MEAT QUALITY OF SOUTH AFRICAN INDIGENOUS GOAT AND SHEEP BREEDS

by

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Dedicated to:

Lerie, Zwelie and Khanyi, my children,

- who taught me there are other things to life than crying

and to Mandla, my husband,

- who had the patience and gave me the strength

My mother and late father and the spirit of open mindedness

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- To my mother and late father for teaching me that the only way out is to be focused and finish whatever you start.

- To Sindi my husband's niece: all the small things you have done for us will one day grow and become inmeasurably big.

ABSTRACT

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In South Africa there are different meat preferences. The palatability of goat meat is regarded inferior to that of mutton and lamb particularly by white South Africans. Two breeds of goats, Indigenous(n=12) and Boer goats (n=12), and two breeds of sheep Damara (n=12) and Dorper (n=12), were used in this study. Indigenous goats were sourced from Victoria West, in the Northern Province, Damara sheep from Bethuli in the Free State, Boer goats and Dorper sheep from the Colesberg district in the Northern Cape Province. All the animals used in this study were young castrated males with no permanent incisors. The animals were slaughtered, processed into wholesale cuts and subcutaneous fat, meat and bone per cut were determined by means of dissection. Proximate and fatty acid analyses were done on the soft tissues of the carcasses (muscle + fat). A trained panel evaluated sensory quality characteristics of patties manufactured from meat and subcutaneous fat, sampled from the whole carcass.

Abstract

Goats had proportionally larger feet, spleen and liver compared to sheep and therefore, dressed-off lower than sheep. Sheep breeds contained significantly more subcutaneous fat than goat breeds. The fore limb, ventral trunk and dorsal trunk of goat breeds were proportionally heavier than those of sheep breeds while sheep breeds had proportionally heavier hind legs. The proportional lean content per cut of Boer goats was comparable to that of sheep breeds. The percentage carcass bone content was highest in Indigenous goat carcasses.

The aroma intensity of Boer goat patties was significantly more intense compared to that of Indigenous goat patties and Dorper and Damara sheep patties. The flavour intensity of sheep patties was stronger than that of goat patties. Boer goat patties were significantly more flavoursome than Indigenous goat patties. Sheep meat patties were more tender, juicy and greasy than goat meat patties as a result of differences in fat content. Indigenous goat meat patties were more chewy and less tender and juicy than those of Boer goats.

Both goat and sheep meat contained higher molar percentages of saturated than polyunsaturated fatty acid. Oleic acid was the most abundant fatty acid and its concentrations were highest in Damara sheep meat.

The fatness of carcasses was influenced by species, breed and diet, which in turn affected the carcass composition and eating qualities. Sheep carcasses contain more subcutaneous fat and less bone than goat carcasses. Sheep meat is more juicy and more flavoursome than goat meat. The high levels of fat in sheep meat mask the non-meat flavours that are often found in lean meat.

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1 INTRODUCTION

Small ruminants (goats and sheep) are an integral part of small-holder farming systems. These animals have an important contribution to make to sustainable development (Devendra, 1994). Small ruminants are concentrated mainly in rainy, arid or humid regions, often on marginal land. Goats and sheep make a significant contribution to the total farm income, the stability of farming systems and human nutrition; directly benefiting the poorest people. They provide the main, if not only, means of livelihood in marginal areas, combining economic and food security, nutrition and a means of survival (Devendra, 1994).

Although the primary purpose of sheep and goat is meat production for local consumption, the animals are also a source of emergency income. Production systems are generally characterised as small-scale because they are easy to manage and require low-input, and few breeding or production records are kept (Vokaty & Torres 1997). According to Vokaty & Torres (1997), the small-ruminant industry has the following competitive advantages:

- There is an increasing demand for goat meat and sheep meat.
- The small-ruminant-industry requires only a small initial investment and the risk of loss is small.
- Goats and sheep can easily be integrated with other crop-based farming systems.
- Small ruminants have the ability to utilise cellulosic feed materials and to survive in marginal environments. According to Smith, Carpenter & Shelton (1978), goats exist largely because of their ability to effectively graze very poor quantity rangelands and yet, yield acceptable quantities of edible meat.
- Goats and sheep have short gestation periods that allow meat and milk production in relatively short periods. Goats and sheep are efficient meat producers and some goat breeds produce mainly twins and some breeds kid more frequently than once per year (Smith *et al.*, 1978).

However, disadvantages in the small-ruminant industry include a lack of breeder stock, high mortality rate at pre-weaning stage, limited market outlets for goat meat and inadequate credit facilities, economic incentives, and other support services (Vokaty & Torres, 1997).

Goats are part of Africa. Throughout the continent, but particularly in extensive savannah and subtropical areas, the people of Africa live in close association with their goats (Casey & Naudé, 1992). In many developing countries, goats and sheep are traditionally owned by small farmers, peasants and landless agricultural labourers to whom the ownership of these animals have significant nutritional and socio-economic advantages (Devendra, 1988). In comparison with other domestic animals, goats are often victims of prejudice and neglect, but have nevertheless fulfilled a most useful task of providing commodities namely, meat, milk, skin and hair (Devendra & Burns, 1970).

In less developed countries, there is a constant demand for food essential for energy and protein supply. Increased crop yields provide sufficient energy, but do little to relieve protein deficiencies especially for low-income groups. Sheep and goats are the most neglected of the farm animals with value to humans in the less developed countries, particularly for the most vulnerable groups pregnant and nursing mothers and the young. Both these species (goats and sheep) provide a small but consistent supply of animal proteins of biological value in the form of meat and milk, plus essential minerals and fat-borne vitamins (Devendra, 1988).

Sheep and goats possess important economic characteristics, which are reflected in aspects relating to asset reserves, provision of cash for schooling and special and unanticipated occasions, and forms of exchange and sharing of animals to help provide income opportunities for land-less or land-scarce producers (World Bank, 1983).

The aim of this project was to characterise the effects of species and breed on the carcass composition and sensory qualities of meat from some indigenous ruminants in South Africa.

1.1 Problem statement

There is little scientific information available about goat meat, yet it can become an important source of good quality animal protein in the future. The majority of goat farmers have small-herds, limited resources and little education. In South Africa, goats are an under-utilised resource that can be improved to uplift the livelihood of rural inhabitants through increased utilisation of goats and value addition to several goat products (Smuts, 1997). Increasing the acceptability of goat meat and improving the poor supply of goats through organised farming will make goat farming commercially viable. There is scope for grooming entrepreneurs for commercial goat farming (Ojha & Yadav, 1995). According to Casey (1982), African people traditionally kept sheep for their food and skin value. Today, Africans sell their stock either to speculators or through the co-operatives which have been established to upgrade the rural peoples' agricultural practices from subsistence levels to viable enterprise.

1 INTRODUCTION

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2 OBJECTIVES

- To determine the effects of breed and species on meat: fat: bone content and chemical composition of Indigenous and Boer goats, and Damara and Dorper sheep.
- To determine the effects of breed and species on sensory characteristics of Indigenous and Boer goats, and Damara and Dorper sheep meat.
- To determine the effects of breed and species on fatty acid profile of Indigenous and Boer goats, and Damara and Dorper sheep meat.

3 LITERATURE REVIEW

3.1 Introduction

Africa is mainly a cattle continent, although, in Southern Africa, indigenous goats have been found for more than 1500 years, preceding cattle and probably following sheep (Snijders, 1998). Sheep and goats are small in size, ranging in mature weight from 15 to 75 kg (World Bank, 1983). They have lower per-head nutrient requirements which means that sheep and goats may fit the limited resources of small farms or marginal grazing lands which cannot sustain larger ruminants throughout the production cycle. The small size is associated with small yields of meat per head slaughtered, and small amounts of milk per lactating female. These small quantities are often well suited to the daily needs of subsistence families with limited ability to preserve extra surplus. In rural areas, indigenous goats and sheep are better adapted to the harsh conditions of the African continent than cattle (Smuts, 1998).

Devendra (1988); Babiker, El-Khider & Shafie (1990) demonstrated that the highest indigenous production of goat carcasses is in Africa, where 94 % of the world goat population occurs. Africa also exhibits the highest per capita goat supply (Table 1). Indigenous goats and sheep are used as investments, as insurance against the failure of crops, for the purposes of ownership, for slaughter during festive occasions and as a supply of manure for fertiliser. Goats and sheep also supply horns, hooves and skins (Smuts, 1998)

Table 1: The percentage of the indigenous production of carcass meat accounted for by goat and *per capita* goat meat consumption in 1984 throughout the world (Devendra, 1988)

Region	% of Indigenous goat production	Per capita goat meat supply (kg/year)
Africa	94	1.13
North America	0.1	0.08
South America	0.6	0.24
Asia	3.9	0.44

3.2 Cultural uses of sheep and goats in rural areas

Mahanjana (1998) showed that in South Africa in the Eastern Cape, goats are associated with traditional issues. Some people will keep a goatskin in the house so that when they have bad luck, they can sleep on the skin where they believe they can dream and speak to their forefathers. Goats are generally used during the initiation process. In the Ndebele culture, a goat is slaughtered to inform the ancestors that a family member is going to the mountains for initiation and the ancestors are asked to look after him.

Religion and tribal customs play an important part in the preferences given to a particular hide color and generally, attention is first given to the color of the animal before other factors such as milk production or conformation are taken into account (Hugo, 1968). In some production systems in rural areas, sheep and goat owners also rent out breeding stock to neighbours and jointly share the offspring. This system reduces disease risks associated with high animal populations, and creates social bonds. Lending of sheep and goats provides a mechanism for poor farmers to acquire initial breeding stock which can be used to build their own flocks (World Bank, 1983).

3.3 Consumption patterns of indigenous goat and sheep meat

Traditional farmers keep goats and do not use them in a way that is linked to the economy of their countries. The majority of South African goat population is found in the developing agricultural sector. The Eastern Cape, Northern Province, KwaZulu-Natal and North-West Provinces are the most important goat producing areas, managing nearly 86 % of the total goat population (Table 2). However, KwaZulu-Natal was reported by USAID/South Africa (1998), as the major consumer region of live goats, marketing approximately 10 to 12 thousand goats per month. The main buyers of goats are blacks. It is estimated that 80 % of goats traded in KwaZulu-Natal are consumed by blacks and the rest by Indians and other consumers.

Table 2: Estimated livestock numbers in the provinces of South Africa (The National Department of Agriculture, 1999)

Province	Cattle	Sheep	Goats	Pigs
Gauteng	262	87	14	192
Northern Province	1237	202	949	161
Mpumalanga	1490	1830	87	192
Kwazulu-Natal	3136	965	884	224
Free State	2312	5758	77	163
Eastern Cape	3105	8185	3264	282
Western Cape	492	3114	257	225
Northern Cape	503	7221	77	163
North West	1844	804	794	212

"Numbers are in thousands

For little investment, goats provide an easy source of meat and milk to rural people who cannot afford to buy these products, or, are unable to sustain cattle and buffalo farming. Frequently, sheep and goats are butchered and consumed in the villages and the meat never formally enters the marketing chain. Unfortunately, the demand for goat meat has encouraged increased slaughter of breeding animals with a consequent erosion of the base population in qualitative and quantitative terms (Devendra, 1988).

Although the consumption of goat meat is higher in Africa than elsewhere (Table 1), Narasimha (1995) showed that in the African context, the low apparent formal utilization of sheep and goat meat could be attributed to the fact that most traditional slaughterhouses lack basic facilities like water, light, ventilation, drainage, flooring, overhead rails and waste disposal. Consequently, traditional slaughter practices are followed without proper ethics and sanitational concerns for the animals being slaughtered. Carcasses are exposed to heavy contamination due to slaughtering of animals on the open ground. Inadequate ante and post-mortem inspection further aggravates the situation, resulting in meat of poor quality. Problems responsible for the above situations are illiteracy, religious taboos, low priority sector and negative attitude of local bodies. In general, prices for agricultural products are low and this impacts on general rural purchasing power, which limits the ability of farm families to purchase sheep and goats or their products and also limits their ability to invest in and improve sheep and goat production (World Bank, 1983).

In South Africa, marked differences exist in the meat preferences of the different population In many developing countries, goat meat is relished and sought after although sheep and goat meat is perceived as low quality meat. Meat quality according to Wood, Enser, Fisher, Nute, Richardson & Sheard (1999), is the attractiveness of meat to consumer. According to Naudé & Hofmeyr cited by Gall (1981), evaluation of the cutting and processing of meat is strongly influenced by local customs and preferences. groups. Goat meat does not enjoy a high status among whites because, in the past, goats were marketed as full tooth adults yielding tough meat (Van Tonder, 1980).

Compared to sheep and cattle, knowledge of yield and quality of goat meat is limited due to the traditionally low economic significance of goats in developed countries. Generally, consumption of goat meat is limited to certain groups in speciality dishes centred around festival or holiday events. In South Africa, meat from young Boer goat kids is sold as an alternative to lamb whereas, meat from mature goats is specifically sought after by the local Indian community which prefers it to beef and lamb.

According to Schönfeldt, Naudé, Bok, van Heerden & Smit (1993), the consumption of lamb and mutton is relatively low in America and Europe where consumers prefer beef or pork. Three types of goat meat are consumed:

- Meat from kids (8-12 weeks)
- Meat from young goats (2-6 years) and,
- Meat from old goats (6+ years).

Young goat meat is the most common type consumed. In terms of quality, the best young goat meat is produced at live weight range of 11-12 kg depending on breed and environment (Devendra, 1988).

The live goat market is characterised by peak demand periods. This is because Indians slaughter white goats with long ears at their religious festivals and consequently the prices of goat meat rise dramatically each year at Christmas, Easter and Ramadan (Pinkerton, Harwell, Drinkwater & Escobar, 1994). The demand for sheep and goat meat is affected by seasonal factors. The consumption of small ruminants increases at the end of the dry season when cattle are scarce and producers are reluctant to sell their available cattle. As a result, prices fluctuate over the year and in most countries, including South Africa, holiday prices for live animals are double the normal price.

Due to factors such as rural-urban migration and increases in income, the demand for sheep and goat meat is increasing in urban areas (Harwell & Pinkerton, s.a). Harwell & Pinkerton (s.a) showed that in America, increases in demand of goat meat will come with increase in ethnic populations and improvements in purchasing power. Rural migrants often prefer the consumption of these meats. In America, like in South Africa, the economic status of immigrants continue to improve. This creates a market opportunity for small-scale goat producers who could supply goat meat and goat meat products to the commercial retail markets in urban areas.

3.4 Small-ruminants in South Africa

South African goats are of four distinct types, namely; Angora goats, Boer goats, Milch goats and Indigenous goats. The Boer goat and Indigenous goats are regarded as the most important types in terms of numbers and contribution towards the economy of the agricultural sector in South Africa (USAID/South Africa, 1998). In terms of lean meat produced per unit of input, goats cannot compete with other meat producing species on grasslands, improved pastures or on concentrate feeds. However, on native ranges with substantial quantities of palatable browse, goats have a competitive advantage and are most efficient in the conversion of browse to muscle protein (Machen, s.a).

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3.4.1 Indigenous goats

Indigenous goats have various origins and vary widely in colour, size and length of hair (Figure 1). They are browsers and their browsing habit enables stock farmers to increase their meat yield from the same area of land by combining goats with grazing cattle or sheep depending on the nature of the vegetation cover. In South Africa, indigenous goats are classified into four classes namely, Ordinary Boer goats, Long-haired goats, Polled Boer goats and Native goats. The native goats are mainly found with black farmers in the developing agricultural sector of South Africa. These goats are mostly weak in conformation and vary in colour according to choice of the tribe (USAID/South Africa, 1998).

Figure 1: A group of typical South African Indigenous goats exhibiting different colours

3.4.2 Boer goats

Boer goats originated by means of a selection process from various existing indigenous goat breeds in Southern Africa and European stock and therefore bears some resemblance to Indigenous goats (Casey & Van Niekerk, 1988). The most commonly kept goat in rural areas is the unimproved "Boer" goat that is lean, long-legged and has a variety of coat colours. In rural areas, the local unselected Boer goats are milked for home consumption (Casey & Van Niekerk, 1988).

According to USAID/South Africa (1998), the selection process was initiated in the Eastern Cape. The Boer goats are therefore an improved breed characterised by good conformation, fast growing kids, high fertility averaging 98 % of does bred under good management and nutrition, and uniformity with regard to colour and type and adaptability (Campbell, 1984). This breed has short hair with red markings around the head and shoulders (Figure 2). The breed is primarily for meat production. Boer goat meat is reported to be superior to that produced by Botswana goats and sheep (Casey & Van Niekerk, 1988).

In general, the Boer goat is regarded as very adaptable, thriving in all climatic regions of Southern Africa, including the Mediterranean climate, the tropical bush and the semi-desert regions of the Karoo and greater Kalahari (Casey & Van Niekerk, 1988). Boer goats are more adapted to hot than cold environments because of their small size, large surface area to body weight ratio, ability to conserve water, limited subcutaneous fat and the particular nature of their coats (Casey & Van Niekerk, 1988). Since Boer goats are browsers, they have been used successfully to control bush encroachment. Boer goats browse leaves but also debark stems and branches of particularly small plants. Boer goats utilise tropical and scrub pastures more efficiently than cattle and they exploit available feed resources selectively and hence can survive under harsh tropical and semi-arid conditions (Van Soet according to Casey & Van Niekerk, 1988).

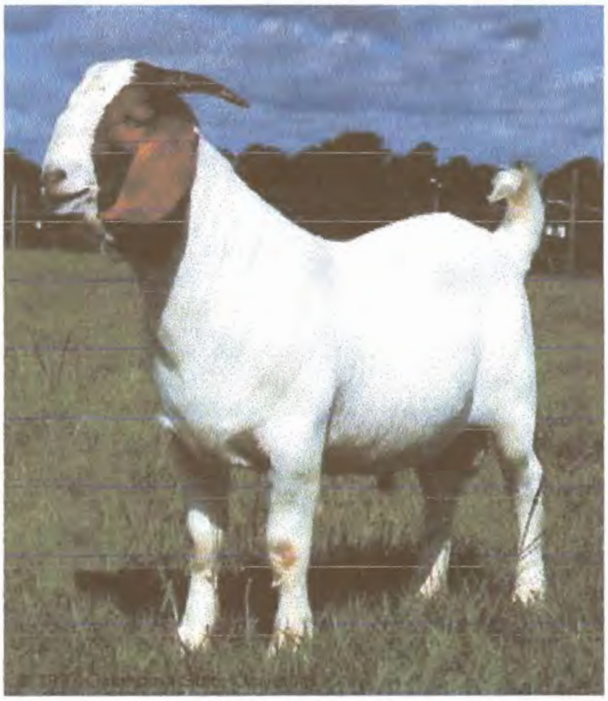


Figure 2: Example of a Boer goat

3.4.3 Damara sheep

Damara sheep originated from the Hamites of Eastern-Asia and Egypt and moved down to Namibia and Angola. The name Damara sheep was derived from the specific region where the sheep were originally encountered in South West Africa (Namibia) (then known as Gross Damaraland). Damara sheep have typical characteristics of a desert breed, namely long legs, fat tail, short hair and a respiratory conformation (Figure 3). According to Casey (1982), the fat-tailed sheep breeds are indigenous to Africa. This breed is a predominately horned sheep with rams having well developed spiral horns standing well away from the head. The ewes appear feminine, whereas the rams are more robust and masculine. Damara sheep produce an excellent carcass. Most of the fat is concentrated in the fat tail which, when well developed, makes up less than 10 % of the carcass. If the tail is removed, there is little fat left (Girtten, 1999).

Damara sheep have a high fertility rate, strong maternal instincts, and can grow well under unfavourable conditions. The strong maternal instincts have led to a rare occurrence of orphaned lambs even when ewes with small lambs are transported over long distances, it is uncommon to end up with a single orphaned lamb. Twin births do occur in 5 to 10 % of the births and mothers are capable of rearing them by producing enough milk and fighting off predators when attacked (Damara Breeders' Society 1993).

Damara sheep can survive in a harsh environment and under poor nutritional conditions. The breed is exceptionally vigorous and can produce and reproduce where water and grazing is fairly restricted. Damara sheep have high resistance to most sheep diseases and have good tolerance against internal parasites. The Damara survive on a diverse diet. They feed on grass, bush and shrubs and can almost be classified as browsers which places them in the same feeding category as goats (Damara Breeders' Society 1993).

Figure 3: Example of Damara sheep (Oklahoma State University, 1999)

3.4.4 Dorper sheep

For many years, indigenous sheep breeds (such as the Namaqua-Africaner) as well as the imported fat-rumped Blackheaded Persian, played an important role in lamb production in South Africa. These breeds have slow growth rates and poor mutton characteristics, but they are well adapted to the semi-desert extensive sheep production systems in South Africa. In general, indigenous breeds have a poor performance. In South Africa, performance of the indigenous breeds has been improved by replacing them with "improved" synthetic breeds such as the Dorper breed (Schoeman & Burger, 1992). Dorper sheep is a South African mutton breed developed in the 1930's from the Dorset Horn and Blackheaded Persian. The Dorper sheep became the second most important breed to Merino in South Africa (Schoeman & Burger, 1992). There are black headed and white headed Dorpers with the blackheaded ones constituting about 85 % of the Dorper Sheep Breeder's Society in South Africa (Du Plooy, 1997). Dorpers are hornless (Figure 4). They have a long breeding season that is not limited by season.

The Dorper lamb grows rapidly and attains a high weaning weight that is an economically important characteristic in breeding of mutton sheep. The Dorper lamb can reach a live weight of about 36 kg at the age of 3-4 months. This ensures a high quality carcass of approximately 16 kg (Du Plooy, 1997). Dorper sheep are well adapted to a variety of climatic conditions. Originally, the breed was developed for the more arid areas of South Africa but, today are widely spread throughout all the provinces. The Dorper is hardy and can thrive under a range of conditions where other breeds can barely exist and the ewe can raise a lamb of reasonable quality under fairly severe conditions. As a strong and non-selective grazer the Dorper can advantageously be incorporated into a well-planned range management system (Du Plooy, 1997). According to Du Plooy (1997), the skin of Dorper sheep is the most sought after in the world. The skin comprises a high percentage of the income (20 %) of total carcass value.

Provided by Mr P J Cilliers

Figure : Example of Dorper sheep (Oklahoma State University, 1999)

3.5 Factors affecting carcass composition

Carcass composition refers to the muscle: bone: fat ratio of the carcass. In meat production systems, the aim is to produce carcasses with the maximum amount of muscle, minimum amount of bone and the optimal amount of fat. The left and right sides of the carcass are regarded as identical, therefore, the right side is normally used to assess the carcass composition. The carcass composition is important to the consumer because it largely determines the economic worth of the carcass.

The economic value of a carcass depends upon its yield of saleable meat as well as the cutting and processing quality of the meat. Fat is the most variable tissue of the carcass. It varies in total amount and its partitioning among various depots changes markedly throughout growth. Excess fat reduces the percentage of saleable meat (Berge & Butterfield, 1976). According to Lawrie (1985), the composition and quality of meat can be influenced by both intrinsic (age, breed, sex-type, species and anatomical location) and extrinsic factors (diet, fatigue, stress, fear, pre-slaughter manipulation and environmental conditions at slaughter). In this literature review only the intrinsic factors shall be considered.

3.5.1 Age

In general, the lean: bone ratio increases with ruminant maturity. For example, the body composition of goats changes markedly during growth. According to Warmington & Kirton (1990), in female West African dwarf goats, the proportion of body muscle increased from 32 % to 46 %, and bone decreased from 30 % to 17 % from birth until 13 kg body weight.

3.5.2 Breed

Berge & Butterfield (1976) reported that breed is important in attempting to meet the requirements of desirable carcass composition. Breed exerts the most influence on items such as yield of cuts, lean to fat ratio, intramuscular fat distribution or marbling, firmness of fat, and colour, tenderness and juiciness of cooked meat (Schönfeldt, 1989). Some breeds begin to fatten at lighter-weights and others at heavier weights. Breeds differ in the rate at which fat is deposited during the fattening stages.

In the study carried out by Naudé & Hofmeyr cited in Gall (1981), it was reported that Boer goats have a high muscle and low bone content, resulting in a high mean muscle to bone ratio 4.71:1. More muscle mass translates into greater body weight ta a given age and heavier muscling may also provide opportunities for implementation of different carcass fabrications and diversification of the size and type of goat products offered to the retail consumer (Machen, s.a.). Gaili (1979) showed that desert sheep deposited fat at a slower rate than Dorset horn and Hampshire sheep.

3.5.3 Sex-type

Sex-type influences growth of body tissues and hence affects carcass composition and distribution of weight within the tissues (Berge & Butterfield, 1976). The sex-type influence on carcass is achieved through the fattening process. Differences in fatness between different sexes are manifested by the time of onset of the fattening process and the rate of fattening. Sex-type has a marked influence on the fatness of the meat, with entire males being leaner than castrated males which are, in turn, leaner than females (Watson, 1994). Castration has a highly significant effect on the lean and fat percentages in goat meat cuts although its effects on bone percentage are non-significant.

The entire male animals have more lean meat but less fat than castrates because castrates have the greater ability to lay on fat (El-Bayomi & El-Sheikh, 1989). The removal of sex organs leads to a reduction in the oxidizing process and therefore, increases the assimilation of fat in castrates (Kansal, Manchada & Krishnan, 1982). Castration of goats is a favourable procedure for improving the quality of goat meat (Hammond, Browman & Robinson, 1983). The meat of castrates has only eligible degrees of specific goat smell and the meat flavour is good.

The relatively greater proportion of lean in the meat of entire males is a favourable characteristic and may be attributed to the anabolic effect of testicular hormones, which leads to greater muscular development. Entire males become active and fertile from the age of five months, and expend growth energy on sexual activities (Skea, 1972). There is a high degree of fat in castrates (Table 3) which, agrees with the significantly greater fat content in the meat.

The relatively lower moisture content in castrates is correlated with a higher fat content. These factors are important because fat, moisture, nitrogen and collagen are components of texture and appearance of meat (Dransfield, Casey, Boccard, Touraille, Buchter, Hood, Joseph, Schon, Casteels, Casetino & Tinbergen, 1983). The thinner muscle fiber in castrates could be an indication of better tenderness which is considered an important factor in the evaluation of meat quality.

Table 3: The proximate composition of entire and castrated male goats (El-Bayomi & El-Sheikh, 1989)

Variable	Entire males goats	Castrated male goats
Moisture content (%)	60.90	56.66
Ether extractable fat (%)	19.04	24.17
Crude protein (%)	18.49	20.3-22.2

Colomer-Rocher & Kirton (1989) showed that as carcass weight increased, there was a noticeable decline in carcass muscle of 0.6 % and 10.3 % in male and female Saanen goats respectively. The decline in muscle content for female carcasses reflected an increase in carcass fat from 10.6 to 33.7 % while in males fat increased from 11.7 % to 15.5 %. As the carcass fat increased, there was a decline in carcass bone from 24.7 % to 14 % for females and 23.4 % to 20.4 % for males.

According to Hogg, mercer, Kirton & Duganzich (1992), in New Zealand, commercial castrated males contained more lean than females, while females contained more dissectable carcass fat as illustrated in Table 4. Fat distribution between joints varied between sexes, with female goats having more of their fat in the mid-part of the carcass, while castrates had more of their total fat in the legs.

Table 4: Percentage of dissected fat, lean, bone and waist in goat carcasses of castrated males and females at 15.8 kg hot carcass weight (Hogg *et al.* 1992)

Component	Castrates	Females
Fat %	11.22	14.44
Lean %	66.72	64.40
Bone %	19.96	19.07
Waste %	0.88	0.71

3.5.4 Species

Gaili (1978) reported that animal species affected the skin %, tail %, liver % and loin cuts. At 30 kg empty body-weight, goats yielded heavier carcasses, omentum and head but, lighter skin, tail and feet than sheep. At 15 kg carcass weight, goats possessed less meat in the leg and plate cuts, but more meat in the loin and shoulder cuts. Casey & Naudé (1992) reported that the total body fat content of Boer goat kids was greater when compared with that of South African mutton Merino and Dorper at the same slaughter weights.

However, the main depot for fat in goats is in the abdomen (Table 5). Consequently, Boer goats have a very low content of subcutaneous fat at 6.4 % as compared to 11.5 % for the Dorper. Fat, be it in the body or tail, requires more energy to produce than does lean tissue (Bicer, Pekel & Güney, 1992). Goat carcasses are usually thinner and less compact than other meat animals, but also have more bone than lamb carcasses (Mowlem, 1988). Naudé & Hofmeyer cited in Gall (1981) reported that this thin fat cover and the lanky appearance of Boer goat carcasses result in a poorer commercial value in comparison to lamb carcasses at similar weight. Table 6 demonstrates that goats generally have less subcutaneous fat and sheep less visceral fat.

Table 5: Location of separable fat in goats and lamb (%) (World Bank 1983)

Species	Subcutaneous fat (%)	Intermuscular fat (%)	Cavity[a] fat (%)	Visceral fat (%)
Goats	14	40	15	30
Lambs	30	45	11	15

[a]Kidney, pelvic and heart fat

Table 6: A comparison of lamb and kid carcasses (Mowlem, 1988)

Carcasses	Muscle (%)	Bone (%)	Subcutaneous fat (%)	Intermuscular fat (%)	Kidney fat (%)
21 kg lamb	55	12	16	17	4.1
20 kg kid (Dairy breed)	55.9	15.4	6.7	14.3	8.1
20.5 kg kid (Angora)	56	14.6	12.5	17.0	4.6

3.6 Palatability characteristics of goat and sheep meat

Food quality evaluation may be done by using chemical, physical and sensory methods. However, only sensory methods can determine food preferences and whether or not a certain food is acceptable (palatable) to the specific group tested. Chemical and physical methods are usually applied in conjunction with sensory methods to elucidate sensory scores (Paul & Palmer, 1972). Consumers tend to evaluate meat quality on the basis of tenderness, juiciness and the flavour of cooked meat.

3.6.1 Tenderness of meat

3.6.1.1 Factors that affect meat tenderness

Tenderness of meat appears to be the most important sensory characteristic of meat quality, and a predominant quality determinant (Sanúdo, Santolaria, María, Osorio & Sierra, 1996), which is influenced among others by age of animal prior to slaughter (Bruwer, Grobler, Smit & Naudé, 1987). The overall impression of tenderness to the palate includes texture and involves three aspects namely, the initial ease of penetration of the meat by the teeth, the ease with which the meat breaks into fragments and the amount of residue remaining after chewing (Weir, according to Lawrie, 1985). The more tender the meat, the more rapidly juices are released by chewing, and the less residues remain in the mouth after chewing and the higher the solubility and the lower the content of collagen (Bruwer *et al.* 1987).

Meat tenderness is determined by the amounts and states of three types of protein systems: connective tissue, myofibrils and sarcoplasm (Paul, Suzanne, McCrae & Hofferber, 1973). The <u>content</u> as well as the <u>solubility</u> of <u>connective tissue</u> directly influence the tenderness of meat. The role of connective tissue proteins regarding tenderness or toughness are determined by the age, breed and sex of the animal which influence the content and solubility of connective tissue in the muscles. Residue (fibrous tissue residue) consists of a description of the results of chewing a meat sample to the state at which it would normally be swallowed.

The effects of age on residue was investigated by Bruwer *et al.* (1987). It was concluded that as the age of the animal increases, more residue was left in the mouth after the chewing process. Schönfeldt (1989) reported that young animals irrespective of species contain less tissue residue. According to Cross, cited in Price & Schweigert (1987), the <u>cooking procedures</u> that result in the greatest retention of fluids and fat will yield the juiciest meat and the sensation of juiciness in cooked meat is closely related to the intramuscular fat content. Tenderness of cooked meat is controlled by the heat-induced changes in the collagenous connective tissue and in the contractile proteins.

According to Wood *et al.* (1999), nutrition influences tenderness principally through its effects on the amount and type of fat in meat. Hogg *et al.* (1992) reported that goat meat contains little fat and relatively high levels of protein and minerals (1.18 % fat, and 21.56 % crude protein) compared to sheep. In a study carried out by Rowe, Macedo, Visentainer, Souza & Matsushita (1999), lambs with the lowest amount of fat had the highest moisture content.

Young animals have more connective tissue per unit weight in their muscle. This type of connective tissue differs from the type found in older animals and hence meat of young animals tends to be more tender (Warmington & Kirton, 1990). Meat from young animals gives a watery effect on first chewing and a more lasting impression of dryness. However, for tough meat, the juiciness is greater and more uniform if the release of fluids is fast and the release of fat is slower (Cross, cited in Price & Schweigert, 1987).

Older animals do not have greater amounts of connective tissue per muscle unit in comparison with younger ones, but it is the extent of cross-linkages that increases with age and therefore influences the tenderness of the meat. As the age of the animal increases there is a marked decline in the percentage collagen solubility (Bruwer, *et al.*1987).

Naudé (1985) reported that the tenderness of highly soluble connective tissue muscle of very young animals might, however be completely masked if such carcasses are chilled too rapidly. Electrical stimulation can overcome such a problem. Tahir, Abdulla & AL-Jassim (1994), reported that castration improved flavour, juiciness, tenderness and overall acceptability.

3.6.1.2 Evaluation of meat tenderness

The most commonly used instrument to evaluate meat tenderness is the Warner-Bratzler Shear Device. The accuracy of this instrument can be affected by the doneness of the cooked meat, uniformity of cylindrical sample size, direction of the muscle fibers, amount of connective tissue and the fat deposits present, temperature of the sample and the speed at which the sample is sheared.

Cross, Durland & Seideman (1986) showed that the results usually correlated well with trained sensory evaluation panel scores. Generally, shear force values that exceed 5.5 kg would be considered tough by both a trained sensory panel and by consumers (Schackelford, Morgan, Cross & Savell, 1991).

3.6.2 Flavours

Flavour is a complex sensation obtained from the combination of olfactory and gustatory organs (Cross *et al.*, 1986). Shahidi, Rubin & D'Souza (1986) defined flavour as an important quality attribute which relates to the sensory characteristics of meat. Odour is the most important single factor contributing to the overall characteristics of flavour. Each muscle food contains its own distinct flavour which can either be intensified or altered by different methods of cooking and also by different end-point temperature (Imafidon & Spanier 1994). Red meat flavour may be influenced by type of diet and animal species.

Meat flavour results from the interaction of a mixture of non-volatile and volatile compounds (Imafidon & Spanier, 1994). Imafidon & Spanier (1994) reported that meaty flavour is potentiated by ribonucleotides through the suppression of the sulphury, fatty, burnt, starchy, bitter and hydrolysed vegetable-type flavours in meat.

In sheep and goat meat, inosinic acid contributes to the muttony and goaty flavours. In a study carried out by Arya & Parihar according to Imafidon & Spanier (1994), inosinic acid was the most predominant nucleotide at 6-8 hours postmortem. Several researchers have explored the likely biochemical origins and chemical causes of sheep meat odour and flavour as distinct from all other ruminant meat except perhaps goat. Meat fat is the principal source of species odour and in lamb, the fatty tissue was particularly distinguishable for sheep meat odour (Rousset-Akrim, Young & Berdagué, 1997). A major portion of muttony flavour is contributed by carbonyl compounds such as phenols and alkylphenols (Schönfeldt *et al.*, 1993).

Phenols and alkylphenols are species-specific flavour components that are produced in cooked meat, and are responsible for the muttony flavour (Imafidon & Spanier, 1994). Rousset-Akrim *et al.* (1997) showed that there are other odour volatiles which cause or are modifiers of the characteristic sheep meat odour. These modifiers include sulphur containing compounds, various pyrazines and pyridines and a range of phenolic compounds.

Compounds such as 4-methyloctanoic and 4-ethyloctanoic acids are characteristic of goat meat (Intarapichet, Pralomkan & Chinajarinyawong, 1994). Furthermore, according to Padda, Keshri, Sharma, Sharma & Murthy (1988), the intensity of goaty flavour can be influenced by processing procedures. In their study with goat patties from hot, chilled and frozen goat meat, they reported that flavour scores for the patties from frozen mince were significantly lower as compared with the patties from hot boned and hot frozen chunks. Flavour, juiciness, tenderness and overall acceptability of goat meat improved after castration (Tahir *et al.*,1994).

3.6.3 Water holding capacity and total cooking losses

Fresh meat at slaughter, on average, contains 75 % water (Offer & Trinick, 1983). This amount however, may subsequently be subjected to considerable variation due to the gains that occur during processing, or losses through drip, evaporation or cooking. Such gains or losses are important for economic reasons because meat is sold by weight. For consumer satisfaction, it is important to reduce losses on cooking that reduce the size of meat that can be served.

The juiciness and tenderness of meat and meat products depend to a large extent on their water content. Excess drip furthermore, produces an unattractive appearance (Offer & Trinick, 1983). The water holding capacity of meat and meat products can be determined by measuring the drip loss of raw, whole meat and the water loss of cooked, whole meat (Honikel, 1998). Water losses originate from volume changes of myofibrils induced by pre-rigor pH and the attachment of myosin heads to actin filaments at rigor.

Honikel (1998) further reported that the expelled fluid accumulates between fiber bundles. When a muscle is cut, this fluid drains from the surface under gravity if the viscosity of the fluid is low enough and capillary forces do not retain it. Denaturation of meat proteins during cooking, causes structural changes such as the destruction of the cell membrane, the aggregation of sarcoplasmic proteins and, shrinkage of the connective tissue resulting in cooking loss. It is important to define and regulate the cooking conditions.

Age of the animal has an influence on total cooking losses. Older animals have lower cooking losses than younger ones. In studies carried out by Pinkas, Marinova, Tomov & Monin (1982), it was demonstrated that age significantly influenced the water binding capacity (WBC) and the cooking losses of lamb. Older animals had higher WBC and lower cooking losses of the muscles. According to Zin, Krupa & Swida (1995), goat meat has a good water holding capacity. According to Schönfeldt, (1989) older animals (C age group) had greater drip loss and evaporation loss than corresponding cuts from the A and B age groups.

3.7 The effects of lipid composition on meat quality

The relationship between health and nutrition is becoming increasingly apparent. Total dietary fat and some saturated fatty acids contribute to coronary heart disease, and dietary cholesterol is related to the incidence of atherosclerosis (Rowe *et al.* 1999). The potential incidence of heart disease and atherosclerosis can be monitored by determining the amount of fat and the specific fatty acids in red meat consumed (Harris, Savell & Cross,1991).

Health professionals have demonstrated that low saturated to polyunsaturated ratio or high oleic content are important to reduce the risk of cardiovascular diseases (Martín, Rodríguez, Rota, Rojas, Pascuala, Patón & Tovar, 1999). Small, Oliva & Tercyak (1991) recommended a diet containing less than 30 % of kilojoules in the form of fat, less than 10 % in the form of saturated fat, and less than 300 mg of cholesterol per day.

Both plants and animal proteins are closely associated with lipids which contain varying types and amounts of unsaturated fatty acids (Shortland, 1953). According to Rowe *et al.* (1999) there is an excess amount of saturated fat in lamb compared to fat of other kinds of meat and the fattening system utilised affects the physical composition (muscle, fat and bone). Lipids are one of the major components of animals, comprising 18 % to 30 % and 28 % to 37 % of the carcass weight of beef and pork respectively and are exceeded only by water and protein in their distribution to carcass composition (Jeremiah, 1982). Adachi, Suyama & Tsuchida (1982) reported that the quantity and chemical properties of lipids in the subcutaneous, intermuscular and intramuscular fatty tissue of meat are regarded as an important factor affecting carcass quality. Webb (1992) demonstrated that an increase in the proportion of unsaturated fatty acids in the subcutaneous adipose tissue is associated with a decline in the firmness, colour and acceptability of meat.

Jeremiah (1982) showed that the physical composition of lipids is determined largely by the nature of their constituent fatty acids; on the other hand, the fatty acid composition and the degree of saturation of carcass lipids can be affected by the environment, diet, breed, sex, age and live weight of the animal. Fatty acids affect palatability either directly as short chain volatiles or through the oxidation, decarboxylation or dehydration of long-chain fatty acids (Webb, 1994). This effect influences taste and odour of meat (Warmington & Kirton, 1990).

Fatty acid composition can be altered by diet and breed (May, Sturdivant, Lunt, Miller & Smith, 1993). According to Webb (1992) dietary factors influence the fatty acids of the triacylglycerols in the subcutaneous adipose tissue of sheep. Casey, Van Niekerk & Spreeth (1988) reported that a higher concentrate ration was associated with a slight shift from saturated to unsaturated fatty acids in sheep. Diets containing high proportions of maize meal resulted in the deposition of increased proportions of unsaturated fatty acids in the subcutaneous adipose tissue.

3.8 Sensory evaluation

Sensory evaluation is a scientific discipline used to evoke, measure, analyse and interpret reactions to those characteristics of foods and materials as they are perceived by the senses of sight, smell, taste, touch and hearing (Institute of Food Technology as cited by Stone & Sidel, 1993). Sensory panels can be classified into Analytical (trained) and Affective (consumer or "like/dislike" or hedonic). Trained sensory panelists are individuals who have undergone extensive formalised training, or who have had sufficient experience with a product category to recognise or know the qualities and aroma and flavour intensities of the product (Moskowitz, 1984).

The training process, especially for descriptive analysis, results in subjects who have an analytical approach to product evaluation (Miller, 1999). The panellists function as a human instrument in evaluating the objective impression of an attribute. The attributes according to Jellinek (1995), include total impression of aroma, taste, temperature and tactile components. Cross, Moen & Stanfield (1978) developed a method for selecting, training and testing a meat descriptive panel, which consisted of four steps:

- Personal interview
- Screening
- Training and
- Performance evaluation.

The personal interview pre-screens potential candidates whose selection should be based on ability not age. Information gathered in the personal interview provides the basis for:

- Disqualifying candidates who were neither interested nor available, and
- Classifying candidates as potential panellists for specific tests

The type of individual who has potential as a panellist in the sensory program possesses characteristics that include:

- Interest and eagerness
- Memory for odour, taste, flavour and texture attributes.
- Ability to concentrate
- Perseverance and ability to make judgement
- Reliability
- Availability
- Sensitivity

People who are being considered for screening tests must be users or potential users of the product to be evaluated (Stone & Sidel, 1993). To screen panelists, the sensory specialist should create a battery of tests that are appropriate for the products to be evaluated, and the general tasks required of the panelists.

One of the tests commonly used to screen the panelists is the threshold test. The threshold test measures the sensitivity of the panelist to the basic tastes. This method involves the use of a concentration series of aqueous solutions (sucrose, sodium chloride, citric acid and caffeine). According to Miller (1999), panellists have to be trained so as to calibrate the "instrument to give standardised measurements.

The training session familiarises the prospective panellists with test procedures, improve the ability to recognise and identify sensory attributes, and to improve the individuals sensitivity to and memory for test attributes, so that sensory judgements can be precise and consistent. The panellists have to understand the methods, scales, score sheets and terminology to be used in the test (Cross *et al.*, 1978). The panel should be trained to evaluate differences in tenderness, juiciness, flavour and connective tissue remaining in the mouth at the end of mastication.

4 MATERIALS AND METHODS

4.1 Animal slaughter and processing

Two breeds of goats, Indigenous(n=12) and Boer goats (n=12), and two breeds of sheep Damara (n=12) and Dorper (n=12), were used in this study (Table 7). Indigenous goats were sourced from Victoria West, in the Northern Province, Damara sheep from Bethuli in the Free State, Boer goats and Dorper sheep from the Colesberg district in the Northern Cape Province. All the animals used were castrates which did not have any permanent incisors. The animals were slaughtered at the Animal Nutrition and Animal Products Institute (ANPI-Irene), at different time periods because they were not obtained at the same time. All carcasses were electrically stimulated (specs: 800V, 12.5 pulses per second) to accelerate the normal decline in pH and therefore prevent toughening caused by rapid chilling following dressing. The mass of the warm carcasses and full and empty stomachs and intestines were recorded. The carcasses were then chilled overnight at 4 °C. At 12 hours post-mortem, the cold masses of all carcasses were measured.

Table 7: Experimental design for evaluation of goat and sheep patties

Measurements	Number of carcasses	Breed							
		Dorper sheep		Damara sheep		Boer goats		Indigenous goats	
		RS	LS	RS	LS	RS	LS	RS	LS
Physical dissection	48	12 (raw)	-	12 (raw)	-	12 (raw)	-	12 (raw)	-
Sensory analysis	40	10	-	10	-	10	-	10	-
Aroma	40	Cooked	-	Cooked	-	Cooked	-	Cooked	-
Flavour	40	Cooked	-	Cooked	-	Cooked	-	Cooked	-
Tenderness	40	Cooked		Cooked	-	Cooked	-	Cooked	-
Proximate analysis (% DM and% ash) % protein	48	Thawed and Freeze-dried sample	-	Thawed and Freeze-dried sample	-	Thawed and Freeze-dried sample	-	Thawed and Freeze-dried sample	-
Fatty acid profile	48	Freeze-dried	-	Freeze-dried	-	Freeze-dried	-	Freeze-dried	-

RS = Right side of carcass, LS = Left side of carcass, not used in this study

4.2 Sampling and preparation

4.2.1 Physical composition

For each carcass, the tail was removed from its articulation and weighed. Kidney, and cavity fat (fat around kidneys and in the pelvic and thoracic cavities) were removed and weighed. Each carcass was then carefully split in half by using a band saw. Both halves were weighed. The right side of all the carcasses was subdivided into primal cuts (neck, forelimb, dorsal trunk, ventral trunk and the hind limb) (Figure 5). The dissection method used was similar to that used by Casey (1982), which was as follows:

(1) The abdominal muscles were separated from the hind limb. A cut was made along the lateral plane of the eye muscle to the 13^{th} rib without cutting through the muscle. The hind limb was severed at the usual position between the last lumber and first sacral vertebrae, without cutting through any muscle. Masses were recorded.

(2) The fore limb was removed by cutting from the humeral/scapular junction along the Supra spinatus, along the cartilage of the scapula to the caudal bend. A straight cut was made from there to the point of the radius ulna. The Pectralis was loosened from the shin towards the chest. The shoulder was lifted and the connective tissue severed. The Pectralis was loosened from the humeral/scapular junction. Only the Subscapularis was left on the fore limb, while the other muscles were left with the ventral trunk joint.

(3) The neck was removed by cutting from the cranial edge of the first rib to the neck muscle, and was continued along the neck muscle to separate the Pectoralis from the neck muscles. The neck was severed by cutting next to the spinal proses of the first lumbar vertebrae and the seventh cervical and first lumbar vertebrae.

(4) The trunk was separated into dorsal and ventral joints by cutting along a line drawn from the junction of the first rib and sternum to the middle of the tenth rib. The ventral trunk, mostly of the chest region, thus included the flank. Both dorsal and ventral trunk masses were recorded.

Each cut was weighed, and the subcutaneous fat of each joint was dissected off and the remainder of the joint was deboned. Subcutaneous fat mass, meat mass and bone mass of each joint was recorded. Meat to bone ratio was calculated to determine the physical composition of each cut. The left side of each carcass was weighed, and in addition carcass length and buttock length were measured.

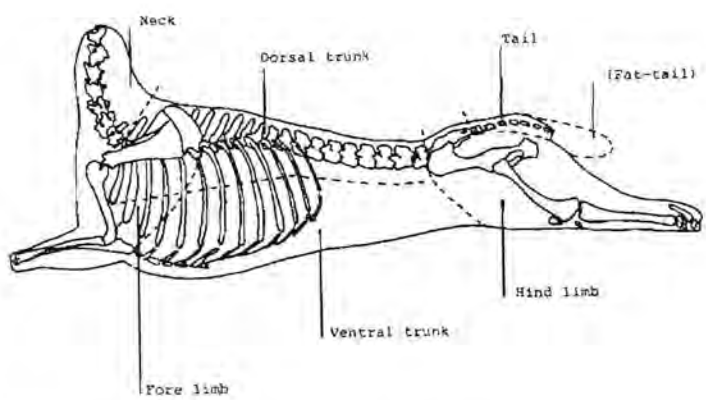


Figure 5: Dissection diagram (Casey, 1982)

4.2.2 Chemical analysis

Samples for the chemical analysis and sensory evaluation were prepared from the right side of each carcass. The meat and subcutaneous fat were minced first through a kidney plate and then through a 5 mm plate.

A representative sample of 300 g for chemical analyses was taken from mince obtained from each cut and the rest of the minced meat was reserved for sensory evaluation. All the mince meat samples were vacuum packaged and frozen at -20 °C until required. The frozen meat samples for chemical analyses were sawn through to take off about 50 g which was thawed and used to determine % dry matter and % ash. The rest of the sample material (250 g) was freeze-dried to minimise moisture presence at -20 °C for 4 days (36 hours) under vacuum. The freeze-dried samples were ground to homogenise, bottled and stored refrigerated at 4 °C until required for analysis of % protein, % water, % ash, % fat and fatty acid profile.

4.2.2.1 Dry-matter and ash

Percentage dry-matter (% DM) and % ash were determined by using the standard procedure (AOAC, 1990) on thawed meat samples. About 8 g of meat sample was weighed into a pre weighed crucible dish. The samples were then incubated in an oven at 100 °C overnight. The crucible dish with dry matter were cooled in a desiccator, and the weights recorded. Ashing was carried out at 600 °C for 6 hours.

The weights of the crucible dishes with ash were established. Formulae used for % DM and % Ash were as follows:

$$\% \text{ DM} = \frac{\text{Mass of dried sample}}{\text{Mass of fresh sample}} \times 100$$

$$\% \text{ Ash} = \frac{\text{Mass of ash}}{\text{Mass of dried sample}} \times 100$$

4.2.2.2 Protein (Kjeldahl Technique)

The protein content was measured by standard Kjeldahl procedure (AOAC, 1990). A sample of 0.5 g of the freeze-dried meat was weighed into a Kjeldahl flask. Potassium sulphate, a pinch of selenium, glass beads and 25 ml sulphuric acid were added to the flask which was then fitted to the Kjeldahl digestion rack and digested for one hour. The mixture was cooled and 350 ml distilled water, 100 ml sodium hydroxide (NaOH) and beads of metallic zinc were added and the flasks were coupled to the distillation apparatus. The discharge tubes of the distillation apparatus were submerged in the boric acid/indicator solution which was contained in a 500 ml Erlenmeyer flask. The colour of the boric acid/indicator was blue and as distillation progressed, the colour changed to green. Distillation continued until the volume in the Erlenmeyer reached 200 ml. The solution was then titrated against 0.714 M sulphuric acid to a blue colour that marked the end point.

The titre volume was recorded. The percent nitrogen was calculated using the formula:

$$\% N = \frac{A(ml) \times M \times 14 \times 100}{1000 \times \text{weight of sample}}$$

Where: A is titre volume minus blank titre

volume M is the molarity of acid used

The protein content was then calculated as follows:

% Crude protein = % N x 6.25

4.2.2.3 Crude fat

The fat content was determined on freeze-dried samples. Two methods were used, The Soxhlet (AOAC, 1984) and the Soxtec HT6 method.

4.2.2.3.1 Soxhlet method

Flat bottomed Soxhlet flasks were cleaned, labelled and dried in the oven at 100 °C overnight. The flasks were cooled in the dissector and their weights were measured and recorded. Approximately 2 g of sample material were weighed onto a filter paper. The sample was wrapped and pushed into a numbered thimble. To each Soxhlet flask, 375 ml petroleum ether was added. The extraction thimbles containing the samples were placed in the extraction unit and extraction took a total of 16 hours. The amount of extractable fat was determined by incubating the flask overnight in a 105 °C oven to allow all the traces of ether to evaporate followed by cooling and weighing the flasks.

4.2.2.3.2 Soxtec method

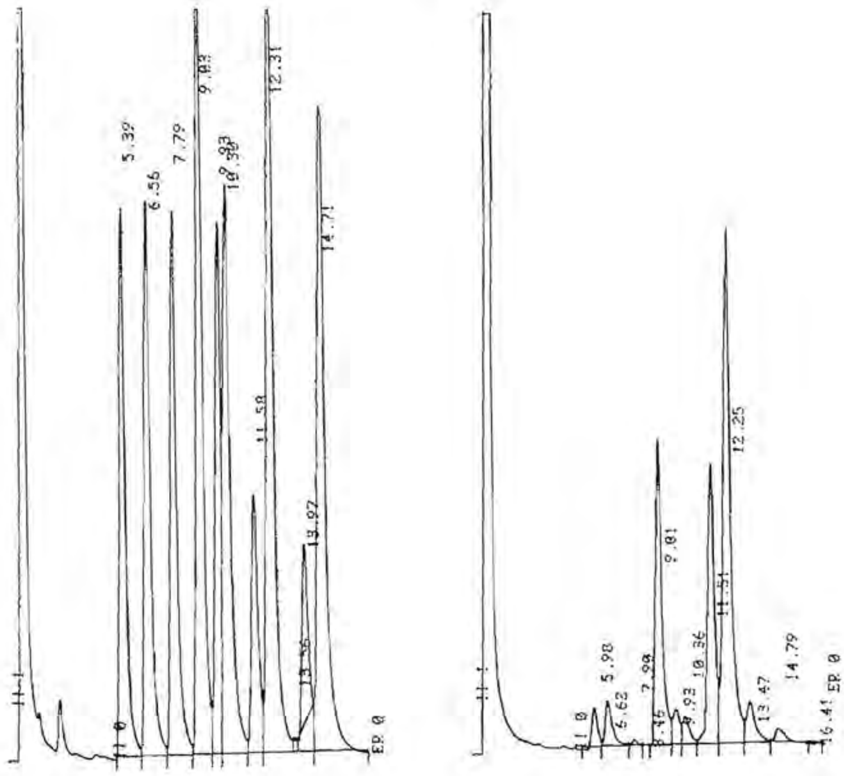
The difference between the Soxhlet and Soxtec methods were mainly the apparatus and the extraction periods. In the Soxtec method, metallic beakers and 50 ml petroleum ether were used. The extraction period was in total 3 hours (2 hours boiling and 1 hour rinsing). The following formula was used in both cases:

$$\text{\% Ether extract} = \frac{\text{Mass of fat}}{\text{Mass of sample}} \times 100$$

4.2.2.4 Fatty acid profile

Freeze-dried sample material (fat and meat mince) was used. The method comprised of three stages, the extraction stage, esterification (preparation of methyl esters) and gas chromatography analysis. One gram of sample material was weighed into an Erlenmeyer flask. Ten milliliters of chloroform ($CHCl_3$) and Butylated Hydroxytoluene (2,6 DI-tert-BUTYL-P-CRESOL) (0.1 g Butyl Hydroxy Touline dissolved in 100 ml chloroform) was added to the flask. Butyl Hydroxy Touline was included as an antioxidant.

The flasks were shaked vigorously and stored at 4 °C overnight. The clear liquid was separated and transferred to a test tube. The methyl esters of the fatty acids were prepared by adding 1ml NaOH/methanol solution, 5 ml chloroform and 0.5 ml sample extract to a centrifuge tube (AOAC, 1975). The mixture was shaked to mix and heated in a waterbath for 30 minutes at 55 °C after which it was allowed to cool. The cold mixture was centrifuged for 15 minutes at 5000 rpm using a Beckman model TJ-6 centrifuge. The clear supernatant (isolated esterified lipid) was separated and refrigerated until required (but not longer than two days) for subsequent fatty acid analysis on a Varian 3300 gas chromatograph (Figures 6 a and b).



(a) Standard Key: C14:0 = 6.56, C15: 0 = 7.79, C16: 0 = 9.03, C16:1 = 9.93, C17:0 0 = 10.3, C18:0 0 = 11.58, C18:1 0 = 12.31, C18:3 0 = 13.97, C20:1 0 = 14.71

(b) Freeze-dried meat sample

Key: C14: 0 = 6.62, C15: 0 = 7.90, C16: 0 = 9.01, C16:1 = 9.93, C17:0 = 10.36, C18:0 = 11.51, C18:1 = 12.25, C18:3 = 13.47, C20:1 = 14.79

Figure 6: Typical gas chromatograms of fatty acid methyl esters in the (a) standard sample and (b) freeze-dried muscle +fat sample

4.3 Sensory evaluation

4.3.1 Panel selection and training

An advert was circulated around the University of Pretoria to invite interested people to take part in the sensory evaluation. It was specified that only consumers of both sheep and goat meat could participate. A questionnaire which included questions on the health status of respondents was developed and used to choose the most suitable candidates and time for the evaluation phase. Health related questions were included mainly because olfactory cells, like taste cells can be affected by use of drugs, antibiotics, tobacco products and chemotherapy (Miller, 1999). Potential panellists were screened for selected personal traits, interest and ability to discriminate differences and generate reproducible results. Two screening tests were performed, a threshold test using aqueous basic taste solutions (Figure 7)and a triangle test with meat patties (Figure 8). A prospective panel was selected based on the results of the screening tests. The selected candidates were then trained to familiarise them with test procedures and to increase their ability to recognise and recall sensory characteristics. A common language to express the sensory attributes was developed. A score sheet (Figure 9) was developed during the training phase. This score sheet was used during the rest of the training days to ensure that all candidates understood and could therefore be able to use consistently. Preliminary testing was carried out to standardise sample preparation, presentation and test the evaluation procedure. The evaluation phase commenced after the preliminary analysis which reflected that the panel was ready.

SCREENING TEST

Project name: **CHARACTERIZATION OF CARCASS COMPOSITION AND SENSORY EVALUATION OF TWO GOAT AND TWO SHEEP BREEDS.**

Test: **Screening test.**

Date:..

Name:..

You have received 8 aqueous solutions. Please evaluate the samples from left to right. Take a sip of water between samples to cleanse your palate. Retasting is allowed. Evaluate the samples according to the presence/absence of each of the four basic tastes using the following scale to indicate intensity of each taste:

0 = Absent, 1 = Very weak, 2 = Weak, 3 = Moderate, 4 = Strong, 5 = Very strong

CODE	SWEET	SOUR	SALTY	BITTER

Figure 7: **Threshold screening form for four basic tastes**

Respondent......

Triangle test: Meat patties

Name:____________________________________

Date: / /1999.

You have received three coded samples of meat patties. Two of these samples are the same and one is odd (different). Please identify the odd one by circling the number of the sample that is odd (different).

Please rinse your mouth with water in between tasting the different samples. Thank you!

Figure 8: The triangle test form

NAME	DATE:	TIME/SESSION:

Please evaluate sample [ ] for the designated characteristics

Characteristic		0	1	2	3	4	5	6	7	8	9	
Overall aroma intensity Take a few short sniffs as soon as you remove the foil and rate the intensity of the aroma	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense
Goaty aroma intensity Rate the intensity of the goaty aroma	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense
Muttony aroma intensity Rate the intensity of the muttony aroma	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense
Overall tenderness Chew the sample with a light chewing action and rate the tenderness	Not tender	0	1	2	3	4	5	6	7	8	9	Extremely tender
Sustained impression of juiciness It is the impression of juiciness that you form while you are chewing	Not juicy	0	1	2	3	4	5	6	7	8	9	Extremely juicy
Greasiness Sensation of fattiness/greasiness in the mouth while you are chewing	Not greasy	0	1	2	3	4	5	6	7	8	9	Extremely Greasy
Chewiness of the meat (Amount of connective tissue/residue) This is the chewiness of the meat	Not chewy	0	1	2	3	4	5	6	7	8	9	Extremely chewy
Overall flavour intensity Rate the overall intensity of the flavour	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense
Goaty flavour intensity Rate the intensity of the goaty flavour	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense
Muttony flavour intensity Rate the intensity of the muttony flavour	Not intense	0	1	2	3	4	5	6	7	8	9	Extremely intense

Figure 9: Sensory evaluation score sheet for goat and sheep patties

4.3.2 Sample preparation for sensory evaluation

Sensory evaluation of the meat patties was performed at the University of Pretoria (UP). The vacuum packaged minced meat samples were transferred from ANPI-Irene to UP where they were kept frozen at –20 °C until required. The required samples were distinguished by the animal number. The frozen minced meat was thawed in a chiller at 0-4 °C for 48 hours prior to preparation. Patties were prepared by weighing 100 g of minced meat and shaping it with a hand model hamburger patty machine. The patties were separated by plastic patty inserts. There were no additions or seasoning added to the patties. The patties were cooked by grilling on an oven rack for 5 minutes on one side, turned, and 5 minutes on the other side in AEG Confidence ovens. One oven was used per animal. The ovens were set to a temperature of 275 °C and the cooking pan was placed on the second shelf position below the element. Using this method, the internal endpoint temperature was 81-85 °C for sheep meat and 75-80 °C for goat meat because of differences in fat content of the species. Samples were cut immediately after cooking.

After the whole patties were cooked and removed from the oven , patties + oven pan + stock were weighed and recorded. The stock was measured in measuring cylinders in ml. These will not be reported in the result section of this dissertation. The patties were quartered with a chef's knife, wrapped in 90 X 90 mm aluminium foil squares. Warming ovens were set at 100 °C where the wrapped samples were kept until served.

4.3.3 Sensory sessions

The panel consisted of 12 persons who were all students. Sensory evaluation was carried out for 5 consecutive days and there were two sessions per day. Ten animals of every breed were used for the sensory study. During the training phase, two animals from each breed were used.

Individual sensory booths were used which had a signal system such that the panel leader could know when an assessor was ready for a sample or had a question. The use of individual booths eliminated distractions and prevented communication between the panellists. In the booths, red light was used which served to mask possible colour differences during testing and therefore visual colour could not affect the perception.

4.3.3.1 Serving of sensory samples

During the evaluation phase, samples were coded with a randomly selected three digital code and, the serving sequence was randomised. Each panellist was presented with four samples representing the different treatments. A glass of water and a piece of carrot were placed in each booth. The panellists were instructed to take a bite of the carrot, chew it, followed by a sip of water and wait for 30 seconds in order to restore the normal fluid environment in the mouth between samples.

4.4 Statistical analysis

Calculations for the fatty acid composition of the meat samples were performed using the statistical package STATGRAPHICS (Statistical Graphics System). All the other data was collected in spread sheets using Excel 6.0 and all the statistical analyses were done using Statistica 5.0 (Statsoft Inc.,1995). Data was analysed as one-way analysis of variance (ANOVA). Significant differences were further analysed using Tukey's multiple range test.

5 RESULTS

5.1 Comparison of the fifth quarter for goats and sheep

The dress-off items or fifth quarter of sheep and goat breeds are presented in Table 8. The dressing percentage of goat breeds was lower compared to the sheep breeds while Damara dressed off significantly lower than Dorper sheep. Although the goat breeds had heavier heads, feet, spleens and liver compared to sheep breeds, the kidney fat of sheep breeds was significantly heavier than that of goat breeds. Within the goat breeds, the Indigenous goat had proportionally larger head, feet, spleens and liver than Boer goat. The feet of Dorper were proportionally larger than those of the Damara, while the Damara had a larger spleen and liver than the Dorper. The skin yield of Boer goats was higher than that of the Indigenous goats and both sheep breeds, while the Damara and Indigenous goats had higher yields than the Dorper. The omentum fat for Indigenous goats was not measured. Dorper sheep contained significantly more omentum fat than Damara. On the other hand Damara sheep did not differ significantly from the Boer goats in terms of omentum fat percentage. As expected, the tail of Damara sheep was proportionally heavier than those of Dorper sheep, Boer and Indigenous goats.

Table 8: Comparison of mean percentages of the fifth quarter of goats and sheep

Traits	p	Dorper sheep	Damara sheep	Boer goats	Indigenous goats
Dressing %	≤0.0500	68.86 ^{c}	59.86 ^{b}	55.72 ^{a}	55.68 ^{a}
		(±1.68)	(±3.92)	(±1.58)	(±1.29)
Cold carcass (kg)	≤0.0500	21.55 ^{d}	18.65 ^{c}	14.02 ^{b}	11.02 ^{a}
		(±1.45)	(±0.96)	(±0.78)	(±0.56)
Head %	≤0.0001	5.91 ^{a}	5.77 ^{a}	7.93 ^{b}	8.84 ^{c}
		(±0.34)	(±1.69)	(±0.52)	(±0.66)
Skin %	≤0.0001	7.41 ^{a}	9.17 ^{b}	9.93 ^{c}	8.86
		(±0.62)	(±1.32)	(±1.00)	(±0.35)
Feet %	≤0.0001	2.95 ^{b}	2.04 ^{a}	3.87 ^{c}	4.17 ^{c}
		(±0.17)	(±1.53)	(±0.21)	(±0.25)
Pluck %	≤0.0001	3.05 ^{c}	2.82 ^{b}	2.78 ^{b}	2.51 ^{a}
		(±0.14)	(±0.14)	(±0.27)	(±0.28)
Liver + Spleen %	≤0.0001	1.73 ^{a}	2.14 ^{b}	2.81 ^{c}	3.47 ^{d}
		(±0.16)	(±0.31)	(±0.34)	(±0.20)
Kidney fat %	≤0.0001	2.12 ^{b}	2.16 ^{b}	1.57 ^{a}	1.31 ^{a}
		(±1.13)	(±0.77)	(±0.52)	(±0.60)
Tail %	≤0.0001	1.48 ^{c}	12.24 ^{d}	0.73 ^{b}	0.44 ^{a}
		(±0.38)	(±2.21)	(±0.10)	(±0.22)
Omentum fat %	≤0.0020	2.22 ^{b}	1.69 ^{a}	1.15 ^{a}	Not measured
		(±0.70)	(±0.88)	(±0.33)	

[a,b, &c] Means within the same row bearing different superscripts differ significantlyat level $p<0.05$

5.2 Carcass composition of goats and sheep

The carcass and proximate composition of sheep and goat are presented in Table 9. The total subcutaneous fat of sheep breeds was proportionally higher compared to goat breeds. There was proportionally more meat in goat breed carcasses compared to Damara carcasses while Dorper carcasses had more meat than Indigenous goat carcasses. The soft tissue (fat and muscle) of goat breeds contained more moisture, ash and protein than sheep breeds while sheep breeds had more fat.

Table 9: Comparison of mean values for proportions of carcass tissue (dissected) and proximate composition of soft tissue (muscle and fat chemically analysed) from goat and sheep

Variable	P	Dorper sheep	Damara sheep	Boer goats	Indigenous goats
Total SCF %	≤0.0001	10.14[c]	10.31[c]	2.88[b]	1.26[a]
		(±1.62)	(±1.47	(±0.66)	(±0.67)
Total Meat %	≤0.0001	75.4[c]	69.96[a]	76.56[d]	74.15[b]
		(±1.21)	(±1.49)	(±0.91)	(±1.69)
Total bone %	≤0.0001	14.46[a]	19.72[b]	20.56[b]	24.59[c]
		(±1.32)	(±1.14)	(±0.81)	(±1.82)
Moisture %	≤0.0001	61.71[a]	60.15[a]	69.4[b]	69.8[b]
Ash %	≤0.0001	0.81[a]	0.83[a]	0.95[a]	0.97[b]
Protein %	≤0.0001	21.35[a]	22.49[b]	22.76[b]	24.83[c]
Fat %	≤0.0001	19.4[c]	20.37[c]	10.45[b]	7.9[a]

[a a,b, &c] Means within the same row bearing different superscripts differ significantly at level $p<0.05$
SCF= Subcutaneous fat

Due to large differences in subcutaneous fat proportion between sheep and goat carcasses (Table 9), large differences in SCF within cuts (Table 10) were expected. In the same way that these differences influenced the proportions of bone and meat in the whole carcass, meat and bone proportions within cuts were obviously affected. For all five cuts, sheep carcasses had significantly more SCF than goat carcasses. Although Dorper and Damara carcasses did not differ significantly for total carcass SCF or proximate fat (Table 10), the Damara had significantly higher proportions of SCF in the fore limb, ventral cut and hind leg with concommitant lower proportions of meat in these cuts (and also the dorsal cut). The percentage carcass bone content of Damara did not differ significantly from that of Boer carcasses and was significantly higher compared to Dorper. In all the cuts, bone proportions were significantly higher for the Damara than for the Dorper.

The Boer goat and Indigenous goat differed significantly for total carcass subcutaneous fat and this manifested into significantly higher proportions of SCF in the fore limb, ventral trunk, dorsal trunk and hind leg cuts. Despite higher fat proportions in most cuts, meat proportions were significantly higher and bone lower in the neck, shoulder, ventral trunk and hind leg of the Boer goat.

Table 10: Comparison of mean yields per cut and of tissue composition in each primal cut of goat and sheep carcasses

Primal cut[1]	Tissue[2] (%)	P	Dorper sheep	Damara sheep	Boer goat	Indigenous goat
Neck	**Total**	0.65	10.00[a] (±0.52)	10.14[a] (±0.98)	10.38[a] (±1.23)	10.44[a] (±1.00)
	SCF	≤0.0001	7.78[b] (±3.32)	8.44[b] (±2.19)	0.88[a] (±1.06)	1.56[a] (±3.02)
	Meat %	≤0.0001	76.19[c] (±3.86)	74.04[b] (±2.23)	79.85[d] (±2.80)	71.88[a] (±3.44)
	Bone %	≤0.0001	16.03[a] (±2.53)	17.52[b] (±2.27)	19.23[c] (±2.24)	26.57[d] (±3.94)
Fore limb	**Total**	≤0.0001	15.68[a] (±0.64)	16.64[b] (±0.63)	19.75[c] (±0.70)	20.04[c] (±0.85)
	SCF %	≤0.0001	5.58[c] (±1.71)	6.84[d] (±1.67)	3.19[b] (±0.83)	1.98[a] (±1.43)
	Meat %	≤0.0001	74.33[c] (±1.39)	68.90[a] (±1.54)	74.96[c] (±1.14)	72.82[b] (±1.51)
	Bone %	≤0.0001	20.10[a] (±1.25)	24.25[b] (±1.51)	21.85[c] (±0.85)	25.20[b] (±1.26)
Ventral trunk	**Total**	≤0.0001	20.45[b] (±1.91)	16.89[a] (±1.91)	19.38[b] (±0.96)	21.50[bc] (±1.13)
	SCF %	≤0.0001	10.20[c] (±2.71)	12.61[d] (±2.95)	4.39[b] (±1.57)	1.34[a] (±1.41)
	Meat %	≤0.0001	78.27[c] (±6.07)	73.58[b] (±2.69)	81.52[d] (±1.71)	68.83[a] (±2.47)
	Bone %	≤0.0001	11.53[a] (±/.47)	13.81[b] (±1.26)	14.10[c] (±1.07)	29.83[d] (±2.87)
Dorsal trunk	**Total**	≤0.0001	21.83[c] (±1.37)	23.59[d] (±1.37)	20.39[b] (±0.87)	16.60[a] (±1.39)
	SCF %	≤0.0001	10.40[b] (±2.51)	11.54[b] (±2.43)	3.84[a] (±0.84)	2.33[a] (±1.20)
	Meat %	≤0.0001	71.08[b] (±3.29)	65.68[a] (±3.18)	69.46[b] (±2.74)	78.74[c] (±2.43)
	Bone %	≤0.0001	18.53[a] (±2.90)	22.79[b] (±2.46)	26.70[c] (±2.72)	18.93[a] (±2.87)
Hind leg	**Total**	≤0.0001	32.05[b] (±0.87)	32.75[b] (±1.26)	30.10[a] (±0.75)	31.48[ab] (±0.86)
	SCF %	≤0.0001	6.43[c] (±2.46)	10.55[d] (±1.71)	1.76[b] (±0.96)	1.07[a] (±1.09)
	Meat %	≤0.0001	77.05[b] (±1.90)	70.53[a] (±1.81)	78.06[b] (±0.99)	76.19[bc] (±1.90)
	Bone %	≤0.0001	16.53[a] (±1.29)	18.93[b] (±0.98)	20.16[c] (±1.09)	22.74[d] (±1.69)

[a,b, c&d] Means within the same row bearing different superscripts differ significantly at level $p<0.05$
[1]Yields for each cut as a proportion of total carcass weight
[2]Tissue Yields for each tissue type as a proportion of cut weight

5.3: Fatty acid composition of goats and sheep

The fatty acid composition of the sheep breeds were compared to goat breeds (Table 11). Saturated fatty acids seemed to be more abundant than unsaturated fatty acids, monounsaturated fatty acids, and polyunsaturated fatty acids in all the breeds. Damara sheep had the lowest Saturated fatty acid content, which was significantly less than the goat breeds. Unsaturated fatty acids and Monounsaturated fatty acids tended to be higher in sheep meat ("meat" refers to meat + fat) compared to goat meat with significant differences between Damara sheep and Boer goat, Damara and Indigenous goats and Dorper and Boer goats for each type of fatty acid. Polyunsaturated fatty acid concentrations were similar in Dorper and Boer goats and significantly lower compared to Damara and Indigenous goat soft tissue. Generally, in this study, polyunsaturated fatty acids were the least abundant of all fatty acid types in both sheep and goat breeds. The molar percentages of tridecanoic acid (C13:0) was significantly higher in goat than in sheep, while Indigenous goat had higher proportions than Boer goat. Margaric (C:17) and stearic acids (C18:0) were significantly higher in goat meat than in sheep meat, while Palmitic (C16:O) being the most abundant saturated acid, was significantly higher in sheep meat compared to goat meat. The most abundant unsaturated fatty acid was oleic acid (C18:1), Damara> Boer + Dorper >Indigenous.. The molar percentage of linoleic acid (C18:3) was the same in Damara sheep and Indigenous goats and was significantly higher compared to Dorper sheep and Boer goats. The molar percentage of eicosenoic acid (C20:1) of Dorper and Damara sheep was significantly higher than Boer and Indigenous goats.

Table 11: Comparison of mean molar percentage (±SD.) of fatty acids of (freeze-dried meat and fat) from goat and sheep

Fatty acids	P	Dorper sheep	Damara sheep	Boer goats	Indigenous goats
C13: 0	≤0.0001	3.0^{a}	2.7^{a}	3.9^{b}	5.0^{c}
Tridecanoic acid		(±0.47)	(±0.47)	(±0.47)	(±0.47)
C14: 0	≤0.0002	8.4^{b}	7.4^{b}	6.1^{a}	6.0^{a}
Myristic acid		(±1.45)	(±2.09)	(±2.00)	(±3.08)
C15 : 0	≤0.0012	0.6^{a}	0.6	0.7	0.8^{b}
Pedtadecanoic acid		(±0.11)	(±0.13)	(±0.30)	(±0.19)
C16 : 0	≤0.0001	24.3	22.5^{c}	21.3^{b}	19.5^{a}
Palmitic acid		(±1.33)	(±1.85)	(±0.67)	(±1.42)
C16 : 1	≤0.0001	4.0^{b}	3.4^{a}	3.3^{a}	3.1^{a}
Palmitoleic acid		(±0.40)	(±0.70)	(±0.30)	(±0.26)
C17 : 0	≤0.0001	2.1^{a}	2.1^{a}	2.3^{b}	2.4^{c}
Margaric acid		(±0.11)	(±0.13)	(±0.17)	(±0.10)
C18 : 0	≤0.0001	14.4^{a}	16.4^{b}	20.4^{c}	20.0^{c}
Stearic acid		(±1.10)	(±2.50)	(±2.28)	(±1.69)
C18 : 1	≤0.0007	37.6^{b}	38.9^{c}	36.7^{a}	37.7^{b}
Oleic acid		(±1.88)	(±1.93)	(±1.90)	(±2.54)
C18 : 3	≤0.0001	3.2^{a}	3.9^{b}	3.4^{a}	3.9^{b}
Linoleic acid		(±0.38)	(±0.62)	(±0.41)	(±0.20)
C20 : 1	≤0.0001	2.2^{b}	2.0^{b}	1.8^{a}	1.6^{a}
Eicosenoic acid		(±0.32)	(±0.26)	(±0.23)	(±0.37)
SFA	≤0.0001	52.8^{ab}	51.8^{a}	54.7^{c}	53.6^{bc}
		(±1.93)	(±1.76)	(±2.23)	(±2.77)
USFA	≤0.0001	47.2^{bc}	48.2^{c}	45.3^{a}	46.4^{ab}
		(±1.93)	(±1.52)	(±2.23)	(±2.77)
MUFA	≤0.0001	43.9^{bc}	44.3^{c}	41.9^{a}	42.5^{ab}
		(±1.29)	(±1.33)	(±0.89)	(±1.05)
PUFA	≤0.0001	3.3^{a}	3.9^{b}	3.4^{a}	3.9^{b}
		(±0.45)	(±0.23)	(±0.35)	(±0.38)

$^{a, b, c \& d}$ Means within the same row bearing different superscripts differ significantly at leve ($p<0.05$)
USFA = Unsaturated fatty acids,
MUFA = Monounsaturated fatty acids
UFA = Polyunsaturated fatty acids

5.4: Sensory quality characteristics of meat patties from goats and sheep

The sensory quality characteristics of patties from all four breeds were compared in one analysis (Table 12). The aroma intensity of Boer goat patties was significantly stronger than that of Indigenous goat and sheep meat patties. Furthermore, Boer goat patties had a stronger goaty aroma than Indigenous goats. The overall flavour intensity for sheep breeds was stronger compared to goat breeds. Flavour intensity of Boer goat patties was higher than that of Indigenous goat meat patties. Sheep patties were found to be more muttony in flavour than goat patties and goat patties were more goaty.

Sheep patties scored higher for overall tenderness, juiciness and greasiness and were found to be less chewy (less connective tissue) than goat patties. Indigenous goat patties were perceived to be the least juicy and greasy and differed significantly from Boer goat patties and those of the sheep breeds.

Table 12: Comparison of the mean values for sensory quality characteristics of meat patties from goats and sheep

Sensory attributes[2]	P	Dorper sheep	Damara sheep	Boer goats	Indigenous goats
Overall aroma intensity	≤0.0001	6.9^{a}	7.1^{a}	7.6^{b}	7.0^{a}
		(±1.60)	(±1.50)	(±1.50)	(±1.60)
Goaty aroma intensity	≤0.0001	1.6^{a}	1.3^{a}	6.4^{c}	5.6^{b}
		(±3.10)	(±2.50)	(±2.80)	(±3.10)
Muttony aroma intensity	≤0.0001	5.7^{b}	6.1^{b}	1.3^{a}	1.3^{a}
		(±2.90)	(±3.00)	(±2.70)	(±2.40)
Overall tenderness	≤0.0001	6.5^{b}	6.8^{b}	4.4^{a}	4.2^{a}
		(±1.60)	(±1.60)	(±1.80)	(±9.00)
Sustainable impression of juicines	≤0.0001	6^{c}	6.4^{c}	3.7^{b}	2.7^{a}
		(±1.60)	(±1.80)	(±2.10)	(±1.80)
Greasiness	≤0.0001	5.8^{c}	6.2^{c}	3.7^{b}	2.6^{a}
		(±1.80)	(±2.00)	(±2.00)	(±1.90)
Chewiness	≤0.0001	4.2^{b}	3.7^{a}	6.4^{c}	6.7^{c}
		(±1.90)	(±2.00)	(±1.70)	(±1.50)
Overall flavour intensity	≤0.0001	6.8^{c}	6.9^{c}	6.5^{b}	6^{a}
		(±1.50)	(±1.90)	(±2.00)	(±2.10)
Goaty flavour intensity	≤0.0001	1.4^{a}	1.5^{a}	5.8^{b}	5.2^{b}
		(±2.90)	(±2.70)	(±2.90)	(±3.10)
Muttony flavour intensity	≤0.0001	5.5^{b}	5.9^{b}	1.3^{a}	1.3^{a}
		(±2.90)	(±3.00)	(±2.60)	(±2.30)

[a,b,c & d] Means within the same row bearing different superscripts differed significantly at leve ($p<0.05$)

2

Overall aroma intensity (0=Not intense, 9 = Extremely intense)
Goaty aroma intensity (0=Not intense, 9 = Extremely intense)
Muttony aroma intensity (0=Not intense, 9 = Extremely intense)
Overall tenderness (0=Not tender, 9 = Extremely tender)
Sustainable impression of juiciness (0=juicy, 9 = Extremely juicy)
Greasiness (0=Not greasy, 9 = Extremely greasy)
Chewiness of meat (0=Not chewy, 9 = Extremely chewy)
Overall flavour intensity (1=Not intense, 9 = Extremely intense)
Goaty flavour intensity (1=Not intense, 9 = Extremely intense)
Muttony flavour intensity (1=Not intense, 9 = Extremely intense)

6 DISCUSSION

6.1 Carcass composition

Carcass dressing % is economically important in any production system. Dorper head bore the same proportional weight as Damara head which was not expected given the fact that Dorper sheep are hornless. The horns of Damara sheep therefore, did not contribute enough to exceed the Dorper head size. The feet, liver and spleen were proportionally larger in goats than in sheep leading to a lower dressing percentage in goats than sheep. Gaili & Ali (1985) reported no significant differences in the proportional weights of feet, liver and spleen of Sudan desert sheep and goats. Between the two goat breeds, dressing percentages of Boer goats were higher than that of Indigenous goats probably due to differences in fatness and weight. The differences observed in dressing percentages between and within species can be ascribed to differences in carcass fat because Warmington & Kirton (1990) reported that dressing percentage is positively correlated with carcass fat. The sheep breeds contained proportionally more kidney fat than the goat breeds which was in contrast to Hadjipayiotou & Koumas (1994), who recorded less kidney fat for lambs compared to kids due to a higher carcass fat content. Casey (1982) reported that Boer goats deposited larger proportions of total fat in the kidney fat depot compared to South African Mutton Merino, Merino, Dorper and Pedi. Casey (1982) added that the high kidney fat percentage could be related to a higher accumulation of total carcass fat in the intermuscular fat depot in Boer goats.

The proximate analysis confirmed higher fat levels in sheep carcasses compared to goat carcasses. The low fat levels in goat meat were comparable to results by Hogg *et al.* (1992), who reported that goat meat contained little fat and therefore relatively high levels of protein and minerals. Goat breeds contained less fat but higher moisture content than sheep breeds. The same trend was reported by Rowe *et al.* (1999) where lambs with the lowest amount of fat had highest moisture content.

According to Hadjipanayiotou & Koumas (1994), goat and sheep meat are preferred to fat-tailed sheep breeds because weight for weight goat meat and lamb have a higher lean content in the carcass. This observation correlated with the proximate analysis results which demonstrated a much higher fat content in sheep than in goat meat. The water content of meat varies largely in relation to the fat content. As the fat content increases, water content in the tissue decreases and approaches the water content of adipose tissue which is about 10 %. The same pattern was observed in this study because the goats which were leaner compared to sheep exhibited a higher moisture content.

The effect of breed on the primal cut yield was apparent on the forelimb, ventral trunk, dorsal trunk and the hind-leg. The neck % was the same for the sheep and goat breeds. Boer goats and Indigenous goats had proportionally heavier forelimb, ventral trunk and dorsal trunk and the sheep breeds had heavier hind-leg. This observation is in line with the report made by Hadjipayiotou & Koumas (1994), where there was a lower proportion of fore limb in Chios lambs compared to Damascus kids. Gaili & Ali (1985) observed slightly better developed forelimb and neck + thorax in goats compared to sheep. These researchers also reported lower proportions of forelimb in lambs compared to goats.

There were differences in the subcutaneous fat percentages for both goat and sheep breeds in the primal cuts analysed. The Dorper sheep contained more lcuts analysed than Damara sheep because of differences in total carcass SCF. Compared to goat breeds, the sheep breeds contained more SCF than goat breeds. Warmington & Kirton (1990) reported that SCF develops slower in goats compared to sheep. Casey (1982) found goat carcasses to contain proportionally less SCF but more intermuscular fat (IMF) which in this study could be a reason for the high meat (muscle + IMF) content observed in Boer goats.

Compared to the sheep breeds, the amount of lean meat of goat breeds was not completely out of range. For example the dorsal trunk of Indigenous goats contained proportionally more lean than Damara, Boer goats and Dorper although, the proportional yield of this cut was lower in the Indigenous goat compared to other breeds and also the Indigenous goat is much leaner than these breeds. The better performance of Boer goats compared to Indigenous goats could be attributed to the fact that unlike Boer goats, Indigenous goats are not an improved meat breed. Although sheep meat is perceived as better quality meat than goat meat, the proportional amount of lean found in the hindleg of Boer goats exceeded that found in the hind-leg of Damara sheep due to large differences in fat content. This observation was in contrast to Gaili & Ali (1985), who reported that goats have less developed leg muscle compared to sheep although the basis of comparison was different to that in this trail. The hind-leg is perceived to be an indicator of quality as far as retailers are concerned. Boer goat hind leg demonstrated a high content of muscle, an indication of desirable meat quality. This trend disputes a statement that, in general, goat carcasses contain a high proportion of total muscle, but its distribution into higher valued carcass regions is less favourable than in sheep. Boer goats also exhibited a higher content of lean than sheep in the neck and ventral trunk compared to sheep.

The carcasses of Boer goats were reported to be less compact compared to sheep carcasses (Fehr *et al.* according to Gall, 1981), but in contrast, the relatively high muscle to bone ratio observed in this study did not correspond with less compact carcasses. According to Naudé & Hofmeyr as cited in Gall (1981), in the market traditionally, Boer goats are regarded inferior due to poor muscling.

These researchers also found the hindleg of Boer goats to be significantly inferior to those of various types of lambs. In contrast to their reports in this study the meat yield of Boer goats compared favourably to sheep breeds mainly due to large differences in fat content. According to Naudé, as cited in Gall (1981), the stage of muscle development in the body of a growing animal is closely related to its level of fat deposition which signifies physiological development of the body tissues. Hogg *et al.* (1992) explained that the differences in fat content and consequently of bone and meat of different joints is a reflection of the pattern of fat deposition and stage of maturity of the animal.

The high bone content of Indigenous goats in the neck, ventral trunk and hind leg, can be explained by the observations made by Fehr *et al.* according to Gall (1981). They reported that most goat breeds are poorly muscled which is indicated by the percentage of bone in the carcass. The highest fat content was found in the ventral trunk and dorsal trunk of sheep breeds. According to Hadjipanayiotou & Koumas (1994), fat in lamb carcasses is acceptable to the consumers. An important feature of goat meat, especially when compared to mutton, is its fat distribution. Goats tend to deposit most of their fat internally (mesenteries, renal tract, and alimentary tract). This feature together with the reduced deposition of subcutaneous fat, makes goat meat leaner than mutton or beef (Devendra, 1988).

The relative high protein content and the low percentage fat found in goat breeds compared to sheep breeds lead to a favourable balance ratio of protein and fat content and is in agreement with the contemporary nutrient requirements (Riedel according to Raljic, Krajinovic, Mašic, Cvetkovic, Dzinic, Popov & Kunc, 1995).

The protein content of Indigenous goats shows the feasibility of utilizing native goats and sheep to assist developing countries in increasing meat production and thereby increasing sources of animal protein and providing a commodity for internal trade (Griffin, Orcutt, Riley, Smith, Savell & Shelton, 1992).

6.2 Fatty acid profiles of goat and sheep meat

Wismer-Pedersen according to Price & Schweigert (1987), reported that palmitic (C16:0), stearic (C18:0) and oleic (C18:1) comprised the greatest proportion of fatty acids in both sheep and goat meat which is in agreement with findings of this study. The degree of saturation was high in all the samples analysed with polyunsaturated acids showing the lowest mean values. According to Martín *et al.* (1999), low saturated to polyunsaturated ratio or high oleic content are important to reduce the risk of cardiovascular diseases. Consumers require meat that is lean and low in cholesterol. Although goat meat is lean, this study showed that the goat and sheep meat do not have the desirable molar proportions of saturated and polyunsaturated fatty acids. According to Dawkins, Phelps, McMillin & Forrest (1999), the fatty acid profile of goat meat can be improved by adding oat bran. They concluded that the addition of oat bran to goat meat produced a high percentage of unsaturated fatty acids and increased the mean values of oleic acid.

In this study, the lowest mean values found were of pentadecanoic acid. Webb (1994) reported significant increases in the molar proportions of pentadecenoic acid, margaric acid, heptadecenoic acid and oleic acid as a result of diet given to the animals. The degree of unsaturation between subcutaneous fat and the adipose fat depots have been reported to differ (Webb, 1994).

In this study, fat was not separated from the different depots but meat was minced together with fat and analysed as a composite sample. A higher proportion of saturated fatty acids is desirable when looking at the shelf life of a product because they are less prone to rancidity as opposed to their unsaturated counterparts. Saturated fatty acids as far as health is concerned are associated with heart diseases. Fatty acids affect the quality of meat particularly juiciness of cooked meat. According to Webb (1994), accumulation of fatty acids leads to the displacement of water molecules in the adipocytes and consequently the meat becomes less juicy. The results from this study confirmed that the higher the concentration of fatty acids, due to total fat differences, the less juicy the meat is.

The concentrations of saturated fatty acids were higher in goats than in sheep meat. The latter scored higher for juiciness and tenderness. The sheep patties scored high for juiciness and were also more flavoursome. Wood *et al.* (1999) reported that when the content of 18:3 was raised in lamb and beef of grass fed animals, the intensity of the flavour increased in comparison with grain-fed animals which consume and deposit relatively more linoleic (18:2). In ruminants very high levels of 18:2 caused cooked meat to be described as oily, bland or pork-like (Wood *et al.* 1999).

6.3 Meat quality of goat and sheep

According to Misock, Campion, Field & Riley (1976), aroma and flavour are the most important in determining palatability of cooked lamb. Although goat meat generally has a stronger aroma intensity than sheep meat, the overall aroma intensity of these two species was comparable. Schönfeldt (1989) in contrast found the aroma of sheep cuts to be significantly more intense than those of the goat cuts. Boer goat meat flavour was found to be more intense than that of Indigenous goat meat with sheep meat flavour significantly more intense compared to goat meat. The panellists were able to distinguish goaty flavour from muttony flavour. The species related goaty and muttony aroma were distinguishable. Webb (1994) showed that the effect of diet on the sensory properties of meat is accomplished through the deposition of unique components in the fat, while the extend of the influence depends on the animal species since the diets of the two species differ (goats are browsers while sheep are grazers).

Webb (1994) concluded that both volatile fatty acids and long-chain fatty acids contributed to the flavour of lamb. Acceptability of ground beef patties has been correlated with fat content (Lin & Keeton, 1994). Berry (1992) showed that for ground beef patties, flavour intensity was affected by the fat levels. Differences between fat levels were minor at high levels of fat but more pronounced at lower levels.

The differences in flavour intensity between goat and sheep patties can be explained by the results of Berry (1992), who concluded that in lean beef patties, the flavour scores tended to be low because the meat flavour is masked by other flavours such as the metallic and liver-like flavours. In this study, the total subcutaneous fat of both goat breeds was less than 5 % which was probably not enough to mask undesirable flavours. According to Berry (1992), fat levels of more than 5 % in ground beef were required to mask flavours derived from meat lean.

Berry & Leddy (1984) did not find differences in flavour of cooked patties over a range of fat. Flavour differences between goat and sheep were due to differences in fat content. In addition to fat content, treatments such as high temperature conditioning and electrical stimulation increased flavour of goat meat (McKeith, Savell, Smith, Dutson & Shelton, 1979).

Scores for tenderness of sheep and goat differed. Sheep patties were found to be more tender than goat patties. Schönfeldt (1989) also found significant difference in tenderness between sheep, Angora and Boer goats although intact muscles (*Mm. Longissimus thoracis et lumborum* and *M. semimembranosus)* were used. Griffin ***et al.*** (1992) showed that sheep had the highest scores for juiciness, tenderness and overall palatability scores compared to goats. According to Johnson, McGowan, Nurse & Anous (1995), the toughness of goat meat could have been created by the effects of chilling on light-weight, thinly finished carcasses. Hogg *et al.* (1992) suggested that the tenderness of goat meat can possibly be improved by electrical stimulation and additional post-mortem aging, especially that of castrates and intact males. In their study, Hogg *et al.* (1992) reported that meat from carcasses that were conditioned for 48 hours was significantly more tender than meat from carcasses conditioned for 24 hours.

The present results suggest that such treatments are not sufficient to improve the tenderness of goat. Hogg *et al.* (1992) further suggested that specific levels of tenderness can be attained through appropriate time/temperature aging conditions. Smith *et al.* (1978) added that tenderness of goat meat can be improved by identifying a minimum age/weight for slaughter to assure that the carcass is large enough to prevent occurrence of processing toughness.

Tenderness of meat is determined by the collagen content and its solubility. According to Schönfeldt (1989), collagen content of Angora and Boer goat cuts were significantly higher than that of corresponding sheep cuts. Schönfeldt (1989) also reported that the collagen of sheep meat was more soluble than that of goat meat cuts. In general, the higher the insoluble collagen content, the tougher the meat. Although the collagen content of Boer goat is similar to that of the Pedi and Merino sheep breeds, it is significantly higher than that of Dorper and South African Mutton Merino sheep breeds (Heinze, Smit, Naudé & Boccard 1986). In this study, the same trend was observed with goat patties being more chewy and less tender than sheep patties probably due to collagen differences. There was a breed effect among the two sheep breeds. Dorper patties were more chewy than Damara patties. The meat patties of Damara and Dorper sheep scored higher than those of goat breeds in terms of greasiness. Greasiness was defined as the sensation of fattiness/greasiness in the mouth while chewing. This trend was expected because sheep lay more fat than goats.

Consumers are more conscious about their diet and tend to change their habits to consume leaner meat because of the increasing importance of chronic diseases, which are linked to morbidity and mortality due to dietary patterns, including the possible role of fat and, in particular, saturated fatty acids (Watson, 1994). Fat contributes to the sensory characteristics of meat in that the meat becomes juicer and more tender. The sensory evaluation results confirmed the above statement because sheep meat patties were rated as more tender and more juicy compared to goat meat patties.

The sustainable impression of juiciness reflected the expected results because Damara and Dorper patties scored higher than those of goat breeds. There was no significant difference in the juiciness within the sheep breeds. Boer goat patties followed sheep samples in juiciness and Indigenous goat samples were the least juicy.

7 CONCLUSIONS AND RECOMMENDATIONS

Goat carcasses are smaller than sheep carcasses of the same sex-type and age. In goats, the feet, liver and spleen are more developed which leads to lower dressing percentages. Goats compared to sheep have leaner carcasses and smaller overall size. The forelimb, ventral trunk and dorsal trunk of goats were heavier than those of sheep breeds while the hindleg of sheep breeds was more developed. Breed affects carcass composition because Dorper carcasses contained more lean and subcutaneous fat compared to Damara in all the primal cuts. This study proved that goat carcasses are not less compact compared to those of sheep, because the muscle content of Boer goats was comparable to that of both sheep breeds. Indigenous goats have a high bone content compared to Boer goats, which also influences the muscle to bone ratio.

This study confirms that palatability attributes are determined by the species and diet particularly in terms of meat flavour. Aroma of meat is a species related quality because goat patties were more goaty and mutton patties were more muttony. In general, this study showed that the overall aroma intensity of goat and sheep meat is comparably strong which disputes the notion that goat meat has a stronger aroma intensity. Sheep meat patties are more tender, juicy and less chewy than goat meat patties. Boer goat patties were more juicy than Indigenous goat patties because Boer goat carcasses contained more fat than their Indigenous counterparts.

Although both sheep and goat meat contain high levels of saturated fatty acids, the tenderness and juiciness of sheep meat is enhanced by lower concentrations of saturated fatty acids compared to goat meat.

Goat and sheep meat should not be compared because although they are both small ruminants, they are two different species and therefore have different qualities like carcass fat content. There are non-meat flavours (metallic flavours) that are found in lean meat. These flavours affect the flavour ratings of meat patties by masking them. Since goat meat contains very little fat, addition of seasoning and flavourants may enhance flavour scores.

Subcutaneous fat should not be used as a predictor of yield for goats because goats have a poor fat covering on the carcass. Goats should be valued as a different species. The tenderness of goat meat can be enhanced by fattening the live animals. Fattening would increase the amount of undesirable fat, but goats respond to fattening by depositing more fat internally (gastrointestinal tract) which will not be consumed as part of meat/muscle. Tenderness of goat meat can also be boosted by a good choice of a cooking method-slow, low heat braising is advisable. The age at which animals are slaughtered influences the eating qualities of meat. Meat of young animals is generally more tender compared to meat of older animals of the same species. Castration of goats reduces the unfavourable goaty smell and carcasses from castrated males have a higher fat content than intact males.

Consumers value low-fat, high quality products. Goat meat can be used as a raw material in the manufacture of value-added products leading to a well developed goat market because of its low fat content, The Boer goat which is an improved breed compared to Indigenous goats can compete with sheep breeds in terms of meat quality characteristics. The relatively poor performance of Indigenous goat carcasses can be improved by implementing breeding techniques and changing production systems by using improved feeding. These animals have a high fertility and produce fast growing kids. Under proper management, goats can rapidly contribute towards agriculture and to improve the livelihoods of people in the rural areas by increasing small ruminant meat supply.

Farming cattle and goats together can increase income because goats are mainly browser and therefore do not compete with cattle which are grazers. Proper marketing of goat meat and meat products can educate consumers about such products and probably eradicate the prejudice towards goat meat. Marketing can facilitate the channeling of goat meat products into appropriate trade areas and to specific consumers.

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