THE INFLUENCE OF DIETARY ENERGY LEVELS ON SUBCUTANEOUS FATTY ACID PROFILES AND MEAT QUALITY IN SHEEP.

by

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Submitted in partial fulfillment of the requirements for the degree

M.Sc.(Agric)(Meat Science)

in the

Faculty of Agricultural Science

UNIVERSITY OF PRETORIA

Pretoria

1992

ABSTRACT

This study investigated the effect of nutritional energy levels on meat quality characteristics, through effects on the fatty acid profiles of the subcutaneous fat in sheep. Two rations containing 11.76MJ ME/kg DM and 10.18MJ ME/kg DM were fed to Dorper and SA Mutton Merino wethers from respectively 20.51 ± 2.51kg and 22.30 ± 3.99kg to 25, 31, 37 and 43kg live mass. M.longissimus lumborum samples were removed and a trained taste panel evaluated sensory parameters on a 10cm unstructured scale. Subcutaneous fat samples and plasma samples were collected, and various carcass measurements were taken.

It was found that high energy nutrition significantly increased the concentration of unsaturated fatty acids in the subcutaneous adipose tissue, with subsequent effects on the fat quality and sensory properties of lamb. Both the aroma and incipient juiciness of taste samples from wethers on the high energy treatment were noticeably improved, while the increased amount of fat, coupled with its poor consistency significantly impaired the overall acceptability of taste samples.

OPSOMMING

In die studie is die invloed van verskillende vlakke van energievoeding op subkutane vetsuurproefiele, vleiskwaliteit en vetkwaliteit nagevors. Twee rantsoene wat onderskeidelik 11.76MJ ME/kg DM en 10.18MJ ME/kg DM bevat het, is aan Dorper en SA Vleismerino hamels gevoer vanaf respektiewelik 20.51 ± 2.51kg en 22.30 ± 3.99kg tot 25, 31, 37 en 43kg lewendige massa. 'n Opgeleide proepaneel het M.longissimus lumborum monsters sensories geëvalueer op 'n 10cm ongestruktureerde skaal. Subkutane vetmonsters en plasmamonsters is versamel, en verskeie karkasmates is geneem.

Dit is bevind dat hoë energie voeding 'n betekenisvolle invloed het op die konsentrasie onversadigde vetsure van die subkutane adipose weefsel, en gevolglik ook op die sensoriese eienskappe en vetkwaliteit van lamsvleis. Die aroma en aanvanklike sappigheid van sensoriese monsters van lammers op die hoë energie voeding het 'n aansienlike verbetering getoon, hoewel die hoeveelheid en swak konsistensie van die vet die algehele aanvaarbaarheid van die monsters betekenisvol benadeel het.

Ad majorem Dei gloriam.
To the greater glory of God

I declare that this thesis for the degree M.Sc.(Agric)(Meat Science) at the University of Pretoria, has not been submitted by me for a degree at any other university.

SUMMARY

THE INFLUENCE OF NUTRITIONAL ENERGY LEVELS ON SUBCUTANEOUS FATTY ACID PROFILES AND MEAT QUALITY IN SHEEP.

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Summary:

The characteristics of lamb that contribute to its palatability are those which are agreeable to the eyes, nose and palate. Fat quality contributes greatly to these characteristics, and includes the amount of visible fat, firmness of the fat, colour of the fat and its fatty acid composition. Although the chemical and physical properties of fat have little influence on the commercial value of carcasses in South Africa, these properties significantly affect both the eating and keeping quality of meat.

Various factors affect the fat quality, but in this study the effect of high energy nutrition, coupled with breed (physiological

maturity) and slaughter mass on the subcutaneous fatty acid profiles and sensory properties of lamb were investigated.

Two rations containing 11.76MJ ME/kg DM and 10.18MJ ME/kg DM, compiled on an isoprotein and mineral basis, were fed ad libitum to 48 Dorper and 48 SA Mutton Merino wethers from respectively 20.51 ± 2.51kg and 22.30 ± 3.99kg to 25, 31, 37 and 43kg live mass. The sheep were slaughtered and the carcasses electrically stimulated (21V, 60Hz, 120sec) and chilled overnight (4°C). The left loin (M. longissimus lumborum) of wethers in the 37 and 43kg slaughter groups were removed, vacuum packed and stored (-20°C) until evaluated. After thawing, the loin samples were roasted in an oven (160°C) to an internal temperature of 70°C. Total cooking loss, drip loss and evaporation loss were determined. A trained taste panel evaluated sensory parameters (aroma, incipient juiciness, sustained juiciness and overall acceptability) on a 10cm unstructured scale. Subcutaneous fat samples and plasma samples were collected for subsequent fatty acid determinations. Various carcass measures were recorded.

Growth results obtained indicate that breed affected the amount of days fed and the subcutaneous fat thicknesses, while treatment emphasised the above-mentioned breed differences. Carcass widths over the shoulders and buttocks were greater for the later physiological maturing breed, but the hind leg lengths of the early maturing breed were longer. The high energy treatment improved both the hind leg compactness and carcass compactness of wethers.

Treatment significantly affected the fatty acid profiles of the subcutaneous fat of wethers. The high energy treatment significantly increased the concentration of unsaturated fatty acids in the subcutaneous fat depots. Higher concentrations of C18:1(*trans*) were found in the subcutaneous fat of wethers on the high energy treatment in comparison with that of wethers on the moderately high energy treatment.

This shift in the subcutaneous fatty acid profiles of wethers on the high energy treatment was not significantly correlated with

changes in the plasma fatty acid profiles, but is due to an ecological succession of predominating types of bacteria in the rumen, and subsequently high concentrations of propionate and methylmalonate (changed end products of ruminal fermentation) are synthesised to branched and odd-numbered fatty acids.

The high energy treatment markedly improved both the aroma and incipient juiciness of taste samples as a result of higher concentrations of unsaturated fatty acids in the subcutaneous fat. However, both the flavour and overall acceptability of taste samples were impaired by high concentrations of unsaturated fatty acids in the subcutaneous fat subsequent to high energy treatment. These increased concentrations of unsaturated fatty acids in the subcutaneous fat reduced the firmness of the fat, and resulted in a undesirable fat colour.

Although both carcass fatness and subcutaneous fat thickness improved the sustained juiciness of taste samples, their effects on the overall acceptability of M.longissimus lumborum samples were extremely detrimental. The odour of taste samples was influenced preferentially by treatment, while the firmness of the subcutaneous fat was indirectly dependent on breed, treatment and slaughter mass through their effects on the concentration of unsaturated fatty acids in the subcutaneous fat.

Finally, regression models were calculated to quantify the relationship between sensory characteristics and a set of independent variables.

ACKNOWLEDGMENTS

Many people were involved simultaneously in this project which encompassed various fields of study namely Meat Science, Animal Nutrition, Physiology, Biochemistry and Home Economics. I therefore wish to thank the following people without whom this study would not have been possible:

Prof. N.H. Casey from the Department of Livestock Sciences at the University of Pretoria, for his help, leadership and support which led to the succesful completion of this study.

Mr. W.A. van Niekerk from the Department of Livestock Sciences at the University of Pretoria, for his advice and support during the trial.

Mrs. M.J.C. Bosman from the Department of Home Economics and Dietetics at the University of Potchefstroom for Christian Higher Education for conducting the sensory evaluation work.

Prof. A.I. Louw from the Department of Biochemistry at the University of Pretoria for his valuable advice and interest with regard to the fatty acid analysis.

Prof. D.J. Stoker from the Human Sciences Research Council (HSRC) and Prof. H.T. Groeneveld from the Department of Statistics at the University of Pretoria for invaluable advice concerning the statistical analysis of data.

Mr. E.B. Spreeth from the Department of Livestock Sciences at the University of Pretoria for his assistance with the laboratory procedures.

Mr. R. Coertze, Mr. T. de Bruyn and their team (in particular Mr. Lucas Sibidi) from the Experimental Farm at the University of Pretoria for their management, help and support during the run of the trial.

My wife, Elize, for her unselfish love, inspiration and support. Also a special word of thanks to my family for their love, understanding and keen support.

Finally, a word of appreciation to the Meat Board, the Foundation for Research Development (FRD), The Standard Bank of South Africa, the South African Society of Animal Production and the University of Pretoria for post graduate bursaries which enabled me to undertake this study.

ABBREVIATIONS

ADG	- Average daily gain (g)
AI	- Aroma-intensity
%B	- Percentage bone in three-rib
B1 and B2	- Hind leg lengths (cm)
CCM	- Cold carcass mass (kg)
CCM/B1 and CCM/B2	- Hind leg compactness (kg/cm)
CCM/K2	- Carcass compactness (kg/cm)
CW1	- Hindlimb width (cm)
CW2	- Forelimb width (cm)
D	- Dorper
D%	- Dressing percentage
%DL	- Percentage drip loss
DM	- Dry material
%EL	- Percentage evaporation loss
F	- Flavour
%F	- Percentage fat in three-rib
%FD	- Percentage fat in drip
HDL	- High density lipoproteins
H	- High energy feeding treatment
IJ	- Incipient juiciness
IU	- International units
K2	- Carcass length (cm)
LDL	- Low density lipoproteins
%M	- Percentage muscle in three-r2ib
M	- Moderately high energy feeding treatment
%ME	- Percentage meat extract in drip
ME	- Metabolisable energy
MJ	- Mega joules
OA	- Overall acceptability
RSM	- Three-ribcut sample mass (g)
R%SFA	- Relative percentage saturated fatty acids
R%UFA	- Relative percentage unsaturated fatty acids

S	- SA Mutton Merino
SCF10	- Subcutaneous fat thickness over 10th rib (cm)
SCF13	- Subcutaneous fat thickness over 13th rib (cm)
SFA/UFA	- Saturated vs. unsaturated fatty acid ratio
SJ	- Sustained juiciness
SM	- Slaughter mass (kg)
t	- Time on feed (days)
%TCL	- Percentage total cooking loss
TM	- Target mass (kg)
TVD	- Total volume drip (ml)
ULM	- Unroasted loin mass (g)
VFD	- Volume fat in drip (ml)
VLDL	- Very low density lipoproteins
VME	- Volume meat extract in drip (ml)

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1 INTRODUCTION AND MOTIVATION

1.1 PROJECT THEME

Growth and Physiology in Farm Animals.

1.2 PROJECT TITLE

The study and quantification of the influence of dietary energy levels on subcutaneous fatty acid profiles and meat quality characteristics in sheep.

1.3 AIM:

I. To study subcutaneous fatty acid responses to differing nutritional energy levels in Dorper and SA Mutton Merino wethers,

II. To study the influence of nutritional energy levels on sensory properties of lamb in two physiologically divergent mutton sheep breeds, the Dorper and SA Mutton Merino;

III. To study the influence of nutritional energy levels on meat and fat quality characteristics in Dorper and SA Mutton Merino wethers.

MOTIVATION

This project is a continuation of the work reported by Casey and Van Niekerk (1985) and Casey, Van Niekerk and Spreeth (1988) on nutritional influences on fatty acid profiles of fat depots in ruminants, and hence meat quality characteristics.

The relevance of the present study to the meat industry is the changed palatability of lamb and mutton raised under high energy feedlot conditions. The Dorper producers in particular have expressed their concern at the possible changes that may

occur. Flavour, a component of palatability, is a complex characteristic influenced by aliphatic compounds, S-compounds, benzanoids, pyridines and other chemical compounds.

Fatty acids affect palatability either directly as short-chain volatiles or through the oxidation, decarboxylation or dehydration of long chain fatty acids, or their physical attributes, e.g. melting point, or texture. The fatty acid profile of subcutaneous fat of sheep may be influenced by increasing levels of maize fed, higher energy content of the ration, the type of pasture grazed and the level of carcass fatness. The ingestion of polyunsaturated C18 fatty acids may affect a shift in the biohydrogenation of these fatty acids so that larger proportions flow through to the duodenum in the unesterified form (Casey and Van Niekerk, 1985; Casey, Van Niekerk and Spreeth, 1988; Orskov, Frazer and Gordon, 1974; Orskov, Grubb, Webster and Corrigall, 1979; Duncan, Orskov, Frazer and Garton, 1974; Mayes and Orskov, 1974).

This shift may be due to various factors and a number of researchers (Tove and Matrone, 1976; Tove and Mochrie, 1963; Sumida, Vogt, Cobb, Iwanaga and Reimer, 1972; Rumsey, Oltjen and Priode, 1972; Garton, DeB Hovell and Duncan, 1972; DeB Hovell, Greenhalgh and Wainman, 1976; Orskov, Grubb, Smith, Webster and Corrigall, 1979; Orskove, Frazer and Garton, 1974; Mayes and Orskove, 1974; Casey and Van Niekerk, 1985; Casey, Van Niekerk and Spreeth, 1988) have tried to establish how it is accomplished. It seems possible that a number of factors are involved simultaneously in affecting this shift in the fatty acid profile.

There is still great uncertainty about the metabolic fate of the high concentrations of propionic acid in the rumen and that which flows through to the duodenum, subsequent to high

energy nutrition. Furthermore, the extent to which a lipid should be hydrolyzed in order to be absorbed, still remains uncertain (Baum, 1979). Lipids ingested in the food and synthesised in the rumen by micro-organisms are absorbed mainly in the duodenum and are transported in the plasma by specialised proteins (referred to as lipoproteins) to various sites in the body. Most studies conducted on lipoproteins have been aimed at studying and understanding cardiovascular disease. In this case the study of the lipoproteins is aimed specifically at establishing whether the fatty acid profile of the plasma lipoproteins differs significantly from that of the subcutaneous fat depots. A significant difference would imply that substantial synthesis de novo of fatty acids occurs in the major fat depots.

A quantification of the fatty acid profiles of the different lipoprotein fractions is attempted, since a shift in the fatty acid profile subsequent to high energy nutrition might cause an associated shift in the concentrations and proportions of fatty acids transported by the specific lipoprotein fractions (HDL, VHDL, LDL and VLDL). The aim is thus to determine whether the shift in the fatty acid profile of the fat depots of lambs on a high energy diet is associated with a concomitant shift in the plasma as a whole as well as the proportions of the different lipoprotein fractions.

Lastly it is postulated that as most previous lipid extraction procedures were conducted by using the ether extraction method (which is now considered to be an inadequete procedure), the chloroform-methanol lipid extraction procedure, together with the use of BHT, would provide a much more acurate determination of the precise fatty acid profiles of the different fat samples. It might very well be that these results differ markedly from those obtained in previous studies.

The value of this project to the meat industry lies in (i) recommendations with regard to feeding ruminants in order to produce the most acceptable product; (ii) a better understanding of the metabolism of long chain fatty acids; (iii) being able to determine the influences of both the diet and breed on fat quality; and (iv) the identification of specific fatty acids that may affect the palatability of lamb.

First a brief outline will be given of lipids and their classification and of lipid metabolism in ruminants in general as it might aid in understanding the complexities involved in lipids and lipid metabolism. Thereafter a detailed discussion of the materials and methods will be given, followed by the experimental results and discussion. Final conclusions will be made in the last chapter of this thesis.

2 LITERATURE REVIEW

2.1 CLASSIFICATION OF LIPIDS

2.1.1 Organic acids

Organic acids are all characterised by the same functional group -COOH, referred to as the carboxyl group (Baum, 1982). This carboxyl group is derived from a combination of carbonyl -CO- and hydroxyl -OH. Subsequently the organic acids are normally referred to as the carboxylic acids with the general formula 'RCOOH.

The carboxylic acid derivatives, acyl halides, acid anhydrides, esters and amides are obtained by substituting respectively a halogen atom, an acyloxy group, an alkoxy group or an amino group for the hydroxyl group of the carboxylic acid.

2.1.2 Broad lipid classification

The lipids are a heterogeneous group of organic compounds which are important constituents of plant and animal tissues. Lipids are considered to be the most important energy storage compounds in the animal kingdom.

According to Davies (1979) the one and only property which classifies lipids apart from all other groups of natural products is their solubility[1]. Lipids are therefore arbitrarily classed together according to their solubility in organic solvents such as benzine, ether, chloroform, carbon tetrachlorate (the so-called fat solvents) and their insolubility in water (Baum, 1982). Furthermore, the term lipid has been traditionally used to describe a wide variety of natural products including fatty acids and their derivatives, steroids, terpenes, carotenoids and bile acids.

[1]Lipids are relatively non-polar compounds which explains their solubility in polar solvents.

All the principal lipid classes consist of fatty acid[1] moieties linked by an ester bond to an alcohol, principally the trihydric alcohol, glycerol, or by amide bonds to long chain bases (Christie, 1982). The lipid sub-groups however, have little in common, either chemically or biologically, other than their source and solubility (Davies, 1979).

According to Christie (1982) lipids may be subdivided into two broad classes (i) "Simple" lipids which can be hydrolysed to give one or two different types of product per mol and (ii) "Complex" lipids which contain three or more hydrolysis products per mol.

Davies (1979) divides the lipid families into four major sub-groups: triglycerides, phospholipids, steroids and terpenes and carotenoids which are each again divided into sub-sub-groups as outlined in figure 2.1.

McDonald, Edwards and Greenhalgh (1981) however, give a broad but useful classification of lipids in figure 2.2. In this scheme lipids are divided in glycerol based and non-glycerol based lipids and the glycerol based lipids are again divided into simple and compound lipids.

2.1.3 Triacylglycerols

The bulk of fats, adipose tissue, fish liver oils and plant seed oils are triacylglycerides[2]. These triacylglycerides are formed by the condensation of fatty acids with glycerol. Triacylglycerols are thus the esters composed of three fatty acids and joined to a glycerol (a trihydroxy alcohol)(Baum, 1982). The reverse of the condensation reaction is hydrolysis. If a fat or oil is heated with sodium hydroxide solution, the

[1]Long-chain aliphatic monocarboxylic acid.

[2]These compounds were formally called triglycerides but an international nomenclature commission has recommended that this chemically inaccurate term no longer be used.

Figure 2.1. DIVISION OF LIPIDS INTO FOUR MAJOR SUB-GROUPS ACCORDING TO DAVIES (1979).

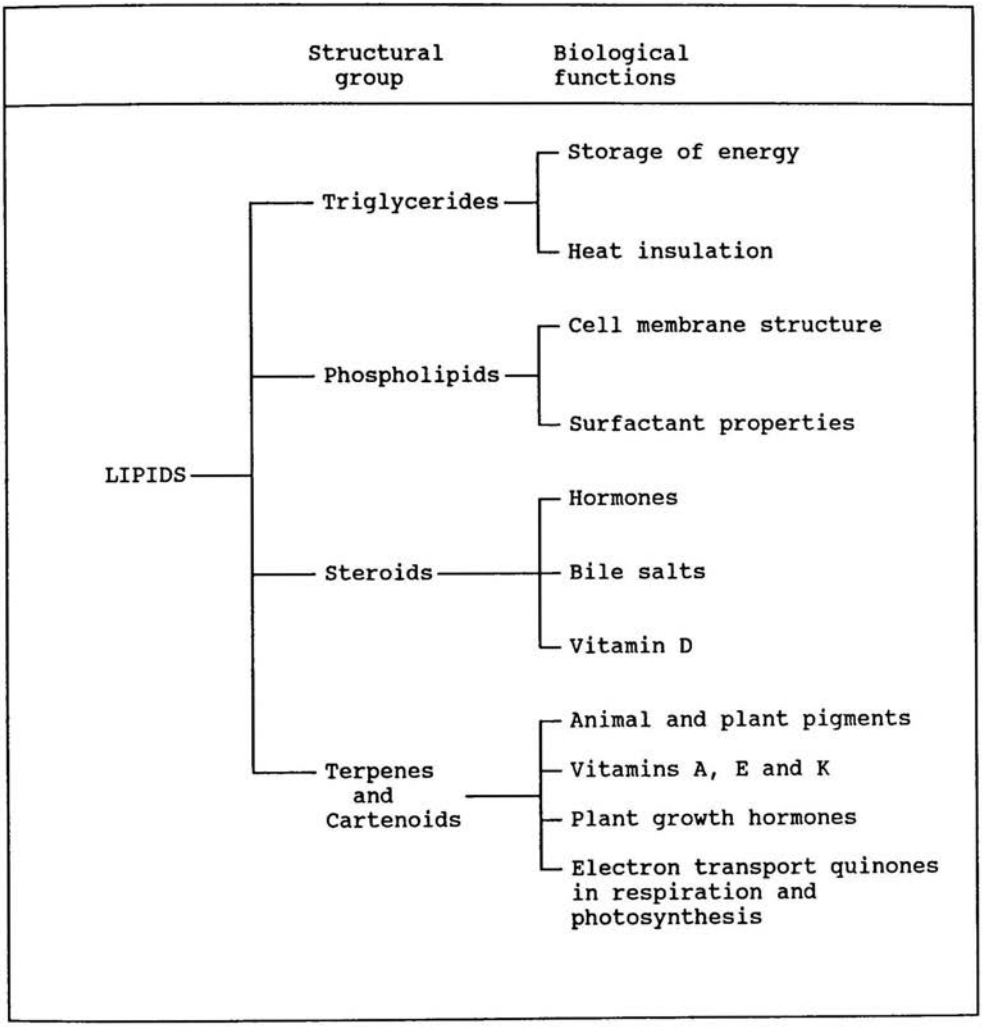
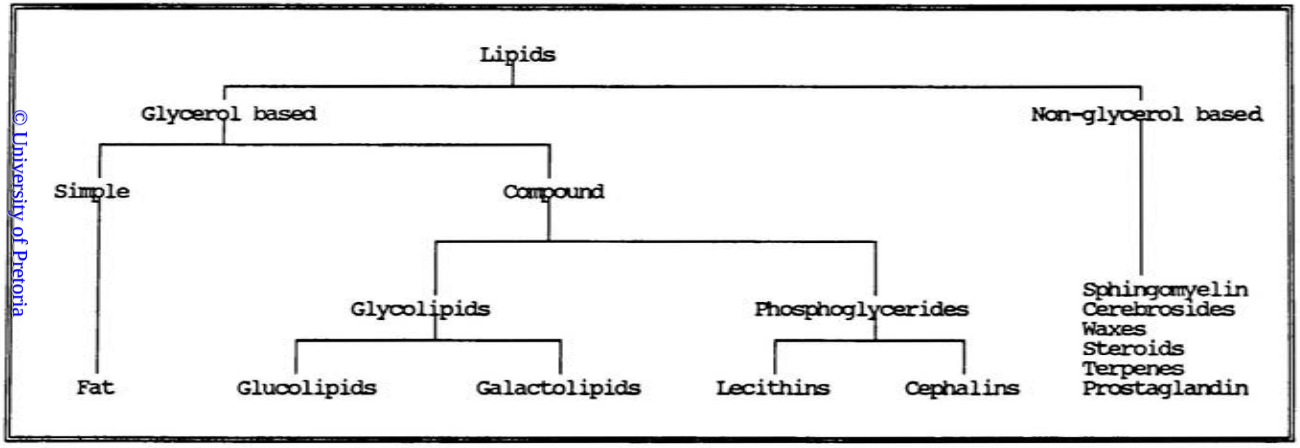
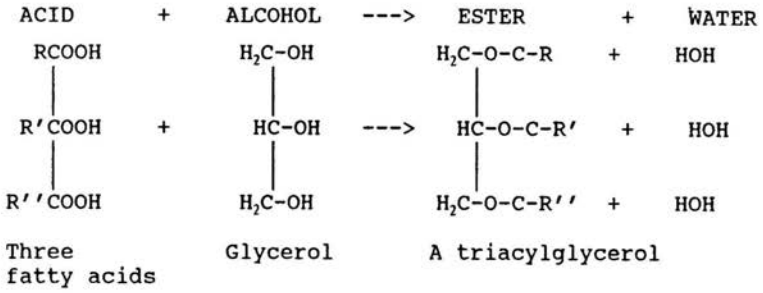


Figure 2.2. LIPIDS CLASSIFICATION ACCORDING TO McDONALD, EDWARDS AND GREENHALGH (1981).



ester bond is hydrolysed to release glycerol and the sodium ion replaces it to form the sodium salt of the fatty acids. This reaction is generally referred to as saponification (Davies, 1979).



2.1.4 Fatty acids

Fatty acids of plant and animal origin contain even[1] numbers of carbon atoms ranging from 4 to 24 in straight chains with terminal carboxyl groups (Christie, 1982; Davies, 1979). These fatty acids may be fully saturated or contain from one to six double bonds which generally, but not always, have the *cis*-configuration.

The greater the degree of unsaturation of a fatty acid, the lower the melting point. This is so because of the particular stereochemistry of the unsaturated fatty acids found in lipids which invariably has the *cis* rather than the *trans* configuration (Baum, 1982).

Unbranched saturated hydrocarbons (these carbon chains are extended in a linear zigzag fashion) are closely packed together and experiences stronger van der Waals attractions. According to Baum (1982) the presence of a *trans* double bond does not distort the linearity of the zigzag chain, but *cis* double bonds place a severe bend in the chain which results in a looser packing of molecules, weaker intermolecular attractions and a lowering of

[1]The reason for this is that the hydrocarbon chain of a given fatty acid is biosynthesized in two carbon units at a time.

the melting point (Figure 2.3.). It can be deduced that fats contain a greater proportion of saturated fatty acids and oils contain a greater percentage of unsaturated fatty acids.

Trans-unsaturated fatty acids are found in ruminants as a result of fatty acid modification in the rumen, and in other animals fed partly hydrogenated plant oils (Enser, 1984)[2].

Plant fatty acids are more complex compared to animal fatty acids in that they may contain a variety of functional groups such as acetylenic bonds, epoxy-, hydroxy-, or keto-groups and cyclopropene rings.

2.1.5 Saturated fatty acids

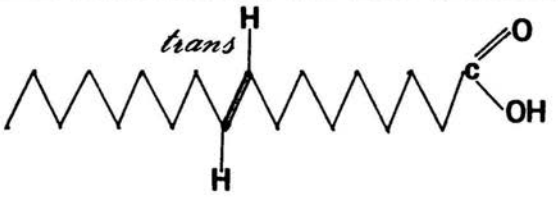
Ordinarily saturated fatty acids are straight chain even-numbered acids containing 14 - 20 carbon atoms. Odd and even-numbered homologues containing 2 - 30 or more carbon atoms have also been found in nature (Christie, 1982).

A list of the saturated acids of general formula $CH_3(CH_2)_nCOOH$ together with their trivial and systematic names and shorthand designations are given in Table 2.1. The C4 to C12 acids are found mainly in milk fats; however certain seed oils contain C10 and C12 acids. Decanoic and higher saturated fatty acids are solids at room temperature and are chemically comparatively inert (Christie, 1982; Baum, 1982).

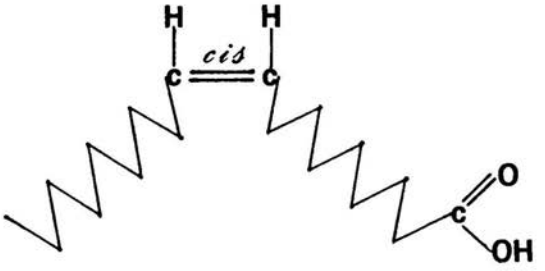
Although myristic acid (C14:0) is a minor component of most animal lipids, it constitutes major amounts in seed oils. On the other hand, palmitic acid is probably the commonest saturated fatty acid and is found in virtually all animal and plant fats and oils. According to Christie (1982) stearic acid (C18:0) is also relatively common and may even be more abundant in complex lipids than palmitic acid. Longer chain saturated fatty acids

[2]In "Fats in Animal Nutrition" Edited by J. Wiseman (1984).

occur less frequently. The odd-chain acids C15 to C19 are found in trace amounts in animal lipids.



Elaidic acid



Oleic acid

Figure 2.3. The presence of either a *trans*- or a *cis*-double bond on the linearity of the zigzag chain

Table 2.1. Saturated fatty acids of general formula $CH_3(CH_2)_nCOOH$ after Christie (1982).

Systematic name	Trivial name	Shorthand designation
ethanoic	acetic	C2:0
propanoic	propionic	C3:0
butanoic	butyric	C4:0
pentanoic	valeric	C5:0
hexanoic	caproic	C6:0
heptanoic	enanthic	C7:0
octanoic	caprylic	C8:0
nonanoic	pelargonic	C9:0
decanoic	capric	C10:0
hendecanoic	-	C11:0
dodecanoic	lauric	C12:0
tridecanoic	-	C13:0
tetradecanoic	myristic	C14:0
pentadecanoic	-	C15:0
hexadecanoic	palmitic	C16:0
heptadecanoic	margaric	C17:0
octadecanoic	stearic	C18:0
nonadecanoic	-	C19:0
eicosanoic	arachidic	C20:0
heneicosanoic	-	C21:0
docosanoic	behenic	C22:0
tetracosanoic	lignoceric	C24:0

2.1.6 Monoenic fatty acids

The monoenic fatty acids[1] which have been characterised from natural sources are straight-chain even-numbered fatty acids

[1]Also refered to as monoenoic fatty acids or monoenoic acids.

containing from 10 to 30 carbon atoms and with the double bonds in the *cis*-configuration. Monoenoic acids with the double bond in the trans-configuration are rarely found (Christie, 1982).

These fatty acids may have the double bond in a number of different positions i.e. oleic acid [C18:1(n), n=9] where n indicates the position of the double bond. (In the recommended numbering system the carboxyl carbon is carbon number one or C-1).

Oleic acid (C18:1) is the most abundant fatty acid in virtually all lipids of plant and animal origin (Christie, 1982). Furthermore a variety of positional isomers of monoenoic acids may be present in a single natural lipid.

Trans-isomers of monoenoic acids are rarely found. The *trans*-isomer of oleic acid (elaidic acid), however, is a by-product of biohydration of polyunsaturated fatty acids in the rumen and is subsequently found in small amounts in the lipids of ruminants.

Cis-monoenoic fatty acids consisting of eighteen carbon atoms or less are low melting-point compounds and the *trans*-isomers generally have slightly higher melting-points than the corresponding *cis*-compounds.

It is important to note that the susceptability of monoenoic fatty acids to chemical attack is increased by the presence of the double bond, particularly by oxidising agents. Christie (1982), however, states that these fatty acids are fairly resistant to autoxidation. A list of the more important monoenoic fatty acids is given in Table 2.2.

Table 2.2. Monoenoic fatty acids [$CH_3(CH_2)_mCH=CH(CH_2)_nCOOH$] after Christie (1982).

Systematic name	Trivial name	Shorthand designation
cis-9-dodeecenoic	lauroleic	C12:0(n-3)
cis-9-tetradecenoic	myristoleic	C14:1(n-5)
trans-3-hexadecenoic	-	C16:1[1]
cis-9-hexadecenoic	palmitoleic	C16:1(n-7)
cis-6-octadecenoic	petroselinic	C18:1(n-12)
cis-9-octadecenoic	oliec	C18:1(n-9)
trans-9-octadecenoic	elaidic	C18:1[2]
cis-11-octadecenoic	*cis*-vaccenic	C18:1(n-7)
trans-11-octadecenoic	*trans*-vaccenic	C18:1[2]
cis-9-eicosenoic	gadoleic	C20:1(n-11)
cis-11-eicosenoic	gondoic	C20:1(n-9)
cis-13-docosenoic	erucic	C22:1(n-9)
cis-15-tetracosenoic	nervonic	C24:1(n-9)

2.1.7 Non-conjugated polyunsaturated fatty acids

According to Mead (1968), as quoted by Christie (1982), non-conjugated fatty acids are subdivided into several simple families according to their biosynthetic derivation from single specific fatty acid precursors. These fatty acids contain two or more *cis*-double bonds, separated by a single methylene group and with the same terminal structure within families.

Linoleic acid [C18:2(n-6)], found in most plant and animal tissues, is the most common and simple acid of this class.

[1]The (n-x) nomenclature is only used with fatty acids containing *cis*-double bonds.

Linoleic acid is an essential fatty acid (EFA)[2] in animals since other fatty acids are synthesised from it by desaturation and chain elongation. The essential fatty acids are thus the unsaturated acids containing more than one double bond, namely linoleic, linolenic and arachidonic acids (Baum, 1982).

It is interesting that the enzymes in mammalian systems are only able to insert double bonds between the carboxyl group and the first double bond already present in the fatty acid, while plant enzyme systems can only insert new double bonds between the last double bond and the terminal portion of the fatty acid (Christie, 1982).

All the polyunsaturated fatty acids have very low melting points. Furthermore, there is a direct relationship between the susceptability of polyunsaturated fatty acids to oxidative deterioration (autoxidation) and the amount of double bonds they possess (Christie, 1982). The important polyunsaturated fatty acids are given in Table 2.3.

[2]These fatty acids cannot be synthesized by the organism.

Table 2.3. The important Non-conjugated polyunsaturated fatty acids after Christie (1982). $[(CH{=}CHCH_2)_m(CH_2)_x(CH_2)_nCOOH]$

Systematic name	Trivial name	Shorthand designation
9,12-octadecadienoic*	linoleic	C18:2(n-6)
6,9,12-octadecatrienoic	δ-linolenic	C18:3(n-6)
8,11,14-eicosatrienoic	homo-δ-linolenic	C20:3(n-6)
5,8,11,14-eicosatetraenoic	arachidonic	C20:4(n-6)
4,7,10,13,16-docosapentaenoic	-	C20:5(n-6)
9,12,15-octadecatrienoic	α-linolenic	C18:3(n-3)
5,8,11,14,17-eicosapentaenoic	-	C20:5(n-3)
4,7,10,13,16,19-docosahexaenoic	-	C22:6(n-3)
5,8,11-eicosatrienoic	-	C20:3(n-9)

The double-bond configuration in each instance is *cis*.

2.1.8 Branched-chain and cyclopropene fatty acids

According to Polgar (1971), as quoted by Christie (1982), branched chain fatty acids are common constituents of bacterial lipids and they can also enter the foodchain to appear in animal tissues. They are often found in small amounts in the fat depots of ruminant animals. Furthermore, animal waxes may contain significant amounts of branched-chain acids which are generally fully saturated compounds and which make them relatively resistant to chemical degradation.

2.1.9 Unusual fatty acids of plant and animal origin

Unusual fatty acids containing uncommon functional groups are most often found in plant lipids. Such unusual fatty acids may be detected in animal tissues after ingestion.

2.2 METABOLISM OF LIPIDS IN RUMINANTS

2.2.1 General

The fatty acids (present as esters of alcohols and mixed esters containing phosphoric acid and sterol moieties) are the most important lipid fraction, particularly in their role in the immune function, prevention of inflamation and as energy sources (Egan, 1976; Wan, Haw and Blackburn, 1989). Far larger quantities of energy are held as fatty acids in relation to energy in the form of ATP, phosphocreatin or glycogen.

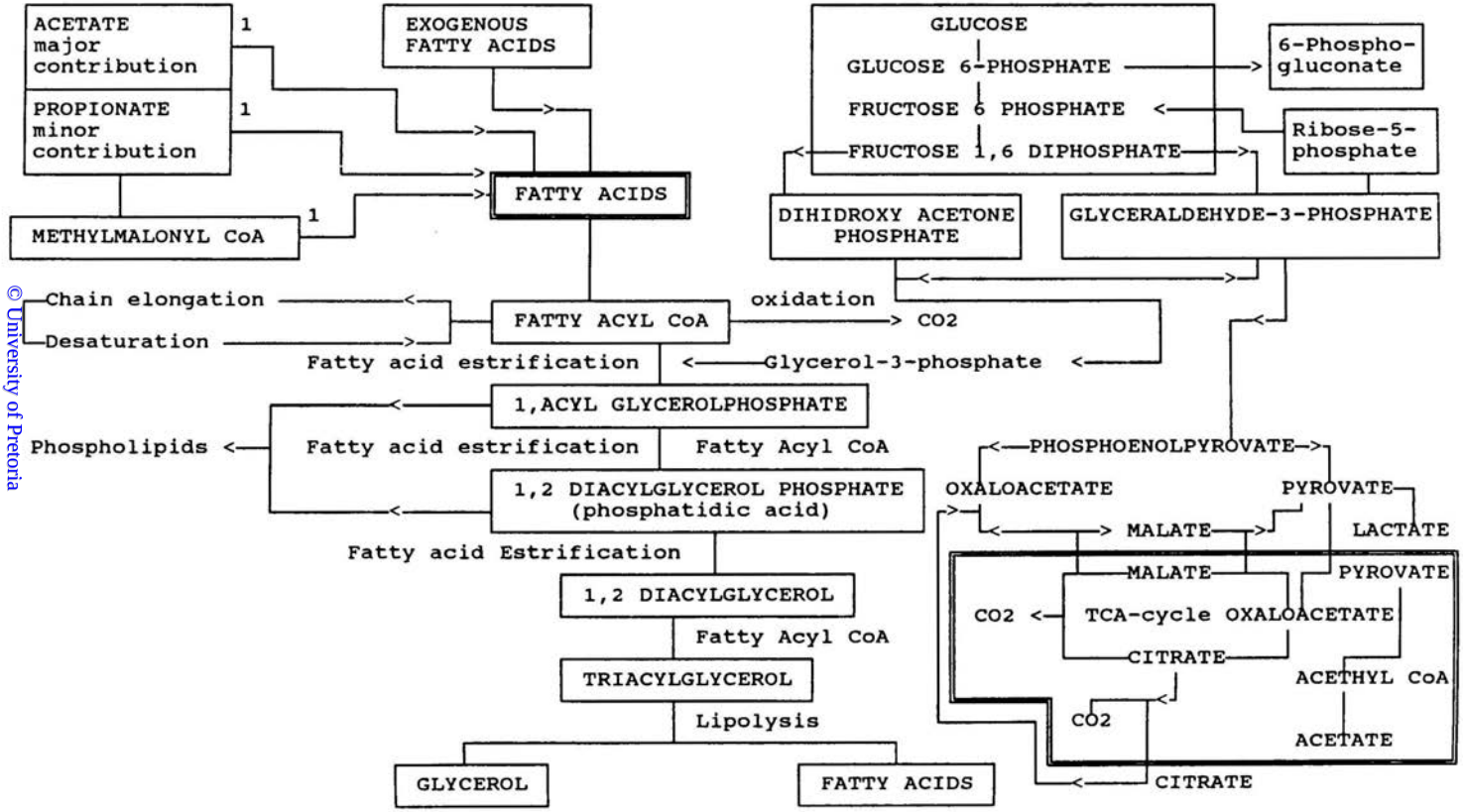
Fat accumulating cells are predominantly aggregated in adipose tissue depots in the body. The amounts of fat held in these depots are variable, but the proportion of energy provided in the diet plays a major role. Furthermore it is accepted now that the process of synthesis and breakdown of body fats continues at all times. The triglycerides of both the adipose tissue and the liver are in a state of rapid flux with constant release of free molecules of fatty acids from the glycerol esters, and subsequent resynthesis of fats (Egan, 1976).

According to Egan (1976) fat molecules appearing for the first time within any tissue may derive (i) directly from the diet, (ii) from other tissues by transfer or (iii) by synthesis *in situ*. A schematic representation of lipid metabolism in ruminants is given in Figure 2.4.

2.2.2 Digestion and absorption of lipids in ruminants

Many of the unusual features which characterize ruminant lipids and their metabolism can be related directly to the exposure of dietary lipids to the process which occurs within the rumen. In spite of the intermittent nature of feed intake in ruminants, the lipid content of the rumen digesta remains constant (Kutz and Keeney, 1966: Keeney, 1970). These authors indicated that on a diet consisting entirely of hay, the concentration of lipid in the rumen digesta is of the order of

Figure 2.4. SCHEMATIC REPRESENTATION OF LIPID METABOLISM IN RUMINANTS.



1 - Fatty Acid Synthesis

500mg/100g wet matter which is distributed between the feed particles and cell-free fluid (80%), protozoa (16%) and bacteria (4%).

The presence of lipolytic activity in the rumen contents has been known for many years. Investigations have shown that the lipolytic ability extends to a wide range of esterified substrates which may or may not be considered as natural constituents of the diet i.e. mono- and digalactosylglycerides (Dawson, Hemmington, Grime, Lander and Kemp, 1974; Hawke, 1971), phospholipids (Dawson, 1959; Hazelwood, Kemp, Lander and Dawson, 1976) and a wide range of triglycerides (Bath and Hill, 1967; Garton, Hobson and Lough, 1958; Garton, Lough and Vioque, 1959) as well as with substrates such as sterol esters, methyl esters and ethyl esters (Hill, Saylor, Allen and Jacobson, 1960). Garton, Lough and Vioque (1961) supported by Hawke and Silcock (1970) demonstrated that these hydrolitic processes in the rumen are both rapid and complete under normal circumstances.

As a result of the hydrogenation process, the C18 polyunsaturated fatty acids of the diet are converted to stearic acid together with smaller quantities of a wide range of positional and geometric isomers of other C18 components (Dawson and Kemp, 1970; Viviani, 1970). It has, however been demonstrated that hydrolysis of the ester linkages is a prerequisite for hydrogenation (Dawson *et al.*, 1974; Hawke and Silcock, 1969).

The mechanism of biohydrogenation is apparently complex and in spite of extensive investigations, the details still remain largely unresolved. Nevertheless, there is no doubt that the biohydrogenation process leads to the production of unesterified fatty acids. Under normal circumstances these unestrified fatty acids comprise only a minor portion of the dietary lipid intake, but become the predominant fraction of the digesta.

Lennox, Lough and Garton (1965) as well as Ward, Scott and Dawson (1964) have indicated that stearic acid constitutes by far the major fatty acid present in the digesta and the dietary linoleic, and linolenic acids are reduced to minor proportions - of the C18 monoenoic acids present, the predominant component is the *trans*-11 isomer. Hereafter the unesterified fatty acids are largely absorbed onto the surface of the particulate matter in the rumen.

Keeney (1970) demonstrated that although the long-chain unesterified fatty acids constitute by far the major dietary lipid class within the rumen digesta, some 20% of the total lipids are found in the protozoal and bacterial populations. The contribution of these microbial lipids to the digesta of the host animal is therefore considerable.

During the fermentation of a wide range of carbohydrates and proteins in the rumen, a number of short-chain (C_2 - C_5) volatile fatty acids are produced. The major components are acetic, propionic and butyric acids that contribute largely to the energy needs of the ruminant animal. According to Church (1969) a considerable proportion (between 60 and 80%) of the dietary energy available to the ruminant is absorbed in the forestomach.

Approximately 70% of the short-chain fatty acids are absorbed in the rumen (Weston and Hogan, 1971). The rate of absorption of these short-chain fatty acids appears to be proportional to their chain length i.e. butyric > propionic > acetic acid (Sutton, McGillard and Jacobson, 1963), as well as the relative concentration of each short-chain fatty acid within the rumen (control being exerted through the relative rates of formation of CoA esters).

It is interesting to note that while extensive metabolism of butyric acid occurs within the rumen epithelium with the

formation of ketone bodies, including ß-hydroxybutarate as well as the metabolism of a small proportion of the propionic acid in the rumen to lactate, little if any metabolism of acetate occurs within the rumen epithelium (Weigand, Young and McGilliard, 1972a; Ash and Baird, 1973; Weingand, Young and McGilliard, 1972b). Furthermore, the overall rate of short-chain fatty acid absorption over the rumen wall increases as the pH of the rumen contents decreases (Sutton *et al.*, 1963; Thorlacius and Lodge, 1973).

Although the short-chain fatty acid concentration in the abomasum is less than half that of the contents of the rumen, extensive absorption of short-chain fatty acids occurs in the omasum. The absorption of short-chain fatty acids was also demonstrated in the abomasum (Ash, 1961). According to Christie (1981) there is evidence that some absorption of long-chain fatty acids takes place before they reach the small intestine, but the quantitative physiological significance of this is limited.

The major site for lipid absorption is the middle and lower jejunum with some fatty acid absorption in the upper jejunum (even during low pH conditions).

The bacteria and protozoa disintegrate in the acid environment of the abomasum and hence their lipid contents are released for further digestion in the posterior part of the digestive tract. Although the short-chain fatty acids present within the small intestine account for less than 1% of those in the whole tract, some absorption of these fatty acids occur in the posterior part of the small intestine (Church, 1969).

Nevertheless, the digesta passing into the duodenum under normal dietary conditions are comprised mainly of unestrified medium and long-chain fatty acids together with small amounts of phospholipids. Little unchanged dietary glyceride ever reaches the small intestine (Christie, 1981). However, when the diet is supplemented with esterified fatty acids, elevated concentrations

of triglyceride in the digesta pass into the duodenum. The amount of lipid entering the duodenum is normally considerably larger than that ingested in the diet.

Sutton, Storry and Nicholson (1970) found the amount of fatty acids entering the duodenum to be respectively 40% and 104% higher than that ingested on either a high roughage or high concentrate diet. It is obvious that microbial synthesis is responsible for these elevated concentrations of fatty acids in the duodenum (Christie, 1981).

While the unestrified fatty acids are almost wholly associated with the particulate matter in the duodenum, the digesta are augmented by the addition of duodenal, bile and pancreatic secretions. Unlike the monogastric animal, the pancreatic duct joins the bile duct so that secretions are discharged together into the duodenum. However, the flow rate of pancreatic secretions is considerably lower than that of the bile (Christie, 1981).

According to Christie (1981) the neutralizing capacities of the duodenal secretions are wholly insufficient to deal with the large volume of digesta leaving the abomasum. Consequently the pH of the digesta remains low well into the jejenum. Apparently this lack of neutralization capacity is due to the low HCO_3 concentrations in the pancreatic secretions and not the bile secretions, since the latter did not differ much from that of monogastric animals.

Nevertheless, the bile secretions in the duodenum contribute increased quantities of C18 unsaturated fatty acids in mainly the esterified form to the digesta of the duodenum (Christie, 1981). It is interesting to take note of the change from saturated unesterified fatty acids in the digesta of the rumen, abomasum and proximal duodenum to the esterified unsaturated fatty acids in the distal duodenum and upper jejenum.

These bile acids[1] are also important in promoting lipid solubilization and digestion. A soluble micellar phase accompanied by a second phase, consisting of particulate matter to which lipid of both dietary and endogenous origin are bound, are formed. The bound lipid is not immediately available for absorption.

Furthermore, the bile secretions in the duodenum assist in the transfer of unestrified fatty acids from the particulate matter into solution (Christie, 1981). This author also indicates the following solubilities over a pH range from 2.0 to 7.4 namely, C18:2 > C18:1(cis-9) > C18:1(trans-9) > C16:0 > C18:0. Furthermore, the solubilities of these long-chain fatty acids in the presence of bile salts rose as the pH rose and this was ascribed to the increasing ionization of the carboxylic group. Although lecithin[2] enhanced the solubilization of C16:0, C18:0 and C18:2, the solubility of both C18:1(cis-9) and C18:1(trans-9) remained the same.

It is important to note that the major bile acids are greatly affected by dietary factors (Christie, 1981). Before absorption of the free fatty acids in the digesta can occur, the fats must be released from their association with the particulate matter of the digesta. Both the biliary and pancreatic secretions are necessary for optimal assimilation, but according to Christie (1981) ruminants require more bile than pancreatic fluid for this purpose. Hereafter, the lipid is absorbed mainly via the portal system. However, the process by which the transfer of lipid in micellar form from the lumen into the mucosal cells of the small intestine takes place, remains unclear (Christie, 1981).

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[1]Basically cholic acid and smaller concentrations of deoxycholic and chenodeeoxycholic acids.

[2]Lecithin plays an important role in the formation of chylomicrons.

2.2.3 Transport of lipids in ruminants

The triglycerides of plasma lipoproteins are the main source of exogenous fatty acids for adipose tissue, and lipoprotein lipase activity has been demonstrated in ovine adipose tissue (Christie, 1981). In ruminants, dietary lipids are absorbed almost wholly as free fatty acids in the mucosal cells. The α-glycerolphosphate pathway was shown to be the main route for the resynthesis of triglycerides in the intestinal mucosal cells. According to Christie (1981) the monoglyceride pathway is also active in foetal and early neonatal mucosal tissue. Phospholipids are also resynthesised in the intestinal mucosal cells, predominantly by the reacylation of 1-lysolecithin as well as some synthesis in lymph *de novo* via the α-glycerophosphate pathway.

Nevertheless, the intake of fatty acids from the micellar solutions by mucosal cells of the small intestine does not occur with any appreciable fatty acid specificity. After absorption into the mucosal cells, the fatty acid chain length, degree of unsaturation and substrate concentration determine their rates of incorporation into triglycerides via the α-glycerophosphate pathway (Bickerstaffe and Annison, 1969).

Furthermore, a significant proportion (7% to 9%) of the biohydrogenated micellar lipids are converted to especially oleic acid within the mucosal cells, by means of a specific microsomal desaturase (Christie, 1981). This author is of the opinion that the relatively high desaturase activities in the tissues of the ruminant relative to that of the non-ruminant, is a specific adaptation to cope with the predominantly saturated fatty acids absorbed from the intestine.

After synthesis of lipid components in the intestinal mucosal cells, it is incorporated into lipoprotein particles (chylomicron and very low density lipoprotein fractions).

According to Miller and Small (1987) the intestinal chylomicrons and hepatic VLDL serve as the major transport vehicles of triglyceride within the circulation. Mamalian chylomicrons consist of 1-2% protein and 98-99% lipid, of which 90% is triglyceride, 1-2% cholesterol ester, 1% cholesterol and 5-8% phospholipid. VLDL on the other hand contain appreciably more protein (7-10%), and of their lipids 65% is triglyceride, 12% cholesterol ester, 5% cholesterol and 18% phospholipid.

These lipids are held together by noncovalent forces in such an organization, that the unfavourable free energy caused by the contact between hydrophobic lipid moieties and the surrounding water in which they are suspended is minimal (Miller and Small, 1987).

The lipid aggregates then enter the intestinal lymphatic system via the lacteals; then the thoracic duct and finally enter the plasma. A small proportion of the long-chain fatty acids are absorbed via the portal vein (Christie, 1981). Results obtained from the analysis of thoracic lymph separated into fraction by ultracentrifugation, showed that 73% of the lipid present was associated with the VLDL fraction while only 27% was associated with the chylomicrons.

Harrison, Leat and Forster (1974) as quoted by Christie (1981) demonstrated changes in the lipid composition of the lymph and a redistribution of the lipid to the chylomicron fraction upon duodenal infusion of maize oil. The same authors also indicated that C18 polyunsaturated fatty acids are preferencially incorporated into the phospholipids for further transport. It is interesting to note that fatty acids associated with the triglycerides are predominantly of exogenous (dietary) origin while those of the phospholipids are derived partly from dietary sources but also from endogenous esterified lipids (biliary phospholipids) (Wadsworth, 1968).

2.2.4 Synthesis and metabolism of lipids in ruminants

In the ruminant the adipose tissue is the only important site of fatty acid synthesis since it is responsible for 90% of the fatty acid biohydrogenation in the non-lactating sheep (Ingle, Bauman and Garrigus, 1972). The capacity of the ruminant liver to synthesize fatty acids is negligible.

Although the ruminant adipose tissue has some potential for using glucose carbon for fatty acid synthesis, it is normally suppressed. Acetate[1] is the principle precursor for fatty acid synthesis in adipose tissue of sheep (Hanson and Ballard, 1967; Ballard, Filsell and Jarrett, 1972). It was found that acetate carbon is incorporated into fatty acids between 10 and 100 times more rapidly than from glucose carbon. According to Vernon (1976) acetate is the precursor for basically all of the fatty acid synthesis in both the perirenal and subcutaneous adipose tissue from sheep.

According to Egan (1981) there appears to be a close association between fat synthesis and active metabolism of carbohydrate through both the glycolytic pathway and hexose monophosphate shunt in adipose tissue. Furthermore, the rate of fatty acid synthesis (under hormonal control) is influenced by the level and composition of the diet.

The utilization of lactate for fatty acid synthesis is unlikely since the concentration of lactate in the blood is usually very low. Nevertheless, *in vitro* studies indicated increased fatty acid synthesis after the lactate concentration of the diet is increased (Whitehurst, Beitz, Pothoven, Ellison and Crump, 1978).

Propionate is a gluconeogenic fatty acid which is of immense importance to the ruminant, because it is responsible for

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[1]This is not surprising in ruminants since most of the glucose is derived from gluconeogenesis.

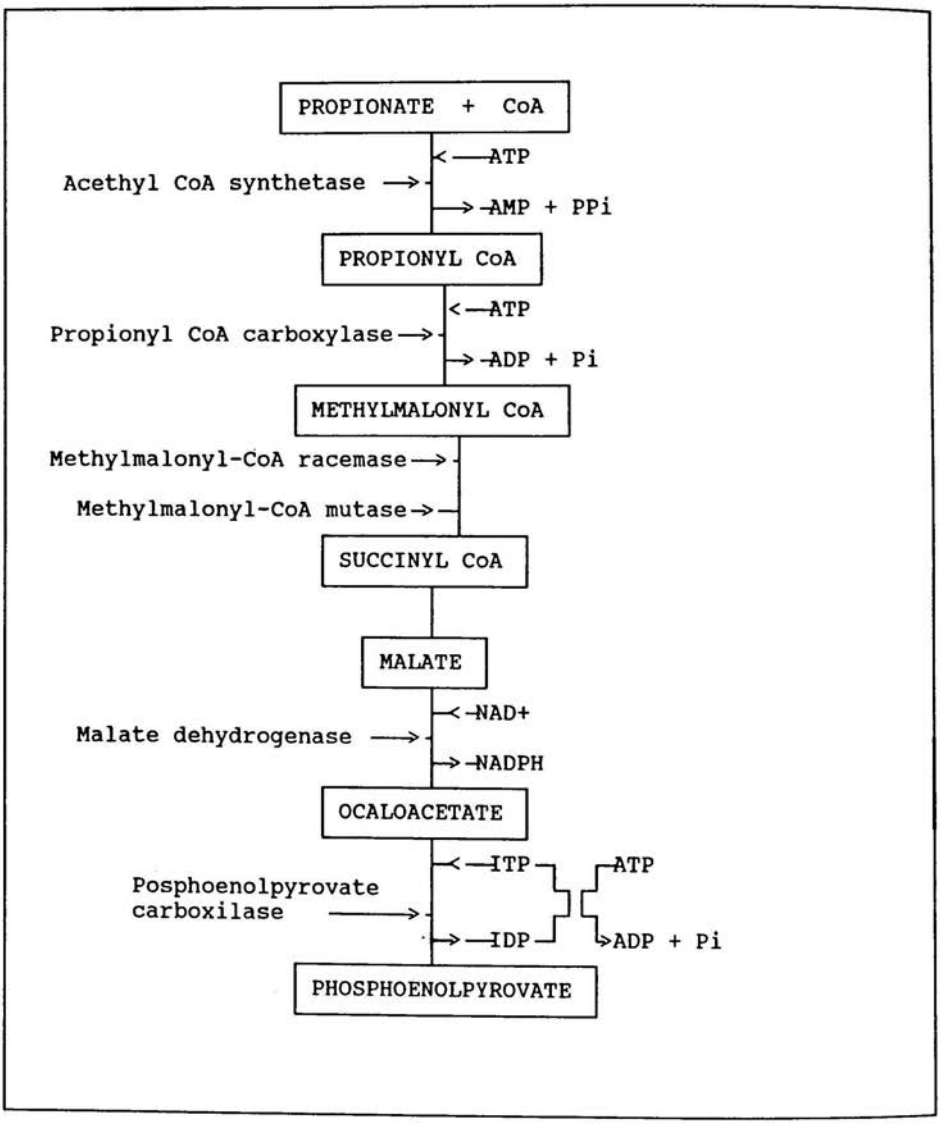
approximately one-half of the glucose entering the ruminant's metabolic system (Egan, 1981). If propionate was utilized for fatty acid synthesis it would give rise to odd-numbered fatty acids, while the utilization of methylmalonate results in the formation of branched-chain fatty acids (Christie, 1981).

However, propionate is normally removed from the hepatic portal blood during its passage through the liver and consequently only relatively small concentrations reach the adipose tissue. Nevertheless, on high energy diets propionate could contribute substantially to the synthesis of fatty acids. According to Hood, Thompson and Allen (1972, as quoted by Christie, 1981) the metabolism of propionate would presumably involve its conversion to the tricarboxylic acid cycle via succinyl CoA. A schematic representation of the normal transformation of propionate to phosphoenolpyrovate is given in Figure 2.5.

High concentrate diets lead to increased amounts of propionate and decreased amounts of acetate (Harfoot, 1981). In the work reported by Garton *et al.* (1972) the concentrations of unusual fatty acids in sheep adipose tissue were increased by propionate supplementation to the barley-enriched diet, while acetate or butyrate supplementation led to a decrease in the concentration of unusual fatty acids (refer to Figure 2.1).

Garton *et al.* (1972) concluded that propionyl CoA can indeed be utilized for fatty acid synthesis in sheep instead of acetyl CoA. This would obviously result in the deposition of odd-numbered fatty acids in the adipose tissue of sheep. Methylmalonyl CoA is produced by the carboxylation of propionate which can also replace malonyl CoA for subsequent fatty acid synthesis.

Figure 2.5. SCHEMATIC REPRESENTATION OF THE TRANSFORMATION OF PROPIONATE TO PHOSPHOENOLPYROVATE IN RUMINANTS (after McDONALD, EDWARDS AND GREENHALGH, 1981).



PROPIONATE ——————» (carboxilation)

METHYLMALONYL CoA ———» FATTY ACID BIOSYNTHESIS → Odd-numbered fatty acids

→ Branched-chain fatty acids

During fatty acid synthesis considerable amounts of cytoplasmic NADPH are required as hydrogen sources. Theoretically approximately fourteen molecules of NADPH are required for synthesis of one molecule of palmitic acid from eight molecules of acetyl CoA. According to Casey *et al.* (1988) and Yang and Baldwin (1978) the availability of H^+ donors could possibly limit fatty acid synthesis.

Vernon (1976) however, found that glucose oxidation[1] via the pentose phosphate cycle could provide more than enough NADPH for fatty acid synthesis. From this study it was evident that the potential for NADPH production from glucose oxidation exceeds the utilization of NADPH for fatty acid synthesis by far. A substantial amount of glucose synthesis under such conditions takes place in the tricarboxyllic acid cycle.

According to various authors, as quoted by Christie (1981), long-chain fatty acids are desaturated to their 9,10, *cis*-mono-unsaturated derivatives in ovine adipose tissue. This desaturase enzyme in the microsomal fraction desaturates stearic acid in preference to palmitic acid.

Approximately 23% of the esterified stearic acid is desaturated in sheep adipose tissue, and *de novo* synthesised fatty acids are also readily desaturated in ruminant adipose tissue. Fatty acids synthesized *de novo* are desaturated in preference to exogenous fatty acids (Christie, 1981). Furthermore, between 25 and 40% of the C18 fatty acids formed

[1]Acetate stimulates glucose oxidation in ruminant adipose tissue and in general the rate of glucose oxidation roughly parallels the rate of fatty acid synthesis.

from acetate are desaturated in abdominal adipose tissue of sheep. Pothoven, Beitz and Zimmerli (1974), as quoted by Christie (1981) found the desaturase activity to increase with age and it was higher in subcutaneous than in abdominal adipose tissue.

As far as chain elongation is concerned, Pothoven *et al.* (1974; as quoted by Christie, 1981) found that 60 to 70% of the fatty acids synthesised in ovine adipose tissue are elongated to C18 fatty acids. Furthermore Duncan, Garton and Matrone (1971) suggested that most fatty acids of the subcutaneous adipose tissue are synthesised *de novo* within the tissue and that 95% of these fatty acids are subsequently esterified.

2.3 FACTORS THAT MAY AFFECT THE QUALITY OF SUBCUTANEOUS ADIPOSE TISSUE AND HENCE MEAT QUALITY

2.3.1 General

Fat is an extremely important quality determinant of meat and it is influenced by four interlinking factors namely (i) colour, (ii) firmness (consistency), (iii) stiffness (stability) and (iv) aroma. A yellow subcutaneous adipose tissue (fat) colour is regarded as undesirable. Poor consistency or firmness of the subcutaneous adipose tissue implies that the fat is too soft, while stiffness or stability is an indication of the oiliness when touched. According to Casey *et al.* (1985) the degree of saturation of fat is one of the most important characteristics affecting meat quality parameters. The degree of saturation of fat is basically determined by the fatty acid composition and it should be obvious that saturated fats solidify easily upon cooling and thus affect the palatability of the meat.

According to Marchello, Cramer and Miller (1967) lamb has the most highly saturated fat of all domestic animals. He argues that a slight decrease in saturation of the fat may improve the eating quality of lamb. Fats containing high levels of

unsaturated fatty acids (unstable soft fat) are sensitive to oxidation[2] which normally results in a less pleasant taste, as well as a reducing shelflife.

The chemical and physical[3] properties of fat usually have little influence on the commercial value of carcasses in South Africa, but according to Kempster, Cuthbertson and Harrington (1982) these properties do indeed influence both the eating and keeping qualities of meat.

The various factors that may or may not influence fat quality are discussed in the forthcoming section. The pigmeat processors were probably the first to become aware of the detrimental effects of nutrition on modern pig carcasses. Meat technology is encountering a major problem concerning the consistency of fat and its stability (Scherf and Bieber-Wlaschny, 1990). These authors emphasize the difficulties associated with the processing of cured product from such problem carcasses as well as the incidence of lipid peroxidation which results in unacceptable tastes.

Scherf *et al.* (1990) found for example that at 20°C the relative rates of autoxidation of oleate, linoleate and linolenate are 1:12:±25. It is evident that the sensitivity to autoxidation increases with rising concentrations of fatty acids which have more than one double bond in their structure.

The question, however, is whether it is possible to alter the fatty acid composition of body fats in ruminants by altering the composition of the diet. Although this is without doubt possible in non-ruminants, various authors deny this possibility for ruminants. Shorland, Weenink and Johns (1955) argue that the

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[2]Lipid peroxidation.

[3]The physical property of fatty acids which affects quality the most, is their melting point. The melting point rises with a lenthening in the carbon (C) chain.

extensive hydrogenation of dietary fat in the rumen gives rise to very stable depot fats irrespective of the nature of the dietary fat. McDonald *et al.* (1981) also state that the body fat of ruminants cannot normally be altered by dietary means as a result of biohydrogenation in the rumen.

Nutritional influences on the body fat of ruminants as a result of an altered fatty acid composition and the associated effect on flavour have, however, been found in beef (Westerling and Hedrick, 1979; Melton, Amiri, Davis and Backus, 1982), in lamb (Kemp, Mahyuddin, Ely, Fox and Moody, 1981; Crouse, Ferrell, Field, Busboom and Miller, 1982; Casey *et al.*, 1988; Webb, Casey, Bosman and Van Niekerk, 1991; Webb and Casey, 1992), and in kid (Bas, Hervieu, Morand-Fehr and Sauvant, 1982; Casey *et al.*, 1985).

2.3.2 Feeding regime

As early as the 1930's Hammond (1932) demonstrated the profound effect of nutrition on the amount of body fat in both pigs and lambs. He subsequently suggested that investigations should be undertaken to clarify the effects of different planes of nutrition on the body fat of animals of the same strain. In experiments conducted by McMeekan (1940a, b & c) as quoted by Elsley, McDonald and Fowler (1964) it was concluded that the developement of different tissues and organs could be greatly influenced by the plane of nutrition. However, Wood (1984) demonstrated that a higher concentrate ration not only raises the proportion of adipose tissue, but is also associated with a shift from saturated to unsaturated fatty acids.

Fat quality in pig carcasses is influenced more by diet (quantity and quality of fat) than by breed, sex or age at slaughter (Scherf *et al.*, 1990). Nevertheless, all over the world an intensification of sheep production is taking place combined with evolutionary techniques aimed at the fattening of

early weaned lambs. These lambs are fattened using pellets of complete concentrated feeds based on milled cereals with added nitrogen, minerals and vitamins, offered *ad libitum* with straw or hay. On these diets lambs realize high growth rates with low feed consumptions per kilogram live mass gain.

According to Cazes, Vallade and Van Quackebeke (1990) these carcasses are sometimes under-valued because of a discolouration or a lack of firmness or required stiffness of the subcutaneous adipose tissue. Kemp, Mahyuddin and Ely (1981) found that fat from pasture fed lambs contained less total unsaturated fatty acids than did fat from creep fed lambs.

These differences were due mostly to a higher level of stearic acid and a lower level of oleic acid ($P<0.01$) in the fat of pasture fed lambs. Linolenic acid was found to be higher in the fat of pasture fed lambs. Nutrition also affected the muscle fatty acids although its effect was limited to the long-chain fatty acids (Kemp *et al.*, 1981). These authors found that pasture fed lambs had a higher level of stearic acid ($P<0.05$) and a lower level of oleic and total unsaturated fatty acids ($P<0.05$) than did creep fed lambs. According to Kemp *et al.* (1981) the effect of nutrition on palatability was restricted to flavour.

Miller, Varnell and Rice (1967) also observed that a higher roughage diet produced a higher concentration of stearic acid in lamb fat than did high concentrate diets. In experiments on indoor concentrate fed lambs, various authors observed soft subcutaneous adipose tissue and ascribed this condition mainly to an increased amount of unsaturated fatty acids in both subcutaneous and perinephric fat (Shelton *et al.*, 1972, as quoted by L'Esterange and Mulvihill, 1975). L'Esterange *et al.* (1975) suggest that the discolouration of the subcutaneous adipose tissue may be associated with the oxidation of unsaturated fatty acids on the exposed surface of the carcasses. This is partly in

agreement with results obtained by Pearce and Chestnut (1974) who found higher levels of oleic acid and odd-numbered *n*-acids in the fat of concentrate-fed lambs.

In an experiment conducted by Miller, Kunsman and Field (1980) it was concluded that the subcutaneous adipose tissue of concentrate fed lambs was softer (as determined by visual scoring and thermal testing) than those fed on corn-silage diets. These results were also obtained by Hartman, Staheili, Holleman and Horn (1959) in a similar experiment. According to Miller *et al.* (1980) the most consistent fatty acid relationships to fat softness were decreases in C18:0 and increases in branched-chain and odd-numbered acids.

These authors also argue that soft fat would be a logical result of a reduced concentration C18:0 since this fatty acid has a high melting point. Furthermore, Markley (1960; as quoted by Miller *et al.*, 1980) showed that odd-numbered fatty acids exibit lower melting points in comparison with even-numbered acids and also that methyl branching decreases melting points.

However, it is important to note that L'Estrange and Spillane (1975) observed a decrease in C18:0 but reported that there were increases in C18:1 rather than branched-chain and odd-numbered acids. Nevertheless, Miller *et al.* (1980) emphasized that the decrease in fat firmness was not explained by high levels of branched-chain and odd-numbered acids. Finally, Miller *et al.* (1980) found that *trans*-acids were not involved in fat hardness.

Molenat and Theriez (1973) also reported the incidence of soft subcutaneous adipose tissue in indoor lambs fattened on concentrates. These carcasses were characterized by a smaller proportion of saturated fatty acids and an increased percentage of odd-numbered *n*-acids. Duncan, Orskove and Garton (1974), however, reported very high levels of total odd-numbered and total branched-chain acids in the subcutaneous adipose tissue of

lambs fattened on concentrate diets based on barley, maize or wheat. According to Garton, Howell and Duncan (1972) the unusually soft subcutaneous adipose tissue was due to the enhanced availability of propionate from the rumen of lambs on concentrate diets.

In an experiment undertaken by Casey *et al.* (1988) it was found that both the pastures grazed and carcass fatness influenced the fatty acid profile of the subcutaneous adipose tissue of sheep. They proposed that the ingestion of polyunsaturated C18 fatty acids may affect a shift in the biohydrogenation of these fatty acids so that a larger proportion flows through to the intestine in the unestrified form.

They also ascribed this shift to either a change in microbial population (particularly the protozoal population) or to a limitation in the availability of H^+ donors.

It is evident that the fat quality of ruminants reared on high energy diets poses a similar problem to that observed in pigs. Perhaps in the near future we might even state that the fat quality of ruminants is influenced more by diet than by anything else.

2.3.3 Mode of presentation of concentrate: whole grain vs. ground grain

Cazes *et al.* (1990) investigated the effect of the mode of presentation of a concentrate on the fat quality. He identified two main posibilities namely whole grain concentrates and pellets of milled cereals. The conclusions of this trial were that the use of whole grain concentrates improved the firmness of the subcutaneous adipose tissue of lamb carcasses, but it had no effect on the stiffness (oiliness to touch) or the colour of such carcasses.

Cazes *et al.* (1990) established that whole grain concentrates increase the content of paired saturated fatty acids in the subcutaneous adipose tissue and reduce the content of unpaired saturated and branched-chain fatty acids ($P<0.01$) relative to that fed on pellets of milled cereals. L'Estrange (1979) also found that whole cereals have a beneficial effect on fat quality in comparison with ground or pelleted milled agglomerates.

In studies conducted by Orskov *et al.* (1974) to establish the effect of processing of cereals on rumen metabolism, physiology and pathology and on the firmness of the subcutaneous fat, the following observations were made:

(i) diets containing whole barley in a loose mix and /or whole maize, oats or wheat, demonstrated an increased proportion of acetic acid while propionic acid decreased in comparison with pelleted diets,

(ii) no changes in rumen pH were observed when feeding rolled or whole barley, but barley, maize, oats or wheat in the loose form increased the rumen pH by about 1 unit in comparison with pelleted feeds,

(iii) processing of cereals did not significantly affect the digestibilities of the organic matter; however the tendencies observed were in favour of whole and loose barley rather than pelleted barley and pelleted wheat rather than whole wheat,

(iv) diets containing loose whole barley increased the firmness of the subcutaneous adipose tissue, and this was associated with a decrease in the proportion of propionic acid in the rumen fluid,

(v) rumination time was increased from 3.6 to 6.6 h/24h when loose whole barley instead of pelleted barley was fed.

It is evident from these results that the processing of cereals causes alterations in the type of rumen fermentation, which is accompanied by changes in rumen pH. Whenever whole

grains rather than processed grains are fed, the conditions in the rumen become more stable, and Orskov *et al.* (1974) showed that the feeding of loose grains had desirable effects on the rumen wall since the pathological changes generally associated with pelleted grain feeding were eliminated.

2.3.4 Nature of cereals and the kind of cereals used

According to Cazes *et al.* (1990) the kind of cereals used in the diet significantly affects the colour, firmness and stiffness of the subcutaneous adipose tissue. The use of maize in such diets tends to produce a larger proportion of carcasses with poor colour (yellow), firmness and stiffness in comparison with those fed with wheat or barley. Furthermore, lambs fed maize-based diets had the lowest concentration of saturated fatty acids and the highest concentration of unsaturated fatty acids in the subcutaneous adipose tissue.

Barley improved the colour, firmness and stiffness of the subcutaneous adipose tissue. It is also interesting to note that although wheat improved the colour of the subcutaneous adipose tissue of lambs, it reduced both the firmness and stiffness in comparison with maize. It can be concluded that barley and Triticale improves the fat quality of the subcutaneous adipose tissue, while maize and rye impairs the fat quality.

2.3.5 Kind and method of presentation of coarse fodder of roaghage

In an experiment conducted by Casey *et al.* (1988) it was concluded that the fatty acid profile of the subcutaneous adipose tissue of sheep may be influenced by the pastures grazed. In this trial groups of eight SA Mutton Merino wether lambs were allowed to graze eight different pastures namely five winter crops (maize stubble, Z. Maize; Triticale; Midmar rye grass, L. multiflorum; Nui rye grass; L. perenne; Cocksfoot, D. glomerate) and three summer grasses (Smuts finger, D. eriantha; Couch,

C.dactylon; Lucerne, M. sativa). According to the results obtained there is an indication that the pasture treatments may have a direct influence on the fatty acids in the subcutaneous adipose tissue since the fatty acid profiles between treatments were highly repeatable. The pasture treatments significantly influenced myristic (C14:0, $P<0.01$), heptadecenoic (C17:1, $P<0.01$), linoleic (C18:2, $P<0.01$) and stearic acid (C18:0, $P<0.05$).

Cazes *et al.* (1990) found that the replacement of straw by lucern hay or permanent pasture hay as a complement to ad libitum supply of complete concentrates, does not significantly improve the proportion of good carcasses. They also add that the replacement of straw by lucerne hay reduced the amount of poor carcasses by 32%. A reduction in the amount of poor carcasses could however, not be achieved when grass of mediocre quality was used.

Furthermore, in experiments where straw was treated with either ammonia (4% dry mass), or milled and treated with caustic soda (1% dry mass), the straw consumption increased without improvements in fat quality and the proportion of good carcasses.

2.3.6 Rationing concentrates during later stages of fattening

In further experiments conducted by Cazes *et al.* (1990) where severe concentrate rationing (14%) was practised at either 27kg live mass (60% of live mass at slaughter) or 33kg live mass (75% of live mass at slaughter) it was established that the saturated fatty acid content of the subcutaneous adipose tissue increased by 6.5% while the content of branched fatty acids was reduced by 14% for both barley and maize-based diets. Rationing also improved the proportion of carcasses with a good subcutaneous adipose tissue quality.

These authors came to the important conclusion that rationing has a greater effect on the saturated and branched

fatty acid content of the subcutaneous adipose tissue than the nature of the cereal used in the diet.

2.3.7 Maize: whole plant or milled cob silage vs. whole grain

Meat producers who aimed at an increased profit margin, quickly became aware of the fact that whole plant silage or milled cob silage reduced the feed consumption and average daily gain of sheep in comparison with high energy maize-based diets. Since then, these high energy concentrates have played a dominant role in the fattening of lambs for the market.

Unfortunately high energy cereal-based diets have a detrimental effect on the subcutaneous adipose tissue quality of the carcasses. Miller *et al.* (1980) found that the visual ranking of fat from silage-fed lambs was harder than that in maize-fed lambs. These authors indicated a positive correlation between the firmness of the subcutaneous fat of silage-fed lambs and the concentration of C18:0 in the subcutaneous adipose tissue.

Similarly, Cazes *et al.* (1990) established that the subcutaneous adipose tissue quality is improved when maize cob silage is fed in comparison with whole grain or pelleted maize. It seems that since subcutaneous fat quality contributes greatly to carcass quality and consumer satisfaction, which subsequently influence the *per capita* consumption of lamb (and mutton as a whole), it is important to establish a fine balance between the performance of lambs and the subcutaneous fat quality.

2.3.8 Slaughter mass of lambs

As an animal grows and developes from birth to maturity, continuous changes are occurring in its body conformation and composition (Forrest, Aberle, Hendrick, Judge and Merkel, 1975). The shape of the postnatal growth curve is similar in all species and is represented by a sigmoid curve.

After birth an animal goes through a phase of very slow

growth, which is followed by a phase of rapid growth, during which the rate of increase in size may be nearly constant and the slope of the curve remains almost unchanged. Later in this phase the growth of muscles, bones and vital organs begins tapering off, and fattening begins to accelerate. When the animal reaches full size, a retardation of growth occurs (Forrest *et al.*, 1975). Earlier maturing sheep breeds reach maturity at an earlier chronological age and consequently fattening begins to accelerate at an earlier age.

Shorland (1953) was one of the first researchers to relate dietary fat to growth and body fat composition. He postulated that (i) the amount and composition of dietary fat, (ii) the rate of growth of fatty tissues, (iii) differential distribution of dietary fatty acids between various fatty tissues and (iv) differences in animal species could influence the composition of animal depot fats.

Callow (1958) then observed that fat from the earlier maturing muscles of sheep (shoulder and rack) consistently had higher iodine numbers than fat from later maturing muscles such as those in the loin and pelvic regions.

It is interesting to note that selective deposition of saturated fatty acids increased with live mass in swine (Sink, Watkins, Ziegler and Miller, 1964). These authors found that fatty acids were preferentially deposited in perinephric rather than subcutaneous<xat and within inside subcutaneous fat layers rather than in the outside layers.

Kemp *et al.* (1981) slaughtered ram, ewe and wether lambs at 32, 41 or 50kg live mass and concluded that slaughter mass affected the perinephric fatty acid composition only slightly. Slaughter mass, however, affected the perinephric fatty acid composition of lambs reared on pastures (without additional

protein creep). A shift towards longer chain fatty acids was demonstrated in the perinephric fat of lambs slaughtered at a heavier mass. Myristic ($P<0.01$) and palmitic acid ($P<0.01$) decreased linearly while stearic acid ($P<0.05$) increased linearly. A decrease in the concentration of perirenal myristic acid as slaughter mass increased, was also reported by both Jacobs (1970) and Tichenor (1969) as quoted by Kemp *et al.* (1981).

Total unsaturated fatty acids were not affected by slaughter mass. However, subcutaneous fatty acid profiles were significantly influenced by slaughter mass (Kemp *et al.*, 1981). An increase in oleic acid ($P<0.01$) and a decrease in palmitoleic ($P<0.05$), linoleic ($P<0.01$) and total unsaturated fatty acids ($P<0.05$) were associated with an increased slaughter mass. In other experiments conducted by Kemp *et al.* (1981) only small differences were found between various slaughter mass groups.

Although slaughter mass affected a shift in the subcutaneous fatty acid profiles, the amount of change propably had little practical significance (Kemp *et al.*, 1981).

2.3.9 Sex of lambs

Differences in perinephric fatty acids between ewes and wethers, or wethers and rams were not significant (Kemp *et al.*, 1981). However, a slight difference in oleic, linoleic and total unsaturated fatty acids ($P<0.06$) were observed between wether and ram lambs. The concentration of oleic, linoleic and total unsaturated fatty acids were slightly higher for ram lambs than for wethers. Tichenor (1969; as quoted by Kemp *et al.*, 1981) achieved similar results and concluded that ram carcasses had softer fat than wether carcasses.

Sex affected the subcutaneous fatty acid profiles of lamb carcasses (Kemp *et al.*, 1981). The subcutaneous fat of ewes

contained more oleic (P<0.01) and unsaturated fatty acids (P<0.05) than wethers, and that of rams contained more palmitoleic, stearic and total unsaturated fatty acids than wethers. The subcutaneous fat of rams were softer than that of ewes or wethers. These findings concur with those made by Tichenor, Kemp, Fox, Moody and Deweese (1970).

However, Cramer and Marchello (1964) found that female fat had both higher iodine numbers and melting points than male subcutaneous fat. Furthermore, they found that female fat possessed larger amounts of fatty acids containing 16 carbons or more (regardless of the degree of saturation) and had lower percentages of all acids with less than 16 carbons. Finally, Cramer *et al.* (1964) came to the conclusion that sex differences only appeared after 10 to 12 months of age.

2.3.10 Seasonal and ambient temperature effects on subcutaneous adipose tissue

The environment undoubtedly exerts a strong influence on fat quality with ambient temperature and diet as the most variable environmental factors (Cramer and Marchello, 1964). It is important to note that environmental temperature influences the digestion of feed in the digestive tract. Kennedy, Christopherson and Milligan (1976) and Thomson (1972; as quoted by Kennedy *et al.*, 1976), found for example that the apparent digestability of dry material and organic matter in the gastrointestinal tract decreased in sheep exposed to cold temperatures (-1°C to 1°C). This was ascribed to an increase in the rate of passage of digesta from the rumen, with a consequent reduction in the fermentation rate in the rumen. Furthermore, the digestion in the intestines only partialy compensate for the reduced digestion in the rumen.

Nevertheless, Cramer *et al.* (1964) found that the subcutaneous adipose tissue had higher iodine numbers during warm

weather and lower values during cold weather. Higher iodine numbers are found during spring and lower values during winter. Since these results are not in accordance with those obtained by Cramer, Marchello and Sutherland (1961; as quoted by Cramer *et al.*, 1964), it was concluded that the diet produced alterations in body fat composition which consequently masked the temperature effects.

Callow (1958) suggested that the local temperature might affect the fatty tissue, since perinephric fat is more saturated than subcutaneous fat, which is normally exposed to a warmer environment. Furthermore, Hendriques and Hansen (1901; as quoted by Marchello, Cramer and Miller, 1967) found distinctly lower iodine values for the outer fat layers of pigs covered with sheepskin.

Marchello *et al.* (1967) established without doubt that environmental temperature extremes (7°C to 30°C) result in differences in the subcutaneous fat with regard to both the iodine numbers and melting points. Iodine numbers are higher at low temperatures than high temperatures for both subcutaneous and perinephric fat, but the melting points are obviously higher at high than at low environmental temperatures.

The above-mentioned authors also demonstrated a significant interaction between temperature and shearing. Shearing resulted in a decrease in the iodine number of the subcutaneous fat in comparison with unshorn sheep.

Kidney fat composition was influenced to a lesser degree by temperature, probably since the abdominal cavity is relatively independent of environmental temperature. Finally these authors concluded that although exposure to low temperatures leads to the deposition of more unsaturated fat, lambs synthesise an increasingly higher degree of unsaturated fat during growth,

regardless of temperature.

2.3.11 Fatty acid composition at various sites in the body of the sheep

Irrespective of diet, mass or sex, the results of Kemp *et al.* (1981) and those of Tichenor *et al.* (1970) demonstrate a markedly higher concentration of stearic acid and lower concentrations of oleic and total unsaturated fatty acids in perirenal than in subcutaneous adipose tissue.

Differences were also found in the fatty acid composition of triglycerides from various tissues of the pig, horse, ox and sheep (Hilditch and Williams, 1964; Dahl, 1958 and Hartman and Shorland, 1961, as quoted by Duncan *et al.*, 1967). These results show that fatty acids originating from internal tissues usually contain a higher proportion of saturated fatty acids than that derived from external tissues.

Duncan and Garton (1967) isolated triglycerides from a number of different tissues of sheep, including internal fat depots (perinephric and mesenteric), subcutaneous fat depots (rump and chest) and the subcutaneous region of the metatarsal part of the hind limb and the pinnae of the ears. It was subsequently found that the internal tissues contained a much higher proportion of saturated fatty acids in comparison with the external tissues.

The concentration of stearic acid was appreciably higher in the internal tissues. Oleic acid, however, accounted for as much as 60 to 70 % of the total fatty acids present in the most exposed tissues (legs and ears). The greatest concentration of *trans*-fatty acids (almost entirely C18 mono-unsaturated) was found in the internal tissue triglycerides.

Exogenously-supplied polyunsaturated C18 fatty acids are also preferentially deposited in the internal tissues of sheep (Duncan and Garton, 1967). Duncan and Garton (1967) concluded that long-chain fatty acids absorbed from the intestine primarily influence the composition of the triglycerides of internal adipose tissues.

In an experiment with Boer goats, Casey *et al.* (1985) found that the subcutaneous fat (iodine number = 31.3) was less saturated than that of the kidney depot (iodine number = 28.2). Furthermore, the two fat depots differed very significantly ($P<0.01$) in fatty acid content in seven of the eight fatty acids measured. Stearic acid formed the greatest fraction in the kidney fat while *n-cis*-p-octadecenoic acid represented the greatest fraction in the subcutaneous fat.

2.3.12 Dietary unsaturated fat, buffer level and protein source on fat quality

The lipid content of ruminant diets is normally low (less than 50g/kg) since the capacity of the rumen micro-organisms for digesting lipids is limited. If the lipid content of the diet is increased to above 100g/kg (>10% of the diet) the activities of the rumen microbes are reduced (McDonald *et al.*, 1981).

Gibney and L'Estrange (1975) found that when a diet supplemented with sunflower oil was fed to sheep, the feed intake decreased while both average daily gain and feed conversion efficiency remained basically unchanged in comparison with the controls.

Furthermore Gibney *et al.* (1975) fed lambs diets supplementd with either 8% casein or 2% urea (each contributing the same level of nitrogen to the diet) and with or without a supplement of 5.8% of sunflower oil. Since other authors[1] found an increase

[1]Grigor, Dunckey and Purves, (1970) as quoted by Gibney *et al.* (1975).

in the proportion of branched-chain fatty acids in the skin surface of rats fed increased amounts of protein, they argued about the same possibility in ruminants fed increased amounts of casein and/or urea. However, their aim to increase the levels of branched-chain fatty acids did not materialize and they subsequently concluded that although the level of dietary unsaturated fat appreciably affects the melting point of the fat as well as the composition of the carcass, protein supplementation has little or no effect.

Although rumen biohydrogenation has a major effect on dietary unsaturated oils, the inclusion of even small amounts of such oils in the diet alters the degree of unsaturation of the depot fat (Gibney *et al.*, 1975). In this study 5.8% sunflower oil supplementation decreased the melting point of perinephric fat by approximately 3% and that of subcutaneous fat by a smaller but non-significant percentage.

Sunflower oil supplementation was associated with an increase in the proportions of palmitoleic, oleic, linoleic and linolenic acids and a decrease in palmitic and stearic acids in the perinephric fat. The proportions of linoleic and linolenic acid increased and the proportion of palmitic acid decreased in the subcutaneous fat of lambs supplemented with sunflower oil.

Garton, Hovell and Duncan (1972) investigated the effect of propionate on the presence of branched-chain components and found that the triglycerides of lambs fed supplementary propionate were characterized by the presence of large proportions of a variety of monomethyl branched-chain fatty acids.

Reduced proportions of long-chain saturated fatty acids were also observed on the propionate supplemented diet in comparison with either the acetate, buterate or conventional diets. Garton *et al.* (1972) argue that high concentrations of propionate

probably exceed beyond the capacity of the liver to metabolize[1] it normally which results in the direct incorporation of enhanced amounts into long-chain fatty acids.

Marchello, Fontenol and Kelly (1969) examined the effect of pre-and post-ruminal administration of corn oil on ovine fat. They found that abomasal administration of corn oil produced higher levels of unsaturated fatty acids in the depot fats within 30 days of continuous administration, in comparison with corn oil administered in the feed. After 45 days these differences were highly significant. In lambs administered corn oil post-ruminally, the linoleic acid content of depot fats rose from 3% to as high as 14%. It is also interesting to note that the corn oil digestability of lambs fed corn oil was 97.9% in comparison with a value of 88.6% for lambs injected with corn oil into the abomasum. Similar results were obtained for dairy cattle (Tove and Mochie, 1963).

Lassiter (1968) conducted experimental work aimed at establishing the effects of dietary fat source and buffers, on the rate of gain and fatty acid composition of depot fat of sheep. Fat sources (corn oil or tallow) did not influence the average daily gains of lambs, but both gains and feed intake of lambs receiving the higher buffer (3.5% $NaHCO_3$) level were significantly higher than those receiving lower (1.4% $NaHCO_3$) buffer levels.

Furthermore, fat source significantly affected the composition of the depot fat since cornoil-fed sheep deposited more linoleic and oleic acids than tallow-fed sheep. However, more palmitic and palmitoleic acids were deposited in tallow-fed than cornoil-fed sheep. There was also no interaction between

[1]Abnormal metabolism of propionate results in accumulating concentrations of methyl-malonate, which may be utilized for fatty acid synthesis.

buffer level and fat source which indicates that this did not affect the composition of the fats in the fat depots.

Finally, it is noteworthy that although the stearic acid content of the tallow diet was more than double than that of the corn oil diet, the stearic acid content of the depot fats of both treatment groups was essentially the same. This probably demonstrates that (i) diet unsaturated fatty acids are at least partially hydrogenated in the rumen, (ii) it supports the principle of the differential distribution of dietary fatty acids between various fatty tissues (Shorland, 1953) and (iii) animal fat has to maintain a degree of malleability at the temperature of the tissue (McDonald *et al.*, 1981).

2.3.13 Supplementary cobalt and cyanocobalamin

Garton, Hovell and Duncan (1972a, b) indicated that the production of branched-chain and odd-numbered *n*-fatty acids (unusually soft fat) in the fat depots of wethers fed rolled barley was probably associated with a failure of the liver to metabolize excess propionate normally, resulting in its direct incorporation into fatty acids. They argue that perhaps methylmalonate was utilized for fatty acid synthesis, with the subsequent formation of branched-chain components.

Figure 2.6.

Propionyl Co A ^{1}**---> Methylmalonate** $^{2\&3}$**---> Succinyl Co A**

^{1}Carboxylation
^{2}Methylmalonyl Co A racemase
^{3}Methylmalonyl Co A mutase

The conversion of succinyl Co A from methylmalonate is depicted in Figure 2.6. Methylmalonyl Co A racemase and methylmalonyl Co A mutase are both involved in this rapid

conversion process. Methylmalonyl Co A mutase contains 5'-deoxyadenosylcobalamin.

Duncan, Orskov, Fraser and Garton (1974) speculated that since vitamin B_{12} absorption are lower in sheep given high-grain diets (Sutton and Elliot, 1972 as quoted by Duncan *et al.*, 1974), the supply of dietary cobalt may have limited the amount of vitamin B_{12} available for hepatic metabolism of methylmalonate. Furthermore, Smith, Osborn-White and Russel (1969) and Smith and Maston (1971; as quoted by Duncan *et al.*, 1974) demonstrated that methylmalonate accumulates in the liver and blood of vitamin B_{12}-deficient sheep.

Nevertheless, Duncan et al (1974) concluded that neither additional cobalt nor the administration of cyanocobalamin (alone or in combination with additional cobalt) influenced the proportions of branched-chain acids in the triglycerides of sheep.

2.3.14 Dietary copper, biotin and vitamin E vs. fat quality

Research concerning the influence of dietary copper, biotin and vitamin E has only been conducted in pigs and may or may not be applicable to ruminants. Nevertheless, a short discussion of these factors seems relevant.

High levels of dietary copper (125 to 250ppm. commonly used to enhance growth performance in pig production) increase the softness of the backfat in pigs. This effect is apparently due to an increase in the ratio of oleic to stearic acid, brought about by the stimulating effect of high concentrations of copper on the desaturase enzyme activity in the digestive tract (Scherf *et al.*, 1991).

The B-complex vitamin, biotin, plays an important role in the synthesis of fatty acids. It is essential for the formation

of malonyl CoA and the elongation of linoleic acid and linolenic acid to C20-and C22-carbon essential fatty acids (Scherf *et al.*, 1991). This also explains the accumulation of linoleic and linolenic acids in the fat depots when biotin deficiency occurs in the feed. It was also demonstrated that the degree of saturation of the fat, and hence fat hardness, increases with the biotin level in the diet (Scherf *et al.*, 1991).

Finally, supplementary vitamin E (a very effective natural antioxidant that protects body fat from oxidation) improves the storage stability of pigmeat. It is included in pig feed at levels of between 100 to 200mg/kg of feed for 2 to 4 weeks before slaughter or at 50mg/kg of feed continuously.

2.3.15 Influence of diet on liver manganese

In a study conducted by Lassiter (1968), liver manganese levels were significantly higher in cornoil-fed lambs (9.6ppm.) in comparison with tallow-fed lambs (8.2ppm.). According to this author manganese is considered to be a lipotrophic substance in non-ruminant metabolism and also effects the bile duct and bile of cattle. This suggests a relationship between manganese and fat metabolism in ruminants. Lassiter (1968) concluded that manganese metabolism in ruminants is influenced by the type of fat which is fed.

2.4 THE INFLUENCE OF LIPIDS ON MEAT QUALITY

Forrest *et al.* (1975) is of the opinion that the use of a trained taste panel or a consumer panel represents the ultimate technique for the quality evaluation of meat. However, he agrees that even this method is not without substantial error since some variation in quality assessment obviously stems from the variation in preferences among the panel members.

In this experiment the eating quality of lamb was evaluated by a trained taste panel consisting of six members. Gibney and

L'Estrange (1975) conducted a similar sensory study using a six-membered untrained taste panel, while Kemp *et al.* (1981) did the same work but they used a nine-member panel experienced in tasting. Nevertheless, only five characteristics were included in the evaluation procedure since more factors would contribute to a less accurate sensory estimation.

Since this study was actually aimed at identifying aroma and/or odour differences between energy treatments, coupled with incipient and sustained juiciness and the subsequent acceptability, it was decided to exclude the evaluation of tenderness. According to Bosman (1991, personal communication), whose taste panel has been performing sensory evaluation work on lamb for the past four years, tenderness was never a complicating factor. However, the panel was asked to make a remark about each sample in case of an unacceptable sensory characteristic. From these results it was concluded that tenderness did not influence the sensory estimation procedure. The only complaint received from most of the taste panel members concerned the unacceptable amount of subcutaneous fat associated with Dorpers on both treatments.

Although fat, specifically intermuscular fat or marbling, has often been discussed as a factor associated with tenderness in meat of certain species, research over the years has failed to prove this (Forrest *et al.*, 1975). According to these authors, marbling contributes more to the juiciness and flavour of fresh products.

Gibney and L'Estrange (1975) examined the effect of dietary unsaturated fat and protein source on the fatty acid composition and the sensory properties of lamb. According to these authors there was no difference in the palatability (flavour, juiciness and tenderness) of the meat samples between different treatments.

The results of Kemp *et al.* (1981) and Kemp *et al.* (1976) are generally in accordance with those of Gibney and L'Estrange (1975). Kemp *et al.* (1981) found that neither sex or slaughter mass affected the Warner-Bratzler shear values. Diet affected the shear values, probably since the diets contained different concentrations of both protein and added fat. Nevertheless, the major effect of nutrition was restricted to flavour. Although the flavour scores were higher in roasts from protein creep-fed lambs than pasture-fed lambs, the most roasts scored above six on a nine point scale. This suggests that there is no practical advantage from a palatability point of view for either of the sexes, slaughter mass groups or feeding systems.

Cramer et al (1970) as quoted by Ockerman, Emsen, Parker and Pierson (1982), however, reported that mutton flavour is influenced by breed. Increases in the fineness of wool in wool-breeds were accompanied by increased mutton flavour.

Ercanbrack (1979) and Tichenor et al (1969; as quoted by Ockerman *et al.*, 1982) on the other hand, both reported that flavour and juiciness of lamb were not affected by slaughter mass, rate of gain, breed or sex of lambs. In the work conducted by Tichenor (1969) as quoted by Ockerman (1982) it was concluded that although the average tenderness score for roasts from wethers was higher than that for rams, both groups were still acceptable.

Ockerman (1982) used fat-trimmed loin samples and found that both tenderness and flavour of roasts from wooled-breeds were higher in comparison with haired-breeds. It is interesting to note that the roasts of wooled-breeds contained almost twice as much fat (40.87%) as the haired-breeds (20.74%).

3 MATERIALS AND METHODS

3.1 METHOD

3.1.1 Experimental factors and design

Research proposals I and II were addressed concurrently in a single experiment, which was divided into four phases, namely:

i. Phase 1: Growth trial, slaughtering procedures, carcass measures and carcass photographs,
ii. Phase 2: Fatty acid analysis of subcutaneous fat, plasma and feed samples,
iii. Phase 3: Sensory evaluation procedures,
iv. Phase 4: Statistical analysis.

Experimental design:

The experimental design was: 2 breeds (Dorper and SA Mutton Merino wethers) X 2 nutritional energy treatments X 4 target weights X 6 animals per group = 96 experimental animals[1]. Table 3.1. gives a schematic representation of the experimental design.

Nutritional treatments was: (1) a high energy ration[2] containing 11.76MJ ME/kg DM (76.64% maize), and (2) a moderately high energy ration[3] containing 10.18MJ ME/kg DM (31.84% maize). Both rations were compiled on an isoprotein and mineral basis, and were fed ad lib. to Dorper and SA Mutton Merino wethers from respectively 20.51 ± 2.51kg and 22.30 ± 3.99kg to 25, 31, 37 and 43kg live mass.

After a 14 day adaptation period, all animals were weighed (empty body weight: fasted for 16 hours) and the treatments begun. Feed components were purchased and the diets were mixed

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[1]96 experimental animals + 1 animal per group to allow for mortalities.

[2]High Energy Ration abbreviated as H.

[3]Moderately High Energy Ration abbreviated as M.

Table 3.1. Schematic representation of the experimental design.

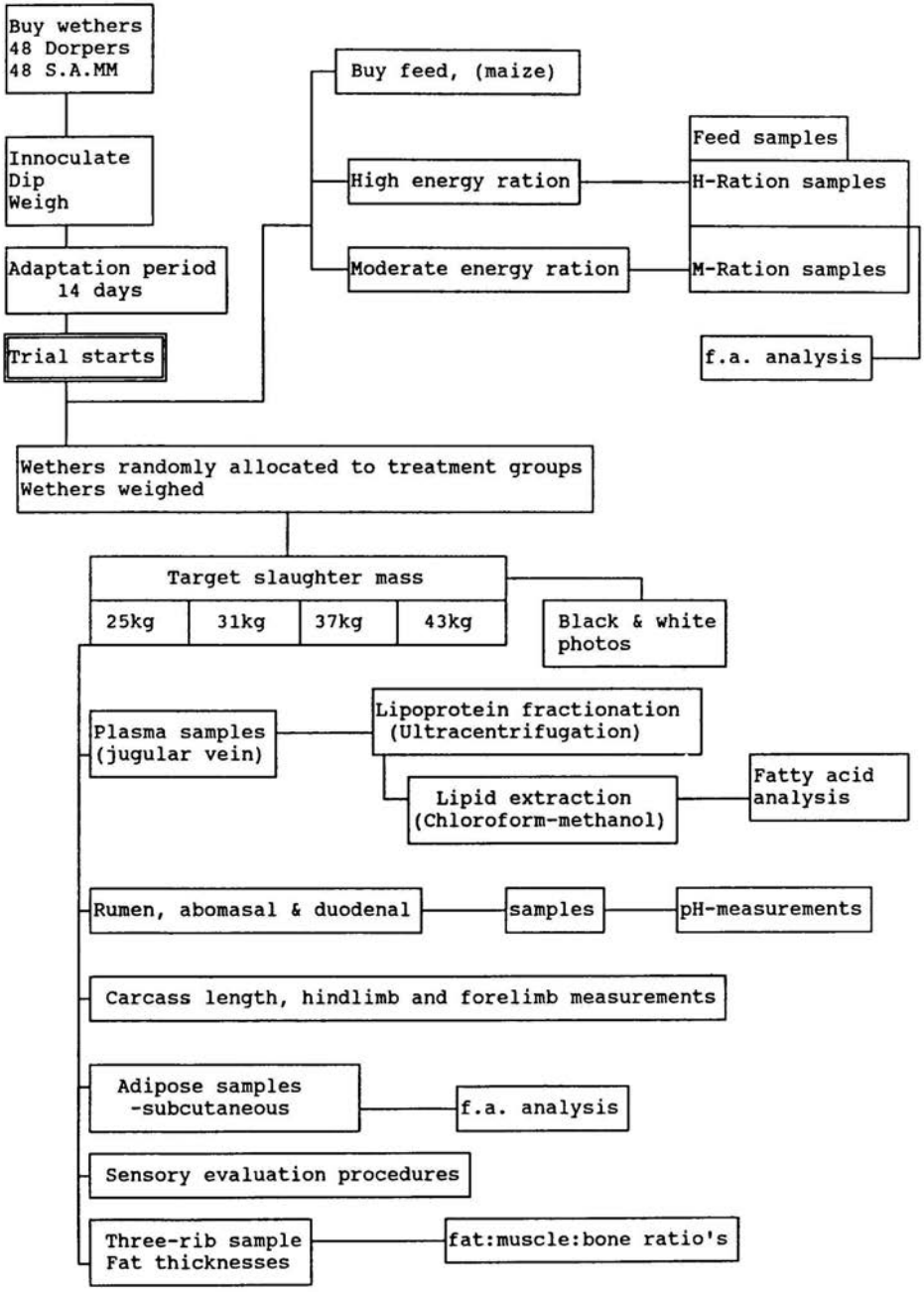
LIVE MASS		25kg	31kg	37kg	43kg
BREED A	H-DIET	6 (7)	6 (7)	6 (7)	6 (7)
	M-DIET	6 (7)	6 (7)	6 (7)	6 (7)
BREED B	H-DIET	6 (7)	6 (7)	6 (7)	6 (7)
	M-DIET	6 (7)	6 (7)	6 (7)	6 (7)

* 2 x 2 x 4 = 16 treatment combinations ≈ 16 experimental blocks
* 6 + 1 repetitions / block
* 6 x 16 = 96 experimental animals

Note: The experimental units refer to "blocks" or pens and not the individual animals. The six wethers per pen may be regarded as subunits. Furthermore, there are two sources of variation i.e. a) variation within pens and b) variation between pens.

The subunit analysis is kept separate in order to gain a new source of variation i.e. the variation caused by the random test error.

Table 3.1.b. Flow diagram of trial procedures.



on the experimental farm at the University of Pretoria. The two diets were prepared on a weekly basis in order to ensure its freshness and subsequent acceptability to the experimental animals. Representative samples of the two diets were collected weekly until the end of the trial, when these samples were pooled for fatty acid analysis. Samples were also taken of the different individual feed components used in these diets.

The two sheep breeds used represent: (1) an early physiological maturing type (Dorpers) and (2) a late physiological maturing type (SA Mutton Merinos).

The third factor included in the trial was slaughter mass, namely at 25, 31, 37 and 43kg live mass. Approximately 3 month old weaned wether lambs (shorn) of the two different breeds were allocated randomly to different experimental groups. The wethers were weighed weekly and slaughtered upon reaching the target mass of the specific experimental group.

The sheep were stunned electrically and then slaughtered by severing the jugular vein. A 10ml blood sample[3] was collected from wethers in the 37kg and 43kg slaughter groups for lipoprotein fractionation and lipoprotein extraction (fresh blood was required). All the carcasses were electrically stimulated and dressed down hanging from the rail (21V, 60Hz for 120 seconds).

The pH was measured in the rumen, abomasum, duodenum and jejunum. Chilling of the carcasses commenced overnight at 4°C.

Colour photographs and slides were taken of each carcass (dorso-transverse and dorsomedial presentations) under normal white incandescent lighting. These photographs were taken according to a standard procedure so that the photographs could be compared (a standard grid, in centimeters, was drawn on a

[3]Blood samples were collected from the jugular vien.

whight board, 150cm x 150cm).

Fat thicknesses were measured by means of a caliper on the right side at three different locations namely (i) at a point over the 13th rib, 25mm from the medial plane, (ii) at a point over the 10th rib, 25mm from the medial plane and (iii) at the brisket over the second rib.

Approximately 5g samples of subcutaneous fat (SCF) were collected and stored in sealed polyethylene bags at -20°C for fatty acid analysis. The subcutaneous fat samples were taken from the left side at a point over the 13th rib, 25mm from the medial plane as described by Casey, Van Niekerk and Spreeth (1988).

A three-rib cut sample (ribs 8-9-10) was taken from the left side of each carcass, the ventral extremity of the sample being on a line drawn from the cranial point of the pubic symphysis to the middle of the first rib, in order to give an estimate of total carcass composition (Casey et al, 1988).

Each three-rib cut sample was weighed and then carefully dissected[4] into bone, muscle (connective tissue was grouped with muscle) and fat. A total of 118 three-rib cut samples were dissected. These fractions were then weighed and expressed as a percentage of the three-rib cut mass i.e. percentage muscle, percentage fat and percentage bone.

The pH of the M.longissimus lumborum samples were measured by inserting an orion meat-probe into the M.longissimus et. lumborum (at a point over the 13th rib, 25mm from the midline), allowing a few seconds for stabalization and then taking the average of three measurements.

[4]Chemical techniques are expensive and time consuming, (refer to section 3.1.4.6).

Finally portions of the loins were removed and stored in sealed polyethylene bags at -20°C for subsequent sensory evaluation by a trained taste panel on a 10cm unstructured scale.

3.1.2 Diet formulations

Two rations (H - high energy ration and M - moderately high energy ration) were formulated according to the daily nutrient requirements of early weaned wether lambs (25kg - 30kg) on the basis of the recommendations of the NRC (Nutrient requirements of sheep, 1975). Both rations were compiled on an isoprotein and mineral basis. Zea mays (maize meal) was used as energy source in both rations.

The aim was to provide as much energy as possible (± 13MJ ME/kg DM) to the wethers on the high energy feeding level, but without inducing nutritional disorders or metabolic diseases. A high energy ration containing approximately 11,76MJ ME/kg DM was achieved. The aim of the moderately high energy feeding level was to provide just enough energy for maintenance and growth. The final moderate energy ration provided approximately 10.18MJ ME/kg DM. There was thus a significant difference of 1,58MJ ME/kg DM between the two rations. The nutritional requirements of early weaned wethers are summarised in Table 3.2. (NRC, 1975).

Table 3.2. Daily nutritional requirements of early weaned wethers (25kg - 30kg), 100% dry material basis.

NUTRIENT	REQUIREMENT / kg OF DM	REQUIREMENT / DAY
DRY MATTER/ANIMAL:		1.4kg (4.7% of live mass)
ENERGY (ME):	10.71MJ	15MJ
TOTAL PROTEIN:	140g	196g
DIGESTABLE PROTEIN:	95g	133g
Ca (Calcium):	3.57g	5.0g (± 0.36%)
P (Phosphorus):	2.36g	3.3g (± 0.24%)
CAROTENE:	2.7mg	3.8mg
VITAMIN A:	1821.43IU	2550IU
VITAMIN D:	142.9IU	200IU

The following feed components were used:

a) Roughage: Tef (Eragrostis tef)
b) Energy feed: Maize-meal (Zea mays)
c) Protein supplements: Cotton seed cake
Urea (protein from NPN)
d) Minerals: Salt (NaCl, feedgrade)
Dicalcium phosphate (DiCaP)
Feed lime
e) Micro-minerals: Embemen T.A.
f) Vitamins: Phoenix A (Vit A D E)
g) Additives: Sodium bicarbonate ($NaHCO_3$)

Sodium bicarbonate ($NaHCO_3$) was added to the rations for its buffering caracteristics in the rumen, whereas feed lime (calcium carbonate, $CaCO_3$) was added for both its ability to act as buffer in the lower part of the digestive tract and its contribution of

calcium (Ca) to the ration. The Ca:P ratio[5] was found to be very critical on the high energy diet. The H-ration formulations were as follows:

Table 3.3. HIGH ENERGY DIET FORMULATION:

FEEDSTUFF	INCLUSION RATE	ME (MJ/kg)	PROT. (g/kg)	Ca (g/kg)	P (g/kg)	CF (g/kg)	PRICE (R)
Maize meal	70.64%	11.93	103	0.2	2.0	23	360.00
Kalori 3000	00.00%	11.40	40	8.9	0.8	8	625.50
Tef	16.41%	7.50	60	1.1	1.0	329	200.00
Cottonseed[6]	9.95%	11.73	467	2.5	11.5	168	720.00
Urea	0.50%		2880				550.00
Feed lime	0.90%			380.0			335.00
$NaHCO_3$	0.50%						1874.00
DiCaP	0.60%			260.0	180.0		885.20
Salt (NaCl)	0.50%						80.00
TOTAL	100.00%	11.76	143.5	5.6	3.8	87	R379.21

Experimental animals on the high energy feeding level were gradually adapted on the high energy diet. During the first week of the adaptation period the basic high energy ration was fed, but only 57.2% maize was mixed into the total diet.

The percentage of maize in the diet was increased to 67.15% in the second week and finally to 70.64% in the third week of adaptation. The adaptation diets for the high energy feeding group are shown in Table 3.4. It is evident that the higher the percentage maize in the ration, the higher its energy value and the lower is its crude fibre (CF) content. However, the percentage of crude protein (CP), calcium (Ca) and phosphorus (P) remained relatively constant.

[5]Maize meal and Cotton seed cake have poor Ca:P ratios.

[6]Cotton seed cake (decorticated)

Table 3.4. ADAPTATION DIETS ON HIGH ENERGY FEEDING LEVEL

HIGH ENERGY DIET FOR 20kg WETHERS (57.2% MAIZE MEAL)

FEEDSTUFF	% INCLUSION	ME (MJ/kg)	PROT. (g/kg)	Ca (g/kg)	P (g/kg)	CF (g/kg)	PRICE (R/Ton)
Maize meal	57.20	13.2	100.0	0.2	2.0	23.0	360.00
Kalori 3000	0.00	12.0	40.0	8.9	0.8	8.0	625.50
Tef	29.85	7.5	60.0	3.7	1.2	329.0	200.00
Cottonseed	9.95	12.1	437.0	2.5	10.7	168.0	720.00
Urea	0.50		2880.0				550.00
Feed lime	0.90			380.0			335.00
NaHCO3	0.50						1874.00
DiCaP	0.60			250.0	210.0		885.20
NaCl	0.50						80.00
Total	100.00	10.99	132.99	6.39	3.83	128.08	357.71

HIGH ENERGY DIET FOR 20kg WETHERS (67.15% MAIZE MEAL)

FEEDSTUFF	% INCLUSION	ME (MJ/kg)	PROT. (g/kg)	Ca (g/kg)	P (g/kg)	CF (g/kg)	PRICE (R/Ton)
Maize meal	67.15	13.2	100.0	0.2	2.0	23.0	360.00
Kalori 3000	0.00	12.0	40.0	8.9	0.8	8.0	625.50
Tef	19.90	7.5	60.0	3.7	1.2	329.0	200.00
Cottonseed	9.95	12.1	437.0	2.5	10.7	168.0	720.00
Urea	0.50		2880.0				550.00
Feed lime	0.90			380.0			335.00
NaHCO3	0.50						1874.00
DiCaP	0.60			250.0	210.0		885.20
NaCl	0.50						80.00
Total	100.00	11.56	136.97	6.04	3.91	97.63	373.63

HIGH ENERGY DIET FOR 20kg WETHERS (70.64% MAIZE MEAL)

FEEDSTUFF	% INCLUSION	ME (MJ/kg)	PROT. (g/kg)	Ca (g/kg)	P (g/kg)	CF (g/kg)	PRICE (R/Ton)
Maize meal	70.64	13.2	100.0	0.2	2.0	23.0	360.00
Kalori 3000	0.00	12.0	40.0	8.9	0.8	8.0	625.50
Tef	16.41	7.5	60.0	3.7	1.2	329.0	200.00
Cottonseed	9.95	12.1	437.0	2.5	10.7	168.0	720.00
Urea	0.50		2880.0				550.00
Feed lime	0.90			380.0			335.00
NaHCO3	0.50						1874.00
DiCaP	0.60			250.0	210.0		885.20
NaCl	0.50						80.00
Total	100.00	11.76	143.5	5.60	3.80	86.95	379.21

Wethers on the moderately high energy feeding level were fed the final balanced M-ration (containing 31.84% maize), from the start of the adaptation period. The moderately high energy diet is summarised in Table 3.5.

Table 3.5. MODERATELY HIGH ENERGY DIET (25kg wethers)

FEEDSTUFF	INCLUSION RATE	ME (MJ/kg)	PROT. (g/kg)	Ca (g/kg)	P (g/kg)	CF (g/kg)	PRICE R
Maize meel	31.84%	12.93	103	0.2	2.0	23	360.00
Kalori 3000	7.96%	11.4	40	8.9	0.8	8	625.50
Tef	42.52%	7.5	60	1.1	1.0	329	200.00
Cottonseed	15.02%	11.73	467	2.5	11.5	168	720.00
Urea	0.52%		2880				550.00
Feed lime	0.60%			380.0			335.00
$NaHCO_3$	0.50%						1874.00
DiCaP	0.50%			260.0	180.0		885.20
Salt (NaCl)	0.54%						80.00
TOTAL	100.00%	10.18	146.6	5.2	3.7	173	R376.26

3.1.3 Animal health

All wether lambs received water ad libitum and the water containers were cleaned daily. The wethers were innoculated with Pasteurella (2ml subcutaneously) and Enterotoxaemia[7] (1ml subcutaneously) vaccines obtained from Onderstepoort (South Africa).

All wethers were also dosed with an oral suspension (ml/5kg live mass) in order to prevent investation of Nasal worm, Liver Fluke, Immature Conical Fluke, Lungworm, Milk Tapeworm and Roundworm, with residual protection against re-infestation of Wireworm and Hookworm.

[7]Alum-precipitated vaccine.

During the second week of the adaptation period, all wethers were dosed with a micro-mineral supplement (6ml/animal) and a vitamin[8] supplement (2ml/animal). Wethers were checked twice daily and unhealthy animals were treated accordingly. However, it was necessary to expel two wethers from the trial since the one broke its leg and the other experienced nutritional founder. Both animals recovered upon treatment, but they remained expelled from the trial group.

3.1.4 ANALYTICAL METHODS

3.1.4.1 General

- Body mass (weekly)
- Feed consumption/pen/day
- Average daily gain
- Growth/day/age
- Carcass yield percentage determined

3.1.4.2 Carcass samples

* 10g samples of subcutaneous fat (SCF) were obtained from each wether in the trial and stored at -20°C. These samples were individually taken for chloroform:methanol extraction (2:1, v/v) according to the methods of Folch, Lees and Stanley (1957) and Ways and Hanahan (1964) followed by the determination of fatty acids on the gas chromatograph.

* an extra 10g subcutaneous fat sample was obtained from each Dorper and SA Mutton Merino wether in the 43kg slaughter group, and pooled in 4 major groups (DH4, MH4, DM4 and MM4) for subsequent fatty acid analysis at the division of Food Science and Technology at the Council for Scientific and Industrial Research (CSIR). These samples were stored in polyethylene bags at -20°C until required.

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[8]Vitamin A = 50 000 I.U./ml; Vitamin D3 = 25 000 I.U./ml; Vitamin E = 20mg/ml.

3.1.4.3 Diet fatty acid samples

* Samples of the high (H) and moderately high energy (M) diets, as well as maize-meal, decorticated cotton seed cake and Smuts finger samples, were taken weekly and kept in sealed polyethylene bags at -20°C. These samples were pooled and used for the determination of fatty acids on a gas chromatograph.

Methyl esters of feed samples were prepared according to a slight modification of the BF_3/methanol method (AOAC, 1975). Both the esterification and chromatographical procedures were conducted at the Oilseeds Board.

3.1.4.4 Plasma lipoproteins

* Blood samples[9] (10ml) were taken from the 37kg and 43kg slaughter groups at the time of slaughter. These samples were centrifuged at 5000rpm for 15 minutes in order to separate the plasma from the blood sample.

The hematocrit of each sample was determined and the plasma was subsequently used for lipoprotein fractionation by discontinuous ultracentrifugation (Bechman L-70 Ultracentrifuge, Serial No. LOA715) into the different lipoprtein fractions namely the very low density lipoproteins (VLDL) and chilomicrons, the low density lipoproteins (LDL) and the high density lipoproteins (HDL) (Christie, 1982).

This lipoprotein fractionation procedure was time-consuming and took a lot of effort, and consequently only a few samples were successfully fractionated. Therefore, it was decided to only keep unfractionated plasma samples for the determination of its fatty acid profiles.

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[9]Blood samples were collected from the jugular vien and treated with heparin.

Lipids were extracted from the plasma and different lipoprotein fractions by means of the chloroform:methanol procedure proposed by Folch, Lees and Stanley (1957) with the modifications suggested by Ways and Hanahan (1964). The extracted lipid samples were esterified to their methyl esters in order to determine the fatty acid profiles on the gas chromatograph.

3.1.4.5 Intestines

* The pH of the rumen, abomasum, duodenum and jejunum were measured by means of an Orion liquid pH-meter. This instrument was calibrated using both the pH4-standard (pH=4.0) and pH7-standard (pH=7.0) at 4°C. The probe was rinsed with deionized water and dried between different samples. The calibration of the pH-meter was checked after every ten samples by testing with the pH4-standard.

3.1.4.6 Meat samples

* The meat pH of each carcass was measured at a point over the 13th rib, 25mm from the medial plane.

* A three-rib cut sample (ribs 8-9-10) was taken from the left side of each carcass, the ventral extremity of the sample being on a line drawn from the cranial point of the pubic symphysis to the middle of the first rib (Casey *et al.*, 1988).

* Each three-rib cut sample was weighed and then carefully dissected into bone, muscle (connective tissue was grouped with muscle) and fat. The fat content of the muscle was determined by means of the ether extraction method (AOAC, 1975). A total of 118 three-rib cut samples were dissected. These fractions were then weighed and expressed as a percentage of the three-rib cut mass i.e. percentage muscle, percentage fat and percentage bone.

Relatively simple determinations are useful in predicting

muscle proportions, retail yield or retail value, especially when a large number of animals are involved (Hoke, 1961; Zin, 1961; Hiner and Thornton, 1967; Field, Kemp and Varney, 1963; Carpenter, King, Orts and Cunningham, 1964; and Jude, Martin and Outhouse, 1966).

The first thorough tissue separation or dissection approach was initiated by Hammond (1932) as quoted by Rouse, Topel, Vetter, Rust and Wickersham (1970). However, several researchers tried to simplify the complete dissection technique by excision of an individual muscle, muscle group or bone in order to evaluate lamb carcasses (Field *et al.*, 1963; Latham, Moody, Kemp and Woolfolk, 1964; Barton and Kirton, 1958 and Hankins, 1947 as quoted by Rouse *et al.*, 1970).

Furthermore Ulyatt and Barton (1963), Barnicoat and Shorland (1952), Clark and McMeekan (1952), Kemp and Barton (1965), Kirton and Barton (1967) and Knight and Foote (1961) demonstrated a significant relationship between chemically determined moisture, fat, protein and ash with dissected fat, muscle and bone.

Field *et al.*, (1963) conducted a study on lambs in which they used the right seven rib section of each carcass, combined with a cutting procedure recommended by Kemp (1952) and they obtained the following correlations namely 0.89 between the disected percentage fat and percentage carcass fat, 0.82 between the percentage dissected lean and percentage lean in the carcass and 0.84 for the dissected percentage bone and percentage bone in the carcass. Field *et al.*, (1963) mentions the problem of splitting the carcasses accurately and argues that this is the main reason for the somewhat lower correlation coefficient obtained between the percentage dissected bone and the percentage bone in the carcass.

This sound advice was kept in mind in this study so as to be able to split the carcasses as accurately as possible.

Precautions taken to ensure accurate splitting of carcasses included the following: (i) a sharp blade was used at all times, (ii) the splitting procedure was conducted by two trained people and (iii) the carcasses were split carefully and slowly.

According to Naudè (1972) the dissection of the three-rib cut sample as proposed by Hankins and Howe (1946) provided a high correlation between the dissected percentage muscle and the percentage muscle in the carcass (r=0.94). The chemical analysis provided an r-value of 0.95 for the correlation between percentage muscle in the carcass, relative to that determined from the primerib.

Naudè (1972) also quoted the following correlations for three-rib cut sample estimates namely 0.94 (Hopper, 1944), 0.85 (Hankins and Howe, 1946), 0.94 (Crown and Damon, 1960) and 0.95 (Martin and Toreele, 1962).

Naudè (1972) also found that the correlation between fat and dissected fat from the three-rib cut sample was very high (r=0.97) while chemical analysis of the primerib provided the same high correlation. It seems that the only objection against the dissection of the three-rib cut sample as an estimate of carcass composition is that it does not fit into the South African grading system. However, for the purpose of this study the disection of three-rib cut samples seems appropiate.

* The pH of the M.longissimus lumborum samples (loin samples) were measured by inserting an orion meat-probe into the M.longissimus lumborum (at a point over the 13th rib, 25mm from the midline), allowing a few seconds for stabalization and then taking the average of three measurements.

* Portions of the loin samples were removed and stored in sealed polyethylene bags at -20°C for subsequent sensory

evaluation[10] by a traned taste panel.

* Total cooking loss, drip loss and evaporation loss from these loin samples were determined after roasting. The unroasted loin, oven rack and oven pan were weighed. After roasting the loin + oven rack + oven pan was weighed and then the oven rack + pan + remaining drip was weighed[1]. Loin masses and drip losses were then determined by calculation. Percentage total cooking loss (%TCL), percentage drip loss (%DL) and percentage evaporation loss (%EL) were calculated using the following formulas:

$$\%TCL = \frac{\text{Unroasted loin mass - roasted loin mass}}{\text{Unroasted loin mass}} \times 100$$

$$\%DL = \frac{\text{(pan + rack + drip)-(pan + rack)}}{\text{Unroasted loin mass}} \times 100$$

$$\%EL = \%TCL - \%DL$$

Finally, the volume fat (ml) and meat extract (ml) in the drip as well as the total volume of drip (ml) were measured in order to describe the characteristics of the drip loss.

3.1.5 Carcass compactness

Carcass compactness is one of the objective methods available to assess the conformation of carcasses, but according to Kempster, Cuthbertson and Harrington (1982) carcass compactness[11] is less well related to meat yield than visual scores. These authors are of the opinion that sheep do not show such a wide variation in conformation types. Nevertheless,

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[10]Refer to section 3.1.7.

[11]Fat-corrected conformation is not a valuable predictor of composition in sheep carcasses.

carcass compactness was included as a predictor of leaness (lean to bone ratio). It is important to note that breeds with a better conformation do not necessarily have higher lean to bone ratios (Kempster *et al.*, 1982).

Carcass length (K2) was measured (on the intact carcass hanging from the rail) from the most distal part of the hindleg to the most cranial part of the neck as indicated in Figure 3.1. Carcass compactness was subsequently calculated by a modification of the method used by Bruwer[12] (1984), according to the following formula:

$$\text{Carcass compactness (kg/cm)} = \frac{\text{Cold carcass mass (kg)}}{\text{Carcass length (cm)}}$$

3.1.6 Hindleg compactness

Hindleg length was measured in two ways as described by Bruwer (1984). Hindleg length was measured from the *Symphysis pubis* to the most distal part of the hindleg (B1) and from the first sacral vertebra to the most distal part of the hindleg (B2). These measurements are indicated in Figure 3.1. Carcass compactness was again calculated by a modification of the method used by Bruwer (1984), by dividing either B1 or B2 by cold carcass mass.

Two more carcass measurements were also recorded namely hindlimb width and forelimb width (Figure 3.1.). Hindlimb width was measured from the left to right *Acetabulum* (CW1) and forelimb width was measured over the left and right *Tuber spinae* (CW2).

[12]Bruwer (1984) used the mass of the right side of the carcass, but since carcass separation is not always accurate, total cold carcass mass was used.

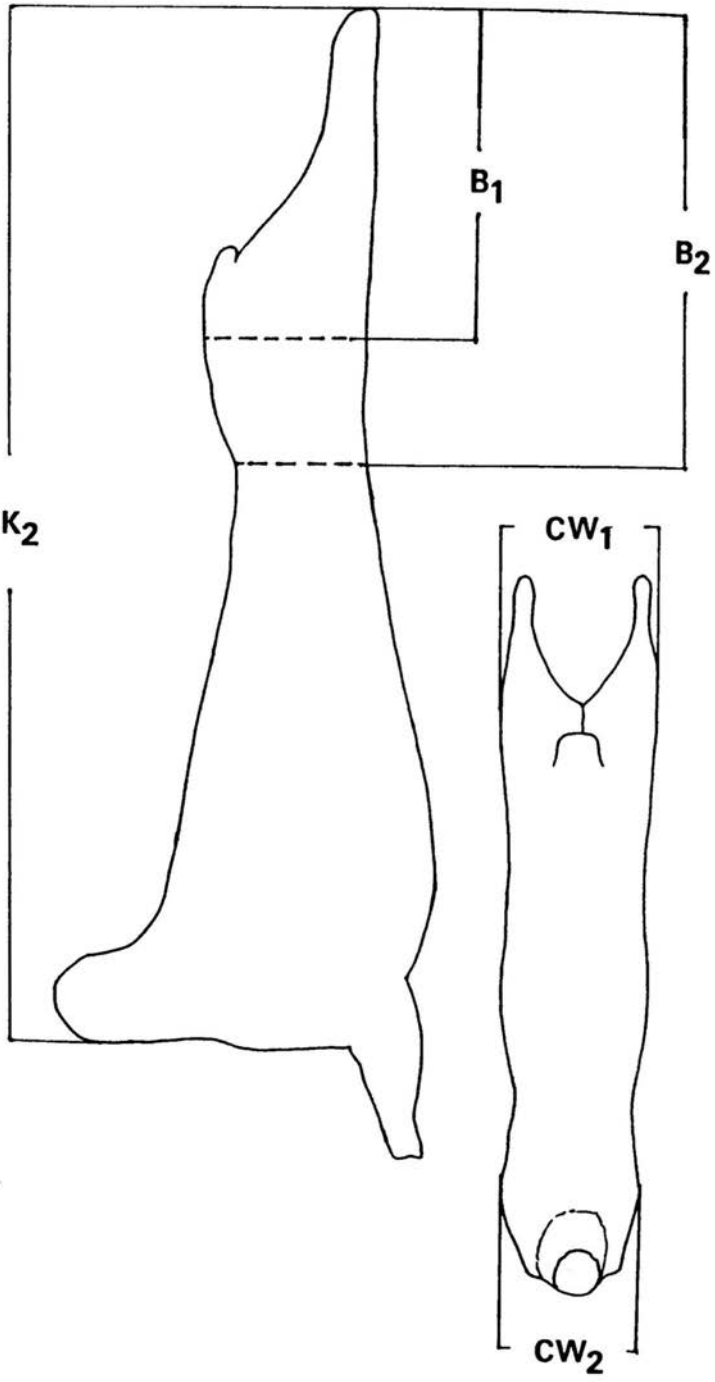


Figure 3.1. Carcass measurements on the intact lamb carcass

3.1.7 Sensory evaluation

3.1.7.1 Preliminary study

3.1.7.1.1 Standardisation

During the preliminary study all the methods and techniques regarding the preparation, cooking, serving and evaluation of loin samples were standardised and evaluated.

3.1.7.1.2 Sensory panel training

Since the Department of Home Economics and Diethetics has an analytical taste panel with more than four years of experience in the evaluation of the eating quality of lamb, it was only necessary to conduct a retraining program as outlined in Figure 3.2. Initially an informal orientation session was held in order to introduce and discuss the evaluation-form with the instructions and criteria (Figure 3.3.).

During the retraining program, mutton samples representing the whole spectrum of sensory characteristics were evaluated. Several tests were conducted in order to obtain results namely:
(i) triangle tests to establish differences between quality characteristics,
(ii) range tests to determine the order of acceptabilities of different intensities of the same sensory character, and
(iii) quality estimation tests to judge the relative intensities of a specific character and to give it a numeric value.

In the first range of tests, samples were evaluated in duplicate according to one sensory character at a time, followed by a discussion. Whenever the inter-person variation was too big and or where there was uncertainty about a specific sample, the session was repeated.

These training sessions were conducted under the same conditions as the final study. Finally, the samples were all coded and tested randomly.

Figure 3.2. SENSORY RETRAINING PROGRAM.

SESSION 1: ORIENTATION: SENSORY EVALUATION FORM AND CRITERIA

SESSION 2: TRIANGLE TESTS TO ESTABLISH DIFFERENCES BETWEEN QUALITY CHARACTERISTICS

WEDNESDAY 8 AUGUST 09:50 - 11:00

09:50-10:00	Welcome and arrangements
10:00-10:20	Orientation and discussion of standards
10:20-10:25	Identification of tipical aroma and flavour
10:25-10:30	Triangle tests: juiciness
10:30-10:36	Triangle tests: tipical aroma and flavour
10:36-10:42	Triangle tests: tastiness of meat samples
10:42-10:48	Triangle tests: tastiness of meat samples (with fat)
10:48-11:00	Discussion of results, thank taste panel and serve soft drinks

SESSION 3: RANGETESTS AND QUALITY ESTIMATION TESTS

SESSION 4: QUALITY ESTIMATION TESTS OF ALL SENSORY CRITERIA

TUESDAY 16 OCTOBER 10:00 - 11:00

10:00-10:02	Rangetests: juiciness
10:02-10:07	Quality estimation tests: juiciness
10:07-10:10	Discussion of results and serve apple slices
10:10-10:13	Quality estimation tests: aroma / odour
10:13-10:15	Range tests: tastiness of meat samples
10:15-10:25	Quality estimation tests: overall acceptability
10:25-10:35	Discussion of results and serve apple slices
10:40-10:50	Quality estimation tests: all criteria
10:50-11:00	Discussion of results, thank taste panel and serve soft drinks

SESSION 5: PERFORMANCE EVALUATION - COEFFICIENT OF CONFIDENCE

WEDNESDAY 17 OCTOBER - Session 1 10:00-10:10

THURSDAY 18 OCTOBER - Session 2 10:00-10:10

FRIDAY 19 OCTOBER - Session 3 10:00-10:10

EVALUATION PROGRAM DURING PROJECT 1990

Evaluation sessions were held weekly on tuesdays and wednesdays at 10:00, and two sets of samples were served randomly.

Dates: 23/10; 24/10; 30/10; 31/10; 06/11 and 07/11

10:00-10:10	Quality estimation tests (set no.1)
10:10	Serve apple slices
10:30-10:40	Quality estimation tests (set no.2)
10:40	Thank taste panel and serve soft drinks

Figure 3.3. SENSORY EVALUATION-FORM WITH THE INSTRUCTIONS AND CRITERIA.

EVALUATION OF LAMB 1990

SESSION No.		SET No.		MEMBER No.	

Taste and judge the sample by making a vertical mark on the horisontal scale provided.

SAMPLE CODE:_____

DESCRIPTION OF AROMA: _____

WETHER NO.			
TREATMENT			
SEQUENCE			

AROMA	undesirable	extremely desirable
INCIPIENT JUICINESS	undesirable	extremely desirable
SUSTAINED JUICINESS	undesirable	extremely desirable
FLAVOUR	undesirable	extremely desirable
OVERALL ACCEPTABILITY	undesirable	extremely desirable

SAMPLE CODE:_____

DESCRIPTION OF AROMA: _____

WETHER NO.			
TREATMENT			
SEQUENCE			

AROMA	undesirable	extremely desirable
INCIPIENT JUICINESS	undesirable	extremely desirable
SUSTAINED JUICINESS	undesirable	extremely desirable
FLAVOUR	undesirable	extremely desirable
OVERALL ACCEPTABILITY	undesirable	extremely desirable

Figure 3.3(b). DATA CARD - ROASTING PROCEDURES

TREATMENT CODE:_____ SESSION NO._____ SET NO._____

WETHER NO._____ DATE_____ REMARKS

SAMPLE CODE_____ OVEN TEMP._____ Odour:_____

Firmness:_____

Fatness:_____

ROASTING TIME 30min/500 g + 20min	
Time out	
Time in	
ROASTING TIME	
INTERNAL TEMPERATURE	
unroasted	
roasted	
COOKING LOSSES	Mass (g)
A Mass of unroasted loin	
B Mass of pan + rack	
C Mass of pan + rack + drip + roasted loin	
D Mass of roasted loin (C-D)	
E Mass of total drip (D-B)	
CHARACTERISTICS OF DRIP	
G Volume total drip	
H Volume meat extract	
Volume fat (G-H)	
CALCULATION OF COOKING LOSSES	
% Total cooking loss (A-E)/A x 100 = I	
% Drip loss F/A x 100 = J	
% Evaporation loss I-J = K	

3.1.7.1.3 Taste panel performance evaluation

At the end of the training program the taste panel's performance was evaluated in order to determine the accuracy and repeatability of individual standard evaluations. Three evaluation sessions were conducted during which duplicate samples of portions of the M. longissimus lumborum of a lamb and a fullgrown ram were served to the taste panel.

Analysis of variance was conducted by means of the Statistical Analysis System (SAS) which indicated that the meat samples differed significantly ($p<0.01$) from each other as far as all sensory characteristics were concerned.

Furthermore, the inter- and intra-taste panelist variances were determined and subsequently the coefficient of confidence of the taste panel for each sensory characteristic was calculated according to the following formula:

$$\text{Coefficient of confidence} = 1 - \frac{\text{Intra-taste panelist variance}}{\text{Inter-taste panelist variance}}$$

The coefficient of confidence was also calculated for each panelist relative to every sensory characteristic by one-way analysis of variance test with sheep as factor.

$$\text{Confidence of individual panelist} = \frac{F - 1}{F} \quad \text{(Winer, 1971)}$$

The levels of confidence for the taste panel and the individual panelists for the different sensory characteristics are indicated in Table 3.6. (Values of 1.0 represent very high levels of confidence for the taste panel or individual panelists).

Results obtained indicate that the taste panel, consisting of six members, was adequately trained and could be regarded as

Table 3.6. LEVELS OF CONFIDENCE FOR THE TASTE PANEL AND THE INDIVIDUAL PANELISTS FOR THE DIFFERENT SENSORY CHARACTERISTICS.

CRITERIA	TASTE PANEL	MEMBER NO.1	MEMBER NO.2	MEMBER NO.3	MEMBER NO.4	MEMBER NO.5	MEMBER NO.6
AROMA	0.8477	0.9999	0.6622	0.9999	0.9963	0.9999	0.9974
INCIPIENT JUICINESS	0.8967	0.9955	0.9734	0.9977	0.9985	0.9982	0.9987
SUSTAINED JUICINESS	0.9013	0.9908	0.9801	0.9983	0.9978	0.9983	0.9985
FLAVOUR	0.7358	0.9984	0.9839	0.9985	0.9955	0.9932	0.9997
OVERALL ACCEPTABILITY	0.5661	0.9979	0.9909	0.9992	0.9976	0.9983	0.9991

an accurate scientific measure instrument.

3.1.7.2 Final study

3.1.7.2.1 Random allocation of samples

M. longissimus lumborum samples (loin samples) were removed from the left side of 37kg and 43kg wether carcasses, vacuum-packed and stored in polyethylene bags at -20°C. After completion of the trial the frozen loin samples were transported to the Department of Home Economics and Diethetics at the University of Potchefstroom for Christian Higher Education, where the samples[13] were coded and randomly allocated to different sessions according to slaughter mass-groups. A schematic representation of the experimental design for sensory evaluation is presented in Figure 3.4.

3.1.7.2.2 Preparation of samples

One loin sample from each experimental group was removed from the deep freezer 48 hours prior to every evaluation session and placed in a refrigerator to thaw to an internal temperature of between 0.5°C and 2.5°C. After thawing the samples were removed from the vacuum packaging and weighed to determine the roasting time according to the following formula:

Roasting time = 30minutes / 500g sample + 20minutes

The oven racks, pans and roasted loin samples were weighed in order to determine the percentage drip loss, evaporation loss and total cooking loss.

3.1.7.2.3 Cooking procedures

Loin samples were placed in oven pans and roasted at 160°C to an internal temperature of 70°C. Hereafter the roasted loin samples were allowed to set for 10 minutes during which time the samples, racks and pans were weighed. Loin samples were deboned

[13]The coded samples were stored at -20°C until required.

Figure 3.4a. SCHEMATIC REPRESENTATION OF THE EXPERIMENTAL DESIGN FOR SENSORY EVALUATION.

SLAUGHTER GROUPS		37 kg (1)	43 kg (2)
BREED A (Dorper)	High Energy Diet (a)	6	6
	Medium Energy Diet (b)	6	6
BREED B (SAMM)	High Energy Diet (a)	6	6
	Medium Energy Diet (b)	6	6

Figure 3.4b. TREATMENT CODES USED IN SENSORY EVALUATION.

TREATMENT CODES:	BREED	A	B
	DIET	a	b
	SLAUGHTER GROUP	1	2

(M. longissimus lumborum removed from the lumbar vertebrae) but the subcutaneous fat was not removed since it contributes largely to the aroma and taste of lamb.

3.1.7.2.4 Sample division

Six taste samples (0.5cm slices) were cut from the centre of each loin (Figure 3.5.), wrapped in foil and placed in coded white lukewarm porcelain bowls. Since aroma intensity cannot be estimated from such small samples, the remainder of each loin was coded, wrapped in foil and presented as an additional sample to the taste panel for them to judge aroma.

During the division of loins into taste samples, the aroma intensity, a discription of the odour (typical or strange), firmness of the fat and fat-to-bone ratio were determined by the laboratory personnel.

3.1.7.2.5 Serving of taste samples

The sequence in which samples were to be evaluated was predetermined according to a randomised test design. The result was that different treatment samples and slaughter-group samples were evaluated in a random sequence within and between sessions.

3.1.7.2.6 Mouth-rinse

A glass of water (15°C) was placed in each booth. After panelists had rinsed their mouths they waited for 30 seconds, in order to restore the normal fluid environment in the mouth, before evaluating the next sample. Apple slices were served between different sets in order to refresh the mouth.

3.1.7.2.7 Sensory evaluation

The eating quality of lamb was evaluated by a trained taste panel consisting of six members, by means of a quality estimation test on a 10cm unstructured scale of which the lower end (0) indicated the lowest assessment and the upper end (10) the highest (Jellinek, 1985; Breukink and Casey, 1989).

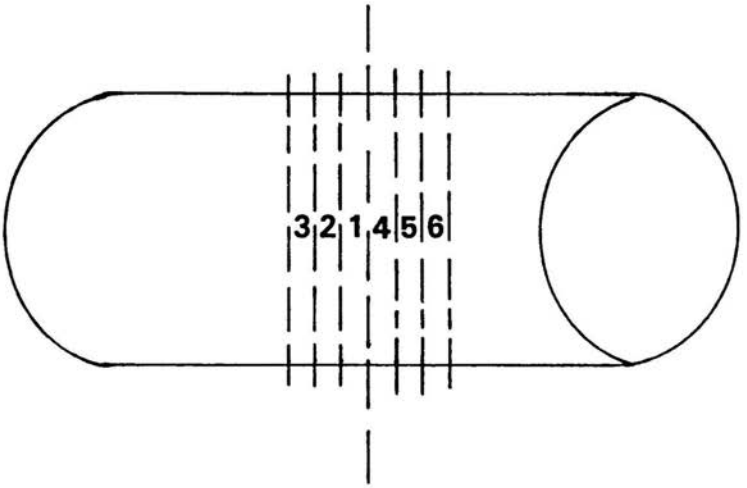


Figure 3.5. Method by which loin samples were cut into 0.5 cm slices for sensory samples

The following parameters were used: 1) aroma intensity, 2) incipient juiciness, 3) sustained juiciness, 4) flavour and 5) overall acceptability. The evaluation criteria, with an explanation of each, were provided to each panelist at the start of each session (Figure 3.6.).

In order to reduce loss of aroma, the first sample was fully analysed before the next sample was attempted. The first sensory characteristic evaluated was aroma intensity followed by a discription of aroma (typical or strange).

3.1.7.2.8 Criteria for the evaluation of lamb

3.1.7.2.8.1 Aroma-intensity

The sensation of smell observed during snuff-taking as a result of stimuli from volatile substances.

0	-	not intense
-1-2-3	-	slightly intense
-4-5-6	-	more intense
-7-8	-	most intense
-9-10	-	extremely intense

3.1.7.2.8.2 Incipient juiciness

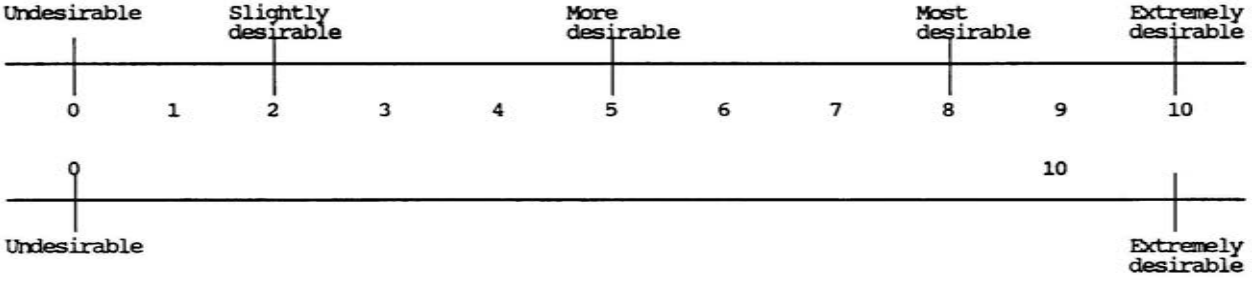
The amount of juice (meat juice) released from the taste sample after the teeth cut through the meat and squeeze it against the palate during the first three mastications.

0	-	not juicy - extremely dry
-1-2-3	-	slightly juicy - moderately dry
-4-5-6	-	moderately juicy - mouth slightly moistened
-7-8	-	very juicy - mouth moderately moistened
-9-10	-	extremely juicy - mouth extremely moistened

3.1.7.2.8.3 Sustained juiciness

The impression of mouth moistening subsequent to chewing a

Figure 3.6. CRITERIA FOR THE SENSORY EVALUATION OF LAMB.



sample more than three times as a result of expressed meat juice and saliva stimulation by the fat present in the taste sample.

0	-	not juicy - extremely dry
-1-2-3	-	slightly juicy - moderately dry
-4-5-6	-	moderately juicy - mouth slightly moistened
-7-8	-	very juicy - mouth moderately moistened
-9-10	-	extremely juicy - mouth extremely moistened

3.1.7.2.8.4 Flavour

The odour and taste during the mastication and swallowing processes as a result of a combination of the basic meat flavour, typical meat flavour and acquired flavour (influenced by the cooking method).

0	-	not tasty - flavourless - not-typical (unacceptable)
-1-2-3	-	slightly tasty - poor meat taste
-4-5-6	-	more tasty - moderate meat taste
-7-8	-	most tasty - very acceptable meat taste
-9-10	-	extremely tasty - extremely acceptable meat taste

3.1.7.2.8.5 Overall acceptability

The overall impression of eating quality and acceptability.

0	-	unacceptable - inedible
-1-2-3	-	slightly acceptable - poor
-4-5-6	-	more acceptable - moderate
-7-8	-	most acceptable - good
-9-10	-	extremely acceptable - exellent

3.1.8 Lipid isolation and determination of fatty acid composition

3.1.8.1 The isolation of lipids from animal and plant tissues

The isolation of lipids from carcass fat depots and plasma samples basically comprises two steps namely, an extraction procedure followed by the removal of non-lipid contaminants. Precautions must be taken at each stage of the lipid isolation to minimise the risk of autoxidation of polyunsaturated fatty acids and hydrolysis of lipids.

In the forthcoming sections a brief outline of the general and theoretical aspects of lipid isolation will be given, followed by a description and discussion of the methods used in this study.

3.1.8.2 General principles of lipid isolation

3.1.8.2.1 Storing carcass and plasma fat samples

Lipid extraction procedures should be performed as soon as possible after removal of samples from the living organism. This would limit the possibility of changes occuring in the lipid components[14].

Due to various limitations it is often necessary to store these samples for longer periods of time. In such instances the tissue samples should be frozen as rapidly as possible and stored in sealed glass containers at -20°C in an atmosphere of nitrogen.

According to Christie (1982) the freezing process may permanently damage the tissue samples as a result of osmotic shock which disrupts the cell membranes. The original environment of the tissue lipids is consequently altered so that the lipids may come in contact with enzymes from which they are normally protected. Even at -20°C lipolytic enzymes are released

[14]Christie, 1982.

that may hydrolise the lipids after prolonged standing or thawing. Contact with organic solvents aids this process.

The presence of large amounts of unesterified fatty acids in animal or plant tissue, may be an indication that some irreversible damage to the tissue and subsequently to the lipids has occurred[1]. Holmann (1966) suggests that tissue samples should be stored at -20°C in all glass containers or in bottles with teflon lined caps containing chloroform. Furthermore the tissue samples should be homogenised and extracted without being allowed to thaw.

3.1.8.2.2 Choosing an extracting solvent

In practice a number of organic solvents are used for lipid extraction which may deactivate enzymes and render a complete recovery of lipids. The ideal solvent or solvent mixture for lipid extraction should, however, be sufficiently polar in order to remove all lipids from their association with all membranes or with lipoproteins, but without reacting chemically with those lipids.

The extracting solvent should not be so polar that triacylglycerols and other non-polar simple lipids do not dissolve and are left adhering to the tissue[15].

If the extracting solvent is not carefully chosen it may, instead of preventing enzymatic hydrolysis of lipids, actualy stimulate side reactions. The last factor which Christie (1982) emphasized strongly was the potential toxicity of solvents to the operator. Chloroform and methanol are highly toxic and the mixtures are powerful irritants if they come in contact with the skin. Appreciable amounts of vapour are introduced into the atmosphere during the filtration procedure. Chloroform and methanol, as well as other such solvents, should thus only be

[15]Christie, 1982.

used in well-ventilated areas.

According to Zahler and Niggli (1970) the most important factors affecting the solubility of lipids in organic solvents are (i) the non-polar hydrocarbon chains of the fatty acids or other aliphatic moieties and (ii) any polar functional groups such as phosphate or sugar residues.

At this stage no single solvent is suitable as a general purpose lipid extractant. Most workers, however, appear to accept that a mixture of chloroform and methanol of 2:1 (v/v) will extract lipid more exhaustively from animal, plant or bacterial tissues than most other simple solvent systems[16]. According to Christie (1982) the water in the tissue should perhaps be considered as a ternary component of the solvent system.

3.1.8.2.3 Removal of non-lipid contaminants

The non-lipid contaminants extracted by polar organic solvents during lipid extraction are normally sugars, urea, amino acids and salts.

Most of these contaminating compounds are removed from chloroform-methanol (2:1 v/v) mixtures simply by shaking the combined solvents with one quarter their total volume of water. Diluted salt solutions like 0.88 % potassium chloride (KCl) are sometimes used in stead of water[17].

The purified lipids are present in the lower phase which comprises approximately 60 % of the total volume. The upper phase contains the non-lipid contaminants together with varying amounts of gangliosides and glycolipids. A centrifugation procedure is usually necessary in order to ensure that the two layers are

[16]Christie, 1982.

[17]Folch, Lees & Stanley, 1957.

completely separated

3.1.8.2.4 Precautions before extraction procedures

The extractants (extracting solvents) should preferably be distilled before use, as they might contain small amounts of potential lipid contaminants.

Polyunsaturated fatty acids autoxidise very rapidly if left unprotected in air. This necessitates the use of an additional antioxidant such as butylated hydroxytolueen (BHT; 2,6-di-tert-butyl-p-cresol) at a level of 50-100mg per liter of the solvents. BHT does not interfere with chromatographic analyses as it tends to elude near to, or coincidently with methyl myristate on polyester stationary phases.

Furthermore, tissue samples should be homogenised with solvents in a Waring blender or a similar instrument in which the drive to the knives or grinders is from above, so that there is no contact between solvent and any washers or greased bearings[18].

Lipids should not be stored dry but instead, if possible, in an inert non-alcoholic solvent such as chloroform. In order to obtain the weight of lipid per gram of wet tissue and/or amount of dry material in the tissue, it is advisable to extract a small sample separately for these purposes.

The potential toxicity of chloroform and methanol (and the mixtures) must always be kept in mind when using these solvents during filtration procedures. Protective clothing and a well-ventilated working area is essencial.

[18]Christie, 1982.

3.1.8.3 Method: lipid isolation

3.1.8.3.1 Fat and feed sample collection

* Approximately 5g samples of subcutaneous fat (SCF) were collected from 114 wether carcasses. Subcutaneous fat samples were taken from the left side of each carcass at a point over the 13th rib, 25mm from the medial plane as described by Casey, Van Niekerk and Spreeth (1989). A clean tweezer, scalpel and pair of scissors were used to remove each fat sample cautiously.

Small tags containing the number, experimental group and code of each wether were prepared prior to slaughter, in order to speed up the sampling and marking processes. These samples were sealed in polyethylene bags and stored at -20°C in a freezer as quickly as possible. The storage period varied between two and eight weeks depending on the slaughter date.

* High and moderately high energy feed samples as well as maize meal, cotton seed cake and Smuts finger hay samples were collected weekly, sealed in polyethylene bags and stored in a freezer at -20°C.

3.1.8.3.2 Storing fat and feed samples

Fat and feed samples were stored as quickly as possible in a standard abbatoir freezer at -20°C. These samples were only removed prior to lipid isolation procedures. The freezer temperature was checked on a daily basis.

Plasma samples were centrifuged as soon as possible after collection in order to separate the different lipoprotein fractions. The lipoprotein fractions were sealed in plastic containers with teflon caps and stored at -20°C.

Plasma samples, not intended for lipoprotein separation, were stored in all-glass test tubes at -20°C.

3.1.8.3.3 Homogenising fat samples

* Fat samples were not allowed to thaw. A sample of 1g was mixed with 18ml of chloroform ($CHCl_3$) + 1.8ml BHT (Butylated hydroxy tolueen) and crushed with a glass rod. The sample mixture was stored at 2-4°C and vigorously shaken every hour for at least six hours, in order to remove contaminants and extract lipids. The water in the fat tissue was considered as a ternary component of the solvent system[19].

* Subcutaneous fat samples intended for *cis-trans* fatty acid analysis were homogenised at the CSIR in a Warning Blender. Sub-samples (5g) were then taken for futher analysis.

3.1.8.3.4 Removal of non-lipid contaminants

The lipid mixture (2g fat sample + 18ml chloroform + 1.8ml BHT[20]) was shaken vigorously every hour in order to extract lipids and to remove contaminants. No extra water or salt solutions like potassium chloride (KCl) were added to the sample to remove contaminants.

3.1.8.3.5 Preparation of methyl esters

* A mixture of 1ml 2M sodium hydroxide in methanol (8g NaOH in 100ml methanol) and 5ml of chloroform was added to 1ml of the sample extract. The final mixture was placed in a waterbath at 50°C for 20 minutes, afterwhich it was allowed to cool.

The final cooled mixture was then centrifuged at 5000 rpm for 15 minutes and the supernatant (isolated esterified lipid) separated into an all-glass sample bottle. This final sample was used to determine the fatty acid composition on the gas chromatograph.

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[19]Christie, 1982.

[20]Butylyted hydroxytolueen.

* The 5g subcutaneous fat sub-samples were treated with *n*-hexane (CH_3-$[CH_2]_4CH_3$) at 35°C for 24 hours in order to extract the lipid. The solvent was then removed under vacuum and the remaining fat (lipid) used for fatty acid determination. The saponification and esterification procedures were done according to the method of Van Wijngaarden (1967).

3.1.8.4 Theoretical aspects: determination of fatty acid composition by gas chromatography

There are two ways in which the integrator identifies the components of interest namely, the absolute retention time (ART) and the relative retention time (RRT).

The gas chromatograph in this instance was connected to a integrator which identified the components (fatty acids, C14 - C20) according to the relative retention time (RRT) method. The RRT-method is more accurate in situations where the chromatogram contains many resolved components that may not be well resolved, or when elution times change from run to run[21].

Since variations in the chromatography usually affect all components, including the reference peak, peaks can be more accurately identified relative to the time reference peak. The largest peak in the reference peak window is usually selected as reference peak 1.

The component window (CW) is set to 10% (CW = 0.1) so that when the actual retention time of a peak in the chromatogram matches within plus or minus 10% of the retention time entered in the method file, it is identified. Once the peak is identified, the integrated area for the peak is calculated and the concentration of the component is determined.

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[21]4270/4290 Integrator Users Guide, 1986. Varian Accociation, California, USA.

Different calculation methods are used to convert peak areas to concentrations. The method number (MN) refers to the method used to accomplish this calculation. The integrator was programmed to use method number 1 (MN = 1). In method number 1, response factors are used and the peak areas (or heights) are corrected[22] for the detector characteristics before conversion to percentages.

Peak detection is dependent on the peak width (PW) and peak threshold (PT), which together affect the most critical function of the integrator namely data acquisition. When peaks are not detected it is normally because they are to small or too large for the peak detection parameters being used.

3.1.8.5 Method: determination of fatty acid composition

3.1.8.5.1 Preparation of methyl esters

Methyl esters were prepared according to the NaOH/methanol method (AOAC, 1975). A 1g sample of subcutaneous adipose tissue was mixed with 18ml of chloroform ($CHCl_3$) and crushed with a glass rod. The sample in the container was stored at 2-4°C and vigorously shaken every hour. The extracted sample was held at 2-4°C for at least 6 hours.

*1ml of a 2M sodium hydroxide in methanol (CH_3OH) solution with 5 ml of chloroform was prepared. 0.5 ml of the sample extract was added to the above mentioned mixture. The final mixture was placed in a waterbath at 50°C for 20 minutes after which it was removed and allowed to cool. The final mixture was then centrifuged at 5000rpm for 15 minutes and the supernatant poured into an all-glass sample bottle. This final esterified sample was kept refrigerated until required (but not longer than two days) for subsequent fatty acid analysis on the gas

[22]The area of each component is corrected, relative to a reference component, for its detector response.

chromatograph.

3.1.8.5.2 Gas chromatography: adipose and plasma samples

3.1.8.5.2.1 Gas chromatographic column used

The instrument used was a Varian 3300 gas chromatograph, equipped with a flame ionization detector, with a 2m glass column, ID 3mm packed with Silar 10C on Gas Chrom Q.

Support: Chromosorb WHP-SP
Mesh Range: 100/120
Liquid Phase: SP2330
Temperature: 25 - 275°C

The gas chromatograph was connected to a Varian 4270 Integrator which converted the peak areas to concentrations according to method number one (MN=1)[23]

3.1.8.5.2.2 G.C. and integrator settings and programs

F.I. Detector gas:	H_2 - 0.9kg/cm2
	O_2 - 1.1kg/cm2
Carrier gas:	N_2 - 0.9kg/cm2 (30ml/min; 18p.s.i.)
G.C. Program:	Stabalisation: 2 minutes to stabalise
	Starting temperature: 150°C
	Holding time: 2 minutes
	Rise in temperature: 5°C/minute
	Final column temperature: 210°C
	Injector temperature: 210°C
	Detector temperature: 240°C
Integrator setting:	Attenuation: 2
	Chart speed: 0.25cm/minute
	Dialog: 19 minutes end run
	Method number[24]: MN = 1

[23]Refer to section 3.1.3.4.1.

[24]Refer to section 3.1.3.4.1.

Inject:=1μl samples of the esterified lipids extracted from SCF,
=2μl samples of the extracted and esterified lipid from plasma.

3.1.8.5.2.3 Conditions of column standard

The carrier gas flow was maintained at all times (before and between runs) and the oven temperature was set at 225°C overnight.

3.1.8.5.2.4 Standard

A standard solution containing methyl esters of the fatty acids in the range C14 to C20, was injected in order to determine and check the retention times of the different fatty acids. The integrator was programmed accordingly, with a component window[25] of 10% for each fatty acid.

3.1.8.5.3 Gas chromatography: feed samples

Fatty acid profile analysis of feed samples were conducted using a Hewlett-Packard chromatograph equipped with a Carbowax column (20m x 0.2mm ϕ). The carrier gas used was nitrogen (N_2). Fatty acid standards were obtained from Nu-Chek-Prep.Inc., Elysian, Minnesota (USA).

Column starting temperature:	160°C
Holding time:	10 minutes
Rise in temperature:	10°C / minute
Final column temperature:	215°C
Dialog:	30 minutes end run

3.1.8.5.4 Gas chromatography: *cis-trans* fatty acid samples

A Varian 3700 equipped with a SP2560 column (100m x 0.2mm ϕ) was used to analyse the *cis-trans* fatty acid profiles of

[25]Refer to section 3.1.3.4.1.

subcutaneous fat samples from Dorper and SA Mutton Merino wethers in the 43kg slaughter group. Standards for the *cis-trans* fatty acids were also obtained from Nu-Chek-Prep.Inc., Elysim, Minesota (USA). Column temperature: 185°C - 220°C

Rise in temperature: 2°C/minute

Injector temperature: 240°C

Detector temperature (FID): 240°C

Split ratio: 1:100

3.2 ANALYSIS OF DATA

The results (variables and their interactions) were statistically analysed by analysis of variance and general linear regression models. Levels of significance were tested by means of the F-test or t-test and multiple range analysis was performed by either least significant differences (LSD), Tukey or Sheiffe methods. Significances are quoted at the $P<0.01$, $P<0.05$ and $P<0.10$ levels and F- or t-values along with the R, and R^2-values are provided.

Regression analysis techniques used include simple and multiple regression models, and analysis of variance techniques includes one-way analysis of variance as well as multifactor analysis of variance.

Covariance analysis procedures were also conducted and percentage fat (estimated from three-rib cut samples) was mostly included as covariate. This was done in order to correct for differences in maturity types between breeds. Classification factors were crosstabulated in order to show frequency counts, and differences were analysed by means of Chi-square tests.

LIST OF PARAMETERS

- Date - start of trial
- Date - end of trial
- Slaughter dates

- Time on feed (t)
- Live mass - start of trial
- Live mass - weekly / animal
- Live mass - prior to slaughter
- Average daily gain, (g/day)
- Plasma sample (external jugular vein)
- Mass - head + tongue
- Mass - paws and tail
- Mass - skin
- Mass - digestive system
- Rumen-pH, abomasal-pH, duodenal-pH
- Subcutaneous fat samples
- Fat thickness (13th rib)
- Fat thickness (brisket)
- Fat thickness (10th rib)
- Carcass mass (hot) (HCM)
- Carcass mass (cold) (CCM)
- Dressing percentage (D%)
- Carcass conformation
- Hindleg length (B1 and B2)
- Hindlimb width (CW1 and CW2)
- Carcass length (K2)
- Hindleg compactness (CCM/B1 and CCM/B2)
- Carcass compactness (CCM/K2)
- Fat distribution (photos)
- Carcass mass loss during cooling
- Three-rib cut sample mass (RSM)
- Fat %
- Meat %
- Bone %
- Meat-pH
- Loin samples (M.Longissimus et.lumborum)
- Aroma-intensity
- Incipient juiciness
- Sustained juiciness

- Flavour (Tastiness)
- Overall acceptability
- Unroasted loin mass (ULM)
- Roasted loin mass (RLM)
- Volume of total cooking loss (g)
- % Total cooking loss
- Volume of drip loss (g)
- % Drip loss - Total volume drip loss (ml)
  - Volume meat extract in drip (ml)
  - Volume fat in drip (ml)
- % Evaporation loss
- Subcutaneous adipose tissue: fatty acid profiles (C14:0 - C20:0)
- Plasma fatty acid profiles: (C16:0 - C20:0)
- Relative percentage saturated fatty acids in adipose tissue
- Relative percentage unsaturated fatty acids in adipose tissue
- Saturated vs. unsaturated fatty acid ratio
- Relative percentage saturated plasma fatty acids
- Relative percentage unsaturated plasma fatty acids
- Saturated vs. unsaturated plasma fatty acid ratio
- Odour or aroma of roasted M.longissimus lumborum samples
- Firmness of subcutaneous adipose tissue of roasted M.longissimus lumborum
- Amount of visible fat in roasted M.longissimus lumborum samples
- Fatty acid profiles of feed samples

4 GROWTH AND CARCASS RESULTS

4.1 GROWTH RESULTS

4.1.1 Influence of treatment on average daily gain

All wethers were weighed weekly and the average daily gain (ADG) of each wether was calculated by the difference between the slaughter and initial mass, divided by the amount of days spent on trial. Treatment (H and M-treatment) significantly influenced growth rate and consequently average daily gain (ADG). Although the aim was to minimize differences in daily intake between the different experimental animals, it was expected that the ADG would differ quite markedly between different treatment groups and possibly between breeds. When a randomised experimental design is used there should, however, be very little differences in the ADG's of the different slaughter groups within the same breed and treatment.

The ADG differed very significantly between the two treatment groups, with the H-treatment tending to have on average higher values than the M-treatment ($P<0.001$, $F=43.929$) as depicted in Table 4.3.[1] These values ranged from 0.189 ± 0.044kg/wether/day for the H-group to 0.139 ± 0.033kg/wether/day for the M-group (Table 4.2).

The covariance analysis results also emphasise the marked difference between the H and M-treatment groups ($P<0.001$, $F=44.281$). Differences in ADG's between treatments were significant for both Dorpers ($P<0.001$, $F=12.508$) and SA Mutton Merinos ($P<0.001$, $F=18.759$) at the 25kg ($P<0.011$, $F=7.842$), 31kg ($P<0.008$, $F=8.946$), 37kg ($P<0.001$, $F=25.549$) and 43kg slaughter mass ($P<0.002$, $F=12.732$)(Table 4.4).

Nevertheless, it is interesting to note that the ADG's increased as the target mass increased for both H and M-treatment groups. The ADG's of the H-treatment group increased from 0.176

[1]Tables 4.1 to 4.10 are presented at the end of chapter 4.

the ANOVA-model (Table 4.4.), and the effect of breed on the percentage bone in the three rib-cut samples also became noteworthy ($P<0.057$, $F=3.710$).

Average values obtained for muscle percentages in three rib-cut samples were respectively 53.70 ± 6.59% and 55.95 ± 4.59% for Dorpers and SA Mutton Merinos (Tables 4.1. and 4.2.). The average percentage bone in three rib-cut samples from Dorpers (20.90 ± 3.58%) was only slightly higher than that from SA Mutton Merinos (20.47 ± 3.02%). These differences were basically due to major breed differences between both the percentage bone ($P<0.011$, $F=7.874$) and muscle ($P<0.011$, $F=7.889$) of wethers in the 37kg slaughter group. Differences in the percentage bone and muscle were less pronounced in the 43kg slaughter group and almost completely absent in both the 25 and 31kg slaughter groups.

Although the difference between the average percentage fat of Dorpers and SA Mutton Merinos was small, highly significant differences in fatness were observed on the M-treatment ($P<0.048$, $F=4.166$), coupled with the 37kg ($P<0.044$, $F=4.631$) and 43kg ($P<0.005$, $F=10.07$) slaughter groups (Table 4.4.).

The average percentage fat in the carcasses of Dorpers and SA Mutton Merinos at 43kg live mass were respectively 34.96 ± 6.23% and 28.39 ± 3.70%. The percentage fat already differed markedly between Dorpers (28.69 ± 5.63%) and SA Mutton Merinos (24.56 ± 2.95%) at 37kg live mass, but no significant differences were observed at 25 or 31kg live mass. It is clear that the difference between breeds in carcass fatness is more pronounced when the wethers are slaughtered at a heavier target mass.

4.2.4.3 The influence of slaughter group on the bone:muscle:fat ratios

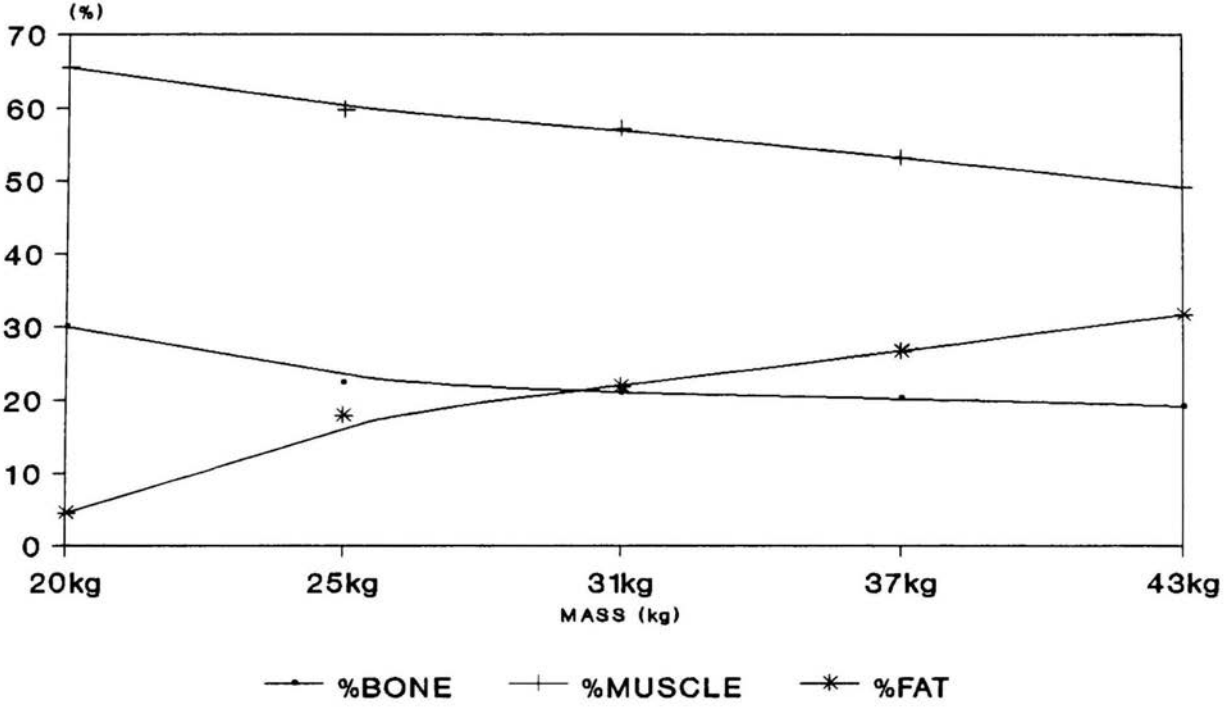
Dorpers and SA Mutton Merinos were both divided into four target slaughter groups namely 25, 31, 37 and 43kg live mass.

In section 2.3.8. it was explained that as an animal grows and developes from birth to maturity, continuous changes are occurring in its body conformation and composition (Forrest *et al.*, 1975). After birth an animal goes through a phase of very slow growth, which is followed by a phase of rapid growth, during which the rate of increase in size may be nearly constant and the slope of the sigmoid curve remains almost unchanged. Later in this phase the growth of muscles, bones and vital organs begins to taper off, and fattening begins to accelerate. When the animal reaches mature size, a retardation of growth occurs (Forrest *et al.*, 1975). In early maturing sheep breeds like the Dorper, fattening begins to accelerate at an earlier chronological age.

Both Dorpers and SA Mutton Merinos demonstrated an increase in carcass fatness ($P<0.001$, $F=35.192$) from 25 to 43kg live mass, while the percentage muscle ($P<0.001$, $F=29.113$) and bone ($P<0.001$, $F=006$, $F=4.465$) decreased. However, Dorpers (34.96 ± 6.23% fat) were markedly fatter in comparison with SA Mutton Merinos (28.39 ± 3.70% fat) at 43kg live mass. At 37kg live mass the Dorper carcasses contained less bone and muscle than the SA Mutton Merino carcasses. This tendency, although not significant, was also demonstrated at 25, 31 and 43kg live mass. The percentage bone, muscle and fat of Dorpers and SA Mutton Merinos at 25, 31, 37 and 43kg live mass are summarised in Table 4.2. and Graph 4.1.

Differences in the percentage muscle and bone between slaughter groups were negligible when fat percentage was included as covariate in the model. Furthermore, significant second order interactions between breed and slaughter mass for both the percentage muscle ($P<0.010$, $F=4.023$) and fat ($P<0.003$, $F=5.171$) were observed, but again, after the inclusion of fatness as covariate, the interactions were unimportant (Table 4.4.).

%BONE, MUSCLE AND FAT IN THREE RIB-CUT SAMPLES OF WETHERS



Graph 4.1

Regression equations were fitted between fat percentage and slaughter mass for both breeds. A linear model indicated that slaughter mass was responsible for at least 60% of the variation in fat percentage in Dorper carcasses (P<0.001, F=69.170).

$$Y_{\%FD}=a+bX_{SM}$$

$Y_{\%FD}$ = %Fat in three rib-cut samples of Dorpers carcasses
X_{SM} = Slaughter mass (kg)
a = -9.036 (P<0.037, T=-2.142)
b = 1.035 (P<0.001,T=8.317).....Graph4.2.

However, for SA Mutton Merinos a multiplicative model, with slaughter mass included as independent variable, explained most of the variation (± 58%) in fat percentage (P<0.001, F=62.111).

$$Y_{\%FS}=aX^{b}$$

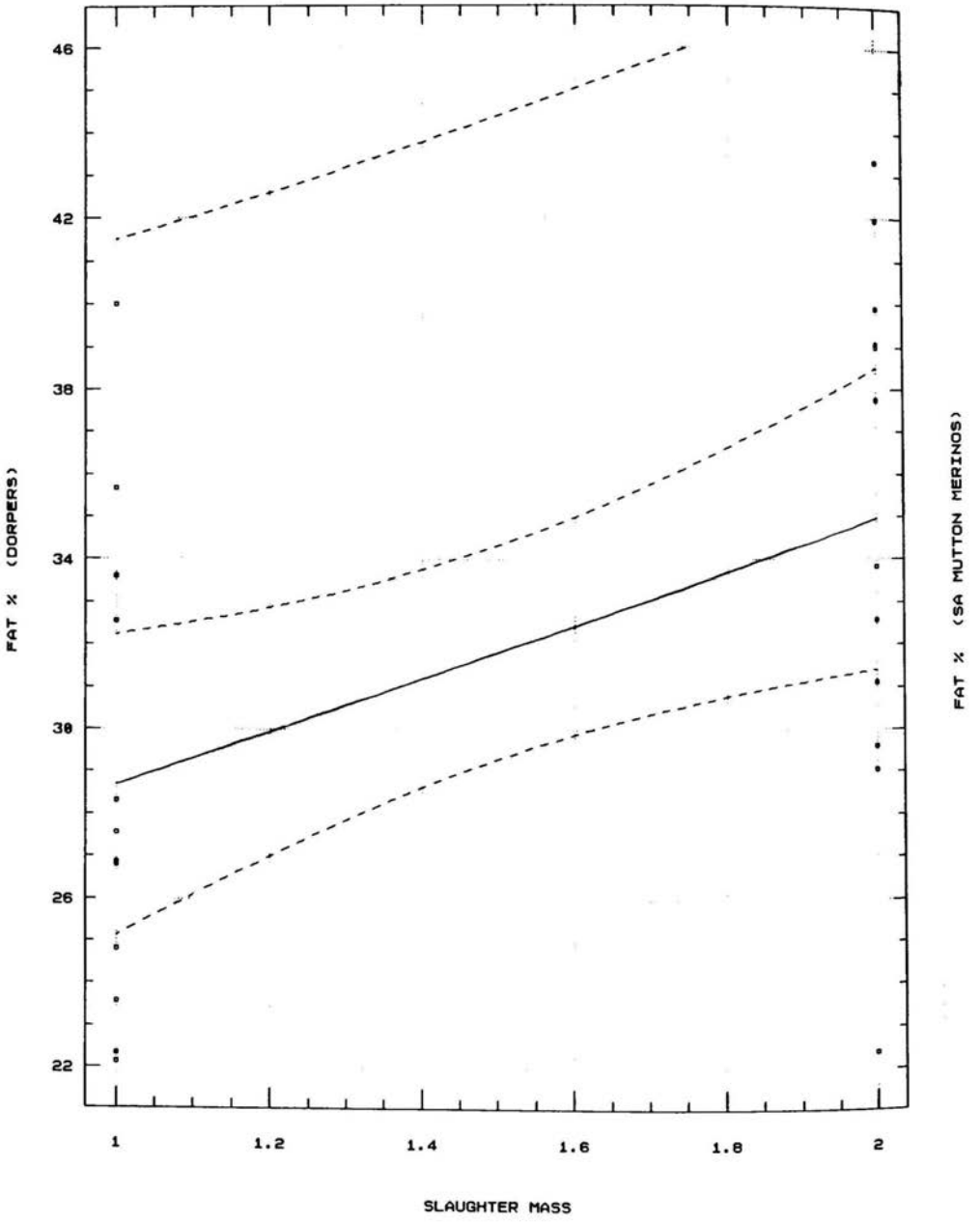
$Y_{\%FS}$ = % Fat in carcasses of SA Mutton Merinos
X = Slaughter mass (kg)
a = 0.444 (P<0.201, T=1.295)
b = 0.771 (P<0.001, F=7.881).....Graph 4.3.

It is evident that Dorpers were already in the phase where fattening begins to accelerate, while SA Mutton Merinos were in a phase of rapid growth. From the abovementioned equations it was calculated that Dorpers contain 31% fat at approximately 39.5kg live mass and that SA Mutton Merinos contain the same percentage fat at approximately 50kg live mass. Consequently, SA Mutton Merino wethers reached the same degree of fatness as Dorpers at a heavier mass (±10.5kg heavier mass).

Graph 4.2

LINEAR REGRESSION BETWEEN FAT PERCENTAGE

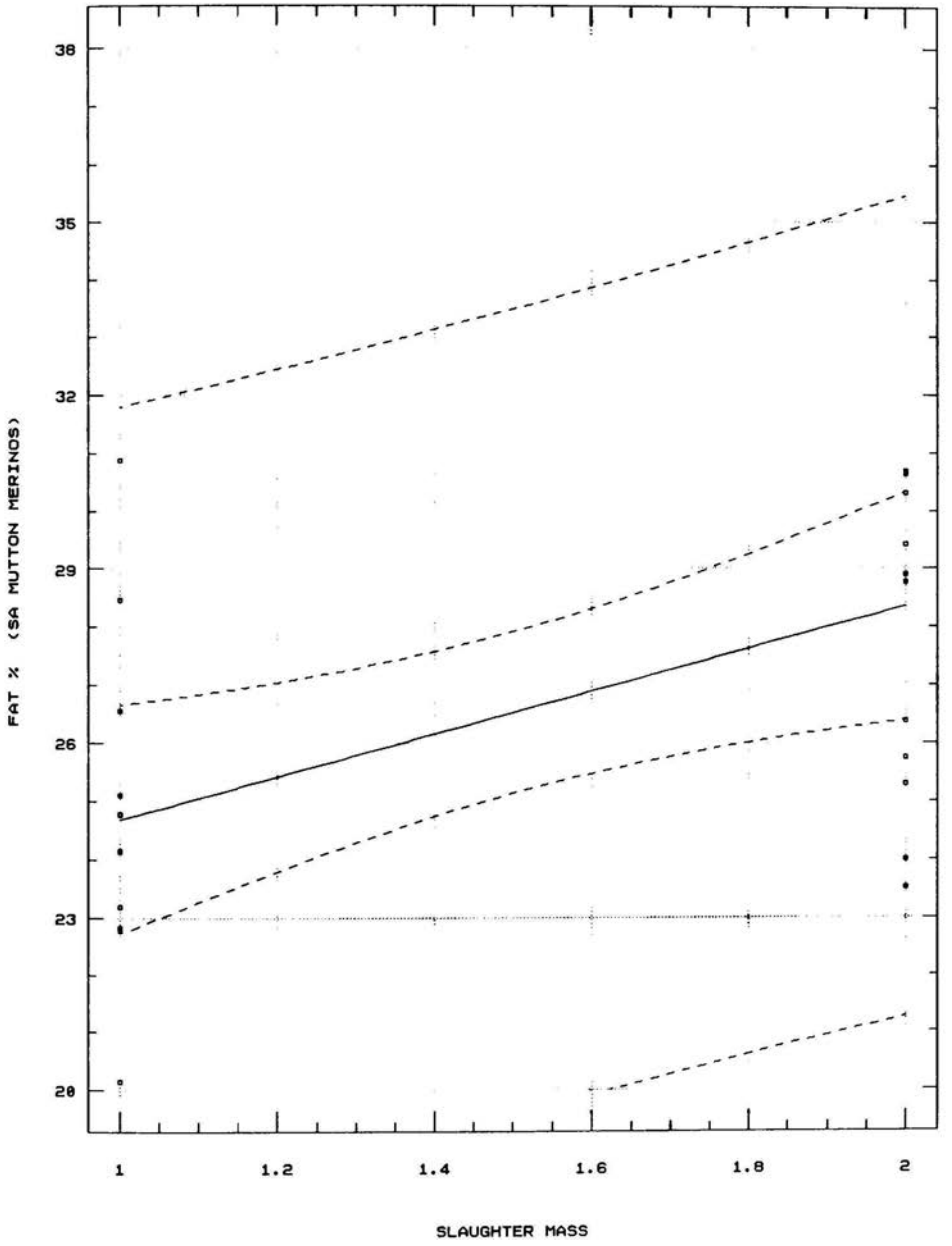
(DORPERS) AND SLAUGHTER MASS



Graph 4.3

LINEAR REGRESSION BETWEEN FAT PERCENTAGE

(SA MUTTON MERINOS) AND SLAUGHTER MASS



4.2.5 Carcass width measurements

4.2.5.1 Influence of treatment on carcass width measurements

Hindlimb width, measured from the left to right *Acetabulum* (CW1), and forelimb width, measured over the left and right *Tuber spinae* (CW2), were included as additional carcass conformation measurements. Both measurements were taken on the intact carcasses, hanging from the rail (Tables 4.5. and 4.6.).

Treatment significantly influenced the forelimb width ($P<0.001$, $F=12.490$), while its effect of the hindlimb width tended to be significant ($P<0.061$, $F=3.608$). The effect of treatment on both CW1 and CW2 remained important even after the inclusion of the percentage dissected fat as covariate in the model (Table 4.8.). The average hindlimb width of wethers on the H-treatment (27.443 ± 2.276cm) was greater than that of wethers on the M-treatment (26.803 ± 1.993cm), and the average forelimb width of wethers on the H-treatment (20.106 ± 2.054cm) was also greater than that of wethers on the M-treatment (19.252 ± 1.824cm).

Although treatment significantly affected both the hindlimb width ($P<0.059$, $F=3.820$) and forelimb width ($P<0.002$, $F=11.160$) of SA Mutton Merinos, its effect was limited to the forelimb width ($P<0.043$, $F=4.374$) of Dorpers.

The average CW1 (26.285 ± 2.236cm) and CW2 (19.558 ± 1.997cm) values of Dorpers on the H-treatment were greater than the average CW1 (25.888 ± 1.533cm) and CW2 (18.736 ± 1.787cm) values obtained on the M-treatment. SA Mutton Merinos followed the same trend since their average CW1 (28.651 ± 1.893cm) and CW2 (20.679 ± 1.995cm) values on the H-treatment were both greater than the average CW1 (27.806 ± 1.985cm) and CW2 (19.818 ± 1.731cm) values on the M-treatment.

4.2.5.2 Influence of breed on carcass width measurements

Hindlimb width (r_{xy}=0.490, P<0.001) and forelimb width (r_{xy}=0.282, P<0.007) were both greater in the later physiological maturing breed. Statistical correlations between physiological maturity and hindlimb width , as well as that between physiological maturity and forelimb width were high and positive. Both hindlimb (P<0.001, F=44.319) and forelimb widths (P<0.001, F=21.674) of SA Mutton Merinos were significantly greater in comparison with that of Dorpers (Table 4.7.). The differences in CW1 (P<0.001, F=40.780) and CW2 (P<0.001, F=19.605) between SA Mutton Merinos and Dorpers remained highly significant after the inclusion of fatness as covariate (Table 4.8.).

Average hindlimb width values for SA Mutton Merinos and Dorpers were respectively 28.247 ± 1.962cm and 26.091 ± 1.914cm, and the average forelimb width values for the above mentioned breeds were respectively 20.268 ± 1.903cm and 19.156 ± 1.922cm. Breed affected the hindlimb widths of wethers regardless of treatment or slaughter mass. Similar differences in forelimb width were observed within both H and M-treatment groups, but at the 43kg target mass, the differences were less important.

4.2.5.3 Influence of slaughter group on carcass width measurements

Hindlimb width (P<0.001, F=16.732) and forelimb width (P<0.001, F=47.142), like most other growth traits, were significantly influenced by slaughter mass. Slaughter mass and CW1 (r_{xy}=0.514, P<0.001) as well as slaughter mass and CW2 (r_{xy}=0.731, P<0.001) varied statistically in the same direction.

Although both CW1 (r_{xy}=0.289, P<0.006) and CW2 (r_{xy}=0.476, P<0.001) were positively correlated with carcass fatness, the inclusion of the latter as covariate did not alter the levels of

significance markedly (Table 4.8.). Nevertheless, slaughter mass significantly affected both CW1 and CW2 regardless of treatment or breed.

The average hindlimb widths of wethers in the 25, 31, 37 and 43kg slaughter groups were respectively 25.497 ± 1.791, 26.773 ± 2.283, 27.847 ± 1.870 and 28.457 ± 1.730cm. Average forelimb widths at 25, 31, 37 and 43kg slaughter mass were respectively 17.759 ± 1.197, 18.986 ± 1.241, 20.585 ± 1.492 and 21.466 ± 1.509cm.

4.2.6 Carcass length and hindleg length

4.2.6.1 Influence of treatment on carcass length and hindleg length

Hindleg length as measured from the *Symphysis pubis* to the most distal part of the hindleg (B1), was influenced by treatment ($P<0.057$, $F=3.739$). This distance was greater on the M-treatment (46.362 ± 7.315cm) than on the H-treatment (44.288 ± 6.823cm), and increased significantly after the inclusion of fatness as covariate in the model ($P<0.024$, $F=5.305$)(Tables 4.7. and 4.8.).

The effect of treatment on the remaining two carcass measures, carcass length (K2) and hindleg length as measured from the first sacral vertebra to the most distal part of the hindleg (B2), were negligible. Average K2-values on the H and M-treatments were respectively 125.252 ± 7.443cm and 126.599 ± 7.802cm, while average B2-values on the H-treatment (58.267 ± 6.941cm) were remarkably similar to those obtained on the M-treatment (58.896 ± 7.638cm).

4.2.6.2 Influence of breed on carcass length and hindleg length

The effects of breed on the B1 ($P<0.010$, $F=6.874$) and B2 ($P<0.029$, $F=4.924$) measures were more important than its effect on the K2-measure. However, when percentage fat was included as covariate in the model, the effect of breed on carcass length

became more pronounced (P<0.079, F=3.174), particularly at the 43kg target mass (P<0.060, F=4.042).

Dorper carcass lengths were slightly shorter (125.182 ± 7.870cm) than those of SA Mutton Merinos (126.674 ± 7.325cm), but both hindleg length measurements (B1 and B2) were greater for Dorpers than for SA Mutton Merinos (Table 4.6).

4.2.6.3 Influence of slaughter group on carcass length and hindleg length

Slaughter mass significantly affected the carcass lengths (P<0.001, F=14.824) and hindleg lengths as measured from both the *Symphysis pubis* (P<0.001, F=20.572) and the first sacral vertebra to the most distal part of the hindleg (P<0.001, F=17.736). These differences were significant regardless of treatment or breed (Table 4.8.). Both carcass and hindleg lengths increased with increasing slaughter mass. Carcass lengths increased from 118.19 ± 5.351cm for wethers slaughtered at 25kg live mass to 131.352 ± 3.565cm for wethers slaughtered at 43kg live mass. Summary statistics of carcass dimensions are provided in Table 4.5 and 4.6.

4.2.7 Hindleg compactness results

4.2.7.1 Influence of treatment on hindleg compactness

Hindleg compactness was expressed either as cold carcass mass/B1 or as cold carcass mass/B2 (kg/cm). However, the effect of treatment was limited to hindleg compactness as calculated by the use of B1 in the abovementioned formula (P<0.012, F=6.566). From the covariance analysis procedure it is evident that the average hindleg compactness (CCM/B1) of wethers on the H-treatment (0.358 ± 0.069kg/cm) was denotingly higher than that of wethers on the M-treatment (0.335 ± 0.055kg/cm)(P<0.013, F=6.493). On the H-treatment the compactness of the hindlegs of wethers was 6.87% higher than that of wethers on the M-treatment.

Differences in hindleg compactness as a result of treatment were, however, limited to SA Mutton Merinos on the different feeding regimes ($P<0.004$, $F=9.291$)(Table 4.8.), coupled with the 43kg slaughter group ($P<0.007$, $F=9.110$). In this instance the hindleg compactness of SA Mutton Merinos on the H-treatment was approximately 11% higher than that on the M-treatment. Treatment also altered the CCM/B2 of SA Mutton Merinos ($P<0.032$, $F=4.970$) with the greatest differences occuring at the 43kg target mass($P<0.009$, $F=8.642$).

4.2.7.2 Influence of breed on hindleg compactness

The influence of breed on hindleg compactness (calculated either by CCM/B1 or CCM/B2) was negligible. However, on the H-treatment the hindleg compactness (CCM/B1) of SA Mutton Merinos (0.370 ± 0.076kg/cm) tended to be quite a bit higher than that of Dorpers (0.345 ± 0.061kg/cm) ($P<0.059$, $F=3.791$). Breed differences in hindleg compactness were not important on the M-treatment or in most of the slaughter groups.

Although the correlation between CCM/B1 and CCM/B2 is high and positive ($r_{xy}=0.939$, $P<0.001$), breed differences occured only in CCM/B1 coupled with the H-treatment.

4.2.7.3 Influence of slaughter group on hindleg compactness

As the slaughter mass of wethers increased, the percentage fat increased ($r_{xy}=0.752$, $P<0.001$). Correlations between CCM/B1 and the percentage fat ($r_{xy}=0.534$, $P<0.001$) as well as that between CCM/B2 and the percentage fat ($r_{xy}=0.748$, $P<0.001$) were high and positive. The important effects of slaughter mass on CCM/B1 ($P<0.001$, F47.517) and CCM/B2 ($P<0.001$, $F=89.660$) were independent of breed or treatment (Table 4.8).

Average hindleg compactness values (CCM/B1) obtained in the 25, 31, 37 and 43kg target mass groups were respectively 0.281

± 0.031, 0.349 ± 0.033, 0.342 ± 0.041 and 0.417 ± 0.054kg/cm (Tables 4.5. and 4.6.). The average CCM/B2-values of wethers in the abovementioned mass groups were slightly lower namely: 0.209 ± 0.006kg/cm at 25kg, 0.261 ± 0.021kg/cm at 31kg, 0.273 ± 0.028kg/cm at 37kg and 0.326 ± 0.027kg/cm at 43kg.

4.2.8 Carcass compactness results

4.2.8.1 Influence of treatment on carcass compactness

Although sheep do not normally show a wide variation in conformation types, the effect of treatment on carcass compactness (CCM/K2) tended to be significant ($P<0.057$, $F=3.741$). Results obtained from the covariance analysis procedure for the effect of treatment on carcass compactness were remarkably similar ($P<0.056$, $F=3.759$), but from the more detailed analysis it was established that the effect of treatment was limited to the later physiological maturing breed ($P<0.001$, $F=23.345$)(Table 4.8.).

The difference in carcass compactness between wethers on the H-treatment (0.126 ± 0.027kg/cm) and M-treatment (0.122 ± 0.026kg/cm) was small, but the average carcass compactness of SA Mutton Merinos on the H-treatment (0.126 ± 0.028kg/cm) was 7.69% higher than that on the M-treatment (0.117 ± 0.023kg/cm). These differences occurred mainly at the 43kg target mass ($P<0.010$, $F=8.190$), but for Dorpers the difference remained negligible.

A significant breed x treatment interaction was observed ($P<0.020$, $F=5.609$) which explains the increase in carcass compactness for SA Mutton Merinos and slight decrease in carcass compactness of Dorpers as the energy content of the diet increased. In the covariance analysis procedure, this interaction tended to be unimportant.

4.2.8.2 Influence of breed on carcass compactness

Breed significantly affected the carcass compactness of wethers ($P<0.039$, $F=4.419$). Although Dorper carcasses (0.127 ± 0.027kg/cm) were more compact than those of SA Mutton Merinos (0.122 ± 0.026kg/cm), the differences were less obvious when the percentage fat was included as covariate in the ANOVA-model ($P<0.088$, $F=2.976$)(Tables 4.7. and 4.8.).

Nevertheless, these breed differences were limited to the M-treatment ($P<0.012$, $F=7.071$). The average carcass compactness of SA Mutton Merinos (0.117 ± 0.023kg/cm) was 8.6% lower than that of Dorpers (0.127 ± 0.028kg/cm) on the M-treatment. Remarkably similar carcass compactness values were obtained for Dorpers and SA Mutton Merinos on the H-treatment.

Although Dorpers tended to have a better conformation than SA Mutton Merinos on the M-treatment, they did not necessarily have higher lean to bone ratios (percentage fat was included as covariate). The association between carcass compactness and carcass fatness was high and positive ($r_{xy}=0.748$, $P<0.001$) and this may perhaps explain the higher carcass compactness values obtained for Dorpers on the M-treatment.

4.2.8.3 Influence of slaughter group on carcass compactness

Slaughter mass significantly affected the carcass compactness of wethers ($P<0.001$, $F=215.342$), irrespective of breed or treatment (Table 4.8.). The correlation coefficient obtained between carcass compactness and cold carcass mass was high and positive ($r_{xy}=0.982$, $P<0.001$). A similar correlation was obtained between slaughter mass and carcass compactness ($r_{xy}=0.928$, $P<0.001$).

Carcass compactness values obtained at 25, 31, 37 and 43kg slaughter mass were respectively 0.091 ± 0.006, 0.117 ± 0.012, 0.133 ± 0.011 and 0.157 ± 0.009kg/cm.

4.2.9 Subcutaneous fat thicknesses

4.2.9.1 Subcutaneous fat thickness as measured over the 13th rib

4.2.9.1.1 The relationship between treatment and 13th rib subcutaneous fat thickness

The average subcutaneous fat thickness of wethers (measured over the 13th rib) in this experiment was 0.261 ± 0.195cm and the minimum and maximum values were respectively 0.04 and 1.05cm. Results obtained from both the ANOVA and covariance analysis procedures indicates that the effect of treatment on the subcutaneous fat thicknesses of wethers as measured over the 13th rib (SCF13), is negligible (Tables 4.3. and 4.4.). Average subcutaneous fat thicknesses (SCF13) obtained on the H and M-treatments were respectively 0.281 ± 0.177 and 0.241 ± 0.212cm.

However, it is important to note that treatment significantly affected the SCF13 of SA Mutton Merinos (percentage fat included as covariate, $P<0.010$, $F=7.421$). Subcutaneous fat thicknesses of SA Mutton Merinos were much higher on the H-treatment (0.232 ± 0.112cm) than those on the M-treatment (0.162 ± 0.058cm). Differences in SCF13-values between Dorpers on the H-treatment (0.330 ± 0.215cm) and M-treatment (0.320 ± 0.274cm) were small.

Although the effect of treatment on SCF13 was more significant at the 25 ($P<0.074$, $F=3.581$) and 37kg ($P<0.036$, $F=5.115$) slaughter mass, the differences dissapeared almost completely at the 43kg slaughter mass.

4.2.9.1.2 The relationship between breed and 13th rib subcutaneous fat thickness

Breed significantly influenced the 13th rib subcutaneous fat thicknesses of wethers ($P<0.001$, $F=15.837$). Although physiological maturity (breed) and SCF13 are two statistically dependent variables, they varied in the opposite directions

(r_{xy}=-0.329, P<0.001). The average subcutaneous fat thickness of Dorpers (0.325 ± 0.244cm) was greater than that of SA Mutton Merinos (0.197 ± 0.095 cm). Inclusion of the percentage fat as covariate in the model did not alter the final ANOVA results, and breed differences were significant on both the H-treatment (P<0.018, F=6.133) and M-treatment (P<0.016, F=6.308).

Although the subcutaneous fat thicknesses of Dorpers were already slightly higher than that of SA Mutton Merinos at the 25kg target mass, the differences only became significant at the 31kg target mass (P<0.006, F=9.754). Breed differences were less important in both the 37 and 43kg target mass groups.

Negative correlations were calculated between SCF13 and the percentage bone (r_{xy}=-0.454, P<0.001) as well as between SCF13 and the percentage muscle in three rib-cut samples (r_{xy}=-0.685, P<0.001), while the correlation between SCF13 and the time each wether spent on feed was positive (r_{xy}=0.354, P<0.001).

4.2.9.1.3 The relationship between slaughter group and 13th rib subcutaneous fat thickness

Highly significant differences were observed between the 13th rib subcutaneous fat thicknesses of wethers in the different slaughter groups (P<0.001, F=13.129). These differences, however, should be present in any growth study since the percentage fat in the carcass increases with increasing carcass mass (r_{xy}=0.570, P<0.001) and hence the fat thicknesses increase.

However, with fat percentage included as covariate in the model, the differences in SCF13 between slaughter groups were negligible (P<0.262, F=1.355)(Table 4.8.). Nevertheless, the average 13th rib subcutaneous fat thicknesses for wethers slaughtered at 25, 31, 37 and 43kg were respectively 0.162 ± 0.070, 0.181 ± 0.129, 0.287 ± 0.180 and 0.414 ± 0.247cm.

4.2.9.2 Subcutaneous fat thickness as measured over the 10th rib

This study did not originally propose to measure the subcutaneous fat thickness over the 10th rib, but since the observed differences in SCF13-measurements seemed to be small (especially in the SA Mutton Merino breed) it was decided to record this measurement.

Subcutaneous fat thicknesses were much greater over the 10th rib (0.543 ± 0.272cm) than over the 13th rib (0.261 ± 0.195cm)(Table 4.1. and 4.2.). Although the effects of breed, treatment and slaughter mass on SCF10 were similar to that on SCF13, meaningful interactions were observed between breed x treatment and breed x slaughter mass. Furthermore, the effects of both breed ($P<0.001$, $F=11.517$) and treatment ($P<0.010$, $F=4.107$) on SCF10 remained significant regardless of the inclusion of fat percentage as covariate in the model (Table 4.8.).

Average SCF10-values obtained from Dorpers (0.325 ± 0.244cm) were significantly greater ($P<0.001$, $F=11.517$) than that of SA Mutton Merinos (0.197 ± 0.095cm), on both the H-treatment ($P<0.079$, $F=3.319$) and M-treatment ($P<0.004$, $F=10.135$). Breed differences (percentage fat included as covariate) were significant in both the 31 ($P<0.014$, $F=7.411$) and 37kg slaughter groups ($P<0.001$, $F=15.609$), but became unimportant at the 43kg slaughter mass ($P<0.818$, $F=0.056$).

Although the average SCF10-value of wethers on the H-treatment (0.281 ± 0.177cm) was slightly higher than on the M-treatment (0.241 ± 0.212cm), the difference was not significant ($P<0.194$, $F=1.715$). Furthermore, the SCF10-values differed significantly between slaughter mass groups ($P<0.010$, $F=4.107$) as calculated from the covariance analysis procedure, but the differences were less important on the M-treatment ($P<0.697$, $F=0.366$) than on the H-treatment ($P<0.001$, $F=11.575$). Average SCF10-values obtained in the 25, 31, 37 and 43kg slaughter mass

groups were respectively 0.162 ± 0.070, 0.181 ± 0.129, 0.287 ± 0.180 and 0.414 ± 0.247cm.

An interesting interaction (fat percentage excluded from model) between breed and slaughter mass was observed on the H-treatment ($P<0.055$, $F=2.669$). The average SCF10 of SA Mutton Merinos in the 31kg slaughter group was slightly higher than that of Dorpers, but in both the 37 and 43kg slaughter groups Dorpers attained higher SCF10-values (Graph 4.4.). This interaction indicates that Dorpers fatten faster than SA Mutton Merinos.

The second meaningful interaction was that between breed and treatment ($P<0.084$, $F=3.078$). While the SCF13-values of wethers on the H-treatment were greater than that on the M-treatment, the SCF10-values of Dorpers were greater on the M-treatment than on the H-treatment (Graph 4.5.). Average SCF10-values obtained for the later physiological maturing breed on the H-treatment remained higher in comparison with that on the M-treatment. This evidence seems to indicate that the effect of treatment on SCF10 tends to become important as the wethers reach physiological maturity.

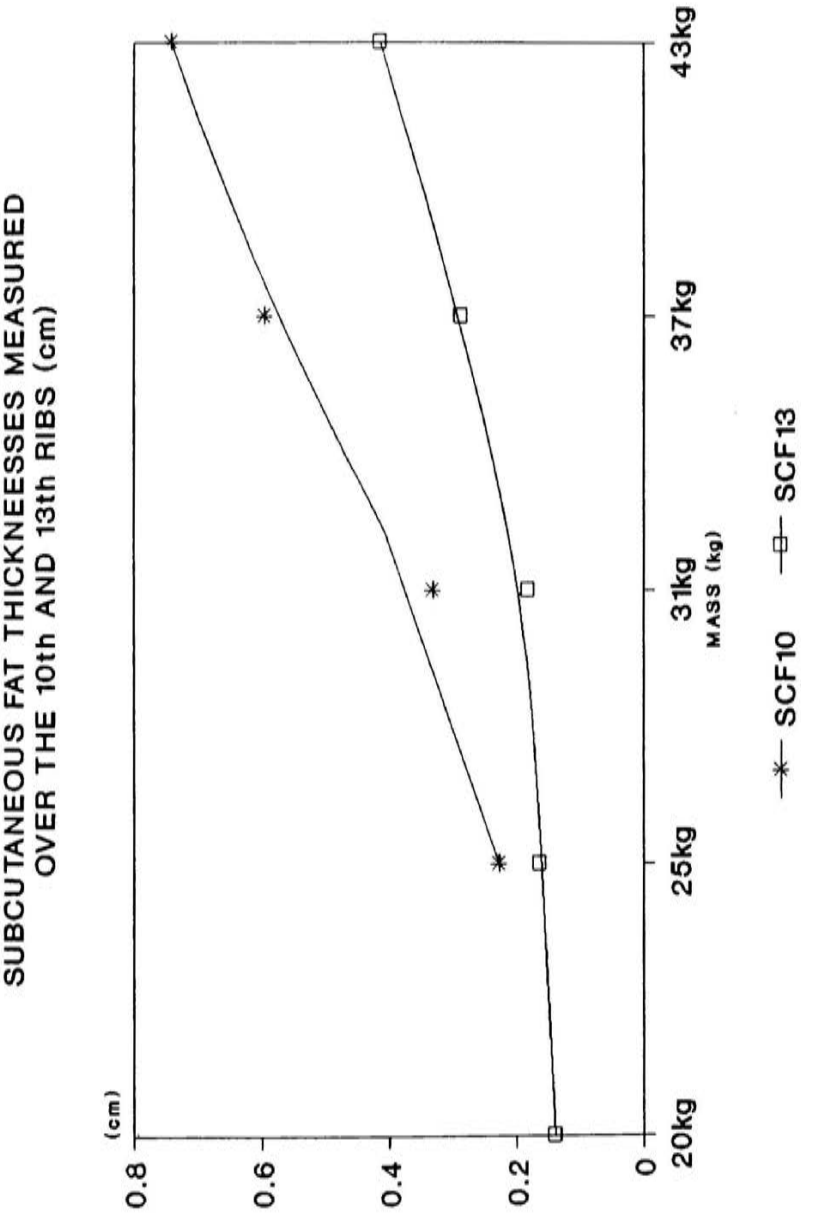
4.2.9.3 Subcutaneous fat thickness as measured at the brisket

4.2.9.3.1 The relationship between treatment and brisket fat thickness

The results obtained from the brisket fat thicknesses tended to coincide with those obtained from the 13th rib fat thicknesses. However, brisket fat thickness is generally a much less accurate measure since appreciable amounts of the brisket might be removed during the slaughtering process.

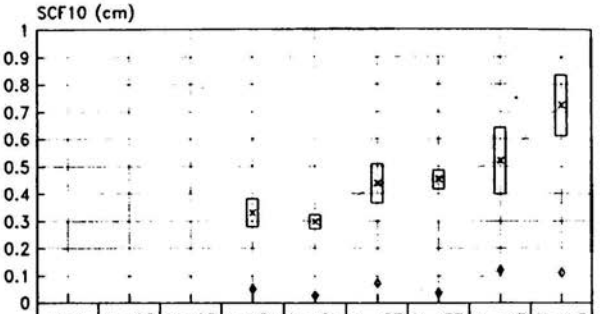
Considerable time was spent in skinning each carcass so that accurate brisket fat thickness measurements could be taken. Whether it was worth the time spent remains doubtful. Nevertheless, even more significant results were obtained than those over the 13th rib. From the covariance analysis results

Graph 4.4



Graph 4.5

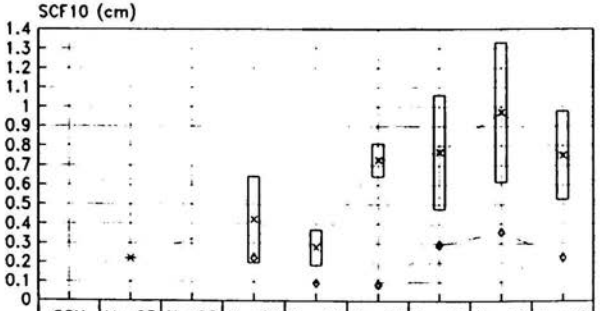
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. SCF10*
FOR SAMM'S



	CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD				0.279	0.271	0.366	0.417	0.399	0.612
X+SD				0.381	0.323	0.508	0.487	0.641	0.834
X				0.33	0.297	0.437	0.452	0.52	0.723
SD				0.051	0.026	0.071	0.035	0.121	0.111

* SCF10 – SUBCUTANEOUS FAT THICKNESS
MEASURED OVER THE 10th RIB (cm)

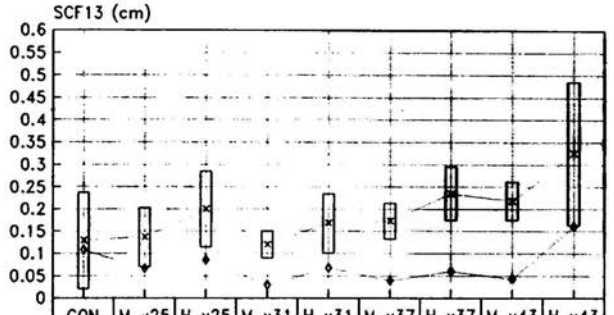
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. SCF10*
FOR DORPERS



	CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD		0.22		0.199	0.186	0.644	0.477	0.615	0.526
X+SD		0.22		0.645	0.37	0.812	1.059	1.329	0.978
X		0.22		0.422	0.278	0.728	0.768	0.972	0.752
SD				0.223	0.092	0.084	0.291	0.357	0.226

* SCF10 – SUBCUTANEOUS FAT THICKNESS
MEASURED OVER THE 10th RIB (cm)

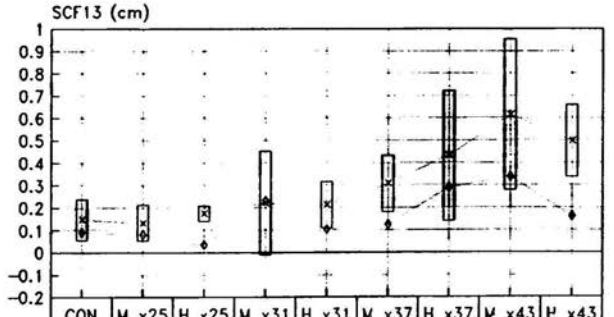
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. SCF13*
FOR SAMM'S



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X−SD	□	0.021	0.071	0.115	0.09	0.101	0.133	0.175	0.175	0.164
X+SD	□	0.237	0.203	0.285	0.15	0.235	0.213	0.295	0.261	0.486
X	×	0.129	0.137	0.2	0.12	0.168	0.173	0.235	0.218	0.325
SD	◇	0.108	0.066	0.085	0.03	0.067	0.04	0.06	0.043	0.161

* SCF13 – SUBCUTANEOUS FAT THICKNESS
MEASURED OVER THE 13th RIB (cm)

95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. SCF13*
FOR DORPERS



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X−SD	□	0.057	0.053	0.142	−0.008	0.11	0.182	0.142	0.278	0.336
X+SD	□	0.237	0.213	0.208	0.454	0.316	0.432	0.722	0.952	0.66
X	×	0.147	0.133	0.175	0.223	0.213	0.307	0.432	0.615	0.498
SD	◆	0.09	0.08	0.033	0.231	0.103	0.125	0.29	0.337	0.162

* SCF13 – SUBCUTANEOUS FAT THICKNESS
MEASURED OVER THE 13th RIB (cm)

it is evident that treatment significantly affected the fat thicknesses of wethers as measured over the brisket ($P<0.001$, $F=12.259$). The average brisket fat thickness of wethers on the M-treatment (2.696 ± 0.780cm) was considerably greater than that of wethers on the H-treatment (2.429 ± 0.651cm). Both Dorpers and SA Mutton Merinos showed increased brisket fat thicknesses on the M-treatment in comparison with the H-treatment.

Breed	Treatment	Brisket fat thickness
Dorper	M	3.176 ± 0.732cm
Dorper	H	2.692 ± 0.681cm
SAMM	M	2.216 ± 0.474cm
SAMM	H	2.166 ± 0.507cm

4.2.9.3.2 The relationship between breed and brisket fat thickness

The average brisket fat thickness of Dorpers (2.934 ± 0.741cm) was considerably greater than that of SA Mutton Merinos (2.191 ± 0.486cm), regardless of the inclusion of fat percentage as covariate ($P<0.001$, $F=73.097$). These breed differences proved to be even more significant than that obtained with SCF13-measurements.

A strong negative correlation was calculated between physiological maturity and brisket fat thickness ($r_{xy}=-0.514$, $P<0.001$): this statistical association indicates that the early physiological maturing type has a greater brisket fat thickness at the same chronological age as the later physiological maturing type.

4.2.9.3.3 The relationship between slaughter group and brisket fat thickness

Positive correlations were calculated between the time each wether spent in the trial and its brisket fat thickness (r_{xy}=0.690, P<0.001), slaughter mass and brisket fat thickness (r_{xy}=0.617, P<0.001), cold carcass mass and brisket fat thickness (r_{xy}=0.671, P<0.001), and the percentage fat in the carcass and brisket fat thickness (r_{xy}=0.637, P<0.001).

Consequently slaughter mass significantly influenced the brisket fat thicknesses of wethers (P<0.001, F=9.247). The lowest values were recorded in the 25kg slaughter group, but with increasing values for the 31kg, 37kg and 43kg groups. The brisket fat thicknesses obtained for the 25, 31, 37 and 43kg slaughter groups were respectively 1.938 ± 0.468, 2.359 ± 0.549, 2.849 ± 0.701 and 3.104 ± 0.572cm.

4.2.10 RUMINAL, ABOMASAL, DUODENAL AND JEJUNAL pH-VALUES

The pH of the rumen, abomasum, duodenum and jejunum were measured within 10 minutes after slaughter by means of an Orion liquid pH-meter. These results are presented in Table 4.9. Wethers were starved for at least 16 hours which explains the slightly higher average ruminal pH-values obtained in this trial in comparison with that obtained by Mackie, Gilchrist, Robberts, Hannah and Schwarts (1978) and Mackie and Gilchrist (1979).

These authors took ruminal samples approximately 2 hours after the first feed (containing 71 % maize) of the day and found that the pH decreased to the lowest values after the afternoon feed, and then remained low for at least 4-5 hours afterwards. Average ruminal pH-values obtained before feeding and 2 hours after feeding were respectively ± 6.8 and ± 5.5. However, they did not continue sampling for long enough to observe the rise to pre-feeding values.

Orskov *et al.* (1974) also reported significantly higher pH-values for wethers receiving a loose grain diet ($P<0.01$) in comparison with those receiving the pelleted diet. Furthermore, they found the propionic acid concentration in ruminal fluid of loose grain fed lambs to be significantly ($P<0.01$) greater than that of lambs receiving the pelleted diet.

Nevertheless, it was found that the ruminal-pH of wethers on the high energy treatment tended to be lower than that of wethers on the moderately high energy treatment ($P<0.116$, $F=2.572$). Average ruminal pH-values obtained for the wethers on the H and M-treatments were respectively 6.929 ± 1.318 and 7.529 ± 1.141 (Table 4.9.). Mackie *et al.* (1978) and Mackie and Gilchrist (1979) also reported that the ruminal pH decreased as the grain content of the diet was increased. The ruminal pH-values obtained in this experiment are also in agreement with the prefeeding values obtained by Mackie *et al.* (1978) and Mackie and Gilchrist (1979).

Furthermore, Mackie *et al.* (1978) showed that the changes in the predominant types of bacteria in the rumen were related to the ruminal pH[7], and since the same pH changes were observed in the present study, shifts in the bacterial population should be similar. It can therefore be accepted that the numbers of lactate-utilizing bacteria in the rumens of wethers on the H-treatment increased relative to those of the amylolytic bacteria. Mackie and Gilchrist (1979) demonstrated that such a shift results in a change in the ruminal fermentation end products, because the acetate to propionate ratio tends to decrease from 3 to 2.1. The proportion of propionate formed through lactate as intermediate increases considerably. The ruminal pH influenced an ecological succession of predominating

[7]pH optima for growth of different types of bacteria within the rumen.

types of bacteria and this succession started with the acid-sensitive *Veillonell* and *Selenomonal* which were superseded by more acid-tolerant *Anaerovibrio* and *Propionibacterium* (Mackie and Gilchrist, 1979). According to Mackie *et al.* (1978) the conditions in the rumen tend to become unstable within 7 days after high energy feeding and hence the acetate/propionate ratio decreases and the acid-tolerant species of lactate-utilizing bacteria multiplies rapidly.

Differences in ruminal pH between breeds or slaughter mass groups were negligible. The pH-values of the abomasum, duodenum and jejunum generally followed the same trend as that observed for the rumen, but the differences between treatments became more important as the ingesta passed from the rumen into the abomasum ($P<0.098$, $F=2.852$), duodenum ($P<0.048$, $F=4.122$) and jejunum ($P<0.018$, $F=6.073$)(Table 4.10.). Although the abomasal pH of wethers on the H-treatment tended to be lower than that of wethers on the M-treatment, both the duodenal and jejunal pH-values of wethers on the H-treatment were significantly lower than that of wethers on the M-treatment. Finally, the effect of slaughter mass and hence time on feed also affectd the pH in both the duodenum and jejunum. The duodenal and jejunal pH of wethers slaughtered at 25kg were respectively 5.879 ± 0.656 and 6.185 ± 0.339, but they stabilised at 31, 37 and 43kg live mass.

Table 4.1. TARGET MASS (TM), SLAUGHTER MASS (SM), COLD CARCASS MASS (CCM), pH, DRESSING PERCENTAGE (D%), TIME ON FEED (t), AVERAGE DAILY GAIN (ADG), RIBCUT SAMPLE MASS (RSM), PERCENTAGE MUSCLE (%M), FAT (%F) AND BONE (%B) IN RIBCUT AND SUBCUTANEOUS FAT THICKNESS OVER 10th (SCF10) AND 13th RIB (SCF13).

BREED	TREATMENT	TM (kg)		n	SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%F	%B	SCF10 (cm)	SCF13 (cm)
SAMM	CONTROL	-	$\bar{X}$	5	21.12	-	-	8.62	5.49	41.3	99.5	66.07	4.11	29.8	-	0.129
			SD		5.34	-	-	1.86	0.08	3.53	44.02	6.259	2.79	6.99	-	0.108
	H	25	$\bar{X}$	6	24.67	19.00	0.172	10.75	5.53	43.3	180.9	60.59	18.25	21.1	-	0.200
			SD		0.575	8.922	0.043	0.691	0.15	2.22	23.06	3.932	3.594	4.27	-	0.085
		31	$\bar{X}$	6	31.46	47.83	0.164	14.25	5.45	45.2	232.2	54.72	24.21	21.0	0.297	0.168
			SD		1.282	25.97	0.027	1.439	0.15	3.33	27.99	3.732	3.373	3.03	0.026	0.067
		37	$\bar{X}$	6	36.56	72.33	0.194	17.96	5.48	49.1	271.8	56.09	24.16	19.7	0.452	0.235
			SD		1.031	3.615	0.033	0.408	0.16	0.63	34.76	2.008	2.420	2.42	0.035	0.060
		43	$\bar{X}$	6	42.86	72.33	0.197	21.13	5.44	49.3	337.5	50.67	30.05	19.2	0.723	0.325
			SD		0.677	9.564	0.034	0.450	0.09	0.85	49.89	4.014	4.102	0.98	0.111	0.161
	M	25	$\bar{X}$	6	25.03	50.16	0.136	10.53	5.46	41.9	152.3	59.19	18.46	22.3	0.230	0.137
			SD		0.907	23.18	0.046	0.468	0.08	1.36	22.69	5.327	2.847	3.29	-	0.066
		31	$\bar{X}$	6	29.86	60.66	0.141	13.43	5.47	44.9	225.4	58.21	21.82	19.9	0.330	0.120
			SD		0.766	20.12	0.013	0.742	0.13	1.78	32.48	2.696	2.662	4.63	0.051	0.030
		37	$\bar{X}$	6	36.63	78.16	0.132	16.93	5.39	46.0	257.3	55.55	24.94	19.4	0.437	0.173
			SD		0.975	18.99	0.029	0.766	0.07	3.06	30.50	4.285	3.593	2.19	0.071	0.040
		43	$\bar{X}$	6	42.16	85.16	0.176	19.43	5.50	46.0	315.7	52.52	26.72	20.7	0.520	0.218
			SD		0.480	12.05	0.021	0.408	0.10	0.79	19.03	0.751	2.563	2.22	0.121	0.043

SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 4.1. (CONTINUED)

BREED	TREATMENT	TM (kg)		n	SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%F	%B	SCF10 (cm)	SCF13 (cm)
DORPER	CONTROL	-	$\bar{X}$	5	20.20	-	-	8.20	5.49	40.5	89.3	64.86	4.86	30.2	-	0.147
			SD		3.782	-	-	1.56	0.05	1.30	25.13	5.237	4.57	5.22	-	0.090
	H	25	$\bar{X}$	6	24.67	28.00	0.180	10.63	5.50	42.8	161.2	60.29	17.76	21.9	-	0.175
			SD		0.873	41.29	0.062	0.829	0.05	2.23	14.99	3.710	3.237	3.21	-	0.033
		31	$\bar{X}$	6	31.06	52.50	0.215	14.86	5.44	47.8	221.0	58.83	20.94	20.2	0.278	0.213
			SD		0.665	23.73	0.080	1.343	0.17	4.38	23.94	2.082	3.527	3.02	0.092	0.103
		37	$\bar{X}$	6	36.76	79.33	0.185	16.83	5.51	45.4	263.0	49.45	28.65	21.8	0.768	0.432
			SD		1.091	9.564	0.024	2.378	0.09	6.75	41.80	3.584	6.849	4.08	0.291	0.290
		43	$\bar{X}$	6	42.33	81.66	0.207	21.03	5.43	49.7	318.0	47.25	33.41	19.3	0.752	0.498
			SD		1.401	5.716	0.021	1.183	0.11	2.72	26.36	4.841	7.076	2.80	0.226	0.162
	M	25	$\bar{X}$	6	24.46	41.00	0.102	10.80	5.58	43.7	159.6	59.02	17.01	23.9	0.220	0.133
			SD		0.501	14.79	0.041	0.693	0.10	2.15	16.90	4.109	5.886	4.03	-	0.080
		31	$\bar{X}$	6	30.00	76.00	0.136	14.66	5.46	48.8	213.8	56.98	20.24	22.7	0.422	0.223
			SD		0.620	24.82	0.020	2.134	0.06	6.18	57.48	5.683	6.166	2.85	0.223	0.231
		37	$\bar{X}$	6	36.26	103.83	0.137	17.80	5.50	49.0	269.7	51.44	28.72	19.8	0.728	0.307
			SD		0.450	5.269	0.017	0.456	0.08	1.19	12.79	4.059	4.766	2.26	0.084	0.125
		43	$\bar{X}$	6	40.60	105.00	0.154	20.53	5.52	50.4	318.8	46.27	36.51	17.2	0.972	0.615
			SD		1.748	10.84	0.022	1.009	0.10	1.84	42.74	3.648	5.438	2.77	0.357	0.337

SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 4.2. SUMMARY STATISTICS OF CARCASS AND GROWTH PARAMETERS: TARGET MASS (TM), SLAUGHTER MASS (SM), COLD CARCASS MASS (CCM), pH, DRESSING PERCENTAGE (D%), TIME ON FEED (t), AVERAGE DAILY GAIN (ADG), RIBCUT SAMPLE MASS (RSM), PERCENTAGE MUSCLE (%M), FAT (%F) AND BONE (%B) IN RIBCUT AND SUBCUTANEOUS FAT THICKNESS OVER 10th (SCF10) AND 13th RIB (SCF13).

		n	SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%F	%B	SCF10 (cm)	SCF13 (cm)
DORPER	$\bar{X}$	48	33.28	70.92	0.165	15.90	5.50	47.23	240.67	53.70	25.41	20.90	0.642	0.325
	SD		6.49	32.64	0.053	3.94	0.11	4.54	66.62	6.59	8.67	3.58	0.324	0.244
SAMM	$\bar{X}$	48	33.66	60.71	0.164	15.55	5.47	45.75	246.68	55.95	23.58	20.47	0.448	0.197
	SD		6.72	25.55	0.038	3.78	0.12	3.04	66.07	4.59	4.79	3.02	0.163	0.095
H-FEEDING	$\bar{X}$	48	33.81	56.63	0.189	15.93	5.48	46.60	248.24	54.74	24.68	20.58	0.545	0.281
	SD		6.75	29.19	0.044	4.03	0.12	4.11	65.48	5.88	6.81	3.07	0.261	0.177
M-FEEDING	$\bar{X}$	48	33.13	75.00	0.139	15.52	5.49	46.38	239.12	54.90	24.31	20.79	0.542	0.241
	SD		6.45	27.32	0.033	3.69	0.10	3.75	67.03	5.70	7.30	3.55	0.284	0.212
DORPER x H	$\bar{X}$	24	33.73	60.38	0.197	15.84	5.47	46.47	240.84	53.96	25.19	20.85	0.599	0.330
	SD		6.76	31.97	0.052	4.08	0.11	4.87	64.35	6.75	8.12	3.30	0.312	0.215
DORPER x M	$\bar{X}$	24	32.83	81.46	0.132	15.95	5.52	48.00	240.50	53.43	25.62	20.95	0.682	0.320
	SD		6.33	30.38	0.032	3.88	0.09	4.14	70.19	6.56	9.35	3.91	0.338	0.274
SAMM x H	$\bar{X}$	24	33.89	52.88	0.182	16.03	5.48	46.74	255.64	55.52	24.17	20.31	0.491	0.232
	SD		6.88	26.27	0.035	4.06	0.14	3.27	67.12	4.89	5.33	2.86	0.193	0.112
SAMM x M	$\bar{X}$	24	33.43	68.54	0.146	15.08	5.46	44.76	237.73	56.37	22.99	20.64	0.409	0.162
	SD		6.70	22.70	0.033	3.50	0.10	2.48	65.19	4.34	4.23	3.22	0.124	0.058
25kg SM	$\bar{X}$	24	24.73	34.54	0.148	10.68	5.52	42.96	163.56	59.78	17.87	22.35	0.227	0.162
	SD		0.72	26.48	0.055	0.65	0.11	2.00	21.35	4.08	3.84	3.64	0.006	0.070
31kg SM	$\bar{X}$	24	30.60	59.25	0.164	14.31	5.46	46.72	223.14	57.19	21.81	21.01	0.332	0.181
	SD		1.07	24.72	0.052	1.51	0.13	4.30	35.91	3.89	4.16	3.42	0.129	0.129
37kg SM	$\bar{X}$	24	36.56	83.42	0.162	17.38	5.47	47.41	265.49	53.14	26.62	20.24	0.596	0.287
	SD		0.88	16.11	0.037	1.31	0.11	3.92	30.24	4.40	4.87	2.83	0.214	0.180
43kg SM	$\bar{X}$	24	41.99	86.04	0.183	20.53	5.48	48.88	322.52	49.18	31.67	19.14	0.742	0.414
	SD		1.41	15.24	0.031	1.04	0.10	2.35	35.33	4.28	6.03	2.52	0.267	0.247

SM - Slaughter mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 4.2. (CONTINUED)

(n=12)		SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%F	%B	SCF10 (cm)	SCF13 (cm)
DORPER x 25kg:	$\bar{X}$	24.60	34.50	0.141	10.72	5.543	43.29	160.46	59.66	17.39	22.95	0.220	0.154
	SD	0.693	30.34	0.065	0.734	0.089	2.140	15.26	3.790	4.546	3.637	-	0.062
DORPER x 31kg:	$\bar{X}$	30.53	64.25	0.175	14.77	5.453	48.34	217.43	57.91	20.59	21.50	0.350	0.218
	SD	0.828	26.21	0.069	1.703	0.125	5.132	42.15	4.194	4.803	3.107	0.179	0.170
DORPER x 37kg:	$\bar{X}$	36.51	91.58	0.161	17.32	5.508	47.24	266.38	50.45	28.69	20.86	0.748	0.369
	SD	0.838	14.76	0.032	1.709	0.084	4.990	29.68	3.796	5.626	3.256	0.206	0.222
DORPER x 43kg:	$\bar{X}$	41.47	93.33	0.181	20.78	5.475	50.06	318.42	46.76	34.96	18.28	0.862	0.557
	SD	1.761	14.72	0.034	1.080	0.112	2.478	33.87	4.119	6.230	2.881	0.307	0.259
SAMM x 25kg:	$\bar{X}$	24.85	34.58	0.154	10.64	5.497	42.62	166.67	59.86	18.36	21.75	0.230	0.168
	SD	0.749	23.35	0.046	0.574	0.120	1.880	26.44	4.524	3.093	3.690	-	0.080
SAMM x 31kg:	$\bar{X}$	30.67	54.25	0.153	13.84	5.464	45.10	228.85	56.47	23.02	20.52	0.313	0.144
	SD	1.308	23.14	0.024	1.173	0.134	2.554	29.12	3.599	3.155	3.782	0.043	0.055
SAMM x 37kg:	$\bar{X}$	36.60	75.25	0.163	17.45	5.439	47.57	264.61	55.83	24.56	19.62	0.444	0.204
	SD	0.957	13.39	0.044	0.796	0.127	2.672	32.09	3.203	2.948	2.205	0.054	0.058
SAMM x 43kg:	$\bar{X}$	42.52	78.75	0.186	20.28	5.475	47.70	326.61	51.60	28.39	20.01	0.622	0.272
	SD	0.669	12.35	0.029	0.978	0.098	1.855	37.77	2.918	3.695	1.814	0.154	0.125
H x 25kg:	$\bar{X}$	24.70	23.50	0.176	10.69	5.517	43.06	171.11	60.44	18.01	21.55	-	0.188
	SD	0.706	28.87	0.051	0.730	0.107	2.131	21.21	3.648	3.270	3.632	-	0.063
H x 31kg:	$\bar{X}$	31.27	50.17	0.189	14.56	5.448	46.55	226.63	56.78	22.58	20.64	0.287	0.191
	SD	0.996	23.85	0.063	1.365	0.154	3.958	25.51	3.594	3.707	2.926	0.065	0.086
H x 37kg:	$\bar{X}$	36.67	75.83	0.190	17.40	5.498	47.29	267.44	52.78	26.41	20.82	0.610	0.333
	SD	1.017	7.803	0.028	1.731	0.126	4.965	36.95	4.440	5.429	3.390	0.258	0.224
H x 43kg:	$\bar{X}$	42.60	77.00	0.202	21.08	5.437	49.50	327.77	48.96	31.73	19.31	0.738	0.412
	SD	1.085	8.954	0.027	0.855	0.099	1.935	39.39	4.600	5.787	2.007	0.171	0.178
M x 25kg:	$\bar{X}$	24.75	45.58	0.119	10.67	5.523	42.85	156.01	59.11	17.74	23.15	0.227	0.135
	SD	0.759	19.15	0.045	0.581	0.110	1.946	19.46	4.537	4.473	3.612	0.006	0.070
M x 31kg:	$\bar{X}$	29.93	68.33	0.138	14.05	5.468	46.89	219.65	57.60	21.03	21.37	0.376	0.172
	SD	0.668	22.99	0.016	1.654	0.099	4.781	44.93	4.289	4.603	3.953	0.162	0.166
M x 37kg:	$\bar{X}$	36.45	91.00	0.135	17.37	5.448	47.52	263.55	53.50	26.84	19.66	0.583	0.240
	SD	0.749	18.88	0.022	0.752	0.092	2.725	23.22	4.521	4.481	2.130	0.169	0.113
M x 43kg:	$\bar{X}$	41.38	95.08	0.165	19.98	5.513	48.26	317.26	49.40	31.62	18.98	0.746	0.417
	SD	1.471	15.06	0.023	0.932	0.095	2.638	31.59	4.119	6.523	3.026	0.347	0.309

Table 4.3. ANALYSIS OF VARIANCE OF CARCASS QUALITY AND GROWTH RESULTS: TARGET MASS (TM), SLAUGHTER MASS (SM), COLD CARCASS MASS (CCM), pH, DRESSING PERCENTAGE (D%), TIME ON FEED (t), AVERAGE DAILY GAIN (ADG), RIBCUT SAMPLE MASS (RSM), PERCENTAGE MUSCLE (%M), FAT (%F) AND BONE (%B) IN RIBCUT AND SUBCUTANEOUS FAT THICKNESS OVER 10th (SCF10) AND 13th RIB (SCF13). (BR = BREED; TR = TREATMENT AND SM = SLAUGHTER MASS)

		SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%F	%B	SCF10 (cm)	SCF13 (cm)
BR:	P<F	0.129	0.009	0.948	0.140	0.260	0.022	0.172	0.040	0.157	0.617	0.001	0.001
	F	2.352	7.250	0.004	2.223	1.283	5.422	1.898	4.342	2.037	0.260	19.040	15.837
	Signif.	ns	***	ns	ns	ns	**	ns	**	ns	ns	***	***
TR:	P<F	0.003	0.001	0.001	0.072	0.566	0.730	0.104	0.725	0.595	0.720	0.601	0.215
	F	9.062	23.490	43.929	3.313	0.342	0.124	2.709	0.129	0.294	0.134	0.285	1.559
	Signif.	***	***	***	*	ns	ns	ns	ns	ns	ns	ns	ns
SM:	P<F	0.001	0.001	0.012	0.001	0.259	0.001	0.001	0.001	0.001	0.006	0.001	0.001
	F	1000.0	40.352	3.847	338.63	1.364	15.658	111.87	29.113	35.192	4.465	22.964	13.129
	Signif.	***	***	**	***	ns	***	***	***	***	***	***	***
BRxTR:	P<F	0.301	0.485	0.056	0.024	0.158	0.007	0.042	0.389	0.222	0.467	0.084	0.362
	F	1.084	0.510	3.765	5.284	2.031	7.584	4.278	0.780	1.518	0.553	3.078	0.877
	Signif.	ns	ns	*	**	ns	***	**	ns	ns	ns	*	ns
BRxSM:	P<F	0.401	0.422	0.401	0.398	0.569	0.213	0.940	0.010	0.003	0.335	0.055	0.006
	F	0.990	0.946	0.991	0.997	0.676	1.528	0.133	4.023	5.171	1.148	2.669	4.454
	Signif.	ns	ns	ns	ns	ns	ns	ns	***	***	ns	*	***
BRxTRxSM:	P<F	0.060	0.938	0.790	0.321		0.830	0.912	0.677	0.958	0.458	0.766	0.728
	F	2.557	0.137	0.349	1.184		0.293	0.176	0.509	0.104	0.874	0.092	0.436
	Signif.	*	ns	ns	ns		ns	ns	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 4.4. COVARIANCE ANALYSIS OF CARCASS QUALITY AND GROWTH RESULTS WITH % FAT INCLUDED AS COVARIATE: TARGET MASS (TM), SLAUGHTER MASS (SM), COLD CARCASS MASS (CCM), pH, DRESSING PERCENTAGE (D%), TIME ON FEED (t), AVERAGE DAILY GAIN (ADG), RIBCUT SAMPLE MASS (RSM), PERCENTAGE MUSCLE (%M), FAT (%F) AND BONE (%B) IN RIBCUT AND SUBCUTANEOUS FAT THICKNESS OVER 10th (SCF10) AND 13th RIB (SCF13). (BREED = BR; TREATMENT = TR AND SLAUGHTER MASS = SM)

		SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%B	SCF10 (cm)	SCF13 (cm)
BR:	P<F	0.089	0.011	0.795	0.318	0.200	0.076	0.077	0.057	0.057	0.001	0.001
	F	2.952	6.767	0.070	1.010	1.669	3.230	3.213	3.718	3.710	11.517	12.570
	Signif.	*	**	ns	ns	ns	*	*	*	*	***	***
TR:	P<F	0.001	0.001	0.001	0.082	0.592	0.811	0.168	0.886	0.889	0.291	0.194
	F	11.505	23.238	44.281	3.097	0.299	0.059	1.934	0.021	0.020	1.133	1.715
	Signif.	***	***	***	*	ns	ns	ns	ns	ns	ns	ns
SM:	P<F	0.001	0.001	0.025	0.001	0.410	0.010	0.001	0.358	0.357	0.010	0.262
	F	622.21	19.644	3.259	132.76	0.972	3.998	35.418	1.089	1.092	4.107	1.355
	Signif.	***	***	**	***	ns	***	***	ns	ns	***	ns
BRxTR:	P<F	0.608	0.782	0.185	0.109	0.323	0.038	0.518	0.952	0.951	0.416	0.876
	F	0.501	0.246	1.721	2.278	1.144	3.386	0.663	0.049	0.050	0.889	0.133
	Signif.	ns	ns	ns	ns	ns	**	ns	ns	ns	ns	ns
BRxSM:	P<F	0.499	0.573	0.645	0.205	0.664	0.091	0.669	0.495	0.498	0.266	0.296
	F	0.848	0.731	0.626	1.515	0.599	2.073	0.593	0.853	0.849	1.336	1.251
	Signif.	ns	ns	ns	ns	ns	*	ns	ns	ns	ns	ns
BRxTRxSM:	P<F	0.050	0.981	0.901	0.463	0.440	0.889	0.966	0.586	0.584	0.850	0.428
	F	2.480	0.102	0.263	0.908	0.949	0.282	0.141	0.712	0.715	0.163	0.970
	Signif.	*	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 4.4. (CONTINUED)

		SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%B	SCF10 (cm)	SCF13 (cm)
BR x H:	P<F	0.595	0.210	0.189	0.533	0.866	0.663	0.047	0.227	0.228	0.079	0.018
	F	0.296	1.622	1.791	0.409	0.030	0.199	4.198	1.508	1.499	3.319	6.133
BR x M:	P<F	0.058	0.021	0.071	0.018	0.015	0.002	0.700	0.136	0.136	0.004	0.016
	F	3.806	5.756	3.448	6.062	6.465	11.642	0.155	2.315	2.315	10.135	6.308
BR x 25kg:	P<F	0.411	0.960	0.594	0.814	0.380	0.424	0.538	0.569	0.569	-	0.769
	F	0.734	0.003	0.304	0.059	0.844	0.694	0.407	0.348	0.348	-	0.091
BR x 31kg:	P<F	0.969	0.346	0.408	0.033	0.357	0.015	0.903	0.989	0.989	0.014	0.006
	F	0.002	0.975	0.745	5.307	0.930	7.178	0.016	0.001	0.001	7.411	9.754
BR x 37kg:	P<F	0.497	0.003	0.873	0.177	0.381	0.082	0.693	0.011	0.011	0.001	0.251
	F	0.496	11.197	0.027	1.968	0.838	3.368	0.165	7.889	7.874	15.609	1.401
BR x 43kg:	P<F	0.054	0.006	0.931	0.479	0.758	0.025	0.074	0.394	0.394	0.818	0.174
	F	4.212	9.712	0.008	0.539	0.100	5.970	3.588	0.793	0.793	0.056	1.993
TR x DORPER:	P<F	0.005	0.001	0.001	0.855	0.114	0.192	0.875	0.696	0.696	0.117	0.633
	F	8.957	12.508	27.898	0.035	2.607	1.766	0.026	0.160	0.160	2.615	0.238
TR x SAMM:	P<F	0.089	0.004	0.001	0.001	0.560	0.003	0.120	0.970	0.967	0.085	0.010
	F	3.046	9.530	18.759	16.263	0.357	9.801	2.522	0.001	0.002	3.185	7.421
TR x 25kg:	P<F	0.885	0.051	0.011	0.929	0.923	0.819	0.080	0.309	0.309		0.074
	F	0.022	4.355	7.842	0.008	0.010	0.055	3.424	1.091	1.091		3.581
TR x 31kg:	P<F	0.003	0.086	0.008	0.675	0.931	0.515	0.918	0.931	0.931	0.001	0.707
	F	11.892	3.269	8.946	0.187	0.008	0.456	0.011	0.008	0.008	14.055	0.149
TR x 37kg:	P<F	0.614	0.004	0.001	0.844	0.243	0.988	0.724	0.294	0.290	0.457	0.036
	F	0.271	10.791	25.549	0.041	1.453	0.001	0.132	1.166	1.185	0.599	5.115
TR x 43kg:	P<F	0.023	0.001	0.002	0.005	0.085	0.103	0.471	0.581	0.581	0.868	0.909
	F	6.128	19.743	12.732	9.876	3.314	2.936	0.561	0.326	0.326	0.029	0.014

Table 4.4. (CONTINUED)

		SM (kg)	t (days)	ADG (kg)	CCM (kg)	pH	D%	RSM (g)	%M	%B	SCF10 (cm)	SCF13 (cm)
SM x DORPER:	P<F	0.001	0.001	0.294	0.001	0.182	0.049	0.001	0.106	0.106	0.110	0.823
	F	229.98	10.807	1.281	35.507	1.702	2.862	11.926	2.180	2.179	2.385	0.303
SM x SAMM:	P<F	0.001	0.001	0.006	0.001	0.787	0.002	0.001	0.693	0.695	0.001	0.066
	F	385.32	8.332	4.812	154.10	0.353	15.912	16.228	0.487	0.484	23.077	2.593
SM x H:	P<F	0.001	0.001	0.250	0.001	0.515	0.146	0.001	0.295	0.292	0.001	0.185
	F	310.46	9.647	1.426	61.107	0.775	1.900	15.620	1.279	1.287	11.575	1.690
SM x M:	P<F	0.001	0.001	0.089	0.001	0.113	0.033	0.001	0.719	0.719	0.697	0.388
	F	351.77	9.470	2.337	82.362	2.125	3.211	17.851	0.450	0.450	0.366	1.034

Table 4.5. HINDLEG LENGTH MEASURED FROM Symphysis pubis (B1) AND FIRST SACRAL VERTEBRA (B2) TO MOST DISTAL PART OF HINDLEG, CARCASS LENGHT (K2), HINDLIMB WIDTH MEASURED FROM LEFT TO RIGHT Acetabulum (CW1) AND FORELIMB WIDTH MEASURED OVER LEFT AND RIGHT Tuber spinae (CW2), HINDLEG COMPACTNESS: COLD CARCASS MASS/B1 (CCM/B1) AND COLD CARCASS MASS/B2 (CCM/B2), AND CARCASS COMPACTNESS (CCM/K2).

BREED	TREATMENT	TM		n	B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
SAMM	H	25	$\bar{X}$	6	36.297	49.083	118.339	27.193	18.951	0.296	0.219	0.091
			SD		2.591	3.539	4.022	1.231	1.169	0.010	0.007	0.005
		31	$\bar{X}$	6	40.814	54.464	122.821	27.770	19.156	0.350	0.263	0.116
			SD		3.718	6.566	7.613	2.042	1.135	0.033	0.018	0.011
		37	$\bar{X}$	6	50.119	65.037	131.399	29.682	21.962	0.363	0.279	0.138
			SD		4.101	2.425	2.867	1.085	0.669	0.028	0.010	0.003
		43	$\bar{X}$	6	45.559	61.185	131.324	30.129	22.861	0.470	0.347	0.161
			SD		5.345	4.930	2.395	1.406	0.882	0.065	0.028	0.003
	M	25	$\bar{X}$	6	38.409	50.706	118.624	26.024	17.822	0.279	0.210	0.089
			SD		5.535	5.985	3.852	1.864	1.159	0.038	0.023	0.004
		31	$\bar{X}$	6	40.328	51.847	125.280	28.751	19.085	0.338	0.262	0.108
			SD		4.437	4.922	4.242	1.720	0.251	0.027	0.018	0.007
		37	$\bar{X}$	6	49.415	61.649	133.057	28.252	20.859	0.346	0.278	0.127
			SD		5.522	6.979	2.546	0.671	0.895	0.042	0.034	0.005
		43	$\bar{X}$	6	51.845	65.462	134.110	28.651	21.549	0.377	0.299	0.146
			SD		2.334	2.361	3.529	2.394	0.609	0.023	0.014	0.005

TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 4.5. (CONTINUED)

BREED	TREATMENT	TM		n	B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
DORPER	H	25	$\bar{X}$	6	37.540	52.279	116.060	24.708	17.500	0.284	0.205	0.092
			SD		2.025	3.764	7.030	1.080	0.837	0.027	0.028	0.007
		31	$\bar{X}$	6	42.637	58.000	124.201	25.397	19.759	0.353	0.257	0.120
			SD		6.615	6.059	7.420	2.477	1.031	0.036	0.020	0.008
		37	$\bar{X}$	6	51.578	63.613	127.963	27.116	20.094	0.329	0.266	0.132
			SD		3.574	3.730	4.160	2.645	2.092	0.057	0.043	0.019
		43	$\bar{X}$	6	50.733	63.605	130.933	27.919	20.876	0.416	0.331	0.161
			SD		2.552	2.743	2.170	0.866	2.156	0.034	0.021	0.009
	M	25	$\bar{X}$	6	41.368	53.915	119.739	24.061	16.764	0.265	0.203	0.091
			SD		5.253	6.271	6.536	1.263	0.450	0.039	0.025	0.009
		31	$\bar{X}$	6	42.345	55.974	119.732	25.647	17.775	0.351	0.264	0.123
			SD		6.833	6.837	8.419	1.062	1.391	0.042	0.031	0.019
		37	$\bar{X}$	6	53.418	66.219	132.416	26.645	19.655	0.335	0.270	0.135
			SD		3.583	3.020	4.462	1.026	0.972	0.032	0.018	0.007
		43	$\bar{X}$	6	52.000	63.652	129.502	27.160	20.592	0.397	0.323	0.159
			SD		3.854	3.177	4.857	0.304	0.789	0.039	0.024	0.009

TM - TARGET MASS
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 4.6. SUMMARY STATISTICS OF CARCASS DIMENSIONS: HINDLEG LENGTH MEASURED FROM Symphysis pubis (B1) AND FIRST SACRAL VERTEBRA (B2) TO MOST DISTAL PART OF HINDLEG, CARCASS LENGHT(K2), HINDLIMB WIDTH MEASURED FROM LEFT TO RIGHT Acetabulum (CW1) AND FORELIMB WIDTH MEASURED OVER LEFT AND RIGHT Tuber spinae (CW2), HINDLEG COMPACTNESS: COLD CARCASS MASS/B1 (CCM/B1) AND COLD CARCASS MASS/B2 (CCM/B2), AND CARCASS COMPACTNESS (CCM/K2).

		n	B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
DORPER	$\bar{X}$	47	46.547	59.743	125.182	26.091	19.156	0.341	0.265	0.127
	SD		7.140	6.579	7.870	1.914	1.922	0.061	0.051	0.027
SAMM	$\bar{X}$	44	43.957	57.327	126.674	28.247	20.268	0.352	0.269	0.122
	SD		6.893	7.792	7.325	1.962	1.903	0.067	0.047	0.026
H-FEEDING	$\bar{X}$	47	44.288	58.267	125.252	27.443	20.106	0.358	0.271	0.126
	SD		6.823	6.941	7.443	2.376	2.054	0.069	0.052	0.027
M-FEEDING	$\bar{X}$	44	46.362	58.896	126.599	26.803	19.252	0.335	0.263	0.122
	SD		7.315	7.638	7.802	1.993	1.824	0.055	0.046	0.026
DORPER x H	$\bar{X}$		45.622	59.374	124.789	26.285	19.558	0.345	0.265	0.126
	SD		7.073	6.221	7.742	2.236	1.997	0.061	0.053	0.028
DORPER x M	$\bar{X}$		47.497	60.112	125.591	25.888	18.736	0.336	0.265	0.127
	SD		7.241	7.054	8.155	1.533	1.787	0.061	0.050	0.028
SAMM x H	$\bar{X}$		42.896	57.112	125.735	28.651	20.679	0.370	0.277	0.126
	SD		6.409	7.585	7.259	1.893	1.995	0.076	0.051	0.028
SAMM x M	$\bar{X}$		45.118	57.563	127.703	27.806	19.818	0.333	0.260	0.117
	SD		7.367	8.193	7.435	1.985	1.731	0.050	0.042	0.023
25kg SM	$\bar{X}$	24	38.404	51.496	118.190	25.497	17.759	0.281	0.209	0.091
	SD		4.319	5.050	5.351	1.791	1.197	0.031	0.022	0.006
31kg SM	$\bar{X}$	21	41.607	55.335	122.948	26.773	18.986	0.349	0.261	0.117
	SD		5.259	6.151	7.020	2.283	1.241	0.033	0.021	0.012
37kg SM	$\bar{X}$	23	51.177	64.090	131.200	27.847	20.585	0.342	0.273	0.133
	SD		4.281	4.528	3.954	1.870	1.492	0.041	0.028	0.011
43kg SM	$\bar{X}$	23	49.956	63.390	131.352	28.457	21.466	0.417	0.326	0.157
	SD		4.442	3.588	3.565	1.730	1.509	0.054	0.027	0.009

SM - Slaughter mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 4.6. (CONTINUED)

		n	B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
DORPER x 25kg:	$\bar{X}$	12	39.454	53.097	117.899	24.385	17.132	0.274	0.204	0.091
	SD		4.290	5.004	6.751	1.170	0.747	0.033	0.025	0.008
DORPER x 31kg:	$\bar{X}$	11	42.504	57.079	122.169	25.511	18.857	0.352	0.261	0.121
	SD		6.370	6.178	7.831	1.880	1.543	0.037	0.025	0.013
DORPER x 37kg:	$\bar{X}$	12	52.498	64.916	130.189	26.881	19.875	0.332	0.268	0.133
	SD		3.545	3.510	4.725	1.928	1.572	0.044	0.032	0.014
DORPER x 43kg:	$\bar{X}$	12	51.367	63.629	130.217	27.539	20.734	0.406	0.327	0.160
	SD		3.186	2.830	3.664	0.735	1.555	0.036	0.022	0.008
SAMM x 25kg:	$\bar{X}$	12	37.353	49.894	118.482	26.609	18.386	0.287	0.215	0.090
	SD		4.265	4.764	3.757	1.625	1.257	0.028	0.017	0.004
SAMM x 31kg:	$\bar{X}$	10	40.620	53.417	123.805	28.163	19.127	0.345	0.263	0.113
	SD		3.782	5.818	6.310	1.887	0.859	0.030	0.017	0.010
SAMM x 37kg:	$\bar{X}$	11	49.735	63.189	132.303	28.902	21.360	0.354	0.278	0.132
	SD		4.702	5.462	2.698	1.120	0.955	0.036	0.025	0.007
SAMM x 43kg:	$\bar{X}$	11	48.416	63.129	132.590	29.458	22.265	0.428	0.325	0.154
	SD		5.220	4.401	3.157	1.969	1.003	0.068	0.033	0.009
H x 25kg:	$\bar{X}$	12	36.919	50.681	117.199	25.951	18.226	0.290	0.212	0.091
	SD		2.310	3.863	5.588	1.704	1.230	0.020	0.021	0.006
H x 31kg:	$\bar{X}$	12	41.725	56.232	123.511	26.584	19.458	0.351	0.260	0.118
	SD		5.204	6.300	7.204	2.494	1.080	0.033	0.018	0.010
H x 37kg:	$\bar{X}$	11	50.915	64.260	129.525	28.283	20.943	0.344	0.272	0.135
	SD		3.700	3.140	3.894	2.401	1.822	0.048	0.032	0.014
H x 43kg:	$\bar{X}$	12	48.146	62.395	131.128	29.024	21.869	0.443	0.339	0.161
	SD		4.822	4.008	2.189	1.604	1.882	0.057	0.025	0.006
M x 25kg:	$\bar{X}$	12	39.888	52.310	119.181	25.043	17.293	0.271	0.206	0.090
	SD		5.371	6.080	5.148	1.832	1.004	0.037	0.023	0.006
M x 31kg:	$\bar{X}$	9	41.449	54.140	122.198	27.026	18.357	0.345	0.263	0.117
	SD		5.644	6.098	7.123	2.086	1.212	0.035	0.025	0.016
M x 37kg:	$\bar{X}$	12	51.417	63.934	132.736	27.449	20.257	0.341	0.274	0.131
	SD		4.906	5.655	3.479	1.178	1.090	0.036	0.026	0.007
M x 43kg:	$\bar{X}$	11	51.930	64.474	131.597	27.838	21.027	0.388	0.312	0.153
	SD		3.100	2.859	4.751	1.717	0.842	0.033	0.023	0.010

Table 4.7. ANALYSIS OF VARIANCE OF HINDLEG LENGTH MEASURED FROM Symphysis pubis (B1) AND FIRST SACRAL VERTEBRA TO MOST DISTAL PART OF HINDLEG, CARCASS LENGHT (K2), HINDLIMB WIDTH MEASURED OVER LEFT AND RIGHT Acetabulum (CW1), AND FORELIMB WIDTH MEASURED OVER LEFT AND RIGHT Tuber spinae (CW2), HINDLEG COMPACNESS: COLD CARCASS MASS/B1 (CCM/B1) AND COLD CARCASS MASS/B2 (CCM/B2), AND CARCASS COMPACTNESS (CCM/K2).
(BR = BREED, TR = TREATMENT AND SM = SLAUGHTER MASS)

		B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
BR	P<F	0.010	0.029	0.123	0.001	0.001	0.123	0.303	0.039
	F	6.874	4.924	2.430	44.319	21.674	2.424	1.076	4.419
	Signif.	***	**	ns	***	***	ns	ns	**
TR	P<F	0.057	0.718	0.277	0.061	0.001	0.012	0.174	0.057
	F	3.739	0.135	1.199	3.608	12.490	6.566	1.881	3.741
	Signif.	*	ns	ns	*	***	**	ns	*
SM	P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	F	46.534	37.678	37.182	16.732	47.142	47.517	89.660	215.342
	Signif.	***	***	***	***	***	***	***	***
BRxTR	P<F	0.945	0.822	0.934	0.884	0.944	0.126	0.163	0.020
	F	0.005	0.053	0.142	0.217	0.005	2.385	1.980	5.609
	Signif.	ns	ns	ns	ns	ns	ns	ns	**
BRxSM	P<F	0.969	0.685	0.934	0.884	0.218	0.560	0.740	0.463
	F	0.083	0.497	0.142	0.217	1.512	0.691	0.419	0.865
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns
TRxSM	P<F	0.360	0.457	0.527	0.264	0.975	0.111	0.147	0.605
	F	1.085	0.875	0.747	1.350	0.072	2.067	1.836	0.619
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
TM - Target mass
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 4.8. COVARIANCE ANALYSIS (%FAT INCLUDED AS COVARIATE) OF HIND LEG LENGTH MEASURED FROM Symphysis pubis (B1) AND FIRST SACRAL VERTEBRA TO MOST DISTAL PART OF HIND LEG, CARCASS LENGHT (K2), HINDLIMB WIDTH MEASURED OVER LEFT AND RIGHT Acetabulum (CW1), AND FORELIMB WIDTH MEASURED OVER LEFT AND RIGHT Tuber spinae (CW2), HIND LEG COMPACTNESS: COLD CARCASS MASS/B1 (CCM/B1) AND COLD CARCASS MASS/B2 (CCM/B2), AND CARCASS COMPACTNESS (CCM/K2).
(BR = BREED, TR = TREATMENT AND SM = SLAUGHTER MASS)

		B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
BR	P<F	0.055	0.042	0.079	0.001	0.001	0.137	0.215	0.088
	F	3.795	4.257	3.174	40.780	19.605	2.256	1.559	2.976
	Signif.	*	**	*	***	***	ns	ns	*
TR	P<F	0.024	0.718	0.272	0.061	0.001	0.013	0.175	0.056
	F	5.305	0.135	1.226	3.611	12.741	6.493	1.868	3.759
	Signif.	**	ns	ns	*	***	**	ns	*
SM	P<F	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	F	20.572	17.736	14.824	8.890	24.353	22.895	34.184	79.905
	Signif.	***	***	***	***	***	***	***	***
BRxTR	P<F	0.974	0.985	0.872	0.882	0.430	0.304	0.890	0.095
	F	0.026	0.015	0.308	0.293	0.967	1.207	0.281	2.421
	Signif.	ns	ns	ns	ns	ns	ns	ns	*
BRxSM	P<F	1.000	0.688	0.872	0.882	0.430	0.700	0.443	0.489
	F	0.004	0.567	0.308	0.293	0.967	0.550	0.822	0.865
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns
TRxSM	P<F	0.528	0.634	0.700	0.419	0.993	0.201	0.235	0.728
	F	0.800	0.643	0.550	0.988	0.061	1.531	1.419	0.511
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - p<0.01

Table 4.8. (CONTINUED)

		B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
BR x H:	P<F	0.062	0.155	0.415	0.001	0.010	0.059	0.105	0.860
	F	3.700	2.109	0.706	21.307	7.445	3.791	2.756	0.032
BR x M:	P<F	0.124	0.124	0.123	0.001	0.001	0.724	0.843	0.012
	F	2.485	2.490	2.493	18.764	16.926	0.131	0.041	7.071
BR x 25kg:	P<F	0.196	0.156	0.893	0.001	0.006	0.273	0.276	0.693
	F	1.795	2.178	0.019	19.625	9.741	1.275	1.261	0.166
BR x 31kg:	P<F	0.374	0.149	0.890	0.008	0.732	0.497	0.854	0.071
	F	0.872	2.302	0.020	9.262	0.125	0.502	0.036	3.741
BR x 37kg:	P<F	0.152	0.507	0.326	0.011	0.010	0.078	0.205	0.429
	F	2.237	0.476	1.018	7.992	8.403	3.494	1.733	0.682
BR x 43kg:	P<F	0.376	0.633	0.060	0.017	0.106	0.645	0.501	0.104
	F	0.859	0.243	4.042	6.876	2.901	0.226	0.488	2.927
TR x DORPER:	P<F	0.243	0.719	0.769	0.386	0.043	0.466	0.943	0.922
	F	1.409	0.135	0.090	0.802	4.374	0.562	0.005	0.010
TR x SAMM:	P<F	0.159	0.922	0.125	0.059	0.002	0.004	0.032	0.001
	F	2.072	0.010	2.466	3.820	11.160	9.291	4.970	23.345
TR x 25kg:	P<F	0.092	0.463	0.386	0.090	0.030	0.153	0.547	0.530
	F	3.155	0.583	0.819	3.200	5.480	2.214	0.389	0.423
TR x 31kg:	P<F	0.902	0.444	0.732	0.529	0.039	0.705	0.677	0.780
	F	0.016	0.641	0.125	0.428	5.076	0.153	0.186	0.083
TR x 37kg:	P<F	0.733	0.893	0.059	0.186	0.177	0.749	0.946	0.357
	F	0.123	0.019	4.062	1.890	1.979	0.108	0.005	0.932
TR x 43kg:	P<F	0.026	0.154	0.696	0.082	0.151	0.007	0.009	0.010
	F	5.917	2.220	0.162	3.384	2.248	9.110	8.642	8.190

Table 4.8. (CONTINUED)

		B1 cm	B2 cm	K2 cm	CW1 cm	CW2 cm	CCM/B1 kg/cm	CCM/B2 kg/cm	CCM/K2 kg/cm
SM x DORPER:	P<F	0.001	0.002	0.017	0.014	0.002	0.001	0.001	0.001
	F	8.464	6.171	3.838	4.033	6.029	11.067	14.566	22.544
SM x SAMM:	P<F	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001
	F	10.436	9.750	11.760	5.667	23.604	11.187	19.195	100.180
SM x H:	P<F	0.001	0.001	0.001	0.008	0.001	0.001	0.001	0.001
	F	12.159	10.202	6.303	4.573	10.988	19.582	24.836	44.429
BR x M:	P<F	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001
	F	9.794	8.501	8.951	5.673	15.102	7.049	11.532	34.567

Table 4.9. RUMINAL, ABOMASAL, DUODENAL AND JEJUNAL pH-VALUES OF STARVED WETHERS TAKEN JUST AFTER SLUAGHTER (starved for approximately 16 hours).

		RUMINAL pH	ABOMASAL pH	DUODENAL pH	JEJUNAL pH
M-treatment	$\bar{X}$	7.529	4.939	6.401	6.562
	SD	1.141	1.853	0.231	0.252
H-treatment	$\bar{X}$	6.929	4.225	6.159	6.308
	SD	1.318	1.022	0.482	0.389
Dorper	$\bar{X}$	7.170	4.354	6.178	6.430
	SD	1.419	1.717	0.496	0.289
SAMM	$\bar{X}$	7.185	4.728	6.347	6.410
	SD	1.103	1.110	0.283	0.421
25kg SM	$\bar{X}$	6.797	4.653	5.879	6.185
	SD	1.685	1.804	0.656	0.339
31kg SM	$\bar{X}$	7.636	4.798	6.384	6.453
	SD	1.175	1.695	0.225	0.174
37kg SM	$\bar{X}$	7.043	4.695	6.343	6.328
	SD	1.289	1.356	0.285	0.443
43kg SM	$\bar{X}$	7.202	3.981	6.365	6.638
	SD	0.802	0.900	0.209	0.288

SM - Slaughter mass; SAMM - SA Mutton Merino;

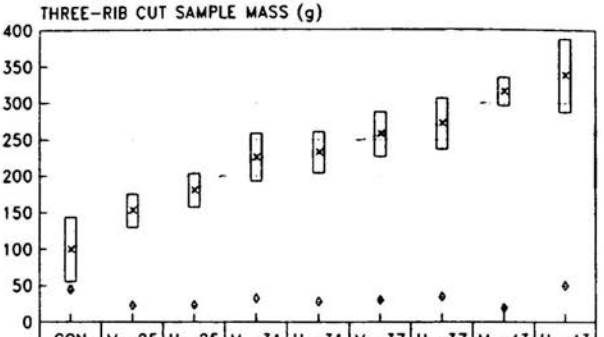
Table 4.10. ONE-WAY ANALYSIS OF VARIANCE OF RUMINAL, ABOMASAL, DUODENAL AND JEJUNAL pH-VALUES OF STARVED WETHERS TAKEN JUST AFTER SLAUGHTER (starved for approximately 16 hours).

		RUMINAL pH	ABOMASAL pH	DUODENAL pH	JEJUNAL pH
BREED:	P<F	0.969	0.397	0.168	0.858
	F	0.002	0.761	1.965	0.033
	Signif.	ns	ns	ns	ns
TREATMENT:	P<F	0.116	0.098	0.048	0.018
	F	2.572	2.852	4.122	6.073
	Signif.	ns	*	**	**
SLAUGHTER MASS:	P<F	0.455	0.521	0.008	0.024
	F	0.888	0.764	4.465	3.510
	Signif.	ns	ns	***	**

* - P<0.1; ** - P<0.05; *** - P<0.01

The influence of treatment and slaughter group on the three rib-cut mass (Dorpers and SAMM)

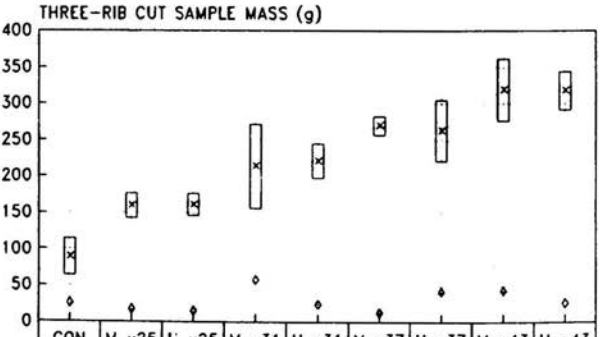
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. RSM*
FOR SAMM'S



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	□	55.48	129.61	157.84	192.92	204.21	226.8	237.04	296.67	287.61
X+SD	□	143.52	174.99	203.96	257.88	260.19	287.8	306.56	334.73	387.39
X	×	99.5	152.3	180.9	225.4	232.2	257.3	271.8	315.7	337.5
SD	◊	44.02	22.69	23.06	32.48	27.99	30.5	34.76	19.03	49.89

*RSM - THREE-RIB CUT SAMPLE MASS (g)

95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. RSM*
FOR DORPERS

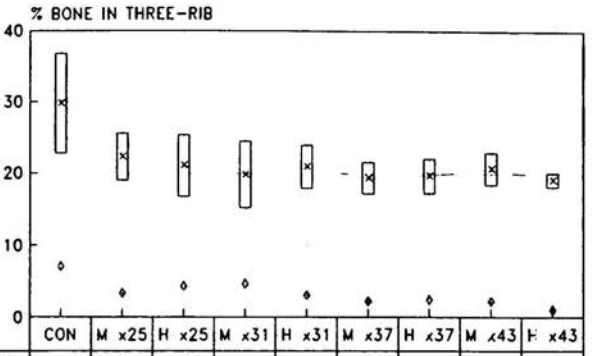


		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	□	64.17	142.7	146.21	156.32	197.06	256.91	221.2	276.06	291.64
X+SD	□	114.43	176.5	176.19	271.28	244.94	282.49	304.8	361.54	344.36
X	×	89.3	159.6	161.2	213.8	221	269.7	263	318.8	318
SD	◊	25.13	16.9	14.99	57.48	23.94	12.79	41.8	42.74	26.36

*RSM - THREE-RIB CUT SAMPLE MASS (g)

The influence of treatment and slaughter mass on the percentage bone in three rib-cut samples.

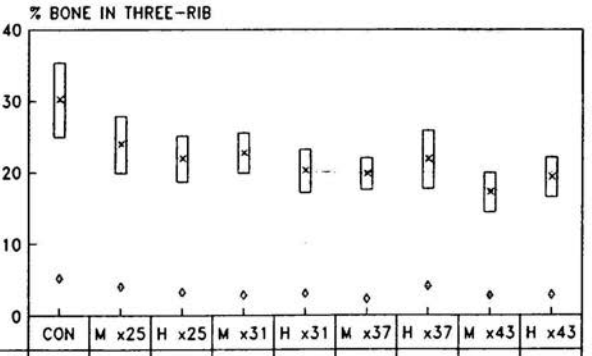
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %B*
FOR SAMM'S



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	□	22.81	19.01	16.83	15.27	17.97	17.21	17.28	18.48	18.22
X+SD	□	36.79	25.59	25.37	24.53	24.03	21.59	22.12	22.92	20.18
X	×	29.8	22.3	21.1	19.9	21	19.4	19.7	20.7	19.2
SD	◊	6.99	3.29	4.27	4.63	3.03	2.19	2.42	2.22	0.98

* %B – PERCENTAGE BONE IN THREE-RIB

95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %B*
FOR DORPERS

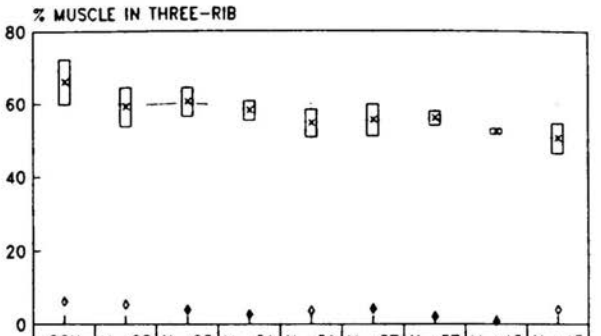


		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	□	24.98	19.87	18.69	19.85	17.18	17.54	17.72	14.43	16.5
X+SD	□	35.42	27.93	25.11	25.55	23.22	22.06	25.88	19.97	22.1
X	×	30.2	23.9	21.9	22.7	20.2	19.8	21.8	17.2	19.3
SD	◊	5.22	4.03	3.21	2.85	3.02	2.26	4.08	2.77	2.8

* %B – PERCENTAGE BONE IN THREE-RIB

The influence of treatment and slaughter mass on the percentage muscle in three rib-cut samples.

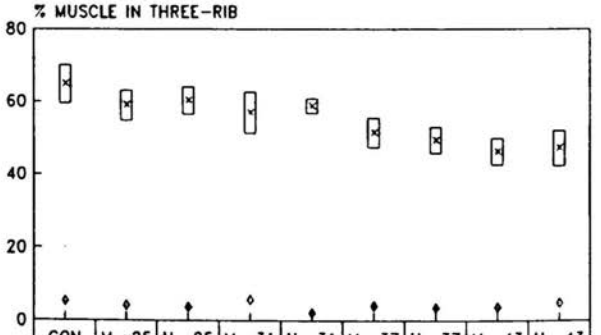
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %M*
FOR SAMM'S



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	▯	59.811	53.863	56.658	55.514	50.988	51.265	54.082	51.769	46.656
X+SD	▯	72.329	64.517	64.522	60.906	58.452	59.835	58.098	53.271	54.684
X	×	66.07	59.19	60.59	58.21	54.72	55.55	56.09	52.52	50.67
SD	◊	6.259	5.327	3.932	2.696	3.732	4.285	2.008	0.751	4.014

*%M - PERCENTAGE MUSCLE IN THREE-RIB

95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %M*
FOR DORPERS

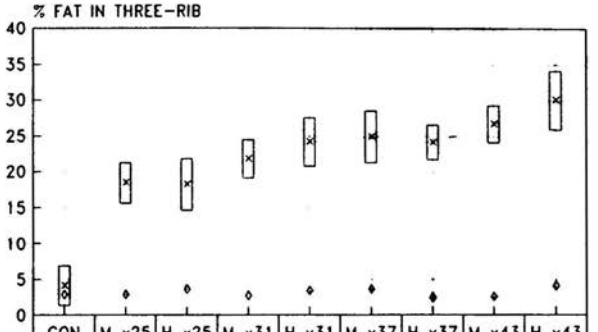


		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	▯	59.623	54.911	56.58	51.297	56.748	47.381	45.866	42.622	42.409
X+SD	▯	70.097	63.129	64	62.663	60.912	55.499	53.034	49.918	52.091
X	×	64.86	59.02	60.29	56.98	58.83	51.44	49.45	46.27	47.25
SD	◊	5.237	4.109	3.71	5.683	2.082	4.059	3.584	3.648	4.841

*%M - PERCENTAGE MUSCLE IN THREE-RIB

The influence of treatment and slaughter mass on the percentage fat in three rib-cut samples.

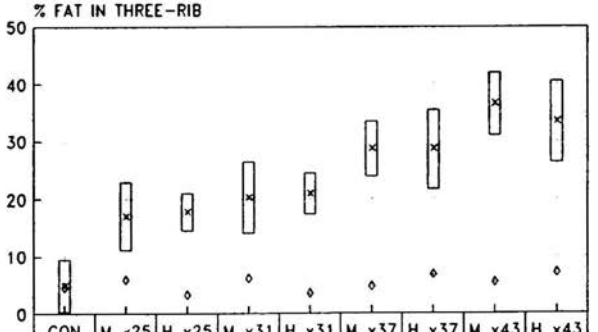
95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %F*
FOR SAMM'S



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	▯	1.32	15.613	14.656	19.158	20.837	21.347	21.74	24.157	25.948
X+SD	▯	6.9	21.307	21.844	24.482	27.583	28.533	26.58	29.283	34.152
X	×	4.11	18.46	18.25	21.82	24.21	24.94	24.16	26.72	30.05
SD	◊	2.79	2.847	3.594	2.662	3.373	3.593	2.42	2.563	4.102

* %F – PERCENTAGE FAT IN THREE-RIB

95% CONFIDENCE INTERVAL FOR FACTOR MEANS
TREATMENT AND SLAUGHTER GROUP vs. %F*
FOR DORPERS



		CON	M x25	H x25	M x31	H x31	M x37	H x37	M x43	H x43
X-SD	▯	0.29	11.124	14.523	14.074	17.413	23.954	21.801	31.072	26.334
X+SD	▯	9.43	22.896	20.997	26.406	24.467	33.486	35.499	41.948	40.486
X	×	4.86	17.01	17.76	20.24	20.94	28.72	28.65	36.51	33.41
SD	◊	4.57	5.886	3.237	6.166	3.527	4.766	6.849	5.438	7.076

* %F – PERCENTAGE FAT IN THREE-RIB

5 FATTY ACID PROFILE ANALYSIS

5.1 DIET FATTY ACID PROFILES

A summary of dietary fatty acid profiles is given in Table 5.A[1]. Samples of the high and moderately high energy diets as well as maize meal, cotton seed cake and Smuts finger hay (D.eriantha) samples were taken weekly and pooled for subsequent fatty acid analysis (C14:0 to C24:0). Although the pooled samples were analysed in duplicate, standard deviations could not be calculated between individual samples. Standard deviations between duplicate samples were negligible.

Linoleic acid (C18:2, 42.2g/100g) was the most abundant (Table 5.A.) fatty acid in the high energy diet while oleic acid (C18:1, 45.9g/100g) was the major fatty acid present in the moderately high energy diet. Palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) concentrations were considerably greater in the moderately high energy diet than in the high energy diet. Average concentrations of palmitic (C16:0), stearic (C18:0) and oleic acid (C18:1) in the moderately high energy diet were respectively 24.8, 5.7, and 45.9g/100g, and in the high energy diet respectively 13.9, 3.2, and 38.6g/100g.

On the other hand the concentration of linoleic acid (C18:2) was much greater in the high energy diet (42.2g/100g) than in the moderately high energy diet (13.5g/100g). Differences in the concentrations of myristic (C14:0), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1) and lignoceric acid (C24:0) between the two diets were negligible. However, the concentration of behenic acid (C22:0) in the moderately high energy diet was denotingly higher than that of the high energy diet.

Maize meal contained prodigious concentrations of both C18:1 (40.9g/100g) and C18:2 (42.5g/100g), but its C14:0, C16:0, C18:0, C18:3, C20:0, C20:1, C22:0 and C24:0 concentrations were small.

[1]Tables 5.A. to 5.9. are presented at the end of chapter 5.

Cotton seed oil cake on the other hand contained enormous concentrations of C18:2 (55.5g/100g) followed by smaller concentrations of C16:0 (24.5g/100g), but most of the other fatty acids were present in significantly smaller concentrations.

The concentration of C18:1 (40.7g/100g) in Smuts finger hay was almost as high as that in maize meal, while the concentration of C18:2 (29.2g/100g) was close to half of that in maize meal. The concentration of C22:0 in Smuts finger (3.0g/100g) hay was significantly higher than that of the other diet-components and therefore similarly high C22:0 concentrations were depicted in the moderately high energy diet that contained 42.52% Smuts finger hay.

5.2 SUBCUTANEOUS FATTY ACID PROFILES

5.2.1 The effect of treatment on subcutaneous fatty acid profiles

Energy treatment significantly influenced the fatty acid profiles of the subcutaneous adipose tissue of wethers (Tables 5.3. and 5.4.). The relative concentrations of the following fatty acids were determined namely: C14:0, C15:0, C15:1, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3 and C20:0. Energy treatment did not influence the relative percentage myristic acid (C14:0) and the relative percentage arachidic acid (20:0) was negligible in the subcutaneous adipose tissue of wethers on both treatments (Tables 5.3. and 5.4.).

Saturated fatty acids that differed most between high and moderately high energy feeding were pentadecanoic acid C15:0, palmitic acid (C16:0), margaric acid (C17:0) and stearic acid (C18:0). Monoenoic fatty acids that differed most between the different energy treatments were C17:1 and oleic acid (C18:1). Linoleic acid (C18:2*n*=6) was the only non-conjugated polyunsaturated fatty acid that differed between the two energy treatments.

The percentage of C15:0 fatty acid was significantly higher ($P<0.001$, $F=30.99$) in the subcutaneous fat of wethers on the H-treatment (0.860 ± 0.237%) than those on the M-treatment (0.514 ± 0.194%). The relative percentage palmitic acid (C16:0), however, was lower ($P<0.001$, $F=16.84$) on the H-treatment (21.39 ± 1.513%) than on the M-treatment (22.85 ± 1.121%).

Both the relative percentages of C17:0 ($P<0.001$, $F=72.54$) and C17:1 ($P<0.001$, $F=37.82$) were higher on the H-treatment than on the M-treatment. Average relative percentages of respectively 2.926 ± 0.599% and 1.737 ± 0.411% were recorded for C17:0 on the H and M-treatments. Values obtained for C17:1 were respectively 0.963 ± 0.250% and 0.573 ± 0.219% for the H and M-treatments (Tables 5.1. and 5.2.).

The relative percentage oleic acid (C18:1) was significantly higher ($P<0.001$, $F=32.19$) on the H-treatment (40.21 ± 2.235%) than on the M-treatment (36.69 ± 2.389%), whereas both the relative percentages of stearic acid (C18:0; $P<0.001$, $F=13.18$) and linoleic acid (C18:2; $P<0.012$, $F=6.820$) were denotingly lower on the H-treatment than on the M-treatment (Table 5.2.).

It is evident that there was a shift from C18:0 and C18:2 to C18:1, coupled with an increase in both the relative percentages of C17:0 and C17:1 in the subcutaneous adipose tissue of wethers on the H-treatment. Furthermore, all the abovementioned effects of treatment on the subcutaneous adipose tissue of wethers remained highly significant regardless of the inclusion of fatness as covariate (Table 5.4.). However, the effect of treatment on both C18:2 ($P<0.011$, $F=7.990$) and C18:3 ($P<0.073$, $F=3.608$) was only significant in the early physiological maturing Dorper breed. In addition, the effect of treatment on C16:0 was more pronounced in fat from Dorpers, while its effct on C18:0 was more important in the fat from SA Mutton Merinos.

Treatment affected the concentrations of C16:0, C18:2 and C18:3 in the subcutaneous adipose tissues of the early physiological maturing breed more than that of the later physiological maturing breed, while its affects on C18:0 were more pronounced in the later physiological maturing breed (Table 5.4.).

5.2.2 The effect of breed on subcutaneous fatty acid profiles

The effect of breed on the subcutaneous fatty acid profiles of wethers were limited to C16:0 ($P<0.01$, $F=9.701$), C17:0 ($P<0.05$, $F=7.037$), C17:1 ($P<0.01$, $F=7.867$) and C18:1 ($P<0.01$, $F=8.526$)(Table 5.3.). When fatness was included in the model as covariate, the effect of breed on C17:0 ($P<0.062$, $F=3.683$) and C17:1 ($P<0.051$, $F=4.051$) only tended to be significant, while the percentage of C18:1 did not differ significantly between breeds (Table 5.4.).

On the M-treatment the relative percentage C18:2 was significantly higher in the subcutaneous fat of Dorpers (4.634 ± 1.133%) in comparison with that of SA Mutton Merinos (4.237 ± 0.819%; $P<0.001$, $F=25.57$), but the difference was very small on the energy treatment (Table 5.2.).

The covariance analysis results accentuated the higher concentration of C16:0 ($P<0.024$, $F=5.449$) in the subcutaneous adipose tissue of SA Mutton Merinos (22.68 ± 1.401%) in comparison with that of Dorpers (21.57 ± 1.434%). However, the difference in C16:0 between breeds tended to be more significant at the 43kg slaughter mass ($P<0.081$, $F=3.392$) coupled with the M-treatment ($P<0.060$, $F=4.005$).

Differences in the relative percentage C17:0 between breeds also became more important at the 43kg slaughter mass than at the 37kg slaughter mass, but in this instance Dorpers (2.707 ± 0.807%) contained higher concentrations of C17:0 than SA Mutton Merinos (2.143 ± 0.571%; $P<0.015$, $F=7.189$).

Finally the relative percentage of C16:1 in the subcutaneous adipose tissue of Dorpers (2.707 ± 0.807%) was significantly higher than that of SA Mutton Merinos (2.316 ± 0.258%) slaughtered at 37kg live mass (P<0.027, F=5.756), but the difference declined noticeably at the 43kg slaughter mass (P<0.211, F=1.673).

5.2.3 The effect of slaughter mass on subcutaneous fatty acid profiles

Contrary to growth and carcass results, no significant differences could be found between any of the fatty acids in the subcutaneous fat of wethers slaughtered at either 37 or 43kg live mass. (The ANOVA-results are tabulated in Table 5.3.). However, results obtained from the covariance analysis procedure shows that the relative percentage of C18:2 tended to be slightly higher in the subcutaneous fat of wethers slaughtered at 43kg (4.163 ± 0.845%) in comparison with those slaughtered at 37kg live mass (3.983 ± 1.183%).

In subcutaneous adipose samples from SA Mutton Merinos the C16:1 (P<0.055, F=4.195), C17:1 (P<0.034, F=5.252) and C18:2 (P<0.001, F=14.89) fatty acid concentrations were significantly greater for wethers slaughtered at 43kg live mass while the relative concentration of C18:0 (P<0.069, F=3.703) was significantly greater for wethers slaughtered at 37kg live mass (Table 5.4.).

The C18:3 concentration in subcutaneous adipose samples from Dorpers declined significantly from 1.164 ± 0.507% for wethers slaughtered at 37kg live mass to 0.738 ± 0.239% for wethers slaughtered at 43kg live mass.

5.3 SATURATED vs. UNSATURATED SUBCUTANEOUS FATTY ACID RATIOS

Both treatment (P<0.001, F=14.31) and breed (P<0.014, F=6.538) significantly influenced the saturated / unsaturated

subcutaneous fatty acid ratios of wethers (Table 5.3.). Slaughter mass per se did not affect the relative percentages of either saturated or unsaturated fatty acids of the subcutaneous adipose tissue.

The inclusion of fatness emphasised the important influence of treatment on the saturated / unsaturated fatty acid ratio, while the effect of breed became almost negligible (Table 5.4.). Nevertheless, the relative percentage unsaturated fatty acids tended to be greater for Dorpers (47.65 ± 2.636%) than for SA Mutton Merinos (45.66 ± 3.352%; $P<0.066$, $F=3.568$) coupled with the M-treatment ($P<0.020$, $F=6.506$). However, at the 43kg slaughter mass these differences were insignificant.

Although the effect of breed on the saturated / unsaturated fatty acid ratio was very similar to that observed for the relative percentage unsaturated fatty acids, its effect on the relative percentage saturated fatty acids was negligible.

The relative percentage saturated fatty acids in the adipose tissue of wethers declined as the energy content of the diets increased, and consequently the relative percentage of unsaturated fatty acids increased. Average unsaturated fatty acid concentrations of subcutaneous adipose tissue of wethers reared on the high energy diet was 48.16 ± 2.488% and on the moderately high energy diet it was 45.15 ± 3.056%. On the other hand the relative concentration of saturated fatty acids in the subcutaneous fat of wethers on the high energy diet (51.57 ± 2.482%) was 2.56% less than those on the moderately high energy diet (54.13 ± 2.966%).

As the energy content of diet increased, the saturated / unsaturated fatty acid ratios of the subcutaneous fat declined from 1.208 ± 0.148 to 1.076 ± 0.108. Treatment influenced the fatty acid profiles regardless of slaughter mass or breed, but

the differences were more noticible in the later physiological maturing breed and at the lighter slaughter mass. However, it is clear that the relative percentage of unsaturated fatty acids increases in the subcutaneous fat of wethers on both the H and M-treatments as they become heavier (Table 5.2.).

5.4 PLASMA FATTY ACID PROFILES

Plasma fatty acid profiles of wethers were analysed in order to determine whether the changes in the subcutaneous fatty acids on the H-treatment were associated with that of the plasma. The covariance analysis results shows that neither treatment or breed significantly influenced the plasma fatty acid profile of wethers and the relative percentages of C14:0, C15:0, C15:1 and C20:0 were negligible (Table 5.8.). Apart from the significant increase in the relative percentage of C18:0 with increasing slaughter mass, the effect of slaughter mass also tended to be negligible. The relative percentage of C18:0 increased from 15.91 ± 4.287% at the 37kg live mass to 19.58 ± 3.891% at 43kg live mass ($P<0.011$, $F=7.041$).

Nevertheless, some important breed and treatment differences were found within breeds and treatments. Plasma C16:1-concentrations of Dorpers were smaller on the H-treatment than on the M-treatment ($P<0.038$, $F=4.957$), while larger concentrations of both C17:0 ($P<0.002$, $F=14.11$) and C17:1 ($P<0.012$, 7.772) were found in the plasma of SA Mutton Merinos on the M-treatment.

Furthermore, it was found that within the 43kg slaughter group,the relative percentage of C18:1 tended to be at least 2.89% higher on the H-treatment (42.91 ± 3.702%) than on the M-treatment (40.02 ± 4.355%; $P<0.080$, $F=3.414$). This increase in the C18:1-plasma concentration on the H-treatment might contribute greatly to the shift towards C18:1 in the subcutaneous adipose tissue.

5.5 SATURATED vs. UNSATURATED PLASMA FATTY ACID RATIOS

Although neither treatment, breed or slaughter mass affected the relative percentages of either saturated or unsaturated fatty acids in the plasma of wethers, some interesting differences were observed within breeds and also within slaughter groups (Table 5.8.).

Treatment significantly increased the relative percentage of unsaturated fatty acids in the plasma of SA Mutton Merinos on the H-treatment to 58.98 ± 4.479% in comparison with that on the M-treatment of 56.25 ± 4.691% ($P<0.030$, $F=5.502$).

On the other hand the relative percentage saturated fatty acids increased from 41.02 ± 4.480% on the H-treatment to 43.75 ± 4.691% on the M-treatment ($P<0.030$, $F=5.502$). Consequently SA Mutton Merino wethers attained a noticeably smaller saturated / unsaturated plasma fatty acid ratio on the H-treatment (0.704 ± 0.127) than on the M-treatment (0.789 ± 0.144), which accentuates the increase in the relative percentage of unsaturated fatty acids on the higher energy diet.

The relatively high concentrations of unsaturated fatty acids in the plasma of Dorpers on the M-treatment, may be attributed to the fact that the Dorpers were more selective feeders. They subsequently consumed relatively high concentrations of maize meel (energy) and cotton seed cake, while the greater portion of the Smuts finger hay remained in the feed troughs. Nevertheless, the plasma fatty acid ratios of Dorpers were not significantly affected by treatment, and the percentage unsaturated fatty acids of Dorpers on both treatments remained well above 55%.

Although the effect of slaughter mass on the plasma fatty acid ratios was limited more to SA Mutton Merinos, the saturated / unsaturated fatty acid ratios tended to increase with slaughter mass. The relative percentage unsaturated fatty acids in the

plasma of SA Mutton Merinos tended to decrease slightly as the slaughter mass increased, but it remained fairly constant for Dorpers (Table 5.6.).

5.6 *CIS* - *TRANS* FATTY ACID CONFIGURATIONS

Since the *cis-trans* fatty acid analysis procedure was extremely expensive, the procedure was limited to subcutaneous adipose samples of wethers in the 43kg slaughter group. *Trans*-11-octadecenoic acid (*trans*-vaccenic acid or C18:1(*trans*)) was the only fatty acid of the *trans*-configuration present in the adipose samples, but small concentrations of branched chain fatty acids were also detected in the adipose samples (Table 5.9.).

Trans-11-octadecenoic acid was present in significantly higher concentrations in the adipose tissue of wethers on the H-treatment in comparison with that of wethers on the M-treatment ($P<0.001$, $F=149.0$). Average C18:1(*trans*) concentrations on the H and M-treatment were respectively 3.845 ± 0.104 and 3.100 ± 0.118g/100g. The concentration of C18:1(*trans*) in the adipose tissue of SA Mutton Merinos on the H-treatment (4.02 ± 0.028g/100g) showed an increase of almost 39%, while the increase was less drastic for Dorpers (11.6%). Differences in the concentration of C18:1(*trans*) in adipose samples of Dorpers (3.480 ± 0.113g/100g) and SA Mutton Merinos (3.465 ± 0.323g/100g) were not important ($P<0.820$, $F=0.060$).

Although the effect of treatment on the concentration of C18:1(*cis*) in subcutaneous adipose samples was negligible, important breed differences were observed. The subcutaneous adipose tissue of Dorpers (37.518 ± 0.518g/100g) contained a higher concentration of C18:1(*cis*) than that of SA Mutton Merinos (34.915 ± 0.345g/100g).

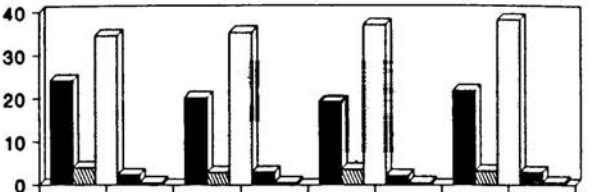
Nevertheless, the C18:1(*cis*) concentration in the fat of both breeds tended to be slightly higher on the M-treatment in comparison with that on the H-treatment. The *cis:trans* fatty

acid ratios of subcutaneous fat of wethers on the H and M-treatments were respectively 9.299 : 1 and 11.931 : 1. It is evident that the *cis:trans* fatty acid ratios of subcutabeous adipose samples is reduced when wethers consume high energy diets.

Breed differences in the concentration of branched chain fatty acids were insignificant, but it is interesting to note that the concentrations of these fatty acids were slightly higher in the subcutaneous adipose tissue of Dorpers (4.033 ± 0.645g/100g) in comparison with that of SA Mutton Merinos (3.625 ± 2.110g/100g).

Treatment significantly affected the concentration of branched chain fatty acids in the subcutaneous adipose tissue of wethers ($P<0.056$, $F=7.104$). Although the concentration of branched chain fatty acids was higher in the adipose samples of Dorpers reared on the H-treatment, the adipose samples of SA Mutton Merinos on the M-treatment contained higher concentrations of branched chain fatty acids. It seems that if physiological mature wethers are fed on a high energy diet, considerable increases in the concentration of branched chain fatty acids can be expected.

CIS-TRANS FATTY ACID CONFIGURATIONS OF SUBCUTANEOUS ADIPOSE TISSUE OF WETHERS

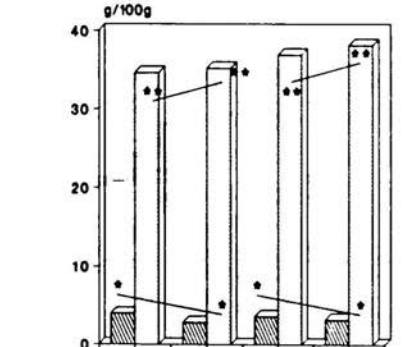


	MH4	MM4	DH4	DM4
C18:0	24.08	20.14	19.13	21.71
C18:1 (trans)	4.02	2.91	3.67	3.29
C18:1 (cis)	34.6	35.23	36.91	38.12
C18:2	2.38	2.9	2.18	2.92
C18:3	0.51	0.56	0.51	0.56

C18:0 C18:1 (trans) C18:1 (cis)
C18:2 C18:3

(MEASURED IN g/100g)

CIS-TRANS FATTY ACID CONFIGURATIONS OF SUBCUTANEOUS ADIPOSE TISSUE OF WETHERS



	MH4	MM4	DH4	DM4
C18:1 (trans)*	4.02	2.91	3.67	3.29
C18:1 (cis)**	34.6	35.23	36.91	38.12

C18:1 (trans)* C18:1 (cis)**

(MEASURED IN g/100g)
* - SIGNIFICANT FEED DIFFERENCES, P<0.1
** - SIGNIFICANT BREED DIFFIRENCES, P<.1

Table 5.A. LONG CHAIN FATTY ACID COMPOSITIONS (C14:0 - C24:0) OF FEED SAMPLES: MODERATELY HIGH ENERGY DIET (M), HIGH ENERGY DIET (H), MAIZE MEEL (MM), DECORTICATED COTTON SEED CAKE (CSC) AND SMUTS FINGER HAY (D. eriantha) (SFH).

		C14:0	C16:0	C18:0	C18:1	C18:2	C18:3	C20:0	C20:1	C22:0	C24:0
H-DIET	$\bar{X}$	0.1	13.9	3.2	38.6	42.2	<0.1	0.5	0.1	1.4	0.1
M-DIET	$\bar{X}$	0.2	24.8	5.7	45.9	13.5	<0.1	1.4	0.1	3.4	0.1
MM	$\bar{X}$	<0.1	12.4	2.9	40.9	42.5	0.5	0.5	0.3	0.1	0.2
CSC	$\bar{X}$	0.8	24.5	2.6	15.6	55.5	0.3	0.3	0.1	0.1	<0.1
SFH	$\bar{X}$	0.1	14.2	5.1	40.7	29.2	<0.1	1.1	0.1	3.0	1.4

Samples of the H- and M-diets as well as maize meel, cotton seed cake and Smuts finger hay samples were taken weekly and kept in sealed polyethylene bags at -20°C. These samples were pooled for subsequent fatty acid determinations.

Table 5.1. SUBCUTANEOUS FATTY ACID PROFILES OF WETHERS: C14:0, C15:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE SATURATED FATTY ACIDS (R%SFA), RELATIVE PERCENTAGE UNSATURATED FATTY ACIDS (R%UFA) AND SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA).

BREED	TREATMENT	TM		n	C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
SAMM	H	37	$\bar{X}$	6	5.056	0.725	21.71	2.356	2.790	0.846	21.72	39.60	4.002	0.687	52.00	47.49	1.098
			SD		0.855	0.320	1.671	0.232	0.854	0.154	1.402	1.688	0.723	0.338	2.170	1.951	0.090
		43	$\bar{X}$	6	5.507	0.857	22.37	2.704	2.639	0.911	20.64	39.46	3.920	0.892	52.02	47.89	1.092
			SD		1.159	0.219	1.207	0.274	0.305	0.251	3.562	2.355	0.839	0.195	2.594	2.674	0.119
	M	37	$\bar{X}$	6	4.163	0.458	23.25	2.276	1.512	0.432	26.87	34.99	3.538	0.875	56.23	42.11	1.342
			SD		1.049	0.174	1.294	0.299	0.293	0.136	3.339	2.075	0.322	0.229	3.181	2.702	0.147
		43	$\bar{X}$	6	5.393	0.554	23.35	2.459	1.646	0.529	23.55	36.10	4.937	1.113	54.50	45.13	1.215
			SD		1.064	0.094	0.958	0.550	0.180	0.105	3.133	2.263	0.444	0.433	2.879	2.830	0.143
DORPER	H	37	$\bar{X}$	6	5.319	0.954	20.55	2.562	2.938	0.996	21.44	40.54	3.389	0.945	51.21	48.43	1.065
			SD		1.028	0.217	1.242	0.260	0.660	0.358	3.313	2.694	1.499	0.352	3.104	3.201	0.135
		43	$\bar{X}$	6	4.510	0.902	20.91	2.283	3.337	1.099	21.36	41.23	3.530	0.659	51.02	48.80	1.050
			SD		0.432	0.162	1.528	0.258	0.267	0.174	1.967	2.195	0.509	0.145	2.505	2.463	0.104
	M	37	$\bar{X}$	6	4.934	0.471	22.47	2.538	1.714	0.623	23.10	37.39	5.004	1.383	52.70	46.94	1.126
			SD		0.697	0.168	0.909	0.294	0.186	0.080	1.382	1.790	1.285	0.571	1.933	1.864	0.086
		43	$\bar{X}$	6	4.888	0.572	22.31	2.370	2.078	0.711	23.22	38.24	4.264	0.817	53.07	46.41	1.150
			SD		0.521	0.306	1.161	0.101	0.642	0.365	2.939	2.502	0.918	0.300	3.010	2.716	0.131

(FATTY ACID CONCENTRATIONS EXPRESSED IN RELATIVE PERCENTAGE UNITS)
TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 5.2. SUMMARY STATISTICS OF SUBCUTANEOUS FATTY ACID PROFILES OF WETHERS: C14:0, C15:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE SATURATED FATTY ACIDS (R%SFA), RELATIVE PERCENTAGE UNSATURATED FATTY ACIDS (R%UFA) AND SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA).

		n	C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
DORPER	$\bar{X}$	24	4.913	0.725	21.57	2.438	2.517	0.857	22.28	39.36	4.047	0.951	52.00	47.65	1.098
	SD		0.722	0.295	1.434	0.253	0.804	0.324	2.516	2.701	1.233	0.444	2.661	2.636	0.116
SAMM	$\bar{X}$	24	5.023	0.649	22.68	2.449	2.147	0.679	23.20	37.54	4.099	0.892	53.69	45.66	1.187
	SD		1.113	0.257	1.401	0.375	0.739	0.262	3.682	2.860	0.780	0.330	3.132	3.352	0.158
H-FEEDING	$\bar{X}$	24	5.098	0.860	21.39	2.476	2.926	0.963	21.30	40.21	3.710	0.796	51.57	48.16	1.076
	SD		0.932	0.237	1.513	0.294	0.599	0.250	2.565	2.235	0.938	0.284	2.482	2.488	0.108
M-FEEDING	$\bar{X}$	24	4.838	0.514	22.85	2.411	1.737	0.573	24.19	36.69	4.436	1.047	54.13	45.15	1.208
	SD		0.928	0.194	1.121	0.341	0.411	0.219	3.063	2.389	0.988	0.441	2.966	3.056	0.148
DORPER x H	$\bar{X}$	12	4.914	0.928	20.74	2.423	3.137	1.048	21.40	40.89	3.459	0.802	51.12	48.62	1.057
	SD		0.863	0.185	1.340	0.287	0.523	0.273	2.598	2.370	1.070	0.297	2.691	2.730	0.115
DORPER x M	$\bar{X}$	12	4.911	0.522	22.40	2.454	1.896	0.667	23.16	37.82	4.634	1.100	52.89	46.68	1.138
	SD		0.587	0.241	0.998	0.227	0.489	0.256	2.190	2.121	1.133	0.526	2.420	2.238	0.106
SAMM x H	$\bar{X}$	12	5.281	0.791	22.05	2.530	2.714	0.878	21.19	39.53	3.961	0.790	52.02	47.69	1.095
	SD		0.999	0.271	1.433	0.303	0.616	0.201	2.642	1.955	0.748	0.284	2.280	2.241	0.101
SAMM x M	$\bar{X}$	12	4.764	0.506	23.31	2.368	1.579	0.480	25.21	35.55	4.237	0.994	55.37	43.63	1.279
	SD		1.202	0.142	1.087	0.433	0.242	0.126	3.541	2.149	0.819	0.353	3.031	3.074	0.153
37kg SM	$\bar{X}$	24	4.861	0.652	22.00	2.433	2.238	0.724	23.29	38.14	3.983	0.973	53.04	46.45	1.158
	SD		0.968	0.298	1.588	0.282	0.834	0.294	3.246	2.936	1.183	0.449	3.158	3.411	0.156
43kg SM	$\bar{X}$	24	5.074	0.721	22.24	2.454	2.425	0.812	22.20	38.76	4.163	0.870	52.66	47.06	1.127
	SD		0.897	0.255	1.453	0.353	0.742	0.315	3.028	2.893	0.845	0.318	2.886	2.876	0.133

SM - Slaughter mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino
(Fatty acid concentrations expressed in relative percentage units)

Table 5.2. (CONTINUED)

(n=12)		C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
DORPER x 37kg:	$\bar{X}$	5.127	0.713	21.52	2.550	2.326	0.809	22.27	38.97	4.196	1.164	51.958	47.690	1.095
	SD	0.861	0.313	1.443	0.265	0.788	0.315	2.571	2.732	1.576	0.507	2.586	2.617	0.113
DORPER x 43kg:	$\bar{X}$	4.699	0.737	21.61	2.326	2.707	0.905	22.30	39.74	3.897	0.738	52.051	47.609	1.100
	SD	0.497	0.290	1.487	0.192	0.807	0.340	2.574	2.733	0.805	0.239	2.849	2.771	0.124
SAMM x 37kg:	$\bar{X}$	4.596	0.592	22.49	2.316	2.150	0.639	24.30	37.30	3.770	0.781	54.121	44.806	1.220
	SD	1.031	0.282	1.638	0.258	0.903	0.257	3.631	3.007	0.586	0.292	3.408	3.597	0.173
SAMM x 43kg:	$\bar{X}$	5.450	0.706	22.87	2.582	2.143	0.720	22.08	37.78	4.429	1.003	53.264	46.515	1.153
	SD	1.062	0.226	1.159	0.434	0.571	0.271	3.540	2.817	0.832	0.340	2.915	2.993	0.141
H x 37kg:	$\bar{X}$	5.188	0.840	21.14	2.459	2.863	0.921	21.58	40.08	3.695	0.816	51.610	47.966	1.081
	SD	0.912	0.287	1.527	0.258	0.732	0.274	2.430	2.199	1.167	0.355	2.587	2.575	0.111
H x 43kg:	$\bar{X}$	5.008	0.879	21.64	2.494	2.988	1.005	21.01	40.35	3.725	0.776	51.526	48.349	1.071
	SD	0.983	0.185	1.520	0.336	0.455	0.228	2.770	2.360	0.692	0.204	2.486	2.498	0.109
M x 37kg:	$\bar{X}$	4.535	0.465	22.87	2.407	1.613	0.527	24.99	36.20	4.271	1.129	54.469	44.530	1.234
	SD	0.946	0.163	1.141	0.314	0.257	0.146	3.131	2.232	1.177	0.492	3.114	3.354	0.161
M x 43kg:	$\bar{X}$	5.140	0.563	22.84	2.414	1.862	0.620	23.39	37.18	4.601	0.965	53.789	45.774	1.182
	SD	0.841	0.216	1.152	0.380	0.503	0.273	2.901	2.536	0.772	0.388	2.905	2.727	0.135

Table 5.3. ANALYSIS OF VARIANCE OF SUBCUTANEOUS FATTY ACID PROFILES OF WETHERS: C14:0, C15:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE SATURATED FATTY ACIDS (R%SFA), RELATIVE PERCENTAGE UNSATURATED FATTY ACIDS (R%UFA) AND SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA).
(BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR	P<F	0.692	0.226	0.003	0.911	0.011	0.008	0.258	0.007	0.853	0.597	0.032	0.011	0.014
	F	0.163	1.509	9.701	0.013	7.037	7.867	1.316	8.526	0.036	0.292	4.892	7.078	6.538
	Signif.	ns	ns	***	ns	**	***	ns	***	ns	ns	**	**	**
TR	P<F	0.355	0.001	0.001	0.496	0.001	0.001	0.001	0.001	0.012	0.026	0.002	0.001	0.001
	F	0.912	30.99	16.84	0.487	72.54	37.82	13.18	32.19	6.820	5.289	11.26	16.17	14.31
	Signif.	ns	***	***	ns	***	***	***	***	**	**	***	***	***
SM	P<F	0.447	0.271	0.514	0.826	0.188	0.171	0.179	0.319	0.528	0.363	0.625	0.283	0.388
	F	0.610	1.241	0.448	0.051	1.793	1.938	1.870	1.017	0.418	0.882	0.250	1.184	0.791
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
BRxTR	P<F	0.361	0.344	0.586	0.307	0.711	0.894	0.162	0.473	0.113	0.675	0.306	0.164	0.147
	F	0.889	0.955	0.311	1.067	0.143	0.019	2.023	0.543	2.614	0.182	1.073	2.009	2.186
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
BRxSM	P<F	0.017	0.482	0.692	0.008	0.162	0.912	0.171	0.820	0.091	0.002	0.547	0.241	0.317
	F	6.198	0.522	0.164	7.879	2.029	0.013	1.941	0.054	2.998	11.02	0.381	1.415	1.024
	Signif.	**	ns	ns	***	ns	ns	ns	ns	*	***	ns	ns	ns
TRxSM	P<F	0.151	0.645	0.460	0.886	0.663	0.945	0.538	0.581	0.607	0.580	0.705	0.581	0.574
	F	2.134	0.222	0.577	0.022	0.199	0.005	0.399	0.319	0.277	0.321	0.149	0.319	0.331
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 5.4. COVARIANCE ANALYSIS (%FAT INCLUDED AS COVARIATE) OF SUBCUTANEOUS FATTY ACID PROFILES OF WETHERS: C14:0, C15:0, C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE SATURATED FATTY ACIDS (R%SFA), RELATIVE PERCENTAGE UNSATURATED FATTY ACIDS (R%UFA) AND SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR	P<F	0.857	0.313	0.024	0.587	0.062	0.051	0.645	0.141	0.307	0.463	0.226	0.066	0.096
	F	0.034	1.042	5.449	0.309	3.683	4.051	0.223	2.251	1.072	0.568	1.507	3.568	2.906
	Signif.	ns	ns	**	ns	*	*	ns	ns	ns	ns	ns	*	*
TR	P<F	0.361	0.001	0.001	0.499	0.001	0.001	0.001	0.001	0.007	0.027	0.002	0.001	0.001
	F	0.889	30.32	16.78	0.481	72.15	37.64	13.17	35.43	8.015	5.247	11.53	15.99	14.27
	Signif.	ns	***	***	ns	***	***	***	***	***	**	***	***	***
SM	P<F	0.415	0.363	0.367	0.422	0.427	0.422	0.493	0.870	0.084	0.593	0.822	0.580	0.771
	F	0.704	0.881	0.867	0.684	0.668	0.685	0.496	0.028	3.124	0.300	0.053	0.321	0.089
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	*	ns	ns	ns	ns
BRxTR	P<F	0.610	0.616	0.794	0.450	0.881	1.000	0.456	0.922	0.111	0.872	0.713	0.441	0.423
	F	0.500	0.490	0.232	0.815	0.127	0.001	0.801	0.082	2.321	0.138	0.341	0.836	0.879
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
BRxSM	P<F	0.062	0.767	0.955	0.040	0.427	1.000	0.304	0.997	0.341	0.010	0.708	0.428	0.510
	F	2.966	0.267	0.046	3.481	0.869	0.001	1.226	0.003	1.104	5.197	0.348	0.866	0.684
	Signif.	*	ns	ns	**	ns	ns	ns	ns	ns	***	ns	ns	ns
TRxSM	P<F	0.364	0.897	0.744	0.985	0.900	0.996	0.808	0.814	0.882	0.848	0.915	0.846	0.837
	F	1.035	0.109	0.297	0.015	0.106	0.004	0.214	0.207	0.126	0.165	0.089	0.168	0.178
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 5.4. (CONTINUED)

		C14:0	C15:0	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR x H:	P<F	0.388	0.142	0.116	0.634	0.125	0.149	0.709	0.437	0.304	0.999	0.776	0.719	0.768
	F	0.812	2.345	2.706	0.241	2.576	2.259	0.148	0.656	1.115	0.001	0.086	0.137	0.092
BR x M:	P<F	0.440	0.499	0.060	0.299	0.531	0.376	0.342	0.227	0.001	0.233	0.160	0.020	0.046
	F	0.646	0.492	4.005	1.139	0.422	0.856	0.993	1.558	25.57	1.520	2.137	6.506	4.544
BR x 37kg:	P<F	0.250	0.345	0.192	0.027	0.633	0.104	0.182	0.254	0.107	0.017	0.179	0.026	0.047
	F	1.406	0.981	1.827	5.756	0.242	2.923	1.916	1.386	2.866	6.920	1.949	5.816	4.509
BR x 43kg:	P<F	0.109	0.727	0.081	0.211	0.015	0.314	0.534	0.403	0.480	0.027	0.797	0.837	0.828
	F	2.834	0.129	3.392	1.673	7.189	1.068	0.416	0.760	0.538	5.783	0.070	0.045	0.050
TR x DORPER:	P<F	0.982	0.001	0.004	0.659	0.001	0.002	0.051	0.001	0.011	0.073	0.067	0.044	0.059
	F	0.001	20.92	10.82	0.207	43.34	13.76	4.347	17.88	7.990	3.608	3.782	4.666	4.047
TR x SAMM:	P<F	0.260	0.003	0.044	0.212	0.001	0.001	0.004	0.001	0.615	0.161	0.009	0.001	0.002
	F	1.349	11.89	4.674	1.669	35.47	44.75	11.14	20.67	0.270	2.133	8.502	17.10	12.73
TR x 37kg:	P<F	0.105	0.001	0.005	0.679	0.001	0.001	0.004	0.001	0.163	0.061	0.015	0.004	0.006
	F	2.898	15.57	10.34	0.182	28.13	20.13	10.80	22.41	2.107	3.976	7.129	10.92	9.785
TR x 43kg:	P<F	0.720	0.002	0.031	0.577	0.001	0.001	0.067	0.003	0.006	0.122	0.058	0.029	0.041
	F	0.136	12.90	5.415	0.333	48.75	14.87	3.782	11.98	9.535	2.614	4.064	5.585	4.816
SM x DORPER:	P<F	0.266	0.805	0.679	0.144	0.343	0.971	0.355	0.547	0.876	0.033	0.365	0.376	0.378
	F	1.313	0.065	0.182	2.324	0.988	0.001	0.939	0.388	0.026	5.305	0.899	0.857	0.850
SM x SAMM:	P<F	0.109	0.098	0.387	0.055	0.519	0.034	0.069	0.456	0.001	0.127	0.455	0.044	0.152
	F	2.831	3.022	0.	815	4.195	0.446	5.252	3.703	0.602	14.89	2.543	0.604	4.662	2.228
SM x H:	P<F	0.683	0.529	0.162	0.364	0.685	0.506	0.853	0.599	0.846	0.665	0.568	0.797	0.698
	F	0.177	0.426	2.116	0.903	0.175	0.476	0.036	0.295	0.040	0.199	0.348	0.137	0.160
SM x M:	P<F	0.082	0.699	0.699	0.613	0.525	0.756	0.385	0.725	0.001	0.808	0.732	0.216	0.383
	F	3.369	0.159	0.159	0.273	0.433	0.102	0.825	0.131	17.40	0.062	0.125	1.640	0.833

Table 5.5. PLASMA FATTY ACID PROFILES OF WETHERS: C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE PLASMA SATURATED FATTY ACIDS (R%SFA) AND PLASMA UNSATURATED FATTY ACIDS (R%UFA) AND PLASMA SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA).

BREED	TREATMENT	TM		n	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
SAMM	H	37	$\bar{X}$	6	23.084	2.867	0.000	0.000	14.281	41.478	14.860	3.429	37.744	62.256	0.608
			SD		1.505	3.179	0.000	0.000	4.381	1.753	0.930	1.023	2.568	2.568	0.066
		43	$\bar{X}$	6	23.529	2.058	1.198	0.000	19.956	44.670	4.697	0.892	43.672	56.328	0.776
			SD		0.514	1.649	0.938	0.000	1.588	4.048	0.778	0.736	0.858	0.857	0.027
	M	37	$\bar{X}$	6	23.990	2.538	2.167	0.000	15.292	41.319	12.385	2.308	41.490	58.510	0.723
			SD		1.843	3.126	2.122	0.000	5.449	1.879	4.361	1.801	5.667	5.667	0.176
		43	$\bar{X}$	6	23.658	0.000	2.955	0.872	19.438	41.797	10.067	1.211	45.964	54.035	0.852
			SD		0.614	0.000	0.709	0.781	1.814	1.384	0.567	0.948	1.631	1.631	0.055
DORPER	H	37	$\bar{X}$	6	24.415	1.218	2.117	0.454	16.888	43.790	9.223	1.893	44.387	55.613	0.808
			SD		2.488	1.890	2.320	0.722	4.480	2.593	3.519	1.222	4.404	4.405	0.146
		43	$\bar{X}$	6	19.726	1.143	2.079	0.405	21.626	41.150	11.187	2.684	39.760	60.239	0.688
			SD		7.487	1.776	1.094	0.678	3.253	2.517	5.112	2.960	8.080	8.080	0.233
	M	37	$\bar{X}$	6	23.294	2.745	1.407	0.501	17.161	43.272	10.139	1.481	41.862	58.137	0.727
			SD		1.482	2.179	1.336	0.815	2.989	2.953	2.903	1.260	4.086	4.086	0.122
		43	$\bar{X}$	6	21.750	2.708	0.764	0.000	17.283	38.233	16.978	2.285	37.431	62.568	0.624
			SD		3.251	0.832	0.625	0.000	6.457	5.673	12.142	2.776	9.024	9.024	0.224

(FATTY ACID CONCENTRATIONS EXPRESSED IN RELATIVE PERCENTAGE UNITS)
TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 5.6. SUMMARY STATISTICS OF PLASMA FATTY ACID PROFILES OF WETHERS: C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE PLASMA SATURATED FATTY ACIDS (R%SFA) AND PLASMA UNSATURATED FATTY ACIDS (R%UFA) AND PLASMA SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA).

		n	C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
DORPER	$\bar{X}$	24	22.29	1.954	1.592	0.340	18.23	41.61	11.88	2.086	42.13	57.87	0.748
	SD		4.420	1.808	1.492	0.632	4.656	4.089	7.197	2.112	6.521	6.521	0.188
SAMM	$\bar{X}$	24	23.57	1.866	1.580	0.218	17.24	42.32	11.25	1.960	42.39	57.61	0.747
	SD		1.217	2.492	1.598	0.530	4.284	2.715	3.452	1.511	4.697	4.697	0.139
H-FEEDING	$\bar{X}$	24	23.57	1.822	1.349	0.215	17.29	42.77	10.74	2.225	42.23	57.78	0.744
	SD		1.217	2.183	1.548	0.512	4.520	3.066	4.023	1.871	5.121	5.121	0.155
M-FEEDING	$\bar{X}$	24	22.30	1.998	1.823	0.343	18.19	41.16	12.39	1.821	42.29	57.71	0.751
	SD		4.420	2.168	1.505	0.646	4.439	3.686	6.805	1.780	6.196	6.196	0.175
DORPER x H	$\bar{X}$	12	22.07	1.181	2.098	0.430	19.26	42.47	10.21	2.288	43.43	56.57	0.784
	SD		5.855	1.749	1.730	0.668	4.478	2.800	4.308	2.198	5.623	5.623	0.176
DORPER x M	$\bar{X}$	12	22.52	2.727	1.085	0.250	17.22	40.75	13.56	1.883	40.83	59.17	0.713
	SD		2.541	1.572	1.049	0.609	4.798	5.051	9.143	2.098	7.322	7.322	0.201
SAMM x H	$\bar{X}$	12	23.31	2.463	0.599	<0.001	17.12	43.07	11.28	2.161	41.02	58.98	0.704
	SD		1.097	2.451	0.890	-	4.319	3.409	3.829	1.574	4.480	4.479	0.127
SAMM x M	$\bar{X}$	12	23.82	1.269	2.561	0.436	17.37	41.56	11.23	1.760	43.75	56.25	0.789
	SD		1.321	2.489	1.564	0.696	4.436	1.593	3.203	1.487	4.691	4.691	0.144
37kg TM	$\bar{X}$	24	23.70	2.342	1.423	0.239	15.91	42.47	11.65	2.278	41.024	58.98	0.706
	SD		1.831	2.566	1.826	0.563	4.287	2.453	3.716	1.467	4.643	4.643	0.140
43kg TM	$\bar{X}$	24	22.17	1.477	1.749	0.319	19.58	41.46	11.48	1.768	43.49	56.51	0.788
	SD		4.158	1.584	1.178	0.606	3.891	4.220	7.078	2.113	6.315	6.315	0.178

TM - Target mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino
(Fatty acid concentrations expressed in relative percentage units)

Table 5.6. (CONTINUED)

(n=12)		C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
DORPER x 37kg:	$\bar{X}$	23.85	1.982	1.762	0.477	17.03	43.53	9.682	1.687	42.64	57.36	0.751
	SD	2.038	2.102	1.843	0.734	3.634	2.663	3.113	1.203	3.972	3.972	0.124
DORPER x 43kg:	$\bar{X}$	20.74	1.926	1.422	0.203	19.45	39.69	14.08	2.484	41.61	58.39	0.745
	SD	5.603	1.555	1.093	0.504	5.377	4.453	9.383	2.744	8.518	8.518	0.242
SAMM x 37kg:	$\bar{X}$	23.54	2.703	1.084	<0.001	14.79	41.40	13.62	2.868	39.41	60.59	0.661
	SD	1.673	3.010	1.824	-	4.743	1.735	3.272	1.514	4.858	4.858	0.145
SAMM x 43kg:	$\bar{X}$	23.59	1.029	2.077	0.436	19.70	43.23	8.882	1.052	45.37	54.63	0.832
	SD	0.544	1.547	1.213	0.696	1.648	3.251	1.398	0.826	1.774	1.775	0.060
H x 37kg:	$\bar{X}$	23.75	2.043	1.059	0.227	15.59	42.63	12.04	2.661	40.39	59.61	0.688
	SD	2.080	2.638	1.916	0.541	4.439	2.431	3.832	1.341	4.645	4.645	0.138
H x 43kg:	$\bar{X}$	21.63	1.601	1.639	0.203	20.79	42.91	9.442	1.788	44.06	55.94	0.800
	SD	5.435	1.703	1.075	0.504	2.592	3.702	3.934	2.259	5.092	5.092	0.156
M x 37kg:	$\bar{X}$	23.64	2.642	1.787	0.250	16.23	42.30	11.26	1.894	41.66	58.34	0.725
	SD	1.636	2.571	1.737	0.609	4.302	2.571	3.722	1.544	4.757	4.757	0.145
M x 43kg:	$\bar{X}$	22.70	1.354	1.859	0.436	18.36	40.02	13.52	1.748	42.92	57.08	0.777
	SD	2.443	1.521	1.310	0.696	4.660	4.355	8.954	2.056	7.534	7.534	0.203

Table 5.7. ANALYSIS OF VARIANCE OF PLASMA FATTY ACID PROFILES OF WETHERS: C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE PLASMA SATURATED FATTY ACIDS (R%SFA) AND PLASMA UNSATURATED FATTY ACIDS (R%UFA) AND PLASMA SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR	P<F	0.182	0.886	0.977	0.475	0.416	0.490	0.708	0.820	0.874	0.874	0.976
	F	1.837	0.021	0.001	0.539	0.700	0.502	0.146	0.054	0.026	0.026	0.001
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
TR	P<F	0.613	0.774	0.233	0.452	0.465	0.111	0.321	0.466	0.968	0.969	0.887
	F	0.268	0.086	1.465	0.597	0.563	2.641	1.006	0.560	0.002	0.002	0.021
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
SM	P<F	0.110	0.157	0.419	0.635	0.004	0.319	0.919	0.360	0.131	0.132	0.082
	F	2.669	2.073	0.692	0.236	9.471	1.015	0.011	0.894	2.365	2.364	3.164
	Signif.	ns	ns	ns	ns	***	ns	ns	ns	ns	ns	*
BRxTR	P<F	0.972	0.028	0.001	0.071	0.354	0.921	0.307	0.997	0.104	0.104	0.101
	F	0.001	5.203	14.388	3.430	0.915	0.010	1.071	0.001	2.754	2.755	2.815
	Signif.	ns	**	***	*	ns	ns	ns	ns	ns	ns	ns
BRxSM	P<F	0.087	0.202	0.138	0.036	0.303	0.003	0.004	0.012	0.031	0.031	0.059
	F	3.075	1.682	2.282	4.699	1.086	10.032	9.124	6.807	4.976	4.977	3.768
	Signif.	*	ns	ns	**	ns	***	***	**	**	**	*
TRxSM	P<F	0.536	0.515	0.582	0.551	0.201	0.197	0.142	0.509	0.478	0.478	0.529
	F	0.403	0.447	0.317	0.373	1.689	1.716	2.238	0.459	0.531	0.530	0.416
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 5.8. COVARIANCE ANALYSIS (% FAT INCLUDED AS COVARIATE) OF PLASMA FATTY ACID PROFILES OF WETHERS: C16:0, C16:1, C17:0, C17:1, C18:0, C18:1, C18:2, C18:3, RELATIVE PERCENTAGE PLASMA SATURATED FATTY ACIDS (R%SFA) AND PLASMA UNSATURATED FATTY ACIDS (R%UFA) AND PLASMA SATURATED vs. UNSATURATED FATTY ACID RATIO (SFA/UFA). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR	P<F	0.732	0.665	0.491	0.057	0.479	0.804	0.361	0.663	0.577	0.577	0.673
	F	0.122	0.196	0.500	3.839	0.530	0.064	0.890	0.199	0.326	0.326	0.187
	Signif.	ns	ns	ns	*	ns	ns	ns	ns	ns	ns	ns
TR	P<F	0.616	0.780	0.219	0.454	0.470	0.106	0.297	0.474	0.980	0.980	0.903
	F	0.264	0.082	1.561	0.592	0.552	2.733	1.116	0.541	0.001	0.001	0.016
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
SM	P<F	0.816	0.362	0.916	0.123	0.011	0.856	0.262	0.192	0.066	0.066	0.525
	F	0.056	0.884	0.012	2.480	7.041	0.034	1.292	1.762	3.558	3.557	0.655
	Signif.	ns	ns	ns	ns	**	ns	ns	ns	*	*	ns
BRxTR	P<F	0.969	0.074	0.001	0.266	0.648	0.998	0.714	0.992	0.320	0.320	0.414
	F	0.031	2.774	8.177	1.367	0.438	0.002	0.340	0.008	1.171	1.172	0.903
	Signif.	ns	*	***	ns	ns	ns	ns	ns	ns	ns	ns
BRxSM	P<F	0.439	0.358	0.203	0.228	0.594	0.022	0.040	0.067	0.146	0.146	0.198
	F	0.840	1.053	1.656	1.534	0.527	4.202	3.467	2.888	2.013	2.013	1.694
	Signif.	ns	ns	ns	ns	ns	**	**	*	ns	ns	ns
TRxSM	P<F	0.787	0.807	0.849	0.805	0.446	0.434	0.323	0.802	0.774	0.775	0.777
	F	0.240	0.216	0.165	0.218	0.823	0.851	1.161	0.222	0.258	0.257	0.254
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 5.8. (CONTINUED)

		C16:0	C16:1	C17:0	C17:1	C18:0	C18:1	C18:2	C18:3	R%SFA	R%UFA	SFA/UFA
BR x H:	P<F	0.514	0.900	0.396	0.014	0.342	0.937	0.032	0.477	0.138	0.138	0.140
	F	0.458	0.017	0.784	7.408	0.992	0.007	5.339	0.547	2.404	2.404	2.370
BR x M:	P<F	0.470	0.558	0.146	0.712	0.898	0.642	0.958	0.869	0.642	0.642	0.624
	F	0.564	0.368	2.294	0.144	0.017	0.230	0.003	0.029	0.230	0.230	0.256
BR x 37kg:	P<F	0.215	0.862	0.798	0.011	0.286	0.051	0.005	0.014	0.099	0.099	0.121
	F	1.645	0.032	0.069	7.882	1.207	4.345	10.15	7.392	3.017	3.017	2.643
BR x 43kg:	P<F	0.861	0.183	0.025	0.923	0.742	0.273	0.623	0.163	0.560	0.560	0.591
	F	0.032	1.913	5.889	0.010	0.115	1.274	0.258	2.104	0.365	0.364	0.309
TR x DORPER:	P<F	0.698	0.038	0.054	0.587	0.310	0.301	0.296	0.636	0.412	0.412	0.437
	F	0.159	4.957	4.230	0.315	1.088	1.131	1.153	0.238	0.732	0.732	0.654
TR x SAMM:	P<F	0.414	0.156	0.002	0.012	0.572	0.185	0.731	0.379	0.030	0.030	0.030
	F	0.726	2.180	14.11	7.772	0.341	1.893	0.126	0.846	5.502	5.502	5.527
TR x 37kg:	P<F	0.853	0.609	0.290	0.947	0.738	0.730	0.579	0.179	0.507	0.507	0.520
	F	0.037	0.280	1.184	0.005	0.119	0.126	0.329	1.947	0.474	0.473	0.444
TR x 43kg:	P<F	0.523	0.645	0.494	0.295	0.141	0.080	0.148	0.964	0.675	0.675	0.757
	F	0.438	0.226	0.505	1.160	2.363	3.414	2.279	0.002	0.187	0.187	0.101
SM x DORPER:	P<F	0.533	0.681	0.084	0.987	0.220	0.105	0.579	0.692	0.919	0.919	0.785
	F	0.417	0.180	3.323	0.001	1.607	2.899	0.330	0.167	0.011	0.011	0.654
SM x SAMM:	P<F	0.728	0.443	0.130	0.072	0.091	0.189	0.003	0.016	0.017	0.017	0.024
	F	0.128	0.636	2.502	3.644	3.181	1.853	11.76	6.985	6.851	6.851	6.047
SM x H:	P<F	0.970	0.563	0.515	0.490	0.012	0.622	0.004	0.073	0.047	0.047	0.054
	F	0.001	0.359	0.456	0.513	7.795	0.259	11.03	3.612	4.519	4.519	4.203
SM x M:	P<F	0.532	0.078	0.697	0.176	0.295	0.530	0.874	0.909	0.515	0.515	0.455
	F	0.419	3.475	0.161	1.973	1.162	0.423	0.027	0.014	0.456	0.456	0.605

Table 5.9. *CIS-TRANS* FATTY ACID CONFIGURATIONS AND RATIOS OF SUBCUTANEOUS ADIPOSE TISSUE OF DORPER AND SA MUTTON MERINO WETHERS ON TWO LEVELS OF ENERGY FEEDING.

		C18:1(*cis*)	C18:1(*trans*)	*CIS-TRANS* RATIO
H:	$\bar{X}$	35.755[a]	3.845[a]	9.229 : 1[a]
	SD	0.724	0.104	
M:	$\bar{X}$	36.678[a]	3.100[b]	11.831 : 1[b]
	SD	0.922	0.118	
DORPER:	$\bar{X}$	37.518[b]	3.480[c]	10.780 : 1[c]
	SD	0.518	0.113	
SAMM:	$\bar{X}$	34.915[c]	3.465[c]	10.077 : 1[c]
	SD	0.345	0.323	
DxH	$\bar{X}$	36.910	3.670	10.057 : 1
	SD	0.180	0.090	
DxM:	$\bar{X}$	38.130	3.290	11.590 : 1
	SD	1.310	0.040	
SAMMxH:	$\bar{X}$	34.600	4.020	8.607 : 1
	SD	0.960	0.028	
SAMMxM:	$\bar{X}$	35.230	2.910	12.107 : 1
	SD	0.330	0.140	

H=H-treatment; M=M-treatment; D=Dorper; SAMM=SA Mutton Merino;

[a] - [c] Means with different superscripts differ significantly (P<0.01).

6 COOKING LOSSES

6.1 TOTAL COOKING LOSS

6.1.1 The influence of treatment on cooking loss

The percentage total cooking loss was determined by the following formula:

$$\% \text{ Total cooking loss} = \frac{(\text{loin mass} - \text{roasted loin mass})}{\text{loin mass}} \times 100$$

The total volume drip (*ml*) and fat (*ml*) were also measured in order to provide some more information about the characteristics of the drip. Treatment *per se* did not affect the percentage total cooking loss of M.longissimus lumborum samples[1] from wethers ($P<0.627$, $F=0.247$), and the covariance analysis procedure provided similar results ($P<0.581$, $F=0.319$). These results are summarised in Tables 6.3 and 6.4[2]. Average total cooking losses obtained for M.longissimus lumborum samples from wethers on the H and M-treatments were respectively 20.245 ± 3.369 and 19.829 ± 3.112%.

Besides the above-mentioned evidence, it was found that the total cooking loss of M.longissimus lumborum samples from SA Mutton Merinos, reared on the H-treatment (20.988 ± 2.719%), tended to be greater than that of wethers reared on the M-treatment (18.533 ± 2.409%; $P<0.057$, $F=4.122$). Furthermore a significant breed X treatment interaction was found ($P<0.019$, $F=5.933$), which indicated higher total cooking losses in M.longissimus lumborum samples from Dorpers on the M-treatment than on the H-treatment, while the percentage total cooking loss was highest in the loin samples of SA Mutton Merinos on the H-treatment.

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[1]Loin samples.

[2]Tables 6.1 to 6.8 are presented at the end of chapter 6.

Although the expected tendency would be towards a higher percentage total cooking loss on the H-treatment as demonstrated in the later physiological maturing breed, the opposite tendency in loin samples from Dorpers is easily explained.

Dorpers on the M-treatment spent appreciably more time (81.46 ± 30.38 days in stead of 60.36 ± 31.97 days) in the trial, irrespective of their slaughter mass, and consequently attained higher average fat percentages (25.62 ± 9.35% fat) in comparison with wethers on the H-treatment (25.19 ± 8.12% fat). Furthermore, the correlation between fat percentage in three rib-cut samples and total cooking loss was high and positive (r_{xy}=0.495, P<0.01) and therefore higher total cooking losses in loin samples from Dorpers on the M-treatment were evident. Nevertheless, the breed X treatment interaction proved to be negligible after the inclusion of the percentage fat in the model as covariate (P<0.113, F=0.296)(Table 6.4.).

6.1.2 The influence of breed on cooking loss

Although the percentage total cooking loss of loin samples of Dorpers (20.313 ± 3.616%) tended to be somewhat higher than that of SA Mutton Merinos (19.761 ± 2.808%; P<0.054, F=4.228; Table 6.4), the major effect of breed on total cooking losses was negligible (P<0.0.376, F=0.835; fat included as covariate). The covariance analysis results demonstrated no important interactions.

6.1.3 The influence of slaughter group on cooking loss

Significantly greater total cooking losses were recorded in loin samples from wethers slaughtered at 43kg live mass (21.232 ± 3.358%) in comparison with those of wethers slaughtered at 37kg live mass (18.843 ± 2.621%; P<0.007, F=8.144).

Differences in the percentage total cooking loss between slaughter mass groups disappeared after the inclusion of fat percentage as covariate. However, total cooking losses of loin

samples from Dorpers slaughtered at 43kg live mass (22.347 ± 3.450%) still tended to be higher than that of wethers slaughtered at 43kg live mass (18.280 ± 2.533%; P<0.059, F=4.046).

6.2 DRIP LOSS

6.2.1 The influence of treatment on drip loss

Drip loss was determined by dividing the total amount of drip in the pan by the mass of the non-roasted loin sample, which in turn was multiplied by a factor 100 in order to express drip loss in percentage units.

It was concluded from the covariance analysis procedure that treatment did not influence the percentage drip loss in the loin samples of either breed (P<0.868, F=0.029)(Table 6.4.). Average drip losses recorded in loin samples from wethers on the H and M-treatments were respectively 5.002 ± 2.223 and 5.096 ± 2.524%.

6.2.2 The influence of breed on drip loss

Breed tended to be an important determinant of the percentage drip loss from loin samples (P<0.089, F=3.039), but it was limited to wethers on the M-treatment where the drip loss was significantly greater from the loin samples of Dorpers 6.725 ± 2.418% in comparison with that of SA Mutton Merinos (3.467 ± 1.296%; P<0.021, F=6.334).

Although the drip loss also tended to be greater from the loin samples of Dorpers on the H-treatment (5.496 ± 2.441%) in comparison with that of SA Mutton Merinos on the H-treatment (4.508 ± 1.960%), it was not of real statistical importance. These breed differences were highly significant as calculted by the ANOVA-procedure.

6.2.3 The influence of slaughter group on drip loss

Drip losses from loin samples of wethers in heavier slaughter groups increased significantly (P<0.065, F=3.591).

ANOVA-results = P<0.001, F=16.578. Average drip loss values obtained at the 37 and 43kg slaughter groups are respectively 3.998 ± 1.567 and 6.100 ± 2.560%. However, the more significant differences in the percentage drip loss between slaughter mass groups were limited to loin samples from wethers on the M-treatment (P<0.075, F=3.539).

The average drip loss from loin samples of wethers on the M-treatment increased noticeably from 3.975 ± 1.616% at the 37kg slaughter mass to 6.217 ± 2.822% at the 43kg slaughter mass. Average drip losses from samples of wethers on the H-treatment and slaughtered at 37 and 43kg live mass were respectively 4.021 ± 1.589 and 5.983 ± 2.389%.

6.3 DRIP LOSS CHARACTERISTICS

Drip loss characteristics recorded were the total volume drip (ml), the volume meat extract in the drip (ml) and the volume fat in the drip (ml). The relative percentage fat in the drip, volume fat in the drip per 100g of unroasted loin, total volume drip loss relative to the unroasted loin mass and the percentage meat extract in the drip were calculated in order to put the basic drip loss characteristics in the right perspective. These results are summarised in Tables 6.5. and 6.6.

Both ANOVA and covariance analysis results emphasise the negligible effect of treatment on all drip loss characteristics. Although breed X treatment interactions were observed, their importance diminished considerably after the inclusion of fat as covariate in the model (These interactions will thus not be discussed, but they are summarised in Tables 6.7. and 6.8.).

It is important to note that the breed differences in the total volume drip loss were attributed mostly to differences in the volume fat in the drip (P<0.089, F=3.037). Drip from loin samples of Dorpers (54.417 ± 41.990ml) contained higher volumes

of fat in comparison with that of SA Mutton Merinos (22.938 ± 16.983ml). The average volume fat per 100g of unroasted loin was significantly higher for Dorpers (4.403 ± 2.652ml/100g) than for SA Mutton Merinos 2.034 ± 1.208ml/100g; P<0.024, F=5.497).

If fatness is excluded from the model, the effect of breed on the percentage meat extract and the percentage fat in the drip become important. The drip from loin samples of SA Mutton Merinos contained a higher percentage of meat extract and a smaller percentage fat in comparison with that of Dorpers (refer to Table 6.6).

Finally, the effect of slaughter mass remained important as far as all the drip loss characteristics were concerned. However, the relative percentages of fat and meat extract in the drip were not affected by breed (Table 6.8.). Nevertheless, higher values were calculated for all the drip loss characteristics of loin samples from wethers slaughtered at the heavier mass.

6.4 EVAPORATION LOSS

The percentage evaporation loss from loin samples of wethers was calculated by the following formula:

% Total cooking loss - % Drip loss = % Evaporation loss

All the results obtained proved without doubt that the effects of both treatment and slaughter mass on the percentage evaporation loss were negligible (Table 6.4.). However, extremely important breed differences were observed (P<0.018, F=6.024; fat percentage included as covariate).

The average evaporation losses from loin samples of SA Mutton Merinos (15.769 ± 2.285%) were greater than that of Dorpers (14.186 ± 1.686%). This was expected since Dorpers (0.325 ± 0.244cm) had on average thicker subcutaneous fat

thicknesses in comparison with SA Mutton Merinos (0.197 ± 0.095cm), that greatly reduced the evaporation losses from the loin samples.

Table 6.1. COOKING LOSSES: PERCENTAGE TOTAL COOKING LOSS (%TCL), PERCENTAGE DRIP LOSS (%DL) AND PERCENTAGE EVAPORATION LOSS (%EL).

BREED	TREATMENT	TM		n	%TCL	%DL	%EL
SAMM	H	37	$\bar{X}$	36	20.560	3.533	17.027
			SD		2.304	0.946	1.970
		43	$\bar{X}$	36	21.417	5.483	15.933
			SD		3.244	2.297	2.073
	M	37	$\bar{X}$	36	18.250	2.883	15.367
			SD		2.729	1.382	2.588
		43	$\bar{X}$	36	18.817	4.050	14.750
			SD		2.265	0.985	2.403
DORPER	H	37	$\bar{X}$	36	17.560	4.508	13.052
			SD		3.138	2.022	1.298
		43	$\bar{X}$	36	21.443	6.483	14.943
			SD		3.793	2.584	1.948
	M	37	$\bar{X}$	36	19.000	5.067	13.900
			SD		1.740	0.987	1.503
		43	$\bar{X}$	36	23.250	8.383	14.850
			SD		3.138	2.299	1.575

TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 6.2. SUMMARY STATISTICS OF COOKING LOSSES: PERCENTAGE TOTAL COOKING LOSS (%TCL), PERCENTAGE DRIP LOSS (%DL) AND PERCENTAGE EVAPORATION LOSS (%EL).

		n	%TCL	%DL	%EL
DORPER	$\bar{X}$	144	20.313	6.110	14.186
	SD		3.616	2.457	1.686
SAMM	$\bar{X}$	144	19.761	3.988	15.769
	SD		2.808	1.710	2.285
H-FEEDING	$\bar{X}$	144	20.245	5.002	15.239
	SD		3.369	2.223	2.280
M-FEEDING	$\bar{X}$	144	19.829	5.096	14.717
	SD		3.112	2.524	2.008
DORPER x H	$\bar{X}$	72	19.502	5.496	13.998
	SD		3.889	2.441	1.862
DORPER x M	$\bar{X}$	72	21.125	6.725	14.375
	SD		3.283	2.418	1.549
SAMM x H	$\bar{X}$	72	20.988	4.508	16.480
	SD		2.719	1.960	2.011
SAMM x M	$\bar{X}$	72	18.533	3.467	15.058
	SD		2.409	1.296	2.403
37kg TM	$\bar{X}$	144	18.843	3.998	14.836
	SD		2.621	1.567	2.354
43kg TM	$\bar{X}$	144	21.232	6.100	15.119
	SD		3.358	2.560	1.946

TM - Target mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 6.2. (CONTINUED)

(n=72)		%TCL	%DL	%EL
DORPER x 37kg:	$\bar{X}$	18.280	4.788	13.476
	SD	2.533	1.545	1.411
DORPER x 43kg:	$\bar{X}$	22.347	7.433	14.897
	SD	3.450	2.534	1.689
SAMM x 37kg:	$\bar{X}$	19.405	3.208	16.197
	SD	2.693	1.179	2.358
SAMM x 43kg:	$\bar{X}$	20.117	4.767	15.342
	SD	2.993	1.844	2.227
H x 37kg:	$\bar{X}$	19.060	4.021	15.039
	SD	3.057	1.589	2.615
H x 43kg:	$\bar{X}$	21.430	5.983	15.438
	SD	3.365	2.389	1.986
M x 37kg:	$\bar{X}$	18.625	3.975	14.633
	SD	2.217	1.616	2.158
M x 43kg:	$\bar{X}$	21.033	6.217	14.800
	SD	3.488	2.822	1.937

Table 6.3. ANALYSIS OF VARIANCE OF COOKING LOSSES: PERCENTAGE TOTAL COOKING LOSS (%TCL), PERCENTAGE DRIP LOSS (%DL) AND PERCENTAGE EVAPORATION LOSS (%EL). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		%TCL	%DL	%EL
BR	P<F	0.520	0.001	0.009
	F	0.436	16.908	7.537
	Signif.	ns	***	***
TR	P<F	0.627	0.859	0.380
	F	0.247	0.033	0.820
	Signif.	ns	ns	ns
SM	P<F	0.007	0.001	0.631
	F	8.144	16.578	0.241
	Signif.	***	***	ns
BRxTR	P<F	0.019	0.033	0.126
	F	5.933	4.837	2.434
	Signif.	**	**	ns
BRxSM	P<F	0.056	0.318	0.051
	F	3.843	1.021	4.032
	Signif.	*	ns	*
TRxSM	P<F	0.983	0.802	0.847
	F	0.001	0.066	0.039
	Signif.	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 6.4. COVARIANCE ANALYSIS (% FAT INCLUDED AS COVARIATE) OF COOKING LOSSES: PERCENTAGE TOTAL COOKING LOSS (%TCL), PERCENTAGE DRIP LOSS (%DL) AND PERCENTAGE EVAPORATION LOSS (%EL). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		%TCL	%DL	%EL
BR	P<F	0.376	0.089	0.018
	F	0.835	3.039	6.024
	Signif.	ns	*	**
TR	P<F	0.581	0.868	0.384
	F	0.319	0.029	0.805
	Signif.	ns	ns	ns
SM	P<F	0.224	0.065	0.744
	F	1.525	3.591	0.111
	Signif.	ns	*	ns
BRxTR	P<F	0.113	0.170	0.320
	F	0.296	1.851	1.171
	Signif.	ns	ns	ns
BRxSM	P<F	0.247	0.866	0.155
	F	1.446	0.144	1.952
	Signif.	ns	ns	ns
TRxSM	P<F	0.996	0.905	0.982
	F	0.004	0.100	0.018
	Signif.	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 6.4. (CONTINUED)

		%TCL	%DL	%EL
BR x H:	P<F	0.089	0.837	0.007
	F	3.204	0.045	9.141
BR x M:	P<F	0.481	0.021	0.620
	F	0.536	6.334	0.262
BR x 37kg:	P<F	0.054	0.127	0.005
	F	4.228	2.551	10.226
BR x 43kg:	P<F	0.655	0.302	0.794
	F	0.212	1.927	0.072
TR x DORPER:	P<F	0.284	0.200	0.603
	F	1.218	1.765	0.288
TR x SAMM:	P<F	0.057	0.214	0.114
	F	4.122	1.657	2.751
TR x 37kg:	P<F	0.598	0.774	0.616
	F	0.297	0.087	0.268
TR x 43kg:	P<F	0.774	0.738	0.463
	F	0.087	0.118	0.582
SM x DORPER:	P<F	0.059	0.117	0.091
	F	4.046	2.696	3.161
SM x SAMM:	P<F	0.822	0.292	0.724
	F	0.054	1.176	0.133
SM x H:	P<F	0.396	0.305	0.681
	F	0.787	1.113	0.179
SM x M:	P<F	0.294	0.075	0.810
	F	1.165	3.539	0.061

Table 6.5. A DESCRIPTION OF DRIP LOSS CHRACTERISTICS OF LOIN SAMPLES FROM DORPER AND S A MUTTON MERINO WETHERS ON TWO LEVELS OF ENERGY FEEDING AND SLAUGHTERED AT EITHER 37 OR 43 kg LIVE MASS: UNROASTED LOIN MASS (ULM), TOTAL VOLUME DRIP (TVD), VOLUME MEAT EXTRACT IN DRIP (VME), VOLUME FAT IN DRIP (VFD), TOTAL VOLUME DRIP LOSS PER 100g UNROASTED LOIN SAMPLE (TVD/ULM), PERCENTAGE FAT IN DRIP (%FD), VOLUME FAT IN DRIP PER 100g UNROASTED LOIN SAMPLE (VFD/ULM) AND PERCENTAGE MEAT EXTRACT IN DRIP (%ME/TVD).

BREED	TREATMENT	TM		n	ULM g	TVD ml	VME ml	VFD ml	TVD/ULM ml/100g	%FD %	VFD/ULM ml/100g	%ME/TVD %
SAMM	H	37	$\bar{X}$	6	1013.33	18.333	2.083	16.250	1.758	88.401	1.555	11.599
			SD		59.91	6.890	1.281	6.616	0.587	6.848	0.562	6.848
		43	$\bar{X}$	6	1197.67	48.667	9.333	39.333	3.933	78.849	3.166	21.151
			SD		140.47	27.573	4.274	25.626	1.883	9.839	1.759	9.839
	M	37	$\bar{X}$	6	858.50	12.833	2.167	10.667	1.452	83.817	1.207	16.183
			SD		174.92	8.424	2.463	6.540	0.702	9.966	0.568	9.966
		43	$\bar{X}$	6	1187.17	31.000	5.500	25.500	2.651	82.650	2.207	17.350
			SD		167.77	4.099	4.037	4.324	0.464	12.880	0.557	12.880
DORPER	H	37	$\bar{X}$	6	1030.33	33.583	3.417	30.167	3.128	86.023	2.780	13.977
			SD		223.53	24.921	2.200	24.580	1.945	15.022	1.937	15.022
		43	$\bar{X}$	6	1156.00	56.500	3.083	53.417	5.153	93.475	4.869	6.525
			SD		158.00	28.332	2.333	28.731	2.947	4.061	2.944	4.061
	M	37	$\bar{X}$	6	1148.00	40.833	4.417	36.417	3.544	90.028	3.171	9.972
			SD		158.86	12.384	3.200	9.952	0.872	6.146	0.686	6.146
		43	$\bar{X}$	6	1361.83	106.667	9.000	97.667	7.404	91.933	6.794	8.067
			SD		264.53	61.763	7.430	56.934	2.927	6.750	2.714	6.750

TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 6.6. SUMMARY STATISTICS OF DRIP LOSS CHARACTERISTICS OF LOIN SAMPLES FROM DORPER AND S A MUTTON MERINO WETHERS ON TWO LEVELS OF ENERGY FEEDING AND SLAUGHTERED AT EITHER 37 OR 43 kg LIVE MASS: UNROASTED LOIN MASS (ULM), TOTAL VOLUME DRIP (TVD), VOLUME MEAT EXTRACT IN DRIP (VME), VOLUME FAT IN DRIP (VFD), TOTAL VOLUME DRIP LOSS PER 100g UNROASTED LOIN SAMPLE (TVD/ULM), PERCENTAGE FAT IN DRIP (%FD), VOLUME FAT IN DRIP PER 100g UNROASTED LOIN SAMPLE (VFD/ULM) AND PERCENTAGE MEAT EXTRACT IN DRIP (%ME/TVD).

		n	ULM g	TVD ml	VME ml	VFD ml	TVD/ULM ml/100g	%FD %	VFD/ULM ml/100g	%ME/TVD %
DORPER	$\bar{X}$	24	1174.04	59.396	4.979	54.417	4.807	90.365	4.403	9.635
	SD		227.68	44.955	4.726	41.990	2.771	8.881	2.652	8.881
SAMM	$\bar{X}$	24	1068.67	27.708	4.771	22.938	2.448	83.429	2.034	16.57
	SD		194.25	19.818	4.291	16.983	1.403	10.050	1.208	10.05
H-FEEDING	$\bar{X}$	24	1103.83	39.271	4.479	34.792	3.493	86.687	3.093	13.31
	SD		164.76	26.615	3.874	25.577	2.269	10.621	2.215	10.62
M-FEEDING	$\bar{X}$	24	1138.88	47.833	5.271	42.563	3.763	87.107	3.345	12.89
	SD		259.95	46.807	5.043	43.392	2.714	9.596	2.215	9.60
DORPER x H	$\bar{X}$	12	1093.17	45.042	3.250	41.792	4.141	89.749	3.824	10.25
	SD		195.87	28.114	2.169	28.236	2.605	11.190	2.615	11.19
DORPER x M	$\bar{X}$	12	1254.92	73.750	6.708	67.042	5.474	90.981	4.983	9.02
	SD		236.11	54.641	5.956	50.414	2.881	6.234	2.672	6.23
SAMM x H	$\bar{X}$	12	1114.50	33.500	5.708	27.792	2.845	83.625	2.361	16.38
	SD		134.71	24.861	4.836	21.534	1.749	9.497	1.502	9.50
SAMM x M	$\bar{X}$	12	1022.83	21.917	3.833	18.083	2.051	83.234	1.707	16.77
	SD		236.99	11.397	3.633	9.378	0.845	10.996	0.748	11.00
37kg TM	$\bar{X}$	24	1017.04	26.396	3.021	23.375	2.470	87.067	2.178	12.93
	SD		186.84	18.080	2.434	16.836	1.409	9.739	1.325	9.74
43kg TM	$\bar{X}$	24	1225.67	60.708	6.729	53.979	4.785	86.727	4.259	13.27
	SD		194.27	44.681	5.261	42.385	2.787	10.491	2.722	10.49

TM - Target mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 6.6. (CONTINUED)

(n=12)		ULM	TVD	VME	VFD	TVD/ULM	%FD	VFD/ULM	%MED
DORPER x 37kg:	$\bar{X}$	1089.17	37.21	3.917	33.29	3.336	88.03	2.975	11.97
	SD	194.83	19.14	2.670	18.17	1.453	11.14	1.400	11.14
DORPER x 43kg:	$\bar{X}$	1258.90	52.78	6.042	75.54	6.278	92.70	5.832	7.30
	SD	233.90	52.78	6.092	48.81	3.037	5.372	2.880	5.37
SAMM x 37kg:	$\bar{X}$	944.92	15.58	2.125	13.46	1.605	86.11	1.381	13.89
	SD	153.90	7.879	1.872	6.917	0.637	8.496	0.568	8.50
SAMM x 43kg:	$\bar{X}$	1192.42	39.83	7.417	32.42	3.292	80.75	2.687	19.25
	SD	147.63	20.94	4.441	18.95	1.469	11.11	1.341	11.11
H x 37kg:	$\bar{X}$	1030.83	25.95	2.750	23.21	2.443	87.21	2.167	12.79
	SD	156.02	19.17	1.853	18.64	1.545	11.20	1.503	11.20
H x 43kg:	$\bar{X}$	1176.83	52.58	6.208	46.38	4.543	86.16	4.018	13.84
	SD	114.19	26.97	4.629	26.98	2.443	10.48	2.477	10.48
M x 37kg:	$\bar{X}$	1003.25	26.83	3.292	23.54	2.498	86.92	2.189	13.08
	SD	219.63	17.77	2.965	15.66	1.328	8.534	1.188	8.53
M x 43kg:	$\bar{X}$	1274.50	68.83	7.250	61.58	5.027	87.29	4.501	12.71
	SD	230.05	57.47	5.987	53.87	3.186	10.94	3.038	10.94

Table 6.7. ANALYSIS OF VARIANCE OF DRIP LOSS CHARACTERISTICS OF LOIN SAMPLES FROM DORPER AND SA MUTTON MERINO WETHERS ON TWO LEVELS OF ENERGY FEEDING AND SLAUGHTERED AT EITHER 37 OR 43kg LIVE MASS: UNROASTED LOIN MASS (ULM), TOTAL VOLUME DRIP LOSS (TVD), VOLUME MEAT EXTRACT IN DRIP (VME), VOLUME FAT IN DRIP (VFD), TOTAL VOLUME DRIP LOSS EXPRESSED PER 100g OF UNROASTED LOIN SAMPLE (TVD/ULM), PERCENTAGE FAT IN DRIP (%FD), VOLUME FAT IN DRIP PER 100g OF UNROASTED LOIN (VFD/ULM) AND PERCENTAGE MEAT EXTRACT IN DRIP (%MED). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		ULM	TVD	VME	VFD	TVD/ULM	%FD	VFD/ULM	%MED
BR	P<F	0.044	0.001	0.859	0.001	0.001	0.018	0.001	0.018
	F	4.307	14.539	0.033	16.204	20.056	6.016	21.820	6.016
	Signif.	**	***	ns	***	***	**	***	**
TR	P<F	0.501	0.309	0.501	0.337	0.617	0.884	0.627	0.884
	F	0.476	1.062	0.476	0.987	0.263	0.022	0.247	0.022
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns
SM	P<F	0.001	0.001	0.002	0.001	0.001	0.906	0.001	0.906
	F	16.882	17.048	10.445	15.316	19.307	0.014	16.830	0.014
	Signif.	***	***	***	***	***	ns	***	ns
BRxTR	P<F	0.017	0.020	0.025	0.031	0.050	0.779	0.081	0.779
	F	6.227	5.877	5.401	4.996	4.077	0.082	3.189	0.082
	Signif.	**	**	**	**	**	ns	*	ns
BRxSM	P<F	0.483	0.255	0.192	0.156	0.254	0.072	0.137	0.072
	F	0.518	1.330	1.761	2.083	1.336	3.392	2.293	3.392
	Signif.	ns	ns	ns	ns	ns	*	ns	*
TRxSM	P<F	0.248	0.396	0.840	0.378	0.702	0.806	0.667	0.806
	F	1.371	0.766	0.042	0.826	0.152	0.063	0.193	0.063
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 6.8. COVARIANCE ANALYSIS (% FAT INCLUDED AS COVARIANT) OF DRIP LOSS CHARACTERISTICS OF LOIN SAMPLES FROM DORPER AND SA MUTTON MERINO WETHERS ON TWO LEVELS OF ENERGY FEEDING AND SLAUGHTERED AT EITHER 37 OR 43kg LIVE MASS: UNROASTED LOIN MASS (ULM), TOTAL VOLUME DRIP LOSS (TVD), VOLUME MEAT EXTRACT IN DRIP (VME), VOLUME FAT IN DRIP (VFD), TOTAL VOLUME DRIP LOSS EXPRESSED PER 100g OF UNROASTED LOIN SAMPLE (TVD/ULM), PERCENTAGE FAT IN DRIP (%FD), VOLUME FAT IN DRIP PER 100g OF UNROASTED LOIN (VFD/ULM) AND PERCENTAGE MEAT EXTRACT IN DRIP (%MED). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		ULM	TVD	VME	VFD	TVD/ULM	%FD	VFD/ULM	%MED
BR	P<F	0.239	0.129	0.710	0.089	0.040	0.191	0.024	0.191
	F	1.428	2.398	0.144	3.037	4.485	1.765	5.497	1.765
	Signif.	ns	ns	ns	*	**	ns	**	ns
TR	P<F	0.511	0.242	0.511	0.252	0.553	0.896	0.560	0.896
	F	0.455	1.408	0.455	1.348	0.370	0.018	0.356	0.018
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns
SM	P<F	0.004	0.046	0.025	0.079	0.031	0.375	0.065	0.375
	F	9.205	4.222	5.382	3.248	4.990	0.838	3.598	0.838
	Signif.	***	**	**	*	**	ns	*	ns
BRxTR	P<F	0.079	0.109	0.108	0.164	0.243	0.999	0.377	0.999
	F	2.697	2.333	2.346	1.889	1.466	0.001	0.998	0.082
	Signif.	*	ns	ns	ns	ns	ns	ns	ns
BRxSM	P<F	0.673	0.759	0.336	0.557	0.778	0.272	0.503	0.272
	F	0.400	0.278	1.121	0.593	0.253	1.345	0.699	1.345
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns
TRxSM	P<F	0.492	0.507	0.974	0.468	0.812	0.958	0.769	0.958
	F	0.722	0.690	0.026	0.772	0.209	0.043	0.265	0.043
	Signif.	ns	ns	ns	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

7 SENSORY EVALUATION RESULTS

7.1 AROMA-INTENSITY

7.1.1 The influence of treatment on aroma-intensity

As in previous chapters, the discussions of the effects of the experimental factors on the different variables are based on the covariance results, but ANOVA-results are quoted when necessary. Since the two breeds included in this trial are characterised as having different physiological growth patterns (Dorpers tend to reach maturity at an earlier chronological age than SA Mutton Merinos and therefore tend to fatten more quickly) fatness has to be included as a covariate in the ANOVA-procedure. When the effect of fatness is removed, wethers from different breeds and of the same live mass can be compared on the same physiological age. All sensory evaluation results are summarised in Tables 7.1. and 7.2[1].

Treatment *per se* significantly improved the aroma-intensities of loin samples[2] ($P<0.054$, $F=3.087$). A positive correlation was calculated between the energy content of the diet and the aroma-intensity of taste samples ($r_{xy}=0.322$, $P<0.026$), which explains the higher average aroma scores of samples from wethers on the H-treatment (6.624 ± 0.486) in comparison with that of samples from wethers on the M-treatment (6.507 ± 0.536). Furthermore, fat percentage was a poor covariate ($P<0.8677$, $F=0.029$) and the main effects (treatment, breed and slaughter mass) significantly affected the aroma-intensity of lamb ($P<0.0164$, $F=3.774$)(Table 7.4.).

Although the aroma-intensities of taste samples from both Dorpers and SA Mutton Merinos on the H-treatment were higher than those of wethers on the M-treatment, the differences were only statistically significant in the SA Mutton Merino breed ($P<0.026$,

[1]Tables 7.1 to 7.7 are presented at the end of chapter 7.

[2]M.longissimus lumborum samples.

F=5.041). Differences in aroma-intensities between taste samples of Dorpers on the H and M-treatment are definitely not of any practical importance because no taste panel could assess such a small difference.

Finally it is interesting to note that significant differences in the aroma-intensity of taste samples from wethers on respectively the H and M-treatments were found during the first set of each session ($P<0.047$, $F=4.01$), but during the second set of each session ($P<0.50$, $F=0.462$) the differences were not detected. (Loin samples were randomly allocated to different sessions and sets regardless of breed, treatment or slaughter mass). These results suggest that the taste panel's judgement of aroma-intensity tended to be less accurate in the second set of each session, presumably because various volatile substances are released in the air after the first set of evaluations.

7.1.2 The influence of breed on aroma-intensity

Differences in aroma intensity between breeds were negligible ($P<0.667$, $F=0.191$), regardless of treatment or slaughter mass (Table 7.4.). Average aroma intensities obtained for loin samples of Dorpers and SA Mutton Merinos were respectively 6.565 ± 0.522 and 6.566 ± 0.507 (Tables 7.1. and 7.2.). The aroma of taste samples from both breeds was reasonably intense and this improved the flavour ($r_{xy}=0.192$) and overall acceptability ($r_{xy}=0.222$) of the samples.

7.1.3 The influence of slaughter group on aroma-intensity

Slaughter mass only tended to influence the aroma-intensity of lamb ($P<0.080$, $F=3.087$), but its effect was limited significantly to the Dorper breed ($P<0.007$, $F=7.428$). The aroma-intensities of taste samples from Dorpers increased noticeably with slaughter mass, namely from 6.468 ± 0.488 at 37kg to 6.663 ± 0.540 at the 43kg slaughter mass.

Higher aroma-intensities were calculated for M.longissimus lumborum samples from wethers on the H-treatment and slaughtered at 43kg live mass than in the case of wethers on the M-treatment that were slaughtered at 37kg live mass (Table7.2). This seems to suggest that the aroma of M.longissimus lumborum samples can be intensified by rearing wethers on a high energy diet coupled with a heavier slaughter mass.

Finally the relationship between aroma-intensity and the saturated / unsaturated fatty acid ratio needs to be discussed. First of all it is important to note that the correlation between slaughter mass and the saturated / unsaturated fatty acid ratio was statistically almost negligible, and neither carcass fatness or subcutaneous fat thickness were significantly correlated with the aroma-intensities of taste samples.

Secondly, the significant negative correlation between aroma-intensity and the saturated / unsaturated subcutaneous fatty acid ratio (r_{xy}=-0.282, P<0.052) clearly indicates that the increased concentation of unsaturated fatty acids in the subcutaneous adipose tissue was primarily responsible for the higher aroma-intensities of taste samples from wethers on the H-treatment. These results are discussed in more detail in section 7.11.

7.2 INCIPIENT JUICINESS

7.2.1 The influence of treatment on incipient juiciness

Treatment did not significantly affect the incipient juiciness of M.longissimus lumborum samples from either Dorpers or SA Mutton Merinos (P<0.294, F=1.107)(Table 7.4.). However, the high positive correlation between dietary energy content and incipient juiciness (r_{xy}=0.824, P<0.01) shows that the energy content of the diet is an important determinant of incipient juiciness through its effect on the percentage saturated and unsaturated fatty acids in the subcutaneous fat depots.

High concentrations of unsaturated fatty acids in the subcutaneous adipose tissue improved both the aroma-intensity and incipient juiciness of taste samples, which subsequently explaines the high correlation between aroma-intensity and incipient juiciness (r_{xy}=0.546, P<0.01).

7.2.2 The influence of breed on incipient juiciness

Breed significantly affected the incipient juiciness of M.longissimus lumborum samples (P<0.011, F=6.569). The average incipient juiciness of taste samples from Dorpers (7.429 ± 0.715) was higher than that of samples from SA Mutton Merinos (7.320 ± 0.702), but both were truly acceptable.

However, these breed differences tended to be more important for wethers reared on the H-treatment (P<0.051, F=3.872) coupled with the 37kg slaughter mass (P<0.028, F=4.905). Although the average incipient juiciness of samples from Dorpers in the 43kg slaughter group was slightly higher than that of SA Mutton Merinos in the same experimental group, the differences were negligible.

These results are in line with that discussed in section 7.2.1. where it was explained that the concentration of unsaturated subcutaneous fatty acids increase on high energy treatments, and that this increased concentration of unsaturated fatty acids improves the incipient juiciness of loin samples.

Since Dorpers fatten more quickly than SA Mutton Merinos, they deposit more unsaturated fatty acids at an earlier age and hence the incipient juiciness of M.longissimus lumborum samples from Dorpers in the 37kg slaughter group attained higher values than that of samples from SA Mutton Merinos. At the 43kg slaughter mass the breed differences in incipient juiciness were less important because the concentration of unsaturated fatty acids deposited in the subcutaneous fat of SA Mutton Merinos was approximately the same as that of Dorpers.

7.2.3 The influence of slaughter group on incipient juiciness

Slaughter mass per se significantly affected the incipient juiciness of lamb ($P<0.034$, $F=4.525$)(Table 7.4.). Incipient juiciness values obtained for wethers slaughtered at 43kg live mass (7.410 ± 0.726) were higher than those from wethers slaughtered at 37kg live mass (7.338 ± 0.693).

Taste samples from Dorpers in the 43kg slaughter group (7.460 ± 0.693) scored significantly higher values for incipient juiciness than those from wethers in the 37kg slaughter group (7.399 ± 0.741). The differences in incipient juiciness between SA Mutton Merinos in the different slaughter groups were not significant, but the average values obtained were higher for samples from wethers slaughtered at 43kg (7.362 ± 0.760) than at 37kg live mass (7.278 ± 0.641).

Although slaughter mass and incipient juiciness are statistically independent (0.058, $P<0.694$), significant differences were observed between slaughter groups. As explained in section 7.2.1. the incipient juiciness of M.longissimus lumborum samples icreased significantly as the concentration of subcutaneous saturated fatty acids decreased and unsaturated fatty acids increased ($r_{xy}=-0.416$, $P<0.003$). The concentration of unsaturated fatty acids tended to increases with increasing slaughter mass and this significantly improved the incipient juiciness of taste samples.

7.3 SUSTAINED JUICINESS

7.3.1 The influence of treatment on sustained juiciness

Results obtained from the covariance analysis procedure indicates that treatment ($P<0.623$, $F=0.250$) did not influence the sustained juiciness of taste samples (Table 7.4.). Average values obtained for sustained juiciness were, respectively 6.694 ± 0.749 and 6.736 ± 0.754 on the high and moderately high energy treatments (Tables 7.1. and 7.4.). Treatment did not affect the

sustained juiciness as evaluated between different sessions[3] or sets of the sensory evaluation procedure.

Although not significant, the sustained juiciness of taste samples from wethers on the M-treatment were consistently higher than that of wethers on the H-treatment. Furthermore, the sustained juiciness of these samples were not affected by either fatness or the saturated / unsaturated fatty acid ratio.

7.3.2 The influence of breed on sustained juiciness

Breed significantly affected the sustained juiciness ($P<0.047$, $F=3.964$) of lamb as evaluated by the trained taste panel. Taste samples from Dorpers (6.757 ± 0.785) were more juicy than those of SA Mutton Merinos (6.673 ± 0.715), but they were limited more to the H-treatment ($P<0.092$, $F=2.884$) coupled with the first (37kg) slaughter group ($P<0.048$, $F=3.967$). The sustained juiciness of taste samples between breeds was almost negligible in the 43kg slaughter group ($P<0.387$, $F=0.784$). Therefore, it can be concluded that as long as wethers are not yet physiologically mature, breed can be regarded as the only important factor that affects the sustained juciness of taste samples.

7.3.3 The influence of slaughter group on sustained juiciness

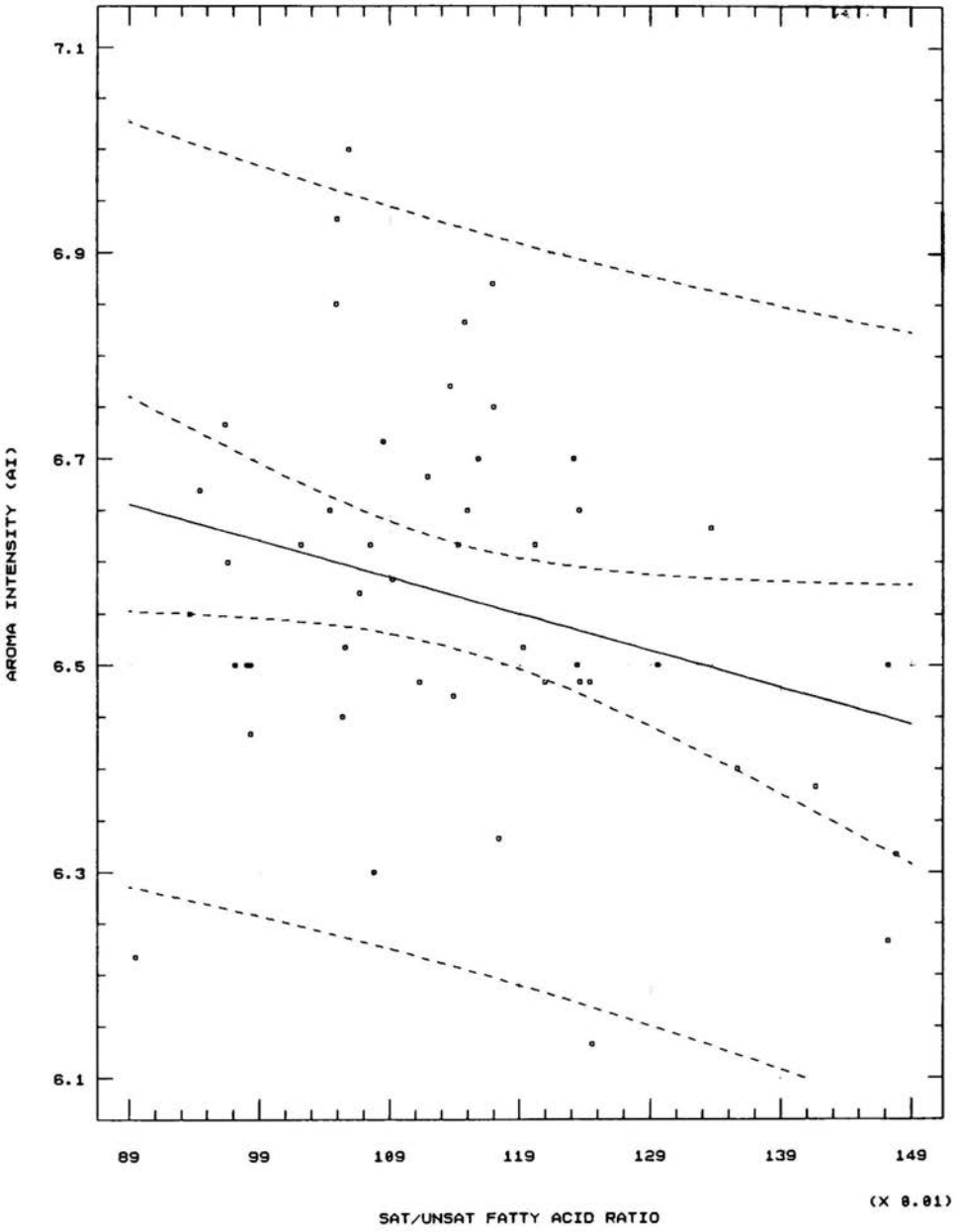
Slaughter mass tended to affect the sustained juiciness of M.longissimus lumborum samples ($P<0.078$, $F=3.133$), but these differences were only important for Dorpers ($P<0.070$, $F=3.339$) coupled with the H-treatment ($P<0.088$, $F=2.951$)(Table 7.4.). It was calculated that 21.12% ($R^2=21.12$) of the variation in sustained juiciness of taste samples from wethers slaughtered at 37kg live mass could be ascribed to carcass fatness ($P<0.020$, $F=6.159$). However, at the 43kg slaughter mass, carcass fatness no longer seemed to affect the sustained juiciness, since the correlation coefficient was reduced to close to zero.

[3]The sensory evaluation procedure consisted of six sessions, which was evaluated in two sets.

Graph 7.3

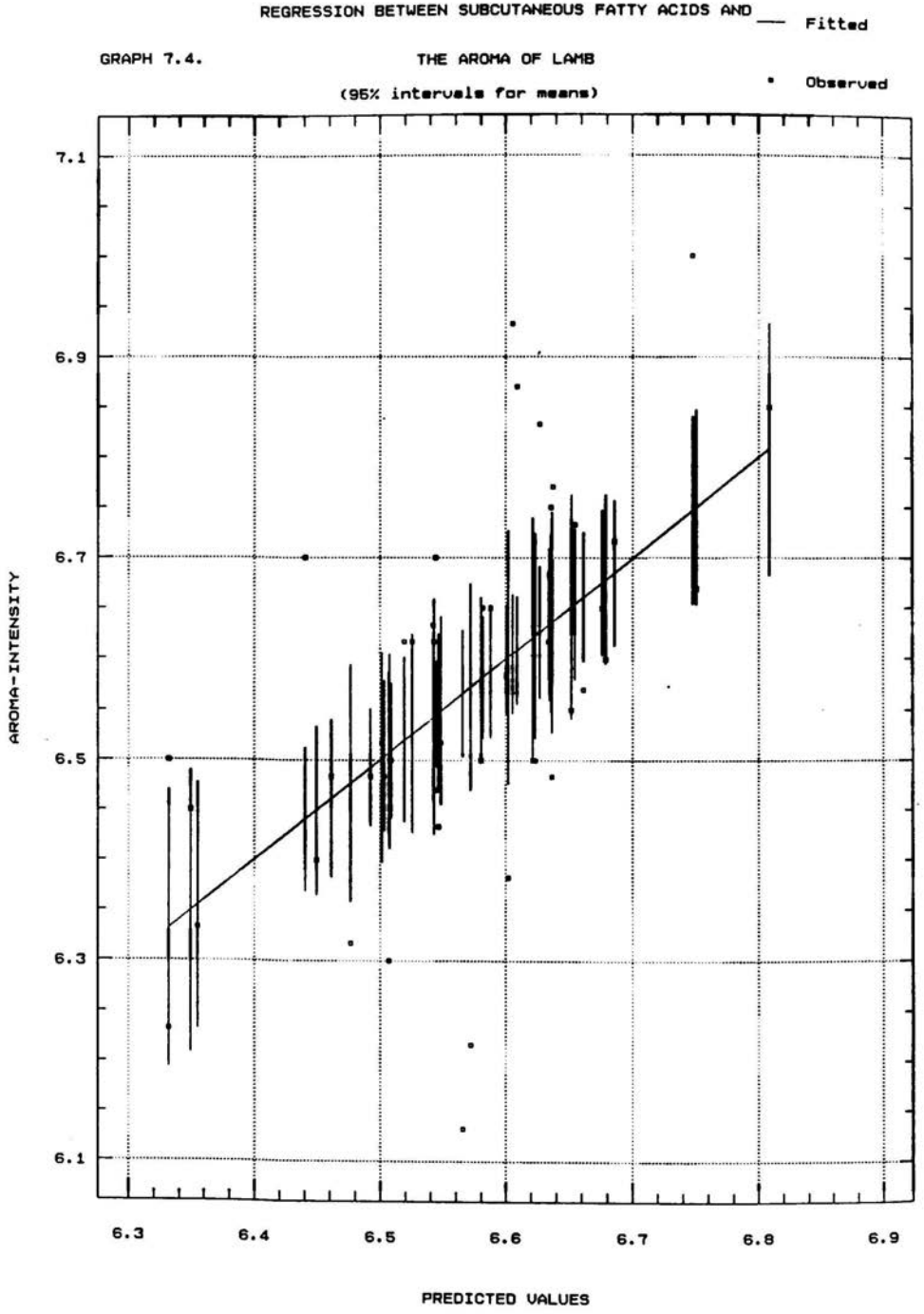
THE EFFECT OF THE PERCENTAGE SATURATED

UNSATURATED FATTY ACIDS ON AI OF LAMB



GRAPH 7.4. REGRESSION BETWEEN SUBCUTANEOUS FATTY ACIDS AND THE AROMA OF LAMB

(95% intervals for means)



INCIPIENT JUICINESS: Important correlations were obtained between the incipient juiciness of taste samples and the concentrations of saturated and unsaturated fatty acids in the subcutaneous fat of wethers. High concentrations of unsaturated fatty acids in the subcutaneous fat of wethers improved the incipient juiciness of M.longissimus lumborum samples significantly (r_{xy}=0.418, P<0.003). Consequently negative correlations were calculated between both the concentration saturated fatty acids (r_{xy}=-0.366, P<0.010), the saturated / unsaturated fatty acid ratio (r_{xy}=-0.415, P<0.003), and the incipient juiciness of taste samples (Graph 7.5.).

High concentrations of C15:0 (r_{xy}=0.542, P<0.001), C17:0 (r_{xy}=0.623, P<0.001), C17:1 (r_{xy}=0.541, P<0.001) and C18:1 (r_{xy}=0.552, P<0.001) enhanced the incipient juiciness of taste samples, while high concentrations of C16:0 (r_{xy}=-0.404, P<0.004), C18:0 (r_{xy}=-0.407, P<0.004), C18:2 (r_{xy}=-0.352, P<0.014) and C18:3 (r_{xy}=-0.336, P<0.020) decreased the incipient juiciness of these samples. An impressive 49.64% of the variability in the incipient juiciness of taste samples were ascribed for by the regression model, consisting of C16:1, C17:0 and C18:3 as independant variables (P<0.001, F=14.458). The regression equation was as follows:

$$Y_{IJ}=a+b_1X_1+b_2X_2+b_3X_3$$

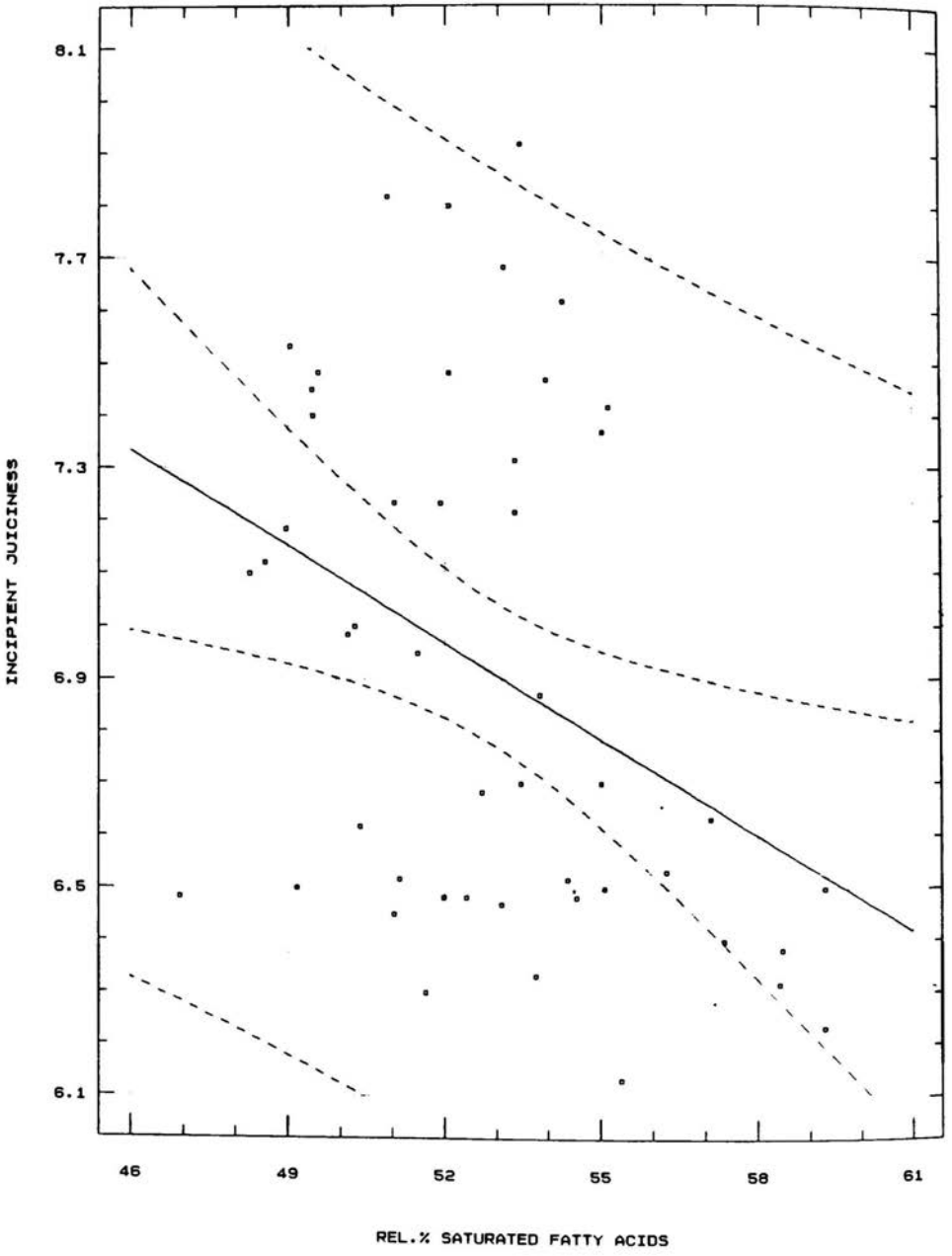
(Graph 7.6.)

Y_U = Incipient juiciness
a = 5.408 (t=12.000, P<0.001)
b_1 = 0.432 (t=2.355, P<0.023)
X_1 = [C16:1]
b_2 = 0.359 (t=5.150, P<0.001)
X_2 = [C17:0]
b_3 = -0.417 (t=-2.730, P<0.009)
X_3 = [C18:3]

Graph 7.5

RELATIONSHIP BETWEEN THE CONCENTRATION

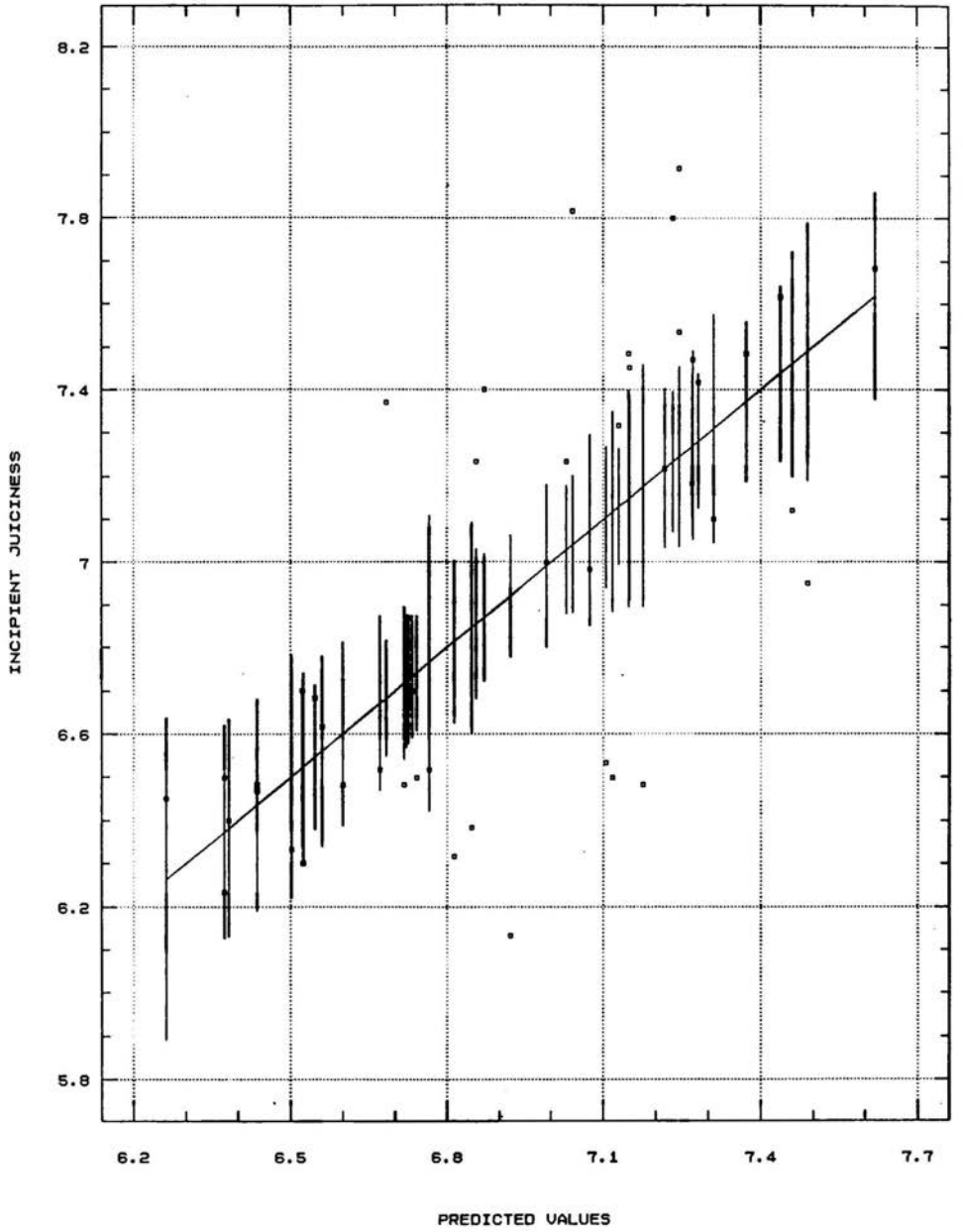
SATURATED F.A. AND INCIPIENT JUICINESS



REGRESSION BETWEEN SUBCUTANEOUS FATTY ACIDS AND ___ Fitted

GRAPH 7.6. THE INCIPIENT JUICINESS OF LAMB • Observed

(95% intervals for means)



SUSTAINED JUICINESS: Correlations obtained between sustained juiciness and either saturated / unsaturated fatty acids or any individual fatty acid were negligible. The amount of variation in sustained juiciness explained by the subcutaneous fatty acid profiles was also almost negligible.

FLAVOUR: The concentration of unsaturated fatty acids in the subcutaneous fat of wethers tended to affect the flavour of M.longissimus lumborum samples (r_{xy}=-0.236, P<0.1). Increasing concentrations of unsaturated fatty acids in the subcutaneous fat reduced the flavour of taste samples. Individual subcutaneous fatty acids responsible for the decreased flavour of taste samples were, in order of importance, C17:1 (r_{xy}=-0.351, P<0.014), C15:0 (r_{xy}=-0.328, P<0.023), C17:0 (r_{xy}=-0.265, P<0.069) and C18:1 (r_{xy}=-0.248, P<0.089). It is important to note that these very fatty acids were responsible for higher aroma-intensities in the M.longissimus lumborum samples of wethers.

Nevertheless, the regression model with C17:1 as its only important independent variable, was responsible for only 12.34% of the variation in the flavour of taste samples (P<0.014, F=6.475). It is evident that most of the variation in the flavour of M.longissimus lumborum samples was due to the fatness of the samples, and not as a result of altered fatty acid profiles.

OVERALL ACCEPTABILITY: The firmness of the subcutaneous adipose tissue significantly affected the overall acceptability of taste samples due to increased concentrations of unsaturated fatty acids in the subcutaneous fat depots (r_{xy}=-0.287, P<0.048). High concentrations of unsaturated fatty acids reduce the firmness or consistency of the subcutaneous fat, and hence the taste samples from wethers on the H-treatment were less acceptable than those of wethers on the M-treatment. Since the concentrations of both

C15:0 (r_{xy}=-0.323, P<0.025) and C17:0 (r_{xy}=-0.330, P<0.022) are associated with the fatness of the M.longissimus lumborum samples, these fatty acids impaired the overall acceptability of taste samples. The fatty acids responsible for the reduced firmness of the subcutaneous fat and consequently to the reduced acceptability of the M.longissimus lumborum samples were C17:1 (r_{xy}=-0.405, P<0.004) and C18:1 (r_{xy}=-0.303, P<0.036). High concentrations of C16:0 in the subcutaneous fat tended to improve the overall acceptability of taste samples (r_{xy}=0.267, P<0.066).

Almost 26% of the variability in the overall acceptability of taste samples was explained by the concentrations of C17:1 and C18:3 in the subcutaneous fat of wethers (P<0.008, F=3.971). Nevertheless, fatness clearly contributes more to the overall acceptability of M.longissimus lumborum samples in comparison with the fatty acids in the subcutaneous fat of wethers.

7.10 THE FIRMNESS OF SUBCUTANEOUS ADIPOSE TISSUE vs. SENSORY PROPERTIES OF M.longissimus lumborum SAMPLES

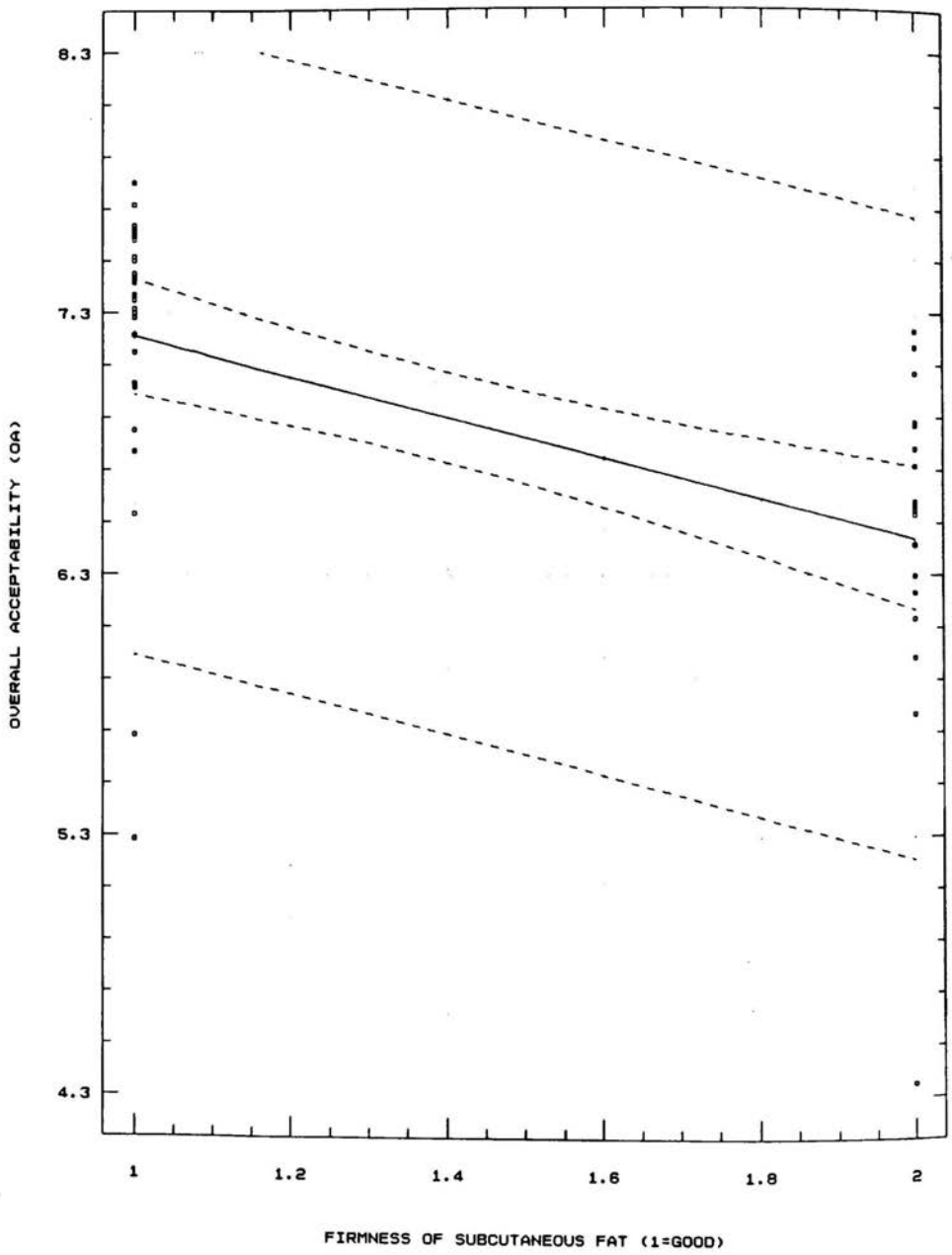
High concentrations of fat in the M.longissimus lumborum samples impaired the flavour (r_{xy}=-0.530, P<0.001) and overall acceptability (r_{xy}=-0.642, P<0.001) of taste samples. Since 95% of the M.longissimus lumborum samples that contained soft subcutaneous fat, also contained abundant amounts of fat, it can be deduced that the firmness of the fat affected the overall acceptability of taste samples (Graph 7.7.). High concentrations of unsaturated fatty acids in the subcutaneous adipose tissue were associated with reduced overall acceptabilities of taste samples. Increased concentrations of saturated fatty acids improved both the firmness and overall acceptability of the taste samples (section 7.7.).

Although high concentrations of saturated fatty acids in the subcutaneous fat depots seems preferential, unsaturated fatty acids improves both the aroma and incipient juiciness of taste

Graph 7.7

REGRESSION BETWEEN THE FIRMNESS OF SUB-

CUTANEOUS FAT AND OA OF TASTE SAMPLES



samples. Subsequently feeding systems that improve the aroma and juiciness of lamb, without impairing the firmness of the subcutaneous fat, should be the ultimate goal. However, since the physiological maturity of the animal contributes greatly to the amount and type of fat deposited, it provides an important mechanism by which the acceptability of the product can be manipulated without changing the composition of the diet. Since the deposition of unsaturated fatty acids increases with physiological age, high energy diets can be fed prior to physiological maturity without impairing the firmness of the fat, coupled with improvements in both the aroma and juiciness of the meat.

Table 7.1 SENSORY EVALUATION RESULTS: AROMA INTENSITY (AI), INCIPIENT JUICINESS (LJ), SUSTAINED JUICINESS (SJ), FLAVOUR (F) AND OVERALL ACCEPTABILITY (OA).

BREED	TREATMENT	TM		n	AI	LJ	SJ	F	OA
SAMM	H	37	$\bar{X}$	36	6.661	7.242	6.614	7.531	7.414
			SD		0.518	0.582	0.604	0.540	0.636
		43	$\bar{X}$	36	6.664	7.283	6.653	7.467	7.236
			SD		0.508	0.837	0.887	0.745	0.755
	M	37	$\bar{X}$	36	6.483	7.314	6.658	7.314	7.108
			SD		0.446	0.701	0.670	0.926	0.961
		43	$\bar{X}$	36	6.456	7.442	6.767	7.500	7.400
			SD		0.534	0.678	0.691	0.638	0.692
DORPER	H	37	$\bar{X}$	36	6.438	7.367	6.675	7.106	6.636
			SD		0.444	0.853	0.810	0.833	1.027
		43	$\bar{X}$	36	6.689	7.439	6.836	7.039	6.589
			SD		0.460	0.687	0.676	0.606	0.849
	M	37	$\bar{X}$	36	6.453	7.431	6.781	7.083	6.661
			SD		0.534	0.621	0.653	0.728	0.663
		43	$\bar{X}$	36	6.636	7.481	6.739	7.022	6.328
			SD		0.616	0.707	0.981	0.920	1.304

TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
H - HIGH ENERGY FEEDING LEVEL
M - MODERATELY HIGH ENERGY FEEDING LEVEL

Table 7.2. SUMMARY STATISTICS OF SENSORY EVALUATION RESULTS: AROMA INTENSITY (AI), INCIPIENT JUICINESS (IJ), SUSTAINED JUICINESS (SJ), FLAVOUR (F) AND OVERALL ACCEPTABILITY (OA).

		n	AI	IJ	SJ	F	OA
DORPER	$\bar{X}$	144	6.565	7.429	6.758	7.063	6.553
	SD		0.522	0.715	0.785	0.773	0.988
SAMM	$\bar{X}$	144	6.566	7.320	6.673	7.453	7.289
	SD		0.507	0.702	0.715	0.724	0.773
H-FEEDING	$\bar{X}$	144	6.624	7.333	6.694	7.285	6.969
	SD		0.486	0.744	0.749	0.717	0.897
M-FEEDING	$\bar{X}$	144	6.507	7.417	6.736	7.230	6.874
	SD		0.536	0.674	0.754	0.826	1.019
DORPER x H	$\bar{X}$	72	6.586	7.403	6.756	7.072	6.613
	SD		0.461	0.770	0.745	0.724	0.936
DORPER x M	$\bar{X}$	72	6.544	7.456	6.760	7.053	6.494
	SD		0.580	0.661	0.828	0.824	1.041
SAMM x H	$\bar{X}$	72	6.663	7.262	6.633	7.499	7.325
	SD		0.510	0.716	0.754	0.647	0.698
SAMM x M	$\bar{X}$	72	6.469	7.378	6.713	7.407	7.254
	SD		0.489	0.688	0.678	0.795	0.845
37kg TM	$\bar{X}$	144	6.520	7.338	6.682	7.258	6.955
	SD		0.489	0.693	0.684	0.783	0.893
43kg TM	$\bar{X}$	144	6.611	7.411	6.749	7.257	6.888
	SD		0.535	0.726	0.813	0.765	1.023

TM - Target mass, H - High energy feeding, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 7.2. (CONTINUED)

(n=72)		AI	LJ	SJ	F	QA
DORPER x 37kg:	$\bar{X}$	6.468	7.399	6.728	7.094	6.649
	SD	0.488	0.741	0.733	0.776	0.859
DORPER x 43kg:	$\bar{X}$	6.663	7.460	6.788	7.031	6.458
	SD	0.540	0.693	0.838	0.774	1.100
SAMM x 37kg:	$\bar{X}$	6.572	7.278	6.636	7.422	7.261
	SD	0.489	0.641	0.634	0.760	0.824
SAMM x 43kg:	$\bar{X}$	6.560	7.362	6.710	7.483	7.318
	SD	0.528	0.760	0.791	0.689	0.724
H x 37kg:	$\bar{X}$	6.572	7.304	6.644	7.318	7.025
	SD	0.488	0.728	0.710	0.729	0.934
H x 43kg:	$\bar{X}$	6.676	7.361	6.744	7.253	6.913
	SD	0.481	0.764	0.788	0.708	0.861
M x 37kg:	$\bar{X}$	6.468	7.372	6.719	7.199	6.885
	SD	0.489	0.660	0.660	0.835	0.851
M x 43kg:	$\bar{X}$	6.546	7.461	6.753	7.261	6.864
	SD	0.580	0.688	0.842	0.822	1.169

Table 7.3. ANALYSIS OF VARIANCE OF SENSORY EVALUATION RESULTS: AROMA-INTENSITY (AI), INCIPIENT JUICINESS (IJ), SUSTAINED JUICINESS (SJ), FLAVOUR (F) AND OVERALL ACCEPTABILITY (OA). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		AI	IJ	SJ	F	OA
BR	P<F	0.991	0.193	0.343	0.001	0.001
	F	0.001	1.700	0.900	19.290	49.590
	Signif.	ns	ns	ns	***	***
TR	P<F	0.052	0.315	0.641	0.532	0.367
	F	3.810	1.010	0.220	0.390	0.820
	Signif.	*	ns	ns	ns	ns
SM	P<F	0.132	0.391	0.455	0.988	0.524
	F	2.290	0.740	0.560	0.001	0.410
	Signif.	ns	ns	ns	ns	ns
BRxTR	P<F	0.210	0.712	0.677	0.688	0.825
	F	1.576	0.141	0.179	0.167	0.050
	Signif.	ns	ns	ns	ns	ns
BRxSM	P<F	0.087	0.891	0.939	0.488	0.239
	F	2.944	0.019	0.006	0.499	1.395
	Signif.	*	ns	ns	ns	ns
TRxSM	P<F	0.829	0.850	0.712	0.493	0.691
	F	0.048	0.037	0.141	0.489	0.163
	Signif.	ns	ns	ns	ns	ns

MULTIFACTOR ANALYSIS OF VARIANCE
Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 7.4. COVARIANCE ANALYSIS (%FAT INCLUDED AS COVARIATE) OF SENSORY EVALUATION RESULTS: AROMA INTENSITY (AI), INCIPIENT JUICINESS (IJ), SUSTAINED JUICINESS (SJ), FLAVOUR (F), OVERALL ACCEPTABILITY (OA). (BR=BREED, TR=TREATMENT AND SM=SLAUGHTER MASS)

		AI	IJ	SJ	F	OA
BR	P<F	0.667	0.011	0.047	0.083	0.083
	F	0.191	6.569	3.964	3.025	3.025
	Signif.	ns	**	**	*	*
TR	P<F	0.054	0.294	0.623	0.557	0.557
	F	3.756	1.107	0.250	0.357	0.357
	Signif.	*	ns	ns	ns	ns
SM	P<F	0.080	0.034	0.078	0.036	0.036
	F	3.087	4.525	3.133	4.423	4.423
	Signif.	*	**	*	**	**
BRxTR	P<F	0.443	0.996	0.982	0.619	0.819
	F	0.816	0.004	0.018	0.480	0.200
	Signif.	ns	ns	ns	ns	ns
BRxSM	P<F	0.178	0.968	0.970	0.994	0.945
	F	1.736	0.033	0.030	0.006	0.057
	Signif.	ns	ns	ns	ns	ns
TRxSM	P<F	0.973	0.987	0.922	0.819	0.959
	F	0.027	0.013	0.082	0.199	0.042
	Signif.	ns	ns	ns	ns	ns

Signif. - Significance level
ns - not significant
* - P<0.1
** - P<0.05
*** - P<0.01

Table 7.4. (CONTINUED)

		AI	IJ	SJ	F	OA
BR x H:	P<F	0.517	0.051	0.092	0.024	0.001
	F	0.437	3.872	2.884	5.178	10.718
BR x M:	P<F	0.200	0.175	0.374	0.776	0.159
	F	1.662	1.861	0.829	0.084	2.006
BR x 37kg:	P<F	0.501	0.028	0.048	0.231	0.025
	F	0.471	4.905	3.967	1.449	5.130
BR x 43kg:	P<F	0.201	0.174	0.387	0.213	0.023
	F	1.649	1.872	0.784	1.569	5.325
TR x DORPER:	P<F	0.794	0.347	0.666	0.565	0.820
	F	0.071	0.929	0.193	0.344	0.053
TR x SAMM:	P<F	0.026	0.268	0.430	0.490	0.653
	F	5.041	1.235	0.650	0.495	0.209
TR x 37kg:	P<F	0.216	0.490	0.449	0.403	0.375
	F	1.546	0.496	0.599	0.732	0.825
TR x 43kg:	P<F	0.142	0.426	0.958	0.969	0.717
	F	2.177	0.662	0.003	0.002	0.141
SM x DORPER:	P<F	0.007	0.026	0.070	0.034	0.012
	F	7.428	5.048	3.339	4.598	6.490
SM x SAMM:	P<F	0.909	0.803	0.891	0.729	0.856
	F	0.013	0.064	0.019	0.124	0.034
SM x H:	P<F	0.155	0.120	0.088	0.230	0.065
	F	2.041	2.450	2.951	1.451	3.449
SM x M:	P<F	0.210	0.183	0.481	0.072	0.069
	F	1.589	1.793	0.518	3.292	3.361

Table 7.5. OBSERVED FREQUENCIES OF CERTAIN LOIN SAMPLE CHARACTERISTICS AFTER ROASTING (PRIOR TO SENSORY EVALUATION): ODOUR (typical or strange), FIRMNESS OF SUBCUTANEOUS FAT (firm or soft) AND THE AMOUNT OF VISIBLE FAT RELATIVE TO THE AMOUNT OF MUSCLE (normal or abundant). (FREQUENCIES DETERMINED BY LOG-LINEAR ANALYSIS; EXPECTED FREQUENCIES INDICATED IN BRACKETS)

BREED	TREATMENT	TM	ODOUR		FIRMNESS OF SUBCUTANEOUS FAT		AMOUNT OF VISIBLE FAT	
			TYPICAL	STRANGE	FIRM	SOFT	NORMAL	ABUNDANT
SAMM	M	37	12.50% (6.25%)	00.00% (6.25%)	12.50% (6.25%)	00.00% (6.25%)	12.50% (6.25%)	00.00% (6.25%)
		43	12.50% (6.25%)	00.00% (6.25%)	10.42% (6.25%)	2.08% (6.25%)	10.42% (6.25%)	2.08% (6.25%)
	H	37	8.33% (6.25%)	4.17% (6.25%)	12.50% (6.25%)	00.00% (6.25%)	12.50% (6.25%)	00.00% (6.25%)
		43	10.42% (6.25%)	2.08% (6.25%)	12.50% (6.25%)	00.00% (6.25%)	10.42% (6.25%)	2.08% (6.25%)
DORPER	M	37	12.50% (6.25%)	00.00% (6.25%)	6.25% (6.25%)	6.25% (6.25%)	4.17% (6.25%)	8.33% (6.25%)
		43	12.50% (6.25%)	00.00% (6.25%)	2.08% (6.25%)	10.42% (6.25%)	00.00% (6.25%)	12.50% (6.25%)
	H	37	10.42% (6.25%)	2.08% (6.25%)	2.08% (6.25%)	10.42% (6.25%)	00.00% (6.25%)	12.50% (6.25%)
		43	12.50% (6.25%)	00.00% (6.25%)	2.08% (6.25%)	10.42% (6.25%)	00.00% (6.25%)	12.50% (6.25%)

TM - TARGET MASS
SAMM - SOUTH AFRICAN MUTTON MERINO
M - MODERATELY HIGH ENERGY FEEDING LEVEL
H - HIGH ENERGY FEEDING LEVEL

Table 7.6. CROSSTABULATION OF CERTAIN LOIN SAMPLE CHARACTERISTICS AFTER ROASTING (PRIOR TO SENSORY EVALUATION): ODOUR (typical or strange), FIRMNESS OF SUBCUTANEOUS FAT (firm or soft) AND THE AMOUNT OF VISIBLE FAT RELATIVE TO THE AMOUNT OF MUSCLE (normal or abundant).

	ODOUR		FIRMNESS OF SUBCUTANEOUS FAT		AMOUNT OF VISIBLE FAT	
	TYPICAL	STRANGE	FIRM	SOFT	NORMAL	ABUNDANT
Dorper	95.80%	4.20%	25.00%	75.00%	8.30%	91.70%
SAMM	87.50%	12.50%	95.80%	4.20%	91.70%	8.30%
M-treatment	100.00%	0.00%	62.50%	37.50%	54.20%	45.80%
H-treatment	83.30%	16.70%	58.30%	41.70%	45.80%	54.20%
37kg-Slaughter Mass	87.50%	12.50%	66.70%	33.30%	58.30%	41.70%
43kg-slaughter Mass	95.80%	4.20%	54.20%	45.80%	41.70%	58.30%
Dorper X M-treatment	100.00%	0.00%	33.30%	66.70%	16.70%	83.30%
Dorper x H-treatment	91.70%	8.30%	16.70%	83.30%	0.00%	100.00%
SAMM x M-treatment	100.00%	0.00%	91.70%	8.30%	91.70%	8.30%
SAMM x H-treatment	75.00%	25.00%	100.00%	0.00%	91.70%	8.30%
Dorper x 37kg	91.70%	8.30%	33.30%	66.70%	16.70%	83.30%
Dorper x 43kg	100.00%	0.00%	16.70%	83.30%	0.00%	100.00%
SAMM x 37kg	83.30%	16.70%	100.00%	0.00%	100.00%	0.00%
SAMM x 43kg	91.70%	8.30%	91.70%	8.30%	83.30%	16.70%
M-treatment x 37kg	100.00%	0.00%	75.00%	25.00%	66.70%	33.30%
M-treatment x 43kg	75.00%	25.00%	58.30%	41.70%	50.00%	50.00%
H-treatment x 37kg	100.00%	0.00%	50.00%	50.00%	41.70%	58.30%
H-treatment x 43kg	91.70%	8.30%	58.30%	41.70%	41.70%	58.30%

H - HIGH ENERGY FEEDING, M - Moderately high energy feeding, SAMM - SA Mutton Merino

Table 7.7. EVALUATION OF THE RELATIONSHIPS BETWEEN BREED, TREAMENT, MASS AND CERTAIN LOIN SAMPLE CHARACTERISTICS AFTER ROASTING (PRIOR TO SENSORY TESTING): ODOUR, FIRMNESS OF SUBCUTANEOUS ADIPOSE TISSUE (FSAT) AND THE AMOUNT OF VISIBLE FAT RELATIVE TO THE AMOUNT OF MUSCLE (AVF).

CHI-SQUARE TESTS		ODOUR	FSAT	AVF
BREED:	Chi-square	1.091	25.176	33.333
	P<F	0.296	0.001	0.001
	Signif.	ns	***	***
TREATMENT:	Chi-square	4.364	0.087	0.333
	P<F	0.037	0.768	0.564
	Signif.	**	ns	ns
MASS:	Chi-square	1.091	0.784	1.333
	P<F	0.296	0.376	0.248
	Signif.	ns	ns	ns
BREED x TREATMENT:	Chi-square	1.091	25.176	33.333
	P<F	0.296	0.001	0.001
	Signif.	ns	***	***
BREED x MASS:	Chi-square	1.091	25.176	33.333
	P<F	0.296	0.001	0.001
	Signif.	ns	***	***
BREED x TREATMENT x MASS:	Chi-square	1.091	25.176	33.333
	P<F	0.297	0.001	0.001
	Signif.	ns	***	***

Signif.- Significance level; * - P<0.1; ** - P<0.05; *** - P<0.01;

Table 7.7. (CONTINUED)

		ODOUR	FSAT	AVF
BR x H:	P<F	0.001	0.008	0.001
	F	1000.000	8.824	24.842
BR x M:	P<F	0.603	0.001	0.001
	F	0.289	24.451	68.524
BR x 37kg:	P<F	0.688	0.001	0.001
	F	0.171	17.047	48.155
BR x 43kg:	P<F	0.613	0.003	0.001
	F	0.273	12.099	27.781
TR x DORPER:	P<F	0.343	0.466	0.168
	F	0.987	0.574	2.057
TR x SAMM:	P<F	0.105	0.407	0.634
	F	2.894	0.747	0.242
TR x 37kg:	P<F	0.083	0.261	0.112
	F	3.344	1.342	2.778
TR x 43kg:	P<F	0.354	0.567	0.990
	F	0.942	0.350	0.001
SM x DORPER:	P<F	0.469	0.811	0.477
	F	0.567	0.061	0.545
SM x SAMM:	P<F	0.753	0.541	0.852
	F	0.105	0.400	0.037
SM x 37kg:	P<F	0.001	0.419	0.501
	F	1000.000	0.711	0.488
SM x 43kg:	P<F	0.507	0.710	0.450
	F	0.473	0.147	0.618

8 DISCUSSION

8.1 GROWTH AND CARCASS RESULTS

Earlier maturing sheep breeds reach maturity at an earlier chronological age and consequently fattening begins to accelerate at an earlier age (Forrest *et al.*, 1975). It is therefore not surprising that breed significantly affected both the number of days fed and the subcutaneous fat thicknesses as measured over the 10th and 13th ribs. The later maturing breed spent on average less time in the trial than the earlier maturing breed. However, these differences were limited to the 37 and 43kg target mass groups and can be attributed to the fact that the earlier maturing breed gained weight much slower during the last two phases in comparison with the later maturing breed. Breed differences in subcutaneous fat thicknesses were negligible at 25kg live mass, but became significant at 37 and 43kg live mass, after which the differences tended to diminish.

Breed effects in the dressing percentage and the percentage muscle and bone in three rib-cut samples tended to remain important even after the inclusion of fat percentage as covariate, but again the differences were more obvious in the 37 and 43kg target mass groups. Carcasses from the early maturing breed tended to dress better than those of the later maturing breed, while the percentage muscle in three rib-cut samples from SA Mutton Merinos was greater than that of Dorpers.

Treatment significantly affected the slaughter mass of wethers, the time they spent on feed and their average daily gains. Wethers on the H-treatment achieved a slightly higher average slaughter mass, but their average daily gains were markedly higher than that of wethers on the M-treatment, and consequently they reached their target mass in a significantly shorter time. Hammond (1953), Elsley, McDonald and Fowler (1964) and Wood (1984) are some of the researchers who demonstrated the profound effects of nutrition on both growth traits and the

development of different tissues and organs. Furthermore, the treatment differences observed in the present study emphasized certain breed differences like the time spent on feed, dressing percentage and differences in the subcutaneous fat thicknesses. Such differences were also reported by other researchers (McDonald *et al.*, 1981; Cazes *et al.*, 1990).

Growth and carcass differences between different slaughter mass groups were unavoidable. It was to be expected that the slaughter mass, time on feed, average daily gain, cold carcass mass, dressing percentage, three rib-cut sample mass and subcutaneous fat thicknesses would increase as the target mass increased. Furthermore, the ANOVA-results show that slaughter mass significantly affects the percentage bone, muscle and fat in three rib-cut samples from wethers. While the percentage of muscle increased with increasing slaughter mass, both the percentage of muscle and bone decreased. These results are summarised in Tables 4.1 and 4.2.

8.2 CARCASS COMPACTNESS MEASUREMENTS

Although it is generally accepted that sheep do not show such a wide variation in conformation types (Kempster *et al.*, 1982), some interesting information was obtained from the covariance analysis of carcass compactness measurements.

The hindleg lengths of the early maturing breed was greater than that of the later maturing breed, however, both the carcass lengths and carcass widths of the latter were greater than that of the earlier maturing breed. It is interesting to note that breed *per se* did not influence the hindleg compactness of wethers, but that its effect tended to be important as far as carcass compactness is concerned. Carcass compactness values obtained for Dorpers were generally greater than that obtained for SA Mutton Merinos. The differences in carcass compactness between Dorpers and SA Mutton Merinos on the H-treatment were

negligible, but on the M-treatment Dorpers produced carcasses with a better conformation than those of SA Mutton Merinos.

The effect of treatment on hindleg lenghts and carcass lenths was limited, but the carcass widths, hindleg compactness and carcass compactness of wethers on the H-treatment were significantly greater than those of wethers on the M-treatment. Carcass mass significantly affected the carcass compactness measurements as expected.

Although there is still uncertainty about the emphasis that should be given to conformation in sheep (Kempster *et al.*, 1982), these results show that there is no real advantage in selecting breeds with a better conformation, because nutritional factors coupled with slaughter mass, are evidently the most important factors that affect the conformation of sheep carcasses.

8.3 DIET FATTY ACID PROFILES

Linoleic acid (C18:2) was the most abundant fatty acid in the H-diet while oleic acid (C18:1) was the major fatty acid present in the M-diet. Palmitic acid (C16:0), stearic acid (C18:0) and oleic acid (C18:1) concentrations were also greater in the M-diet than in the H-diet. Differences in the concentrations of myristic (C14:0), linolenic (C18:3), arachidic (C20:0), gondoic (C20:1) and lignoceric acid (C24:0) between the two diets were unimportant. Diet fatty acid profiles of maize meal, cotton seed cake and Smuts finger hay were also determined. However, from the results obtained it is evident that the major difference between the two diets was its energy content.

8.4 SUBCUTANEOUS FATTY ACID PROFILES

In contrast with the views held by Shorland *et al.* (1955) and McDonald *et al.* (1981), the results obtained in this study demonstrate that treatment significantly affect the subcutaneous fatty acid profiles of wethers. These results are in accordance with those obtained by Tove and Matrone (1976), Rumsey *et al.* (1972), Garton *et al.* (1972), DeB Hovell *et al.* (1976), Orskov *et al.* (1979), Orskov *et al.* (1974), Mayes and Orskov (1974), L'Estrange and Mulvihill (1975), Kemp *et al.* (1981), Miller *et al.* (1980), Casey and Van Niekerk (1985), Casey *et al.* (1988) and Cazes *et al.* (1990).

In this trial the high energy treatment significantly increased the deposition of C15:0, C17:0, C17:1 and C18:1 fatty acids in the subcutaneous adipose tissue of wethers. Similar increases in the concentrations of C18:1 were observed by other researchers (Casey and Van Niekerk, 1985; Casey *et al.*, 1988; L'Estrange and Spillane, 1976 and Cazes *et al.*, 1990), but the differences in the concentrations of C15:0, C17:0 and C17:1 were not as significant.

Garton *et al.* (1972) reported that the concentrations of unusual fatty acids (odd-numbered and branched chain fatty acids) increased subsequent to high energy feeding. L'Estrange and Spillane (1976) observed a decrease in the concentration of C18:0 in the subcutaneous adipose tissue of sheep on the high energy treatment, but added that the concentration of C18:1 increased rather than the branched-chain and odd-numbered acids. Miller *et al.* (1980) are also of the opinion that the higher levels of branched-chain and odd-numbered acids do not explain the large decrease in C18:0 that occurs as the subcutaneous fat becomes softer. The results obtained in the present study support these findings, since concentrations of unusual fatty acids in the subcutaneous adipose tissue of wethers on the H and M-treatments did not differ significantly. According to Miller *et al.* (1980) considerable amounts of C18:0 are desaturated to oleate (C18:1)

which explains the decrease in C18:0 in the soft fat of lambs fed corn diets.

Nevertheless, greater concentrations of C16:0, C18:0, C18:2 and C18:3 fatty acids were deposited in the subcutaneous fat of wethers on the M-treatment, while the concentrations of C14:0 and C16:1 remained unaltered. Although Miller *et al.* (1980) found that fat with a better consistency contains higher concentrations of C18:0, the differences between treatments were not as significant. Most important of all is the fact that the H-treatment significantly increased the concentrations of unsaturated fatty acids in the subcutaneous fat depots. Both L'Estrange and Mulvihill (1975) and Shelton *et al.*(1972) also found that the major factor associated with the soft fat carcasses of high energy fed lambs is an increase in the ammount of unsaturated fatty acids in the subcutaneous and perirenal adipose tissues.

Although breed differences were limited to C16:0 coupled with less important differences in the concentrations of C17:0 and C17:1, this study is propably the first to indicate such differences. Furthermore, the results indicate that the subcutaneous adipose tissue of Dorpers tended to contain slightly higher concentrations of unsaturated fatty acids in comparison with that of the later maturing breed.

Differences in fatty acid profiles of wethers in different slaughter groups were less important. However, Crouse *et al.* (1982) reported greater quantities of C17:0, C18:1 and C18:2 with increasing fatness of lambs. Similar results were obtained in the present study, but the increasing concentrations of C17:0 and C18:1 were not of stastistical significance, while that of C18:2 only tended to be significant. Results obtained by Kemp *et al.* (1981) also suggest that the concentration of C18:1 increased with slaughter mass, while that of both C16:1 and C18:2 decreased. It is interesting to note that increases in the

concentration of C18:1 in the plasma of wethers on the H-treatment were found in the present study, which might be linked to the above-mentioned results. Nevertheless, Kemp *et al.* (1981) are of the opinion that the amount of change had little practical significance.

8.5 PLASMA FATTY ACID PROFILES

Information regarding the effect of energy treatment on plasma fatty acid profiles is sparse. Results obtained in this study show that nutritional effects on the plasma fatty acid profiles seems to be limited, but some important tendencies were observed. Plasma C18:0 and C18:2 concentrations of wethers on the M-treatment were greater than that of wethers on the H-treatment. Similar differences were observed for C18:0 and C18:2 in the subcutaneous adipose tissue of wethers in this trial (these results are discussed elsewhere in this chapter). Concentrations of C18:1 in the plasma of wethers on the H-treatment were greater than that of wethers on the M-treatment, and these differences tended to be of statistical significance. Greater concentrations of C18:1 were also detected in the subcutaneous adipose tissue of wethers on the H-treatment, in comparison with that of wethers on the M-treatment (these results are discussed elsewhere in this chapter). However, since the effect of energy treatment on the plasma fatty acid profiles is not highly significant, it is perilous to relate the observed tendencies to the remarkable shift in the subcutaneous fatty acid profiles of wethers on high corn diets.

Another interesting finding was that treatment tended to influence the concentration of C18:1 in the plasma of wethers in the 43kg slaughter group. In this slaughter group the concentration of C18:1 in the plasma of wethers on the H-treatment tended to be significantly higher than that of wethers on the M-treatment. This shift in plasma C18:1 might contribute to the highly significant shift towards C18:1 in the subcutaneous adipose tissue. Further research is needed to fully

elucidate these findings.

8.6 CIS-TRANS SUBCUTANEOUS FATTY ACIDS

Elaidic acid (*trans*-9-octadecenoic acid) was the only *trans*-fatty acid detected in the subcutaneous adipose tissue of wethers. Treatment significantly influenced the concentration of C18:1(*trans*) in the subcutaneous adipose tissue: higher concentrations of C18:1(*trans*) were detected in the subcutaneous fat of wethers on the H-treatment in comparison with that of wethers on the M-treatment. On the other hand significant breed differences were found in the concentration of C18:1(*cis*) which presumably contribute to the higher concentrations of unsaturated fatty acids in the subcutaneous adipose tissue of Dorpers. These results are in accordance with those observed by Miller *et al.* (1980), but according to these authors the differences between the two feeding groups were not significant. Nevertheless, they also found lower levels of C18:1(*trans*) in the fat from silage fed lambs than in corn fed lambs. Miller *et al.* (1980) concluded that C18:1(*trans*) was not involved in fat hardness, in spite of the fact that the *trans*-configuration is chemically more stable than the *cis*-configuration. Finally, the present study is probably the first to report the significant effect of treatment on the *cis-trans* subcutaneous fatty acid ratio. As the energy content of the diet increased, the *cis-trans* ratio became significantly smaller.

8.7 THE EFFECT OF HIGH ENERGY TREATMENT ON THE FAT DEPOTS OF WETHERS

Diet does not change the body fat composition in ruminants as much as in monogastric animals, but various authors (Cramer *et al.*, 1967; Ziegler *et al.*, 1967; Miller *et al.*, 1967; Orskov *et al.*, 1974; Mayes and Orskov, 1974; Orskov *et al.*, 1979; Kemp *et al.*, 1981; Casey and Van Niekerk, 1985; Casey *et al.*, 1988 and Cazes *et al.*, 1990) reported diet-induced changes in fat composition. Manipulation of rumen fermentation has, however,

been quite clear in dairy cows, because the non-glucogenic energy ratio of the volatile fatty acids has been shown to influence the partitioning of energy between milkfat production and body-energy gain (McClymont and Vallace, 1962; Van Soest, 1963, Orskov, Flatt, Moe, Munson, Henken and Katz, 1968, as quoted by Orskov *et al.*, 1974).

Nevertheless, it is accepted that the adipose tissue is the major site of fatty acid synthesis in ruminants (Ingle *et al.*, 1972), but some fatty acids are synthesised in the liver. The fat quality (fatty acid profiles) of wethers is affected by a combination of various factors like the feeding regime (Hammond, 1932; Elsley *et al.*, 1964; Wood, 1984; Scherf *et al.*, 1990; Miller *et al.*, 1967; Miller *et al.*, 1980; L'Estrange and Spillane, 1976; Molenat and Theriez, 1973; Duncan *et al.*, 1974; Garton *et al.*, 1972 and Casey and Van Niekerk, 1985), the mode of presentation of the cereals (Orskov *et al.*, 1974 and Cazes *et al.*, 1990), the kind and nature of the cereals (Miller *et al.*, 1980 and Cazes *et al.*, 1990), the kind and presentation of roughage (Casey *et al.*, 1988 and Cazes *et al.*, 1990), the age and sex of the wethers (Callow, 1958; Sink *et al.*, 1964; Kemp *et al.*, 1981; TichenorHx1969; Tichenor *et al.*, 1970 and Cramer *et al.*, 1964) and seasonal and ambient temperature effects (Cramer and Marchello, 1964 and Marchello *et al.*, 1967).

In the present study it was established that the ruminal-pH of wethers on the high energy treatment tended to be lower than that of wethers on the moderately high energy treatment. Mackie *et al.* (1978) and Mackie and Gilchrist (1979) also reported that the ruminal pH decreased as the grain content of the diet was increased, which resulted in an ecological succession of predominating types of bacteria. This succession started with the acid sensitive bacteria species which were superseded by more acid-tolerant species and consequently the end products of ruminal fermentation changed considerably. Conditions in the

rumen became more unstable and the proportion of propionate through lactate as intermediate increased markedly (Mackie *et al.*, 1978 and Mackie and Gilchrist, 1979).

The results obtained by Orskov *et al.* (1974) show that when barley maize, oats or wheat is presented to lambs in a loose form, instead of in the rolled or pelleted form, an increase in the rumen pH of about 1 unit can be expected. These authors found that diets containing loose whole barley increased the firmness of the subcutaneous fat, which was associated with a decrease in the proportion of propionic acid in the rumen fluid, coupled with increases in the rumination time from 3.6 to 6.6 h/24h. Harfoot (1981) confirmed that high concentrate diets lead to increased amounts of propionate and decreased amounts of acetate in the rumen. In other experiments in which lambs were fed on barley diets, the propionic acid content in the rumen liquor increased and problems were encountered with soft subcutaneous fat (Duncan *et al*, 1972). Hereafter, the association with propionic acid was confirmed in an experiment in which propionate was added to a basal diet (Garton *et al.*, 1972[a,b]). According to Hungate (1966) as quoted by Orskov *et al.* (1974), stoichiometric relationships prove that methane production decreases with an increase in the proportion of propionic acid, and increases with a high proportion of acetic acid and butyric acid.

Finally Orskov *et al.* (1974) reported that the liver weights for lambs receiving the pelleted diet were significantly greater than that of those receiving the loose whole barley. These findings support the idea that the high concentrations of propionate and methylmalonate are not completely metabolised in the liver, but synthesised to branched and odd-numbered fatty acids in the subcutaneous adipose tissue as suggested by Garton *et al.* (1972[a,b]). These findings coupled with that of the present study on the ruminal pH, subcutaneous fatty acid profiles and the concentration of C18:1 in the plasma, contribute greatly to the

understanding of the soft fat problem in sheep.

8.8 M.longissimus lumborum SAMPLE CHARACTERISTICS

If the carcasses of intensively fed lambs are classified according to the scale proposed by Lea, Swoboda and Gatherum (1970, as quoted by L'Estrange *et al.*, 1975) for pigs, most of the carcasses would be classified as having hard fat. L'Estrange *et al.* (1975) are of the opinion that the soft fat problem in sheep is different from that in pigs, and is confounded by the developement of a yellow-brown colour on the surface of the fat around the tail, back and breast regions. Both Miller *et al.* (1980) and L'Estrange *et al.* (1975) found that stearic acid (C18:0) is a superlative chemical index of subcutaneous fat softness in sheep. Increases in subcutaneous fat softness result in an consistenHxdecrease in the concentration of stearic acid and increases in C18:1 and other unusual fatty acids. However, in addition to the above-mentioned, three important classification factors were analysed in the present study namely, the firmness of the subcutaneous fat, the odour of M.longissimus lumborum samples just after roasting and the amount of visible fat.

The prevalence of soft subcutaneous fat was significantly higher in the earlier maturing breed than in the later maturing breed. Since the deposition of unsaturated fatty acids in the subcutaneous adipose tissue of wethers on especially the H-treatment increased as they reached maturity, the above-mentioned findings are acceptable. It is therefore not surprising that the effect of treatment on the firmness of the subcutaneous fat was less important, and that the interaction between breed and treatment was significant. The incidence of soft subcutaneous fat also increased significantly with increasing slaughter mass in both breeds. Although the soft fat condition was undesirable, Marchello *et al.* (1967) feels that a slight decrease in the saturation of the fat may actually improve

the eating quality of lamb, because lamb is known to have the most highly saturated fat of all domestic animals. However, various authors (Casey and Van Niekerk, 1985; Scherf *et al.*, 1990; Kemp *et al.*, 1981 and Cazes *et al.*, 1990) support the findings of the present study, namely that high concentrations of unsaturated fatty acids and subsequently soft fat, reduce the acceptability of lamb.

The odour of loin samples was influenced primarily by the energy treatment. Loin samples from wethers on the M-treatment produced a typical odour while that of wethers on the H-treatment gave off a strange odour. This strange odour was extremely offensive. The effect of breed and slaughter mass on the odour of M.longissimus lumborum samples were negligible.

Finally, the amount of visiHxe fat was influenced primarily by breed, which on its turn, affected the firmness of the subcutaneous adipose tissue of wethers on high energy diets.

8.9 COOKING LOSSES

Both treatment and breed did not affect the total cooking losses, but significantly greater total cooking losses were recorded in M.longissimus lumborum samples from wethers slaughtered at the heavier target mass. However, these differences were more important in the earlier maturing breed than in the later maturing breed. These results are in accordance with those reported by Bosman *et al.* (1991) and Webb *et al.* (1991), but further information on the effect of treatment on cooking losses from M.longissimus lumborum samples seems to be limited.

The percentage drip loss tended to be greater in the M.longissimus lumborum samples from Dorpers in comparison with that of SA Mutton Merinos, and these differences were also more pronounced in samples from wethers on the M-treatment. Breed differences in the total drip loss were attributed mostly to

differences in the volume of fat in the drip. Furthermore, the drip losses from M.longissimus lumborum samples of wethers in heavier slaughter groups increased significantlty, but again these differences were more pronounced in samples from wethers on the M-treatment.

The average volume fat per 100g of unroasted M.longissimus lumborum sample was significantly higher for Dorpers than for SA Mutton Merinos. Drip losses from M.longissimus lumborum samples of SA Mutton Merinos also contained a greater percentage of meat extract and a smaller percentage fat in comparison with that of Dorpers. Finally, higher values were calculated for all drip loss characteristics of M.longissimus lumborum samples from wethers slaughtered at the heavier mass.

8.10 SENSORY EVALUATION RESULTS

High energy treatment significantly improved the aroma-intensity of taste samples and a positive correlation was calculated between the energy content of the diet and the aroma-intensity of the M.longissimus lumborum. However, the practical significance of the differences in aroma-intensity between Dorpers on the H- and M-treatments is questionable. Gibney and L'Estrange (1975) examined the effect of dietary unsaturated fat and protein source on the fatty acid composition and the sensory properties of lamb. According to these authors there was no difference in the palatability (flavour, juiciness and tenderness) of the meat samples between different treatments. The results of Kemp *et al.* (1981) were generally in accordance with those of Gibney and L'Estrange (1975), but they added that the major effect of nutrition was restricted to flavour.

Although breed did not influence the aroma-intensity of taste samples, increasing slaughter mass significantly improved the aroma of the M.longissimus lumborum samples from Dorpers. Important breed differences in the incipient juiciness and sustained juiciness, and less important differences in the

flavour and overall acceptability of taste samples were observed. Cramer *et al.* (1970) as quoted by Ockerman *et al.* (1982), also reported that mutton flavour is influenced by breed. Furthermore, slaughter mass tended to affect all the sensory characteristics evaluated, but its effect was dependant on treatment in most casses. However, both Ercanbrack (1979) and Tichenor *et al.* (1969; as quoted by Ockerman *et al.*, 1982) reported that flavour and juiciness of lamb were not affected by slaughter mass, rate of gain, breed or sex of lambs.

Correlation coefficients calculated between aroma, incipient juiciness, sustained juiciness and the various fat measures were unimportant. Significant correlations were calculated between fat measures and both the flavour and overall acceptability of M.longissimus lumborum samples. M.longissimus lumborum samples from wethers with thick subcutaneous fat depots were less acceptable and these taste samples were less flavoursome. It was concluded that fatness significantly affects the overall acceptability of M.longissimus lumborum samples from Dorpers, but that its effect is less evident in samples from SA Mutton Merinos.

On the other hand, the percentage saturated and unsaturated fatty acids in the subcutaneous fat significantly affected both the aroma-intensity and incipient juiciness of taste samples. The high energy treatment intensified the aroma-intensity and incipient juiciness of taste samples, through its effect on the percentage of unsaturated fatty acids in the subcutaneous fat. In comparison with the obove-mentioned findings, it was established that greater concentrations of unsaturated fatty acids in the subcutaneous adipose tissue reduced the flavour and subsequently the overall acceptability of taste samples. Interesting interrelationships were also observed between the sensory characteristics, which indicated that all the sensory characteristics contribute directly or indirectly to the overall acceptability of taste samples.

8.11 FACTORS THAT AFFECTED THE SENSORY PROPERTIES OF TASTE SAMPLES

Regression models by which the sensory properties of M.longissimus lumborum samples from wethers can be calculated, are an inevitable consequence of a project like this. Although the regression equations might not be practically applicable, such models provide measures of the relationships between each sensory characteristic and a number of independent variables. In this case all possible variables were included in the regression procedures, in order to predict new values based on observed relationships.

AROMA: A regression model was compiled that explaines 53.41% of the variation in the aroma-intensity of M.longissimus lumborum samples ($P<0.001$, $F=7.835$). This model consisted of six independent variables namely: the incipient juiciness of taste samples, the concentrations of C15:0, C18:1 and C18:3, the concentration of saturated fatty acids relative to the concentration of unsaturated fatty acids and finally the total volume drip loss (ml) from the M.longissimus lumborum samples. The concentrations of C18:1 and C18:3 tended to be less important variables in the model, but since the concentration of C15:0 in the subcutaneous adipose tissue is an important variable in the model, both C18:1 and C18:3 were included.

$$Y_{AI}=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6$$

(Graph 7.8.)

Y_{AI} = Aroma intensity

a = 8.096 (t=5.516, P<0.001)

b_1 = 0.231 (t=4.100, P<0.001)

X_1 = Incipient juiciness

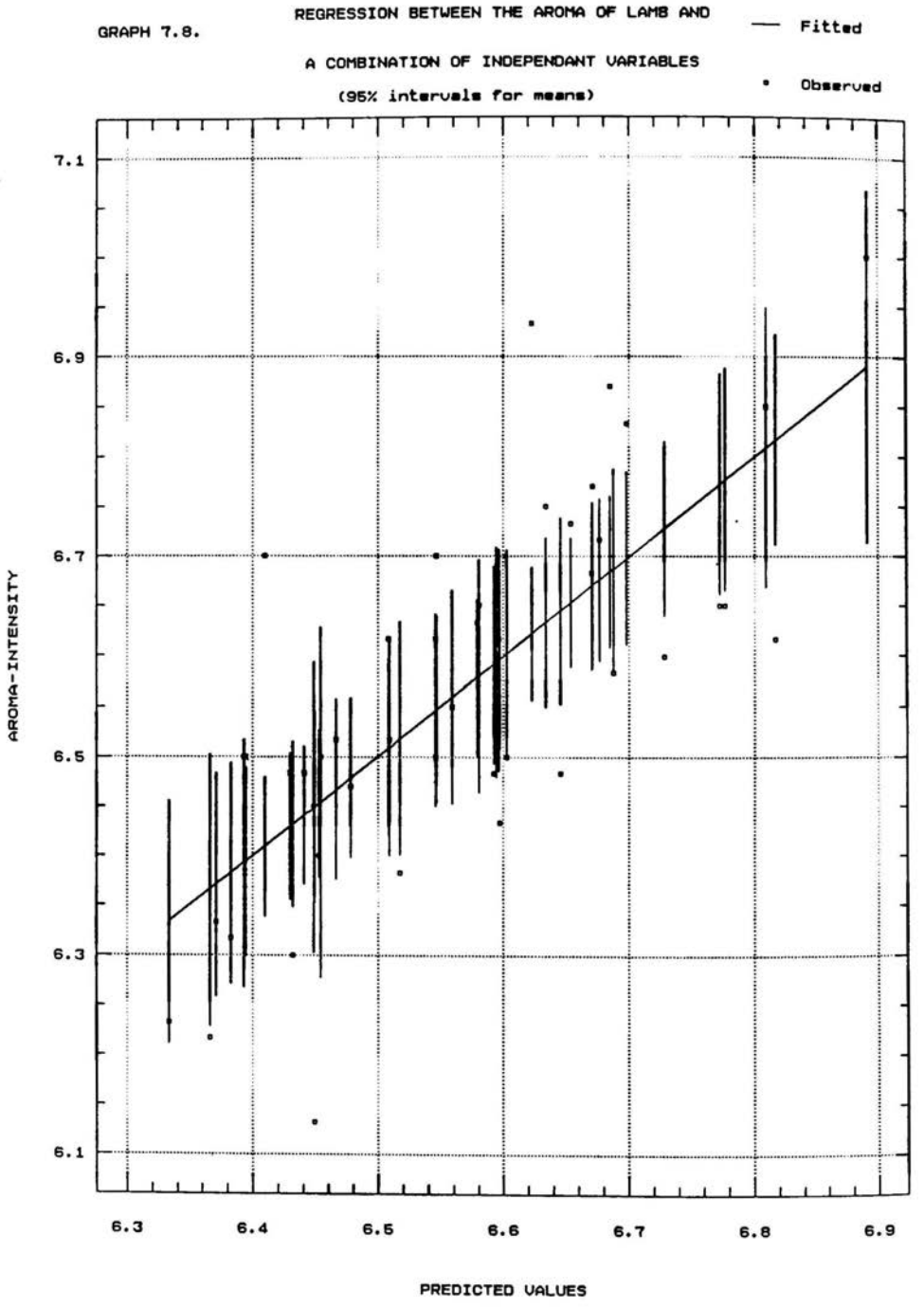
b_2 = -0.221 (t=-2.484, P<0.0.017)

X_2 = [C15:0]

GRAPH 7.8.

REGRESSION BETWEEN THE AROMA OF LAMB AND A COMBINATION OF INDEPENDANT VARIABLES

(95% intervals for means)



b_3 = -0.212 (t=-2.540, P<0.015)
X_3 = [C18:3]
b_4 = -0.044 (t=-1.974, P<0.055)
X_4 = [C18:1]
b_5 = -1.007 (t=-2.230, P<0.031)
X_5 = [Saturated fatty acids] / [unsaturated fatty acids]
b_6 = 0.001 (t=1.970, P<0.056)
X_6 = Total volume drip (ml)

INCIPIENT JUICINESS: Almost 72% of the variation in the incipient juiciness of taste samples was explained by a regression model consisting of six independent variables namely: aroma-intensity, sustained juiciness, the fat percentage and the concentrations of subcutaneous C17:0, C18:1 and C15:0 (P<0.001, F=17.103). The model is as follows:

$$Y_{IJ}=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5+b_6X_6$$

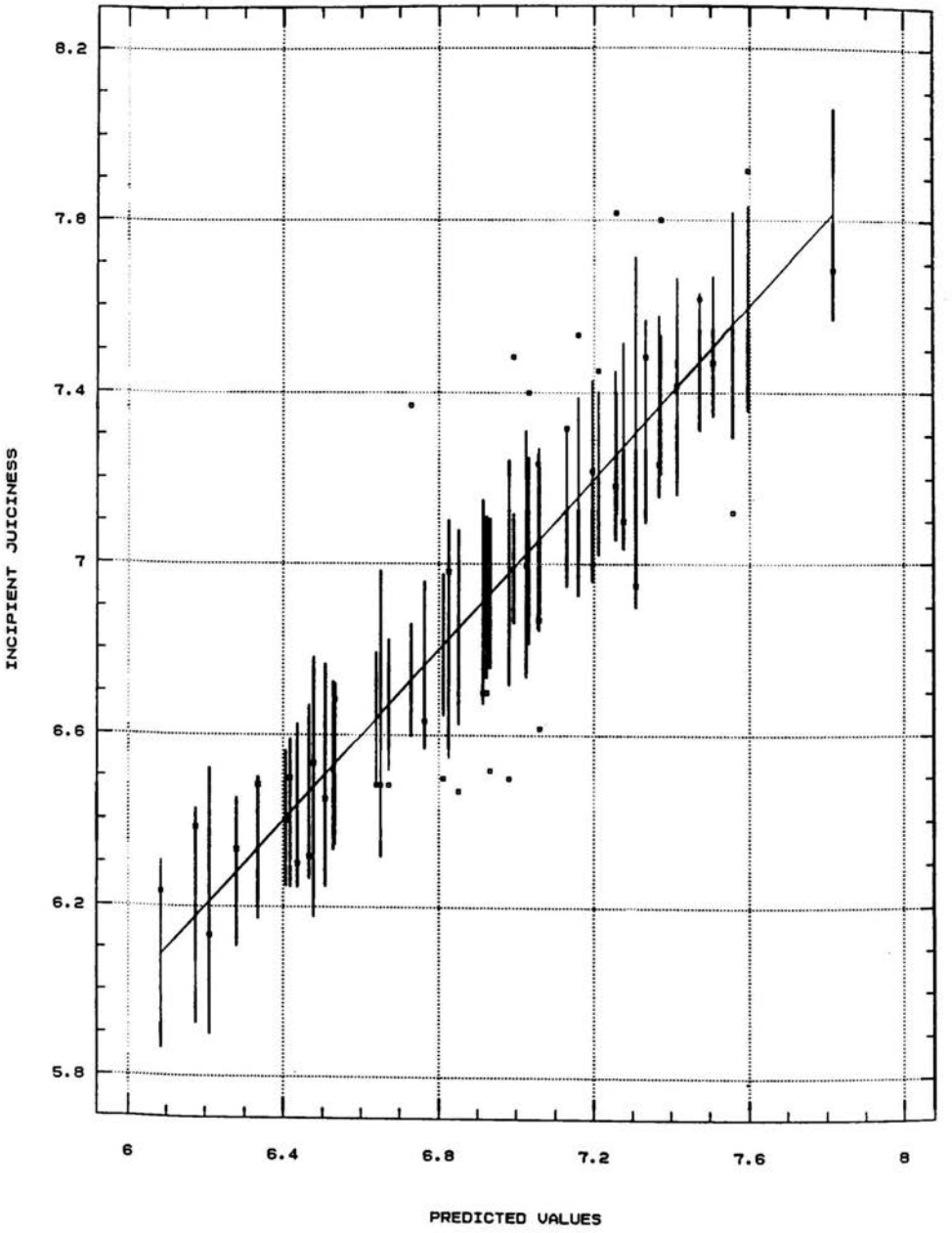
(Graph 7.9.)

Y_U = Incipient juiciness
a = -3.494 (t=-2.080, P<0.044)
b_1 = 0.929 (t=3.630, P<0.001)
X_1 = Aroma intensity
b_2 = 0.407 (t=3.123, P<0.003)
X_2 = Sustained juiciness
b_3 = -0.018 (t=-2.250, P<0.030)
X_3 = Fat percentage
b_4 = 0.191 (t=1.753, P<0.0.087)
X_4 = [C17:0]
b_5 = 0.035 (t=1.629, P<0.111)
X_5 = [C18:1]
b_6 = 0.402 (t=1.552, P<0.128)
X_6 = [C15:0]

REGRESSION BETWEEN THE INCIPIENT JUICINESS OF LAMB AND Fitted

GRAPH 7.9. A COMBINATION OF INDEPENDANT VARIABLES • Observed

(95% intervals for means)



SUSTAINED JUICINESS: Unfortunately the best regression model calculated explained only 26.58% of the variation in sustained juiciness ($P<0.001$, $F=8.144$). This was presumably due to the fact that the incipient juiciness and the concentration of saturated fatty acids explained approximately 51% of the variability in the incipient juiciness of taste samples from Dorpers, while the concentration of unsaturated fatty acids improved the incipient juiciness of taste samples from SA Mutton Merino wethers. Other factors that are not included in this study are therefore responsible for the major component of variation in the sustained juiciness of M.longissimus lumborum samples from wethers.

FLAVOUR: A significant percentage of the variability in the flavour of M.longissimus lumborum samples from wethers was explained by a model that included the percentage fat, the subcutaneous fat thickness as measured over the 10th rib, the aroma-intensity of M.longissimus lumborum samples, the drip loss from the loins, the sustained juiciness of the loins and the total volume of drip per 100g of unroasted loin sample ($P<0.001$, $F=8.363$). Since breed significantly influenced the flavour of lamb, two more regression models were calculated within breeds. The regression model calculated for Dorpers explained approximately 63% ($P<0.001$, $F=7.935$) of the variability in the flavour of taste samples, while the model calculated for SA Mutton Merinos explained 64.3% ($P<0.001$, $F=6.484$) of the variability in the flavour of taste samples. The following regression models were calculated within breeds namely:

1. Dorpers:

$$Y_{FxDorpers}=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4$$

$Y_{FxDorpers}$ = The flavour of M.longissimus lumborum samples from Dorpers

a = 3.562

b_1 = 0.984 (t=2.603, P<0.018)

X_1 = Aroma intensity

b_2 = -0.072 (t=-2.058, P<0.054)

X_2 = Total volume drip per 100 g uroasted M.longissimus lumborum samples

b_3 = -0.048 (t=-1.748, P<0.096)

X_3 = [Unsaturated fatty acids]

b_4 = -0.415 (t=-1.089, P<0.289)

X_4 = SCF10 (cm)

2. SA Mutton Merinos:

$$Y_{FxSAMM}=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4+b_5X_5$$

Y_{FxSAMM} = The flavour of M.longissimus lumborum samples from SA Mutton Merinos

a = 1.686

b_1 = 0.755 (t=4.562, P<0.001)

X_1 = Sustained juiciness

b_2 = 0.217 (t=2.868, P<0.010)

X_2 = % Drip loss

b_3 = -0.230 (t=-2.456, P<0.024)

X_3 = Total volumme drip per 100g of unroasted M.longissimus lumborum samples

b_4 = 0.192 (t=2.397, P<0.028)

X_4 = [C18:2]

b_5 = -0.405 (t=-2.007, P<0.060)

X_5 = [C18:3]

OVERALL ACCEPTABILITY: A remarkably significant regression model was calculated which explained approximately 89% of the variability in the overall acceptability of taste samples (P<0.001, F-172, 606). Only the subcutaneous fat thickness as measured over the 10th rib and the flavour of taste samples were

included as independent variables in the model. Both variables were important predictors of the acceptability of M.longissimus lumborum samples and no other variable could improve the accuracy of the model significantly. The regression model that included the overall acceptability of M.longissimus lumborum samples as dependent variable was as follows:

$$Y_{OA}=a+b_1X_1+b_2X_2$$

(Graph 7.10.)

Y_{OA} = Overall acceptability

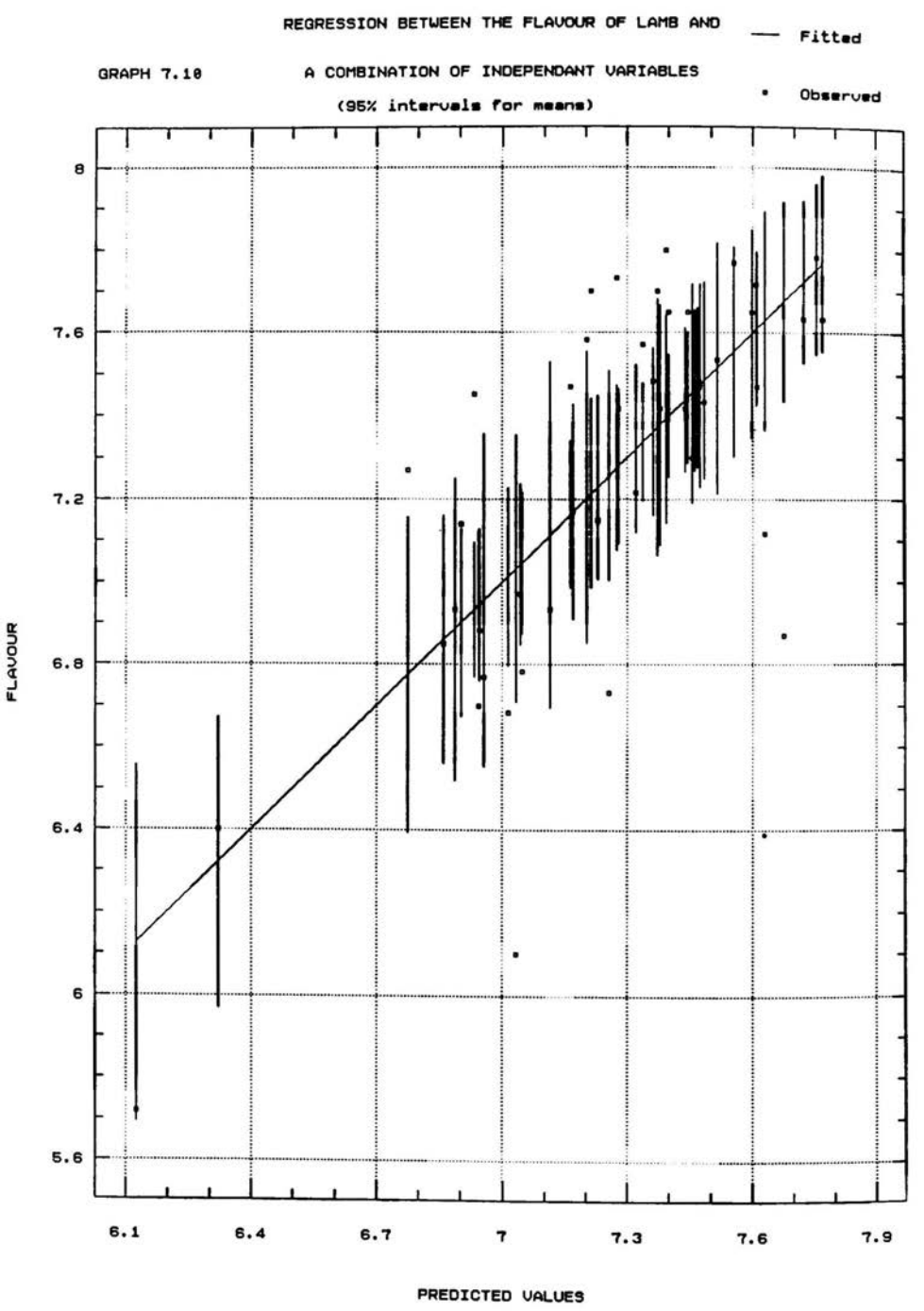
a = -0.405

b_1 = -0.925 (t=-5.391, P<0.001)

X_1 = SCF10 (cm)

b_2 = 1.093 (t=11.665, P<0.001)

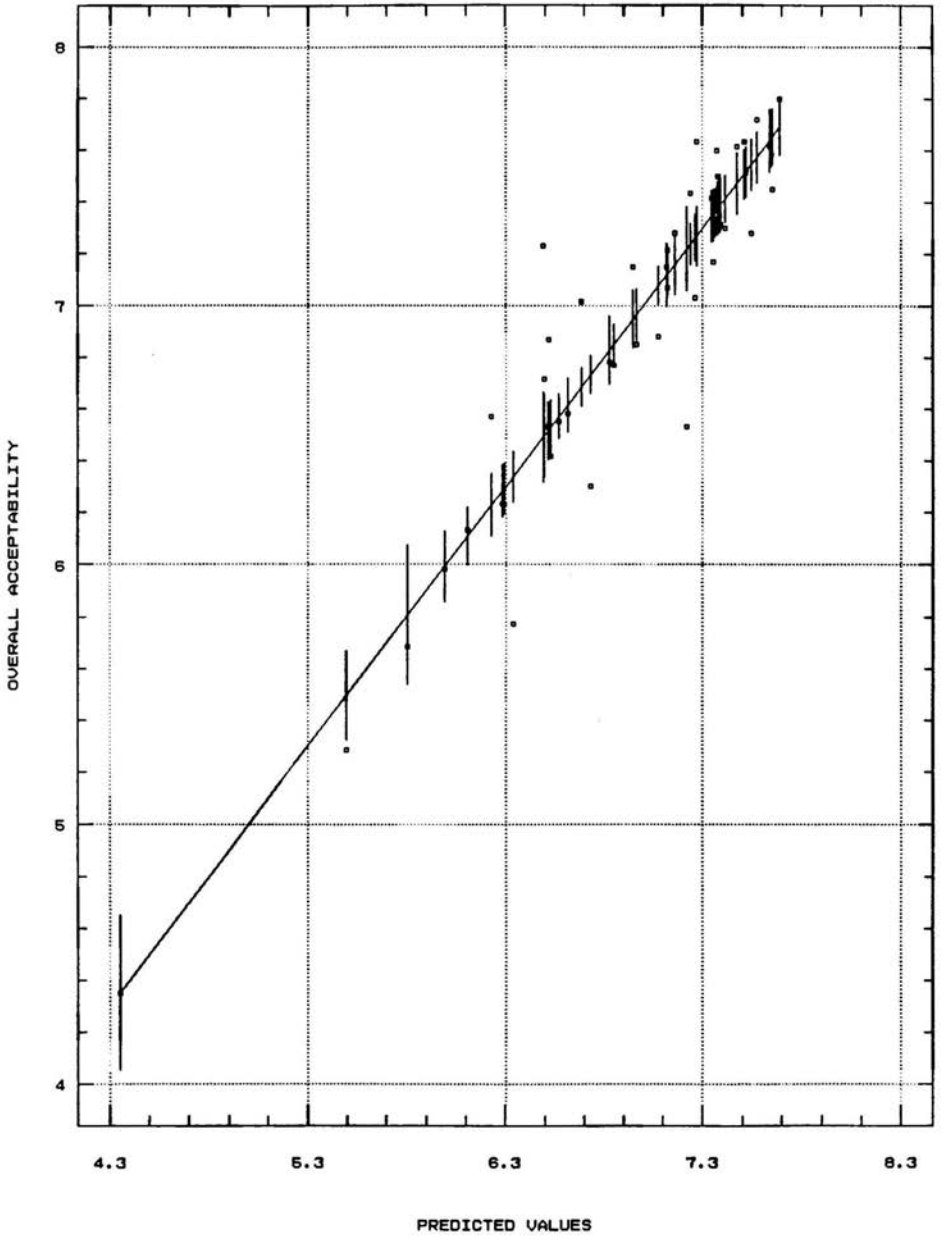
X_2 = Flavour



REGRESSION BETWEEN THE OVERALL ACCEPTABILITY OF LAMB AND Fitted

GRAPH 7.11. A COMBINATION OF INDEPANDANT VARIABLES Observed

(95% intervals for means)



9 CONCLUSIONS AND RECOMMENDATIONS

9.1. CONCLUSIONS

GROWTH AND CARCASS RESULTS:

Breed significantly affected the number of days fed and the subcutaneous fat thicknesses as measured over the 10th and 13th ribs. Treatment influenced the slaughter mass of wethers, the time they spent on feed and their average daily gains. These treatment differences emphasized certain breed differences like the time spent on feed, dressing percentage and differences in the subcutaneous fat thicknesses. Growth and carcass differences between slaughter groups were unavoidable.

CARCASS COMPACTNESS MEASUREMENTS:

Carcass widths over the shoulders and buttocks were greater for the later physiological maturing breed, while the hindleg lengths of the early physiological maturing breed were greater than that of the later maturing breed. High energy treatment improved both the hindleg compactness and carcass compactness, regardless of breed. Again mass differences were inevitable.

SUBCUTANEOUS FATTY ACID PROFILES:

Treatment significantly affected the subcutaneous fatty acid profiles of wethers. High energy treatment increased the deposition of C15:0, C17:0, C17:1 and C18:1 fatty acids in the subcutaneous fat of wethers. Greater concentrations of C16:0, C18:0, C18:2 and C18:3 fatty acids were deposited in the subcutaneous fat of wethers on the M-treatment, while the concentrations of C14:0 and C16:1 remained unaltered. Most important of all is the fact that the H-treatment significantly increased the concentration of unsaturated fatty acids in the subcutaneous fat depots.

Breed differences were limited to C16:0, while less important breed differences in the concentrations of C17:0 and C17:1 were observed. Subcutaneous fat from Dorpers tended to contain slightly higher concentrations of unsaturated fatty

acids. Differences in fatty acid profiles of wethers in different slaughter groups were negligible.

PLASMA FATTY ACID PROFILES:

Breed differences in the plasma fatty acid profiles were insignificant, but the concentration of C18:0 increased with slaughter mass and the concentration of C18:1 tended to increase in the plasma as the energy content of the diet increased. A few important interactions were observed, but at this stage it is perilous to relate the observed tendencies to the remarkable shift in the subcutaneous fatty acid profiles of wethers on high corn diets.

***CIS-TRANS* SUBCUTANEOUS FATTY ACIDS:**

The only *trans*-fatty acid detected in the subcutaneous adipose tissue was C18:1(*trans*) which was influenced significantly by treatment. Higher concentrations of C18:1(*trans*) were detected in the subcutaneous fat of wethers on the H-treatment in comparison with that of wethers on the M-treatment. Breed differences in the concentration of C18:1(*cis*) were found which presumably contribute to the higher concentration of unsaturated fatty acids in the subcutaneous fat of Dorpers.

THE EFFECT OF HIGH ENERGY DIETS ON THE FAT DEPOTS OF WETHERS:

In the ruminant the adipose tissue is the major site of fatty acid synthesis, but some fatty acids are synthesised in the liver. The fat quality (fatty acid profiles) of wethers are affected by a combination of various factors like the feeding regime, the mode of presentation of the cereals, the kind and nature of the cereals, the kind and presentation of roughage, the age and sex of the wethers and seasonal and ambient temperature effects. The ruminal pH of wethers decreased as the grain content of the diet increased, which resulted in an ecological succession of predominating types of bacteria. This succession

started with the acid-sensitive bacteria species which were superseded by more acid-tolerant species and consequently the end products of ruminal fermentatmxn changed considerably. Conditions in the rumen became more unstable and the proportion of propionate through lactate as intermediate increased markedly. The subsequent shift in the subcutaneous fatty acid profiles observed in wethers on the H-treatment is therefore a consequence of the high concentrations of propionate and methylmalonate that are not completely metabolised in the liver, but synthesised to branched and odd-numbered fatty acids in the subcutaneous adipose tissue.

SENSORY PROPERTIES AND COOKING LOSSES:

High energy treatment significantly improved the aroma-intensity of taste samples, but its effect on the other sensory parameters was less important. Important breed differences in the incipient juiciness, sustained juiciness, flavour and overall acceptability of taste samples were observed. Slaughter mass tended to affect all the sensory characteristics, but its effect was dependent on treatment in most casses.

Breed influenced the percentage drip loss and the percentage evaporation loss from M.longissimus lumborum samples, while slaughter mass affected the percentage drip loss from M.longissimus lumborum samples. Treatment did not significantly affect the cooking losses. Most of the drip loss characteristics were affected by slaughter mass.

M.longissimus lumborum SAMPLE CHARACTERISTICS:

Three important classification factors were analysed namely the firmness of the subcutaneous fat, the odour of the M.longissimus lumborum samples just after roasting and the amount of visible fat. High energy treatment significantly increased the incidence of strange odours in M.longissimus lumborum samples of both breeds. Breed was responsible for the major differences in

the firmness of the subcutaneous fat, but less important differences were observed, as a result of the high energy treatment. The amount of visible fat in M.longissimus lumborum samples was affected mostly by breed, coupled with treatment.

FACTORS THAT AFFECTED THE SENSORY PROPERTIES OF M.longissimus lumborum samples:

Regression models by which the sensory properties of M.longissimus lumborum samples from wethers can be calculated, are an inevitable consequence of a project like this.

Aroma: A regression model was compiled that explaines 53.41% of the variation in the aroma-intensity of loin samples.

Incipient juiciness: Almost 72% of the variation in the incipient juiciness of taste samples was explained by a regression model consisting of six independent variables namely: aroma intensity, sustained juiciness, the fat percentage and the concentrations of subcutaneous C17:0, C18:1 and C15:0 ($P<0.001$, $F=17.103$).

Sustained juiciness: Unfortunately the best regression model calculated explained only 26.58% of the variation in sustained juiciness ($P<0.001$, $F=8.144$). Other factors that are not included in this study are therefore responsible for the major component of variation in the sustained juiciness of loins from wethers.

Flavour: A significant percentage of the variability in the flavour of loins from wethers was explained by a model that included the percentage fat, the subcutaneous fat thickness as measured over the 10th rib, the aroma intensity of loins, the drip loss from the loins, the sustained juiciness of the loins and the total volume of drip per 100g of unroasted loin sample ($P<0.001$, $F=8.363$).

Overall acceptability: A remarkably significant regression model was calculated which explained approximately 89% of the variability in the overall acceptability of taste samples ($P<0.001$, F-172, 606). Only the subcutaneous fat thickness as measured over the 10th rib and the flavour of taste samples were included as independent variables in the model.

9.2. RECOMMENDATIONS

According to Naudè (1974) the main objective of meat production is the maximum yield of saleable product with optimal organoleptic and processing qualities. This product should acquire the highest possible price in a short time, coupled with low production costs. Retailers seem to favour the marketing of heavier lambs because many of the overhead costs in the packing plant and in the retail store are on a carcass basis (Lambuth, Kemp and Glimp, 1970).

According to H.J. Tuma as quoted by Southam and Field (1969) less labor per kilogram of retail cuts is required for lamb carcasses weighing 29.5 to 31.8kg than for carcasses weighing 20.4 to 22.7kg. The retailers also want leaner and trimmer carcasses because leanness of cuts ranks high on consumer response lists (Carpenter, 1966).

Consumers on the other hand have their own expectations of the product of which their own conception of "value" is the most important parameter (Weyers, 1982 as quoted by Naudè, 1985). Naudè (1985) is of the opinion that meat quality needs to be defined so as to fully appreciate the needs of the consumer. Appearance, palatability, nutritive value, processibility and shelf life contribute greatly to meat quality, which can be manipulated by biological or technological means (Naudè, 1985).

Fat quality affects all the above-mentioned meat quality characteristics and in my opinion technological manipulations will not economically improve the qualitative deficiencies of such products. Improvements in carcass fat quality of most domestic species is limited more to biological factors prior to slaughter. Since fat quality deteriorates with increasing slaughter mass, the most obvious (but unpopular) suggestion would be to market animals earlier. Nevertheless, the nutritional and physiological tools available to the producer are probably the

most important means of achieving this goal. The following suggestions are applicable to sheep, namely:

* concentrates should be rationed during later stages of fattening,
* high energy concentrates should be avoided in the later stages of fattening,
* moderately high energy concentrates should be formulated for the fattening stage,
* whole grain concentrates, containing smaller concentrations of maize and greater concentrations of barley or Triticale are advisable,
* early physiological maturing breeds should enter the final fattening stage at an earlier chronological age (± 30kg live mass) and later maturing breeds at approximately 38 to 40kg live mass,
* finally, wethers are preferred since the incidence of poor fat consistency was higher in both rams and ewes.

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