THE EFFECT OF CASTRATION AND CASTRATION METHODS ON THE GROWTH PERFORMANCE, CARCASS AND MEAT QUALITY OF SOUTH AFRICAN BOER GOATS

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ABSTRACT

The effect of immunocastration as an alternative method to physical castration, of South African (SA) Boer goats on growth performance, carcass and meat quality has not received much scientific attention and were investigated in this study. Boer goat males (between 3.5 and 4.5 months of age) were castrated using a Burdizzo emasculator (physical castration), Improvac® vaccine (immunocastration), while an intact group served as a control. The goats were fed a pelleted feedlot diet for 84 days and housed in individual pens. Intact goats gain weight faster and more efficiently and produced heavier carcasses than the two castrated groups. The meat of the two castrated groups had a lighter colour compared to meat intact males. A trained analytical sensory panel scored goat-like flavour of intact goats higher by only 2 units (100 point scale) than meat from castrated groups. No differences were noted between treatments for the meat texture attributes. If intact male and female animals can be separated in production system, intact Boer goats will perform better in feedlots without compromising meat quality.

Keywords: Boer goat, immune castration, goat-like aroma, meat colour

INTRODUCTION

South African (SA) Boer goats are mainly farmed extensively and are sold to the informal market and for religious and cultural ceremonies and rituals (DALRRD, 2023). The common perception regarding a species-specific ‘goaty’ flavour and aroma of goat meat has been the reason for the reluctance of many consumers to buy goat meat, along with goat meat being rarely available in South African retail stores (Makusha et al., 2023). The goaty flavour in goat meat is presumably due to specific branched-chain fatty acids (4-methyloctanoic and 4-ethyloctanoic acid) possibly influenced by age and sex (Nagamine and Sunagawa, 2017). Thus, the significant reduction of testosterone by physical and/or immunocastration have been identified as possible methods to reduce the goaty flavour and aroma of goat meat (Zamiri et al., 2012), thereby potentially increasing urbanised consumers’ acceptability of goat meat. In addition, because goats tend to deposit fat later in their growth cycle than sheep (Gawat et al., 2023), intensive feeding for pre-slaughter conditioning on high-energy/protein diets may further enhance the eating quality of goat meat (Pophiwa et al., 2017). Furthermore, physical castration methods which include either using a Burdizzo emasculator, rubber band elastrator or surgical testicle removal is most commonly used. However, many consumers have an antipathy towards physical castration methods used in livestock production due to ethical and animal welfare concerns (Coetzee, 2010). An alternative castration method is an immunocastration vaccine that stimulates an immune response to develop antibodies and inhibit the action of the gonadotropin-releasing hormone (GnRH) resulting in an impairment of testes functionality (Needham et al., 2017).

This study aimed to investigate the effect of the castration method on the growth, meat quality and composition, and sensory profile of SA Boer goats fed a concentrate diet in a feedlot for an extended period.

MATERIALS AND METHODS

Trial layout and growth phase and slaughter

SA Boer goat males (between 3.5 and 4.5 months of age) were castrated using different castration methods: Burdizzo emasculator (physical castration; n = 15), Improvac® vaccine (immunocastration; 2ml/animal at start and repeated twice with 4-week intervals; n = 15), while an intact group served as a control (n = 15). The goats were fed a pelleted grain/lucerne and oil-cake-based diet (dry matter: crude protein = 15.3%) for 84 days and housed in individual pens. Animals were slaughtered a commercial abattoir after overnight lairage.

Sampling and carcass measurements

Carcasses were weighed and chilled overnight (3 ± 3 °C) and cold carcass weight (CCW; kg) was calculated as 3% shrinkage and dressing percentage calculated by dividing the calculated CCW by the final body weight. A handheld pH meter (Thermo Scientific™ Eutech™ pH 450 Meter, Thermo Fisher Scientific, Waltham, MA, USA) was used to measure pH and temperature at 1 h and 48 h post-mortem of the *longissimus thoracis* (LT) muscle. The loin rack (*longissimus thoracis et lumborum,* LTL muscle with bones) were sampled from each carcass and shipped to the Meat Science Laboratory of the Stellenbosch University. The LTL from each carcass was cut into smaller samples as required for proximate analysis, shelf-life colour analysis, physical analysis (WBSF, thawing loss, and cooking loss) and descriptive sensory analysis (DSA).

Colour and chemical composition

Three chops of 2.5 cm thickness used for shelf-life measurements were randomly placed on polystyrene trays, labelled and wrapped with 10 µm polyvinyl chloride (PVC) film and stored at 3 ± 1°C in a chiller room for 0, 4 or 8 days. A Spectro-guide 45/0 gloss colourimeter (BYK-209 Gardner GmbH, Gerestried, Germany; illuminant/observer of D65/10°; 11 mm aperture) was used to measure the CIELAB colour descriptors (lightness (L^*), redness (a^*), and yellowness (b^*)) at various positions on the surface of the cut meat of each chop (King et al., 2023) on day 0 after 60 minutes bloom and on 4 and 8 days. Subsamples (2.5 g) of the homogenised sample were used to determine the moisture, ash, protein and fat of the LT (no external fat; AOAC, 2005).

Sensory analyses

LL and LT portions of the left side of the carcass were used sensory training and tasting. The cuts were roasted uncovered, with bone and subcutaneous fat still intact, in a preheated (163 ± 1°C) industrial oven (Hobart, Paris, France) according to American Meat Science Association (AMSA) (2016) guidelines to an internal temperature of 71 ± 1°C. Three cubes of meat (1cm^3 cubes, fat removed) per sample were individually wrapped, labelled with a unique code and served to a ten-member trained sensory panel. Training was done beforehand for 4 consecutive days to familiarise the panellists with aromas, flavour (various attributes) and texture (tenderness and juiciness) variation across samples and to develop a lexicon for aromas and flavours. Testing was conducted in the following days in three sessions per day where each panellist received one sample of each of the three treatment groups. Intensity rating of each attribute was done using a 100-point unstructured line scale with anchor words (0 = none/; 100 = prominent).

Statistical analyses

Data was analysed using a linear mixed-effects model approach with the castration method as a fixed effect and animal and/or carcass/taste sample as random effects. For colour shelf life, days on the shelf was added as fixed effect. Analysis of variance (ANOVA) was performed on the data using SAS software (Version 9.4, SAS Institute Inc., Cary, USA). Outliers were identified and removed if the Shapiro–Wilk test indicated significant deviation from normality ($p \leq 0.050$) and the standardised residual of an observation deviated by more than three standard deviations from the model value. Post hoc Fisher's LSD multiple comparisons were used to determine differences between treatments.

RESULTS AND DISCUSSION

Intact animals gained weight faster ($p < 0.001$) and more efficiently ($p = 0.011$) and therefore produced heavier animals at slaughter ($p = 0.001$) with higher carcass weights ($p = 0.003$) than animals in the two castrated groups. The comparison of intact and Burdizzo castrated animals agree with the results of Tesema et al. (2023) and El-Waziry et al. (2011) who grain-fed Iranian goats Ardhi goats and also with the general assumption that intact animals will grow faster and efficiently due to the effect of testosterone. The testes circumference of intact goats increased from 21 cm to 31 cm over the growth period showing sexual development towards puberty. In contrast, the Improvac group recorded a final testes circumference of 21.5 cm and the Burdizzo group 19 cm. Hochmanova et al. (2024) who also reported a decrease in the size of the testes and testosterone concentration of Improvac® treated goats, compared to intact goats at four and eight weeks, respectively, after the initial vaccine was administered. No growth or carcass data were reported in these studies. Interestingly, Needham et al. (2018; 2019) reported that a Improvac® vaccinations decreased scrotal circumference and seminiferous tubule size of Dohne Merino lambs, reduced serum testosterone concentrations but had no effect on growth performance or cold carcass weight and carcass yield compared to intact lambs, although both burdizzo castrated and immunocastrated lambs produced carcasses with higher fat thickness than intact lambs (Needham et al., 2019). In the current study, castration and castration method had no effect back fat thickness of goats and also no effect on muscle fat (Table 2). The critical point on a growth curve where the rate of fat deposition is faster than muscle growth for most sheep breeds is between 20 and 42 kg, while goats are expected to reach this point at body weights of higher than 50 kg. This late maturing characteristic is the main contributor to the leanness of goat carcasses in our study as reflected by the low back fat thickness values.

Castration and castration method had no effect on initial (warm carcass) and final pH, although the final pH showed mean values above 5.8 which indicate the lower threshold for dark firm and dry meat (DFD) (Page et al., 2001) and were typical for goat meat due to higher excitability and susceptibility to peri-mortem stress (Gawat et al., 2023). In agreement, no differences in final pH were recorded across between intact lambs and burdizzo and immunocastrated treatments but all final pH values were below 5.8 (Needham et al., 2019).

Table 1: Effect (Mean ± SEM) of castration method on growth parameters of SA Boer goats after a 12-week feedlot finishing period

Growth parameters	**Treatment**			***p* value**
	Intact	**Burdizzo**	**Improvac®**	
Initial body weight [kg]	24.63 ± 0.927	23.00 ± 0.960	24.04 ± 0.927	0.475
Average daily gain [kg]	0.32 ± 0.008[a]	0.26 ± 0.008[b]	0.26 ± 0.008[b]	**<0.001**
Feed conversion ratio [kg/kg]	5.00 ± 0.148[a]	5.49 ± 0.153[b]	5.63 ± 0.148[b]	**0.011**
Slaughter weight [kg]	51.85 ± 1.324[a]	44.94 ± 1.371[b]	45.60 ± 1.324[b]	**0.001**
Cold carcass weight [kg]	24.28 ± 0.670[a]	21.83 ± 0.700[b]	20.84 ± 0.670[b]	**0.003**
Dressing [%]	46.93 ± 1.071	47.07 ± 1.109	45.84 ± 1.071	**0.680**

Notes: a, b Means in rows with different superscripts differ (p < 0.05) with p values in bold. SEM = standard error from the mean

Even though colour is not necessarily an indication of actual eating quality, consumers do tend to interpret it as such (Tomasevic et al., 2021). Ultimate pH and temperature as well as the rate of pH and temperature decline have been reported as the main contributors to the ultimate meat colour. These characteristics may be influenced by numerous factors such as peri-mortem stress, breed, sex, age, weight, degree of fatness, cool room capacity, and load (Mahmood et al., 2019).

Table 2: Means (± SEM) of the effect of castration method on intramuscular fat, pH and colour descriptors and drip loss

Parameter	Treatment			*p* value
	Intact	Burdizzo	Improvac®	
Back fat thickness [mm]	**2.74 ± 0.212**	2.94 ± 0.219	2.52 ± 0.212	0.397
Muscle fat [%]	3.38 ± 0.151	3.76 ± 0.156	3.67 ± 0.151	0.194
pH_1	6.53 ± 0.055	6.45 ± 0.057	6.53 ± 0.055	0.523
pH_u	5.89 ± 0.069	5.87 ± 0.071	5.85 ± 0.069	0.938
T_1, [°C]	29.72 ± 0.704	30.11 ± 0.729	30.83 ± 0.704	0.534
Colour descriptors				
L*	37.34 ± 0.360^b	38.43 ± 0.373^a	38.51 ± 0.360^a	**0.040**
a*	12.53 ± 0.204	12.99 ± 0.211	12.66 ± 0.204	0.280
b*	10.60 ± 0.260	11.22 ± 0.269	10.93 ± 0.260	0.260

Notes: a, b Means in rows with different superscripts differ ($p < 0.05$). SEM = standard error from the mean. pH_1 = pH one hour post-mortem, pH_u = pH 48 hours post-mortem, T_1 = temperature one hour post-mortem

Loin muscle of intact goats was darker (lower *L** values; $p = 0.040$), even though there was no difference between the mean pH values of the treatment groups. The numerical difference in *L** was only 1 unit. In contrast to our study, Van Wyk et al. (2022) recorded higher values for *L** and lower values for *a** for the loin muscle of intact Boer goats compared to castrates on day 1 of display, but no effects were recorded at day 4. The colour of intact animals also tended to deteriorate sooner, as measured by higher hue angle values on days 1 and 4. Our study showed no interactions between treatment and shelf days and hue angle values of all treatments increased towards day 4 and then declined (not presented). Needham et al. (2019) reported no differences between intact, Burdizzo and immunocastrated (Improvac®) lambs for *L** and *b** values. However, castration by Burdizzo or immunocastration resulted in lower values for *a**. Immunocastration with the last injection 6 weeks prior to slaughter produced the poorest colour outcomes in their study. Pophiwa et al. (2017) found that higher pH values in goats resulted in darker meat (low L* values) and higher water holding capacity, thus lower drip loss values. pH_u values in our study varied and 50% of the values were above 5.8, the lower threshold for dark, firm and dry (DFD) meat, and 30 % above 6.0, although this was not affected by castration or castration method. Higher pH values showed an farly strong inverse relationship with *L** ($r = 0.77$) as was expected.

No effect of castration and castration method was found for any aroma or flavour, juiciness or tenderness, except that 'goat-like flavour' (but not aroma) was scored higher for intact animals ($p = 0.004$). This is in agreement with Aung et al. (2023). However, the mean difference in scores was small in our study, i.e. 3–3.5 units. and it is unlikely that an untrained consumer will be able to identify a difference. The intensity of the goat-like aroma or flavours of the intact treatment group was expected to be more prominent due to the presumed effect of male hormones (such as testosterone) (Nagamine and Sunagawa, 2017; Needham et al., 2017) but the low scores and small differences are probably due to the young age of the goats and could be expected to increase at higher maturity.

Table 3: Mean scores (± SEM) for selected aroma, flavour and texture attributes of SA Boer goat *longissimus* muscle as affected by different castration methods.

Attribute	Treatment			*p* value
	Intact	Burdizzo	Improvac®	
Meaty aroma	66.14 ± 0.375	66.72 ± 0.373	66.52 ± 0.201	0.440
Fatty aroma	20.83 ± 0.048	20.94 ± 0.072	20.88 ± 0.064	0.471
Goat-like aroma	9.77 ± 0.892	9.11 ± 0.612	9.03 ± 0.615	0.731
Meaty flavour	70.78 ± 0.370	71.79 ± 0.428	70.45 ± 0.435	0.073
Fatty flavour	22.64 ± 0.217	22.88 ± 0.205	22.76 ± 0.192	0.717
Goat-like flavour	19.81 ± 0.750^{a}	17.90 ± 0.409^{b}	16.89 ± 0.531^{b}	**0.004**
Sustained juiciness	69.36 ± 0.904	69.54 ± 0.808	68.51 ± 0.851	0.665
Tenderness	70.82 ± 0.968	70.49 ± 1.265	70.76 ± 1.069	0.976

Notes: a, b Values in the same row with different superscripts differ significantly (p < 0.05). SEM = standard error from the mean. All scores were given on a 100-point unstructured line scale with anchor words: 0 = none, 100 = prominent for aroma and flavour, 0 = extremely dry, 100 = extremely juicy for sustained juiciness and 0 = not tender, 100 = tender for tenderness

CONCLUSIONS

Immunocastration with Improvac proved to have the same effect on growth and carcass characteristics as burdizzo castration and could effectively be used on goats as a less invasive or painful castration method. Intact goats produced over an extended intensive feeding period, i.e. longer than sheep (lambs) will grow faster and more efficiently and produce larger carcasses than castrated animals and will have acceptable carcass fatness levels at slaughter. Intact Boer goats will produce acceptable meat quality in terms of flavour, tenderness and juiciness, comparable to castrated animals with a small risk of off-flavours.

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