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Review

Factors influencing the flavour of game meat: A review

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ABSTRACT

Flavour is a very important attribute contributing to the sensory quality of meat and meat products. Although the sensory quality of meat includes orthonasal and retronasal aroma, taste, as well as appearance, juiciness and other textural attributes, the focus of this review is primarily on flavour. The influence of species, age, gender, muscle anatomical location, diet, harvesting conditions, ageing of meat, packaging and storage, as well as cooking method on the flavour of game meat are discussed. Very little research is available on the factors influencing the flavour of the meat derived from wild and free-living game species. The aim of this literature review is thus to discuss the key ante- and post-mortem factors that influence the flavour of game meat, with specific focus on wild and free-living South African game species.

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1. Introduction

The meat industry is capable of producing meat products derived from domestic species that is consistent in meat quality, especially with regard to meat appearance, nutrition, safety and overall sensory quality (Troy & Kerry, 2010). This is, however, not as easy to achieve with the production of game meat and game meat products (Kritzinger, Hoffman, & Ferreira, 2003), as there is very little control of the key ante-mortem factors, as well as the slaughter processes known to influence game meat quality (Table 1). Although few of these have been researched, standard operating procedures (SOPs) for the commercial harvesting of game species have been compiled (Van Schalkwyk & Hoffman, 2010).

Factors that determine the overall quality of meat includes its microbiological safety, ethical production practices (animal welfare), in

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Table 1
Ante-mortem factors and slaughter processes influencing the meat quality of game and domestic species.

Factor	Controllable	Uncontrollable	Explanation
	Domestic species	Game species	
Species	Yes	Yes	Although there are many game species harvested, these are easily identifiable.
Age	Yes	Random	Mature game species are selected for harvesting.
Gender	Yes	Species-specific	With some game species the males are easily recognisable e.g. horns (kudu, *Tragelaphus strepsiceros*), while with other game species this proves more difficult, particularly with night harvesting (black wildebeest, *Connochaetes gnou*).
Ante-mortem stress	Yes	Difficult	Influenced by terrain, species, mating season, day vs. night harvesting and harvesting method (rifle vs. helicopter).
Method of killing	Yes	Partly	The major objective is killing with head shot using a free bullet; however, this is not always possible due to the ante-mortem stress factors.
Abattoir processes	Yes	No	All 'dirty' processes are conducted in the field where normal interventions such as electrical stimulation cannot be applied.
Cooling	Yes	No	Difficult to apply a standard cooling regime due to field slaughter/dressing and the use of refrigerated trucks.
Processing	Yes	Partly	When linked to commercial export, well defined SOPs exist. Most game meat is exported as deboned, vacuum-packed, frozen muscles/muscle cuts. Packaging material is not standardised. However, for home consumption there are no guidelines.
Cold-chain management	Yes	Partly	When linked to commercial export, well defined SOPs exist. However, for home consumption there are no guidelines and frequently no refrigeration facilities.
Hygiene practices	Yes	Partly	When linked to commercial export, well defined SOPs exist. However, for home consumption there are no guidelines. Water availability is often limited.

SOPs, Standard Operating Procedures.

addition to healthiness (intramuscular lipid content and composition) and the sensory profile (aroma, flavour, taste and overall eating quality) (Barendse, 2014; Wood et al., 1999). Sensory or eating quality of meat initially includes the appearance (raw and cooked), followed by the cooked attributes such as texture/tenderness, juiciness, orthonasal and retronasal aroma, as well as taste and flavour. Retronasal aroma refers to the sensation experienced when food is consumed, whereby flavour molecules travel from the mouth area to the nasal cavity, while orthonasal aroma is only experienced through the nasal cavity by means of the external nares (Roberts & Acree, 1995). Aroma therefore refers to orthonasal aroma, whereas flavour refers to a combination of taste (experienced on the tongue) and retronasal aroma. Odour-active volatile aroma compounds are often assessed by use of dynamic headspace-solid phase extraction (DHS-SPE) and gas chromatographic-olfactometric (GC-O) analysis (Resconi et al., 2012). However, to the author's knowledge no such research has been conducted on game meat, particularly the meat derived from South African game species.

Game meat is often an 'acquired taste', of which the aroma and flavour have been defined as: 'an aroma and flavour associated with a wild animal species' (Hoffman, Jones, Muller, Joubert, & Sadie, 2014; Hoffman, Kroucamp, & Manley, 2007d; North & Hoffman, 2015; Rødbotten, Kubberød, Lea, & Ueland, 2004; Van Schalkwyk, McMillan, Booyse, Witthuhn, & Hoffman, 2011); 'an aroma and flavour associated with a strong game meat aroma and flavour' (Jones, Hoffman, & Muller, 2015); and 'the intensity of a typical game meat aroma and flavour' (Hoffman, Mostert, & Laubscher, 2009b). However, many consumers will still prefer commercially available meat products derived from domestic species (Hoffman, 2007; Pollock, 1969). Nonetheless, consumers judge the quality of game meat under similar criteria (Table 1) as those set out for commercial meat products derived from domestic species (Hoffman & Wiklund, 2006). In addition, consumer expectations of game meat quality can be affected by their personality, beliefs, attitudes and past experiences and exposures (Calkins & Hodgen, 2007; Piqueras-Fiszman & Spence, 2015). These expectations influence how consumers perceive game meat quality and consequently their eating experience (Piqueras-Fiszman & Spence, 2015).

South African consumers perceive meat from game species differently from 'traditional' meat types such as those derived from domestic species (Hoffman, Muller, Schutte, Calitz, & Crafford, 2005b). Additionally, game meat in South Africa is only available during the colder seasons due to field harvesting and processing limitations (Apps et al., 1994). Consumers therefore perceive game meat as a seasonal product (Hoffman et al., 2005b). The modern consumer expects meat products to be healthy, produced according to ethical standards and from sustainably reared animals (Kristensen, Støier, Würtz, & Hinrichsen, 2014).

Game meat derived from South African species can be marketed as a healthier alternative to the more traditional red meat products (Hoffman, Kritzinger, & Ferreira, 2005a, Hoffman, Van Schalkwyk, & Muller, 2008b). The meat derived from game species can be classified as being low in fat and high in protein (Daszkiewicz, Kubiak, Winarski, & Koba-Kowalczyk, 2012; Hoffman & Wiklund, 2006; Kandeepan, Anjaneyulu, Kondaiah, Mendiratta, & Lakshmanan, 2009; Marks, Stadelman, Linton, Schmieder, & Adams, 1997; Ramanzin et al., 2010; Stevenson, Seman, & Littlejohn, 1992), although this varies with species, age, gender, anatomical location, season and diet. A well-established positive correlation exists between intramuscular lipids (IML) and juiciness and tenderness (Corbin et al., 2015). The low fat content of game meat together with incorrect cooking methods often contribute to negative perceptions of game meat products by consumers who wrongly perceive a dry meat product as being tougher; the so-called 'halo' effect (see Section 3.9 on *cooking methods*) (Dhanda, Pegg, & Shand, 2003; Miller, 2004; Warriss, 2000). Even so, the low fat content of meat is perceived as a positive attribute (Resurreccion, 2003) and health conscious consumers will often sacrifice the sensory quality of meat for a product that is lower in fat (Hoffman et al., 2005b; Miller, 2004). However, the high proportion of polyunsaturated fatty acids (PUFA) (polar lipid fraction) in game meat is more susceptible to oxidation, leading to the development of off-flavours (Wood et al., 1999, 2003). This may negatively influence the shelf-life and sensory quality of game meat.

Game meat and meat products are often perceived as being very dark in colour (Hoffman et al., 2005b, 2008b; Kandeepan et al., 2009; Marks et al., 1997; Ramanzin et al., 2010). Consumers regularly perceive darker coloured meat as being inferior in quality, as they prefer meat that is not extremely pale neither extremely dark in colour (Jeremiah, Carpenter, & Smith, 1972). A darker meat colour can be attributed to higher ante-mortem muscle activities (increased red muscle fibres) (Daszkiewicz et al., 2012; Hoffman, 2001; Hoffman et al., 2008b), as well as to ante-mortem stress, resulting in meat with higher ultimate pH (pHu) values (pH > 6.0) that can often be classified as being dark, firm and dry (DFD) (Daszkiewicz et al., 2012; Hoffman et al., 2005b; Honikel, 2004) (see Section 3.6 on *harvesting conditions*). The inherent dark colour of game meat is linked to a higher myoglobin content (Young & West, 2001). Furthermore, game meat marketing is also limited by low colour stability and short shelf-life (Onyango, Izumimoto, & Kutima, 1998; Wiklund, Hutchison, Flesch, Mulley, & Littlejohn, 2005; Wiklund, Sampels, Manley, Pickova, & Littlejohn, 2006) (see Section 3.8 on *packaging and storage conditions*). In contrast, game meat derived