 1005.3 IU/kg, Vitamin E: 27.6 IU/kg, Vitamin K: 2.8 mg/kg, niacin: 22.0 mg/kg, riboflavin 4.9 mg/kg, D-pantothenate: 16.5 mg/kg, Vitamin B_{12}: 22.0 mcg/kg, zinc: 100 mg/kg, iron: 66 mg/kg, manganese: 25 mg/kg, copper: 10 mg/kg, iodine: 0.33 mg/kg and selenium: 0.25 mg/kg. This is an approximate premix composition obtained for grow-finish PIC© pigs from 68 kg live weight to slaughter from PIC© Nutrients Specification Manual (2011). These are suggested specifications for the amount of vitamins/minerals per kg of a complete diet.
NE: net energy.
ME: metabolizable energy.
TSSA: total sulphur-containing amino acids.