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Full Length Research Paper

Correlations among sensory characteristics and relationships between aroma scores, flavour scores, off-flavour scores and off-flavour descriptors of chevon from four goat genotypes

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The objective of the current study was to determine the correlations among sensory characteristics and relationships between flavour scores and off-flavour descriptors of chevon. Forty-eight male 6-months old Xhosa lop-eared, Nguni, Xhosa-Boer cross and Boer goat kids were kept at the University of Fort Hare Farm until slaughter. Sample cuttings for meat tasting were made from the hind leg. Aroma score was independent of off-flavour descriptors from meat from all goat genotypes (P > 0.05). Off-flavour descriptors and their frequencies varied with genotypes. There were significant (P< 0.001) correlations between most sensory characteristics of meat across genotypes although; there were variations in some goat genotypes. There were relationships among sensory scores, while flavour scores, aroma scores, off-flavour scores and off-flavour descriptors of chevon are independent. This implies that, all sensory characteristic scores and off-flavour descriptors should be included when carrying out sensory evaluations with meat from different goat genotypes.

Key words: Goat genotypes, off-flavours, off-flavour descriptors, sensory evaluations, sensory score relationships.

INTRODUCTION

Goat meat has been established as lean meat with favourable nutritional quality (Simela, 2005). The meat is almost universally acceptable, but with socio-cultural factors influencing consumer preferences (Dyubele et al,. 2010; Chulayo et al., 2011). Acceptability of meat tends to be indirectly affected by meat sensory characteristics. Meat sensory characteristics, which consumers tend to use when evaluating meat quality (Tshabalala et al., 2003), are said to be a scientific method used to measure and analyse the quality of meat as they are perceived by senses of flavour, aroma, juiciness and tenderness.

Meat sensory characteristics are affected by diet (Andersen et al., 2005; Wheeler et al., 1996), genotype (King et al., 2006, Muchenje et al., 2008a, Chulayo et al., 2011), cooking method and animal species (Stelzleni and Johnson, 2007). Meat tenderness is defined as the ease of mastication; however, it is a function of the collagen content, heat stability and the myofibrillar structure of a muscle. Meat tenderness drastically improves with aging

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of the muscle (Muchenje et al., 2008a, b), due to the breakdown of myofibrillar proteins by *collagenase* enzyme produced by bacteria in meat (Zhang et al., 2005).

Flavour is a complex attribute of meat palatability (Calkins and Hodgens, 2007) and is determined by the chemical senses of taste and smell. It depends on the quantity and composition of fat in meat (Muchenje et al., 2009a). Meat tenderness and flavour appear to be the most important components that determine meat quality (Simela et al., 2003). Meat from goat is characterized by its odour, especially after cooking; therefore, meat flavour is highly affected by animal species (Stelzleni and Johnson, 2007) and cooking method. The same authors reported that, factors such as nutrition, sex and age are highly important in determining meat flavour. The sensation of juiciness in chevon is directly related to the quantity and composition of intramuscular fat (Muchenje et al., 2009a, b), age of an animal (Simela, 2005) and moisture content of the meat (Webb et al., 2005). Relationships between juiciness and fat content and composition vary with genotype (Muchenje et al., 2008a).

Relationships exist among sensory characteristics of meat some of which have desirable effect of meat quality as marbling score increases. Correlations among various sensory attributes could mean that, improvement of one sensory attribute could subsequently have desirable effects on other sensory attributes. Although Muchenje et al. (2010) conducted a study on relationships between off-flavour descriptors and flavour scores in beef from cattle. Little work has been done on meat sensory characteristics, off-flavours and off-flavour descriptors in relation to goats. The purpose of the study was therefore, to determine the correlations among sensory characteristics of chevon from four goat genotypes. The study also sought to determine the relationship between flavour scores, aroma scores, off-flavour scores and off-flavour descriptors of four different goat genotypes.

MATERIALS AND METHODS

Site description

The study was conducted at the University of Fort Hare research Farm. The farm is 520 m above sea level and is located 32.8°S and 26.9°E. The farm is located 5 km East of Alice town in the Eastern Cape Province, South Africa. The farm has an average annual rainfall of 480 mm which dominate in summer and has a mean annual temperature of 18.7°C. It is situated in the false Thornveld of the Eastern Cape. The topography of the area is generally flat with a few steep slopes. The vegetation was a mixture of several trees, shrubs and grass species. The predominant species plant species in the farm are *Acacia karroo, Themeda triandra, Panicum maximum, Digitaria eriantha, Eragrostis spp., Cynodon dactylon and Pennisetum clandestinum*.

Experimental design

Forty-eight castrated 6-months old male Xhosa lop-eared, Nguni, Xhosa-Boer cross and Boer goats with body weights between 15 and 20 kg were used in the study. Twelve goats of each genotype were randomly allotted into two treatment groups; supplemented (S) and non supplemented (NS). The experiment was a 4 × 2 (genotype × dietary level) factorial arrangement with two levels of nutrition (supplemented versus non-supplemented) and four genotypes (Xhosa lop-eared, Nguni, Xhosa-Boer cross and Boer). Each pen contained 6 goats of each of the four genotypes.

Animal management

Before the start of the experiment, the goats were de-wormed to achieve as low faecal egg counts (FEC) as possible then assembled in a single flock for the experiment. The goats were then housed in open sided barn that complied with local welfare standards.

All the goats had free access to a basal diet of 500 g/head/day of *Medicago sativa* hay (CP, 203 g/kg: CF, 335 g/kg) to meet their maintenance and growth requirements (National Research Council, NRC, 2007) with *ad libitum* access to water. The supplemented groups received an additional 200 g/head/day of sunflower cake (CP, 353 g/kg: CF, 259 g/kg), such that the supplemented diet provided almost twice (160 g/day CP) the apparent requirements of metabolisable protein. The sunflower cake was given to the goats individually in two equal portions both in the morning and afternoon. Samples of the diet were taken for analysis (Table 1) according to the standard procedures (AOAC, 1995). The experiment was conducted over a period of 90 days.

On day 90 of the experiment, the animals were slaughtered for meat quality assessment and sensory evaluation. Sample cuttings for sensory evaluation were made from the hind leg specifically from the two muscles; semi-membranosus and semitendinosus muscles. The meat was kept in the refrigerator overnight at -4°C to improve meat tenderness.

Sensory evaluation

Cooked meat samples from each treatment were evaluated randomly by consumer panellists drawn from the University of Fort Hare student body. The panellists were of different gender, ages and tribes. All the participants were taught how to infer and record scores for each variable tasted. The waiting period between meat sample tasting was 10 min. After tasting, the panellists were instructed to rinse their mouth with water before tasting the next sample to avoid crossover effects. Each participant completed evaluation form rating the characteristics of each sample.

Eight point descriptive scales were used to evaluate aroma intensity (1= extremely bland to 8= extremely intense), initial impression of juiciness(1 = extremely dry to 8 = extremely juicy), first bite (1 = extremely tough to 8 = extremely tender), sustained impression of juiciness (1 = extremely dry to 8 = extremely juicy), muscle fibre and overall tenderness (1 = extremely tough, to 8 =

Table 1. Nutritional composition of the experimental diets (%DM basis).

Component	Sunflower cake	*Mediga sativa*
Dry matter	91.1	91.5
Crude protein	35.9	20.3
Crude fibre	25.9	33.5
Ether extract	3.5	2.5
Calcium	1.2	1.4
Phosphorus	0.6	0.8

Table 2. Least square means and standard errors for the effect of genotype on correlations among sensory characteristics of chevon.

Parameter	XLE	NGN	XBC	BOER
AI	4.8 ± 0.15^{ab}	4.7 ± 0.15^{a}	4.9 ± 0.15^{b}	4.7 ± 0.15^{a}
IJ	4.8 ± 0.14^{b}	4.7 ± 0.14^{ab}	4.6 ± 0.14^{a}	4.8 ± 0.15^{b}
SJ	4.6 ± 0.13^{a}	4.7 ± 0.13^{a}	4.7 ± 0.13^{a}	4.9 ± 0.13^{b}
MFT	4.9 ± 0.13	4.9 ± 0.13	4.8 ± 0.13	4.8 ± 0.13
ACT	4.7 ± 0.14^{b}	4.6 ± 0.14^{ab}	4.4 ± 0.14^{a}	4.5 ± 0.15^{a}
OF	4.8 ± 0.13^{a}	4.7 ± 0.13^{a}	4.8 ± 0.13^{a}	5.0 ± 0.13^{b}
ATF	3.9 ± 0.27^{b}	3.7 ± 0.44^{a}	5.15 ± 0.40^{c}	4.15 ± 0.24^{bc}

[a,b,c]Different superscripts in the same row indicate that the means are significantly different at $p < 0.05$. AI = aroma intensity; IJ = initial juiciness; SJ = sustained juiciness; MFT = muscle fibre and overall tenderness; ACT = amount of connective tissue; OF = overall flavour score; ATF = off-flavour score; XLE= Xhosa lop-eared genotype; NGN= Nguni genotype; XBC= Boer goat cross.

extremely tender), amount of connective tissue (1= extremely abundant to 8 = none), overall flavour intensity (1= extremely bland to 8 = extremely intense), a-typical flavour intensity (1= none to 8 = extremely intense). The off-flavour indicators were livery/bloody, cooked vegetable, pasture/grassy, animal-like/kraal (manure), metallic, sour and unpleasant.

Statistical analyses

The general linear model procedure of SAS (2003) was used to analyse the effect of genotype on meat sensory characteristics of chevon. The following model was used:

$$Y_{ijk} = \mu + B_j + E_i$$

Where, μ = overall mean common to all observations; B_i = effect of genotype (Xhosa lop eared, Nguni, Xhosa-Boer cross and Boer); E_i = random error.

Correlations among the sensory characteristic scores were determined using the PROC CORR procedure of SAS (2003). A chi-square test (SAS, 2003) was also used for the analysis of associations between flavour scores, off-flavour scores, aroma scores and off-flavour descriptors of meat.

RESULTS AND DISCUSSION

Correlations among sensory characteristics

The effect of genotype on sensory characteristics is presented in Table 2, while correlations between different sensory attributes are presented in Table 3. Correlation analysis revealed significant relationships between most sensory attributes across all genotypes. No significant relationships were however observed between the majority of sensory characteristics and off-flavours (ATF) across all genotypes. Sensory characteristics and off-flavours were also not correlated in the Boer goat. This means that, the management of the goat genotype for improved meat sensory characteristics will not lead to a development of off-flavours. Nevertheless, sensory characteristics for Xhosa lop-eared goat were correlated ($P < 0.001$) to off-flavours. The variation in sensory characteristics among genotypes reared in the same environment and slaughtered at the same age, weight

Table 3. Correlations among sensory characteristics of four goat genotypes.

Sensory characteristics	Goat genotypes			
	BOER	NGN	XBC	XLE
AI X IJ	0.515***	0.439***	0.299***	0.436***
AI X SJ	0.405***	0.460***	0.235***	0.410***
AI X OF	0.328***	0.487***	0.121*	0.470***
AI X ATF	0.16310	0.129*	-0.00392	0.134*
IJ X SJ	0.748***	0.584***	0.654***	0.655***
IJ X OF	0.522***	0.376***	0.218***	0.372***
IJ X ATF	0.094	0.076	0.07831	0.142*
SJ X OF	0.454***	0.424***	0.179**	0.419***
SJ X ATF	0.104	0.079	0.122*	0.131*
OF X ATF	0.274***	0.182**	0.246***	0.252***

AI = Aroma intensity; IJ = initial juiciness; SJ = sustained juiciness; MFT = muscle fibre and overall tenderness; ACT = amount of connective tissue; OF = overall flavour score; ATF = off-flavour score; NGN = Nguni; XBC= Xhosa-Boer cross; XLE= Xhosa lop-eared. * Significantly correlated at $P < 0.05$; ** significantly correlated at $P < 0.01$; *** significantly correlated at $P < 0.001$.

and degree of finish suggests a genetic influence (Sebsibe, 2006). Heredity may be a major influence since some meat sensory characteristics such as tenderness are 60% heritable in goats (Sebsibe, 2006).

Initial juiciness and sustained juiciness were highly correlated ($P< 0.001$) across the goat genotypes. Results also showed moderate levels of meat juiciness across experimental goat genotypes. Tshabalala et al. (2003) reported that, chevon has to be less juicy, especially for sustained juiciness; given that goat carcasses have been observed to have low fat content. In the current study, the low levels of juiciness could be attributed to the genotype effect (King et al., 2006; Muchenje et al., 2008a) and age of goats at slaughter, given that age is among factors affecting meat juiciness (Simela, 2005). The high positive correlation between juiciness (IJ and SJ) and meat flavour (OF) could be attributed to the effect of intra-muscular fat levels. An increase in intra-muscular fat is normally associated with an increase in juiciness and meat flavour (Swan et al., 1997). Overall flavour intensity was significantly correlated to the off-flavour across the goat genotypes. These results suggest a genetic influence on off-flavour development in meat. The current results concur with those by Rhee et al. (2004) who reported that, beef flavour was positively correlated to off-flavours.

Relationships between flavour scores, off-flavour scores and off-flavour descriptors

The results indicated that, aroma scores were independent of off-flavour descriptors in meat across the goat genotypes (Table 4). This was not expected since genotype is among the factors affecting aroma development (Webb et al., 2005). These results could be due to other factors such as diet and cooking method which also affect the development of aroma (Calkins and Hodgen, 2007; Xazela et al., 2011).

Frequencies of off-flavour descriptors varied across genotypes. Higher aroma frequencies across the goat genotypes were observed in pasture/grassy, animal-like, metallic and sour off-flavour descriptors. The findings agree with Muchenje et al. (2010) who reported that, the frequency of off-flavour descriptors depends on genotype. Boer goat showed moderate aroma intensity than other genotypes used in the experiment. There was an association between aroma scores and off-flavour descriptors in Nguni goats with highest frequency of 23.86 in animal-like off-flavour descriptor.

The observed high frequencies of overall flavour scores in all goat genotypes (Table 5) indicated that, the overall flavour in meat was independent of off-flavour descriptors. Panellist perceived meat from Nguni genotype as having an off-flavour that is associated with animal-like off-flavour descriptor. Majority of panellists were reporting intensity of off-flavour as moderate especially for Xhosa lop-eared goat genotype and Xhosa-Boer cross. Overall flavour intensity increases with age, although reports by Simela et al. (2003) are no conclusive as to which age group is the most acceptable. The association between overall flavour score and off-flavour descriptors could be expected since the off-flavour intensity is likely to vary depending on the

Table 4. Aroma scores in different off-flavour descriptors for meat from four goat genotypes.

Off-flavour descriptor	Aroma scores			
	Boer	Nguni	Xhosa	Boer cross
Bloody/livery	5.03	4.06	1.46	0.72
Cooked	8.38	8.12	6.34	7.89
Pasture/grassy	15.08	18.78	19.51	11.70
Animal-like	19.55	23.86	15.61	22.21
Metallic	17.32	18.78	20.00	22.43
Sour	17.32	19.51	20.04	11.68
Unpleasant	11.17	8.12	5.85	11.22
Goat odour	6.15	6.60	11.71	3.83
Total	100	100	100	100

Table 5. Overall flavour scores in different off-flavour descriptors for meat from four goat genotypes.

Off-flavour descriptor	Overall flavour scores			
	Boer	Nguni	Xhosa	Boer cross
Bloody/livery	0	0	2.45	4.29
Cooked	4.47	7.11	8.71	8.81
Pasture/grassy	10.61	11.68	15.5	16.43
Animal-like	20.67	27.92	20.66	17.62
Metallic	25.70	26.40	22	16.67
Sour	21.23	19.80	14.94	18.57
Unpleasant	11.17	6.60	7.32	9.05
Goat odour	6.15	0.51	8.43	8.57
Total	100	100	100	100

Table 6. Off-flavour scores in different off-flavour descriptors for meat from four goat genotypes.

Off-flavour descriptor	Off-flavour scores			
	Boer	Nguni	Xhosa	Boer cross
Bloody/livery	4.47	1.02	0.49	1.45
Cooked	4.47	3.57	5.85	2.42
Pasture/grassy	16.76	22.45	19.51	19.81
Animal-like	27.37	29.08	31.22	28.99
Metallic	24.58	23.98	20.00	22.71
Sour	15.08	11.73	16.10	17.39
Unpleasant	5.03	6.63	6.34	6.76
Goat odour	2.23	1.53	0.49	0.48
Total	100	100	100	100

off-flavour descriptor (Muchenje et al., 2010).

There were significant relationships between off-flavour scores and off-flavour descriptors across the goat genotypes (Table 6). Higher off-flavour scores observed in meat across the goat genotypes were associated with animal-like and metallic off-flavour descriptors. The frequencies of these two off-flavour descriptors ranged from 20.00 for animal-like off-flavour descriptor in Boer goat to 31.22 in Xhosa lop-eared goat genotype. Pasture/grassy and sour off-flavour descriptors were also associated with off-flavours observed in meat across the genotypes, however; their scores were lower than those of animal-like and metallic off-flavour descriptors. Xhosa lop-eared goat genotype and Boer goat cross were the genotypes with least off-flavour scores, associated with goat odour off-flavour descriptor. Off-flavour score intensity in off-flavour descriptors vary according to genotypes.

Conclusion

Aroma scores, overall flavour scores and off-flavour scores were independent of off-flavour descriptors in meat across the goat genotypes. There were correlations between most sensory characteristics of chevon from different goat genotypes. It can be concluded that, Boer goat is the ideal genotype for meat production given, that it was perceived by the consumers to have low off-flavours compared with the other genotypes. Correlations among sensory characteristics of four goat genotypes did not extremely vary across genotypes. However, relationship between flavours scores, aroma scores, off-flavour scores and flavour descriptors varied across genotypes.

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