Meat Science 80 (2008) 94–100

Contents lists available at ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Review

The yield and nutritional value of meat from African ungulates, camelidae, rodents, ratites and reptiles

L.C. Hoffman *

Stellenbosch University, Private Bag XI, Matieland 7602, South Africa

ARTICLE INFO

Article history:
Received 18 March 2008
Received in revised form 15 May 2008
Accepted 17 May 2008

Keywords:
Fatty acids
Cholesterol
Ungulates
Camelids
Rodents
Ratites
Reptiles

ABSTRACT

The current knowledge of the yield and nutritional (proximate and fatty acid) composition of meat derived from African ungulates, camelidae, rodents, ratites and reptiles is reviewed. Although most of the species discussed give low cholesterol levels consistent with their low meat lipid contents, the tegu lizard gives a very low level (18.2 mg/100 g tissue). The fatty acid profiles of the various species all have low saturated fatty acids and high polyunsaturated fatty acids resulting in favourable saturated to polyunsaturated fatty acid ratios. Although the springbok, camel, ostrich and crocodile are marketed and exported to sophisticated markets, the rodents are the species that show most promise in becoming large commercial commodities. Not only is their meat desirable and nutritional, but they are also highly adaptable to extensive and intensive production systems.

Contents

1. Introduction

It has by now become accepted that the land available for livestock (meat) production is limited, and with the exception of forest clearing (such as in the rain forests) most of the available space is already being utilised. The pressure against countries that are presently clearing forests for cultivation to cease this activity is mounting as the effects of global warming becomes a reality. The only real method of increasing meat production is to utilise the available land more efficiently (Cooper, 1995a). Research to achieve this has been conducted for a number of years via methods such as genetic selection, improved nutrition, better management procedures, etc.

Another strategy that has been advocated for a number of decades is the utilisation of marginal or sub-marginal lands by stocking animals that have adapted to these harsh conditions and farming/ranching them in a sustainable manner (Mossman & Dassman, 1962). Within the Africa context, earlier researchers such as Darling (1960), Ledger (1963), Ledger, Sachs, and Smith (1967) and Conroy and Gaigher (1982) have advocated a production management based approach to the utilisation of naturally occurring game animals within Africa with a special focus on eastern and southern Africa.

* Tel.: +27 21 8084747; fax: +27 21 8084750.
E-mail address: lch@sun.ac.za

0309-1740/$ - see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.meatsci.2008.05.018

Similarly, mini-livestock breeding and farming has been advocated for backyard family production as it can contribute to increased food security (Hardouin, Thys, Joiris, & Fielding, 2003). Species typically suitable for mini-livestock production include vertebrates such as the cane rat (*Tryonomys*), the giant rat (*Cricetomys*), the brush tailed porcupine (*Hydrochoerus*) in Africa, in the Mascarene Islands, the tenrec (*Setifer setosus,* Fam. Tenrecidae); in Latin America the agouti, coypu, paca and guinea pig are suitable. Other animals also include edible frogs, reptiles, snakes and birds. Although these mini-livestock species have a huge potential to supply food, these animal can represent a serious threat as crop pests as the attributes that make them suitable for mini-livestock production also provide them with the ability to flourish when present in the wild. Hardouin (1995) reviews the suitability of a number of animals for mini-livestock production whilst Cooper (1995b) reviews some of the legality issues surrounding the production and utilization of some of these species.

Although the contribution of game to total formal world meat production and consumption is very small and it is even smaller in the international meat trade, it is a very important source of protein in the rural areas of the developing world where it is frequently called bushmeat (Barnett, 2000). Although it is very difficult to quantify the contribution of bush meat sources to the daily protein consumption of people, it is by now recognised as being of great importance. East, Kűmpel, Milner-Gulland, and Rowcliffe (2005) evaluated the determinants of bushmeat consumption in Equatorial Guinea and noted that it was widely available but that its consumption was mainly constrained primarily by income – with the lower income groups being unable to purchase it. The restaurant clients consuming bushmeat were mainly males and the authors predict that the consumption of bushmeat would most likely increase as the country's economic prosperity and population continue to grow. However, the authors also noted a change in the consumption patterns with for example, a shift away from the consumption of mandrills – a number of respondents in their survey stated that they did not eat bushmeat because it was "dirty meat". Similar studies have also been done in other countries in Africa (Brashares et al., 2004; Wilkie et al., 2005) and South America (Apaza et al., 2002; Bodmer & Lozano, 2001; Wilkie & Godoy, 2001).

There is also an increase in the requirement for non-traditional/unconventional meat/protein sources by the modern consumer. Hoffman, Crafford, Muller, and Schutte (2003) noted that tourists visiting South Africa were seeking meat derived from the local wild fauna as it was perceived to be part of the "Africa experience". As international travelling opportunities to the developing world increase, it can be expected that the need to fulfil this type of experience by tourists will increase. There is also an increase for the importation of these exotic species into the affluent countries such as the USA and the EU. Part of this interest in these species by consumers in these countries can be related to their health awareness. With the increase in cardio vascular diseases in modern man, studies have indicated that the diet (mainly wild ruminant tissue) of the pre-agricultural man contained lipids in the meat that were predominantly phospholipid and that the meat from the free living animals was low in total fat but rich in both linoleic and linolenic acids and their elongation products (Cordain et al., 2002; Crawford, 1968; Crawford, Gale, Woodford, & Casped, 1970). Whilst data is readily available indicating the lipid composition of farmed animals (MacRae, O'Reilly, & Morgan, 2005; Wood et al., 2008), it is fairly limited for a large number of wild animals that are consumed either as bushmeat or in the formal meat trade (Hoffman & Wiklund, 2006) or for farmed species that are not readily consumed in the Western world (such as the camelids – Sales, 1995).

Similarly, there is also a paucity of information on the other nutrients such as amino acids, vitamin and mineral profiles in these new alternative meat species.

None the less, a number of Governments, NGO's and private businesses, especially those situated in the developing world, have identified this niche market and have started either researching the production of these, or actively started farming these animals. As soon as these animals are farmed in a commercial manner, or harvested from the wild in a sustainable manner, the threat of over exploitation becomes less (Féron, 1995). To be able to successfully market these species, scientifically accurate information is needed on the nutritional value of the meat. However, it must be noted that comparison between published data is often confounded by the fact the different laboratories do not necessarily used standard sampling and chemical analyses procedures. This review focuses and compiles the data that is available on the yields and nutritional value of some of the alternative species that are being farmed or harvested sustainably and are found predominantly in the southern hemisphere.

2. Ungulates from Africa

In 2006, Hoffman & Wiklund reviewed the nutritional value of the some major ungulates harvested commercially in southern Africa. Some of the differences noted, particularly as pertaining to the fatty acid composition were ascribed to dietary effects. Most of the ungulates mentioned in their review are ruminants and the effect of diet composition on body fatty acid has been reviewed extensively – see for example Wood et al. (2008). One species of note that features regularly in the bushmeat diet is the duiker. Duikers are divided into two genera; the so-called savannah duiker or the grey duiker (*Sylvicapra grimmia*) and then the forest duiker (*Cephalophus*) of which there are 18 species. Only the meat quality of the grey duiker has been studied (Ferreria & Hoffman, 2001; Hoffman & Ferreira, 2000; Hoffman & Ferreira, 2004), although the forest duikers are the species most frequently consumed in the bushmeat trade (Barnett, 2000). Since the review by Hoffman and Wiklund (2006), an intensive study on the effects of region, age and gender on springbok (*Antidorcas marsupialis*) has been published (Hoffman, Kroucamp, & Manley, 2007a; Hoffman, Kroucamp, & Manley, 2007b; Hoffman, Kroucamp, & Manley, 2007c; Hoffman, Kroucamp, & Manley, 2007d). The meat from this species is not only the major game meat exported, but it is also the major species of the larger ungulates hunted in southern Africa. Females had higher intramuscular fat 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 23.9–27.0%. Oleic acid (C18:1) represented the largest component (16.3–20.5%) of the mono-unsaturated fatty acids (MUFA). The major $n-6$ polyunsaturated fatty acid (PUFA) was C18:2$n-6$, which formed 18.8–21.6%, whereas C18:3$n-3$ (3.3–4.0%) 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 (21.0%) than females (16.7%). 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 only had a significant effect on the residual tissue rating of the meat. Gender had no effect

Table 1
Proximate composition (g/100 g fresh portion) of meat from different camelids and rodents

Species		n	Nutrient				Reference
			Moisture	Protein	Fat	Ash	
Camel	*C. dromedarius*	52	75.6	21.7	1.42	1.2	Babiker and Yousif (1990)[a]
Camel	*C. dromedarius*	6	77.2	19.3	2.6	0.9	Elgasim and Alkanhal (1992)[b]
Llama	*L. glama*	20	70.2	20.5	8.23	3.4	Pérez et al. (2000)
Llama	*L. glama*	20	73.9	23.1	0.5	2.4	Cristofanelli et al. (2004)[c]
Alpaca	*L. pacos*	40	73.6	23.3	0.5	2.5	Cristofanelli et al. (2004)
Capybara	*C. hydrochaeris*	18	74.4	20.9	1.81	1.18	Girardi et al. (2005)[d]
Nutria	*M. coypus*	60	72.1	22.3	1.78	–	Saadoun et al. (2006)[e]

[a] Mean of *Supraspinatus* of young (18–24 months), males and mature (12–18 years) cows.
[b] Mean of leg and loin (2 years old).
[c] Mean of *Longissimus thoracis et lumborum*, males.
[d] Mean of loin, 9 months old.
[e] Mean of pectoral muscle, males and 5-months old.

on the chemical (proximate, amino and fatty acids, minerals) composition of kudu (*Tragelaphus strepsiceros*), another large southern African ungulate (Mostert & Hoffman, 2007).

3. Camelids

Camels belong to the family *camelidae* and the genera *Camelus* and *Lama* with two and four species in each genus, respectively. Of the two camel species, *Camelus dromedarius* (one-hump camel) constitute about 91% of all the camels found, with *Camelus bacterium* making up the rest (Elgasim & Alkanhal, 1992). The four Llama species are *Lama glama, Lama pacos* (now changed to *Vicugna pacos* L. as proposed by Kadwell et al., 2001), *Lama guanicoe* and *Vicugna vicugna*.

Camels are frequently found in harsh environments where its meat is more readily available in the dry seasons when beef is in short supply. In the eastern region of Ethiopia, camel meat is regarded as a high quality meat that is socially acceptable (Kurtu, 2004). The one-hump camel dresses out at 55.8% of live body weight (average slaughter weight of mature, fattened desert camels is 456 kg) and 63.6% of empty body weight yielding 56% meat, 19% bone and 13.7% fat (Yousif & Babiker, 1989). Camel meat (*Camelus dromedarius*) has been compared with other red meats (beef, lamb, goat and chicken) and found to have more moisture, less fat, less ash and similar protein contents (Dawood & Alkanhal, 1995; Elgasim & Alkanhal, 1992; Kadim, Mahgoub, & Purchas, 2008; Table 1). However, Abu-Tarboush and Dawood (1993) noted that the cholesterol contents of camel adipose tissue increased with increased animal age (135 mg per 100 g fresh weight for 8 months old vs. 150 mg per 100 g fresh weight for 26 months old animals). The camel meat also had similar mineral profiles but higher Na levels compared to the four traditionally farmed species (Elgasim & Alkanhal, 1992). The effect of age on the proximate and mineral content (as well as on other meat quality parameters) of the camel has been studied by El-Faer, Rawdah, Attar, and Dawson (1991), Kadim et al. (2006) and Kadim et al. (2008) who noted similar age effects to that of other farmed animal species (e.g. decrease in protein with an increase in fat content, increased toughness, etc.). The ratio of essential amino acids to non-essential amino acids was 0.85, very similar to the 0.86 reported for beef, 0.83 for lamb and 0.90 for goat (Dawood & Alkanhal, 1995; Elgasim & Alkanhal, 1992).

The fatty acid profile of camel meat is compared to that of the other camelids in Table 2. The camel hump represents approximately 13% of the carcass weight (Yousif & Babiker, 1989) and its adipose tissue was found to contain 84% lipid and 139 mg cholesterol per 100 g wet weight and 166 mg cholesterol per 100 g lipid (Abu-Tarboush & Dawood, 1993). The hump frequently forms part of the sirloin cut and can cause the latter to have a high lipid content (49% fat) as most of the camel fat is deposited in the hump rather than being distributed throughout the body (Yousif & Babiker, 1989). Kadim, Mahgoub, Al-Maqbaly, Annamalai, and Al-Ajmi (2002) noted that age influenced the fatty acid composition of the hump and abdominal fat of the one-hump camel. Palmitic acid (C16:0) was the major fatty acid followed by oleic acid and stearic acid. An additional function of the hump is probably to insulate the camel from solar radiation. Fat-containing adipose tissue is suitable for insulatory purposes, because fat conducts heat slower than water. Also blood flow can be very low in adipose tissue, because the fatty deposits do not need oxygen (Hill & Wyse, 1989).

Table 2
Fatty acid composition (% of total fatty acids) of meat from different camelids and rodents

Fatty acid	Camel[a]	llama[b]	Capybara[c]	Nutria[d]
Lipid (g/100 g)	1.52[e]	3.5	1.8	1.8
Saturated				
14:0	7.7	4.1	2.0	3.6
15:0	1.7	–	–	–
16:0	26.0	24.8	22.4	21.9
17:0	1.5	–	1.4	0.4
18:0	8.6	21.5	6.3	8.4
20:0	[f]	–	–	0.1
Total	51.5	50.3	35.0	37.8
Monounsaturated				
14:1	1.0	–	–	–
16:1	8.1	5.4	2.1	8.9
17:1	0.9	–	1.5	0.4
18:1	18.9	35.8	26.2	27.5
20:1	[f]	1.3	0.7	0.3
Total	29.9	42.5	32.3	37.4
Polyunsaturated				
18:2	12.1	3.1	28.6	21.3
18:3	0.5	0.8	2.7	–
20:2	0.1	–	–	0.3
20:3	0.3	–	0.1	–
20:4	2.8	1.8	–	1.8
20:5	0.3	–	–	[f]
22:4	0.1	–	–	0.4
22:5	0.5	–	–	0.2
22:6	0.1	–	–	0.1
Total	18.6	7.2	32.7	24.8
P/S	0.36	0.14	0.93	0.66

– Not shown.
[a] Rawdah, El-Faer, and Koreish (1994): *Biceps femoris*, 7 1–3 years old males.
[b] Polidori et al. (2007): *Longissimus thoracis* and *lumborum*, 20 25-month old males.
[c] Girardi et al. (2005): loin, 9-month old reared in confinement with a pond.
[d] Saadoun et al. (2006): Pectoral muscle, 5-month old males.
[e] El-Faer et al. (1991): mean of shoulder, thigh ribs and neck.
[f] Trace (<0.1) or undetectable amount.

Of the genera *Lama*, The llama (*Llama glama*) and the alpaca (*Vicugna pacos*) are domesticated whilst the other two species are still wild and only a few farms have started farming with these two. The nutritional content of these two camelids have been reviewed recently by Saadoun and Cabrera (2008). The alpaca is mainly farmed for its fibre and numerous attempts have been made to cross this species with the llama to try and improve the quantity, but not necessarily the quality of this highly priced commodity (Kadwell et al., 2001).

Young (9–12 months) male llama reared in central Chile were heavier than same aged females (104 vs. 68 kg, respectively) whilst the gender differences in older (>3 years) animals seem less pronounced (101 vs. 105 kg, respectively). Males were found to have slightly heavier dressing percentages (≈56%) than females (≈54%). However, llama reared extensively in the mountains of Peru (Cristofanelli, Antonini, Torres, Polidori, & Renieri, 2004; Cristofanelli, Antonini, Torres, Polidori, & Renieri, 2005) were lighter (63.2 kg – 25 months old males) and had lower dressing percentages (49%) than those from central Chile. The authors postulate that this is probably due to a genetic difference in the llama population living in Chile and the animals living in the Andean highlands of Peru. The proximate chemical composition of llama meat is given in Table 1 and the fatty acid profile in Table 2. The fatty acids of the *Longissimus thoracis* and *lumborum* from 20 25-months old llama males reared in the Peruvian Andean highlands (mean final body weight of 63 kg) contained 50.3% SFA, 42.5% MUFA and 7.2% PUFA (Polidori, Renieri, Antonini, Passamonti, & Pucciarelli, 2007a). This profile differed from that noted for animals reared in Argentina (Coates & Ayerza, 2004) where the two herds had SFA ranging between 45–46% and the MUFA between 34–37%. An interesting report noted by Coates and Ayerza (2004) was the effect of castration on the llama muscle's chemical and fatty acid composition (a small group of the llama had been castrated 8 months prior to slaughter). Castration had decreased the cholesterol content and increased the linolenic fatty acid content of the muscle fat. These changes are seen as being desirable from a health standpoint. On the negative side, castration increased the subcutaneous fat cover and total fat content of the *Longissimus* muscles.

Alpaca from Peru were smaller (46.1 kg) than the llama from the same region, although they had a higher dressing percentage (53%; Cristofanelli et al., 2004; Cristofanelli et al., 2005) – the reason for this later phenomenon is not clear.

The guanaco (*Llama guanicoe*) is a wild camelid distributed in South America, from the Tierra del Fuego to the Andes. Although it is farmed in Chile and Argentina to produce fibre and meat, it is still listed as "lower risk least concern" on the IUCN red list of threatened species. The major use of the guanaco is for its fibre although its meat has also been consumed traditionally (Vilela et al., in press). An adult weighs 88–120 kg, with no gender differences. Seventy male guanaco aged 18–24 months were found to have a mean weight of 104.8 kg and a mean carcass weight of 63.4 kg (60% dressout). The meat (56% of the carcass weight) had a crude protein content of 20.9% and a low fat content of 1%. There was no subcutaneous fat present. The cholesterol was very low (27.2 mg per 100 g meat) whilst the SFA of the *M. Longissimus dorsi* was 47.7% and 52.3% in the *M. Semitendinosus* (González, Smulders, Paulsen, Skewes, & Konig, 2004; González et al., 2003).

Of all the *Lama* and *Vicugna* genera, the *Vicugna vicugna* is the smallest of the camelids and no nutritional data could be sourced on its meat. Of all the *Lama* genera, it has the finest and most valuable wool.

A comparison of the proximate composition between the *Camelidae* would seem to indicate that the *Camelus* have slightly less fat than the *Lama* genera (Table 1) – this is attributed to the former having a more localised fat depot (the hump). This higher muscle lipid in the *Lama* causes lower moisture contents in their muscles, although the protein contents are very similar. The higher ash contents of the *Lama* cannot be explained and whether this is due to genera differences or due to differences in analytical techniques warrants further research.

The cholesterol content of the *M. Longissimus thoracis et lumborum* of llama was significantly higher (56.29 mg per 100 g muscle) than that of the alpaca (51.14 mg per 100 g muscle) (Cristofanelli et al., 2004). The very low cholesterol value noted for guanaco (27.2 mg per 100 g meat) by González et al. (2003) could not be explained. Although Polidori, Antonini, Torres, Beghelli, and Renieri (2007b) found differences in the mineral content of the *Longssimus thoracis* between llama and alpaca muscles, no fixed trends were noted.

4. Rodents

There are altogether 5000 species of rodent in the world, and many of them are prized items in the diet for local people. Fiedler (1990) lists 71 rodent genera representing more than 89 species that are consumed by man. Many have the advantage of large litters combined with short gestation periods and early sexual maturity – making them ideal meat producers (Fiedler, 1990). Kyle (1994) quoted the example of the guinea pig (*Cavia porcellus*) which has been the stable meat for the poorest people in the Andes for at least 3000 years and this species produces 20,000 tons of meat (64 million edible carcasses) annually. Gade (1967) discusses the domestication and traditional farming of this species by the native Indians of the Central Andes. Although data exists on the production and marketing of this species (see for example FAO, 1996; Morales, 1994), no data exists on the nutritional value of this species. Similarly, a FAO (1996) lists four rodents (*Hydrochoerus hydrochaeris* – the capybara; *Agouti paca* – the paca; *A. dasyprocta* – the agouti; *Myocastor coypus* – the nutria or coypu) as having production potential in Latin America, limited data seems to be readily available on the nutritional value of most of these species.

Farm raised guinea pigs have a dressing percentage of 65% and the meat contains approximately 21% protein and 8% fat (there was no indication by Nuwanyakpa, Lukefahr, Gudahl, and Ngoupayou (1997) whether this fat included subcutaneous fat or not).

The Capybara may have been domesticated in Brazil as early as A.D. 1565 (Gonzales-Jimenez, 1977) whilst licensed ranches in Venezuela harvest about 85,000 animal every year (Fiedler, 1990). A model for the sustainable harvesting of this species in the wild has been proposed by Federico and Canziani (2005). This is the largest rodent in the world (weighing about 50 kg) and is of the Hystricomorpha suborder. Rodents in this suborder are usually larger, tastier (they are vegetarians), and easier to catch when available (Fiedler, 1990). However, Fielder (1990) notes that all recipes call for the removal of fat, usually by boiling three times and throwing away the fat and water. The traditional way of processing capybara meat (in Columbia and Venezuela) is to salt and dry it. After skinning, all the meat is separated from the carcass in one piece, washed thoroughly and then covered in coarse salt. This meat is then folded and after 12 h, hung out to dry on poles in the sun. Once the product is dry (10–15 d) it is transported to the market (FAO, 1996). Mones and Ojasti (1986) give an in-depth description of the general characteristics, ontogeny and reproduction, ecology and behaviour of this rodent. Girardi et al. (2005) evaluated the proximate composition and fatty acid profile of semi-confined young capybara that were fed grass, other plant leaves as well as a pelletized diet for rabbits. The lipid content varied between the loin (1.8–2.3%) and the ham (3.9–4.7%) whilst the cholesterol content was similar between the two cuts and varied from 45.7 mg to 52.1 mg/100 g wet weight. The full proximate composition of the loin is shown in Table 1 whilst the fatty acid content is displayed in Table 2. The authors refer to other studies on the fatty acid profile of capybara and note that the differences between the various studies can be attributed to slaughter weight and age, and management conditions.

A study by Fukushima, Takayama, Habaguchi, and Nakano (1997) demonstrated that capybara oil lowers the serum total cholesterol and VLDL + IDL + LDL-cholesterol concentrations in the presence of excess cholesterol in the diets of rats (to the same level as sardine oil). It would be worth while to pursue this phenomenon further in humans.

The coypu or nutria is now farmed commercially and is a large (adults weigh 5–9 kg) semi aquatic rodent native to South America but now also present in Europe, Asia and North America. These animals were originally kept for their fur but as the market for this commodity declined, they became pets which frequently escaped and caused extensive damage to the environment. Although the marketing of nutria meat has had various levels of success, Saadoun, Cabrera, and Castellucio (2006) note that fresh, frozen and processed meat products are now appearing on the commercial market in Uruguay. Nutria were found to have a carcass yield of 52% relative to live weight which resulted in a meat yield (obtained when cutting up the eviscerated carcass) as follows: back 25.0%, 2 hind legs 23.7%, 2 front legs 14.7%, a very fleshy belly or "belly flaps" 12.9% and the rest called "small meat", 23.7%. Nutria show sexual dimorphism with the males being heavier than the females (Cabrera, del Puerto, Olivero, Otero, & Saadoun, 2007; Faverin, Mezzadra, Fernandez, & Melucci, 2005). The review by Saadoun and Cabrera (2008) summarise the factors that influence the nutritional content of nutria. The meat from farm reared nutria had a total lipid content between 1.4% and 1.8% in males and females and a total cholesterol content between 70.1 mg and 72.7 mg/100 g wet tissue. Tulley et al. (2000) noted similar low total petroleum ether extractable fat (1.3%) in wild caught nutria – these animals had 22.1% protein but lower cholesterol levels (36 mg/100 g wet tissue) than the farmed nutria as analysed by Saadoun et al. (2006). These differences (as well as those in the fatty acid profiles) are attributed to dietary effects. Cabrera et al. (2007) showed that dietary protein had no effect on growth or proximate carcass composition, although it did have an effect on phospholipid and cholesterol contents.

The fat covering of wild nutria was 4.5% relative to the total weight (Sperber, Leyk, & Gehle, 1982). The fatty acid profile of the meat is shown in Table 2 whilst Saadoun et al. (2006) also give the fatty acid profiles of the adipose tissue and the brain and liver. The meat showed low SFA (37–39%) and elevated levels of PUFA (24–27%) compared to the red meat composition of other domesticated species consumed in Uruguay.

Grasscutters or cane rats (*Thryonomys swinderianus* and *Thryonomys gregorianus*) are widely-distributed and valuable animals in West and Central Africa. Research has been carried out over the past 15 years to select and improve stock in order to improve their adaptability to a restricted life in captivity and to develop rearing programmes in rural and peri-urban areas of Africa (Jori, Mensah, & Adjanohoun, 1995). In West Africa, the number of grasscutters hunted per year is estimated to be 80 million, the equivalent of 300,000 metric tons of meat. Jori et al. (1995) review the production parameters of this species. With a carcass yield of 64% and 22% protein and 4% fat, this species is highly sought after in Africa. Fiedler (1990) evaluated a number of other rodent species that are also consumed in Africa (and elsewhere) although no data on their nutritional value could be sourced.

5. Ratites

The production and marketing of meat from ratites has been successful. Although earlier workers such as Conroy and Gaigher (1982) noted the potential of ostriches for meat production, there were other factors that also contributed to the success of the ostrich meat industry. One of the major factors that helped in the farming of ostriches was the fact that this species had been domesticated for a number of years (already in the 1800s ostriches were being reared for their feathers; Smit & van Zyl., 1963) and the marketing of the meat from this bird came at the right moment – when the EU were looking for other red meat sources that were not contaminated with BSE (Hoffman, 2005). The meat quality of ostriches has been reviewed extensively with the latest being by Hoffman (in press).

Whereas the ostrich has become known for its skin and meat products, the emu have been know mainly for the oil produced from both the retroperitoneal and subcutaneous adipose tissue sites (Yoganathan et al., 2003). The medicinal property of this oil has been reviewed by Sales (2007). Only a few papers have been published that evaluate the meat yield quality of the emu. Sales, Horbañczuk, Dingle, Coleman, and Sensik (1999a) and Sales et al. (1999b) noted that an emu of 41 kg body weight delivers 14.05 kg total meat (34% of body weight). Factors influencing the yield, chemical composition and quality of the different muscles of the emu have been reviewed by Sales (2007). These factors are very similar to those that influence the quality characteristics of meat derived from the other ratites (e.g. nutrition – see Beckerbauer et al., 2001).

The sports nutrition market may offer a specialty niche market to emu producers (Pegg, Amarowicz, & Code, 2006). Creatine (*N*-[aminoiminomethyl]-*N*-methylglycine) has been marketed as a nutritional supplement, catering to the needs of athletes looking for a performance edge. Pegg et al. (2006) evaluated the creatine content in emu meat (29.3 mg/g DM) and found that it was similar to that of beef (30.4 mg/g DM); slightly higher creatine levels were detected, however, in the emu jerky (22.8 mg/g DM) compared to its beef counterpart (21.7 mg/g DM). The authors noted that this demonstrates a potential for the emu meat snack to be considered as a functional food for athletes looking for performance enhancement, and who are interested in consuming greater quantities of creatine from a natural food source. This coupled with its favourable fatty acid profile (Sales, Horbañczuk, Dingle, Coleman, & Sensik, 1999a; Sales et al., 1999b) may enhance its utilisation in a niche market. No data on the creatine content of any of the other ratite species could be sourced.

The Greater rhea (*Rhea Americana*) and the Lesser rhea (*Pterocnemia pennata*) are the other two ratite species whose production have been commercialised. However, of the commercially farmed ratite species, the rhea is the smallest. Very little data exist on the meat quality traits of these species.

6. Reptiles

Reptiles have served as an important source of protein for humans around the world. Of all the reptiles, turtles are the most heavily exploited for human consumption. This coupled with the south east Asian medicinal trade has caused the overexploitation of reptiles, especially turtles and snakes (Klemens & Thorbjarnarson, 1995). Norman (1987) also evaluates the relationship between man and the exploitation (mainly for skin) of Tegu lizards (*Tupinambis merianae*) in Paraguay and notes that it is not on a sustainable basis. The proximate composition, fatty acid composition and cholesterol content of three different cuts of meat from tegu were determined (Caldironi & Manes, 2006). Moisture (72.1%), protein

(23.6%), fat (4.0%) and ash (1.2%) did not differ from values noted for beef or chicken meat. Although the cholesterol content (18.2 mg/100 g tissue) was similar among the cuts it was lower in tegu meat than in any other meats of similar fat content. The ratio of PUFA to SFA was (1.09).

As early as 1995, Revol indicated that because crocodile (*Crocodylus niloticus*) farming provides meat for human consumption and skins for the luxury leather industry this had a positive side effect on the conservation of this species in the wild. She used the successful crocodile ranching in Zimbabwe as her example. South Africa also has a successful crocodile farming industry as does Australia and other countries in Asia (Hoffman, Fisher, & Sales, 2000). Crocodiles are farmed for their skins and the flesh is a secondary product, the skin presents nearly 20% of the live weight of the Nile crocodile, while a dressing percentage of 56.5% is derived. This was lower than the 63.3% derived by Moody, Coreil, and Rutledge (1981) for *Alligator mississippiensis* of similar length. The tail was found to realise 18% and 33% of the live weight and empty carcass weight, respectively. Values of 60.8, 12.2 and 26.6% of carcass weight were obtained for total lean meat, fat and bone, respectively. While the fat content differed statistically from 0.91% in the raw torso samples to 2.94% in raw neck samples, protein content was relatively constant around a mean of 22.1% in raw meat. Moody et al. (1981) noted similar protein contents, but lower fat contents for alligator meat.

Of the total fatty acids present in the tail samples of crocodiles, 37.7% were saturated, 51.1% monounsaturated and 10.7% polyunsaturated. Oleic acid was predominant (43.1%), whilst palmitic acid (25.4%), stearic acid (9.9%) and linoleic acid (9.1%) were also present in high concentrations (Hoffman et al., 2000). Mitchell, Reed, and Houlihan (1995) also found crocodile meat (*C. porosus* and *C. johnstoni*) to contain high levels of oleic (33.1%), palmitic (22.5%) and linoleic (15.2%) acids. These authors also noted high concentrations of the longer-chain polyunsaturated fatty acids, particularly arachidonic acid (3.6%). The differences in lipid composition between the two studies could be attributed to both species differences and variations in diets. In an analysis of fat trimmings from farm-raised alligators (*A. mississippiensis*), Peplow, Balaban, and Leak (1990) noted that diet strongly influenced the lipid fatty acid profile. The alligators fed fish-based diets had greater amounts of fatty acids with chains of C20:1 and longer than the beef-fed alligators. The lipids from the alligators fed fish diets contained 11.1% docosahexaenoic acid (C22:6$n-6$) and 4.0% eicosapentaenoic acid (C20:5$n-3$), while alligators fed beef diets contained negligible amounts of these fatty acids.

7. Conclusion

This review has shown that although the consumption of other alternative species is more common than anticipated, very little data is available on the nutritional value of their meat. This is partly attributable to the fact that most of these species are consumed by poorer people who tend to hunt and consume them locally or market them on the informal (and often illegal) market. Various organisations have however questioned the sustainability of these largely illegal harvesting/hunting practises. It is only where the commercial production/farming of these species has started, that nutritional information is becoming available. With the globalisation of the world, people of different cultures are now readily found in most countries and their need for their own cultural food dishes will only increase resulting in the expansion of the legal (and illegal) trade in these alternative species and their meat. Of the animals mentioned, the rodents seem to have great potential, although it should always be remembered that these animals can just as readily become pests and cause great harm to commercial crops and the environment.

References

Abu-Tarboush, H. M., & Dawood, A. A. (1993). Cholesterol and fat contents of animal adipose tissues. *Food Chemistry, 46*, 89–93.

Apaza, L., Wilkie, D., Byron, E., Huanca, T., Leonard, W., Perez, E., et al. (2002). Meat prices influence the consumption of wildlife by the Tsimane Amerindians of Bolivia. *Oryx, 36*, 382–388.

Babiker, S. A., & Yousif, O. Kh. (1990). Chemical composition and quality of camel meat. *Meat Science, 27*, 283–287.

Barnett, R. (2000). Food for thought: The utilization of wild meat in Eastern and Southern Africa. TRAFFIC East/Southern Africa, Nairobi, Kenya, 263 pp.

Beckerbauer, L. M., Thiel-Cooper, R., Ahn, D. U., Sell, J. L., Parrish, F. C., Jr., & Beitz, D. C. (2001). Influence of two dietary fats on the composition of emu oil and meat. *Poultry Science, 80*, 187–194.

Bodmer, R. E., & Lozano, E. P. (2001). Rural development and sustainable wildlife use in Peru. *Conservation Biology, 15*, 1163–1170.

Brashares, J. S., Arcese, P., Sam, M. K., Coppolillo, P. B., Sinclair, A. R. E., & Balmford, A. (2004). Bushmeat hunting, wildlife declines, and fish supply in West Africa. *Science, 306*, 1180–1183.

Cabrera, M. C., del Puerto, M., Olivero, R., Otero, E., & Saadoun, A. (2007). Growth, yield of carcass and biochemical composition of meat and fat in nutria (*Myocastor coypus*) reared in an intensive production system. *Meat Science, 76*, 366–376.

Caldironi, H. A., & Manes, M. E. (2006). Proximate composition, fatty acids and cholesterol content of meat cuts from tegu lizard *Tupinambis merianae*. *Journal of Food Composition and Analysis, 19*, 711–714.

Coates, W., & Ayerza, R. (2004). Fatty acid composition of llama muscle and internal fat in two Argentinian herds. *Small Ruminant Research, 52*, 231–238.

Conroy, A. M., & Gaigher, I. G. (1982). Venison, aquaculture and ostrich meat production: Action 2003. *South African Journal of Animal Science, 12*, 219–233.

Cooper, J. E. (1995a). Wildlife species for sustainable food production. *Biodiversity and Conservation, 4*, 215–219.

Cooper, M. E. (1995b). Legal and ethical aspects of new wildlife food sources. *Biodiversity and Conservation, 4*, 322–335.

Cordain, L., Watkins, B. A., Florant, G. L., Kelher, M., Rogers, L., & Li, Y. (2002). Fatty acid analysis of wild ruminant tissues: evolutionary implications for reducing diet-related chronic disease. *European Journal of Clinical Nutrition, 56*, 181–191.

Crawford, M. A. (1968). Fatty-acid ratios in free-living and domestic animals. *Lancet, 22*, 1329–1333.

Crawford, M. A., Gale, M. M., Woodford, M. H., & Casped, N. M. (1970). Comparative studies on fatty acid composition of wild and domestic meats. *International Journal of Biochemistry, 1*, 295–305.

Cristofanelli, S., Antonini, M., Torres, D., Polidori, P., & Renieri, C. (2004). Meat and carcass quality from Peruvian llama (*Lama glama*) and alpaca (*Lama pacos*). *Meat Science, 66*, 589–593.

Cristofanelli, S., Antonini, M., Torres, D., Polidori, P., & Renieri, C. (2005). Carcass characteristics of Peruvian llama (*Lama glama*) and alpaca (*Lama pacos*) reared in the Andean highlands. *Small Ruminant Research, 58*, 219–222.

Darling, F. F. (1960). Wildlife husbandry in Africa. *Scientific America, 203*(5), 123–134.

Dawood, A. A., & Alkanhal, M. A. (1995). Nutrient composition of Najdi-camel meat. *Meat Science, 39*, 71–78.

East, T., Kűmpel, N. F., Milner-Gulland, E. J., & Rowcliffe, J. M. (2005). Determinants of urban bushmeat consumption in Río Muni, Equatorial Guinea. *Biological Conservation, 126*, 206–215.

El-Faer, M. Z., Rawdah, T. N., Attar, K. M., & Dawson, M. V. (1991). Mineral and proximate composition of the meat of the one-humped camel (*Camelus dromedaries*). *Food Chemistry, 42*, 139–143.

Elgasim, E. A., & Alkanhal, M. A. (1992). Proximate composition, amino acids and inorganic mineral content of Arabian camel meat: Comparative study. *Food Chemistry, 45*, 1–4.

FAO. (1996). Wildlife utilization in Latin America: current situation and prospects for sustainable management. FAO Conservation guide – 25. Food and Agriculture Organization of the United Nations – FAO Rome. pp. 149–155. http://www.fao.org/docrep/t0750e/t0750e00.htm#Contents.

Faverin, C., Mezzadra, C. A., Fernandez, H. M., & Melucci, M. (2005). Characterization of growth traits of Greenland and Silver coypus under captivity conditions. *Journal of Agricultural Science, 143*, 199–207.

Federico, P., & Canziani, G. A. (2005). Modeling the population dynamics of capybara Hydrochaeris hydrochaeris: A first step towards a management plan. *Ecological Modelling, 186*, 111–121.

Féron, E. M. (1995). New food sources, conservation of biodiversity and sustainable development: Can unconventional animal species contribute to feeding the world? *Biodiversity and Conservation, 4*, 233–240.

Ferreria, A. V., & Hoffman, L. C. (2001). Body and carcass composition of the common duiker. *South African Journal of Wildlife Research, 31*, 63–66.

Fiedler, L. A. (1990). Rodents as a food source. In Proceedings of the Fourteenth Vertebrate Pest Conference. pp. 149–155. http://digitalcommons.unl.edu/vpc14/30.

Fukushima, M., Takayama, Y., Habaguchi, T., & Nakano, M. (1997). Comparative Hypocholesterolemic effects of capybara (*Hidrochoerus hidrachaeris dabbenei*) oil, horse oil, and sardine oil in cholesterol-fed rats. *Lipids, 32*, 391–395.

Gade, D. W. (1967). The Guinea pig in Andean folk culture. *Geographical Review, 52*(2), 213–224.

Girardi, F., Cardozo, R. M., de Souza, V. L. F., de Moraes, G. V., dos Santos, C. R., Visentainer, J. V., et al. (2005). Proximate composition and fatty acid profile of semi confined young capybara (*Hydrochoerus hydrochaeris hydrochaeris* L. 1766) meat. *Journal of Food Composition and Analysis, 18*, 647–654.

Gonzales-Jimenez, E. (1977). The capybara: An indigenous source of meat in tropical America. *World Animal Review (FAO), 21*, 24–30.

González, F., Paulsen, P., Smulders, F. J. M., Skewes, O., Polsterer-Heindl, E., & Konig, H. E. (2003). Exotics for the meat counter. Specialists cutting of traditional joints of guanaco meat. *Fleischwirtschaft, 83*(10), 32–37 (Abstract).

González, F., Smulders, F. J. M., Paulsen, P., Skewes, O., & Konig, H. E. (2004). Anatomical investigations on meat cuts of guanacos (*Lama guanicoe*, Műller, 1776) and chemical composition of selected. *Wiener Tierärztliche Monatsschrift, 91*, 77–84 (Abstract).

Hardouin, J. (1995). Minilivestock: from gathering to controlled production. *Biodiversity and Conservation, 4*, 220–232.

Hardouin, J., Thys, Ě., Joiris, V., & Fielding, D. (2003). Mini-livestock breeding with indigenous species in the tropics. Livestock Research for Rural Development, 15, 4 (Retrieved May 12, 2008) http://www.cipav.org.co/lrrd/lrrd15/4/hard154.htm.

Hill, R. W., & Wyse, G. A. (1989). *Animal Physiology* (2nd ed.). New York: Harper and Row Publishers.

Hoffman, L. C. (2005). A review of the research conducted on ostrich meat. In *Proceedings of the 3rd International Ratite Science Symposium of the World's Poultry Science Association* (pp. 107–119). Spain: Madrid.

Hoffman, L. C. (in press). Value adding and processing of ratite meat: A review. *Australian Journal of Experimental Agriculture, 48.*

Hoffman, L. C., Crafford, K., Muller, N., & Schutte, D.-W. (2003). Perceptions and consumption of game meat by a group of tourists visiting South Africa. *South African Journal of Wildlife Research, 33*, 125–130.

Hoffman, L. C., & Ferreira, A. V. (2000). pH decline of the M. *Longissimus thoracis* of night-cropped Grey Duiker (*Sylvicapra grimmia*). *South African Journal of Animal Science, 30*, 16–17.

Hoffman, L. C., & Ferreira, A. V. (2004). Chemical composition of two muscles of the common duiker (*Sylvicapra grimmia*). *Journal of the Science of Food and Agriculture, 84*, 1541–1544.

Hoffman, L. C., Fisher, P. P., & Sales, J. (2000). Carcass and meat characteristics of the Nile crocodile (*Crocodylus niloticus*). *Journal of the Science of Food and Agriculture, 80*, 1–7.

Hoffman, L. C., Kroucamp, M., & Manley, M. (2007a). Meat quality characteristics of springbok (*Antidorcas marsupialis*). 1. Physical meat attributes as influenced by age, gender and production region. *Meat Science, 76*, 755–761.

Hoffman, L. C., Kroucamp, M., & Manley, M. (2007b). Meat quality characteristics of springbok (*Antidorcas marsupialis*). 2. Chemical composition as influenced by age, gender and production region. *Meat Science, 76*, 762–767.

Hoffman, L. C., Kroucamp, M., & Manley, M. (2007c). Meat quality characteristics of springbok (*Antidorcas marsupialis*). 3. Fatty acid composition as influenced by age, gender and production region. *Meat Science, 76*, 768–773.

Hoffman, L. C., Kroucamp, M., & Manley, M. (2007d). Meat quality characteristics of springbok (*Antidorcas marsupialis*) 4. Sensory meat evaluation as influenced by age, gender and production region. *Meat Science, 76*, 774–778.

Hoffman, L. C., & Wiklund, E. (2006). Game and venison – meat for the modern consumer. *Meat Science, 74*, 197–208.

Jori, F., Mensah, G. A., & Adjanohoun, E. (1995). Grasscutter production: an example of rational exploitation of wildlife. *Biodiversity and Conservation, 4*, 257–265.

Kadim, I. T., Mahgoub, O., Al-Maqbaly, R. S., Annamalai, K., & Al-Ajmi, D. S. (2002). Effects of age on fatty acid composition of the hump and abdomen depot fats of the Arabian camel (*Camelus dromedarius*). *Meat Science, 62*, 245–251.

Kadim, I. T., Mahgoub, O., Al-Marzooqi, W., Al-Zadjali, S., Annamalai, K., & Mansour, M. H. (2006). Effects of age on composition and quality of muscle *Longissimus thoracis* of the Omani Arabian camel (*Camelus dromedarius*). *Meat Science, 73*, 619–625.

Kadim, I. T., Mahgoub, O., & Purchas, R. W. (2008). A review of the growth, and of the carcass and meat quality characteristics of the one-humped camel (*Camel dromedarius*). *Meat Science*. doi:10.1016/j.meatsci.2008.02.010.

Kadwell, M., Fernandez, M., Stanley, H. F., Baldi, R., Wheeler, J. C., Rosadio, R., et al. (2001). Genetic analysis reveals the wild ancestors of the llama and the alpaca. *Proceedings of the Royal Society of London B, 268*, 2575–2584.

Klemens, M. W., & Thorbjarnarson, J. B. (1995). Reptiles as a food source. *Biodiversity and Conservation, 4*, 281–298.

Kurtu, M. Y. (2004). An assessment of the productivity for meat and the carcass yield of camels (*Camelus dromedarius*) and of the consumption of camel meat in the eastern region of Ethiopia. *Tropical Animal Health and Production, 36*, 65–76.

Kyle, R. (1994). New species for meat production. *Journal of Agricultural Science (Cambridge), 1323*, 1–8.

Ledger, H. P. (1963). Animal husbandry research and wildlife in east Africa. *East African Wildlife Journal, 1*, 18–29.

Ledger, H. P., Sachs, R., & Smith, N. S. (1967). Wildlife and food production. *World Review of Animal Production, 3*, 13–36.

MacRae, J., O'Reilly, L., & Morgan, P. (2005). Desirable characteristics of animal products from a human health perspective. *Livestock Production Science, 94*, 95–103.

Mitchell, G. E., Reed, A. W., & Houlihan, D. B. (1995). Composition of crocodile meat (*Crocodylus porosus* and *Crocodylus johnstoni*). *Food Australia, 47*, 221–224.

Mones, A., & Ojasti, J. (1986). *Hydrochoerus hydrochaeris* (264). Mammalian species. pp. 1–7.

Moody, M. W., Coreil, P., & Rutledge, J. (1981). Alligator meat: an evaluation of a new seafood. In *Proceedings 6th Annual Tropical and Subtropical Fisheries Technological Conference of the Americas*, San Antonio, TX, April, pp. 158–160.

Morales, E. (1994). The Guinea pig in the Andean economy: From household animal to market commodity. *Latin American Research Review, 29*(3), 129–142.

Mossman, A. S., & Dassman, R. F. (1962). *Game ranching handbook for southern Rhodesia*. National Museum of Southern Rhodesia. 15 pp.

Mostert, R., & Hoffman, L. C. (2007). Effect of gender on the meat quality characteristics and chemical composition of kudu (*Tragelaphus strepsiceros*), an African antelope species. *Food Chemistry, 104*, 565–570.

Norman, D. R. (1987). Man and tegu lizards in Eastern Paraguay. *Biological Conservation, 41*, 39–56.

Nuwanyakpa, M., Lukefahr, S. D., Gudahl, D., & Ngoupayou, J. D. (1997). The current stage and future prospects of guinea pig production under smallholder conditions in West Africa; 1. Global overview. Livestock Research for Rural Development, 9 (5) http://www.cipav.org.co/lrrd/lrrd9/5/gp951.htm.

Pegg, R. B., Amarowicz, R., & Code, W. E. (2006). Nutritional characteristics of emu (*Dromaius novaehollandiae*) meat and its value-added products. *Food Chemistry, 97*, 193–202.

Peplow, A., Balaban, M., & Leak, F. (1990). Lipid composition of fat trimmings from farm raised alligator. *Aquaculture, 91*, 339–348.

Pérez, P., Maino, M., Guzmán, R., Vaquero, A., Köbrich, C., & Pokniak, J. (2000). Carcass characteristics of llamas (*Lama glama*) reared in central Chile. *Small Ruminant Research, 37*, 93–97.

Polidori, P., Antonini, M., Torres, D., Beghelli, D., & Renieri, C. (2007b). Tenderness evaluation and mineral levels of llama (*Lama glama*) and alpaca (*Lama pacos*) meat. *Meat Science, 77*, 599–601.

Polidori, P., Renieri, C., Antonini, M., Passamonti, P., & Pucciarelli, F. (2007a). Meat fatty acid composition of llama (*Lama glama*) reared in the Andean highlands. *Meat Science, 75*, 356–358.

Rawdah, T. N., El-Faer, M. Z., & Koreish, S. A. (1994). Fatty acid composition of the meat and fat of the one-humped camel (*Camelus dromedarius*). *Meat Science, 37*, 149–155.

Revol, B. (1995). Crocodile farming and conservation, the example of Zimbabwe. *Biodiversity and Conservation, 4*, 299–305.

Saadoun, A., & Cabrera, M. C. (2008). A review of the nutritional content and technological parameters of indigenous sources of meat in South America. *Meat Science*. doi:10.1016/j.meatsci.2008.03.027.

Saadoun, A., Cabrera, M. C., & Castellucio, P. (2006). Fatty acids, cholesterol and protein content of nutria (*Myocastor coypus*) meat from an intensive production system in Uruguay. *Meat Science, 72*, 778–784.

Sales, J. (1995). Nutritional quality of meat from some alternative species. *World Review of Animal Production, 30*, 48–56.

Sales, J. (2007). The emu (*Dromaius novaehollandiae*): A review of its biology and commercial products. *Avian and Poultry Biology Reviews, 18*, 1–20.

Sales, J., Horbañczuk, J., Dingle, J., Coleman, R., & Sensik, S. (1999a). Carcase characteristics of emus (*Dromaius novaehollandiae*). *British Poultry Science, 40*, 145–147.

Sales, J., Navarro, J. L., Martella, M. B., Lizurume, M. E., Manero, A., Bellis, L., & Garcia, P. T. (1999b). Cholesterol content and fatty acid composition of rhea meat. *Meat Science, 53*, 73–75.

Smit, D. J., & van Zyl. (1963). Ostrich farming in the Little Karoo. Department of Agriculture Technical Services. Bulletin No. 358. pp. 1–102. Pretoria, South Africa.

Sperber, E., Leyk, W., & Gehle, E. (1982). Composition and organoleptic characters of nutria meat (*Myocastor coypus*). *Fleishwirtschaft, 62*, 1329–1331.

Tulley, R. T., Malekian, F. M., Rood, J. C., Lamb, M. B., Champagne, C. M., Redmann, Jr. S. M., et al. (2000). Analysis of the nutritional content of *Myocastor coypus*. *Journal of Food Composition and Analysis, 13*, 117–125.

Vilela, A., Bolkovic, M. L., Carmanchahi, P., Cony, M., de Lamo, D., & Wassner, D. (in press). Past, present and potential uses of native flora and wildlife of the Monte Desert. Journal of Arid Environments. doi: 10.1016/j.jaridenv.2007.10.013.

Wilkie, D. S., & Godoy, R. A. (2001). Income and price elasticities of bushmeat demand in lowland Amerindian societies. *Conservation Biology, 15*, 761–769.

Wilkie, D. S., Starkey, M., Abernethy, K., Nstama, E. E., Telfer, P., & Godoy, R. (2005). Roles of prices and wealth in consumer demand for bushmeat in Gabon, Central Africa. *Conservation Biology, 19*, 268–274.

Wood, J. D., Enser, M., Fisher, A. V., Nute, G. R., Sheard, P. R., Richardson, R. I., et al. (2008). Fat deposition, fatty acid composition and meat quality: A review. *Meat Science, 78*, 343–358.

Yoganathan, S., Nicolosi, R., Wilson, T., Handelman, G., Scollin, P., Tao, R., et al. (2003). Antagonism of croton oil inflammation by topical emu oil in CD-1 mice. *Lipids, 38*, 603–607.

Yousif, O. Kh., & Babiker, S. A. (1989). The desert camel as a meat animal. *Meat Science, 26*, 245–254.