THE MEAT WE EAT: ARE YOU GAME?

INAUGURAL ADDRESS: PROF LOUW HOFFMAN NOV 2007

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ABOUT THE AUTHOR

Louw Hoffman was born on a cattle and pig ranch in Zimbabwe. He studied Animal Sciences at Stellenbosch University. After completing his Master's degree on pig meat quality attributes he was employed as a researcher in aquaculture at Limpopo University. Whilst there, he completed his PhD on the meat quality of the catfish. He spent eight years doing extensive research on fish production with a strong emphasis on fish meat. Thereafter he was employed as an academic and researcher at Stellenbosch University in the Meat Science discipline.

In 2004 Louw received a Rector's Award for Excellence in Research from Stellenbosch University and in 2006 he was awarded the South African Society for Animal Sciences' Silver Medal in acknowledgement of exceptional, meritorious and original research in the furtherance of Animal Science in the country.

Louw has published over 110 scientific peer reviewed research articles in national and international journals. 37 MSc and 4 PhD students have already completed their scientific investigations under his supervision.

His special research interest is in game and ostrich meat. He describes himself as a frustrated farmer who has no farm and is therefore an academic and researcher.

The meat we eat: Are you game?

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ABSTRACT

The tourist industry in South Africa is a growing and lucrative one, based on the fact that visitors, normally from highly industrialised countries, are willing to pay to see wild game in an unspoiled habitat. However, it is only with a strict management programme that game parks/farms can be maintained as apparently unaltered, wild and limitless expanses of country. An inevitable part of this programme to maintain the illusion of wild animals roaming in an unspoilt habitat is the regular culling of surplus animals. Presently, "culled" animals are sold live at auctions, mainly for restocking, utilised for recreational hunting or cropped for the game meat market. However, the demand for stocking animals has started to decrease and an alternative for the surplus has to be sought. One potential outlet is the marketing of game meat on a bigger and more organised scale and with greater sophistication than has been the case hitherto. This can only be accomplished successfully, particularly on the export market, if approached scientifically. Although research was conducted in the late 1960s and 1970s on the production potential of some African ungulates by the likes of Ledger, Van Zyl and von La Chevallerie, very little attention was given to meat quality parameters and factors that influence them. The present synopsis reviews the work that has been conducted at Stellenbosch University since 2000 on the extrinsic and intrinsic factors that influence the meat quality of game. The results from this research have been used successfully by the commercial industry in its marketing strategy, locally in restaurants as well as internationally, where game meat has followed the marketing channels of ostrich meat, another exotic species sold overseas.

Keywords: review, game meat, nutritional value, harvesting techniques

INTRODUCTION

The commercial utilisation of game in South Africa has shown extensive growth during the last 20-25 years, and consequently game farmers now play a key role in the conservation of many game species (Ebedes, 2002). By August 1998 an estimated 2 300 game ranches existed in the Northern Province (now Limpopo) of South Africa alone. These ranches covered an area of approximately 3.6 million hectares (Van der Waal & Dekker, 2000). Van Zyl (2000) estimated that between 17 and 18 million hectares of the country are being utilised for game farming purposes and still the industry is growing at a rate of 2.5% per year. The South African agriculture and conservation authorities have recognised game farming as a bona fide form of agricultural land use (Eloff, 2002). In 2005 it was estimated that ± 9 000 farms were being utilised for wildlife production. A further 15 000 were being used for a combination of wildlife production and cattle farming (Patterson & Khosa, 2005). Most of South Africa's exempted wildlife ranches are found in the Limpopo Province (49%), followed by the Northern Cape Province (19.5%) and the Eastern Cape Province (12.3%). However, the mean size of a game ranch in the Northern Cape Province is 4 920 ha compared to 1 340 ha in the Limpopo Province.

Grobler and Van der Bank (1992) stated that game is utilised in diverse ways, including trophy or safari hunting, biltong hunting, culling for the venison market, and live capture and sale. Presently, capture and sale is a very lucrative business worth millions of rands; however, the time is fast approaching where only the more scarce and exotic species will fetch these high prices and more "common" species will have to be marketed in an alternative way.

Berry (1986) evaluated four forms of consumptive utilisation of game, namely trophy hunting, non-trophy recreational hunting, live animal sales and venison production; he found trophy hunting to give the highest net return, followed by live animal sales, non-trophy recreational hunting and venison production. However, when an index based on numbers of animals involved was developed, the weighted net values showed venison production to be the most profitable, followed by live game sales, non-trophy recreational hunting and trophy hunting. However, not all animals qualify for trophy status. For instance, a kudu bull only reaches trophy status at an age of 8 years and older (Furstenburg, 2002) and there is only a small percentage of trophy animals on a given game ranch. Van der Merwe and Saayman (2004) describe the four pillars of game ranch tourism as ecotourism, hunting (biltong and trophy), live game sales and game products.

In 1995 it was estimated that the hunting industry earned more than R400 million per year and that the international hunter spends an average of R30 000 per trip (Streicher, Horn & Pretorius, 1995-6). In 2000 Van der Waal and Dekker estimated the annual turnover of the game ranching industry in the Northern Province (now Limpopo) alone to be in the region of R221 million. The largest contribution came from hunting, followed by live sales and ecotourism. Game meat production contributed only 3.7% (R7 million) to the annual turnover. The latest figures from the National Agriculture Marketing Committee (NAMC) showed the annual turnover of the game ranching industry in South Africa to be in the range of R4.7 billion (Table 1). Meat production contributed the smallest percentage (1%) to the total turnover, with live sales second lowest at 2% (Anon, 2007).

Table 1: Contribution of different utilisation categories to the annual turnover of the game ranching industry in South Africa

	Turnover (R million)	*Percentage (%)*
Biltong hunting	3 100	66
Translocation	750	16
Trophy hunting	510	11
Taxidermy	200	4
Live sales	94	2
Meat production	42	1
TOTAL	4 696	100

(Anon, 2007)

In recent years auction prices for the more common game species reached a plateau (Eloff, 2002). In Limpopo Province the heads of game sold increased from 6 802 in 2003 to 9 163 in 2004. However, the monetary value decreased from R39 million in 2003 to R35 million in 2004 (Eloff, 2005). When considering the whole of South Africa, the heads of game sold increased from 8 292 to 20 022 since 1991, with an increase in turnover from R8.9 million to R105.1 million in 2002. However, since 2002 animals sold decreased to 17 569, with a turnover of R93.5 million in 2005 (Anon, 2007).

Biltong hunting is still the biggest earner of income for the game ranching industry. When considering the number of animals hunted, the species preferred by biltong hunters is springbok (*Antidorcas marsupialis*), followed by impala (*Aepyceros melampus*), blesbok (*Damaliscus dorcas phillipsi*), kudu (*Tragelaphus strepsiceros*), warthog (*Pachochoerus africanus*) and blue wildebeest (*Connochaetus gnou*), in that order (Table 2) (Van der Merwe & Saayman, 2005).

Table 2: Income generated and numbers of animals hunted by biltong hunters

Species	*Number Hunted*	*Total Generated (R)*	*Average Price (R)*
Nyala	34	243 500	7 161.76
Eland	229	1 049 200	4 581.65
Waterbuck	52	228 900	4 401.92
Zebra	106	345 970	3 263.86
Kudu	1 013	2 512 780	2 480.53
Blue Wildebeest	660	1 443 250	2 186.74
Red hartebeest	219	474 650	2 167.35
Black Wildebeest	123	232 565	1 890.77
Bushbuck	77	92 900	1 206.49
Reedbuck	73	79 500	1 089.04
Ostrich	28	19 550	698.21
Blesbok	1 547	914 735	591.30
Impala	2 240	1 308 205	584.02
Bushpig	103	41 870	406.50
Mountain reedbuck	231	91 285	395.17
Warthog	994	335 760	337.79
Springbok	3 277	961 175	293.72
TOTAL	11 808	11 901 315	

(Van der Merwe & Saayman, 2005)

However, of these six species most often hunted by biltong hunters, kudu generates the highest income, followed by blue wildebeest, while springbok generates the lowest income per animal. Although the hunting of nyala, eland, waterbuck and zebra earns the highest income, the numbers hunted are very low. These more expensive species are mostly hunted for status reasons. While biltong hunting is still the biggest earner of income in the game industry, the potential of meat production cannot be overlooked.

GAME MEAT PRODUCTION POTENTIAL

The venison production potential of various species of ungulates found in southern Africa has long been recognised (Ledger, 1963; Ledger, Sachs & Smith, 1967; Fairall, 1984). As noted by Skinner (1984), when producing meat from wild ungulates the same criteria apply as those applying to meat production from domestic stock. These criteria include factors such as yields, chemical composition and meat quality (Issanchou, 1996).

Normally, the carcass yields of wild ungulates vary between 56-66% of the live weight. Obviously there are species differences (e.g. Hippopotamus 42%). The work of earlier researchers such as Hitchins (1966), Ledger *et al.* (1967), von La Chevallerie (1970), Huntley (1971), von La Chevallerie and Van Zyl (1971) and Irby (1975) can be consulted for more detailed information on the yields of various ungulates found in eastern and southern Africa. There are differences in mature carcass weights within species, particularly between animals from either eastern or southern Africa. Another important facet is the difference in yields between males and females, particularly after sexual maturity (Hitchins, 1966) and sexual dimorphism (Hoffman, 2000a; Hoffman *et al.*, 2005a; Mostert & Hoffman, 2007). The methodology utilised for expressing the carcass yield needs to be explained fully and, where possible, standardised so as to ensure meaningful comparison between different investigations. The dressing percentage is normally expressed as a percentage of live weight or of the empty body weight (live weight minus stomach and intestine content) of the animals. The difference in dressing percentages obtained by the two methods will differ (it was calculated to be 8.4% for male duiker by Ferreira and Hoffman (2001)). When comparisons are made between wild ungulates and the traditionally farmed animals (cattle, sheep, goats and pigs) cognisance must be taken of the fact that the yields of the farmed animals are normally calculated on a 24 hrs empty live weight. Other factors such as fleece weight may also bias the results in favour of game.

With the exception of the work of von La Chevallerie (1972) and Jansen van Rensburg (1997), no other literature on the physical, chemical or organoleptic quality attributes of southern African game meat could be sourced around the turn of the century. The results of von La Chevallerie (1972) show an average moisture content of 75.5% and a fat content below 2.5% for game meat. The work of Jansen van Rensburg (1997) investigated the effects of optimum ageing method and period on the cooking-related and sensory quality characteristics of springbok.

This lack of scientific data on the meat quality attributes of game animals stimulated the Meat Science team at Stellenbosch University to start an in-depth research programme on game meat. To gain sufficient critical mass in scientific expertise, a virtual team was initiated in which scientists from various Departments (mostly within Stellenbosch University, but also outside the University) would provide scientific inputs where required (Table 3). A holistic approach was followed where knowledge of the factors that influence the meat quality of traditionally farmed livestock would be evaluated and quantified for game meat (Fig 1). This resulted in a farm-to-fork approach.

Table 3: Scientific disciplines involved in game meat research at Stellenbosch University (SU)

Discipline	*Expertise*
Sensory	MM Muller, Dept Food Science, SU
Microbiology	LMT Dicks, Dept Microbiology, SU; TJ Britz, Dept Food Science, SU
Processing	FD Mellett, Dept Animal Sciences, SU; LMT Dicks, Dept Microbiology, SU; E Slinde, Norway
Fibre typing	KH Myburgh, Dept Physiological Sciences, SU
Chemical analysis	M Manley, Dept Food Science, SU
Enzyme activity	RJ Naudé, Dept Biochemistry & Microbiology, NMMU

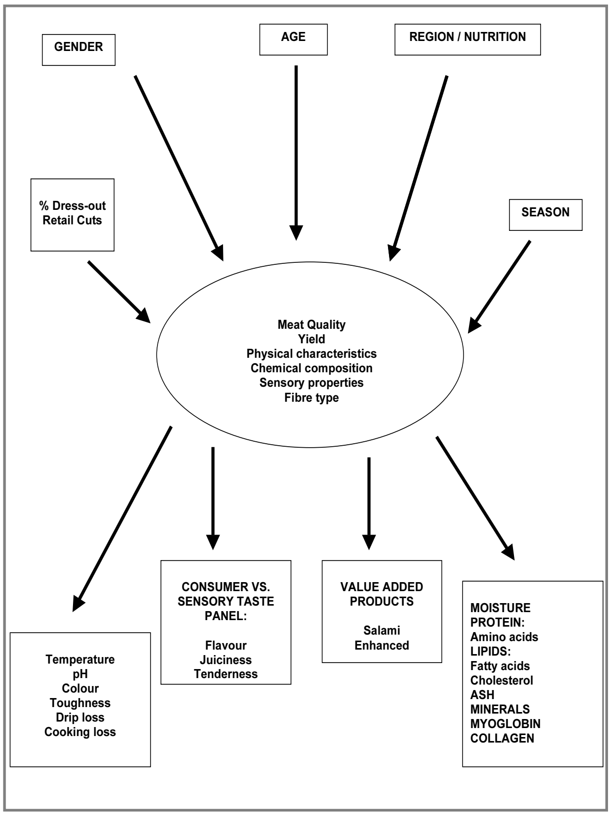

Figure 1: Intrinsic and extrinsic factors influencing the meat quality of game meat

RESEARCH ON GAME MEAT AT STELLENBOSCH UNIVERSITY

The Stellenbosch University research team in partnership with various game farmers and the Provincial Nature Conservation authorities have been involved in researching the effects that various intrinsic and extrinsic factors have on game meat quality attributes. This research has also extended to value-added game products. As some of the research formed part of Master students' theses, it was easier to focus on individual species (Table 4).

Table 4: Game meat species researched at Stellenbosch University

Species	*Thesis*
Springbok	M. Kroucamp. Determination and quantification of factors that influence the meat quality of Springbok.
Impala	B. Kritzinger. The meat quality attributes of Impala *Aepyceros melampus.*
Impala / kudu	R. Mostert. Meat quality characteristics of kudu (*Tragelaphus strepsiceros*) and impala (*Aepyceros melampus*).
Blesbok Hartebeest	K. Smit. Meat quality characteristics of blesbok (*Damaliscus dorcas phillipsi*) and red hartebeest (*Alcelaphus buselaphus caama*).
Black wildebeest / blue wildebeest / mountain reedbuck	S. van Schalkwyk. Meat quality characteristics of three South African game species: black wildebeest (*Conocaetes gnou*), blue wildebeest (*Connochaetus taurinus*) and mountain reedbuck (*Redunca fulvorufula*).
Products and marketing	
Marketing	K. Crafford. Consumer perceptions of game meat.
Salami	K.S.C. Koep. The production of traditional salami using alternative mammal species.
Enhancement	P. du Buisson. Assessing the effect of organic salt and lactic acid injection on the quality characteristics of game meat.

One of the major quality attributes researched is the chemical composition of the game animals, with an emphasis on the extrinsic and intrinsic factors that influence this (Fig 1).

NUTRITIONAL VALUE OF GAME MEAT

In recent years consumers have become more aware of the health implications of the food they eat. Meat, especially red meat, has been labelled as containing high levels of unsaturated fat and high cholesterol. On the other hand, the average fat content of most game species is less than 3%, thus being significantly lower than that of domesticated species such as beef and lamb (Schönfeldt, 1993). Fat content for springbok from three production regions ranged between 1.32% and 3.46% (Hoffman *et al.*, 2007a). Stevenson *et al.* (1992) also commented on the low energy and cholesterol profile of venison. Aidoo and Haworth (1995) noted the low total energy of game meat, which is less than 500 kJ/100 g meat. These aspects make game meat a low-fat, nutrient-dense alternative for the health-conscious consumer. Not only is game meat low in fat, but several studies have shown that the protein content of game meat is high (Table 5). Jansen van Rensburg (2001) noted that there is great potential for game meat production, since it meets the modern consumer's need for lean meat.

South African game meat can be considered an organic product as the animals are wild and free-roaming in contrast with many game species that have been semi-domesticated in other parts of the world (Hoffman & Wiklund, 2006).

Table 5: Nutritional values for game species ompared to that of beef

Species	Protein (%)	Fat (%)
Beef[a]	19.2	14.2
Springbok[b]	20.0	2.20
Nyala[a]	22.2	0.8
Blesbok[c]	22.19-22.45	0.92-1.19
Impala[d]	23.8	2.45

a Jansen van Rensburg, 2001

b Hoffman *et al.*, 2007a

c Smit, 2004

d Hoffman, 2000a

From a health point of view, the fatty acid composition of meat, especially the ratio of polyunsaturated fatty (PUFA) acids to saturated fatty acids (SFA), is of greater importance than the total fat content. Oleic (C18:1), palmitic (C16:0) and stearic (C18:0) acids, all SFAs, are the most omnipresent fatty acids in meat. However, meat from several game species has shown to have high levels of PUFAs. Also of importance is the ratio of omega 6 (*n*-6) to omega 3 (*n*-3) PUFAs in meat.

Game meat offers a healthy alternative to South African red meat eaters; however, a correct marketing strategy and the availability of game products that require less cooking time are needed (Radder & Le Roux, 2005). Also, consumers need to be educated on the health advantages of game meat over other red meats (Radder, 2002).

The protein, moisture and fat content of meat are important determinants of its nutritional value. Moisture constitutes the biggest proportion of meat and several authors have reported on the moisture content ranging from 73-76% (Table 6). World Health Organisation recommendations state that fat should supply between 15 and 30% of calories in the diet (WHO, 2003). Various factors can influence meat fat content, i.e. species, gender, nutrition (diet), muscle and season. One of the major differences between game meat and other red meats is the lack of marbling fat in game meat (Aidoo & Haworth, 1995).

Table 6: Proximate composition of several game species compared to beef and sheep

	Protein (%)	Moisture (%)	Ash (%)	Fat (%)
Springbok [a]	18.80-21.16	73.35-74.40	1.18-1.28	1.32-3.13
Blesbok [b]	22.68	73.47	1.38	2.09
Blue wildebeest [c]	22.73-23.43	74.77-76.17	1.26-1.38	1.26-1.47
Camel [d]	19.3	77.2	0.9	2.6
Beef [e]	-	70.52	7.74	1.20
Sheep [f]	13.9	60.7	-	-

[a] Hoffman *et al*., 2007a
[b] Du Buisson, 2006
[c] Van Schalkwyk, 2004
[d] Elgasim & Alkanhal, 1992
[e] Von Seggern *et al*., 2005
[f] Sayed *et al*., 1999

As water and protein are contained mainly in the lean portion of meat, the low fat content of game meat will cause the moisture and protein content of game meat to be relatively higher than in other red meats (Aidoo & Haworth, 1995). Hoffman (2000a) reported moisture, protein and ash contents of 72.4%, 23.8% and 2.1% for impala (no significant differences between genders). However, the fat content was reported to be higher ($P < 0.05$) in females (3.39%) than in males (2.45%).

Meat has been implicated in causing obesity and cardiovascular diseases because of its fat and cholesterol content. However, it is not only the amount of fat, but also the fatty acid composition that is of importance where the health aspect of meat is concerned. Meat consists mainly of monounsaturated (MUFA) and saturated fatty acids (SFA). Oleic acid (C18:1), palmitic acid (C16:0) and stearic acid (C18:0) are the most abundant fatty acids in meat (Valsta *et al*., 2005).

The lipids in ruminants are known to contain high amounts of SFAs, thereby contributing to the unfavourably high SFA intake in the human diet. The World Health Organisation (WHO) guidelines recommend that less than 10% of the fat intake in the human diet should be from SFAs. Various authors have concluded that the PUFA:SFA ratio in the diet is more important than the total fat content (Chizzolini *et al*., 1999; Wood *et al*., 2003). A PUFA to SFA ratio of 0.4 and more has been recommended by the Department of Health (1994) in the UK. Recent studies (reviewed in Hoffman & Wiklund, 2006) have revealed that meat from most game species has favourable fatty acid profiles (Table 7). Springbok meat had a PUFA:SFA ratio of between 0.96 and 1.18, with an average of 1.06 (Hoffman *et al*., 2007b). The ratio was calculated as 1.16 for mountain reedbuck and ranged from 0.94 to 1.21 for black wildebeest (Van Schalkwyk, 2004).

Table 7: Mean total fat (%), fatty acid composition (%) and total cholesterol content (mg/100g) 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 africanus*), buffalo (*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/100g meat sample)	-	-	51.38	56.9	-	50.9	46.05	51.08	-	-	-

Adapted from:

a Hoffman & Ferreira, 2004

b Hoffman, 2004

c Smit, 2004

d Kroucamp, 2004

e Hoffman *et al.,* 2005b

f Van Schalkwyk, 2004

g Unpublished data chemically analysed as described in Hoffman *et al.,* 2005b

Of equal importance is the right balance of omega-6 (*n*-6) and omega-3 (*n*-3) fatty acids, which is necessary to lower blood pressure, reduce inflammation and encourage healthy blood flow. In most Western diets the ratio of *n*-6:*n*-3 fatty acids is in the region of 15:1. A ratio of less than 5:1 is recommended as a healthy balance. In modern society meat from intensively reared animals adds to this imbalance as their meat contains high quantities of *n*-6 fatty acids (Simopoulus, 2000). In contrast, animals raised on grazing have more *n*-3 fatty acids, as grass contains high amounts of ?-linolenic acid, an *n*-3 polyunsaturated fatty acid (PUFA). The earlier work of Crawford and co-workers (1970) showed that the meat of wild and domesticated animals differs significantly in terms of fatty acid profile, which has important implications for human health. The *n*-6:*n*-3 ratios of meat from game species were all below 4.0.

Cholesterol is an integral part of the cell membranes of animals (Chizzolini *et al.*, 1999) and therefore consumption of red meat can not be dissociated from cholesterol intake. According to the WHO (2003), cholesterol intake should be limited to 300 mg/day. In general the cholesterol content of meat and meat products is in the region of 75 mg/100g. Chizzolini *et al.* (1999) reported the cholesterol in offal such as brains, kidney and heart to be considerably higher. The mean cholesterol content of meat for selected species is represented in Table 8.

Myristic (C14:0) and palmitic (C16:0) acids have been implicated in raising total and low-density lipoprotein (LDL) cholesterol levels, which is a major risk for coronary heart diseases (Valsta *et al.*, 2005). However, not all SFAs have cholesterol-elevating attributes. In general, MUFAs and PUFAs do not increase cholesterol levels. The PUFA, arachidonic acid is associated with serum-cholesterol-lowering attributes. Despite these negative associations, cholesterol has some positive functions in the body such as the production of hormones such as cortisol and the production of bile acids.

Table 8: Mean cholesterol content in meat for selected animal species

Species	*Cholesterol content (mg/100g)*
Nyala[a]	51
Alpaca (*Lama pacos*)[b]	51.14
Blesbok[c]	49.74-54.56
Springbok[d]	54.45-59.34
Llama (*Lama glama*)[e]	56.29
Beef [f]	76

[a,f] Jansen van Rensburg, 2001
[b] Christofanelli *et al.*, 2004
[c] Smit, 2004
[d] Hoffman *et al.*, 2007b
[e] Polidori *et al.*, 2007

The Springbok (*Antidorcas marsupialis*) is presently the game animal that is most extensively cropped in South Africa and most of the research relating to South African game meat has been done on this species. Veary (1991) carried out initial work on the effect of cropping methodology and cooling regime on meat quality, whilst Jansen van Rensburg (1997) researched some aspects of the physical, chemical and sensory quality characteristics. The impact of region, age and gender on these attributes was investigated in depth by Hoffman and co-workers (Hoffman *et al.*, 2007a-d). Von La Chevallerie and Van Zyl (1971) and Fairall, Jooste and Conroy (1990) studied various parameters of the biology relating to meat production. Maximum growth rate had been attained before the age of one year and at that age males had achieved 88% and females 92% of mean mature body mass of 31.5 and 27.1 kg respectively. The dressing percentage of young (3-6 months) springbok was noted as 56.1% for males and 53.3% for females. For older animals (24+ months) this had increased to 58.8% and 55.0% respectively. This indicates that the ideal age for most efficient cropping is between six months and one year for both sexes – an age where meat quality would be at its best.

It is well documented that the flesh of younger animals is more tender and of better quality than that of older animals within the same breed or species. However, neither age nor gender had an effect on the shear values of Springbok meat, which varied from 2.04 to 2.31 kg/ 1.27 cm diameter for the different age categories (Hoffman *et al.*, 2007a). The shear force values obtained for springbok were low compared with values of 3.21-4.08 reported for impala (*Aepyceros melampus*) (Hoffman, 2000b), 3.23-4.28 for black wildebeest (*Connochaetus gnou*), 3.77-4.60 for blue wildebeest (*C. taurinus*), 2.95-3.00 for mountain reedbuck (*Redunca fulvorufula*) (Van Schalkwyk, 2004). Females had higher intramuscular fat levels than males and, although fat levels increased as animals aged, the fat levels were still below 3.5% (Hoffman *et al.*, 2007b). The specific fatty acids were also quantified (Hoffman *et al.*, 2007c) and the major fatty acid of the *M. longissimus dorsi* was stearic acid (C18:0), which contributed 23.92-27.02%. Oleic acid (C18:1) represented the largest component (16.33–20.45%) of the MUFA. The major n-6 PUFA was C18:2n-6, which formed 18.77-21.62%, whereas C18:3n-3 (3.33-4.00%) was the most abundant n-3 PUFA. The n-6:n-3 ratio of the meat varied from 3.02 to 3.35, with an average ratio of 3.2. Polyunsaturated to saturated (P:S) ratios varied between 0.96 and 1.18 and averaged at 1.06. Total MUFA was found to be higher in males (20.99%) than females (16.67%). In the same study the regional effect was greater on the sensory characteristics of springbok than either gender or age (Hoffman *et al*., 2007d). Production region influenced the game meat aroma, initial juiciness, sustained juiciness and residual tissue ratings of the meat, whilst gender and age had a significant effect only on the residual tissue rating of the meat. Gender had no effect on the chemical (proximate, amino and fatty acids, minerals) composition of kudu (*Tragelaphus strepsiceros*) (Mostert and Hoffman, 2007).

Another species that has been researched is the impala (*Aepyceros melampus*). Various models have been described to calculate the sustainable cropping rate. Fairall (1983) found 22% to be sustainable under a predator regime (where large predators such as lions, leopards, wild dogs and spotted hyenas remove a substantial number). The rate could increase to 25-30% in a farming situation without predators. Manipulation of age and sex ratios can lead to an improvement in productivity. Fairall (1985) calculated that changing the sex ratio from 1:3 to 1:10 increases productivity by 30%, while the most complex manipulation, achieved by harvesting all individuals older than three years, gives an increase of 138%. These figures were derived for a population with no predators. On the other hand, Van Rooyen (1994) found that a sex ratio of 1:5 to be the most suitable and that age-selective harvesting does not increase production. The work of Hoffman *et al*. (2005a, b) was the first on African ungulates (impala) indicating that region (and indirectly diet) influenced the chemical composition of game muscle. Differences were noted for the fatty acid composition as well as the mineral content for impala originating either from Mara or Musina.

The potential of the warthog for cropping has also been identified (Mason, 1985; Somers, 1992; Somers & Penzhorn, 1992). Somers (1997) also used simulation models to investigate the sustainability of harvesting a warthog population. Research has also shown that this species is also prone to the phenomenon frequently encountered in domestic pig of pale soft exudative (PSE) flesh (Hoffman & Sales, 2007).

CROPPING METHODOLOGY AND MEAT QUALITY

Traditionally, hunters prefer to shoot animals through the shoulder (hitting either the heart or, more commonly, the lungs) rather than through the neck or head. This shoulder shot can result in up to 20% of the carcass being damaged by the bullet, whilst a shot through the neck shows minimum (3%) wastage (Von La Chevallerie & Van Zyl, 1971). Heart shots are also likely to result in a higher incidence of wounding and do not render the animals instantaneously insensible (Lewis, Pinchin & Kestin, 1997). In the meat trade the neck is also classified as a lower value joint compared to the shoulder. The harvesting technique applied depends on the species, its habitat and the vegetation of the area. In order to be economically competitive, harvesting techniques are continuously being altered so as to harvest the most animals in the least amount of time. For export-quality meat only head or high neck shots are acceptable (Hoffman, 2003).

NIGHT HARVESTING

Night harvesting is usually done with a spotlight from open vehicles so as to cause the least amount of stress to the animals. The shooting is done by professional shots that typically have a success rate of over 90%. It not only causes the least damage and wastage to the carcass, but it was also observed to induce the least stress in the survivors. A head or neck shot normally drops the animal instantly, whilst a shoulder or rib shot could result in animals running substantial distances before dying (Von La Chevallerie & Van Zyl, 1971). Hoffman (2000b) concluded that night cropping of impala had no detrimental effects on meat quality. Research done by Kritzinger *et al.* (2003) clearly showed that night cropping produces meat with a better quality than meat from day-cropped animals. The work done by Veary (1991) and Von La Chevallerie and Van Zyl (1971) indicated that ante-mortem stress, which is limited during night harvesting, could have unfavourable effects on meat quality.

Animals such as kudu are not suitable for night harvesting as they are predisposed to look away from the spotlight or to close their eyes. In contrast impala are ideal for night harvesting as they have a tendency to stay still once caught in the spotlight (Lewis *et al*., 1997). In the open areas of the Northern Cape springbok are mostly harvested from vehicles at night (Hoffman & Wiklund, 2006). From personal observation it is evident that night harvesting is not as successful in the dense Bushveld areas of the Limpopo Province. The dense vegetation makes it difficult to see the animals and it is not always possible to get an open shot, particularly if only head and upper neck shots are acceptable. Another disadvantage of night harvesting is that it is more difficult to determine the gender of an animal, especially in species where both genders have horns.

DAY HARVESTING

Animals can be enticed to feeding points, where they are shot from a hide. This method will cause no stress to the animal; however, this is a very time-consuming method and would not be economically viable.

On large game ranches or areas where the vegetation is too dense, helicopters can be used to herd the animals into a boma as with a game capture operation. The animals are left in the large boma to settle down and from there small groups (± 10) are moved to a smaller boma. They are then shot from above with a small calibre silenced rifle. From here the animals are loaded on a truck (hanging head down and exsanguinated) and transported to a mobile abattoir set up in the veld. Although the effect on the meat quality has not been researched, this method seems to work well with impala, kudu and blue wildebeest. This method also has practical advantages for the dense bushveld areas, which are not always accessible with vehicles; however, the cost involved is the major restricting factor for using this method (Hoffman & Wiklund, 2006).

In the dense bush areas of the Eastern Cape springbok and kudu are harvested during the day from a helicopter. Animals are shot from the helicopter with a 12-gauge shotgun, while a ground team follows to collect the dead animals. From personal observation it was noted that these animals are not all killed by head or neck shots. Broken legs were also noticed as springbok tend to jump when fleeing. The influence of this harvesting technique on the meat quality also needs to be quantified. Personal observations also indicated that there were large bruises on the carcasses harvested in this manner.

GAME MEAT PRODUCTION IN SOUTH AFRICA

Production and consumption of game meat in South Africa is poorly documented. It is virtually impossible to obtain reliable figures for animals taken by hunters and farmers and used for their own consumption or sold locally. According to Jansen van Rensburg (1992), venison is fairly well known and is consumed by 5.625 million people in the RSA, yet many consumers still do not know exactly how to prepare the meat and others detest its taste. In his survey this author found that only 39.9% of the total population had eaten game meat/venison in a form other than dried raw meat (known locally as biltong). His results indicate that 69.29% whites, 49.30% blacks, 56.40% coloureds and 44.64% Asians would buy game meat when available. Demand is strongly seasonal. It is limited mainly to the winter months, except for a minor summer season in the Western Cape corresponding to the influx of foreign tourists. This presently absorbs some 3 000-4 000 springbok. South African housewives will generally only buy game if it is cheaper than conventional meats, an observation borne out by Pauw (1993). The prices farmers can get for game are, in descending order, trophy hunting, live capture, local (meat) hunting and then processing plants.

In Zimbabwe a group of farmers has come up with an interesting strategy to crop some of their ungulates and that is to sell them to a professional hunter at a low cost (e.g. U$30 per impala), who sells it to a client for U$50. The professional hunter uses his equipment, time, infrastructure, etc. to crop the animals. It was noted in Zimbabwe that many clients would like to hunt more animals but cannot afford trophy fees. Using this method, the owner not only gets the meat from the animals identified for cropping (all have to be shot in the head or neck), but also an additional fee using the professional hunter's time and infrastructure. Obviously this has a limited application as there are not that many clients available. A similar strategy has been observed in Namibia for springbok.

The export market has suffered many vicissitudes. In the early 1980s helicopter cropping, especially of springbok, was economically viable. With this very efficient technique and good standards of hygiene a significant export market was developed. Total annual South African exports then were around 900 tons of carcasses with bone in. This represents about 1 500 tons live mass, taking average carcass yield as 60% of body mass. Springbok made up some 75%, the rest consisted of blesbok, impala and assorted big game. Jansen van Rensburg (1997) recorded the following data for venison exports to Europe:

1987	553 t of venison of which 529 t was springbok meat
1990	300 t, bone in. However Neethling (pers. com.) considered 1990 to be the best of recent years with 55 000 springbok representing 700 tons
1993	120 t
1994	50 t (lower due to the drought)
1995	100 t (with an increased demand for venison)
1996	180 t (only deboned venison)

European veterinary authorities restricted imports to deboned cuts. The grounds were apparently the existence of a strain of TB in the Kruger National Park which could be transmitted via bone. Deboning reduces yield to about 44% of live mass and has serious implications for the economic viability of the industry.

In 1998 the two major processors handled some 40 000 springbok and exported 300 tons, together with 15 tons of blesbok and 30 tons of kudu (all deboned). They experienced a dramatic decline in the market in 1999. Springbok were down to 15 000, of which 2 000 were sold locally. Exports amounted to around 100 tons plus 4 tons of blesbok and 12 of kudu. A variety of reasons are given for problems experienced by South African venison on the European market: markets are said to be manipulated by importers and springbok, for example, are commonly sold as roe deer or other species. When such scandals are exposed in the press, South African products get a bad name. There is strong competition, especially from New Zealand farmed deer (total crop 460 000 in 1998, 470 000 in 1999, target 500 000/year). They are easily harvested from fenced pastures and carcasses are large, reducing processing costs. The New Zealand industry has built abattoirs where deer are slaughtered in the same way as domestic stock. This practice automatically results in better control of meat quality.

There is also competition within Europe, where there is a high and constant offtake of indigenous game, e.g. the German roe deer harvest is about 1 million a year. Scottish red deer also appear on European markets. Presently, the South African trade is trying to market under the label "exotic game meat" to get away from the association with venison. This strategy is in line with Pauw's (1993) to market game meat as an organic product.

During 2005 it was 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 (Hoffman & Wiklund, 2006).

RESEARCH NEEDS AHEAD

Simulation models for sustainable harvesting need to be calculated for ungulate species that show potential for commercial cropping. As was indicated by Somers (1997), it cannot just be assumed that traditional harvesting practices will automatically lead to sustainable populations. There are many variables that need to be identified and monitored to ensure a dynamic harvesting model that will not lead to the extinction of that population.

Research is needed on the growth and development of various species and the influence of this on meat quality parameters (for an example, see Von La Chevallerie & Van Zyl, 1971). The importance of factors such as sex, season and stocking density also need to be investigated. If cropping of game is to be combined with trophy hunting, the correlation of horn growth early in the animal's life with horn growth after sexual maturation will, if possible, have to be calculated so as to ensure that potential trophy animals are not cropped.

The effect of season on carcass yield and body chemical composition needs to be quantified (Stevenson *et al*., 1992) because, as noted by Irby (1975), the seasonal effects on Mountain Reedbuck were substantial. Pauw (1993) notes that game meat has very special qualities that render it a unique product to market. Of these, low fat content and diverse tastes are probably the most important. The low fat content is especially important for a healthy diet (McLean-Meyinsse, Hui & Meyinsse, 1995). Under the current extensive game ranching situation in South Africa, game meat may also be described as an organic product, since no dipping takes place and no fertilisers or growth stimulants are used in the production system. The marketing of game meat should therefore focus on these healthful attributes (Pauw 1993). However, more research is required on the bacteriological quality of South African game meat so as to ensure that a wholesome product of the highest quality that meets international standards reaches the consumer (Buys, Nortje & Van Rensburg, 1996).

Another domain that requires research is that of value adding to the game meat.

Basic information gleaned from goal-oriented research is therefore urgently required for local producers and processors in the RSA to get to know their products, markets and (potential) consumers thoroughly. For these reasons it should be important that quality standards be set in order to produce quality products for the market (Jansen van Rensburg, 1997). Already South African producers are looking at the generic marketing of their product as "exotic game meat" so as to be able to distinguish it from venison as farmed in New Zealand, Scotland and other parts of Europe (Hoffman & Wiklund, 2006).

The findings of Jansen van Rensburg (1992), mentioned above, indicate that research on means of making game meat more acceptable to the local consumer could produce valuable paybacks. The determination of proper ageing methods, correct ageing periods, correct cooking methods and optimum cooking times could perhaps contribute towards a better quality product, provided that such information is communicated effectively to potential consumers (Hoffman & Wiklund, 2006).

CONCLUSION

It is clear that a responsible utilisation of ungulates in southern Africa implies not only preserving the species, but also its commercial utilisation. During a meeting of SADC member states in Botswana in 1997, research into the potential of game meat and its markets was identified as a priority given their complementarity to the community-based natural resource management policies of the various member governments (SADC, 1997). The research priorities identified above will therefore not only benefit the commercial sector that crops and ranches game, but also fit into the priorities identified by the governments of the SADC region. However, due to limited financial resources available within South Africa for research, it is imperative that a holistic approach to researching these priorities be followed, which implies stronger linkages between conservationists, commercial farmers, researchers and rural communities.

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