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Game and venison – meat for the modern consumer

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Abstract

This review focuses on how game meat from southern Africa and venison that are increasingly being imported into Europe and the US addresses consumer issues as pertaining to production (wild, free range or intensive production) and harvesting methods, healthiness (chemical composition, particularly fatty acid composition), and traceability. Although African game meat species are farmed extensively, deer species are farmed using extensive to intensive production systems. However, the increasingly intensive production of the cervids and the accompanying practices associated with this (castration, velvetting, feeding of balanced diets, etc.) may have a negative impact in the near future on the consumer's perception of these animals. These alternative meat species are all harvested in a sustainable manner using acceptable methods. All these species have very low muscle fat contents consisting predominantly of structural lipid components (phospholipid and cholesterol) that have high proportions of polyunsaturated fatty acids. This results in the meat having desirable polyunsaturated:saturated and $n-6$:$n-3$ fatty acid ratios. The South African traceability system is discussed briefly as an example on how these exporting countries are able to address the requirements pertaining to the import of meat as stipulated by the European Economic Community.

Keywords: Game meat; Deer; Venison; Lipids; Fatty acids; Cholesterol; Kangaroo

1. Introduction

Consumers are increasingly becoming concerned about healthy and safe products and the demand for these products is escalating. Consumers expect the meat products on the market to have the required nutritional value, be wholesome, fresh, lean and have adequate juiciness, flavour and tenderness (Dransfield, 2001, 2003; Ngapo & Dransfield, 2006). However, consumers are becoming less predictable in their behaviour, resulting in fragmented and inconsistent consumer demands, and therefore leaving producers with an ever-increasing challenge of identifying these demands (Grunert, Harmsen, Larsen, Sørensen, & Bisp, 1997). Consumer behaviour cannot only be explained in terms of what consumers prefer to buy, but also in terms of what is available. According to Dransfield, Zamora, and Bayle (1998), the consumer's perception of meat and other food not only depends on their inherent properties, but also on the way in which these properties interact with immediate external factors and on the previous experiences of the consumer.

A number of universal trends in consumer attitudes to health and food can be identified. According to Armitstead (1998), today's consumer sees health as a macro concept and prefers to lead a balanced lifestyle. Convenience foods have become a permanent part of most consumers' (especially the younger generation) lives (Russell & Cox, 2004). Due to the spread of foot-and-mouth disease, the occurrence of dioxin in poultry, and BSE (*Bovine Spongh-iform Encephalopathy*/mad-cow disease) in the 1990s, consumers are also concerned about the safety and quality of meat products (MacRae, O'Reilly, & Morgan, 2005; Verbeke, 2001). Younger consumers tend to consume less red meat and more chicken and pork, partly because of the negative publicity surrounding red meat and health (Russell & Cox, 2004; Santos & Booth, 1996). Similarly, women tend to consume less of the red meats than men, especially

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when pertaining to venison or game meat (Burger, 2000, 2002; Kubberød, Ueland, Rødbotten, Westand, & Risvik, 2002). This may be linked to the disgust response elicited due to the perception of animality (Kubberød, Dingstad, Ueland, & Risvik, 2006) as well as their concern with the production methods employed and the ethics applicable to the killing of animals (Bernués, Olaizola, & Corcoran, 2003; Dransfield, 2003; Santos & Booth, 1996).

These growing health concerns have led to the demand for low kilojoule and low cholesterol products with increasing emphasis on reducing the ratio of $n-6/n-3$ polyunsaturated fatty acids in the diet (Dransfield, 2001; MacRae et al., 2005). Consumers are also increasingly concerned about the environment and are therefore interested in organic products, as well as products produced by natural production (low input systems) methods (Dransfield, 2003; Steenkamp, 1997).

A new facet that has developed as pertaining to consumers is the emergence of a younger generation of potential meat eaters who earn high incomes, yet still live with their parents and thus have a large amount of ready cash which they wish to purchase experiences with, one of which is dining out. The food consumed is only part of the satisfaction experienced by these diners, while another facet is the ambience as well as a dependence of the appreciation of the interaction with other individuals within the group (Dransfield, 2003), and it is in the later that the meat from alternative species will feature. In South Africa, game meat had been consumed quiet widely amongst different demographic groups (Hoffman, Muller, Schutte, Calitz, & Crafford, 2005a), and the tourist visiting Africa has indicated that they would like to eat game meat as part of the Africa experience (Hoffman, Crafford, Muller, & Schutte, 2003).

Another alternative species whose meat is seen to be healthy and is being imported into the first World in increasing amounts is ostrich. Presently South Africa is the main exporter although the production from Poland is increasing and at the same time, Brazil is rapidly developing its ostrich production. A number of reviews have been published on Ratites (mainly ostrich and emu) meat and its quality attributes (e.g. Hoffman, in press; Sales, 2002) and these species will thus not form part of this review. Cognisance is also taken of the fact that there are other species such as the Coypu or nutria (*Myocastor coypus*) a semi-aquatic rodent native to South America, but now also present in Europe, Asia and North America that has potential as a healthy alternative food which complies with current healthy and dietary recommendations for low fat, low cholesterol diets (Saadoun, Cabrera, & Castellucio, 2006; Tulley et al., 2000; Zou, Wang, Wei, & Zhang, 2001). However due to the low volumes available on the regular commercial meat market, these species are not discussed further. Similarly, the Bush Meat trade is a huge trade, particularly in Africa. This trade is made up of a large variation of species such as primates, ungulates and wild fowl that are consumed (Barnett, 2000; East, Kümpel, Milner-Gulland, & rowcliffe, 2005), however, these species will also not be discussed due to the same limitations as mentioned for the Coypu. Marine mammals (seals and whales) are also potential meat producers, although their harvesting is covered in controversy. A few papers have been published on their meat quality, specifically their healthy fatty acid profiles (Brunborg, Julshamn, Nortveldt, & Frøyland, 2006; Käkela & Hyvärinen, 1996; Koep, Hoffman, Dicks, & Slinde, in press).

This review will focus on the main species produced for meat that is destined for export from the host countries and will mainly include deer and game meat from Africa. Around the world, meat from all game animals is referred to as venison. It is, however, advisable that South Africa should distinguish game meat from venison, as game animals produced for meat in Australia, New Zeeland, Europe and America are increasingly being replaced by domesticated and farmed animals, whereas African game meat originates from wild, free-running animals. Fletcher (1994) gives a historical perspective of why farmers choose to domesticate deer and farm with these cervids. In his paper he also listed some advantages and disadvantages that are still relevant today to the semi-intensive domestication of deer. A production system that could be considered as an intermediate between the wild animals in Africa and intensively farmed deer, is the herding of semidomestic reindeer (*Rangifer tarandus tarandus*) in the Nordic countries and Alaska. Reindeer are free-ranging out in the forest or mountain tundra but handled twice a year in July (marking of new calves) and December (slaughter). For the purpose of this review the term game meat will be used when referring to meat from game antelope in Africa, whereas the term venison will be used when referring to meat from game animals such as deer produced elsewhere.

This review will thus focus on the following key attributes that are important to consumers: production methods (wild, free range, low input systems or intensive production) and ethical harvesting, healthiness (chemical composition, particularly fatty acid composition), and traceability.

2. Production systems

The potential of African ungulates for meat production has long been known (Ledger, 1963; Ledger, Sachs, & Smith, 1967; Von la Chevallerie, 1970). Presently, the ungulates that are harvested for export all originate from wild animals that roam in large enclosures owned by private landowners (Eloff, 2002) or owned by the state (Provincial Nature Reserves). It is generally accepted that these animals are enclosed in areas large enough so as not to impede the natural movement of the animals and that these animals can be classified as being organically raised (Hoffman & Bigalke, 1999). Presently, there is only one producer who has a number of tame Eland (*Taurotragus oryx*) that are finished off in a feedlot prior to being slaughtered (100 animals per annum). There are only a few (<5) deer farmers in South Africa.

In the past season (2005) it is estimated that South Africa exported the deboned meat from 160,000 carcasses, these were predominately springbok (*Antidorcas marsupialis*, >80%), blesbok (*Damaliscus pygargus phillipsi*) and kudu (*Tragelaphus strepsiceros*). Other species such as zebra (*Equus burchelli*), blue wildebeest (*Connochaetes taurinus*), impala (*Aepyceros melampus*) and gemsbok (*Oryx gazelle*) were exported in smaller numbers.

Malmfors and Wiklund (1996) and Wiklund and Malmfors (2004) gave an overview of how the history of reindeer production (particularly by the Saami people) in the Northern hemisphere changed from an intensive herding system to a more extensive system using modern aids such as trucks, helicopters, motorbikes and snowmobiles to help with the herding. As stated previously, reindeer are kept in a free-ranging system and not behind fences, and they are dependent on the natural pasture resources of the mountain tundra and forests. The main reason for giving reindeer supplementary feed in Sweden is radioactive winter pastures in some areas, a result of the Chernobyl nuclear power plant accident in 1986 (Åhman, 1999). In a 2002 overview, it was concluded that the average numbers of reindeer slaughtered between the time period 1994–2001 in Sweden, Norway and Finland were 56,065, 57,664 and 98,644 animals per year respectively (Wiklund, Drew, & Åhman, 2002). Official statistics report that during the slaughter season August 2003–March 2004 48,275 reindeer were slaughtered in Sweden (Swedish Board of Agriculture, 2005) and 106,316 in Finland (Finnish Reindeer Herders Association, 2005).

Red deer (*Cervus elaphus*) and fallow deer (*C. dama*) are the most common cervid species farmed in Europe. As an example, it has been reported that the national deer herd numbers in the United Kingdom are about 36,000, numbers that have been relatively stable since 1995 (Deerfarmer, 2003). The European Deer Farmers Association does not currently have any slaughter statistics available for farmed red deer and fallow deer within Europe.

In North America, commercial game production developed from utilisation of marginal lands to small, intensively managed farms (Renecker, Wiklund, & Stevenson-Barry, 2001). The most common species farmed in the US and Canada is elk or "wapiti" (*Cervus elaphus nelsoni*), fallow deer, sika deer (*Cervus nippon*) and axis deer (*Axis axis*). In Canada, the farmed deer population is estimated to about 162,000 animals, with 14,000 (in 2004) being slaughtered (Ministry of Agriculture, Food & Rural Affairs, 2006).

In New Zealand, deer farming has developed from these animals being seen a pests, into original capturing of wild animals (a pioneer's business) to an important export industry. Farmers have also imported East European red deer genotypes to improve not only the antlers (for velvet production) but also the venison production (Pearse, Drew, & Whaanga, 1994; Renecker et al., 2001). In a recent survey it was estimated that there were about 1.7 million farmed deer in New Zealand, of which 680,000 were slaughtered in 2004 (Statistics New Zealand, 2006). The most common species farmed is red deer (85% of the total number) and more than 90% of the products (venison, velvet and co-products) were exported.

Although most of the deer found in Australia are wild, there are a growing number of animals that are managed extensively under the so called Property-based Game Management Plans (Hall & Gill, 2005). Deer farming for venison and velvet is performed by a small number of farmers mainly located in New South Wales and Victoria.

The three French speaking tropical islands Mauritius, Reunion and New Caledonia produce over 70% of the rusa deer (*Cervus timorensis russa*) farmed in the world (Le Bel, Grimaud, & Sauzier, 2004). Of the three islands, New Caledonia has the largest feral population whilst most of the harvested deer are farmed, with supplementary feed when required.

As has been noted, the farming systems range from wild, extensive to intensive systems that utilise strategic feeding (over wintering) or strategic feeding to finish off the animals (Volpelli, Valusso, & Piasentier, 2002). There have also been reports of deer farmers velvetting as well as castrating stags to ensure less fighting and more space at the feed trough (MacDougall, Shaw, Nute, & Rhodes, 1979; Mulley & English, 1985; Sookhareea, Taylor, Dryden, & Woodford, 2001). With castration and intensive feeding, comes the logical step of herd health and vaccination programmes, the use of AI (artificial insemination) and embryo transfer as well as the possibility of including growth hormones to improve the productivity of the animals (Knox, Hattingh, & Raath, 1991; Mulley, English, Thompson, Butterfield, & Martin, 1996). However, hormones to increase meat production have been totally rejected by the deer industries world-wide. Nevertheless, one cannot but wonder whether these practises will in the long run damage the consumers' perception of game meat/venison being organic or natural and untainted by modern intensive farming methodologies.

3. Ethical harvesting/cropping

For this review, harvesting is defined as the killing of animals for meat production purposes whilst cropping refers to the removal of animals (which may include killing) so as to maintain a balanced eco-system.

Most of the species mentioned are inherently wild and have developed survival instincts that make them successful in the wild, thus these species are perhaps even more pre-disposed to the effects of stress than many of the domesticated species. Typically, their first reaction to any external stimuli (such as the stress induced during harvesting) is the flight or fight reaction. For this reason, behaviour must be accounted for when the handling, transporting (if applicable), and holding facilities at the farm and/or abattoir are designed if optimal meat quality and the welfare of the animal are to be achieved (Renecker et al., 2001). There are basically two main strategies employed during the harvesting of these species, the first deals with the wilder African ungulates whilst the second deals with the more domesticated species such as deer.

3.1. Game species

The free range game production systems found in Africa have necessitated the development of unique harvesting methodologies (Hoffman, 2001a, 2000a, 2003; Sommerlatte & Hopcraft, 1994; Van Rensburg, 1994). The plains game species (springbok, blesbok, black wildebeest, etc.) are normally harvested at night from a vehicle with great success (Hoffman, 2001a, 2003) – a single sharpshooter can remove between 30 and 80 animals per night with a minimum of stress to the remaining animals (Lewis, Pinchin, & Kestin, 1997; Hoffman, 2001a) depending on the prevailing environmental factors (wind speed, brightness of the moon, etc.), the topography and the density of the game animals. These sharpshooters have a very high kill rate (over 90% success), although this drops as the distance from the animal increases and more animals tend to become wounded resulting in not only meat loss but also factory time during the processing of the carcass. Only head or high neck shots are accepted (Hoffman, 2003). The species found in the dense bush are either shot at night (Lewis et al., 1997) or lured to feeding points during the day time where they are then killed with a silenced rifle from hide. Although this system works with species such as kudu that approach the feeding site, it does not work with other species such as impala. The take off rate is also very slow and an alternative method using helicopters is used. Kudu are also not suitable for night cropping as they tend to close their eyes when a spotlight is shined onto them.

The following is a short description of the cropping methodology regularly employed for plains game and is especially efficient in the commercial cropping of springbok. The cropping is according to the guidelines set out in the South African Standard for the Export of Game Meat (Anonymous, 2001) which also describes the traceability requirements for game meat export into the EU.

The sharpshooter is also frequently the driver, thereby eliminating a potential misunderstanding between the hunter and the driver during the cropping operation. There is also a well-trained spotlight operator on board as well as the worker and field operator who exsanguinate and load the carcasses. Prior to the shooting team departing, the vehicle and equipment are all inspected according to the regulations (Anonymous, 2001).

The shooters normally set out as soon as it is sufficiently dark for the animals to be blinded by the spotlight. As soon as an animal is selected and blinded it is shot, normally with a light calibre rifle. The sharpshooter is well trained and it is not unusual for him to use 52 rounds to shoot 50 animals. More than 95% of the shots are in the head. A well-trained team can crop more than 50 animals in an evening although this number largely depends on external factors such as the terrain, weather, etc.

After an animal is shot, it is exsanguinated with a sterile knife and the animal is then hung onto the side of the vehicle. Each animal receives an identification number (Anonymous, 2001). The shooter then proceeds with the cropping until he has shot sufficient numbers (or the time limit is close to running out) for the collecting vehicle to collect the carcasses and transport then to the game depot where they are processed further.

At the game depot the animals are removed from the collecting vehicle to the slaughter frame in such a manner that the carcass does not touch the ground, etc. The slaughter frame (made to the specifications as set out in the Standard; Anonymous, 2001) is moved from time to time as required so as to ensure that there is no build up of mud, faeces, etc in the area beneath and around the frame. The slaughter team is divided into two groups, the first ("dirty" workers) group only performs tasks that will lead to a greater possibility of contamination of hands, protective clothing and equipment, whilst the second group performs tasks on the clean carcasses e.g. completing mid-ventral incision, removal of intestines, thoracic organs, liver, pluck (includes the trachea, lungs and spleen), weighing of carcasses and placing of the carcasses into the cooling facility. The carcass and its pluck are marked with identity tags that contain a serial number that can be traced back to the name of the farm, the date of harvesting, the name and number of the harvesting team and the name and number of the game depot (Anonymous, 2001). All carcasses and pluck are inspected by the appropriate health official prior to being loaded into the cooling facility.

A game animal carcass should arrive at a game depot for chilling not later than 2 h after the animal has been killed. The carcasses should also be loaded into the chiller as soon as the internal surfaces have dried after evisceration. If the environmental temperature is above 15 °C, carcasses must be loaded into the pre-chilled (7 °C) chiller space within 2 h after evisceration (Anonymous, 2001).

After the carcasses have been loaded into the chiller, the latter is sealed and the carcasses are transported to the processing plant (often an EU approved ostrich or similar abattoir) where they are prepared further for export.

Hoffman (2001a) noted that most game animals tend towards DFD meat due to the stress of the cropping process. Buffalo that had been killed using scoline (Hoffman, 2001a) were found to have meat that was PSE. This phenomenon was also similar to what is called white muscle myopathy that is sometimes found during the live capture of game. Hoffman also noted that warthogs, similar to the domesticated pig, can be prone to PSE (Hoffman, 2001b). Research has shown that time of harvesting (Kritzinger, Hoffman, & Ferreira, 2003) does have an impact on the meat quality of the animals – a light calibre silenced rifle used at night seems to have the least effect on the meat quality.

As mentioned, a helicopter is frequently used for the harvesting of species (impala, kudu, blue wildebeest, zebra and eland) commonly found in the bushveld regions. This method entails the use of a helicopter to herd the animals into a boma in the veld, where they then stand for a short period (less than 2 h). Small groups of animals (8–10) are then herded into a smaller boma where they are all shot with a silenced, light calibre rifle in the head. This activity takes approximately 60–90 s. Thereafter, the animals are removed from the boma to the transport truck where they are hung, exanguinated (all activity completed within 10 min) and moved to the field depot. The dressing procedures and health inspections are the same as described for the plains game species. Personal observation has indicated that when two or more herds (such as impala) are maintained together in lairage, the dominant male will start killing off the submissive animals from the other herd. The use of a helicopter is expensive and presently does not seem economically viable if less than 300 animals are to be harvested. The effect of this harvesting system on the meat quality has not yet been quantified.

3.2. Deer

Deer are either harvested in the field with mobile abattoirs (Sharman, 1983) or are transported to commercial abattoirs (MacDougall et al., 1979; Pollard et al., 2002a). The use of mobile slaughter plants have been exploited in different countries. These systems, provided with handling and stun/killing facilities, have the advantage that the animals could be driven in straight from their paddock and that ante and post-mortem inspection could be carried out. In New Zealand, a mobile plant was evaluated as a way of reducing pre-slaughter handling but its use was soon dismissed since it proved to be economically impractical (Yerex, 1979). Similarly, these systems have also shortly operated in Canada and the UK (Pollard et al., 2002b). In Sweden, fully equipped mobile slaughter plants have been used for reindeer since 1993 (Wiklund & Malmfors, 2004). The Nordic countries (Sweden, Finland and Norway), New Zealand and Australia all have licensed deer/reindeer slaughter premises where the rules applied for animal transport, veterinary inspection of living animals and carcasses, stunning methods, slaughter hygiene, carcass grading and chilling conditions are similar to rules applied for domestic species (Renecker et al., 2001).

The effect of the different pre-slaughter handling routines (reindeer: Wiklund, Malmfors, Lundström, & Rehbinder, 1996; Wiklund, Malmfors, & Lundström, 1997), transport (reindeer: Wiklund, Andersson, Malmfors, Lundström, & Danell, 1995; Wiklund, Rehbinder, Malmfors, Hansson, & Danielsson-Tham, 2001a; red deer and fallow deer: Pollard, Stevenson-Barry, & Littlejohn, 1999) and lairage (red deer: MacDougall et al., 1979; Pollard et al., 1999; reindeer: Wiklund, Andersson, Malmfors, & Lundström, 1996) on various of the physical meat quality attributes has been reported and reviewed (Malmfors & Wiklund, 1996; Renecker et al., 2001; Wiklund & Malmfors, 2004). As a conclusion of all these studies, possibilities to improve pre-slaughter handling routines for all deer species included were identified which would further reduce the frequency of DFD (Dark, Firm, Dry) meat with high ultimate pH values.

Studies have also focused on some of the interactions between muscle glycogen and technological meat quality attributes (Wiklund, Manley, & Littlejohn, 2004). Some of the post-mortem interventions that have been utilised to improve quality attributes (mainly meat tenderness) include electrical stimulation (Chrystal & Devine, 1983; Wiklund, Stevenson-Barry, Duncan, & Littlejohn, 2001b) combined with ageing (Drew, Crosbie, Forss, Manley, & Pearse, 1988). The technique of pelvic suspension (''tenderstreching'') of the carcass resulting in positive effects on tenderness in several valuable cuts from fallow deer carcasses have been reported (Sims, Wiklund, Hutchison, Mulley, & Littlejohn, 2004).

4. Healthiness

According to nutritional guidelines, dietary fat should provide 15–30% of the total calorie-intake and saturated fats should not exceed 10% of the caloric intake (Chizzolini, Zanardi, Dorigoni, & Ghidini, 1999). Melanson, Gootman, Myrdal, Kline, and Rippe (2003) reported that many people believe red meat (especially beef) to be unsuited for a balanced, weight-loss diet since red meat is associated with obesity because of its total dietary fat and saturated fat content. However, when tourists (mainly from Germany) visiting South Africa were asked to comment on the possible health benefits they thought game meat held, 80% stated that game meat has health benefits, including being low in fat (32%), cholesterol (32%) and kilojoules (32%) and the fact that game meat was not at all associated with BSE was also mentioned (Hoffman et al., 2003). When local consumers were asked to comment on perceived positive and negative attributes of game meat, the top three positive characteristics were healthfulness (25%), leanness (23%) and taste (14%), while the top three negative characteristics were price (19%), taste (18%) and lack of availability (12%). When respondents were questioned on the possible health benefits of game meat, 48% thought that game meat will benefit health, where low fat (83%) and cholesterol (7%) content were listed as the top beneficial attributes (Hoffman et al., 2005a).

4.1. Game species

The average fat content of most game species has been recorded to be less than 3% (Crawford, 1968; Hoffman, 2000b; Kroon, van Rensburg, & Hofmeyr, 1972; Onyango, Izumimoto, & Kutima, 1998; Pauw, 1993; Schönfeldt, 1993; Von la Chevallerie, 1972). Although Van Zyl and Ferreira (2004) reported fat percentages as high as 4.6% for whole blesbok carcasses, it is still low. From the values in Tables 1 and 2 it is clear that all the species contain low amounts of intramuscular fat. However, the fatty acid composition of meat, particularly the ratio of polyunsaturated fatty acids to saturated fatty acids, is more important for health reasons than the total fat content (Chizzolini et al., 1999; Higgs, 2000; MacRae et al., 2005; Nelson, Schmidt, & Kelley, 1995). Schönfeldt (1993) mentioned that a dietary decrease of saturated fatty acids, especially myristic and palmitic acids, is associated with lower blood serum cholesterol, which ultimately leads to a decrease in

Table 1
Nutritional value of seven game species compared to that of domesticated meat species

Species	Moisture[a] (%)	Protein content of carcass[b] (g/100 g)	Fat content of buttocks[a] (g/100 g)
Springbok	74.7	23.7	1.7
Eland	75.8	–	2.4
Impala	75.7	22.5	1.4
Blesbok	75.5	23.5	1.7
Gemsbok	75.9	–	1.9
Hartebeest	76.3	–	2.0
Black Wildebeest	77.0	–	2.3

[a] Von la Chevallerie (1972).
[b] Van Zyl and Ferreira (2004).

the risk of cardiovascular disease. Wood et al. (2003) reported a recommended P:S value of no less than 0.4, and furthermore noted that the normal P:S ratio for meat is around 0.1. However, Gibney and Hunter (1993) found that high levels of the omega-6 ($n-6$) PUFA could, in fact, have a detrimental impact on health. Inflammatory eicosanoids are produced during the post-absorptive metabolism of $n-6$ PUFA and inflammatory responses are important factors in the development of cardiovascular heart disease and cancer. The omega-3 ($n-3$) PUFA can act as modulators to this inflammation and that is why the ratio of $n-6$:$n-3$ PUFA is so important. The most important $n-6$ PUFA is linoleic acid (C18:2), while linolenic acid (C18:3) is the most important $n-3$ PUFA. The British Department of Health (1994) recommends a $n-6$:$n-3$ ratio of less than 4.0. It was reported that ruminant meat has very low $n-6$:$n-3$ ratios, especially if the animals primarily graze, because of the higher levels of linolenic acid (C18:3) found in grass (Wood et al., 2003).

Thus, it is imperative to know the fatty acid composition of meat from different species so an informed choice regarding the best protein source can be made. Several authors (Hoffman, 2000b; Schönfeldt, 1993; Viljoen, 1999) have commented on the high levels of polyunsaturated fatty acids in game meat (Table 2). This can be linked directly to the higher proportion of polar lipids in the leaner game meat/venison (Marmer, Maxwell, & Williams, 1984). Although most of the animals listed in Table 2 are ruminants, and it is known that diet influences the fatty acid profile of ruminants to a lesser degree than that of monogastric animal (MacRae et al., 2005), dietary effects can still be noticed e.g. compare the values of the kudu vs. springbok. The former is predominantly a browser whilst the later is predominantly a grazer. This was further illustrated in impala (an ungulate that grazes and browsers, depending on the available food), where animals that came from two different habitats (predominantly grass and predominantly bush) had different fatty acid profiles (Hoffman, Kritzinger, & Ferreira, 2005b). Crawford, Gale, Woodford, and Casped (1970) compared the muscle tissue lipids of domestic cattle with that of African buffalo (*Synceros caffer*), giraffe (*Giraffa camelopardalis*), eland (*Taurotragus oryx*), kongoni (*Acephalus buselaphus*) and topi (*Damaliscus korrigum*) in East Africa and found that the meat of the game species reflected the lipid composition of the diet. Similar to the results in Table 2, these authors also found the game species to contain high amounts of the long chained ($C > 20$) unsaturated fatty acids. The fatty acid profiles of the species noted in Table 2 all had P:S ratios above 0.4 and $n-6$:$n-3$ ratios below 4.0. As pertaining to the fatty acid profile, game meat can definitely compete well with domesticated meat as it contains high levels of PUFA, yet has high P:S and low $n-6$:$n-3$ ratios (Table 2). The game species listed (Table 2) have high levels of linoleic acid and it would be interesting to see what the concentrations of the different isomers are so as to be able to quantify the potential health aspects of these in game meat (Schmid, Collomb, Sieber, & Bee, 2006).

As far as could be ascertained, no data has been published where the effect of the feeding of formulated diets to African ungulate game species on the muscle chemical composition is discussed.

4.2. Deer

Venison is also renowned for its low muscle lipid content (Aidoo & Haworth, 1995; Wiklund, Pickova, Sampels, & Lundström, 2001c) although higher levels (4.5% in red deer; Kay et al., 1981; 4.2% in female reindeer; Sampels, Pickova, & Wiklund, 2005) than that for African ungulates have also been noted. The later phenomenon is particularly noted when the animals have been finished off on pelleted diets (Wiklund et al., 2001c; Wiklund, Manley, Littlejohn, & Stevenson-Barry, 2003a). The effects of age, gender (including castration), region, and production system on the meat composition (Stevenson, Seman, & Littlejohn, 1992; Volpelli et al., 2002), including the fatty acid profile (Garton & Duncan, 1971; Manley & Forss, 1979; Sampels et al., 2005; Wiklund et al., 2003a) of the meat (Table 3) have been reported for fallow deer, red deer and reindeer. By and large, deer respond in a manner similar to any ruminant (Raes, DeSmet, & Demeyer, 2004; Wood et al., 2003). The effects of these factors on the palatability and sensory characteristics of the venison have also been explored (Britten, Armes, Ramsey, & Simpson, 1982; Forss, Manley, Platt, & Moore, 1979; Stevenson et al., 1992; Wiklund et al., 2003a). These findings were similar to findings on the traditionally farmed ruminant species, *viz*, large variation between animals within a treatment. The work of Wiklund et al. (2003a) showed amongst others, that the sensory panel could distinguish between the animals that had been fed grain based pellets and those grazed on natural pasture as pertaining to the attribute "grassy flavour", with significantly higher scores for this attribute in meat from deer grazing pasture. Similar results have been reported for reindeer venison where both a trained panel and consumers found that meat from free-ranging reindeer had a stronger gamey flavour compared with meat from animals fed commercial grain based pellets

Table 2
Mean total fat (%), fatty acid composition (%) and total cholesterol content (mg 100 g^{-1}) of the *M. longissimus dorsi* of the common duiker (*Sylvicapra grimmia*), kudu (*Tragelaphus strepsiceros*), blesbok (*Damaliscus dorcas phillipsi*), springbok (*Antidorcas marsupialis*), impala (*Aepyceros melampus*), red hartebeest (*Alcelaphus buselaphus caama*), black wildebeest (*Connochaetes gnou)* blue wildebeest (*Connochaetes taurinus*), warthog (*Phacochoerus aethiopicus*), buttalo (*Syncerus caffer*) and zebra (*Equus zebra*)

Fatty acid	Common duiker (male)[a]	Kudu (male)[b]	Blesbok (male)[c]	Springbok (male)[d]	Impala (male)[e]	Red hartebeest (male)[c]	Black wildebeest (male)[f]	Mountain reedbuck (male)[f]	Warthog[g]	Buffalo[g]	Zebra[g]
Total Fat	2.12	1.58	0.76	1.07	–	4.69	0.97	2.94	–	–	–
14:0	0.75	–	–	–	0.32	–	–	–	0.80	0.64	1.13
16:00	0.86	16.10	16.44	13.93	15.04	18.27	13.2	16.12	20.00	18.03	22.50
16:1 ($n-7$)	18.58	0.52	0.00	0.07	0.57	0.00	0.19	0.18	0.70	1.50	2.02
18:00	19.68	19.72	24.7	25.32	22.25	36.08	26.21	21.47	14.7	18.83	10.22
18:1 ($n-9$)	18.70	19.91	17.98	16.33	19.34	16.01	14.37	16.75	15.8	30.02	20.55
18:2 ($n-6$)	19.91	20.53	18.89	21.62	19.67	14.55	20.97	20.45	26.10	12.93	24.01
18:3 ($n-6$)	0.12	0.05	0.08	0.13	0.14	0.26	0	0.13	0.20	0.08	0.11
18:3 ($n-3$)	4.10	4.85	3.72	3.37	5.09	4.06	4.47	4.57	7.30	3.79	11.46
20:00	0.81	0.11	0.31	0.31	0.14	0.49	0.39	0.33	0.10	0.62	0.14
20:1 ($n-9$)	0.23	0.06	0.04	0.10	0.10	0.38	0.19	0.12	0.10	0.31	0.30
20:2 ($n-6$)	0.29	0.15	0.03	0.28	0.18	0.08	0.19	0.20	0.30	1.00	0.39
20:3 ($n-9$)	–	–	–	–	–	1.11	0.78	–	–	–	–
20:3 ($n-6$)	2.94	1.14	1.85	–	0.86	–	–	–	1.10	0.95	0.75
20:3 ($n-3$)	0.19	–	–	–	0.09	–	–	–	0.90	0.20	0.59
20:4 ($n-6$)	7.83	8.44	10.96	9.30	7.87	7.01	9.9	7.72b	7.50	5.71	3.29
20:5 ($n-3$)	2.10	3.17	2.39	2.38	3.44	2.38	3.11	3.28	0.90	1.55	0.41
22:00	0.08	0.31	0.31	0.26	0.16	0.46	0.39	0.22	0.10	0.56	0.07
22:2 ($n-6$)	0.01	–	–	–	0.14	–	–	–	0.10	0.06	0.06
22:3 ($n-3$)	0.14	–	–	–	–	–	–	–	–	0.30	0.00
22:4 ($n-6$)	0.31	–	0.22	0.27	0.43	0.28	0.58	0.28	0.40	0.27	0.26
22:5 ($n-3$)	1.14	2.75	2.43	2.60	2.82	2.31	3.69	5.38	2.40	1.65	1.24
22:6 ($n-3$)	1.09	2.50	0.39	0.94	1.00	0.37	0.58	0.98	0.40	0.83	0.39
24:00	0.06	–	0.57	0.53	0.19	0.88	0.78	0.41	0.10	0.10	0.06
24:1 ($n-9$)	–	–	0.49	0.17	0.14	11.71	0.58	0.18	0.10	0.78	0.04
SFA	22.24	35.93	42.33	40.35	38.11	56.18	40.97	38.55	35.8	38.78	34.12
MUFA	37.51	20.48	18.51	16.67	20.15	28.1	15.33	17.23	16.7	31.61	22.91
PUFA	40.26	43.59	40.96	31.59	41.74	32.41	44.27	42.99	47.6	29.32	42.96
PUFA:SFA	1.81	1.23	0.97	0.79	1.10	0.58	1.01	1.15	1.33	0.76	1.26
($n-6$)/($n-3$)	–	2.29	3.62	3.28	–	2.75	2.82	2.07	–	–	–
Cholesterol (mg 100 g^{-1} meat sample)	–	–	51.38	56.9	–	50.9	46.05	51.08	–	–	–

Adapted from:
[a] Hoffman and Ferreira (2004).
[b] Hoffman (2004).
[c] Smit (2004).
[d] Kroucamp (2004).
[e] Hoffman et al. (2005b).
[f] Van Schalkwyk (2004).
[g] Unpublished data chemically analyzed as described in Hoffman et al. (2005b).

Table 3
Mean values for fatty acid composition (g kg^{-1}) in *M. longissimus* from pasture and pellet-fed reindeer (*Rangifer tarandus tarandus* L.) and red deer (*Cervus elaphus*), respectively

Fatty acid	Reindeer[a]			Red deer[b]		
	Pasture ($n = 9$)	Pellets ($n = 6$)	Degree of significance[c]	Pasture ($n = 7$)	Pellets ($n = 7$)	Degree of significance[c]
Polar lipids				Polar lipids		
14:0	21.0	29.0	n.s.			
16:0	126.0	138.0	n.s	10.1	10.3	n.s.
16:1	6.0	9.0	**	1.1	0.4	**
17:0	4.0	2.0	***			
17:1	4.0	2.0	***			
18:0	124.0	134.0	*	15.8	14.1	*
18:1	34.0	20.0	***	12.3	12.4	n.s.
18:1 (*trans*)	4.0	3.0	**			
18:1 ($n-9$)	115.0	120.0	n.s			
18:1 ($n-7$)	10.0	17.0	***			
18:2 ($n-6$)	211.0	276.0	***	20.3	29.8	***
18:3 ($n-3$)	61.0	12.0	***	5.2	0.2	***
20:3 ($n-3$)	60.0	80.0	***	1.0	1.3	***
20:4 ($n-6$)	102.0	95.0	n.s	9.0	12.1	***
20:5 ($n-3$)	27.0	16.0	***	3.0	0.8	***
22:4 ($n-6$)	60.0	60.0	n.s.			
22:5 ($n-3$)	46.0	33.0	***	4.0	1.9	***
22:6 ($n-3$)	20.0	20.0	*	0.9	0.2	***
SFA	254.0	263.0	n.s.	25.9	24.4	n.s.
MUFA	173.0	160.0	*	13.8	12.4	n.s.
PUFA ($n-6$)	319.0	394.0	***	29.3	41.9	***
PUFA ($n-3$)	142.0	75.0	***	14.2	4.5	***
($n-6$)/($n-3$)	2.2	5.3	***	2.1	9.3	***
Neutral lipids				Neutral lipids		
12:0	45.0	35.0	**			
14:0	17.0	18.0	n.s.	5.0	6.1	n.s.
14:1				1.6	2.2	*
15:1				0	0.1	n.s.
16:0	238.0	272.0	***	33.3	34.6	n.s.
16:1 (*trans*)	3.0	3.0	n.s.			
16:1	9.0	16.0	***	9.3	11.9	*
17:0	10.0	8.0	***	0.6	0.4	n.s.
18:0	214.0	210.0	n.s.	15.7	9.3	***
18:1				24.7	25.7	n.s.
18:1 (*trans*)	13.0	6.0	***			
18:1 ($n-9$)	341.0	356.0	*			
18:1 ($n-7$)	10.0	11.0	*			
18:2 ($n-6$)	22.0	21.0	n.s.	3.8	5.3	*
18:3 ($n-3$)	10.0	2.0	***	1.5	0.3	***
20:0	5.0	2.0	***	0.1	0.1	n.s.
20:3 ($n-3$)				0	0.1	*
20:4 ($n-6$)	4.0	2.0	***	0.7	0.8	n.s.
20:5 ($n-3$)				0.3	0	***
22:5 ($n-3$)	4.0	1.0	***	0.6	0.2	***
SFA	530.0	546.0	n.s.	54.7	50.6	**
MUFA	376.0	392.0	*	36.4	39.8	*
PUFA ($n-6$)	26.0	23.0	n.s.	4.3	6.6	**
PUFA ($n-3$)	14.0	3.0	***	2.5	0.6	***
($n-6$)/($n-3$)	1.9	7.7	***	1.7	11.0	***

[a] Wiklund et al. (2001c).
[b] Wiklund et al. (2003a).
[c] n.s. Not significant.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

(Wiklund, Johansson, & Malmfors, 2003b). The consumer preference test showed that 50% of the consumers preferred meat from grazing reindeer and 50% preferred meat from pellet fed animals. Recently, seasonal variation in sensory attributes has been studied in meat from Alaskan free-ranging reindeer, when animals were slaughtered at three different times of the year; July, November and March. The strong and gamey flavour of the meat increased over the season, so that reindeer slaughtered in July produced meat with a milder flavour while meat from animals killed in March had a clear gamey flavour (Wiklund, Johansson, Aguiar, Bechtel, & Finstad, 2006). These results are also suggested to be related to the variation in diet composition over the year for the free-ranging reindeer.

Interestingly, Hoffman et al. (2005a) showed that consumers in Africa wished for the same quality characteristics in game meat as is found in the traditionally farmed species, but expected the game meat to have inferior (particularly as pertaining to colour, juiciness and toughness) sensory attributes.

5. Traceability

Most of the game animals exported from South Africa is imported into the European Union and the South African Policy for the Export of Game Meat uses the European Economic Community Council directive (as amended from time to time) as a guideline. Of specific application is Chapter III article 15 of EC directive 92/45/EEC on imports into the Community which states: "The conditions applicable to the placing on the market of wild game meat imported from the third countries shall be at least equivalent to those laid down for the production and placing on the market of wild game meat obtained in accordance with Chapter II, excluding those in Articles 6 and 8". However, this is not a new concept as most of the game meat exporters are also ostrich meat exporters who have been applying these regulations for a number of years. Similarly, Australia and New Zealand (and other countries classified as third countries) have to abide by the same directive. One of the prerequisites is ensuring the traceability of the animals – as illustration the South African scenario will be reviewed in more detail.

In South Africa, all farms that supply game animals for export need to be registered with the Controlling Authority (a person or a body that under a law of the Country or a Province, has statutory responsibility for game meat hygiene) prior to being allowed to export the game meat. If the farm complies with all the requirements, then it is issued with a registration number (renewable annually) that is linked to all the game meat obtained from that farm. This ensures that there is traceability of the meat back to the farm of origin and a detailed knowledge of the health status of the animals.

The game harvesting team and the game depots also need a registration number (renewal annually) if they intend to export game meat. It is the responsibility of the harvester to ensure that the animals are killed by an approved method which is in accordance with animal welfare requirements, which will not contaminate the game animal carcass and can reliably be expected to cause immediate death. Only healthy animals are harvested – animals that are not passed by the health official (due to disease or bad placement of shots) are not allowed into the cooler truck wherein the animals destined for export are cooled. A field meat inspector will accompany each collecting vehicle in the harvesting team. The requirements for the collecting truck as well as the cooling rack are also spelt out in detail in the standards (Anonymous, 2001).

The game depots are only used for the holding of the game animal carcasses and are constructed in a manner and of a standard as approved by the Controlling Authority. Normally this holding facility is a commercial cold (chiller) truck used for the transporting of carcasses in South Africa. The guidelines also specify the type of field containers and equipment that is to be used. There is also a stringent dress code for all the workers with the colour of the protective clothing being suitable for the specific function of the worker.

The inspected carcasses are sealed in the chiller truck and transported to the processing facility where the relevant Controlling Authority inspects the integrity of the seal before allowing the carcasses to be offloaded and processed further. In this facility the normal stringent regulations applicable to the export of meat from South Africa apply.

The South African Standard for the Export of Game Meat also has an intensive residue-monitoring program as well as complete health and hygiene requirements. The Standard also makes provision for inspection by the importing countries (Anonymous, 2001).

Similar to South Africa, the venison imported into the European Union will also use the European Economic Community Council directive (as amended from time to time) as a guideline. The same conditions and requirements are met by the suppliers.

6. Conclusion

It is apparent that game meat and venison is such that it meets most of the criteria demanded by a discerning consumer. However, care should be taken that some of these traits, such as "untainted by modern farming practises" is not lost as the production of these animals is intensified so as to meet the market demand. It also seems as if most of the principles (effects of gender, age, region, etc.) and practises (nutrition, lairage, stunning, electrical stimulation, etc.) that influence the meat quality and composition that are applicable to the more traditional red meat species are also applicable to these alternative meat species. Our knowledge about various factors affecting game meat and venison quality has increased significantly over the last 25 years, but there is still information missing particularly regarding the interaction between production systems, slaughter handling techniques and ultimate meat quality.

Most of the animal species mentioned have very low lipid concentrations in their muscles which are primarily structural lipids (phospholipid and cholesterol) with little contribution from triglycerides. This results in the lipids having a very desirable fatty acid profile. Research has demonstrated that the lipid composition of venison, similarly to meat from other ruminants, is related to the animals' diet and that an intensive production system including feeding with grain based feed mixtures will negatively affect the desirable fatty acid profile. This is another reason for being careful when introducing new production techniques for these alternative meat species.

Although differences have been noted in the fatty acid profiles of game animals as well as deer, it would be interesting to see whether consumers can distinguish (as pertaining to odour, taste, texture, etc.) between the meat derived from different deer and game species. This knowledge will enable marketers in their strategy of whether to market under generic or species specific names. All indications would be that species specific names should be used.

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