RMDRD-PC

NEW PROJECT PROPOSALS AND LITERATURE REVIEWS

Focus Area 5 - Red Meat Safety, Nutritional Quality and Value(Dr L. Simela)

Project: Goat Meat Nutrient and Sensory Analysis

Literature Review

Nutrient composition and sensory quality attributes of goat meat obtained from South African Indigenous Goats

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Introduction

South Africa possess a large number of goats estimated at 6.454 million, of which 2 million are considered commercial and the rest, the 4.454 million are communal and mostly in the rural and peri-urban areas according to the Department of Agriculture, Forestry and Fisheries (DAFF, 2010a). These are also distributed according to province (Table 1), with the E. Cape having the highest percentage (36%) followed by Limpopo (21%) then KwaZulu Natal (13%). The other 30% is amongst the other remaining provinces. South Africa possesses approximately 3% of the total goat population in Africa and less than 1% in the whole world (DAFF, 2010a).

Table 1: Provincial distribution of live goats. Adapted from DAFF,2010a..

Province	**Number of live goats (‘ 000)**
Western Cape	230
Northern Cape	528
Free State	258
Eastern Cape	2 385
KwaZulu Natal	865
Mpumalanga	95
Limpopo	1, 313
Gauteng	45
Northwest	735
	6.454

Source: Agricultural Statistics

Goat meat herein after referred to as 'chevon' has had a steady production rate over the last ten years (1999-2008) and has thus increased its gross value nationally to R133 843 252. Goat breeds, namely the Boer goat, Angora, Savanna and the Kalahari Red are generally owned by "white" commercial farmers whereas the communal goats herein referred to as 'Indigenous Goats' are mostly owned by "black" small-scale subsistence farmers. Such Indigenous Goats are used for their meat and milk but they do not have optimal production conditions, and so they have small carcasses/low meat yields and low milk yields, which can only be sufficient to provide for their kids (DAFF, 2010b).

According to a United States Agency for International Development & Agricultural Research Council-Animal Nutrition and Animal Products Institute (USAID/South Africa & ARC-ANPI, 1998) market survey conducted on the goat industry in South Africa it would seem that little scientific information on goat meat is available in South Africa. Goats are kept and used for cultural traditions (weddings, funerals and other traditional rituals) as well as for subsistence farming and therefore goats are considered to be a commercially under-utilised resource. The unavailability and low consumption rates may be due to problems related to marketing, supply, unfamiliarity with or a dislike of goat meat. The report states that for the goat meat to enter into the mainstream red meat industry, it will have to be accepted and appreciated for its specific characteristics (USAID/South Africa & ARC-ANPI, 1998). In Africa, the low goat production (primary: animal breeding and production and secondary: value addition) rates could be attributed to basic production issues, post-harvest meat quality, infrastructural and government policies and such factors could prevent countries from participating in the global goat meat market and trade (Simela & Merkel, 2008).

This literature review focuses on the nutrient composition and sensory quality attributes of chevon from South Africa's Indigenous Goats. Data from the study (nutrient analysis), the nutritional profile, will be useful for the local red meat industry, Medical Research Council's nutritional database as well as the community at large.

1.1 Overview of the goat meat industry

The goat meat industry in South Africa is still at it infancy stages (DAFF, 2010b). Most of the slaughtering is done informally in most communities, no records are kept and consumption is for purely for ceremonial purposes. Goats which are slaughtered in the commercial sector are the Boer and Angora types. It still remains a fact that South Africa mostly imports live goats and chevon from Namibia and exports it to other African States, with Nigeria having the larger share of 88% in 2008. Most of the meat for export was from the Gauteng Province and this could be due to the fact that this province is regarded as the collection point with a lot of mini-companies doing the retail transactions meaning that foreign nationals in South Africa exporting chevon to other African States. The consumption of chevon has since 1999 increased in South Africa due to the influx of different ethnics groups from neighbouring countries. Australia still remains the major exporter of goats (DAFF, 2010b). The Indigenous Goat Industry is still not organised at any provincial or national level. The development and initiation of a formal goat industry in South Africa was started through a programme entitled "The Commercialisation of Indigenous Goat Production and Products" which entails the primary (animal production) and secondary (meat, milk, leather and cashmere) production of such products (Roets, 2002). A project of that nature, viz. the Umzimvubu Goat Processing Facility was initiated in the period of 2002-2004 in the Eastern Cape and includes an abattoir and a craft centre The development of such a processing model was a result of research and studies conducted to commercialise and formalise such an enterprise (Roets, 2004). In other provinces within South Africa efforts are put into to commercialise Indigenous Goats but it still remains that these types of goats are kept by farmers in rural and peri-urban communities for household consumption as well as for the generation of income through sales (Anteneh, Mekala, Mnisi, Mukisira, Muthui, Murungweni and Sebitloane, 2004; Kayamandi Development Services, 2007).

1.2 Essential nutrients in meat and chevon

According to Whitney & Roelfes (1999), essential nutrients, which are chemical substances obtained from food with a sole purpose of providing the body with energy, are classified as inorganic (water and minerals) and organic (carbohydrates, lipids, proteins and vitamins). Meat is considered as one of the main source of protein, vitamins, minerals especially iron and other trace elements and forms part of a balanced healthy diet for humans (Varnam & Sutherland, 1995; Feiner, 2006). The proximate composition of meat includes water, protein, fat/lipid and ash (minerals) in varying amounts depending on the species and is relatively constant over a wide range of animals (Varnam & Sutherland, 1995). Chevon compared to muscle tissue of othe meat animals has higher water content values and less fat (Table 1)

Table 2: Composition (%) of lean muscle tissue of meat animals.

Adapted from Varnam & Sutherland ,1995

Species	Water, %	Protein, %	Lipid/Fat, %	Ash,%
Beef	70-73	20-22	4.8	1.0
Chicken	73-77	20-23	4.7	1.0
Lamb	73	20	5-6	1.4
Pork	68-70	19-20	9-11	1.4
Goat[1]	69.8	24.83	7.9	0.97
Goat[2]	**75.84**	**20.60**	2.30	1.11

[1] Tshabalala (2003); [2] USDA (2010)

1.2.1 Water/moisture

Water constitutes 70% of the weight of raw meat at slaughter and is inversely related to the fat content (Varnam & Sutherland, 1995). This component, in living animals is bound in between the myofibrils an after slaughter, water loss is inevitable and occurs due to drip loss, evaporation during storage as well as during the processing of meat i.e. cooking. Loss of water often affects the weight of the meat and, in turn, its value economically (Varnam & Sutherland, 1995). The moisture content of goat tissue muscles seems to be higher that

those of beef (USDA, 2010) but less in Indigenous Goats (Tshabalala, 2003) however with the highest protein content.

1.2.2. Fat/lipids and fatty acids

Fats/lipids and naturally, their building blocks, namely fatty acids, occur in meat in varying amounts and depending on the species. Fats are the most important source of food energy and are the carriers of fat soluble vitamins (A, D, E and K) and the essential fatty acids (namely, linoleic and linolenic acids.. Carcass fat can be intramuscular, intermuscular and subcutaneous and fatty acids, which define the fat composition and its chemical configuration are classified as saturated, mono and poly-unsaturated (Feiner 2006). The human body can produce all fatty acids except two essential fatty acids, linoleic (C18:2) an omega-6 fatty acid present in vegetable oils, and linolenic (C18:3) an omega-3 fatty acid present in leafy vegetables. These essential fatty acids are the major constituents of cell walls and mitochondria and they produce a hormone-like substances, eicosanoids, which regulate the blood pressure, aid in blood clot formation and the immune response to injury and infections (Lawrie, 1998; Whitney & Rolfes, 1999). Mono-unsaturated fatty acids when compared to saturated fatty acids, they tend to lower the total low density lipoproteins (LDL) cholesterol levels and increase the high density lipoproteins (HDL) cholesterol levels and thus minimising coronary heart diseases (Kris-Etherton, 1999).

The effect of the sex and age on the composition and proportions of fatty acids in muscle tissue of Indigenous Goats were analysed (Simela, 2005). The results showed that the concentration of unsaturated fatty acids, oleic (C18:1) and linoleic (C18:2) as well as the saturated fatty acid, palmitic (C16:0) were higher and had a tendency to increase with the age of the animal. However, this will mean that younger animals have less saturated fatty acids and, on the other hand, older animals, will have more of the unsaturated fatty acids.

Table 3: Summary of fatty acid concentration in chevon from Indigenous Goats. Adapted from Simela, 2005.

Fatty acid	0 teeth	2 teeth	4-6 teeth	8 teeth	IG[1] [1]
SFA	11.30	14.73	15.09	18.69	53.6
UFA	27.15	33.70	26.90	38.88	46.4
MUFA	18.57	25.02	19.98	29.28	42.5
PUFA	9.81	8.86	6.92	9.56	3.9

IG=Indigenous Goats

[1] Tshabalala (2003)

1.2.3. Amino acids

Nutritionally meat is regarded as a good source of essential amino acids, certain minerals and to a lesser extent vitamins (A, B1 and nicotinic acid) which are found in organ meat, the liver (Lawrie, 1998) and between the breed, specific muscle location, animal age, the amino acid composition may differ (Table 2). Amino acids are considered as the building blocks of proteins. In the nutrition of humans, the body has the ability to synthesize major amino acids using nitrogen derived from food sources and other amino acids, considered essential are insufficient and hence they should be supplied to the human body by consuming foods containing them. However, like amino acid, tyrosine (non-essential) is considered conditionally essential because it can only be made from phenylalanine an essential amino acid (Whitey & Roelfes, 1999; Feiner, 2006). According to Simela (2005), in analysing the amino acid composition of Indigenous Goats, alanine and tyrosine were affected by the age of the animal whereby, their composition increased from that of kids<young female goat< young castrated male goat< mature female goat. Table 2 shows the average values of amino acids composition of Indigenous Goats in South Africa. These results show that nutritionally, chevon has the ability to provide humans with essential amino acids.

Table 4: Amino acid composition in fresh meats (values/100g)

Amino acid	Category	Beef	Pork	Lamb	Goat[1]	Goat[2]
Isoleucine	Essential	5.1	4.9	4.8	3.92	1.04
Leucine	Essential	8.4	7.5	7.4	7.07	1.71
Lysine	Essential	8.4	7.8	7.6	8.00	1.53
Methionine	Essential	2.3	2.5	2.3	2.24	0.55
Cysteine	Essential	1.4	1.3	1.3	0.92	0.24
Phenylalanine	Essential	4.0	4.1	3.9	3.54	0.71
Threonine	Essential	4.0	5.1	4.9	4.65	0.98
Tryptophan	Essential	1.1	1.4	1.3	0.88	0.30
Valine	Essential	5.7	5.0	5.0	4.07	1.10
Arganine	Essential /infants	6.6	6.4	6.9	5.6	1.51
Histidine	Essential/infants	2.9	3.2	2.7	2.43	0.42
Alanine	Non-essential	6.4	6.3	6.3	4.94	na
Aspartic acid	Non-essential	8.8	8.9	8.5	7.88	na
Glutamic acid	Non-essential1	14.4	14.5	14.4	14.00	na
Glycine	Non-essential	7.1	6.1	6.7	3.87	na
Proline	Non-essential	5.4	4.6	4.8	3.27	na
Serine	Non-essential	3.8	4.0	3.9	3.85	na
Tyrosine	Non-essential	3.2	3.0	3.2	3.14	0.63

Source: Lawrie,(1998); Goat[1]: Simela (2005); Goat[2]: USDA (2010)

na= Data not available

1.2.4 Vitamins and minerals

Vitamins are vital components in the human nutrition and their role is to assist enzymes to release energy from nutrients such as carbohydrates, fats and proteins (Whitney & Rolfes, 1999). According to Lawrie (1998) organ meats contain higher levels of vitamin contents than the muscular tissue especially vitamin A and B12. Meat, however, is considered as a good source of B-complex vitamins (B1: thiamine, B2: riboflavin, B3; niacin, B5: pantothenic, B6: Pyridoxine and B12: cynanocobalamin (Lawrie, 1998) and negligible amounts of vitamins D, E & K, A and C which are found in meat organs than in muscle meat (Rice, 1971)..

The minerals in meat include sodium, calcium, phosphorus, potassium, magnesium, iron, copper and zinc However, Iron, copper and zinc occur in higher contents in beef kidney and liver (Lawrie, 1998). Inadequate data is available on the composition of mineral and vitamins in chevon; however some results are shown in Table 4 below.

Table 5: Nutrient composition of raw goat meat. Adapted from USDA, 2010

Nutrient	**Units**	**Value per 100 grams**
Minerals		
Calcium, Ca	Mg	13
Iron, Fe	Mg	2.83
Phosphorus, P	Mg	180
Potassium, K	Mg	385
Sodium, Na	Mg	82
Zinc, Zn	Mg	4.00
Copper, Cu	Mg	0.256
Manganese, Mn	Mg	0.038
Selenium, Se	Mcg	8.8
Vitamins		
Thiamin (B-1)	Mg	0.110
Riboflavin (B-2)	Mg	0.490
Niacin (B-3)	Mg	3.750
Folate, total	mcg	5
Folate, food	mcg	5
Vitamin B-12	mcg	1.13
Vitamin A:IU , Vitamin A:RAE, Vitamin C, Folic acid & Retinol	mcg	All values were recorded to be: 0

1.3 Quality attributes of chevon

Little scientific information about chevon is available, yet it is and could be considered as a good source of protein (Roets, 2002). The overall meat quality in general could be defined by basic components and meat quality factors and these factors could be evaluated by various physical, biochemical, histological and sensory analyses (Simela, 2005). Some of these components are shown in Table 2 below.

Table 6: Meat quality components and factors (Simela, 2005)

Component	**Meat quality factor**
Yield and gross composition	Ratio of fat to lean
	Muscle size and shape
Appearance and technical characteristics	Colour and water holding capacity
	Fat texture and colour
	Marbling (intramuscular fat)
	Chemical composition of lean
Palatability	Texture and tenderness
	Juiciness
	Flavour
	Aroma
Wholesomeness	Nutritional quality
	Chemical safety
	Microbial safety
	Acceptable animal husbandry

In South Africa very few studies have been conducted regarding the Indigenous Goat meat and its products as most studies were conducted on chevon of Boer, Angora and a comparison is often to that of sheep meat/ mutton (Van Niekerk & Casey, 1988; Schönfeldt, 1989). In studies conducted by Tshabalala (2000), carcass characteristics of Indigenous Goats were compared to those of the Boer goat and sheep (Dorper and Damara). The results showed that the Indigenous Goats carcass was smaller in size as compared to that of the Boer goat and also from the two sheep breeds. This is attributed to the less fat on such goat carcasses and inversely affected by the feed intake where Indigenous Goats often roam and are reared extensively. Chevon can be acquired from goat kids as young as 8-12 weeks, young goats of 2-6 years and old goats of more than 6 years (Schönfeldt, 1989).In a review

conducted by Banskalieva, Sahlu & Goetsch (2000), it is stipulated that most of the research on chevon focuses on the effects of breed, age, sex and animal nutrition or rearing systems on the quality of the meat especially on fatty acid composition of goat muscles and fat deposition. Since chevon is considered to be lean, research often focuses on this aspect.

The effect of sex, age and pre-slaughter conditions on the characteristics of South African Indigenous Goats carcasses were determined and the quality of chevon assessed through sensory evaluation (Simela, 2005). The results showed that carcasses from Indigenous Goats are lean and have a low fat content - an observation typical in most goat breeds. Intact males and carcasses from younger animals of two-teeth and six-teeth stages yielded more meat. In similar studies, with the effect of sex, it was shown that chevon from females was more tender than that from their male counterparts which had lower carcass fat (Johnson, McGowan, Nurse & Anous 1995). With an age effect, animals as young as three to five months of age yielded tough meat and this could be attributed to light weight and thin carcasses due to the cold shortening of the muscle fibers (Smith, Carpenter & Shelton, 1978).

1.4 Nutrient composition of chevon

Chevon compared to other red meat is considerably regarded as a “healthy meat” as well as a potential source of protein due to its lower fat content, energy intake, lower cholesterol levels, high levels of unsaturated fatty acids such as, mono-oleic and poly-linoleic structure acids (Park, Kouassi & Chin, 1991; Tshabalala, 2000 & Simela, 2005) and such values correlate well with nutrient values profiled in the U.S. Nutrient Database Handbook according to the United States Department of Agriculture (USDA, 2010). Studies conducted by Simela (2005) showed that chevon from South Africa’s Indigenous Goats possess all of the essential amino acids and thus if consumed it could meet the dietary requirements of an adult consumer.

1.5 Sensory quality attributes of chevon

Sensory evaluation in the food industry is considered to be a vital tool in assessing the worthiness of a commodity and its acceptability and hence addressing an economic interest in the product/s (Meilgaard, Civille & Carr, 1991). Sensory evaluation techniques are often applied in conjuction with chemical and physical testing methods which help to clarify sensory scores (Palmer according to Schönfeldt, Naudé & Bok, van Heerden & Sowden, 1993). A market survey report taking into consideration the age, gender, population group showed that respondents were aware of chevon but it was not at the top of their list of meat preference., Their behaviour towards the meat was that they know of it, were aware of it And consume it occasionally and this was a response mostly from blacks, coloureds and Asians (USAID/South Africa & ARC-ANPI, 1998). Their perception towards it was that it is often used for traditional and religious purposes and on a negative note it was regarded as being smelly and tough (USAID/South Africa & ARC-ANPI, 1998).

Quality attributes of meat are evaluated by consumers based on the juiciness, tenderness, flavour and the overall acceptability. In most sensory studies conducted, chevon is often compared to that of lamb (Babiker, Khider & Shafie, 1990; Schönfeldt *et al*, 1993; Tshabalala, 2003) or beef (James & Berry, 1997; Rhee, Myers & Waldron, 2003) to asses characteristics such as the muscle colour, water holding capacity which addresses cooking losses, tissue strength as well as the subjective evaluation on the colour, flavour, juiciness, tenderness and the overall acceptability. Most of the results showed that the two meat types are different from each other and it would seem that lamb is preferred more than chevon. In most cases such results are supported by other parameters including the sex of the animal, the breed as well as the age. The results showed that meat from younger animals was more acceptable that that from older animals and this is due to the high levels of juiciness in cooked meat of younger animals (Schönfeldt *et al*, 1993) According to James & Berry (1997), chevon, due to its low fat content,. can be used in the development of low-fat comminuted meat products.

1.6 Problem statement

Chevon compared to other red meat, is regarded as a “healthy meat” as well as a good source of protein due to its lower fat content, calorie intake and lower cholesterol levels (Park, Kouassi & Chin, 1991 & USDA, 2010).

Published information related to the quality and the nutritive value of chevon as compared to other meat types is scarce and this could also be attributed to the fact that chevon has received limited attention by human nutritionists to regard and classify it as “another” source of protein (Johnson, McGowan, Nurse & Anous, 1995). In South Africa little scientific information about the nutrient content of chevon is available and yet chevon could be regarded as a major source of protein amongst the low income earners as well as most non-ethnic consumers. A study could be conducted to focus on:

- the nutrient content chevon from Indigenous and Angora goats (different age group and fat codes) which encompasses proximate analysis, fatty acid profile, cholesterol levels, water and fat-soluble vitamins, minerals as well as amino acid profiles including cysteine, tryptophan and methionine and
- a descriptive sensory evaluation of the traditionally and “modern” cooked meat taking into consideration the colour, flavour and aroma, juiciness, tenderness as well as the overall acceptability of the meat.
- The use of chevon in comminuted meats (chevon:beef proportions)

Table 7: Proposed experimental design

Age/Class	Fatness/Fat Code (1-3) 1= very lean, 2= lean & 3=medium			No. of carcasses per class/fat code	Total number of carcasses
A	A1	A2	A3	5	15
B	B1	B2	B3	5	15
C	C1	C2	C3	5	15
					45

Table 8: Summary of Methods Used for Nutrient Analysis

Analysis	Method
Proximate chemical analysis	
Moisture (water)	Official Method 950.46 AOAC (2005)
Ash	Official Method 920.153 AOAC (2005)
Protein (N)	Official Method 992.15 AOAC (2005) (Dumas combustion)
Fat	Official Method 960.39 AOAC (2005) (Soxtec ether extraction)
Energy	Calculated (Atwater and Bryant, 1900)
Minerals	Official Method 956.01 AOAC (2005) – (Ion Chromatography) (IC) sub-contracted laboratory)
Water-soluble vitamins B_1, B_2 B_3 B_6 B_{12} Biotin, Folic acid & Pantothenic acid	High Performance Liquid Chromatography (HPLC) (Fellman et al. 1992) Official Method 961.14 AOAC (2005) Official Method ALASA 7.2.3 Official Method AOAC 986.23 (2005) Microbiological
Fat –soluble vitamins Retinol-Vitamin A Vitamin D	Liquid chromatograph
Fatty acid profile including CLA	Gas Chromatography (GC) (Christopherson and Glass, 1969)
Amino acids (18 amino acids including cysteine, tryptophan and methionine)	High Performance Liquid Chromatography (HPLC) (Fellman et al. 1992)
Cholesterol	Gas Chromatography (GC) (Smuts et al.,1992)

REFERENCES

ANTENEH, N.T., MEKALA, D.G., MNISI, P.E., MUKISIRA. C., MUTHUI, M., MURUNGWENI, C. & SEBITLOANE O., 2004. Goat Production and Livelihood System in Sekhukhune District of the Limpopo Province, South Africa: Opportunities for commercializing goats and their by-products. Agricultural Research Council: Working Document Series 118. pp 1-6.

BABIKER, S.A., EL KHIDER, I.A. & SHAFFIE, S.A., 1990. Chemical composition and quality attributes of goat meat and lamb. *Meat Science* 28, 273-277.

BANSKALIEVA, V. SAHLU, T. & GOETSCH, A.L., 2000. Fatty acid composition of goat muscles and fat depots: a review. *Small Ruminant Research* 37, 255-268.

FEINER, G., 2006. *Meat products handbook.* Cambridge, England: Woodhead Publishing Limited. Pp 3-6 & 21-27.

GRIFFITH, C.L., ORCUTT, M.W., RILEY, R.R., SMITH G.C., SAVELL, J.W. & SHELTON, M. 1982. Evaluation of palatability of lamb, mutton and chevon by sensory panels of various cultural backgrounds. *Small Ruminant Research* 8, 67-74.

JAMES, N.A. & BERRY, B.W., 1997. Use of Chevon in the development of Low-Fat Meat Products. *Journal of Animal Science* 75, 571-577.

JOHNSON, D.D., MCGOWAN, C.H., NURSE, G., & ANOUS. M.R. 1995. Breed type and sex effects on carcass traits, composition and tenderness of young goats. *Small Ruminant Research* 17, 57-63.

KAYAMANDI DEVELOPMENT SERVICES, 2007. Goat Meat Production: Feasibilty Study for Lepelle- Nkumpi Local Municipality. pp 12-20.

KRIS-ETHERTON, P.M., 1999. Mono-unsaturated fatty acids and risk of cardiovascular disease. *Journal of the American Heart Association* 100. pp 1253-1258.

LAWRIE, R.A., 1998. Meat and Human NutritionThe eating quality of meat. In: Lawrie's *Meat Science*. 64th Edition. Woodhead Publishing Series in Food Science and Technology. CambridgePergamon Press: United Kingdom. pp 259-269.

MEILGAARD, MM, CIVILLE, G.V. & CARR, B.T., 1991. Sensory evaluation techniques. New York- Boca Raton: CRC Press. pp192 & 213.

PARK, Y.W., KOUASSI, M.A. & CHIN, K.B. 1991. Moisture, total fat and cholesterol in goat organ and muscle meat. *Journal of Food Science* 56(5), 1191-1193.

RHEE, K.S., MYERS, C.E. & WALDRON, D.F., 2003. Consumer sensory evaluation of plain and seasoned goat meat and beef products. *Meat Science* 65, 785-789.

RICE, E.E., 1971. The nutritional content and value of meat and meat products. In: PRICE, J.F & SCWEIGERT (Ed). *The science of meat and meat products*. San Fransisco: W.H. Freeman and Company. pp 287-314.

ROETS, M., 2002. *Commercialisation of indigenous goat production and products in South Africa (2nd Edition).* Proceedings of a workshop held at the Animal Nutrition and Products Institute of the Agricultural Research Council on 24 June, 1997. Advisory Bureau For Development (Pty) Ltd. for Development: Pretoria. pp 5-7.

ROETS, M., 2004. From Folklore to feasibility: Commercialisation of South Africa's Iindigenous Goats. Ph.D. Dissertation, Department of Agricultural Economics. Extension and Rural Development. University of Pretoria. pp

129-142 & 212.

SCHÖNFELDT, H.C., 1989. A comparison of the quality characteristics of goat meat with those of sheep meat. Dissertation: Masters-Home Economics. pp 47-81.

SCHÖNFELDT, H.C., NAUDéÉ, R.T., BOK, W., VAN HEERDEN. S.M & SOWDEN, L., 1993. Cooking-and juiciness-related quality characteristics of Goat and sheep meat. *Meat Science* 34, 381-394.

SIMELA, L. & MERKEL, R., 2008. The contribution of chevon from Africa to global meat production. *Meat Science*, 80, 101-109.

SIMELA, L. 2005. Meat quality characteristics and acceptability of chevon from South African Iindigenous Ggoats. Ph.D. Dissertation, University of Pretoria. pp 198-210-212.

SMITH, G.C., CARPENTER, Z.L. & SHELTON M., 1978. Effect of age and quality level on the palatability of goat meat. *Journal of Animal Science* **5**, 1229-1235.

SOUTH AFRICA. -Department of Agriculture Forestry and Fisheries 2010b. National Livestock Statistics: Newsletter: -February, 2010.

SOUTH AFRICA. -Department of Agriculture Forestry and A??Fisheries. 2010a. Publications for Agricultural Marketing-Commodity Profiles: Goat market value chain profile, 2009-2010. pp 1-6.

TSHABALALA, P., 2000. Meat quality of South African indigenous goat and sheep breeds. Dissertation. M Inst Agrar Food Processing. pp 62-64.

TSHABALALA, P., STRYDOM, P.E., WEBB, E.C. & DE KOCK, H.L., 2003. Meat quality of designated South African indigenous goat and sheep breeds. *Meat Science* 65, 563-570.

USAID/SOUTH AFRICA & ARC-ANPI., 1998a. Market Survey Report-Volume 1. *Feasibility study of commercialization of indigenous Ggoats in South Africa.* Eccles Associates, Inc & Agriconcept (Pty) Ltd. pp 1-3.

USAID/SOUTH AFRICA & ARC-ANPI., 1998b. Market Survey Report-Volume 2. *Overview of the goat industry in South Africa*. Eccles Associates, Inc & Agriconcept (Pty) Ltd. pp 1-15.

USDA 20010. National Nutrient Database for Standard Reference. Release 23. http://www.nal.usda.gov/fnic/foodcomp/cgi-bin/list_nut_edit.pl. [Accessed January 2011].

VAN NIEKERK, W.A. & CASEY, N.H., 1988. The Boer Goat. II. Growth, nutrient requirement, carcass and meat quality. *Small Ruminant Reserch* 1. 355-368.

VARNAM, A.H. & SUTHERLAND, J.P., 1995. *Meat and Meat Product*. Technology, Chemistry and Microbiology. Chapman and Hall, London. pp 1-30.

WHITNEY, E.N. & ROLFES, S.R., 1999. *Understanding Nutrition* (8th Ed). Wadswort Publishing Company.pp 5-10,161-162 & 291-325.

WISMER-PEDERSEN, J., 1971. Chemistry of animal tissues: Water. In: PRICE, J.F. & SCWEIGERT (Ed). *The science of meat and meat products*. San Francsisco: W.H. Freeman and Company. pp 177-192.