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Effect of sunflower cake supplementation on meat quality of indigenous goat genotypes of South Africa

N.M. Xazela, M. Chimonyo, V. Muchenje, U. Marume

Abstract

The effect of four castrated goat genotypes and sunflower cake supplementation on goat meat quality was determined. Supplemented Boer (BOR) and Xhosa–Boer cross (XBC) goats had significantly higher ($P<0.05$) SLW and CDM than non-supplemented groups. The Xhosa lop-eared (XLE) and Nguni (NGN) goats had higher pH24 ($P<0.05$) than BOR and XBC goats. For each genotype, the sunflower cake supplemented and non-supplemented goats had similar $a^*$ values, except for the XLE goats. In the XLE goats, the $a^*$ values were lower in the sunflower cake supplemented goats. Sunflower cake supplemented BOR goats had higher L* values than their non-supplemented counterparts ($P<0.05$). The sunflower cake supplemented BOR and NGN goats also had higher $b^*$ values as compared to their non-supplemented counterparts. In comparison with the Boer goat, the XLE and NGN goats had lower CDM, $L^*$ and WBF values but generally had higher CL and $a^*$ values. Sunflower cake supplementation improved meat quality attributes of the goats.

1. Introduction

Meat quality is important for consumers when it comes to making purchasing decisions. The colour, tenderness and sensory properties or eating quality are important factors affecting meat acceptability (Muchenje, Dzama, Chimonyo, Strydom, Hugo, et al., 2009; Peña et al., 2009; Warren et al., 2008). One of major factors that affect the eating quality of meat is the nutritional status of goats with breed and diet having an impact on flavour (Warren et al., 2008). Meat quality is also affected by intrinsic factors in the animal, such as the proportions of different muscle fibres (Wood et al., 2004). Meat from goats has gained popularity mainly because of its low-fat content (Peña et al., 2009; Santos et al., 2007), especially in developed countries. Chevon has been reported to contain higher collagen and lower solubility compared to other red meats (Kannan et al., 2006) and its intramuscular connective tissue remains unchanged during post-mortem ageing (Kannan, Chawan, Kouakou, & Gelaye, 2002).

Nutritional status of goats and type of feed have been found to have significant effect on slaughter and carcass weights (Oman, Waldron, Griffin, & Savell, 1999), and carcass measurements (Argüello, Castro, Capote, & Solomon, 2005; Oman et al., 1999), muscle pH decline (Kannan et al., 2006) and possibly the rate of carcass cooling post-mortem. It is, however, not clear whether the influence of dietary supplementation is consistent among different breeds and species.

Dhanda, Taylor, and Murray (2003) reported that genotype had an influence on cooking loss, pigment concentration, muscle colour and sensory scores. Other authors, however, found no breed effects on meat quality (Esenbuga et al., 2009). There are various goat breeds that are used as meat breeds in South Africa. The Boer, a meat breed, is the most popular breed that is commercially farmed in Southern Africa both in communal and commercial production systems. Other breeds kept in the communal areas include the Nguni breed, an ecotype of the small-framed East African goat, the large-framed Xhosa goat (commonly kept in northern eastern parts of South Africa, Namibia and southern Zimbabwe) and the Boer crosses with the Nguni and Xhosa dams. The Xhosa goat is believed to have been used to develop the modern improved Boer goat and other big framed breeds, however its population sizes is fast decreasing (Ramsey, Harris, & Kotze, 2000). There is a renewed interest in farmers that prefer this breed, largely because of its twinning ability, fast growth rates and excellent body conformation.

In general, little goat meat is consumed in South Africa. Most goat meat is consumed during traditional ceremonies (Mahanjana & Cronje, 2000; Masika & Mafu, 2004; Rumosa Gwaze, Chimonyo, & Dzama, 2009). In addition, whether (and to what extent) the quality of meat will be influenced by breed, diet and the body condition of the goat at slaughter has not been established. Understanding the meat quality of these breeds ensures the appropriate characterization and valuation of indigenous goats to assist in making decisions on breed conservation. The response of different goat genotypes to dietary supplementation with sunflower cake has not been established. The objective of the study was, therefore, to determine the interaction...
between genotype and sunflower cake supplementation on the quality of chevon from indigenous goats. It has been hypothesised that there is no interaction between genotype and supplementary feeding on quality scores of chevon.

2. Materials and methods

2.1. Site description

The study was conducted at the University of Fort Hare, Alice, Eastern Cape, South Africa. The site is 520 m above sea level and is located 32.48°S and 26.53°E. It is situated in the False Thornveld of the Eastern Cape, and the vegetation is characterised by several trees, shrubs, and grass species with Acacia karroo, Themeda triandra, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cydonia dactylon, and Pennisetum clandestinum being the dominant plant species. The average rainfall is approximately 480 mm per year, and mostly comes in summer. Mean temperature of the farm is about 18.7°C. The topography of the area is generally flat with a few steep slopes.

2.2. Management of goats

A total of 48 six-month-old Xhosa lop-eared (XLE), Nguni (NGN), Xhosa-Boer cross (XBC) and Boer (BOR) castrated goats with body weights of between 20 and 25 kg were used in the study. From birth till weaning, the goats ran on the pastures with their dams. At weaning (3 months), the kids were vaccinated and de-wormed then assembled in a single flock. The goats were housed in an open-sided barn that complies with local welfare standards in two pens with free access to a basal diet of Medicago sativa. The nutritional composition of the basa diet is shown in Table 1. The basin diet met the needs for growth (80 g/day CP; 5.69 MJ/day ME). The goats also had free access to clean water. The goats were randomly divided into two balanced groups, with half of the goats provided with a supplementary feed. There were six goats per genotype per pen. Each of the two pens had a total of 24 goats.

The supplemented groups were given an additional 200 g per head per day of sunflower cake (Table 1), such that the dietary supplemented diet would provide 160 g/day CP, the apparent requirements of metabolisable protein (MP). The supplementary feed was given to the goats individually in individual craters. The goats were fed twice a day at 0800 h and at 1700 h.

The goats were kept for 90 days. The goats were weighed every two weeks. A day before slaughter, the goats were deprived of feed for 24 h, but clean water was provided ad libitum. The animals were weighed before slaughter. The electrical stunner was used to stun the goats and then slaughtered using standard procedures. Skinning, evisceration and washing procedures were completed while the carcasses were on the overhead rail.

2.3. Meat quality measurements

Slaughter weight (SLW) of each goat was taken before slaughter. Dressed carcasses were stored at 2°C for 24 h for maturation. The Longissimus muscle was collected from the right side at 0, 1, 4, 7, 12 and 24 h post-mortem to determine the pH and temperature of the meat. These were estimated using a pH metre with a piercing electrode and temperature probes (Crison pH 25, Crison instruments, S.A., Alella, Spain). Cold dressed mass (CDM) for each carcass was also taken after 24 h.

Meat instrumental colour (lightness, L*; redness, a*; yellowness, b*) was measured (24 h after slaughter) from the longissimus muscle using a colour-guide 45/0 BYK-Gardener GmbH according to methods described by the Commission International De l’Eclairage (1976). For determination of cooking loss and Warner–Bratzler shear force (WBS) values, samples were weighed and then grilled in the oven for two minutes for each side and turned, which is four minutes in total. After cooling, the samples were reweighed. Cooking loss (CL) was calculated using the following formula: Cooking loss % = [(weight before cooked − weight after cooked) / weight before cooked] × 100.

After measurement of cooking loss, the cooked samples were used to determine shear force values. Three sub samples measuring 10 mm core diameter were cored parallel to the grain of the meat. The samples were sheared perpendicular to the fibre direction using a Warner Bratzler (WB) shear device mounted on an Instron (Model 3344) Universal testing apparatus (cross head speed at 400 mm/min, one shear in the centre of each core).

2.4. Statistical analysis

Analysis of variance (ANOVA) was performed using the general linear model (PROC GLM) procedure to determine the effect of breed and diet of slaughter weight, cold dress mass, cooking loss, L*, a*, b*, shear force values. Data on pH and temperature were analysed using the repeated statement in the mixed model procedure for repeated measures of SAS (2003).

The model used was:

\[ Y_{ijk} = \mu + B_i + D_j + (B \times D)_{ij} + E_{ijk} \]

Where \[ Y_{ijk} \] = slaughter weight, cold dress mass, cooking loss, L*, a*, b*, shear force values

\[ \mu \] = overall mean common to all observations

\[ B_i \] = effect of breed (Xhosa lop eared, Nguni, Xhosa-Boer cross and Boer)

\[ D_j \] = effect of diet

\[ (B \times D)_{ij} \] = interaction between diet and breed

\[ E_{ijk} \] = random error

3. Results

3.1. Slaughter weight and cold dressed mass

The effect of breed and diet on SLW and CDM are shown in Table 2. Diet had an influence (P<0.05) on SLW. The sunflower cake supplemented BOR and XBC goats had a significantly higher SLW than non-supplemented goats. There was no difference in SLW of XLE and NGN irrespective of sunflower cake supplementation (Table 2). The SLW for all the non-supplemented genotypes were similar. Diet had an influence (P<0.05) on CDM in all the genotypes, with sunflower cake supplemented goats being heavier than their non-supplemented counterparts (Table 2). All the non-supplemented genotypes had similar CDM.

<table>
<thead>
<tr>
<th>Component</th>
<th>Medicago sativa</th>
<th>Sunflower cake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry matter</td>
<td>91.5</td>
<td>89.6</td>
</tr>
<tr>
<td>Crude protein</td>
<td>20.3</td>
<td>35.3</td>
</tr>
<tr>
<td>Crude fibre</td>
<td>33.5</td>
<td>25.9</td>
</tr>
<tr>
<td>Neutral detergent fibre</td>
<td>48.3</td>
<td>41.5</td>
</tr>
<tr>
<td>Acid detergent fibre</td>
<td>41.2</td>
<td>32.9</td>
</tr>
<tr>
<td>Ether extract</td>
<td>2.5</td>
<td>3.6</td>
</tr>
<tr>
<td>Calcium</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>
3.2. Changes in pH and temperature in carcasses

Fig. 1a and b show pH changes over time for the sunflower cake supplemented and non-supplemented genotypes. All the genotypes had the same pH after 1 h of slaughter. However, the pH of all breeds except the NGN breed, declined sharply after 4 h to a constant. The decline in pH was more pronounced in the BOR carcasses. The rate of pH drop was slowest in the NGN goats. From 12 h post-mortem, the pH in BOR and XBC was similar, and markedly lower than XLE and NGN carcasses. After 1 h of slaughter, the sunflower cake supplemented XLE and NGN goats had higher pH values than the sunflower cake supplemented BOR and XBC. The pH in all genotypes dropped after four hours, and the sunflower cake supplemented BOR genotype had the lowest pH value. However, an increase in pH was observed in all genotypes after 7 h. The sunflower cake supplemented XLE goats maintained highest pH values throughout the observation period. Sunflower cake supplementation had no effect on the pH24 in all the four genotypes (Table 2). Genotype, on the contrary, had a significant effect on pH24 (Table 2). The XLE and NGN goats had higher pH24 (P<0.05) than BOR and XBC goats. pH24 values were highest for XLE and lowest in the XBC.

Temperature changes over time in the sunflower cake supplemented and non-supplemented genotypes are shown in Fig. 2a and b. The temperature in all genotypes after one hour post-mortem was similar. Post-mortem temperature changes were also similar in all genotypes. After one hour of slaughter BOR and XLE had similar temperature values and NGN had higher value than XBC. At four hours after slaughter BOR, XBC and XLE were similar, NGN was slightly higher. After seven hours of post-mortem XBC and XLE had similar values of temperature, BOR and NGN had similar values. From 12 h BOR and XBC had similar temperature values, markedly lower than XLE and NGN values.

3.3. Meat quality characteristics

As shown in Table 2, genotype had an influence (P<0.05) on WBF. The WBF for all genotypes, however, were not affected by sunflower cake supplementation. Sunflower cake supplementation increased the tenderness of BOR meat (P<0.05). Both diet and genotype had no influence (P>0.05) in CL. There was a significant interaction between genotype and diet (P<0.05) on a* values. For each genotype, the sunflower cake supplemented and non-supplemented goats had higher pH values than the sunflower cake supplemented BOR and XBC. The pH in all genotypes dropped after four hours, and the sunflower cake supplemented BOR genotype had the lowest pH value. However, an increase in pH was observed in all genotypes after 7 h. The sunflower cake supplemented XLE goats maintained highest pH values throughout the observation period. Sunflower cake supplementation had no effect on the pH24 in all the four genotypes (Table 2). Genotype, on the contrary, had a significant effect on pH24 (Table 2). The XLE and NGN goats had higher pH24 (P<0.05) than BOR and XBC goats. pH24 values were highest for XLE and lowest in the XBC.
similar a* values, except for the XLE goats (Table 2). In the XLE goats, the a* values were lower in the sunflower cake supplemented goats. Genotype had an effect (P<0.05) on L* values (Table 2). Sunflower cake supplemented BOR goats had higher L* values than their non-supplemented counterparts (P>0.05). No differences in the NGN and XBC goats were observed. Contrary to the a* values, the sunflower cake supplemented XLE had higher L* values than non-supplemented goats. Significant diet × genotype interaction was observed on b* values. The sunflower cake supplemented BOR and NGN goats had higher b* values as compared to their non-supplemented counterparts. Sunflower cake supplementation had no effect on b* values on the XBC and XLE goats.

4. Discussion

The high SLW observed in the sunflower cake supplemented BOR and XBC compared to the non-supplemented could be that they were able to utilise feed efficiently than XLE and NGN goats. The BOR goat and XBC are regarded as meat breeds which have been selected for efficient utilisation of feed for maximum muscle deposition (Ramsey et al., 2000). The NGN and XLE are indigenous breeds which are adapted to the fibrous feeds which characterise most communal production systems. The disparity in CDM observed between the sunflower cake supplemented and non-supplemented XLE and NGN, having same SLW, could be attributed to the big abdominal cavity in the non-supplemented goats to cater for the fibrous feeds (Silanikove, Tagari, & Shkolnik, 1993) and, hence, small muscle accretion in contrast to the supplemented goats with small abdominal cavity but high muscle accretion.

The observed ultimate pH (pHu, pH24) ranging from 5.7 to 6.2 could be considered to be on the higher side though they are within the acceptable range (Dhanda et al., 2003; Muchenje, Dzama, Chimonyo, Strydom, Hugo, et al., 2009). A high ultimate pH is generally indicative of stress in animals (Dhanda et al., 2003; Muchenje, Dzama, Chimonyo, Strydom, & Raats, 2009). The higher muscle pH values in the NGN and XLE goats irrespective of supplementation could be attributed to inherent breed characteristics and possibly, due to differences in their response to pre-slaughter handling. The BOR goats, with the lowest pH, were developed as a meat breed and, therefore, are normally calm while XLE and NGN are not typically developed as meat breeds. The NGN and XLE are temperamental breeds (Ndou, Muchenje, & Chimonyo, 2010). They are highly active and can be easily agitated, and hence results in significant reduction in glycogen reserves. A high pHu also reflects depletion of muscle glycogen due to stress or other factors (Dhanda et al., 2003; Muchenje, Dzama, Chimonyo, Strydom, & Raats, 2009; Mushi, Safari, Mtenga, Kifarou, & Eik, 2009). Generally, the sunflower cake supplemented goats had lower pH than non-supplemented because the supplemented goats were likely to have higher glycogen levels than the non-supplemented. Unfortunately glycogen concentration was not measured in this study. Mushi et al. (2009) reported that higher pHu for goats can be associated with low glycogen reserve due to insufficient nutrition. Nutritional stress can result in dehydration, electrolyte imbalances, negative energy balance, glycogen depletion in muscle, and catabolism of protein and fat, ultimately increasing the pHu (Dhanda et al., 2003; Mushi et al., 2009). Meat tenderness is normally related to the pHu value (Muchenje, Dzama, Chimonyo, Raats, & Strydom, 2008). Although there was no apparent variations in the overall trend of temperature decline between the breeds in this study, it has been observed that the rates of muscle pH and temperature decline and pH-temperature interaction during the immediate post-mortem period generally have a remarkable effect on goat meat tenderness (Kannan et al., 2006).

The observed insignificant variation in WBF between the breeds concurs with other authors who also observed lack of variation in WBF between breeds (Madruga et al., 2008; Yilmaz et al., 2009). The mean Warner Bratzler shear force results in the current study (between 22.9 and 35.7 N) were within the normal range, but they were lower than those reported for meat samples of several goat kid genotypes (Dhanda et al., 2003; Kadim et al., 2003). Considering that the Warner–Bratzler force values exceeding 54 N would often be considered to be tough to consumers (Stacke, Morgan, Cross, & Savell, 1991), the meat from the indigenous goats from the current study could, therefore, be classified and moderately tender, though it is generally believed that goat meat does not always attain a higher degree of acceptable tenderness (Madruga et al., 2008).

More often than not, the colour of meat is used to judge the freshness and quality of meat by consumers at the point of purchase (Ekiz, Ozcan, Yilmaz, Töli, & Savas, 2010). The XLE had lower a* values in the sunflower cake supplemented goats. The redness values in meat are influenced by factors such as goat breed, (Dhanda, Taylor, Murray, & McCosker, 1999; Ekiz et al., 2010; Santos et al., 2007) slaughter weight, (Martínez-Cerezo et al., 2005) production system, and ultimate pH (Ekiz et al., 2010). From the results, diet and its interaction with genotype caused some significant variation in the redness of the meat. Sunflower cake supplemented BOR goats had higher L* values while the NGN had the highest values for both a* and b*. The darker colour observed is consistent with the high pHu (6.1) recorded for these genotypes. Carcasses with low pHu had a better colour quality (Simela, Webb, & Frylinck, 2004). Sunflower cake supplemented XLE had higher L* values, but lower a* values. Redness of meat is normally related to pHu of meat (Dhanda et al., 1999; Santos et al., 2007).

5. Conclusion

The high SLW observed in the sunflower cake supplemented BOR and XBC compared to the non-supplemented could be attributed to their ability to utilise feed efficiently than XLE and NGN goats. The disparity in CDM observed between the sunflower cake supplemented and non-supplemented XLE and NGN, having same SLW, could be attributed to the big abdominal cavity in the non-supplemented goats to cater for the fibrous feeds. The higher muscle pH values in the NGN and XLE goats irrespective of sunflower cake supplementation could be attributed to inherent breed characteristics and possibly, the differences in their response to pre-slaughter handling. The mean Warner Bratzler shear force results in the current study (between 22.9 and 35.7 N) were within the normal range. Sunflower cake supplemented BOR goats had higher L* values while the NGN had the highest values for both a* and b*. In comparison with the Boer goat, the XLE and NGN goats had lower CDM, L* and WBF values but generally had higher CL and a* values. It can be concluded that sunflower cake supplemented goats. The redness values in meat

Acknowledgements

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References


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