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A COMPARISON OF THE QUALITY CHARACTERISTICS OF GOAT MEAT WITH THAT OF SHEEP MEAT

by

Hettie Carina Schönfeldt (neé Minnaar)

Submitted in fulfillment of the requirements for the degree of

Master in Home Economics

in the

Faculty of Science

University of Pretoria

PRETORIA

JANUARY 1989

LEADER: Prof E Boshoff
CO-LEADER: Dr R T Naudé

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ABSTRACT

A COMPARISON OF THE QUALITY CHARACTERISTICS OF GOAT MEAT WITH THAT OF SHEEP MEAT

by

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for the degree of Master in Home Economics

The purpose of this study was to ascertain how the quality characteristics of Angora and Boer goat meat compare with those of sheep meat. The quality characteristics of the *Mm. longissimus thoracis et lumborum* of the various age groups and fat codes of Angora and Boer goat meat, prepared according to a dry heat cooking method, were compared with those of the identically prepared *Mm. longissimus thoracis et lumborum* of the corresponding age groups and fat codes of sheep meat. Thereupon the quality characteristics of the *M. semimembranosus* of the various age groups and fat codes of Angora and Boer goat meat, prepared according to a moist heat cooking method, were compared with those of the identically prepared *M. semimembranosus* of the comparable various age groups and fat codes of sheep meat. Triplicate sets of comparable cuts from each age group and fat code were evaluated, thus 27 sheep, 27 Angora and 27 Boer goats were compared.

Species affected cooking yield. Sheep meat showed significantly greater drip loss than Boer and Angora goat meat and more evaporation loss than Angora goat meat. On the other hand, sheep and Boer goat meat had greater total cooking losses than Angora meat.

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The aroma of the sheep meat was more intense, it was more juicy, more tender, contained less fibrous tissue residue, the flavour was more acceptable and the species flavour more typical than that of the Angora and Boer goat meat. The Angora goat meat was more juicy, more tender and contained less fibrous tissue residue than the Boer goat cuts. This was confirmed by the expressible moisture and shear force resistance measurements, respectively. Sheep meat contained more expressible moisture than the goat meat. Sheep meat showed less resistance to shear force than Angora meat, which in turn showed less resistance than Boer goat meat. Goat meat contained more collagen and the collagen was less soluble than that of sheep meat.

The age of the various animals affected the cooking losses. Drip loss increased significantly with increasing age. Evaporation and total cooking losses also showed a tendency to increase with age. These were particularly noticeable in the *M. semimembranosus* cuts.

The meat of animals of the A age group was juicier, more tender, contained less tissue residue, the flavour was more acceptable and the species flavour less typical than that of the B and C age groups. This was confirmed by the expressible moisture and shear force resistance measurements. Meat of animals of the A age group contained more expressible moisture than meat from the B and C age groups. Meat from animals of the A age group also showed less resistance to shear force than that of the B and C age groups. There was a significant decrease in collagen solubility of muscles with increasing age of the animal. This can be ascribed to the known increase in the number of crosslinks in the collagen fibrils that occur with increasing age of the animal, resulting in increased resistance to shearing and chewing of the meat. The protein and dry matter content of the cooked cuts increased, while the moisture and ash content decreased with an increase in age.

Cooking yields of meat cuts were closely related to the fat codes of the various carcases. Higher drip, evaporation and total cooking losses were found as the fat codes of cuts increased. With increased fatness of carcases, the juiciness of the cooked cuts tended to decrease and the tenderness and species flavour to increase. The collagen solubility tended to increase and content to decrease with increased fatness. The latter may be ascribed to the increase of muscle fibre volume during the growth of the

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animal. Hence, a decrease in the resistance to shear force with increased fatness was found. With increasing level of fatness, the cuts contained less moisture, more fat and increased amounts of dry matter.

This study confirms that goat meat is unique and should not be grouped with meat from comparable sheep having the same maturity and fatness levels with regard to palatability attributes. Significant differences exist between the quality characteristics of sheep on the one hand, and Angora and Boer goat meat on the other. The aroma of the sheep meat is more intense, it is more juicy, more tender, contains less fibrous tissue residue and the species flavour is more pronounced (typical) than that found in Angora and Boer goat meat. In general, the meat from goat carcases was found to be significantly less acceptable than that from sheep carcases, the Angora to a lesser extent, however, than the Boer goat.

As was anticipated this study confirms the fact that the meat of younger animals is more juicy, more tender, contains less fibrous tissue residue during chewing and the species flavour is less typical than that of older animals. This was irrespective of the fact whether it was obtained from sheep, Angora or Boer goat.

Significant differences in the palatability attributes were found with an increase in the fatness (fat codes) of the animals. With increasing fatness, the juiciness of the cooked cuts tended to decrease and the tenderness and species flavour to increase.

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OPSOMMING

'n VERGELYKING VAN DIE KWALITEITEIENSKAPPE VAN BOK- MET SKAAPVLEIS

deur

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Die doel van die studie was om die kwaliteitseienskappe van twee spesies bokvleis met die van skaapvleis te vergelyk. Die kwaliteitseienskappe van Angora en Boerbok *Mm. longissimus thoracis et lumborum* van die verskillende ouderdomme en vetkodes, is volgens 'n droëhittegaarmaakmetode berei en is met die identies voorbereide skaap *Mm. longissimus thoracis et lumborum* van die ooreenstemmende ouderdomme en vetkodes vergelyk. Vervolgens is die kwaliteitseienskappe van die verskillende ouderdomme en vetkodes Angora en Boerbok *M. semimembranosus* snitte, met 'n klamhitte-gaarmaakmetode voorberei en met die identies voorbereide *M. semimembranosus* skaapvleissnitte van die ooreenstemmende ouderdomme en vetkodes vergelyk. Drie replikasies binne elke ouderdom en vetkode is uitgevoer, dus is 27 skape, 27 Angora- en 27 Boerbokke onderskeidelik met mekaar vergelyk.

Die resultate toon 'n verwantskap tussen gaarmaakopbrengs en die spesie van die dier. Skaapvleis het betekenisvol meer drupverlies as Boer- of Angorabokvleis en meer verdampingsverlies as Angorabokvleis getoon. Aan die anderkant het skaap- en Boerbokvleis groter verdampingsverliese as Angorabokvleis getoon.

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Die aroma van skaapvleis was meer intens, dit was sappiger, sagter, het minder fibreuse weefselresidu, die geur was meer aanvaarbaar en die spesiegeur was meer tipies as die van Angora- en Boerbokvleis. Die Angorasnitte was sappiger, sagter en het minder fibreuse weefselresidu as die Boerboksnitte bevat. Die resultate is verder deur die uitpersbare vog- en snyweerstandbepalings onderskeidelik bevestig. Skaapvleis het meer uitpersbare vog as bokvleis gehad. Skaapvleis het minder weerstand teen snykrag as Angorabokvleis gebied, wat weer minder weerstand teen snykrag as Boerbokvleis gebied het. Bokvleis bevat meer kollageen en die kollageen was minder oplosbaar as die van skaapvleis.

Die ouderdom van die verskillende diere het gaarmaakverliese beïnvloed. Drupverlies het betekenisvol toegeneem met 'n toename in die ouderdom van die dier. Dit was veral by die *M. semimembranosus* snitte waarneembaar.

Die vleis van diere van die A ouderdom was sappiger, sagter, met minder fibreuse weefselresidu, die geur was meer aanvaarbaar en die spesiegeur minder tipies as die van die B en C ouderdomsgroepe. Die resultate is verder deur die uitpersbare vog- en snyweerstandbepalings onderskeidelik bevestig. Vleis van diere van die A ouderdomsgroep het meer uitpersbare vog getoon as die vleis van die B en C ouderdomsgroepe. Vleis van diere van die A ouderdomsgroep het ook minder weerstand teen snykrag getoon as die van die B en C ouderdomsgroepe. Daar was 'n betekenisvolle afname in die kollageenoplosbaarheid van die spiere met 'n toename in ouderdom van die dier. Dit kan aan die bekende verhoging in die aantal kruisbindings in die kollageenfibrille, met 'n toename in die ouderdom van die dier, met gevolglik verhoogde weerstand teen snykrag en kou van die vleis, toegeskryf word. Die proteïen- en droë materiaalinhoud van die gaar snitte het verhoog, terwyl die vog- en asinhoud met 'n toename in die ouderdom van die dier, afgeneem het.

Gaarmaakopbrengs van die vleissnitte het 'n hoë verband met die vetkodes van die verskillende karkasse gehad. Met 'n toename in die vetkodes van die snitte het hoër drup-, verdamping- en totale gaarmaakverliese voorgekom. 'n Toename in die vetheid van die snitte, is met 'n afname in sappigheid en 'n toename in sagtheid en spesiegeur geassosieer. Met 'n toename in vetheid het die kollageenoplosbaarheid geneig om te verhoog en die kollageeninhoud om te verlaag. Laasgenoemde kan moontlik aan 'n toename in spierveselvolume

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gedurende groei van die dier toegeskryf word. 'n Afname in die weerstand teen snykrag met verhoogde vetheid is gevind. Met toenemende vetheid, het die snitte minder vog, meer vet en meer droë materiaal bevat.

Die resultate van hierdie studie bevestig dus die feit dat bokvleis uniek is en nie sonder meer met skaapvleis van dieselfde volwassenheid en vetheidsgraad ten opsigte van eetkwaliteiteienskappe, gegroepeer kan word nie. Daar bestaan duidelik identifiseerbare verskille tussen die kwaliteiteienskappe van skaapvleis aan die een kant, en Angora- en Boerbokvleis aan die anderkant. Die aroma van skaapvleis is meer intens, die vleis is sappiger, sagter, bevat minder fibreuse weefselresidu en die spesiegeur is meer tipies as die wat by Angora- en Boerbokvleis voorkom. Die gevolgtrekking kan dus gemaak word dat bokvleis betekenisvol minder aanvaarbaar is as skaapvleis, met Angora- nogtans meer aanvaarbaar as Boerbokvleis.

Soos wat verwag is, het die studie die feit ondersteun dat vleis van jonger diere sappiger en sagter is, dat minder fibreuse weefselresidu gedurende die kouproses vorm en dat die spesiegeur minder tipies is, as die van fisiologies ouer diere. Die stelling was geldig, ongeag die spesie waarvan die vleis afkomstig was.

Betekenisvolle verskille in die eetkwaliteiteienskappe met 'n verhoging in die vetheid (vetkode) van die diere is gevind. Met 'n toename in die vetheid van die diere, was daar 'n vermindering in die sappigheid en 'n toename in die sagtheid en spesiegeur van die gaar snitte.

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CHAPTER 1

THE SIGNIFICANCE OF THE STUDY

Introduction

The ability of goats to survive and even reproduce under adverse environmental conditions was possibly one of the main reasons why goats were among the first domestic animals kept by man for the production of meat, milk, skins and fibre (Gall, 1981:1). According to Salmon (1987:17) more people in the world eat goat meat than any other meat.

In South Africa marked differences exist in the meat preferences of the different population groups. Based on the 1982 consumer survey, the consumption estimate and market share of each meat type for the different population groups (Table 1), highlight that beef is the most important type of red meat consumed in South Africa (Tomlinson, 1986:135). Differences in consumption are considerable (Table 2). Notably, expenditure on meat forms a very important part of daily consumer budget.

TABLE 1: PER CAPITA RED MEAT CONSUMPTION BY OF DIFFERENT POPULATION GROUPS OF SOUTH AFRICA IN 1982

Meat type	Population group								
	White		Black		Coloured		Asian		Total
	kg	%	kg	%	kg	%	kg	%	kg
Beef	31,7	56	15,7	85	23,6	61	3,2	16	19,0
Sheep and goat meat	13,3	24	1,8	10	10,8	28	15,8	79	5,4
Pork	11,5	20	1,1	5	4,2	11	1,1	5	3,2
Total	56,5	100	18,5	100	38,6	100	20,1	100	27,6

(Tomlinson, 1986:136)

In 1982 the white consumer accounted for most of the national expenditure on

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TABLE 2: RELATIVE EXPENDITURE BY DIFFERENT POPULATION GROUPS ON INDIVIDUAL MEAT TYPES IN 1982 (PERCENTAGE)

Population group	Meat type			
	Beef	Sheep and goat	Pork	Total
White	30,5	45,7	65,2	37,3
Black	55,8	22,9	19,9	45,6
Coloured	13,2	21,6	13,8	14,8
Asian	0,5	9,8	1,1	2,3

(Meat Board, 1987:6)

sheep and goat meat (45,7 %). Unfortunately there are no separate figures available for sheep and goat meat consumption. The black population consumed the largest proportion of the red meat sold in the country (45,6 %). In the case of beef they consumed 55,8 % thereof. However, both the standard of living and the spending capacity of the black population group, are increasing very rapidly; this may have a marked impact on the Meat Industry in the near future.

In a survey by Market Research Africa (1987:2) for the Meat Board it was ascertained that beef, lamb and mutton respectively are the most frequently served meats in white households in South Africa followed by chicken, minced meat and processed meat. Beef and chicken are the types of meat that are served most frequently in black households, followed by processed meat and mutton or lamb.

Livestock numbers

Baker (1987:16) reported a global increase in the production of meat goats on a commercial scale. This statement is, however, not true for South Africa. Over the past 30 years, cattle and goat numbers have remained fairly constant while pig numbers have doubled and sheep numbers have declined (Table 3).

Changes in South African livestock numbers over the past 30 years for

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TABLE 3: LIVESTOCK NUMBERS IN RSA

Year	Livestock numbers			
	Cattle x 10^6	Sheep x 10^6	Goats x 10^6	Pigs x 10^6
1955	8,2	33,4	2,5	0,5
1960	8,8	35,5	2,5	0,6
1965	7,4	36,5	3,0	0,8
1970	7,9	33,1	2,6	0,9
1975	8,8	31,0	2,3	0,9
1980	8,3	30,8	2,7	0,9
1985	7,8	27,1	2,8	1,0
1987	8,1	26,1	3,0	1,0

(Meat Board, 1987:2; Naudé, 1986a:8)

different sheep and goat breeds are given in Table 4. The proportions of Merino and Karakul sheep in the sheep flock have decreased, while the proportion of Angora goats in the goat flock of the country has increased.

Consumer perceptions

Naudé (1988:10) states that according to surveys, clear trends in consumers' needs and demands world wide are emerging. This includes an increase in the ratio of white to red meat consumed in favour of white meat, a demand for leaner meat by consumers, due to the general demand for lower fat intake, and convenience of preparation as a value added characteristic.

On a worldwide scale, consumer health consciousness and economic pressures have obligated livestock producers to produce leaner products (Breidenstein, 1987:43). Goats have leaner carcases than sheep and also a particularly low subcutaneous fat content. The large fat deposit in the cavity region may be removed when the carcase is dressed. Goat carcases contain approximately 60 % lean with about 20 % bone. At comparable lean content, the lean to bone ratio is higher in the goat than in either lamb or beef (Owen, Norman, Philbrooks and Jones, 1978:60).

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TABLE 4: COMPOSITION OF SHEEP AND GOAT FLOCKS

YEAR	SHEEP					GOATS			TOTAL SMALL STOCK
	Merino x10^6	Karakul x10^6	Other x10^6	Non-wool x10^6	Total wool x10^6	Angora x10^6	Other x10^6	Total x10^6	x10^6
1955	26,3	1,6	2,0	3,6	33,4	0,7	1,8	2,5	35,9
1970	25,3	1,7	2,5	3,7	33,1	1,0	1,2	2,6	35,7
1985	15,8	0,7	4,6	5,7	26,8	2,0	0,8	2,8	29,9
1986	16,4	0,5	4,2	5,9	27,0	N/A*	N/A	N/A	N/A

*N/A = not available

(Advisory board committee for cattle, sheep and goat production, 1987:20)

The consumer in South Africa is also following the world wide trend of demanding leaner meat. In a consumer's survey conducted amongst all population groups the following preferences regarding the fatness of lamb and mutton were established (Table 5): generally all population groups have indicated a preference for lean lamb or mutton (40 - 77 %). In the white population group as much as 45 % prefer medium fat sheep meat. Amongst the

TABLE 5: PREFERENCES FOR FATNESS OF LAMB OR MUTTON CHOPS (%)

Fatness (mm)	Population group				
	Whites		Coloureds	Asians	Blacks
	1970	1987	1987	1987	1987
Least (1)	35	41,3	56	77	40
Medium (4,5)	49	45,0	30,5	17,5	36
Most (10)	16	12,3	12	5,5	23
Never	N/A	1,4	1,5	N/A	1

(Market Research Africa, 1987:37)

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black population, however, as many as 23 % still prefer fat meat as opposed to 5 to 12 % of the other population groups.

Statement of the problem

According to Naudé and Hofmeyr (1981:305), both kid and goat meat is internationally quite acceptable to the consumer and, in certain cases, may even replace mutton, lamb or beef. It was pointed out, however, that sensory panels found goat meat less tender than either lamb or mutton. Results from a comparative study of carcasses obtained from kids and lambs of similar ages of up to 18 months however, did not indicate a markedly lower collagen solubility in kids when compared to certain breeds of lamb (Heinze, Smit, Naudé & Boccard, 1986:170). They indicated that the collagen content of Boer goat muscles was similar to that of the Pedi and Merino sheep muscles. However, collagen solubility and total collagen content of muscles may account for only part of the variation found in tenderness. Little scientific information about goat meat is available, yet it may become an important source of good quality animal protein in the future.

The similarity between the solubility of muscle collagen of Boer goats and that of certain sheep breeds was discussed at a National Sheep Committee Meeting on 23 March 1983 and this led to a request by the Meat Board, for a comparative study of the eating quality characteristics, to be done at the Animal and Dairy Science Research Institute (ADSRI) on sheep and goat meat.

The National Small Stock Executive of the Red Meat Producers Organization also requested that the ADSRI re-evaluate the validity of a different grading and roller marking system for goat carcases as compared to that for sheep carcases, to aptly reflect possible differences in meat quality characteristics of goat and sheep carcases. An orange marking ink is used for the roller marking of goat carcases. Consumers are said to be confused by the orange colour of roller marks identifying the goat meat grades, because they only associate the colour purple with the optimal grades of good quality meat. Goat farmers feel their product is being discriminated against even though it is included in the current official grading system.

A further request was to investigate the possible differences between the meat of Boer and Angora goat breeds. A grading system, however, must relate

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to eating quality (palatability) as well as carcase quality. In order to comply with this requirement, the meat as well as carcase characteristics of goats should first of all be determined and described accurately.

Purpose of the study

The purpose of the study was, to ascertain how the quality characteristics of two species of goat meat compare with those of sheep meat.

To this end the following goals were formulated:

To ascertain how the quality characteristics of the *Mm. longissimus thoracis et lumborum* of the various age groups and fat codes of Angora and Boer goat meat, prepared according to a dry heat cooking method, compare with the quality characteristics of the identically prepared *Mm. longissimus thoracis et lumborum* of the corresponding age groups and fat codes of sheep meat.

To ascertain how the quality characteristics of the *M. semimembranosus* of the various age groups and fat codes of Angora and Boer goat meat, prepared according to a moist heat cooking method, compare with the quality characteristics of the identically prepared *M. semimembranosus* of the corresponding age groups and fat codes of sheep meat.

To ascertain what the correlations are between the various measurements of the quality characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* of the various age groups and fat codes of sheep, Angora and Boer goat meat.

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CHAPTER 2

LITERATURE REVIEW

A variety of factors, ante- and post mortem, may affect the quality of the meat that reaches the consumer. Consumers demand meat with a high lean to fat ratio, a bright red colour, which is tender and tasty. Tenderness is the most important parameter of quality to the end-user (Boccard, 1973:352).

The tenderness of meat is influenced by the following factors:

1. Biologically through (ante mortem) the genotype, age, sex, species and size of the animal with regard to the collagen content and solubility of the muscle, size and type of muscle fibre, and enzyme activity.

2. Biochemically (post mortem) through the internal temperature of the muscle after slaughter, type of muscle, ageing and electrical stimulation (Naudé, 1986b:45).

These factors will be discussed, under the following headings: the structure of meat, factors affecting the composition of meat, conversion of the living animal to meat, heat-induced changes in meat and the ultimate qualitative characteristics that are related to palatability.

The structure of meat

Lean meat has been defined by the United Kingdom Food Standards Committee (Ranken, 1984:16) as meat free from trimmable fat and connective tissue containing no more connective tissue than is naturally associated with the particular cut of trimmed meat used, provided that neither the fat nor the connective tissue may exceed 10 % by mass.

A muscle is a complicated composite structure of delicately balanced colloidal protein systems in dilute salt solutions, containing various amounts and types of lipids as well as carbohydrates (Briskey & Kauffman, 1971:367).

The lean portion of muscle consists of 75,5 % water, 18 % protein, 3 % fat,

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1,6 % non-protein nitrogenous compounds, 0,3 % carbohydrate, 1,4 % inorganic salts, vitamins and traces of other compounds (Ranken, 1984:9).

Muscle fibre

The muscle fibre is the primary structural unit of all muscles. Fibres are long, narrow, multi-nucleated cells that differ in diameter from one muscle to another, between species, breeds and sexes (Lawrie, 1985:30). Muscle fibres range in length from a few millimeters up to 340 mm with an average diameter of 60 µm (Bailey, 1972:997).

The diameter of muscle cells vary with exercise, animal, age, sex, nutritional state, breed, species and type of muscle and this may be related to the tenderness of the cooked meat (Bechtel, 1986:2). The state of contraction of the muscle fibre is, however, the most important determinant of the tenderness of cooked muscle (Naudé, 1980:7).

Surrounding each fibre and underneath the connective tissue of the endomysium, is a sheath, the sarcolemma. Within the sarcolemma are the myofibrils which are surrounded by a fluid phase, the sarcoplasm. In the sarcoplasm certain formed structures can be found, as well as the mitochondria, the sarcoplasmic bodies, the sarcotubular system and dissolved or suspended substances. Under magnification it can be seen that each individual fibre is composed of a number of smaller units, the myofibrils. The cross-striations on individual muscle fibres are also visible under magnification. Thus, the dark band is called the A-band and has a central clear area (the H-zone), as well as a light band called the I-band with a associated central dark division (the Z-line).

The distance between two adjacent Z-lines is the functional unit of the myofibril, the sarcomere. The myofibril itself is composed of numerous parallel filaments. The filaments which traverse the A-band are relatively thick (myosin) and those which stop at the edge of the H-zone are relatively thin (actin). The actin and myosin filaments are the functional contractile proteins of the muscle (Lawrie, 1985:31).

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Connective tissue

Connective tissue represents between 3 and 15 % of the total muscle proteins, and consists mainly of collagen, elastin and reticulin. Quantitatively, collagen is the most important fraction (Kahn, 1977:169).

Muscle fibres are supported by a network of connective tissues. Each fibre is enclosed in the cell membrane, or sarcolemma, and groups of myofibrils are formed into bundles by the endomysium which is an extremely thin network of connective tissue. Each bundle is surrounded by a coarser sheath of connective tissue, called the perimysium, and a group of such bundles is surrounded by an outer layer of thick white connective tissue called the epimysium (Voyle, 1979:196). Bailey, Peach and Fowler (1970) as reported in Charley (1982:379) stated that these connective tissue sheaths are comprised mainly of mucopolysaccharides in which fibres of collagen and elastin are embedded.

Collagen is a strong, inextensible fibre with properties that vary considerably with the age of the animal. The collagen becomes more thermally stable and much less soluble, the older the animal becomes with resulting tougher meat. The intermolecular cross linkages become more numerous and stable as the animal ages (Bailey, 1972:1004). Breed and sex also influence the solubility of collagen and collagen content. The relationship between the solubility of collagen and the age of the animal is demonstrated in Figure 1.

The size of the muscle fibre bundles that are enclosed by the perimysium determines the texture of the muscle. The texture is fine in muscles capable of fine movements. The proportion of connective tissue is higher than in the coarser muscles performing gross movements (Lawrie, 1985:27).

Adipose tissue

As an animal is fattened, fat is deposited around certain organs and under the skin and, later, as intermuscular and marbling fat. Intramuscular fat cells (marbling) are located in spaces in the perimysium and contain a higher ratio of phospholipids to triglycerides (Pearson, 1986:127). Sheldon (1969) as reported in Paul (1972:373) stated that fat deposition may be influenced by heredity, stage of growth, level of nutrition, exercise, hormones and sex

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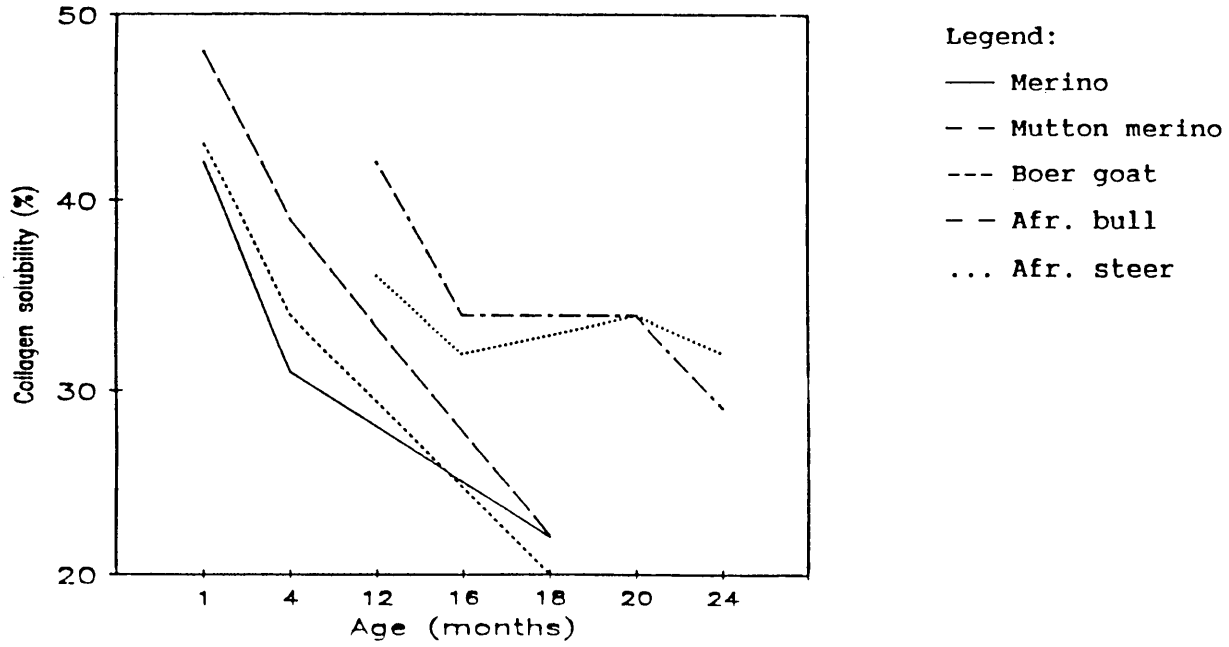

NB. X-axis: scale units not relative to each other, but absolute values

FIGURE 1: INFLUENCE OF SPECIES, BREED AND AGE ON THE COLLAGEN SOLUBILITY OF THE *Mm. longissimus thoracis et lumborum*

(Heinze, et al, 1986:171)

during the post-natal growth of the animal, the muscle grows initially faster than the fat, but as growth continues fat growth will exceed muscle growth. The rate of fat deposition will continue and further growth is mainly due to the growth of fat depots, with only a small increase in lean body mass (Leat & Cox, 1980:43).

Both quantity and distribution of carcase fat are important factors in evaluating meat quality. In South Africa the backfat thickness is used as an indication of carcase fat cover for sheep carcase grading and classification purposes. Carpenter and King (1965:104) reported that the quality of cooked lamb was related to the fatness of the animal. However, Jermiah, Smith, Carpenter and Kammlah (1971:44) found no correlation between differences in fatness and the palatability of lamb carcases.

According to French (1980:142) an important difference between sheep and goat meat is, that goat meat has a lower fat content and the carcase has no caudal

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condition. For instance fat deposits in comparison to sheep of the same age. These results were confirmed by Smith, Klingbiel and Naudé (1982:9). They found in a breed comparison study that the Boer goat has a very low proportion of subcutaneous fat. The thickness of the fat layer, *Mm. longissimus thoracis* at the traditional position in the region of the tenth and eleventh rib was 2,3 mm for the Boer goat, compared to values of between 5,4 and 5,9 mm for the South African Mutton Merino, Merino and Dorper (Naudé & Hofmeyr, 1981:297).

The characteristics of fatty tissues vary with species. It is particularly the fatty acids which vary in their degree of saturation and in chain length. Duncan and Garton (1967) as reported in Campbell, Penfield and Griswold (1980:120) stated that hard fat is associated with a high degree of saturation and that is why sheep fat is considered harder than beef fat. The highly saturated nature of sheep fat may influence its eating quality because it leads to rapid solidification during cooling after cooking, making it less palatable than the more unsaturated fats (Kempster, Cuthbertson & Harrington, 1982:12).

Water-holding capacity

When the temperature of meat increases during the cooking process, the myofibrils and therefore the fibres shrink as the meat reaches an internal temperature of 40 - 60 °C, largely due to the denaturation of the myosin. At temperatures above 60 °C denaturation of the collagen of the endomysium and perimysium occurs tending to cause this network to shrink. This widens the gap between the fibres and the surrounding endomysium already present during rigor, and causes the flow of aqueous solution down the annular channels to the cut ends, with the simultaneous transverse shrinking of the meat. Water-holding capacity (WHC) is important for consumer satisfaction since it affects the juiciness, texture and flavour of meat (Offer, Restall & Trinick, 1984:82).

The changes in WHC of frozen, raw or cooked meat are measured by subjecting a sample of the tissue to high pressure and assessing the amount of fluid forced out, as determined by mass changes, or by spread of the expressed moisture on filter paper (Sanderson & Vail, 1963:597). This method is usually termed the Expressible Moisture Index. High correlations between the degree of expressed fluid obtained from a cooked sample during a Carver press fluid test and sensory evaluations of meat juiciness have been reported

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(Berry,1983:103).

Factors affecting meat composition

According to Lawrie (1985:56) numerous factors associated with the living animal influence the composition and quality of the meat. These intrinsic factors include species, breed, sex, age and anatomical location. Treatment influences such as diet, fatigue, stress, fear, pre-slaughter manipulation and environmental conditions at slaughter are considered as extrinsic factors and will not be considered in this literature review.

Species

Variation between species is considered to be perhaps the most readily appreciated factor that affects and, to a certain extent, determines the composition and resulting sensory qualities of lean meat (Lawrie, 1985:56). Goat carcases contain a proportionally higher lean to bone content than the sheep carcasses, with more dissectable fat in the goat carcases (Owen, et al, 1978:60). Botswana sheep are fatter than goats at similar ages (Table 6). These results were similar to what Fehr, Sauvant, Delage, Dumont and Roy (1976:183) found in a study on the growth performance of young goats. As compared to lambs, kid carcases are characterized by a very low proportion of fat, particularly subcutaneous fat.

TABLE 6: TISSUE COMPOSITION OF GOAT AND SHEEP CARCASES (% MASS)

No. of incisors	Component											
	Lean		Fat		Bone		Trim and loss		Lean:bone ratio		Lean and fat: bone ratio	
	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep	Goat	Sheep
Milk	58,87	52,56	10,77	21,18	23,12	20,51	6,27	4,60	2,59	2,57	2,96	3,34
2	60,10	52,55	10,56	22,46	22,04	19,09	6,35	4,78	2,79	2,79	3,18	3,66
4	59,44	52,45	12,06	22,80	21,26	19,06	6,15	5,25	2,85	2,78	3,36	3,69
6	59,14	49,44	14,81	27,55	20,24	17,89	5,20	4,06	2,99	2,87	3,67	4,21
Full	57,79	-	14,93	-	18,89	-	8,99	-	3,08	-	3,91	-

(Owen, et al, 1978:61)

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Naudé and Hofmeyr (1981:305) concluded that the total fat content and muscling of the South African Boer goat carcases compare favourably with mutton-producing breeds such as the South African Mutton Merino and Dorper. It seems to yield a more superior meat carcase than the Angora, dairy and other meat goats. Boer goat carcases had a high muscle and low bone content, resulting in a high mean muscle to bone ratio (4,71:1), in comparison to the South African Mutton Merino (4,39:1), the Merino (4,32:1) and the Dorper (4,76:1) (Figure 2).

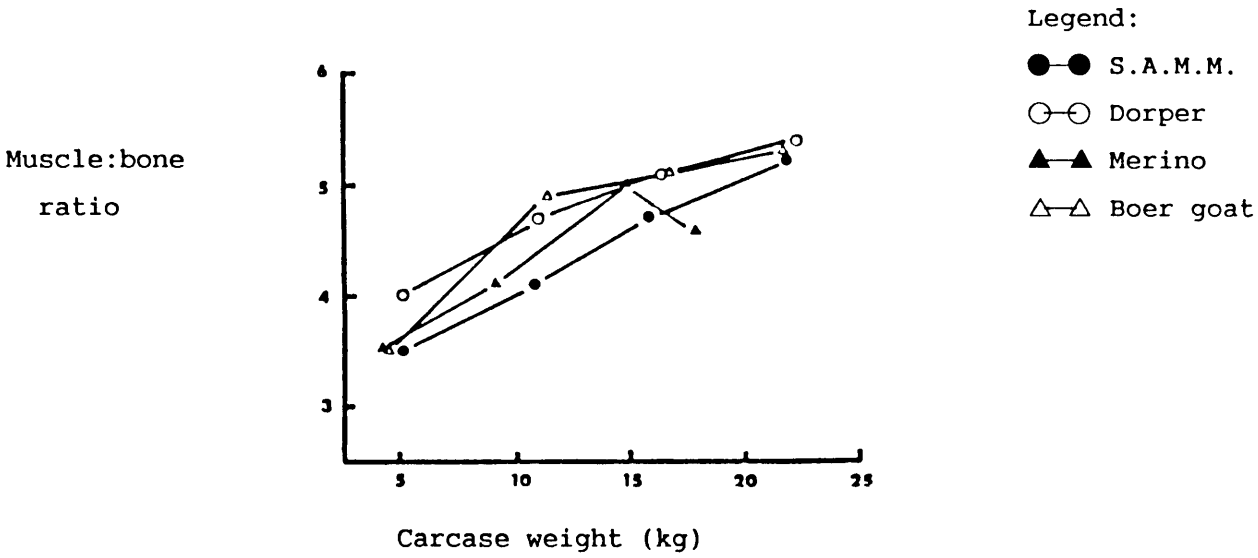

FIGURE 2: CARCASE COMPOSITION OF SOUTH AFRICAN KIDS AND LAMBS SLAUGHTERED AT 10, 23, 32 AND 41 KG LIVE MASS
(Naudé & Hofmeyr, 1981:294)

The essential amino acid composition of goat meat closely resembles that of beef and mutton, although it contains higher arginine, leucine and isoleucine values, as indicated in Table 7.

Breed

After species, breed exerts the most influence on items such as yield of cuts, lean to fat ratio, intramuscular fat distribution or marbling, firmness of fat, and colour, tenderness and juiciness of cooked meat. According to Sink and Caporaso (1977:122) studies on lamb and mutton indicate a great deal of variation between breeds. The percentage of intramuscular fat is considerably greater among certain breeds such as Hampshire and Suffolk in

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TABLE 7: AMINO ACID COMPOSITION OF MEAT SAMPLES (g/16g N)

	Type of meat		
Amino acid	Sheep meat	Goat meat	Beef
Arginine	6,6	7,4	6,8
Histidine	2,8	2,1	3,0
Lysine	7,9	7,5	8,1
Tryptophan	1,4	1,5	1,4
Phenylalanine	3,3	3,5	3,4
Methionine	3,1	2,7	2,9
Threonine	4,6	4,8	4,5
Leucine	7,6	8,4	7,5
Isoleucine	4,6	5,1	4,5
Valine	5,5	5,4	4,9
Tyrosine	3,0	3,1	3,4
Cystine	1,3	1,2	1,1

(Naudé & Hofmeyr, 1981:302)

comparison to Shetland (Lawrie, 1985:59). According to Heinze, et al (1986:3) the type of sheep breed bred primarily for meat or wool production has a marked influence on the collagen content of the muscles. The meat-type sheep breeds have lower average collagen content in comparison to the wool breeds.

Sex

In general, males have less intramuscular fat than females. However, the castrated members of each sex have more intramuscular fat than the corresponding sexually intact animals (Lawrie, 1985:59). Lloyd, Slyter and Costello (1981:319) report no differences ($p \leq 0,05$) between rams and wethers in mean values of palatability traits. However, other workers have reported less desirable flavour, aroma, tenderness and juiciness ratings for ram lambs when compared to wethers and ewes (Sink & Caporaso, 1977:121; Vesely, 1973:673).

Age

Irrespective of species, breed or sex, the ratio of lean to bone, and of fat to bone increases, as the amount of fat increases and the amount of total

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moisture decreases in the soft tissues with an increase in the age of the animal (Paul, 1972:338). According to Owen, et al (1978:60) the percentage of total lean in Botswana billy goat carcases increased up to the two-tooth age and decreased thereafter as indicated in Table 6. In sheep carcases, the total lean content did not change with respect to the other tissues in the various age groups, except in the six-tooth age group where it showed a decrease. Gonzalez, Owen and Cereceres (1983:313) reported a steady decrease in the total lean content with increasing slaughter mass to a level of approximately 76 % in the heaviest group. Ash and protein tended to fall, with intramuscular fat increasing to approximately 16 % of the wet tissue mass.

Although the collagen content seems to decrease with age, it could be ascribed to the increase of the muscle fibre content during the growth of the animal, and not directly to a decline in the total collagen content (Heinze, et al, 1986:172). As has already been mentioned, collagen becomes more thermally stable and less soluble with age due to the increasing degree of crosslinking between the collagen fibres.

A direct relationship exists between toughness and the age of an animal (Bailey, 1972:1004; Klingbiel, 1984:5.18). However, a contradiction seems to exist in the literature whether or not this effect of age on the tenderness of meat is positive or negative. On the one hand Smith, Carpenter and Shelton (1978:1229) found that yearling Angora goats produced chops and roasts which were juicier and more tender than those from more mature goats. Bruwer, Grobler, Smit and Naudé (1987:102) found an decrease in tenderness, juiciness, flavour, residue and collagen solubility as the age of lamb/sheep increased. Van der Westhuysen, Wentzel and Grobler (1985:246) reported that as is the case of sheep meat, the best and most tender meat is obtained from younger goats.

On the other hand Paul, Torten and Spurlock (1964:121) reported higher total cooking losses, more marbling, higher juiciness and tenderness scores, better texture, and a stronger flavour in eleven month old lambs when compared to five month old lambs. Pike, Smith, Carpenter and Shelton (1973:269) found loin chops from young goats less tender and less satisfactory overall than chops from yearling goats. Leg steaks from young goats were less flavourful, less juicy and less tender than steaks from yearling goats.

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The increase or decrease in quality characteristics is not explained in a simple manner and results from different studies are often contradictory (Smith, Carpenter, King & Hoke, 1970:317). For instance Mc Keith, De Vol Miles, Bechtel and Carr (1985:872) reported that total collagen was not a good predictor of tenderness.

Anatomical location

Grouping of the over 100 different muscles in the carcase according to anatomical location may be of value in studies of muscle growth, or when faced with practical commercial problems affecting the size, shape and fatness of specific cuts (Kempster, et al, 1982:15). It is, however, the most complex of the differentiating intrinsic factors. This is partly due to the variation in shape, size and composition of the muscles, thereby reflecting the diversity of activity and development - the details of which are still largely unknown.

For example the chemical composition of different anatomically located muscles varies greatly. Moisture and fat content ranges from 62,5 % and 18,1 % respectively in the intercostal muscles to 76 % and 1,5 % respectively in the *M. extensor carpi radialis*. Differences in hydroxyproline content of the various types of muscles have been demonstrated. Thus the lowest content of connective tissue may be seen in the *M. psoas major* (350 µg/g), but values as high as 2 500 µg/g have been reported for the *M. extensor carpi radialis* (Lawrie, 1985:70). Many similar examples may be quoted but falls beyond the scope of this review, e.g. quantitative differences in myoglobin and/or fatty acid composition.

Conversion of the living animal to meat

Presently the conversion of the living animal to a carcase usually includes stunning, bleeding, electrical stimulation, dressing, chilling and ageing for several days. Both electrical stimulation and ageing have a positive effect on palatability.

Electrical stimulation

Effective electrical stimulation is a method of ensuring that the inherent

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tenderness of the animal at the time of slaughter is passed on to the consumer. To a very large extend it prevents the occurrence of abnormal cold-shortening of muscles (Naudé, 1980:4). The effect of electrical stimulation on the tenderness of meat is demonstrated in Table 8.

TABLE 8: THE EFFECT OF ELECTRICAL STIMULATION ON TENDERNESS OF MEAT

Meat	Shear force values[a]		Sensory panel ratings[b]	
	Number of carcases or samples	Percentage improvement	Number of carcases or samples	Percentage improvement
Beef	656	23	452	26
Pork	90	9	180	3
Lamb	137	24	109	12
Goat	731	29	229	32

[a]The force required to shear a 127 mm core of cooked meat
[b]Rating of comparative tenderness and toughness of cooked product (Smith, 1985:121)

Post mortem electrical stimulation effectively lowers pH values (Figure 3) and markedly accelerates glycolysis. This reduces the time of the onset of rigor mortis. The increased rate of glycolysis in warm muscle may assist in preventing cold-shortening of muscle, as illustrated in Figure 4. When the pH of the meat reaches its minimum value, most of the ATP has been used up and glycogen has been converted to lactic acid (Seideman & Cross, 1982:249).

In recent years, research in the North American context has demonstrated that electrical stimulation not only improves meat tenderness but also enhances lean meat colour and maturity, increases the appearance of marbling, prevents development of the two-toned colour of the rib-eye known as "heat-ring", reduces the time necessary for ageing, enhances the flavour and increases muscle firmness (Seideman & Cross, 1982:248; Pearson & Dutson, 1985:185).

Although electrical stimulation is not generally performed on goat meat,

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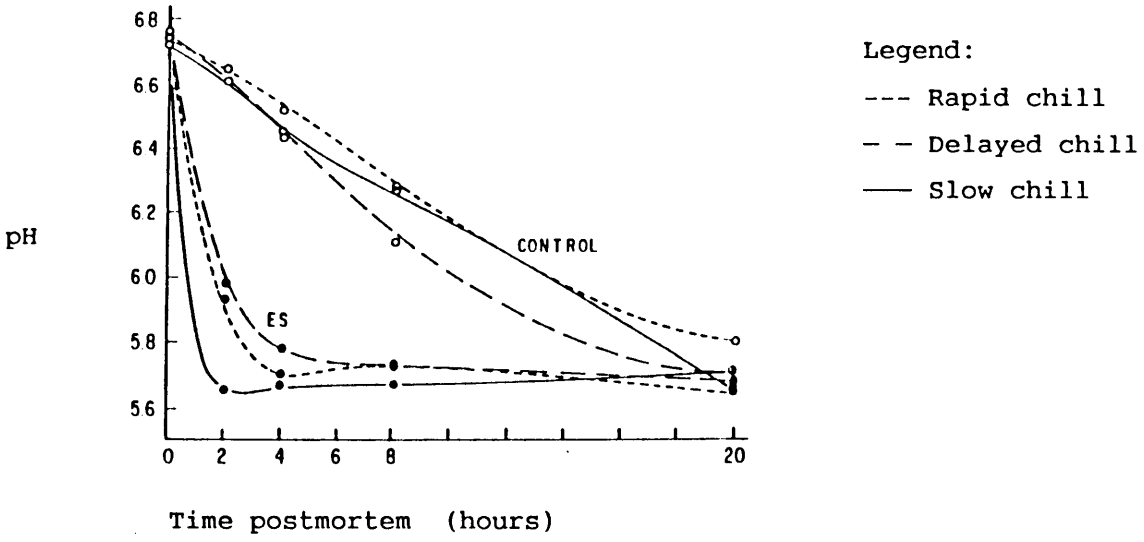

FIGURE 3: DECLINE OF pH IN ELECTRICALLY STIMULATED AND CONTROL SIDES OF LAMB CARCASES HELD UNDER DIFFERENT COOLING TREATMENTS
(Whiting, Strange, Miller, Benedict, Mozersky & Swift, 1981:485)

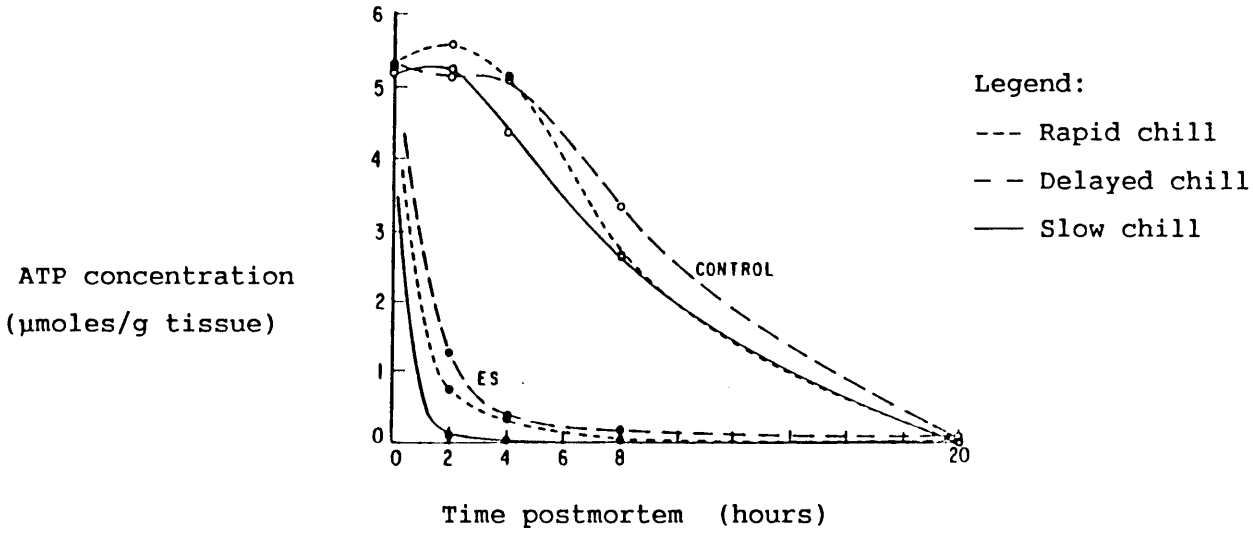

FIGURE 4: DECLINE OF ATP IN ELECTRICALLY STIMULATED AND CONTROL SIDES OF LAMB CARCASES HELD UNDER DIFFERENT COOLING TREATMENTS
(Whiting, et al, 1981:485)

McKeith, Savell, Smith, Dutson and Shelton (1979:977) indicated that electrical stimulation will improve the tenderness of goat muscles and that stimulation can be performed at any of several stages during the slaughter-dressing sequence. Smith, Savell, Dutson, Hostetler, Terrell, Murphey and Carpenter (1980:20) described goat carcases as being very

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susceptible to cold shortening. The researchers reported an increase in tenderness in electrically stimulated lamb and goat carcases.

Dressing

The relationship between the mass of the live animal just prior to slaughtering and the mass of the carcase subsequently produced, is important in a commercial enterprise. This relationship is commonly expressed as the dressing percentage versus carcase mass, given as a percentage of the live mass (Kempster, et al, 1982:23).

Within age and sex groups the live goat mass is a good indication of yield (Eggen, Carpenter, Smith & Shelton, 1971:60). In a study done on Sudan desert sheep and goats, goats yielded a higher carcase mass per unit live mass than sheep, the stomach contents and skin mass relative to live mass being greater in the sheep than in the goats (Gaili, Ghanem & Mukhtar, 1972:351).

A similar study was done on the growth and meat production of Boer goat, South African Mutton Merino, Dorper and Merino wether lambs and kids carcases slaughtered at approximately 10, 23, 32 and 41 kg live mass, respectively. The Boer goat had a remarkably high dressing percentage (Figure 5) of 48,3 % compared to that of the South African Mutton Merino (46,6 %) and the Merino (41,0 %), but similar to that of the Dorper (48,5 %) (Naudé & Hofmeyr, 1981:293).

Ageing

The holding of unprocessed meat above its freezing point is known as "conditioning", "maturing", "ripening" or "ageing". This is associated with an increase in tenderness and flavour as a result of proteolitic or enzymatic action (Lawrie, 1985:82). The major changes of ageing are the increased ease of muscle extension to twice equilibrium length, the loss of intermyofibrillar adhesion, fading of the Z-lines and a loss of g-filaments (Davey, 1984:15). The enzymes most likely to be involved in this proteolitic action are the cathepsins B, D, H and L, and the calcium activated proteases CAF and CANP (Dutson, 1983:203).

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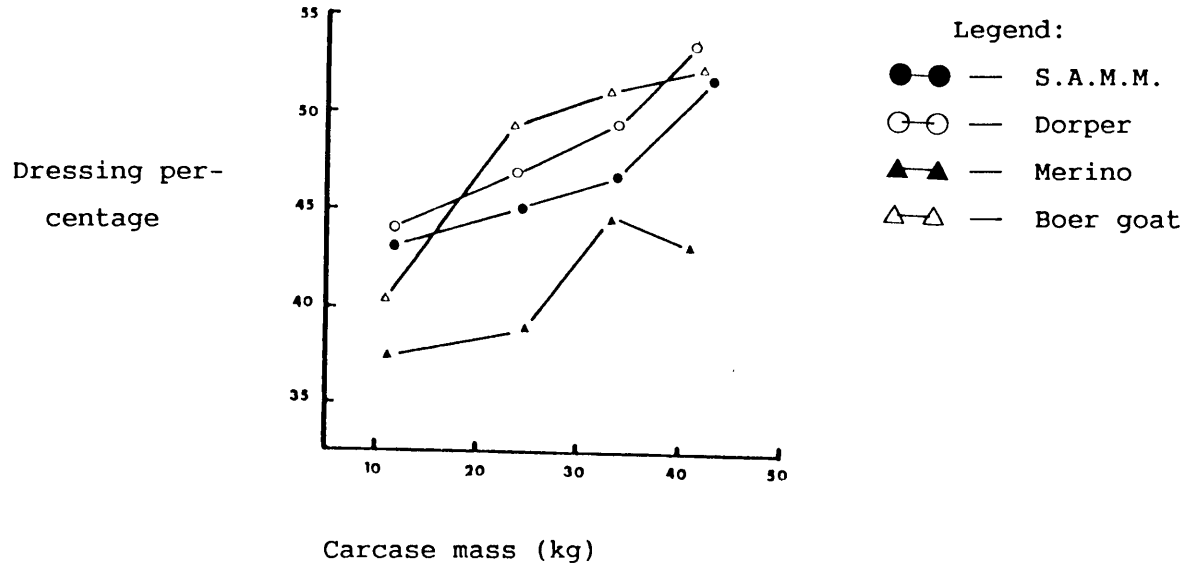

FIGURE 5: DRESSING PERCENTAGE OF THE SOUTH AFRICAN MUTTON MERINO (S.A.M.M.), DORPER AND MERINO LAMBS AND BOER GOAT KIDS SLAUGHTERED AT 10, 23, 32 AND 41 KG LIVE MASS

(Naudé & Hofmeyr, 1981:294)

Ageing is usually carried out at approximately 1 °C with a relative humidity of approximately 70 %. The recommended ageing period for sheep and goats is seven days at 1 to 3,3 °C (Charley, 1982:390). The tenderness, juiciness and flavour attributes of meat, especially the bovine and ovine species, are usually improved by a period of storage or ageing, although it may have adverse effects on the drip loss (Sink & Smith, 1972:181; Alexander & Fox, 1975:284; Stanley, 1974:109). However, modern commercial practice involves vacuum packaged storage of carcase cuts thus solving the problem of drip loss or carcase mass loss during ageing.

Heat-induced changes in meat and methods of heating

Cooking

Heating produces marked physical changes in meat due to the denaturation and coagulation of muscle proteins - even at temperatures as low as 40 °C (Parrish, 1974:127). Heat also causes fat to melt, changes in pH, reduced water-holding capacity and chemical changes in heat-labile compounds. For

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example, many of the myofibrils are broken at the Z-lines, and the I-bands virtually disintegrate (Jones, 1977:83). During the heating period collagen shrinks, swells, disintegrates and is solubilised (Boccard, Naudé, Cronje, Smit, Venter & Rossouw, 1979:269). The type and extent of these changes vary with the composition and mass of the meat, as well as consequent to the method and extent of heating (Paul, 1972:395).

Two separate phases of toughening occur during the heating of muscle. The first, which occurs at an internal temperature of between 40 °C and 50 °C, is associated with a loss of myosin solubility and indicates protein denaturation in the contractile system. The second phase at temperatures between 65 °C and 75 °C, is associated with a 25 - 30 % shrinkage along the muscle fibres and is largely due to denaturation of connective tissue proteins (Seideman & Durland, 1984:293).

In a palatability study by Cross, Stanfield, Garrison and Koch (1975:288), tenderness and juiciness decreased as the internal temperature of steak increased, regardless of the oven temperature. This decrease was more pronounced in the meat from the older animals. According to Charley (1982:403) the loss of mass as meat is cooked, may be considered to be a rough index of the decrease in water-holding capacity, and changes in, the muscle tissue. Solomon, Kemp, Moody, Ely and Fox (1980:1106) ascribed variations in cooking losses among rib roasts, which were similarly prepared, to the differences in sample fatness. Leaner roasts generally had more evaporative loss, while fatter roasts had more drip loss. According to Seideman and Durland (1984:294) oven temperature, relative humidity, sample dimension and initial sample temperature are all factors that play a role in the final temperature, mass loss and yield during the oven-cooking of meat.

According to Cross (1977:184), cooking times were significantly affected by the amount, distribution and texture of marbling. Cooking times were the longest for steaks that were low in amount, distribution and coarse in texture of marbling. However, interactions of oven temperature, internal temperature and carcase maturity, with the amount of marbling, its distribution and texture were not significant.

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Cooking method

The cooking method applied to a specific meat cut may have a pronounced effect on the ultimate palatability of that meat. The rate of heat penetration into the meat depends on the cooking method and affects the ultimate tenderness of the meat. The rate at which the interior of meat is heated is influenced by the rate and intensity level at which the energy is transmitted to the meat, the shape and size of the sample being heated, the composition of the sample, the spatial distribution of areas of lean, fat, connective tissue and bones, the characteristics of the meat surface and any changes induced in the meat by heat, including protein denaturation, loss of water and the melting of fat (Seideman & Durland, 1984:296).

Cooking methods are often designated as dry or moist. These terms refer to the atmosphere surrounding the meat. The influence exerted by the cooking method is usually dependent on the rate at which heat energy is supplied to the external surface, for example water vapor is a more efficient conductor of heat than is dry air. Moist and dry cooking methods also differ in the temperature to which the external surface of the meat is exposed. Unless under pressure, the temperature of water vapor will not exceed 100 °C. This is considerably lower than the external surface temperatures of the meat in an oven or during deep fat frying. The effect of microwave cooking on palatability is unique since microwave energy is not transferred as surface heat but is rather converted to heat within the meat (Paul, 1972:412 and 413).

The method of cooking recommended for a specific cut of meat is based on the classification of the cuts as "tender" or "less tender", according to the relative quantity and solubility of connective tissue and muscle fibres in the muscle. Moist heat is usually recommended for less tender cuts to solubilize the collagen and a dry heat method for tender cuts (Ferger, Harrison & Anderson, 1972:226). Cuts considered to be less tender, contain larger amounts of connective tissue and therefore require long slow cooking in a moist atmosphere to complete the hydrolysis of collagen into gelatin. This action occurs in collagen, but not in elastin (Bratzler, 1971:304).

Ferger and co-workers (1972:229) stated that there is little difference between dry and moist heat cooking methods in terms of cooking time, percentage total cooking loss, flavour, juiciness and tenderness. Meat

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cooked by dry heat at 160 °C and cooked to a internal endpoint temperature of 60 °C, appears less well-done than meat cooked by moist heat to the same endpoint temperature.

Roasting

Roasting is a dry heat cooking method in which the meat is placed on a rack in an uncovered pan and cooked in a closed preheated oven to the desired internal temperature (American Meat Science Association, 1978:3). The principle form of heat transfer is through the air by convection and the meat is heated by conduction (Campbell, et al, 1980:128).

Braising

Braising is a moist heat cooking method. The meat is cooked in a covered utensil and liquid may or may not be added. Heat transfer is by convection from the moist atmosphere surrounding the meat and by conduction from the surface in contact with the meat. The rate of heat penetration in braising is more rapid than in roasting, because steam conducts heat more rapidly than air (latent heat of vaporization) (Campbell, et al, 1980:131; Ferger, et al, 1972:226).

Palatability characteristics

Food quality evaluation may be done by using chemical, physical and sensory methods although only sensory methods can determine food preferences and whether or not a certain food is acceptable (palatable) to the specific group tested. Chemical and physical testing methods are usually applied in conjunction with sensory methods to elucidate sensory scores (Palmer, 1972:727).

Although consumer preferences for meat are extremely difficult to define according to Carpenter (1966:1232), consumers tend to evaluate meat quality on the basis of the tenderness, juiciness and flavour of the cooked meat. Swatland (1984:165) described the degree of tenderness perceived during consumption, when the meat was cooked to a certain endpoint temperature, as the most important physical property of meat. Similarly, Bailey (1972:995) described the tenderness of meat as probably the most important single factor

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in the consumer's assessment of its quality.

Aroma

The aroma of meat is the sensory quality attribute ascribed to certain volatile substances as perceived by the olfactory organ. The odour of fresh raw meat tends to intensify during maturity and exposure to heat (Cross, Durland & Seideman, 1986:289). The ultimate odour of meat is influenced by the cooking method, the kind of meat and the treatment of the meat prior to cooking (Bratzler, 1971:306). According to Wasserman and Talley (1968:223) the aroma-fraction of lamb and mutton fat is water-soluble upon heating.

Juiciness

The juiciness of meat is directly related to the intramuscular lipids and moisture content of the meat (Cross, et al, 1986:313). In combination with water, the melted lipid constitutes a "broth" that, when retained in the meat, is released upon chewing (Forrest, Aberle, Hedrick, Judge & Merkel, 1975:295). These lipids present in meat act as a means of lubrication and thus ensure sustained juiciness (Cross, et al, 1986:313). They may also stimulate the flow of saliva, and thus improve the meat's apparent juiciness. However, the major contributor to the sensation of juiciness is the water remaining in the cooked product (Forrest, et al, 1975:296).

Flavour

Flavour is an important aspect of meat quality and is sometimes even described as being the criterion of the acceptance or rejection of the product (Crouse, 1983:264). Misock, Campion, Field and Riley (1976:1440) suggested that flavour and aroma are most important in determining the palatability of goat meat. Cross, et al (1986:279) describes flavour as the complex sensation from the combination of the olfactory and gustatory attributes perceived during tasting, which may be influenced by tactile, thermal, pain, and even kinaesthetic effects. According to Sink and Caporaso (1977:121) it is a generally accepted fact that meat animal flavour increases with chronological age.

Flavour can also be affected by factors such as texture, temperature and pH.

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Ockermann, Emsen, Parker and Pieterson (1982:1368) reported, for instance that increases in the fineness of wool in different lamb breeds were accompanied by increased mutton flavour. Dry heat cooking imparts certain flavours, particularly at the exposed surfaces where temperatures become very high. On the other hand, cooking with moisture under pressure causes the development of pronounced and unique flavour changes in the deep tissues of the cut (Forrest, et al, 1975:302).

The components in meat mainly responsible for flavour and aroma are thought to be inosine monophosphate (IMP) and hypoxanthine. They are both breakdown products of ATP and this is probably why muscles with large energy stores would have a more pronounced flavour. This may be responsible for the intensity of flavour found in the frequently used muscles of the carcase (Forrest, et al, 1975:296). The "meat" odour and flavour of a sample (species flavour), or its "meatiness" are the natural odour and flavour one would expect in meat from a particular species (Ford & Park, 1977:221). Most of the constituents responsible for the "meaty" flavour are water soluble components of the muscle tissue, while species flavour and aroma are thought to arise from some material in the fat that becomes volatilized upon heating (Forrest, et al, 1975:296).

Wong, Johnson and Nixon (1975:265) correlated a "goaty" odour note common to goat and sheep meat, with the presence of 4-methyloctanoic acid to which the name "hircinoic" acid has been given. Brennard and Lindsay (1982:252) also indicated that both 4-methyloctanoic and 4-methylnonanoic acid are associated with ovine specific flavours. These components have been identified as the characteristic "sweaty-sour" odour in mutton (Wong, et al, 1975:261). In other words branched chain and unsaturated acids having 8 to 10 carbon atoms contributed to the undesirable aroma and flavour of cooked mutton. A nine-point verbal scale (none=1, intense=9) was used by their trained sensory panel.

Tenderness

According to Pearson (1963:135) the sensation of tenderness is a complicated physical process since chewing involves cutting and grinding, and to a lesser extend squeezing, shearing and tearing. A variation in tenderness between meat cuts can be caused by variations in fat content, amount, and chemical

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state of connective tissue and actomyosin effects (Cross, et al, 1986:311). Forrest, et al (1975:290) describes the perception of tenderness in terms of the following conditions of meat during mastication: softness to tongue and cheek; resistance to tooth pressure; ease of fragmentation; mealiness; adhesion and residue after chewing.

The most commonly used instruments in evaluating meat tenderness is the Warner-Bratzler Shear Device and Instron. Factors found to affect the accuracy of these instruments include doneness of the cooked meat, uniformity of cylindrical sample size, direction of the muscles fibers, amount of connective tissue and fat deposits present, temperature of the sample and the speed at which the sample is sheared. The results usually correlate well with trained sensory evaluation scores (Cross, et al, 1986:312).

Residue

Residue (fibrous tissue residue) consists of a description of the result of chewing a meat sample to the state at which it would normally be swallowed and it may include mealiness. The number of chews required to masticate the sample is often used as an objective approach to sensory procedures (Pearson, 1963:139). Residue after chewing is detected as that connective tissue remaining after most of the sample has been masticated. The coarse strands of connective tissue in the perimysium or epimysium are responsible for this component (Forrest, et al, 1975:290).

Summary

Kirton (1970:167) concluded that according to taste panel results, meat from domestic sheep was preferred to the meat from female feral goats, which was in turn preferred to meat from the males. Most of the discrimination against goat meat, they ascribed to lack of tenderness, with no indication of any strong flavour or odour associated with the meat from male animals. The meat of older animals was generally less acceptable than that of young ones. Smith, Pike and Carpenter (1974:1146) found that meat from Angora goat carcases was rated lower in flavour than meat from pork carcases and less desirable than either beef or lamb in sensory panel comparisons. Goat meat was less desirable than beef and pork in flavour and tenderness and less desirable than lamb in flavour, juiciness and tenderness (Pike, Smith &

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Carpenter, 1973:269). The researchers concluded that chops or steaks from goat carcases are not interchangeable with those from lambs of similar ages and are generally less tender and less palatable to consumers than meat from other domesticated species.

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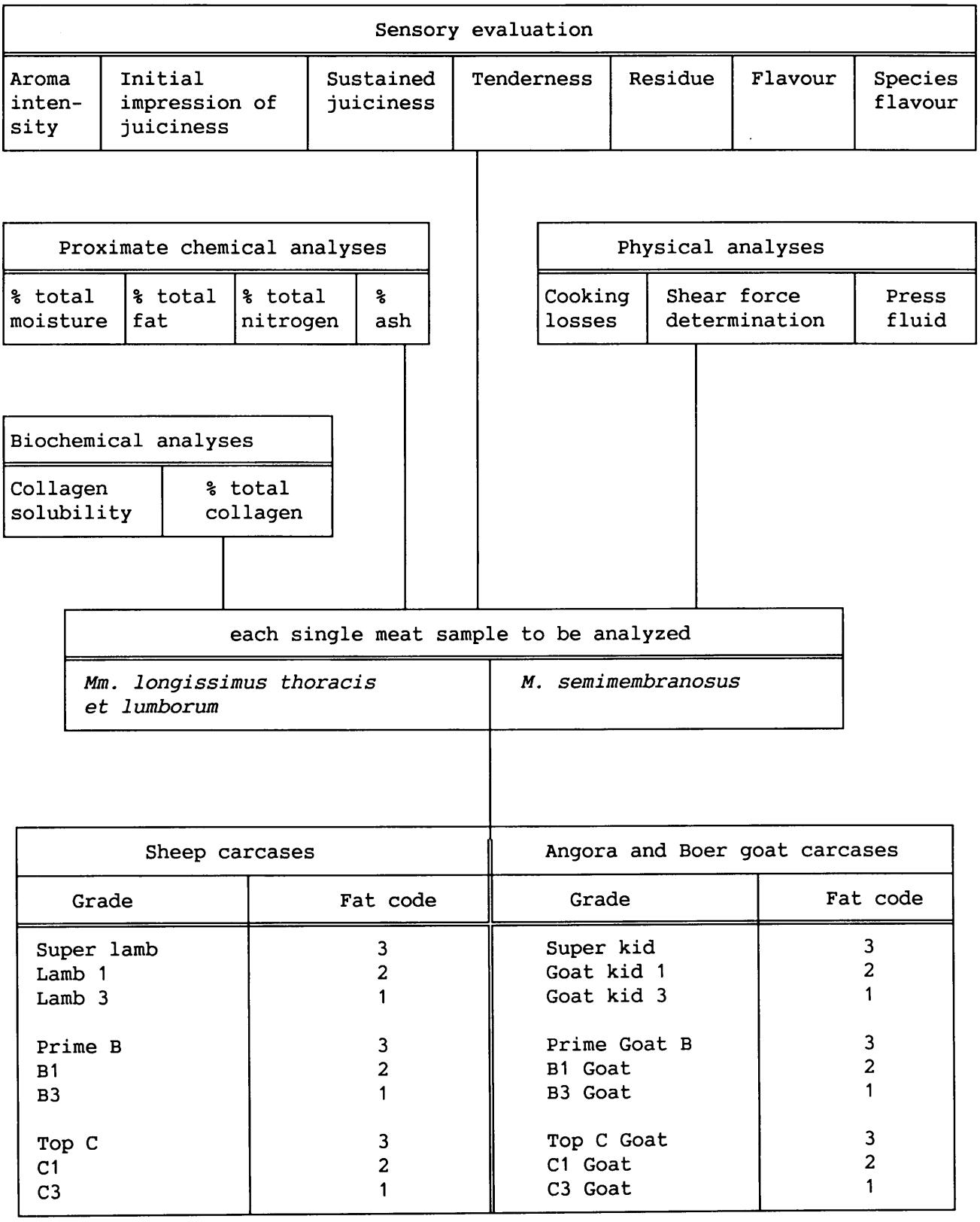
CHAPTER 3

SCOPE AND DEFINITIONS

Conceptual framework



Sheep carcases		Angora and Boer goat carcases	
Grade	Fat code	Grade	Fat code
Super lamb	3	Super kid	3
Lamb 1	2	Goat kid 1	2
Lamb 3	1	Goat kid 3	1
Prime B	3	Prime Goat B	3
B1	2	B1 Goat	2
B3	1	B3 Goat	1
Top C	3	Top C Goat	3
C1	2	C1 Goat	2
C3	1	C3 Goat	1

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Hypotheses

The term "quality characteristics" refers to every aspect of meat as defined in the conceptual framework. Each aspect will be tested individually through statistical analysis.

There will not be any significant difference between the various quality characteristics of the Angora and Boer goat *Mm. longissimus thoracis et lumborum* prepared according to a dry heat cooking method, when respectively compared with the corresponding quality characteristics of the sheep *Mm. longissimus thoracis et lumborum* identically prepared.

There will not be any significant difference between the various quality characteristics of the Angora and Boer goat *M. semimembranosus*, prepared according to a moist heat cooking method, when respectively compared with the corresponding quality characteristics of the sheep *M. semimembranosus* identically prepared.

There will not be any significant difference between the various quality characteristics of the *Mm. longissimus thoracis et lumborum* of the A and B age groups, prepared according to a dry cooking method, when respectively compared with the quality characteristics of the corresponding cuts of the C age group, identically prepared.

There will not be any significant difference between the various quality characteristics of the *M. semimembranosus* of the A and B age groups, prepared according to a moist cooking method, when respectively compared with the quality characteristics of the corresponding cuts of the C age group, identically prepared.

There will not be any significant difference between the various quality characteristics of the *Mm. longissimus thoracis et lumborum* with a fat code of one and two, prepared according to a dry cooking method, when respectively compared with the quality characteristics of the corresponding cuts with a fat code three, identically prepared.

There will not be any significant difference between the various quality characteristics of the *M. semimembranosus* with a fat code of one and two,

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prepared according to a moist cooking method, when respectively compared with the quality characteristics of the corresponding cuts with a fat code three, identically prepared.

Assumptions

The trained sensory panel evaluated the meat samples objectively and consistently without being influenced by external factors.

After initial standardization of techniques during the preliminary study, the meat was treated identically for each test throughout the project.

Left and right sides of a given carcase were considered to be identical.

Operational definitions

Total cooking losses

All the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts were weighed (using a Mettler PE 16 electronic balance) pre- and post-thawing as well as after roasting and braising respectively, for the determination of total moisture losses during the thawing and cooking processes respectively. Total and drip cooking losses were calculated using initial and final total mass of each cut and the volume of drippings from each sample. Evaporation losses were then calculated as the difference between the total cooking losses and drip losses. These calculations were performed according to the guidelines of the American Meat Science Association (1978:20), using a LOTUS 1-2-3 program (Lotus Development Corporation 1983). Evaporation, drip and total cooking losses were expressed as a percentage of the initial raw mass of the meat.

Sensory evaluation

A score sheet (Appendix A), with a six point Likert-type measuring scale, one denoting the least favourable condition and six the most favourable, was used by a trained ten-member sensory panel of the Meat Science Centre of the Animal and Dairy Science Research Institute (ADSRI), to record the assessment of the sensory quality characteristics of aroma intensity, initial impression

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of juiciness, sustained juiciness, tenderness, residue, flavour and characteristic species flavour for each sample.

Shear force determination

Toughness was measured as the maximum force required to shear a 12,5 mm diameter cylindrical core of cooked meat perpendicular to the grain. The shear force was generated with a Warner Bratzler shear attachment fitted to an Instron Universal Testing Machine Model 1140 (Instron Food Testing Instrument, 1974:5.3). The higher the reading obtained, the greater the shear force required to cut through the meat, therefore the tougher the meat.

Press fluid determination

A direct indication of the water holding capacity of the cooked meat was obtained from the amount of expressible moisture measured as a percentage of the initial unpressed mass of sample which was subjected to a compressive force of 1 metric ton for 60 sec by means of a Carver laboratory Press Model C. A quadruplicate test was performed on each sample using a Mettler AE 160 electronic balance to weigh the aluminium foil (45 x 45 mm) and sample. Whatman no 4 filter paper was used to absorb all expressed moisture (Sanderson & Vail, 1963:596).

Biochemical analysis

The total collagen content of the *M. longissimus thoracis* was determined according to a method of Weber (1973:5). Hydroxyproline was determined according to Bergman and Loxley (1963:1967). Total collagen content was calculated as the ratio hydroxyproline relative to the total nitrogen content, expressed as a numeric value. The solubility of the collagen was determined according to a combination of the methods of Hill (1966:163) and of Bergman and Loxley (1963:1967). Collagen solubility was expressed as the percentage hydroxyproline in the filtrate as compared to total amount of hydroxyproline (filtrate plus residue). These determinations were not performed on the *M. semimembranosus* which was too small to yield sufficient analysis material.

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Proximate chemical analysis

Determination of the percentages of total moisture, fat, nitrogen and ash of the cooked samples were done according to the accepted AOAC-methods (1985).

Carcase classification and grading

In the South African grading system two variables are included, namely fat codes (indicating lean yield) and age classes (indicating tenderness). Three age classes can be identified for mutton and goat carcases namely the lamb or kid age group (no permanent incisor teeth), the B age group (1 to 6 permanent incisor teeth) and the C age group (7 to 8 permanent incisor teeth).

Sheep and goat carcases can be described with respect to fatness as:

Fat code (Fatness classification)	Description	Thickness of subcutaneous fat layer
3	Medium	>3 to 5 mm in lamb and sheep carcases
2	Lean	1 to 3 mm in lamb and sheep carcases
1	Very lean	<1 mm in lamb and sheep carcases

(Government Gazette, 1985:14)

The thickness of the subcutaneous fat layer is not specified in the grading system for kid and goat carcases, because of differences in fat distribution. The percentage subcutaneous fat, especially the thickness of fat at the measuring point (13th thoracis vertebra) is less in Boer goats than in sheep carcases (Naudé, 1985:112).

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CHAPTER 4

EXPERIMENTAL PROCEDURE

Population and sampling

An analysis of kid and goat slaughterings in 1986 is furnished according to carcase grade composition in Table 9. Due to the fact that no carcases were available in the Kid 2, B2 Goat and C2 Goat classes, these grades were excluded for both goat and sheep in this study (Table 10). Castrates and ewes were used to exclude the possible negative hormonal effect of intact or entire rams and billy goats on flavour.

TABLE 9: ANALYSIS OF KID AND GOAT SLAUGHTERINGS ACCORDING TO CARCASE GRADE COMPOSITION

Grade	Number of carcases
Super kid	779
Kid 1	7 449
Kid 2	0
Kid 3	9 844
Prime B Goat	1 121
B1 Goat	5 739
B2 Goat	0
B3 Goat	5 568
Top C Goat	5 901
C1 Goat	20 705
C2 Goat	0
C3 Goat	28 402
Total controlled markets	85 517
Total rural markets	11 842

(Meat Board, 1987:7)

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TABLE 10: STANDARDIZED SPECIFICATION FOR SHEEP AND GOAT CARCASES

Sheep carcases				Angora and Boer goat carcases (respectively)			
Grade	Fat code	Cold mass (kg)	No. of car-cases	Grade	Fat code	Cold mass (kg)	No. of car-cases
Super lamb	3	15-25	3	Super kid	3	15-25	3
Lamb 1	2	10-20	3	Kid 1	2	10-20	3
Lamb 3	1	10-20	3	Kid 3	1	10-20	3
Prime B	3	20-30	3	Prime Goat	3	20-30	3
B1	2	15-25	3	B1 Goat	2	15-25	3
B3	1	15-25	3	B3 Goat	1	15-25	3
Top C	3	20-30	3	Top C Goat	3	20-30	3
C1	2	15-25	3	C1 Goat	2	15-25	3
C3	1	15-25	3	C3 Goat	1	15-25	3
Total			27				54

The Angora and Boer goat carcases were procured according to the standardized specification (Table 10), by the Meat Board representatives at the Port Elizabeth and Cato Ridge abattoirs. All carcases were electrically stimulated (600 volts for 60 seconds or 800 volts for 45 seconds) to prevent toughening caused by rapid chilling, then aged for seven days at between 1 and 7 °C, then finally wrapped in stockinette and plastic bags, labeled and stored at -20 °C until transportation in frozen state to the ADSRI, Irene. At Irene the carcases were repacked in thick plastic bags in order to exclude as much air as possible and stored at -20 °C until subdivision (still in the frozen state), coding and vacuum packaging. "Bone guard" was used to prevent damage to packaging material and hence loss of vacuum.

The required sheep carcases procured from City Deep in Johannesburg or Chamdor in Krugersdorp, were similarly electrically stimulated. They were then transported by road to the ADSRI at Irene in a refrigerated truck, aged there for seven days at 1 to 7 °C, labelled, re-wrapped and stored at -20 °C until all the carcases had been obtained. Consequently they were treated identically to the goat carcases. The relevant carcase number, age, date of slaughter, fat code, cold mass, abattoir of slaughter, and geographical area

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of origin for the different breeds are furnished in Appendix B.

Training of the panel

An extensive sensory evaluation training course was presented to the personnel of the Meat Science Centre of the ADSRI over a period of a month. The purpose of the course was to train the personnel in evaluating food as well as to record their sensory abilities. It was attended by an average of 27 personnel. The training was according to the procedures of Amerine, Pangborn and Roessler (1965:223), Jellinek (1985:167) and Charley (1982:5).

The following lectures were presented during the course: definition of sensory analysis, types of panels, importance of selection and training; evaluation of food by means of human sensory organs; test procedures or methods; program design for sensory evaluation; the structure of meat; and computer utilization for taste panel evaluation.

The following practical taste sessions were presented during the course: two general recognition tests of the four basic tastes; threshold tests consisting of sour and salty, water and bitter, sweet and sour; different test procedures namely a paired difference test, triangle test, duo-trio test, ranking test, descriptive and rating test and hedonic test; taste panels on curry and chicken; taste panel to differentiate the four different red meat species namely beef, sheep, pork and goat; as well as two taste panels on the various meat quality characteristics.

Following each taste session the individual results were calculated and displayed according to a specific set of identification numbers so that panelists could compare their results with the group opinion. The results of the most accurate and consistent panel trainees were marked as "star pupils". This was found to be an excellent motivator toward accurate performance. Trainees with the highest scores were selected for further training necessary to complete this study.

Preliminary study

The preliminary study consisted of the planning, utilization, standardization and evaluation of all the techniques and equipment to be used in the final

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study. The following aspects were investigated and final procedures decided upon:

Cutting, labelling and vacuum packaging of carcases

A standardized cutting procedure (Bruwer, 1984:89) was used consisting of the following different cuts:

- The legs cut taken from the position between the 7th lumbar and the 1st sacral vertebrae
- *M. longissimus lumborum* cut taken from the position between the 1st and 2nd lumbar vertebrae to between the 7th lumbar and 1st sacral vertebrae.
- *M. longissimus thoracis* taken from the position between the 6th and 7th thoracic vertebrae to between the 1st and 2nd lumbar vertebrae.
- The shoulders attached to the brisket.
- The ribs were cut from the backbone, cut in half and stored with the flank.
- The remaining parts (neck, shanks and kidneys) were packaged together.

The various cuts were labelled, vacuum packed in "Cryovac" vacuum-shrink bags and stored at -20 °C until further evaluation.

Sensory panel training

In the first training session the *M. triceps brachii caput longum* cuts of a Top C and B3 sheep, as well as the *Mm. longissimus thoracis et lumborum* of a C3 goat and a kid were cooked, subjected to sensory evaluation and subsequently discussed with the panel to ensure that they understood and were familiar with all the attributes to be evaluated. The score sheet was designed and the characteristics to be evaluated were thoroughly discussed with the sensory panel to ensure that the instructions were clearly understood. Panel suggestions regarding applicability, accuracy and acceptable terminology were incorporated.

In a second training session the panel had to discriminate between four species. The *Mm. longissimus thoracis et lumborum* of a C3 goat and the *M. triceps brachii caput longum* cut of a B3 sheep were cooked at 160 °C to an internal temperature of 75 °C. A pork and beef *Mm. longissimus*

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thoracis et lumborum were cooked at 180 °C to an internal temperature of 77 and 70 °C respectively. After sensory evaluation the panel was again screened for taste sensitivity according to species.

Possible variations in tenderness, residue and flavour intensity were demonstrated in a third training session. Calf and beef *M. psoas major*, as well as beef *Mm. longissimus thoracis et lumborum* were cooked at 180 °C to an internal temperature of 70 °C and evaluated by the taste panel.

In a fourth training session the panel had to discriminate between the aroma and flavour of a mature sheep and lamb meat, as well as meat from a mature goat and kid. This completed the training for the evaluation of the *Mm. longissimus thoracis et lumborum* cuts cooked according to a dry cooking method (Phase 1).

At the completion of Phase 1, Phase 2 of the taste panel training commenced for a further three sessions, with the evaluation of the *M. semimembranosus* cuts cooked according to a moist cooking method. During the taste panel sessions the *M. semimembranosus* of a kid, C3 goat and B3 sheep were cooked and evaluated.

Due to the fact that a different cooking method was used the sensory panel experienced difficulties in distinguishing between the various species. The *M. triceps brachii caput longum* cuts of an Angora and Boer goat as well as a sheep were cut into cubes, 200 ml distilled water per kg of meat was added and cooked at low heat on a Defy Solid Plate Hob on setting number two for 120 minutes in 20 cm stainless steel sauce pans. Each taste panel member had to identify the sample species by aroma before identifying by taste. If they were unsuccessful or unsure they had to repeat the exercise until they had memorized the aromas for future reference.

The same score sheet was used for both the evaluation of the *Mm. longissimus thoracis et lumborum* cuts cooked according to a dry method (Phase 1), as well as the evaluation of the *M. semimembranosus* cuts cooked according to a moist cooking method (Phase 2).

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Standardization of cooking procedures

The period necessary to thaw the meat cuts at 10 °C to ensure a standardized internal temperature before cooking, was determined.

The four Defy Gemini ovens used were standardized, at 160°C with a Leeds and Northrup Speedomax 2500 Recorder with Type J thermocouples and mercury thermometers (0 to 300 °C).

In the preliminary study the different roasting conditions of the *Mm. longissimus thoracis et lumborum* cuts were tested. The oven rack position, second shelf from the bottom, and the cooking time required per unit sample mass, to reach an internal temperature of 75 °C (50 minutes per kilogram for the *M. longissimus lumborum* cuts and 45 minutes per kilogram for the *M. longissimus thoracis* cuts) were thus finalized. The right side *M. longissimus lumborum* cuts of the three species were simultaneously roasted in a Defy Gemini Cordon Bleu oven. The left side *M. longissimus lumborum* and *M. longissimus thoracis* cuts representative of each species, were individually roasted without a cover, in Defy Gemini Cordon Bleu ovens set at a temperature of 160 °C.

For braising of the *M. semimembranosus* cuts the cooking time was 50 minutes per kilogram. The right side *M. semimembranosus* cuts of the three species were individually placed in cooking bags, closed with a string and cooked to an internal temperature of 75 °C in Defy Gemini Cordon Bleu ovens set at 160 °C. Due to size the sheep *M. semimembranosus* cut was cooked separately, while the two goat cuts were cooked simultaneously. The left side *M. semimembranosus* cuts for each specie were individually placed in cooking bags on a rack and cooked to 75 °C internal temperature. As it was difficult to measure the internal temperature of the muscle with the J-type thermocouple due to the fact that the whole leg was cooked and then the muscle was dissected out of the leg, the internal temperature was repeatedly checked with a Kane-May 1012 type T probe as soon as the J-type thermocouples registered 73 °C.

Sampling and evaluation

Method of sampling was determined and standardized during the preliminary

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study. Both left and right sides were used as the size of the cuts from the kid carcases was a limiting factor in sampling. Refer to Figures 6 and 7 for a schematic diagram of the various samples taken for the different analyses.

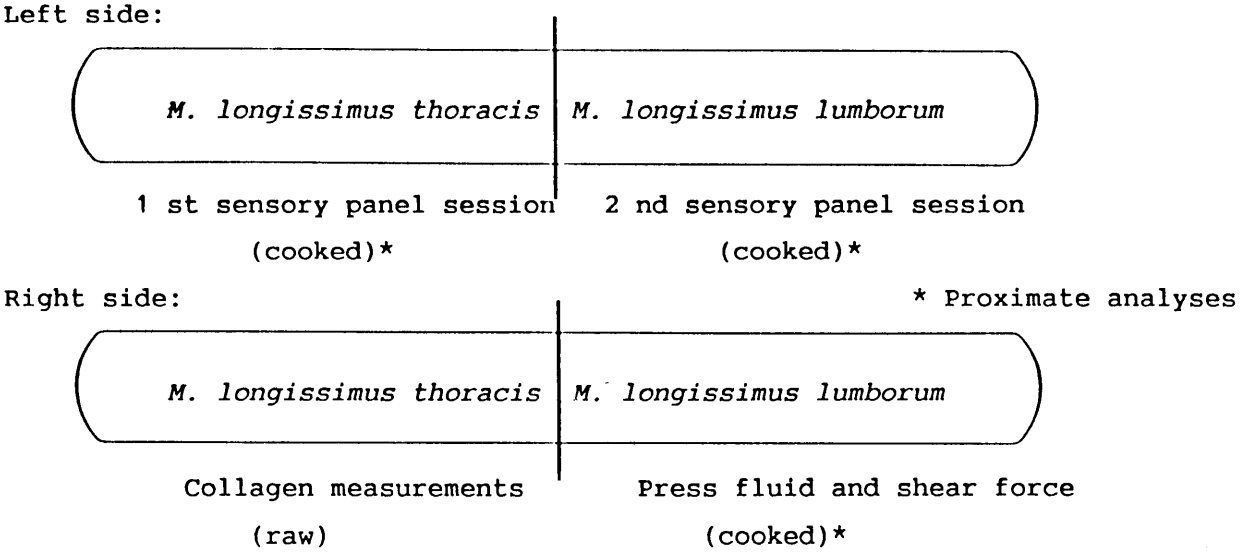

FIGURE 6: SAMPLES TAKEN FOR DIFFERENT ANALYSES, OF LEFT AND RIGHT *Mm. longissimus thoracis et lumborum* SIDES

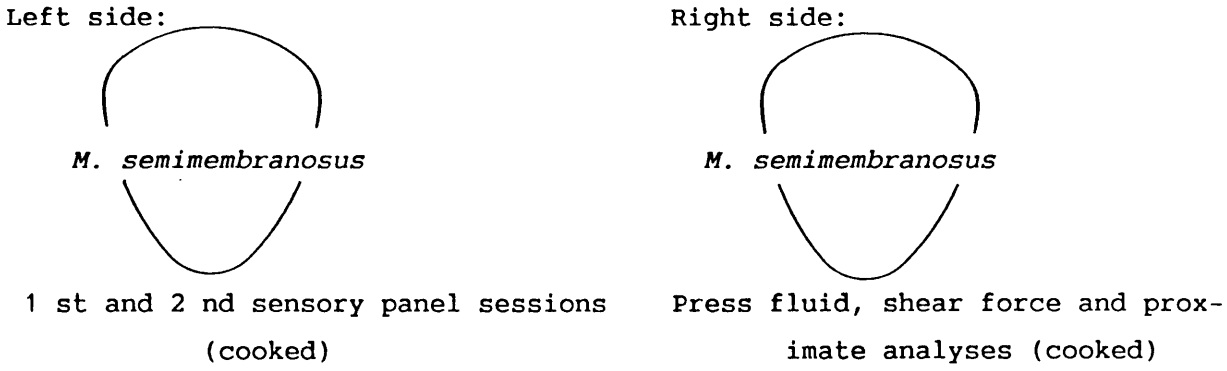

FIGURE 7: SAMPLES TAKEN FOR DIFFERENT ANALYSES, OF LEFT AND RIGHT *M. semimembranosus* SIDES

Cooking losses

The left side *Mm. longissimus thoracis et lumborum* and

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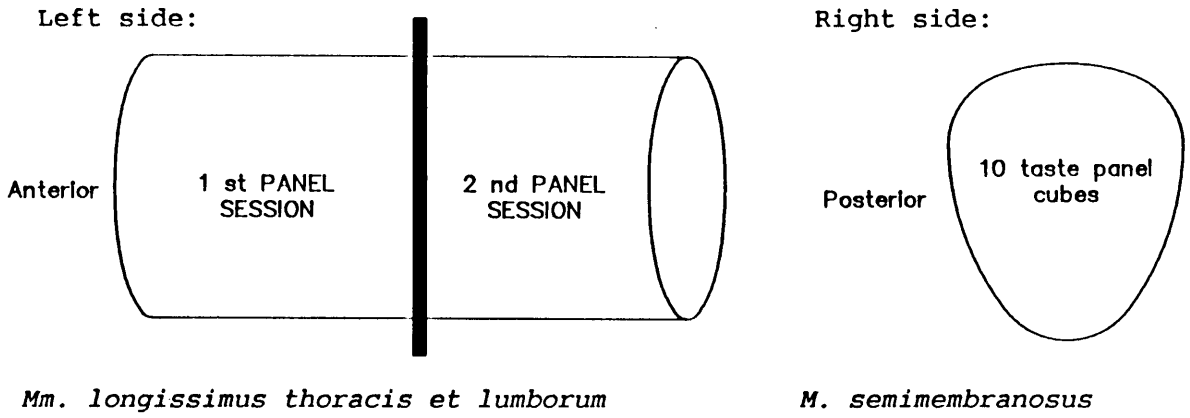
M. semimembranosus cuts were weighed on a Mettler PE 16 electronic balance before and after cooking to determine total cooking losses. A ten minute standing period was then allowed.

Presentation and scoring of samples

The left side *M. longissimus thoracis* and *M. longissimus lumborum* muscles were excised and trimmed. Samples were taken from the middle of each muscle - five cubes per muscle (Figure 8). The cubes from the *M. longissimus thoracis* cut were always presented to members of the first taste panel session and cubes from the *M. longissimus lumborum* cuts to the second session. The left side *M. semimembranosus* muscle was dissected from the leg and cut into ten cubes for the taste panel.

Individual score cards were provided for each taste panel member who was required to judge each sample according to the following quality characteristics namely aroma intensity, initial impression of juiciness, sustained juiciness, tenderness, residue, flavour and species flavour.



Mm. longissimus thoracis et lumborum

M. semimembranosus

FIGURE 8: SAMPLING FOR SENSORY EVALUATION

Each taste panel member received three randomly-assigned cubes of meat (20x20x20 mm) one of each species. The samples were wrapped in 90x90 mm aluminium foil squares, marked with a random three-digit code, and arranged on a preheated white plate. They were evaluated at a internal temperature of 60 °C within 30 minutes from the time the whole cut was removed from the oven.

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Press fluid determination

After the standing period the right side *M. longissimus lumborum* muscle was excised and trimmed. The press fluid sample was obtained from the middle of each muscle (Figure 9). The right side *M. semimembranosus* muscle was dissected from the leg and the press fluid sample taken from the proximal end of the muscle. The sample was then wrapped in aluminium foil in preparation for immediate determination of the expressible moisture. Four samples were cut from the middle of this muscle slice (Figure 10). The reported value represents the average of the four measurements.

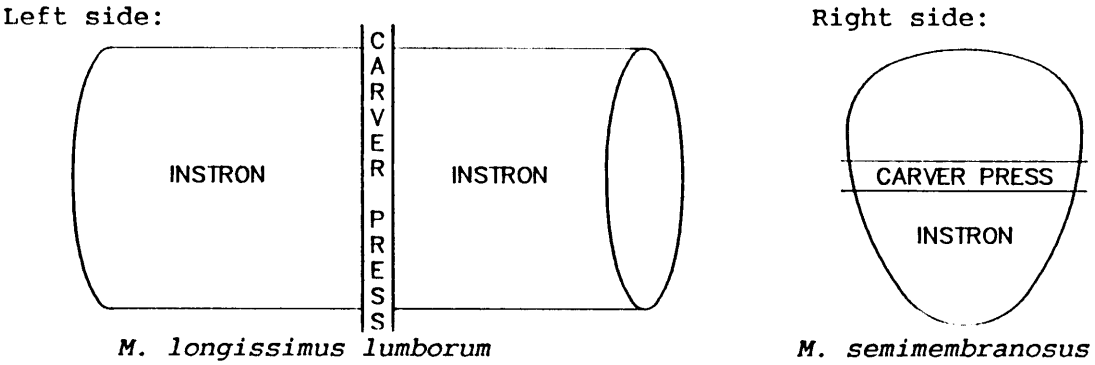

FIGURE 9: SAMPLING FOR PRESS FLUID AND SHEAR FORCE DETERMINATION

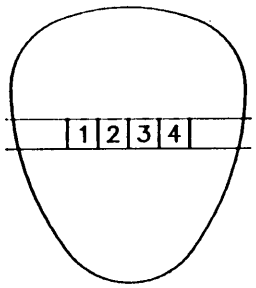

FIGURE 10: PRESS FLUID SAMPLE LOCALITY

Shear force determination

Shear force samples were obtained from the same muscles as those for press fluid analysis (Figure 9). The muscles were cooled to a point where the internal temperature stabilized at 20 °C (after being held for an average of four hours at ambient temperature). Cylindrical samples with a core diameter of 13 mm were removed parallel to the grain of the meat. Each core was

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sheared (perpendicular to the fibre direction) and the reported value in Newton represents the average of the peak force measurements.

Proximate chemical analysis

Determination of the percentages of total moisture, fat, nitrogen (x 6,25 = % protein) and ash of the cooked *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts was done on the part of muscles left over after samples for sensory analysis and shear force determinations were taken (i.e. without the fat layer to be a representative sample of what the sensory panel evaluated). This was done according to the accepted AOAC-methods (1985).

Biochemical analysis

The total collagen content and the solubility of the collagen were determined on the raw right side *M. longissimus thoracis* cut. The mean value represents the average of three determinations.

Storage study

Due to the fact that the carcases were collected over an extended period concern was expressed about the effect of prolonged frozen storage on the sensory quality of the meat. A comparative study was therefore done in which the *M. triceps brachii caput longum* of a B3 and a Top C sheep frozen for 13 months, were compared to sheep cuts of identical grades frozen for two weeks. The cuts were cooked at 160 °C to an internal endpoint temperature of 75 °C. No significant difference ($p \leq 0,05$) was found for any of the various quality characteristics. These results were similar to those of Mawson, Collinson, Carse and McLeod (1975:41). They reported no flavour difference in lamb frozen for 0, 6, 12 and 24 months respectively at -12 °C. They concluded that the lamb would first be rejected on the grounds of brown metmyoglobin formation and heavy surface desiccation, before the palatability of the meat deteriorated to a point where it was unacceptable.

Final study

In the final study the three replications of comparable cuts from goat and

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sheep meat were evaluated for each grade. They were comparatively evaluated in a systematic order, starting with the roasting of three replications of the *Mm. longissimus thoracis et lumborum* cuts of the A age group with a fat code of three and ending with the corresponding cut of the C age group with a fat code of one. Braising of the *M. semimembranosus* cuts were then conducted starting with cuts from the A age group with a fat code of three and ending with the corresponding cuts of the C age group with a fat code of one.

Data collection

The *Mm. longissimus thoracis et lumborum* cuts were defrosted at 10 °C for a period of 24 hours. The *M. semimembranosus* cuts were defrosted at 10 °C for periods varying between 24 - 36 hours according to the mass. All the cuts were cooked according to the methods that were standardized in the preliminary study.

Physical determinations and sensory evaluation

Cooking losses

The data was collected on a standard form (Appendix C.1). The form used during the first phase was modified to accommodate the cooking bag and string used during the second phase (Appendix C.3).

These forms were generated using the program Lotus to include all the formulae (Appendix C.2 and C.4 respectively) necessary for the calculation of the following parameters without further data transfer namely; percentage thawing loss, percentage total cooking loss, percentage drip loss and percentage evaporation loss. Cooking time and cooking rate (°C/minute) were also calculated. The arithmetic mean for the three replications was calculated.

Sensory evaluation

A six point numerical scale was used on the score cards with one donating the least favourable condition and six the most favourable. Mean score data capture following each panel analysis was achieved using the program Lotus.

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Press fluid determination

The data for each muscle was collected on a standard form (Appendix C.4 and C.5) which was generated in Lotus. The reported value represents the average of the four measurements and is expressed as a percentage.

Shear force determination

The data for each muscle was collected on the identical form (Appendix C.4 and C.5) as for press fluid determination. The different chart readings on recorder setting five were divided by two; on setting ten they were unaltered and on setting 20 they were multiplied by two in order to calculate the force in Newton. The average force in Newton was then calculated.

Proximate chemical analysis

Proximate analysis i.e. the percentages of total moisture, fat, nitrogen and ash was performed in triplicate and the arithmetic mean of each value was calculated.

Biochemical analysis

After the mean value for the three measurements was determined the arithmetic mean for the three replications was calculated.

Statistical analysis

Three way analysis of variance with species, age and fat code as the main effects on variation, was calculated, using the Statgraphics program package, for every one of the dependent variables. This test included analysis of interactions between each factor of the three way analysis of variance. If the main effects or the two-factor interactions were significant on a 5 % level, the variable was analyzed further at the 1 % significance level. The three way analysis of variance procedure analyzes the effect of the three factors namely species, age and fat code on each response variable. The intervals for factor means for the main effects and the two factor interactions were then plotted. A correlation matrix was constructed to test for the correlations between different variables (Snedecor & Cochran, 1980:155).

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CHAPTER 5

RESULTS

The results will be discussed in conjunction with tables of analyses of variance and schematic representations. The format is consistent throughout the chapter. Two tables are presented for each variable. The first table is for the *Mm. longissimus thoracis et lumborum* cooked according to a dry heat cooking method and the second table is for the *M. semimembranosus* cooked according to a moist heat cooking method. These two tables will be followed by graphic representations (first figure) with the variable as the ordinate versus the abscissa as follows:

i. species, represented: 1 = sheep
2 = Angora goat
3 = Boer goat

ii. age, represented: 1 = A = Animals with no permanent incisor teeth
(Grades Super lamb or kid, lamb or kid 1 and lamb or kid 3)
2 = B = Animals with 1 to 6 permanent incisor teeth
(Grades Prime B, B1 and B3)
3 = C = Animals with more than 6 permanent incisor teeth
(Grades Top C, C1 and C3)

iii. fat code, represented 1 = Grades A3, B3 and C3
2 = Grades A1, B1 and C1
3 = Grades Super, Prime and Top

In the second figure graphic representations of two factor interactions for each variable will be presented for:

i. species : age

ii. species : fat code

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iii. age : fat code

Both phases will be considered concurrently for a balanced appraisal. The results will be presented in two sections: firstly the results obtained from the three-way analysis of variance and secondly the correlations tested.

Three-way analysis of variance

Explanatory notes

Statistical level of significance

The first two ANOVA tables for each attribute give the least significant difference (LSD) information.

In the last column:

≤0,0100	p≤0,01	1 % confidence level
≤0,0500	p≤0,05	5 % confidence level

Graphical representations

When reading the graphical representations of the mean values of the different variables according to the various factors (species, age and fat code), note that for significant differences between the different variables, the crossbars in the graphs must not overlap. Note also that the ranges on the Y-axes differ. The levels of significance of the diagrams are taken according to the levels of significance as determined by t-tests. Therefore the crossbars in the graph may overlap at the 99 % level of significance and still be significant at the 95 % level - however the diagram will only be supplied on the highest level of significance.

Overall significance

Note that overall significance, based upon LSD-tests as given in the last column of the first two tables, is the major factor used when determining the level of significance, although mean differences (t-tests) within an overall effect may be significantly different.

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Hypothesis

The hypothesis is accepted or rejected according to the levels of significance of the ANOVA tests.

Sensory evaluation

Aroma

The three-way analyses of variance of the sensory evaluation of aroma (Table 11) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 11) the aroma of the sheep *Mm. longissimus thoracis et lumborum* cuts was significantly more intense ($p \leq 0,01$) than that of the corresponding goat cuts. Therefore, the hypothesis that there will not be a significant difference between the aroma of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of aroma (Table 12) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 11) the aroma of the sheep *M. semimembranosus* cuts was significantly more intense than the corresponding Angora ($p \leq 0,01$) and Boer goat ($p \leq 0,05$) cuts. Therefore, the hypothesis that there will not be a significant difference between the aroma of either the Angora or Boer goat *M. semimembranosus* cuts, and the that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of aroma (Table 11) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the aroma of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

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TABLE 11: THREE-WAY VARIANCE OF AROMA OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	16.715448	6	2.7859080	3.067	.0057
SPECIE	12.295474	2	6.1477369	6.768	.0012
AGE	2.312400	2	1.1562000	1.273	.2806
FATCODE	2.114902	2	1.0574509	1.164	.3127
2-FACTOR INTERACTIONS	18.491602	12	1.5409668	1.696	.0629
SPECIE AGE	6.783341	4	1.6958352	1.867	.1143
SPECIE FATCODE	5.959602	4	1.4899006	1.640	.1622
AGE FATCODE	5.750587	4	1.4376469	1.583	.1769
RESIDUAL	708.49758	780	.9083302		
TOTAL (CORR.)	743.70463	798			

11 missing values have been excluded.

TABLE 12: THREE-WAY VARIANCE OF AROMA OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	14.659259	6	2.4432099	3.102	.0052
SPECIE	12.150617	2	6.0753086	7.714	.0005
AGE	1.943210	2	.9716049	1.234	.2918
FATCODE	.565432	2	.2827160	.359	.6985
2-FACTOR INTERACTIONS	18.488889	12	1.5407407	1.956	.0254
SPECIE AGE	7.553086	4	1.8882716	2.398	.0488
SPECIE FATCODE	8.797531	4	2.1993827	2.793	.0254
AGE FATCODE	2.138272	4	.5345679	.679	.6068
RESIDUAL	622.97654	791	.7875810		
TOTAL (CORR.)	656.12469	809			

0 missing values have been excluded.

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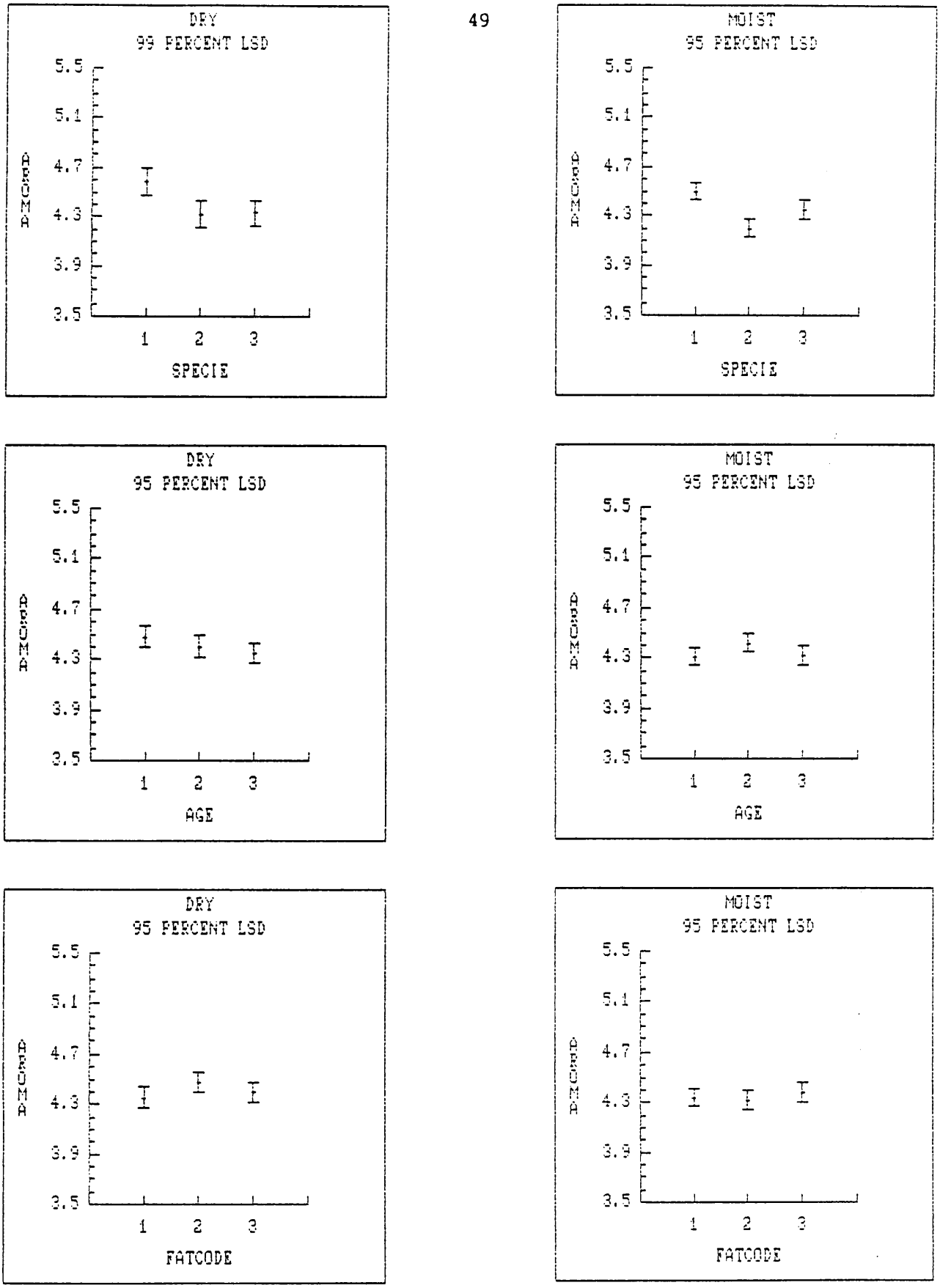

FIGURE 11: GRAPHIC REPRESENTATIONS OF VARIANCE WITH AROMA AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The three-way analyses of variance of the sensory evaluation of aroma (Table 12) show no significant differences between the *M. semimembranosus* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the aroma of the *M. semimembranosus* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of aroma (Table 11) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the aroma of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of aroma (Table 12) show no significant differences between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the aroma of the *M. semimembranosus* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 11 and Figure 12) shows no significant effect on the sensory evaluation of aroma of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 12) shows a significant effect ($p \leq 0,05$) on the sensory evaluation of aroma of the *M. semimembranosus* cuts. According to the t-test (Figure 12) the aroma of the sheep *M. semimembranosus* cuts of the B age group was significantly ($p \leq 0,05$) more intense than that of either the corresponding Boer or Angora goat cuts of the identical age group.

The two-factor interaction analysis of species and fat code (Table 11 and Figure 12) shows no significant effect on the sensory evaluation of aroma of the *Mm. longissimus thoracis et lumborum* cuts.

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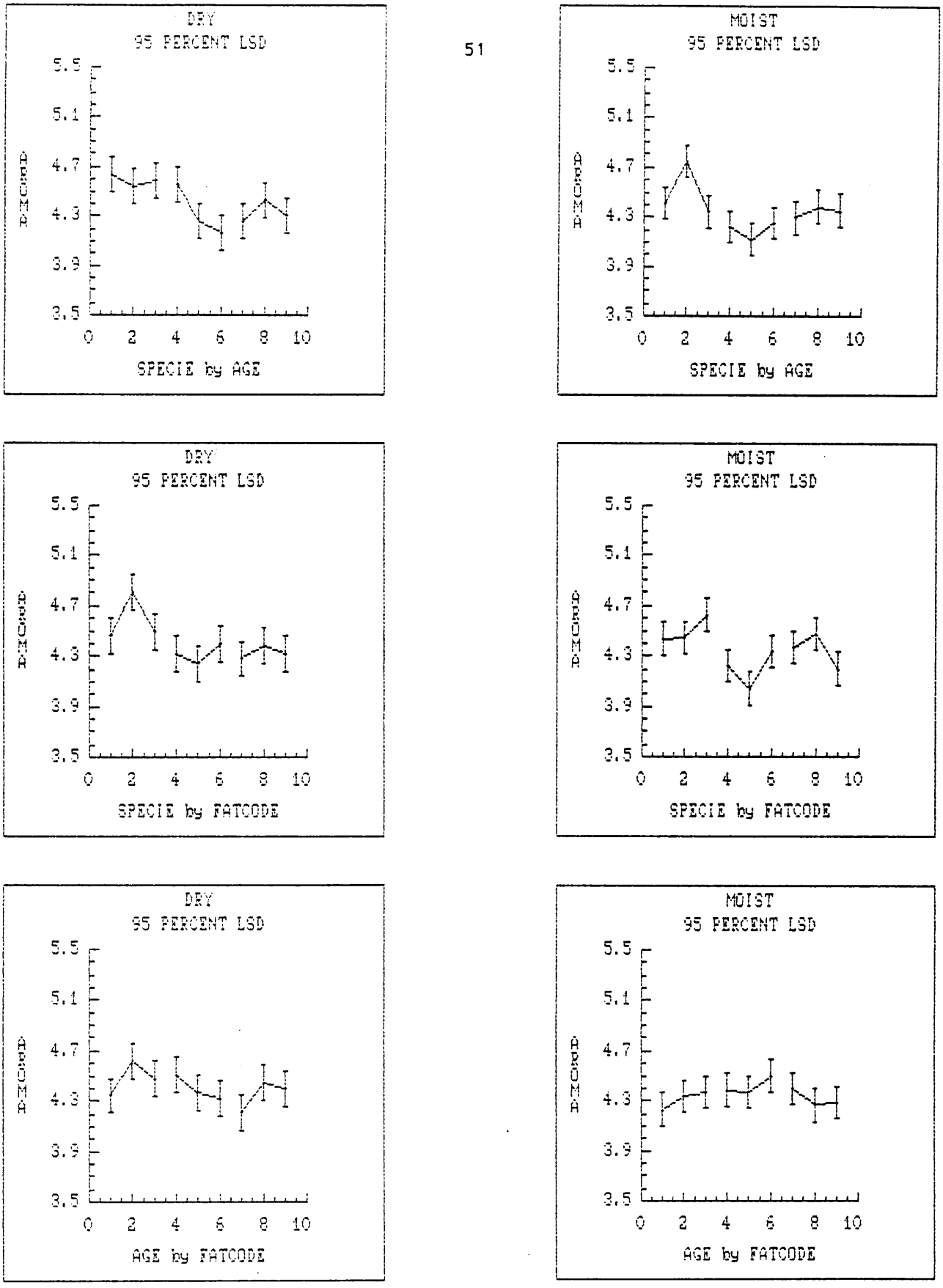

FIGURE 12: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF AROMA OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of species and fat code (Table 12) shows a significant effect ($p \leq 0,05$) on the sensory evaluation of aroma of the *M. semimembranosus* cuts. According to the t-test (Figure 12) the aroma of both the sheep and Boer goat *M. semimembranosus* cuts with a fat code of two was significantly ($p \leq 0,05$) more intense than that of the corresponding Angora goat cuts with a fat code two. The aroma of the sheep *M. semimembranosus* cuts with a fat code of three was significantly ($p \leq 0,05$) more intense than that of both the corresponding Angora and Boer goat cuts with a fat code three.

The two-factor interaction analysis of age and fat code (Table 11 and Figure 12) shows no significant effect on the sensory evaluation of aroma of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 12 and Figure 12) shows no significant effect on the sensory evaluation of aroma of the *M. semimembranosus* cuts.

Initial impression of juiciness

The three-way analyses of variance of the sensory evaluation of the initial impression of juiciness (Table 13) show no significant differences between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the initial impression of juiciness of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of the initial impression of juiciness (Table 14) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 13) the sheep *M. semimembranosus* cuts were juicier ($p \leq 0,05$) than the corresponding Angora goat cuts, which were significantly juicier ($p \leq 0,05$) than the corresponding Boer goat cuts. The sheep *M. semimembranosus* cuts were significantly ($p \leq 0,01$) juicier than the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference

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TABLE 13: THREE-WAY VARIANCE OF INITIAL IMPRESSION OF JUICINESS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	13.245594	6	2.2075990	2.248	.0370
SPECIE	3.066167	2	1.5330836	1.561	.2105
AGE	6.004058	2	3.0020291	3.057	.0476
FATCODE	4.160068	2	2.0800338	2.118	.1209
2-FACTOR INTERACTIONS	28.714403	12	2.3928669	2.437	.0041
SPECIE AGE	3.716982	4	.9292455	.946	.4364
SPECIE FATCODE	3.429001	4	.8572503	.873	.4796
AGE FATCODE	21.590038	4	5.3975095	5.497	.0002
RESIDUAL	767.86272	782	.9819216		
TOTAL (CORR.)	809.82272	800			

9 missing values have been excluded.

TABLE 14: THREE-WAY VARIANCE OF INITIAL IMPRESSION OF JUICINESS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	29.408970	6	4.901495	4.401	.0002
SPECIE	20.055478	2	10.027739	9.004	.0001
AGE	3.720288	2	1.860144	1.670	.1889
FATCODE	5.594418	2	2.797209	2.512	.0818
2-FACTOR INTERACTIONS	40.283231	12	3.3569360	3.014	.0004
SPECIE AGE	7.827252	4	1.9568130	1.757	.1356
SPECIE FATCODE	8.542327	4	2.1355818	1.917	.1056
AGE FATCODE	23.873317	4	5.9683294	5.359	.0003
RESIDUAL	878.75211	789	1.1137543		
TOTAL (CORR.)	948.44431	807			

2 missing values have been excluded.

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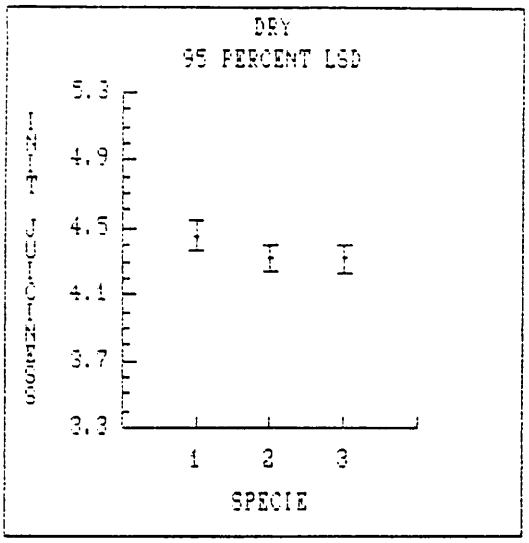

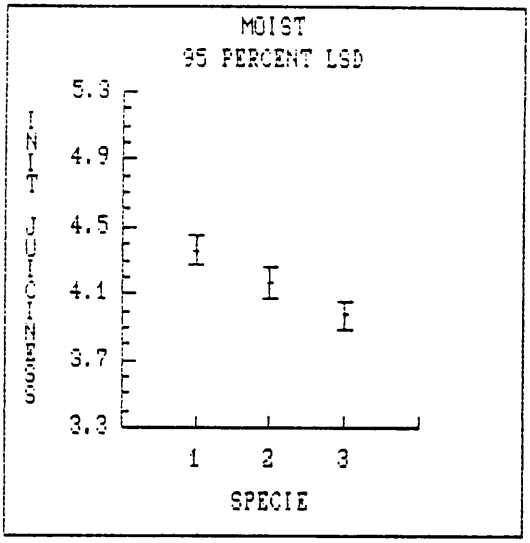

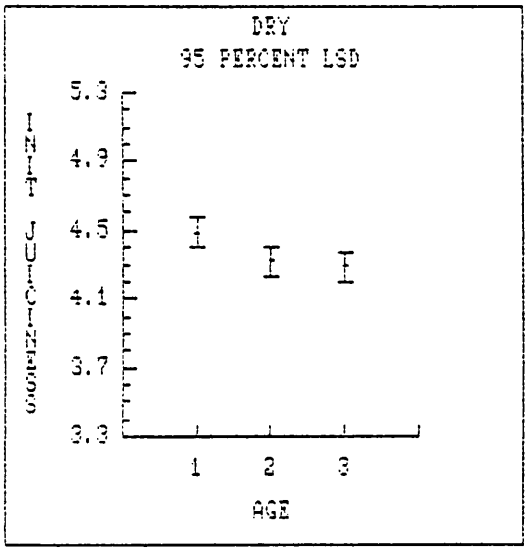

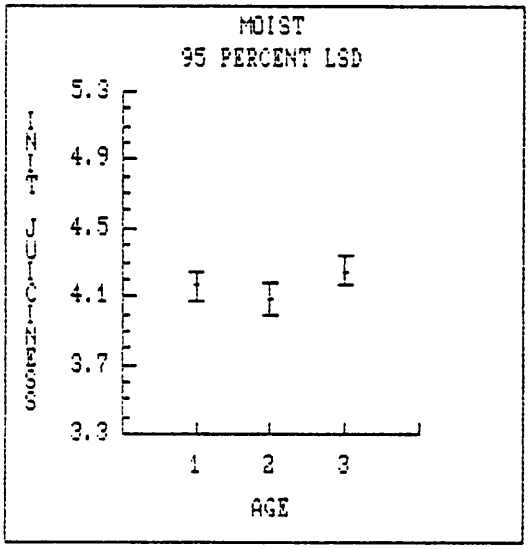

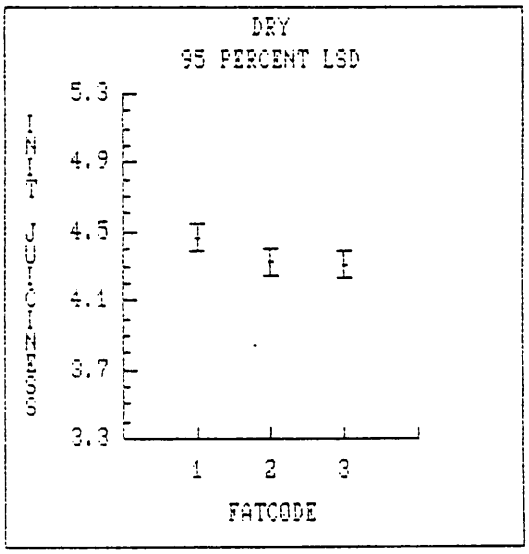

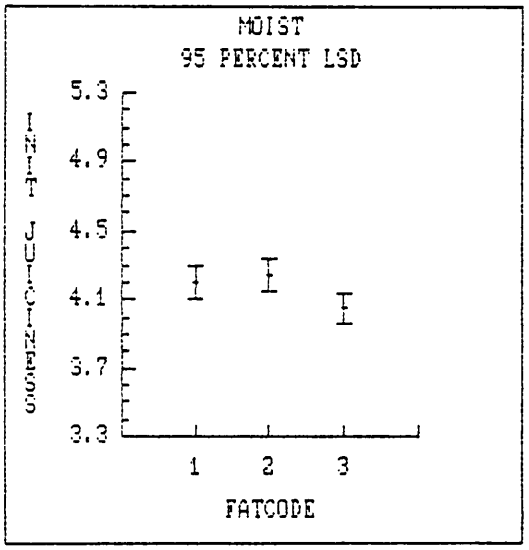

FIGURE 13: GRAPHIC REPRESENTATIONS OF VARIANCE WITH INITIAL IMPRESSION OF JUICINESS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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between the initial impression of juiciness of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of the initial impression of juiciness (Table 13) show significant differences ($p \leq 0,05$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 13) the initial impression of juiciness of *Mm. longissimus thoracis et lumborum* cuts from the A age group was significantly higher ($p \leq 0,05$) than that of the corresponding cuts from the C age group. Therefore, the hypothesis that there will not be a significant difference between the initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts of the A age group, and that of the corresponding cuts of the C age group, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts of the B age group, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of the initial impression of juiciness (Table 14) show no significant differences between the *M. semimembranosus* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the initial impression of juiciness of the *M. semimembranosus* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of the initial impression of juiciness (Table 13) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of the initial impression of juiciness (Table 14) show no significant differences between

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the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the initial impression of juiciness of the *M. semimembranosus* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 13 and Figure 14) shows no significant effect on the sensory evaluation of initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 14 and Figure 14) shows no significant effect on the sensory evaluation of initial impression of juiciness of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 13 and Figure 14) shows no significant effect on the sensory evaluation of initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 14 and Figure 14) shows no significant effect on the sensory evaluation of initial impression of juiciness of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 13 and Figure 14) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 14) the *Mm. longissimus thoracis et lumborum* cuts of the A age group with a fat code of three were significantly ($p \leq 0,01$) more juicy than the corresponding cuts of the C age group with a fat code of three.

The two-factor interaction analysis of age and fat code (Table 14) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of initial impression of juiciness of the *M. semimembranosus* cuts. According to the t-test (Figure 14) the *M. semimembranosus* cuts of the A age group with a fat code of three were significantly ($p \leq 0,01$) more juicy than the corresponding cuts of the B age group with a fat code of three.

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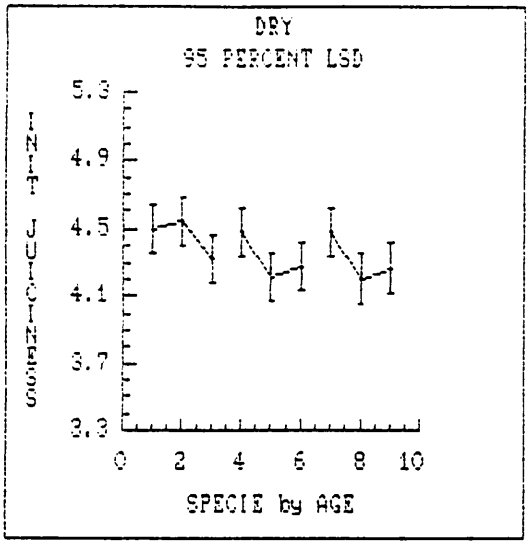

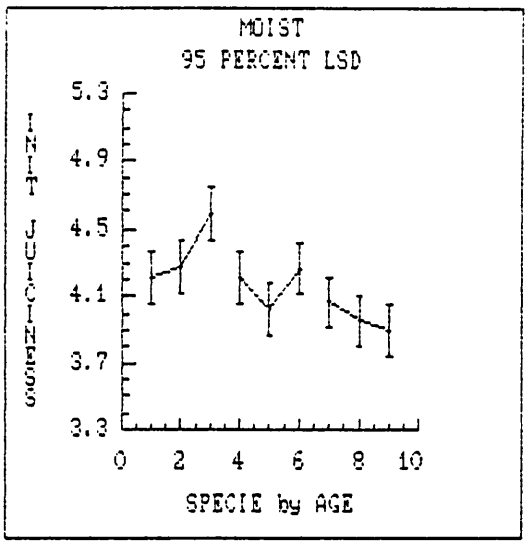

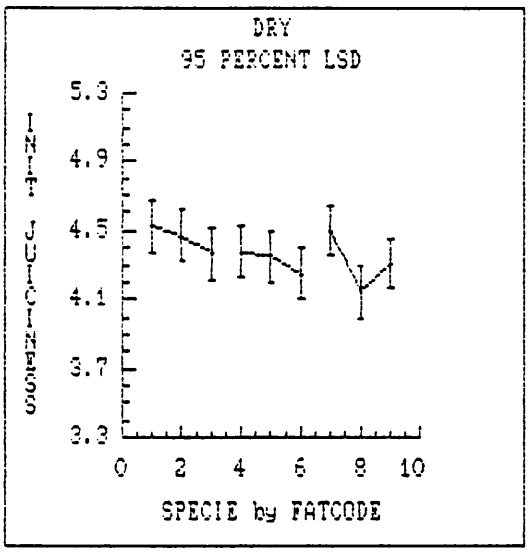

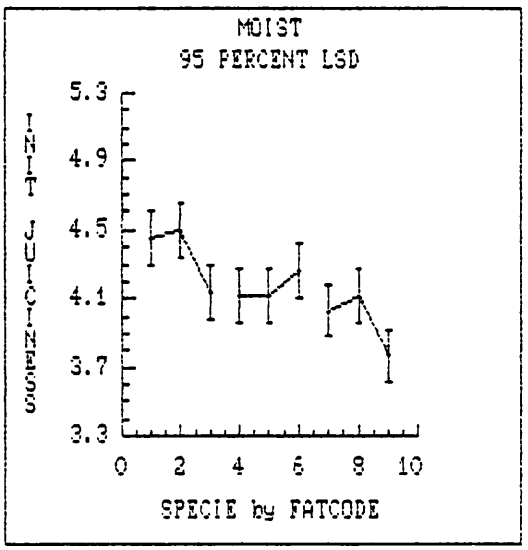

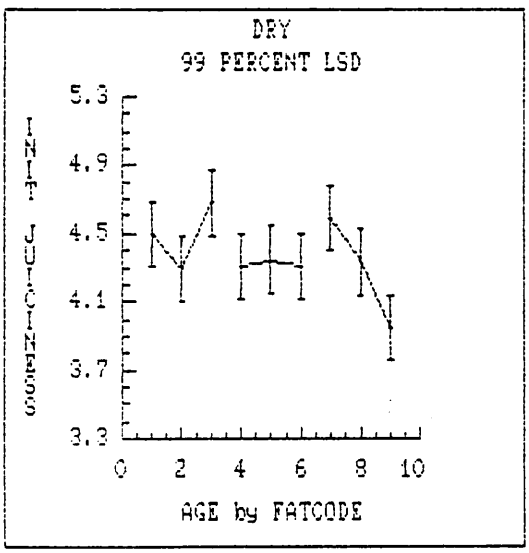

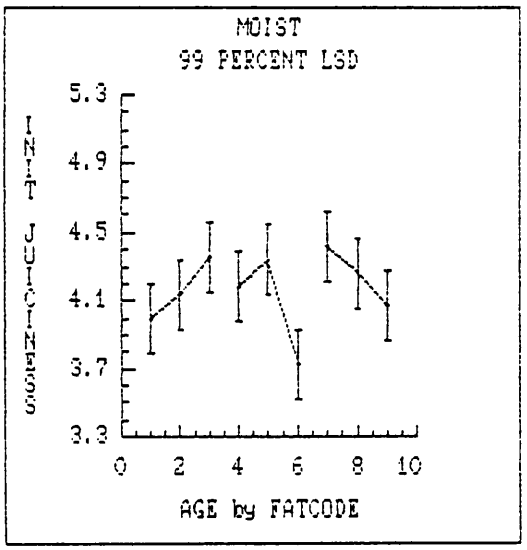

FIGURE 14: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF INITIAL IMPRESSION OF JUICINESS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Sustained juiciness

The three-way analyses of variance of the sensory evaluation of sustained juiciness (Table 15) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 15) the sheep *Mm. longissimus thoracis et lumborum* cuts were significantly juicier ($p \leq 0,05$ and $p \leq 0,01$) than the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of sustained juiciness (Table 16) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 15) the sheep *M. semimembranosus* cuts were significantly juicier ($p \leq 0,01$) than the corresponding Angora goat cuts, which were in turn significantly juicier ($p \leq 0,01$) than the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of sustained juiciness (Table 15) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 15) the *Mm. longissimus thoracis et lumborum* cuts of the A age group were significantly more juicy ($p \leq 0,01$) than the corresponding cuts from the B age group. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of sustained juiciness (Table 16) show significant differences ($p \leq 0,01$) between

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TABLE 15: THREE-WAY VARIANCE OF SUSTAINED JUICINESS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	50.897914	6	8.482986	6.468	.0000
SPECIE	15.502317	2	7.751159	5.910	.0028
AGE	14.754092	2	7.377046	5.625	.0038
FATCODE	20.663600	2	10.331800	7.878	.0004
2-FACTOR INTERACTIONS	16.970273	12	1.4141894	1.078	.3752
SPECIE AGE	1.089718	4	.2724296	.208	.9342
SPECIE FATCODE	3.637958	4	.9094895	.693	.5966
AGE FATCODE	12.226401	4	3.0566002	2.331	.0545
RESIDUAL	1021.6469	779	1.3114850		
TOTAL (CORR.)	1089.5150	797			

12 missing values have been excluded.

TABLE 16: THREE-WAY VARIANCE OF SUSTAINED JUICINESS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	59.263232	6	9.877205	8.621	.0000
SPECIE	42.355348	2	21.177674	18.485	.0000
AGE	11.115209	2	5.557605	4.851	.0081
FATCODE	5.865094	2	2.932547	2.560	.0780
2-FACTOR INTERACTIONS	61.608035	12	5.134003	4.481	.0000
SPECIE AGE	11.898172	4	2.974543	2.596	.0352
SPECIE FATCODE	4.404328	4	1.101082	.961	.4281
AGE FATCODE	45.358420	4	11.339605	9.898	.0000
RESIDUAL	901.66471	787	1.1456985		
TOTAL (CORR.)	1022.5360	805			

4 missing values have been excluded.

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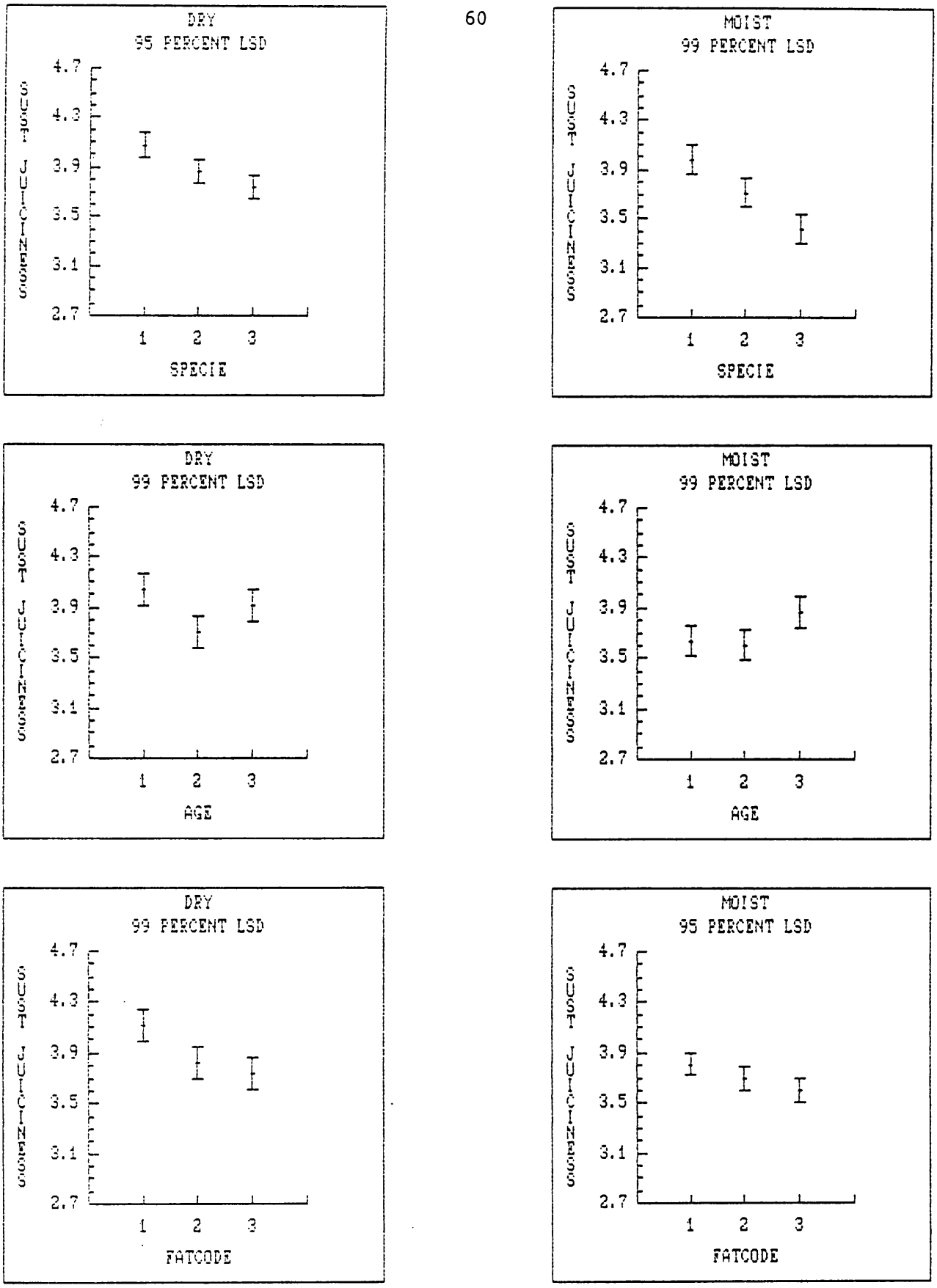

FIGURE 15: GRAPHIC REPRESENTATIONS OF VARIANCE WITH SUSTAINED JUICINESS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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M. semimembranosus cuts from the three age groups. According to the t-test (Figure 15) the *M. semimembranosus* cuts of the C age group were significantly juicier ($p \leq 0,01$) than the corresponding cuts from the B age group. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of the *M. semimembranosus* cuts of the B age group, and the sustained juiciness of the corresponding cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the sustained juiciness of the *M. semimembranosus* cuts of the A age group, and that of the sustained juiciness of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of the sustained juiciness (Table 15) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 15) the *Mm. longissimus thoracis et lumborum* cuts with a fat code of one were significantly juicier ($p \leq 0,01$) than the corresponding cuts with a fat code of two and three. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of one, and that of the corresponding cuts with a fat code of three, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts witha fat code of two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of the sustained juiciness (Table 16) show no significant differences between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the sustained juiciness of the *M. semimembranosus* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 15 and Figure 16) shows no significant effect on the sensory evaluation of sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts.

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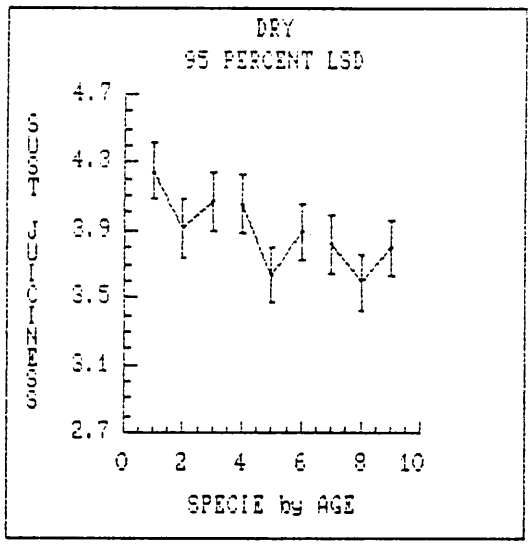

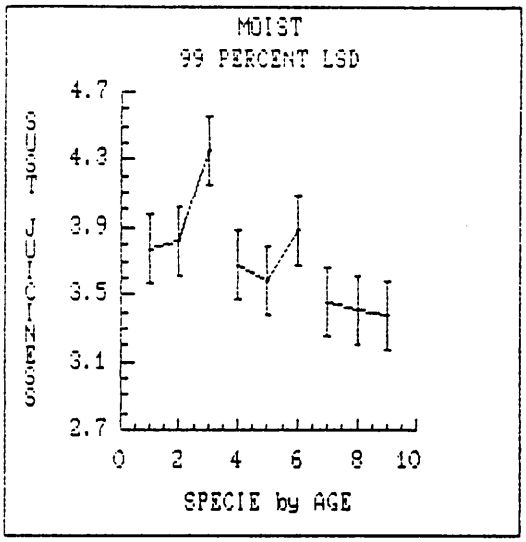

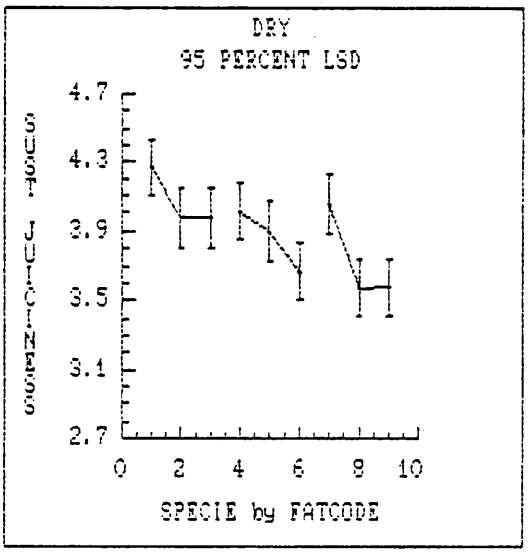

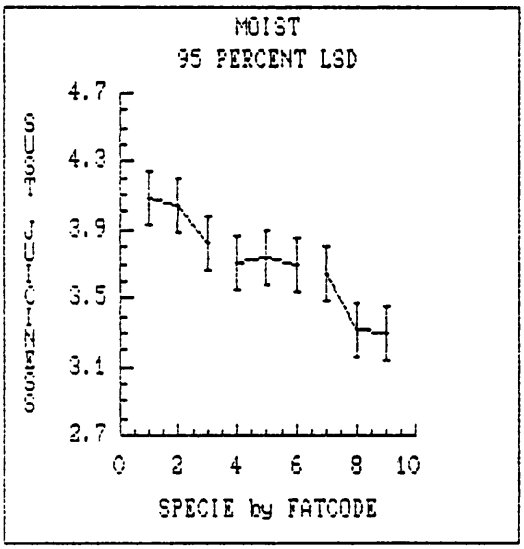

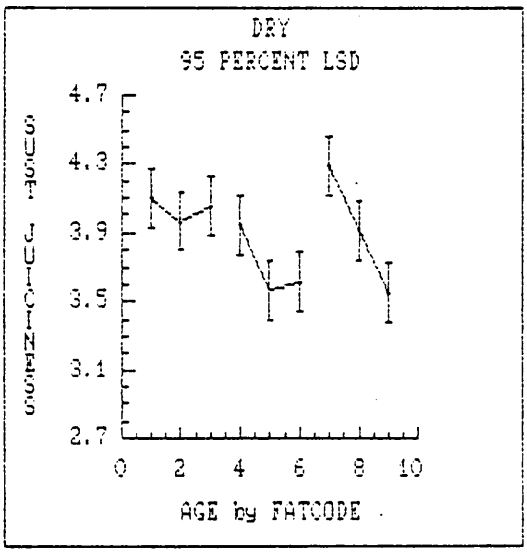

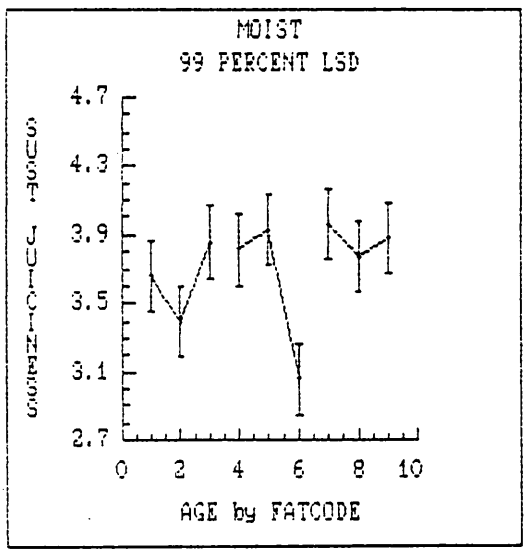

FIGURE 16: GRAPHIC REPRESENTATION OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF SUSTAINED JUICINESS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of species and age (Table 16) shows a significant effect ($p \leq 0,05$) on the sensory evaluation of sustained juiciness of the *M. semimembranosus* cuts. According to the t-test (Figure 16) the sheep *M. semimembranosus* cuts of the C age group were significantly ($p \leq 0,01$) juicier than the corresponding Angora goat cuts of the C age group which was in turn significantly ($p \leq 0,01$) juicier than the corresponding Boer goat cuts of the identical age group.

The two-factor interaction analysis of species and fat code (Table 15 and Figure 16) shows no significant effect on the sensory evaluation of sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 16 and Figure 16) shows no significant effect on the sensory evaluation of sustained juiciness of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 15 and Figure 16) shows no significant effect on the sensory evaluation of sustained juiciness of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 16) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of sustained juiciness of the *M. semimembranosus* cuts. According to the t-test (Figure 16) the *M. semimembranosus* cuts of the B age group with a fat code of two were significantly ($p \leq 0,01$) juicier than the corresponding cuts of the A age group with a fat code of two. According to the t-test (Figure 16) the *M. semimembranosus* cuts of both the A and C age groups with a fat code of three were significantly ($p \leq 0,01$) juicier than the corresponding cuts of the B age group with a fat code of three.

Tenderness

The three-way analyses of variance of the sensory evaluation of tenderness (Table 17) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 17) the sheep *Mm. longissimus thoracis et lumborum* cuts were significantly ($p \leq 0,01$) more tender than that of the corresponding Angora goat cuts, which were in

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turn significantly ($p \leq 0,01$) more tender than the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in tenderness of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of tenderness (Table 18) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 17) the sheep *M. semimembranosus* cuts were significantly ($p \leq 0,01$) more tender than the corresponding Angora goat cuts, which were in turn significantly ($p \leq 0,01$) more tender than the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in tenderness between either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of tenderness (Table 17) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 17) the *Mm. longissimus thoracis et lumborum* cuts of the A age group were significantly ($p \leq 0,01$) more tender than the corresponding cuts of the B and C age groups. Therefore, the hypothesis that there will not be a significant difference between the tenderness of the *Mm. longissimus thoracis et lumborum* cuts of the A age group, and that of the corresponding cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the tenderness of the *Mm. longissimus thoracis et lumborum* cuts of the B age group, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of tenderness (Table 18) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 17) the *M. semimembranosus* cuts of the A age group were significantly ($p \leq 0,01$) more tender than the corresponding cuts of the B age group, which were in turn significantly ($p \leq 0,05$) more tender than the corresponding cuts of the C age group. Therefore, the hypothesis that there

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TABLE 17: THREE-WAY VARIANCE OF TENDERNESS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	861.95782	6	143.65964	126.490	.0000
SPECIE	773.34760	2	386.67380	340.460	.0000
AGE	82.26785	2	41.13392	36.218	.0000
FATCODE	6.71812	2	3.35906	2.958	.0525
2-FACTOR INTERACTIONS	63.251037	12	5.2709198	4.641	.0000
SPECIE AGE	38.002273	4	9.5005682	8.365	.0000
SPECIE FATCODE	21.291937	4	5.3229843	4.687	.0010
AGE FATCODE	4.252801	4	1.0632001	.936	.4423
RESIDUAL	887.01114	781	1.1357377		
TOTAL (CORR.)	1812.2200	799			

10 missing values have been excluded.

TABLE 18: THREE-WAY VARIANCE OF TENDERNESS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	217.48892	6	36.248154	33.789	.0000
SPECIE	112.03356	2	56.016782	52.216	.0000
AGE	94.39569	2	47.197846	43.996	.0000
FATCODE	11.15046	2	5.575229	5.197	.0057
2-FACTOR INTERACTIONS	54.092147	12	4.507679	4.202	.0000
SPECIE AGE	6.967686	4	1.741922	1.624	.1663
SPECIE FATCODE	44.438307	4	11.109577	10.356	.0000
AGE FATCODE	2.556362	4	.639091	.596	.6658
RESIDUAL	845.35078	788	1.0727802		
TOTAL (CORR.)	1116.9318	806			

3 missing values have been excluded.

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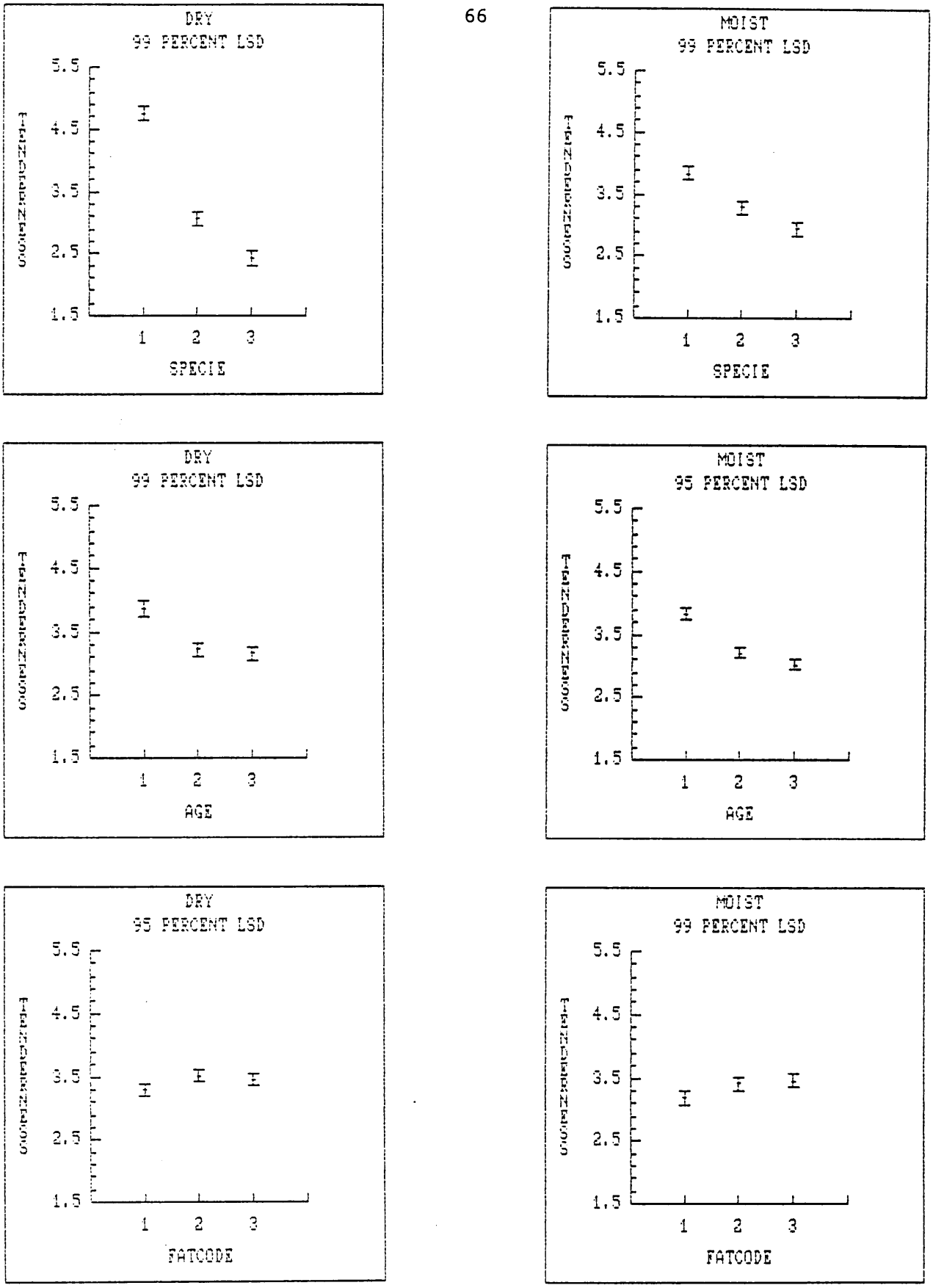

FIGURE 17: GRAPHIC REPRESENTATIONS OF VARIANCE WITH TENDERNESS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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will not be a significant difference between the tenderness of the *M. semimembranosus* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is rejected at the 99 % level of significance.

The three-way analyses of variance of the sensory evaluation of tenderness (Table 17) show significant differences ($p \leq 0,05$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 17) the *Mm. longissimus thoracis et lumborum* cuts with a fat code of two were significantly more tender ($p \leq 0,05$) than the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the tenderness of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of either one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance of the sensory evaluation of tenderness (Table 18) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 17) the *M. semimembranosus* cuts with a fat code of two and three were significantly more tender ($p \leq 0,05$) than the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the tenderness of the *M. semimembranosus* cuts with a fat code of one, and that of the corresponding cuts with a fat code of three, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the tenderness of the *M. semimembranosus* cuts with a fat code of two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 17) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of tenderness of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 18) the sheep *Mm. longissimus thoracis et lumborum* cuts of the A, B and C age groups, were significantly ($p \leq 0,01$) more tender than the corresponding Angora and Boer goat of the identical age groups.

The two-factor interaction analysis of species and age (Table 18 and

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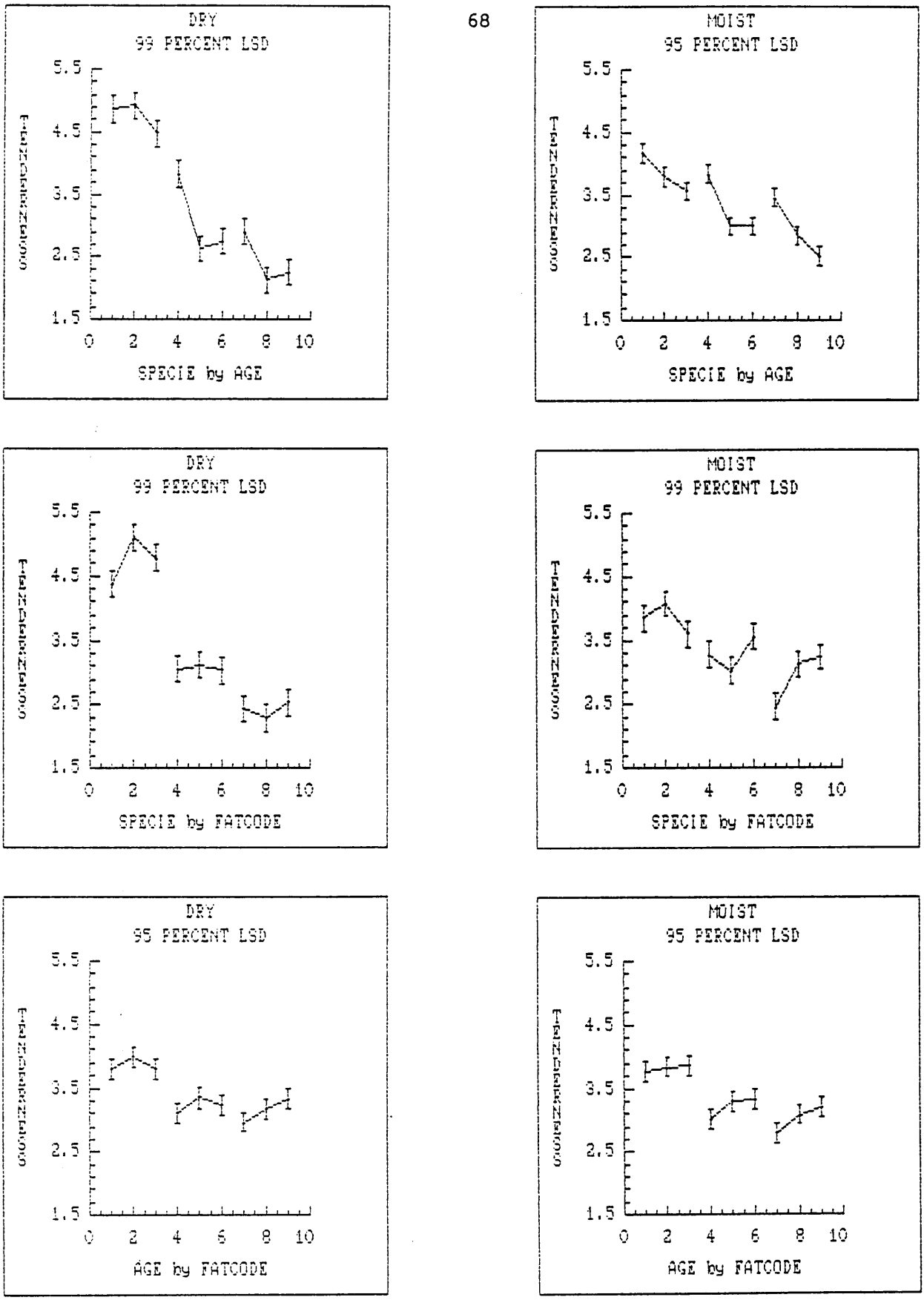

FIGURE 18: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF TENDERNESS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Figure 18) shows no significant effect on the sensory evaluation of tenderness of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 17) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of tenderness of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 18) the sheep *Mm. longissimus thoracis et lumborum* cuts with a fat code of one, two and three, were significantly ($p \leq 0,01$) more tender than the corresponding Angora goat cuts which were in turn significantly more tender than the corresponding Boer goat cuts of the identical fat codes.

The two-factor interaction analysis of species and fat code (Table 18) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of tenderness of the *M. semimembranosus* cuts. According to the t-test (Figure 18) the sheep *M. semimembranosus* cuts with a fat code of one, were significantly ($p \leq 0,01$) more tender than the corresponding Angora goat cuts of the identical fat code, which were in turn significantly ($p \leq 0,01$) more tender than the corresponding Boer goat cuts of the identical fat code. The sheep *M. semimembranosus* cuts with a fat code of two, were significantly ($p \leq 0,01$) more tender than the corresponding Angora and Boer goat cuts of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 17 and Figure 18) shows no significant effect on the sensory evaluation of tenderness of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 18 and Figure 18) shows no significant effect on the sensory evaluation of tenderness of the *M. semimembranosus* cuts.

Residue

The three-way analyses of variance for the sensory evaluation of residue (Table 19) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 19) the sheep *Mm. longissimus thoracis et lumborum* cuts contained significantly ($p \leq 0,01$) less residue than that of the corresponding Angora goat cuts,

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which in turn contained significantly ($p \leq 0,01$) less residue than that of the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in the residue content of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for the sensory evaluation of residue (Table 20) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 19) the sheep *M. semimembranosus* cuts contained significantly ($p \leq 0,01$) less residue than that of the corresponding Angora goat cuts, which in turn contained significantly ($p \leq 0,01$) less residue than the corresponding Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in the residue content of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for the sensory evaluation of residue (Table 19) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 19) the *Mm. longissimus thoracis et lumborum* cuts of the A age group contained significantly ($p \leq 0,01$) less residue than that of the corresponding cuts from both the B and C age groups. Therefore, the hypothesis that there will not be a significant difference between the residue content of the *Mm. longissimus thoracis et lumborum* cuts of the A age group, and that of the corresponding cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the residue content of the *Mm. longissimus thoracis et lumborum* cuts of the B age group, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of residue (Table 20) show significant differences ($p \leq 0,01$) between *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 19) the *M. semimembranosus* cuts of the A age group

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TABLE 19: THREE-WAY VARIANCE OF RESIDUE OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	560.30505	6	93.38417	84.241	.0000
SPECIE	523.13748	2	261.56874	235.960	.0000
AGE	34.28773	2	17.14387	15.465	.0000
FATCODE	3.10628	2	1.55314	1.401	.2469
2-FACTOR INTERACTIONS	42.784020	12	3.5653350	3.216	.0002
SPECIE AGE	28.009734	4	7.0024334	6.317	.0001
SPECIE FATCODE	12.398593	4	3.0996483	2.796	.0253
AGE FATCODE	2.578786	4	.6446966	.582	.6761
RESIDUAL	864.65311	780	1.1085296		
TOTAL (CORR.)	1467.7422	798			

11 missing values have been excluded.

TABLE 20: THREE-WAY VARIANCE OF RESIDUE OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	117.96730	6	19.661216	18.215	.0000
SPECIE	81.93629	2	40.968145	37.955	.0000
AGE	34.41687	2	17.208435	15.943	.0000
FATCODE	1.20954	2	.604770	.560	.5713
2-FACTOR INTERACTIONS	35.309405	12	2.9424504	2.726	.0013
SPECIE AGE	6.697557	4	1.6743892	1.551	.1855
SPECIE FATCODE	22.676512	4	5.6691281	5.252	.0004
AGE FATCODE	5.779339	4	1.4448348	1.339	.2539
RESIDUAL	848.40777	786	1.0793992		
TOTAL (CORR.)	1001.6845	804			

5 missing values have been excluded.

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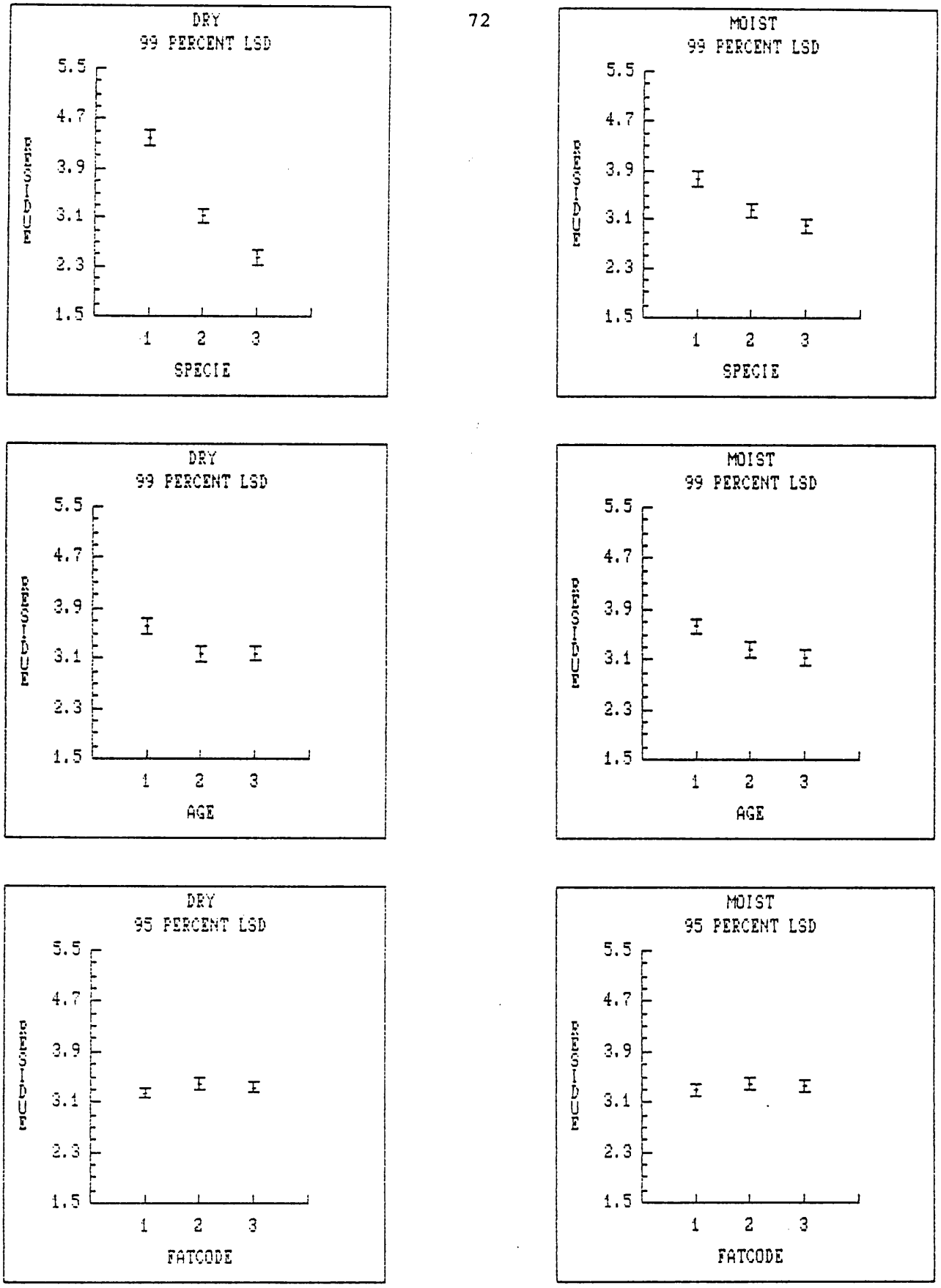

FIGURE 19: GRAPHIC REPRESENTATIONS OF VARIANCE WITH RESIDUE AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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contained significantly ($p \leq 0,01$) less residue than that of the corresponding cuts from both the B and C age groups. Therefore, the hypothesis that there will not be a significant difference between the residue content of the *M. semimembranosus* cuts of the A age group, and that of the corresponding cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the residue content of the *M. semimembranosus* cuts of the B age group, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of residue (Table 19) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the residue content of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of either one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of residue (Table 20) show no significant differences between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the residue content of the *M. semimembranosus* cuts with a fat code of either one or two, and the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 19) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of residue of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 20) the sheep *Mm. longissimus thoracis et lumborum* cuts of the A, B and C age groups contained significantly ($p \leq 0,01$) less residue than that of the corresponding Angora goat cuts of the identical age groups, which contained significantly ($p \leq 0,01$) less residue than that of the corresponding Boer goat cuts of the identical age groups.

The two-factor interaction analysis of species and age (Table 20 and Figure 20) shows no significant effect on the sensory evaluation of residue of the *M. semimembranosus* cuts.

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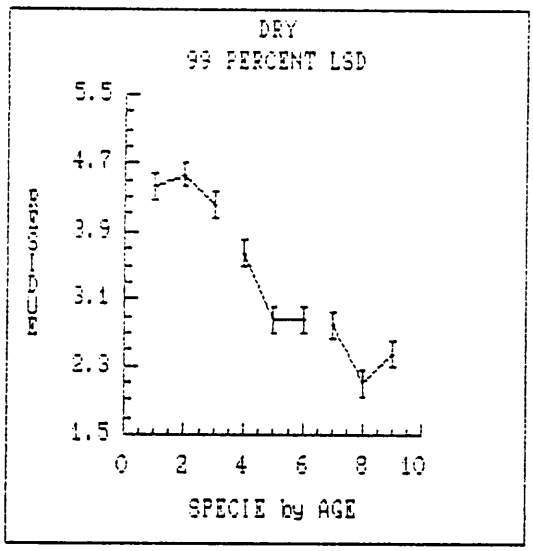

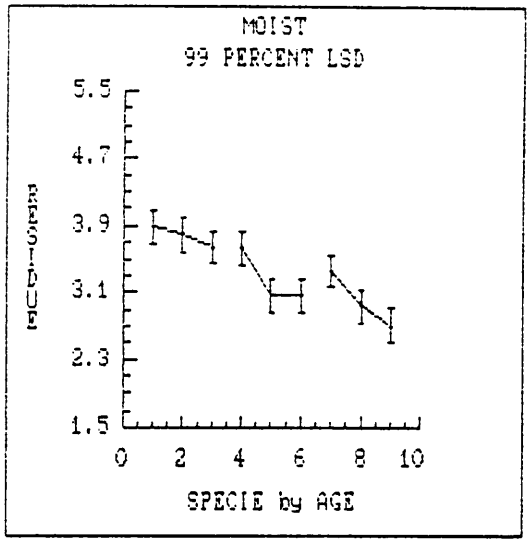

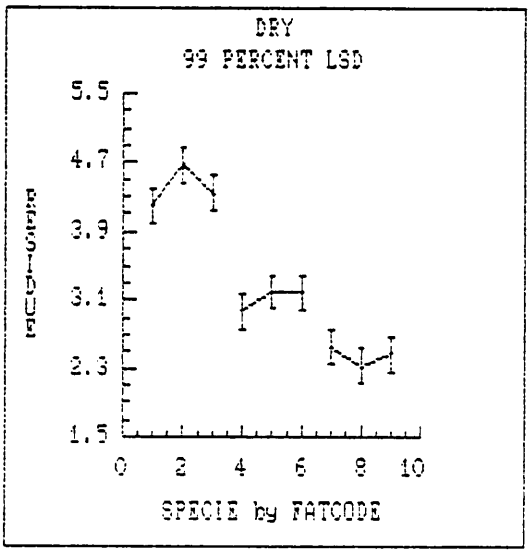

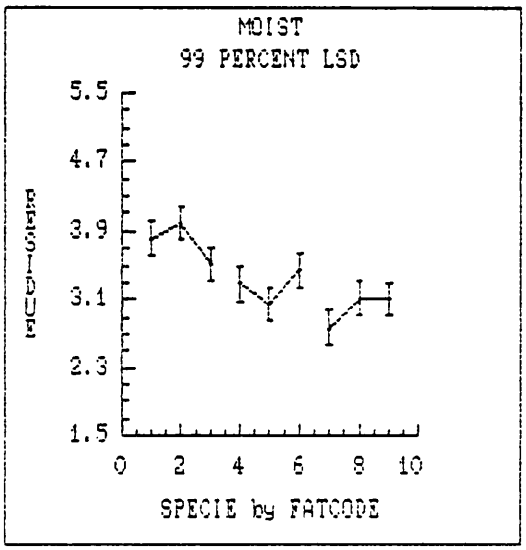

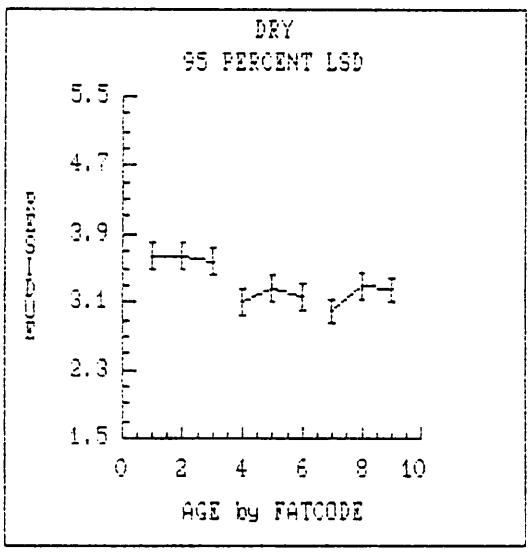

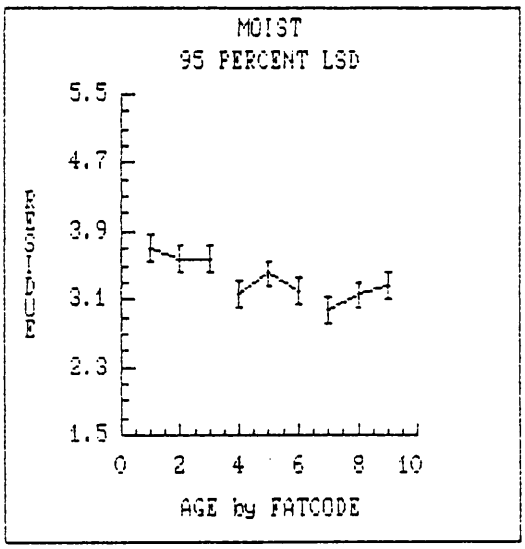

FIGURE 20: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF RESIDUE OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of species and fat code (Table 19) shows a significant effect ($p \leq 0,05$) on the sensory evaluation of residue of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 20) the sheep *Mm. longissimus thoracis et lumborum* cuts with a fat code of one, two and three contained significantly ($p \leq 0,01$) less residue than the corresponding Angora goat cuts of the identical fat codes, which in turn contained significantly ($p \leq 0,01$) more residue than the corresponding Boer goat cuts of the identical fat codes.

The two-factor interaction analysis of species and fat code (Table 20) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of residue of the *M. semimembranosus* cuts. According to the t-test (Figure 20) the sheep *M. semimembranosus* cuts with a fat code of one contained significantly ($p \leq 0,01$) less residue than the corresponding Angora goat cuts of the identical fat code, which in turn contained significantly ($p \leq 0,01$) less residue than the corresponding Boer goat cuts of the identical fat code. The sheep *M. semimembranosus* cuts with a fat code of two contained significantly ($p \leq 0,01$) less residue than the corresponding Angora and Boer goat cuts of the identical fat code. The sheep *M. semimembranosus* cuts with a fat code of three contained significantly ($p \leq 0,01$) less residue than the corresponding Boer goat cuts of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 19 and Figure 20) shows no significant effect on the sensory evaluation of residue of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 20 and Figure 20) shows no significant effect on the sensory evaluation of residue of the *M. semimembranosus* cuts.

Flavour

The three-way analyses of variance for the sensory evaluation of flavour (Table 21) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 21) the flavour of the sheep *Mm. longissimus thoracis et lumborum* cuts were significantly ($p \leq 0,01$) more acceptable than that of the corresponding Angora and Boer

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goat cuts. Therefore, the hypothesis that there will not be a significant difference in flavour between either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for the sensory evaluation of flavour (Table 22) show no significant differences between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in flavour between either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of flavour (Table 21) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the flavour of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of flavour (Table 22) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 21) the flavour of the *M. semimembranosus* cuts of the A age group was significantly ($p \leq 0,01$) more acceptable than that of the corresponding cuts of the C age group. Therefore, the hypothesis that there will not be a significant difference between the flavour of the *M. semimembranosus* cuts of the A age group, when compared with the flavour of the corresponding cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the flavour of the *M. semimembranosus* cuts of the B age group, when compared with the flavour of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of flavour (Table 21) show no significant differences between the *Mm. longissimus*

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TABLE 21: THREE-WAY VARIANCE OF FLAVOUR OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	33.865167	6	5.644195	5.274	.0000
SPECIE	23.845228	2	11.922614	11.140	.0000
AGE	5.929472	2	2.964736	2.770	.0633
FATCODE	4.152265	2	2.076132	1.940	.1444
2-FACTOR INTERACTIONS	33.222950	12	2.7685792	2.587	.0022
SPECIE AGE	12.020733	4	3.0051833	2.808	.0248
SPECIE FATCODE	3.082805	4	.7707013	.720	.5783
AGE FATCODE	18.033420	4	4.5083550	4.212	.0022
RESIDUAL	832.64839	778	1.0702422		
TOTAL (CORR.)	899.73651	796			

13 missing values have been excluded.

TABLE 22: THREE-WAY VARIANCE OF FLAVOUR OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	20.101002	6	3.3501670	3.970	.0006
SPECIE	.664308	2	.3321540	.394	.6748
AGE	13.444850	2	6.7224249	7.965	.0004
FATCODE	6.043494	2	3.0217468	3.580	.0283
2-FACTOR INTERACTIONS	24.943109	12	2.0785925	2.463	.0037
SPECIE AGE	6.371952	4	1.5929881	1.888	.1107
SPECIE FATCODE	3.948349	4	.9870873	1.170	.3228
AGE FATCODE	14.745141	4	3.6862853	4.368	.0017
RESIDUAL	662.50813	785	.8439594		
TOTAL (CORR.)	707.55224	803			

6 missing values have been excluded.

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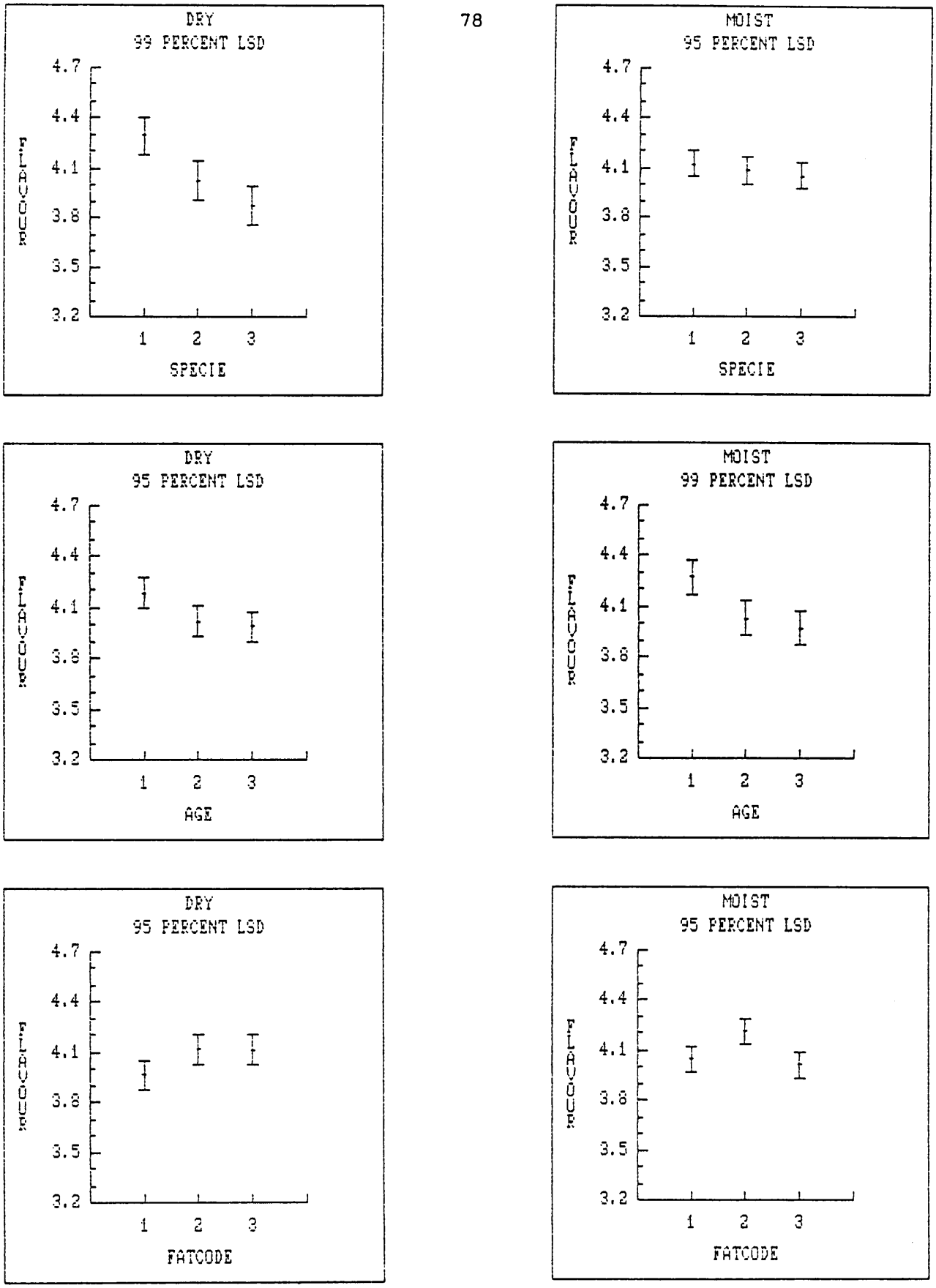

FIGURE 21: GRAPHIC REPRESENTATIONS OF VARIANCE WITH FLAVOUR AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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thoracis et lumborum cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the flavour of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of either one or two, and that of the corresponding cuts with a fat code of two, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of flavour (Table 22) show significant differences ($p \leq 0,05$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 21) the flavour of the *M. semimembranosus* cuts with a fat code of two was significantly ($p \leq 0,05$) more acceptable than that of the corresponding cuts with a fat code of one and three. Therefore, the hypothesis that there will not be a significant difference between the flavour of the *M. semimembranosus* cuts with a fat code of two, and that of the corresponding cuts with a fat code of three, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the flavour of the *M. semimembranosus* cuts with a fat code of one, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 21) show a significant effect ($p \leq 0,05$) on the sensory evaluation of flavour of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 22) the flavour of the sheep and Angora goat *Mm. longissimus thoracis et lumborum* cuts of the A age group, was significantly ($p \leq 0,01$) more acceptable, than that of the corresponding Boer goat cuts of the identical age group. The flavour of the sheep *Mm. longissimus thoracis et lumborum* cuts of the C age group, was significantly ($p \leq 0,01$) more acceptable than when compared with the flavour of the corresponding Angora and Boer goat cuts of the identical age group.

The two-factor interaction analysis of species and age (Table 22 and Figure 22) shows no significant effect on the sensory evaluation of flavour of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 21 and Figure 22) shows no significant effect on the sensory evaluation of flavour of the *Mm. longissimus thoracis et lumborum* cuts.

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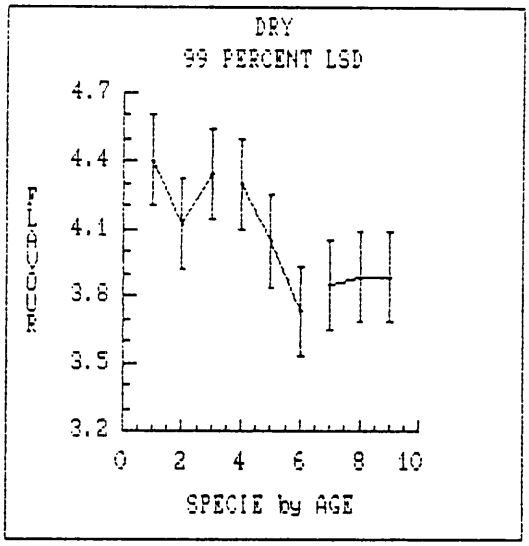

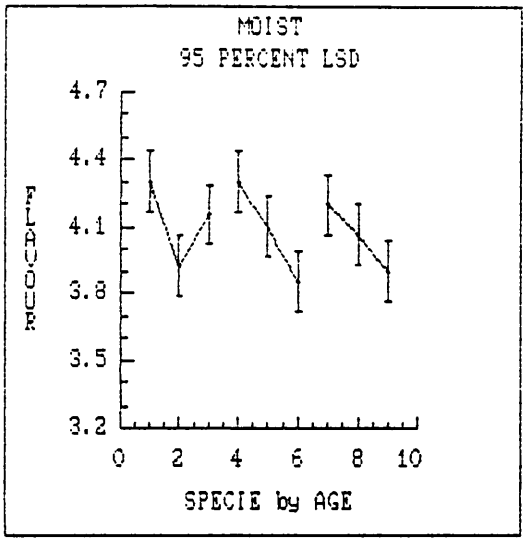

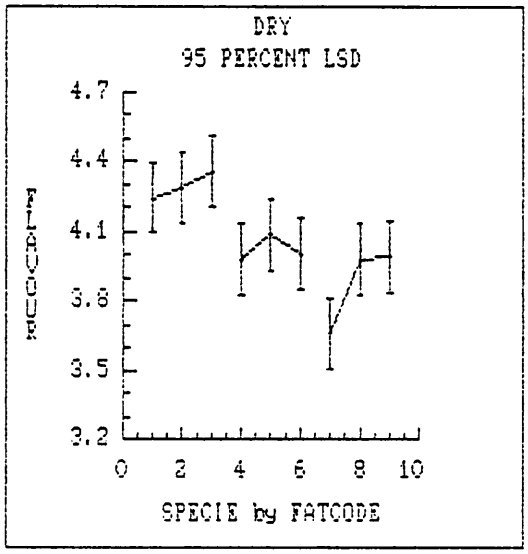

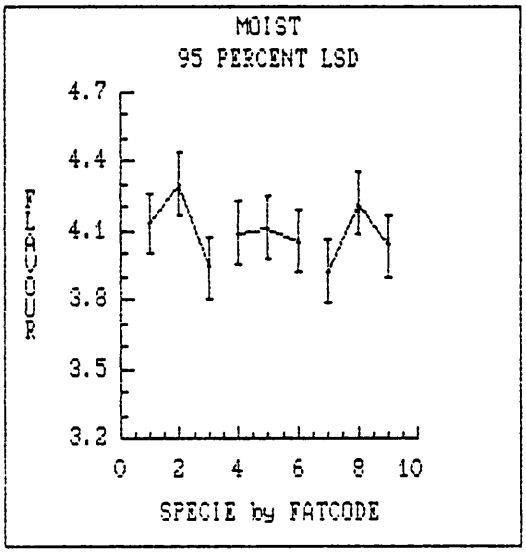

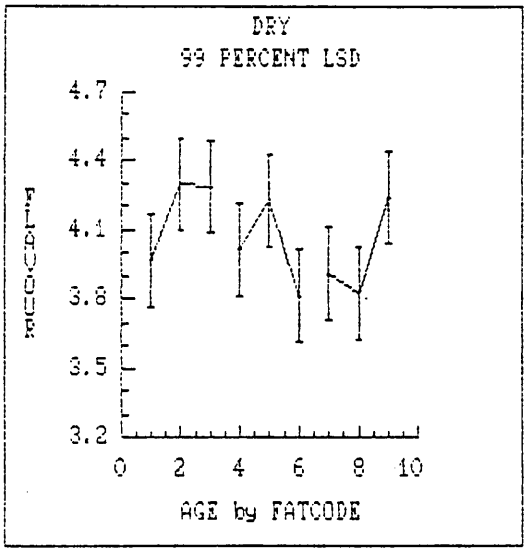

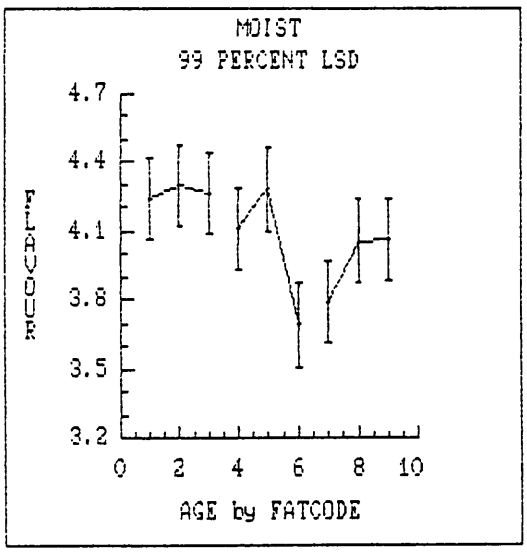

FIGURE 22: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF FLAVOUR OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of species and fat code (Table 22 and Figure 22) shows no significant effect on the sensory evaluation of flavour of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 21) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of flavour of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 22) the flavour of the *Mm. longissimus thoracis et lumborum* cuts of the A and B age groups with a fat code of two, was significantly ($p \leq 0,01$) more acceptable than that of the corresponding cuts of the C age group of the identical fat code. The flavour of the *Mm. longissimus thoracis et lumborum* cuts of the A and C age groups with a fat code of three, was significantly ($p \leq 0,01$) more acceptable than that of the corresponding cuts of the B age group of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 22) shows a significant effect ($p \leq 0,01$) on the sensory evaluation of flavour of the *M. semimembranosus* cuts. According to the t-test (Figure 22) the flavour of the *M. semimembranosus* cuts of the A age groups with a fat code of one, was significantly ($p \leq 0,01$) more acceptable when compared with the flavour of the corresponding cuts of the C age group of the identical fat code. The flavour of the *M. semimembranosus* cuts of the A age groups with a fat code of three, was significantly ($p \leq 0,01$) more acceptable when compared with the flavour of the corresponding cuts of the B age group of the identical fat code.

Species flavour

The three-way analyses of variance for the sensory evaluation of species flavour (Table 23) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 23) the flavour of the sheep *Mm. longissimus thoracis et lumborum* cuts was significantly ($p \leq 0,01$) more intense than that of the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in species flavour between either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level

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of significance.

The three-way analyses of variance for the sensory evaluation of species flavour (Table 24) show a significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 23) the flavour of the sheep *M. semimembranosus* cuts was significantly ($p \leq 0,05$ and $p \leq 0,01$ respectively) more intense than that of the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference in species flavour between either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for the sensory evaluation of species flavour (Table 23) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the species flavour of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of species flavour (Table 24) show a significant differences ($p \leq 0,05$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 23) the species flavour of the *M. semimembranosus* cuts of the B age group was significantly ($p \leq 0,01$) more intense than that of the corresponding cuts of the A age group. Therefore, the hypothesis that there will not be a significant difference between the species flavour of the *M. semimembranosus* cuts of either the A or B age groups, when compared with the species flavour of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of species flavour (Table 23) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the species flavour of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of either one or two, and that of the corresponding cuts

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TABLE 23: THREE-WAY VARIANCE OF SPECIES FLAVOUR OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	17.232221	6	2.8720368	3.482	.0021
SPECIE	15.227901	2	7.6139503	9.230	.0001
AGE	.360934	2	.1804668	.219	.8036
FATCODE	1.713000	2	.8565002	1.038	.3545
2-FACTOR INTERACTIONS	10.297750	12	.8581459	1.040	.4092
SPECIE AGE	4.472202	4	1.1180504	1.355	.2478
SPECIE FATCODE	2.009612	4	.5024029	.609	.6562
AGE FATCODE	3.852116	4	.9630291	1.167	.3238
RESIDUAL	626.91162	760	.8248837		
TOTAL (CORR.)	654.44159	778			

31 missing values have been excluded.

TABLE 24: THREE-WAY VARIANCE OF SPECIES FLAVOUR OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	20.562884	6	3.4271473	4.464	.0002
SPECIE	8.182950	2	4.0914750	5.329	.0050
AGE	5.970472	2	2.9852359	3.888	.0209
FATCODE	6.309321	2	3.1546604	4.109	.0168
2-FACTOR INTERACTIONS	9.8096486	12	.8174707	1.065	.3872
SPECIE AGE	1.3686943	4	.3421736	.446	.7756
SPECIE FATCODE	3.1707756	4	.7926939	1.032	.3895
AGE FATCODE	5.2427208	4	1.3106802	1.707	.1464
RESIDUAL	596.55586	777	.7677682		
TOTAL (CORR.)	626.92839	795			

14 missing values have been excluded.

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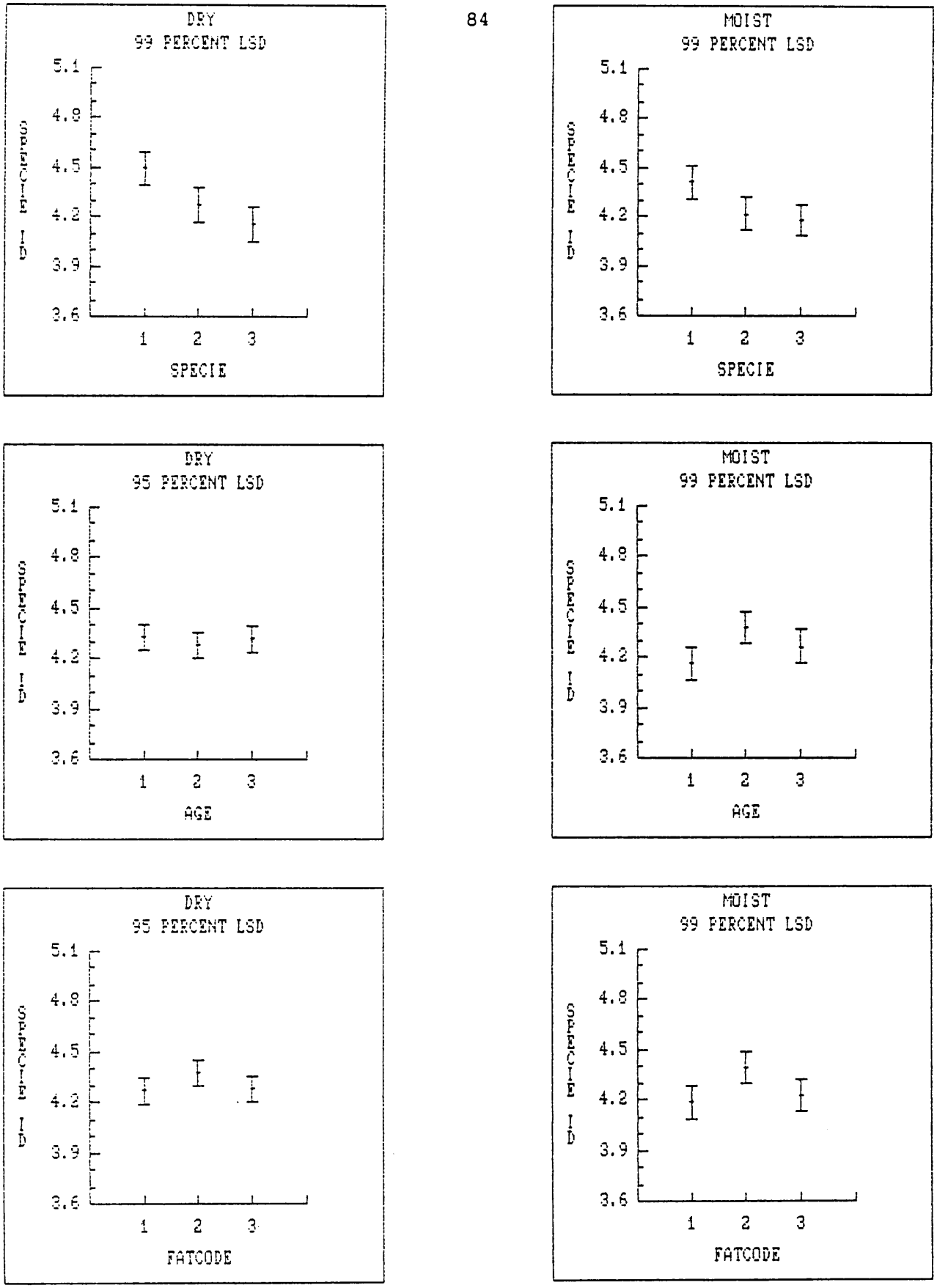

FIGURE 23: GRAPHIC REPRESENTATIONS OF VARIANCE WITH SPECIES FLAVOUR AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for the sensory evaluation of species flavour (Table 24) show significant differences ($p \leq 0,05$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 23) the species flavour of the *M. semimembranosus* cuts with a fat code of two was significantly ($p \leq 0,05$) more intense than that of the corresponding cuts with a fat code of one. The hypothesis that there will not be a significant difference between the species flavour of the *M. semimembranosus* cuts with a fat code of either one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 23 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 24 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 23 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 24 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 23 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 24 and Figure 24) shows no significant effect on the sensory evaluation of species flavour of the *M. semimembranosus* cuts.

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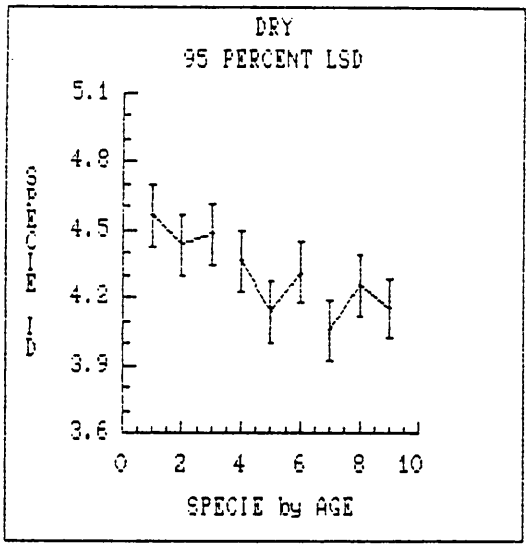

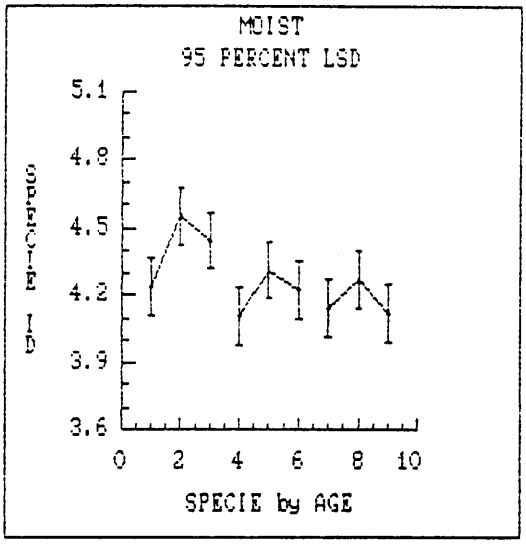

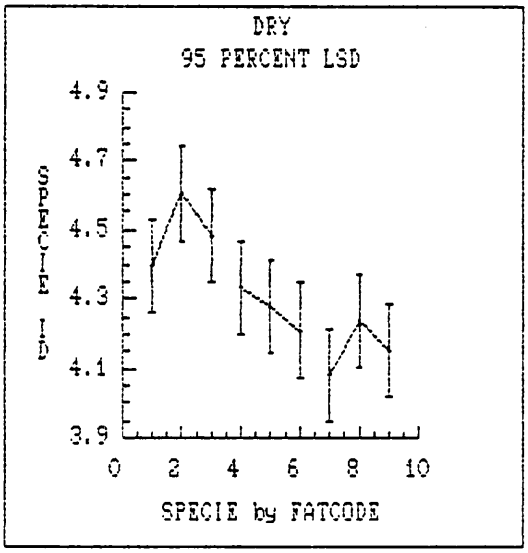

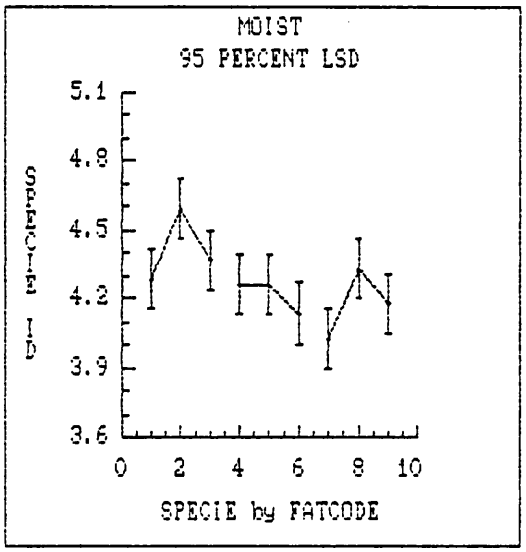

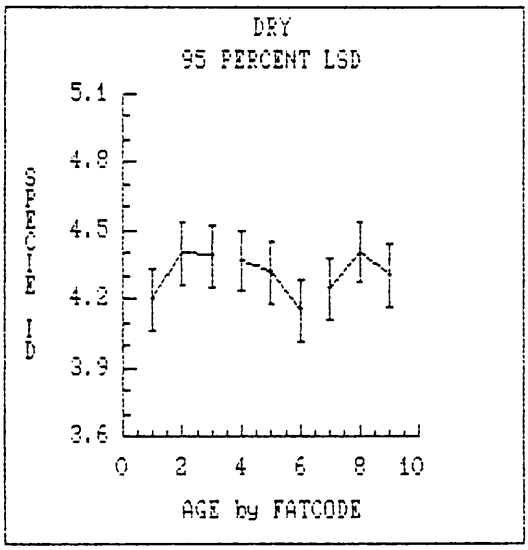

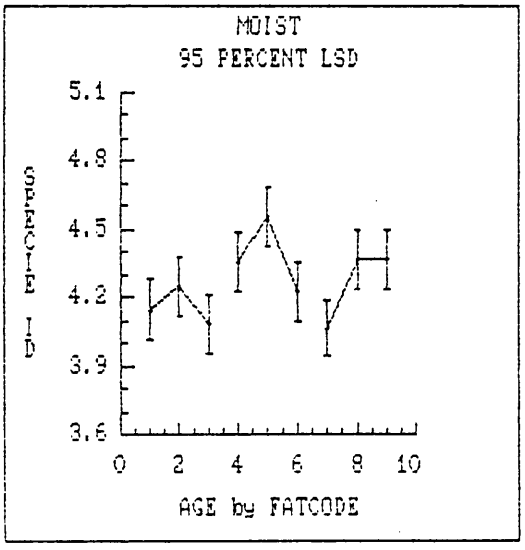

FIGURE 24: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF SPECIES FLAVOUR OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Physical analyses

Thawing and cooking losses

Thawing loss, drip loss, evaporation loss and total cooking loss will be discussed.

Thawing loss The three-way analyses of variance for thawing losses (Table 25) show no significant differences in thawing losses between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the thawing losses of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for thawing losses (Table 26) show a significant differences ($p \leq 0,05$) in thawing losses between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 25) the Angora *M. semimembranosus* cuts had significantly ($p \leq 0,05$) more thawing losses than that of the corresponding Boer goat cuts. The hypothesis that there will not be a significant difference between the thawing losses of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for thawing losses (Table 25) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the thawing losses of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for thawing losses (Table 26) show no significant differences between the *M. semimembranosus* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the thawing losses of the

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TABLE 25: THREE-WAY VARIANCE OF THAWING LOSS OF *Mm. longissimus thoracis et lumborum*

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	8.1910593	6	1.3651765	1.651	.1484
SPECIE	3.7269728	2	1.8634864	2.253	.1136
AGE	3.2932321	2	1.6466160	1.991	.1452
FATCODE	1.1708543	2	.5854272	.708	.4966
2-FACTOR INTERACTIONS	13.683933	12	1.1403278	1.379	.2004
SPECIE AGE	5.744953	4	1.4362383	1.737	.1533
SPECIE FATCODE	3.716020	4	.9290049	1.123	.3538
AGE FATCODE	4.222960	4	1.0557401	1.276	.2889
RESIDUAL	51.278010	62	.8270647		
TOTAL (CORR.)	73.153002	80			

0 missing values have been excluded.

TABLE 26: THREE-WAY VARIANCE OF THAWING LOSS OF *M. semimembranosus*

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	2.0141259	6	.3356877	2.309	.0447
SPECIE	1.2508741	2	.6254370	4.303	.0178
AGE	.6357556	2	.3178778	2.187	.1209
FATCODE	.1274963	2	.0637481	.439	.6469
2-FACTOR INTERACTIONS	3.3646370	12	.2803864	1.929	.0477
SPECIE AGE	1.2996148	4	.3249037	2.235	.0754
SPECIE FATCODE	1.6540741	4	.4135185	2.845	.0313
AGE FATCODE	.4109481	4	.1027370	.707	.5903
RESIDUAL	9.0120593	62	.1453558		
TOTAL (CORR.)	14.390822	80			

0 missing values have been excluded.

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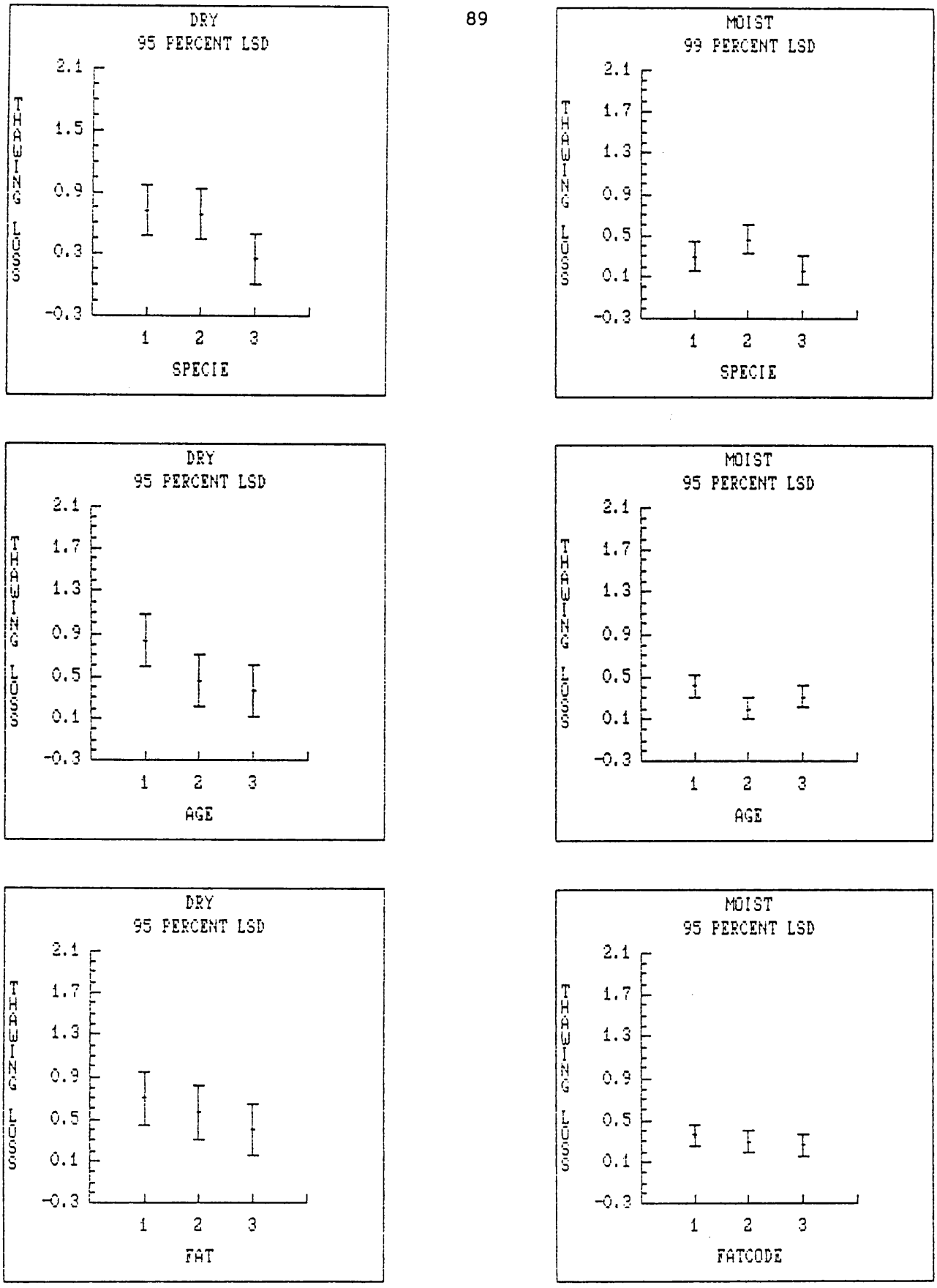

FIGURE 25: GRAPHIC REPRESENTATIONS OF VARIANCE WITH THAWING LOSS AS MAIN EFFECT OF *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS

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M. semimembranosus cuts of either the A or B age groups, and that of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for thawing losses (Table 25) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the thawing losses of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for thawing losses (Table 26) show no significant differences between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the thawing losses of the *M. semimembranosus* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 25 and Figures26) shows no significant effect on the thawing losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 26 and Figures26) shows no significant effect on the thawing losses of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 25 and Figures26) shows no significant effect on the thawing losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 26) shows a significant effect ($p \leq 0,05$) on the thawing losses of the *M. semimembranosus* cuts. According to the t-test (Figure 26) the thawing losses of the Angora goat *M. semimembranosus* cuts with a fat code of one was significantly ($p \leq 0,05$) higher than that of the corresponding sheep and Boer goat cuts of the identical fat code.

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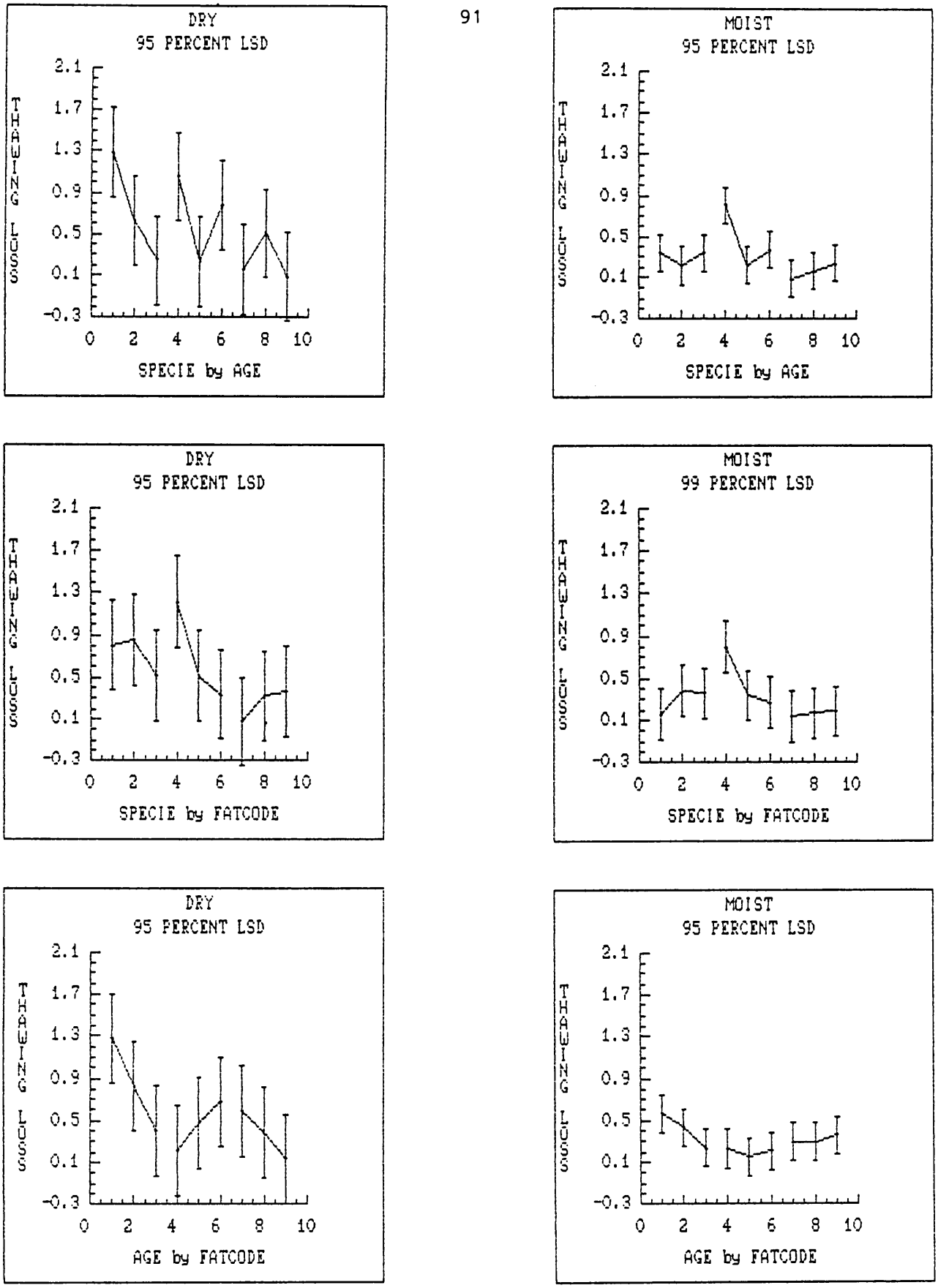

FIGURE 26: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF THAWING LOSS OF *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS

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The two-factor interaction analysis of age and fat code (Table 25 and Figure 26) shows no significant effect on the sensory evaluation of thawing losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 26 and Figure 26) shows no significant effect on the sensory evaluation of thawing losses of the *M. semimembranosus* cuts.

Drip Loss The three-way analyses of variance for drip losses (Table 27) show significant differences ($p \leq 0,01$) in drip losses between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 27) the sheep *Mm. longissimus thoracis et lumborum* cuts had significantly ($p \leq 0,01$) more drip losses than the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the drip losses of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 95 % level of significance.

The three-way analyses of variance for drip losses (Table 28) show no significant differences in drip losses between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the drip losses of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for drip losses (Table 27) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 27) the *Mm. longissimus thoracis et lumborum* cuts of the C age group had significantly ($p \leq 0,01$) more drip losses than the corresponding cuts from the A and B age groups. Therefore, the hypothesis that there will not be a significant difference between the drip losses of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the *Mm. longissimus thoracis et lumborum* cuts of the C age group, is rejected at the 99 % level of significance.

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TABLE 27: THREE-WAY VARIANCE OF DRIP LOSS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	487.27736	6	81.21289	29.243	.0000
SPECIE1	61.96711	2	30.98356	11.157	.0001
AGE1	49.76497	2	24.88248	8.960	.0004
FATCODE1	375.54528	2	187.77264	67.613	.0000
2-FACTOR INTERACTIONS	156.53716	12	13.044764	4.697	.0000
SPECIE1 AGE1	26.32649	4	6.581623	2.370	.0621
SPECIE1 FATCODE1	8.30667	4	2.076668	.748	.5632
AGE1 FATCODE1	121.90400	4	30.475999	10.974	.0000
RESIDUAL	172.18425	62	2.7771654		
TOTAL (CORR.)	815.99877	80			

0 missing values have been excluded.

TABLE 28: THREE-WAY VARIANCE OF DRIP LOSS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	160.54706	6	26.757843	2.964	.0131
SPECIE2	18.81762	2	9.408811	1.042	.3588
AGE2	123.53983	2	61.769915	6.841	.0021
FATCODE2	18.18961	2	9.094804	1.007	.3711
2-FACTOR INTERACTIONS	328.57601	12	27.381335	3.033	.0021
SPECIE2 AGE2	46.17313	4	11.543281	1.278	.2881
SPECIE2 FATCODE2	126.28797	4	31.571993	3.497	.0122
AGE2 FATCODE2	156.11492	4	39.028730	4.323	.0038
RESIDUAL	559.78513	62	9.0287924		
TOTAL (CORR.)	1048.9082	80			

0 missing values have been excluded.

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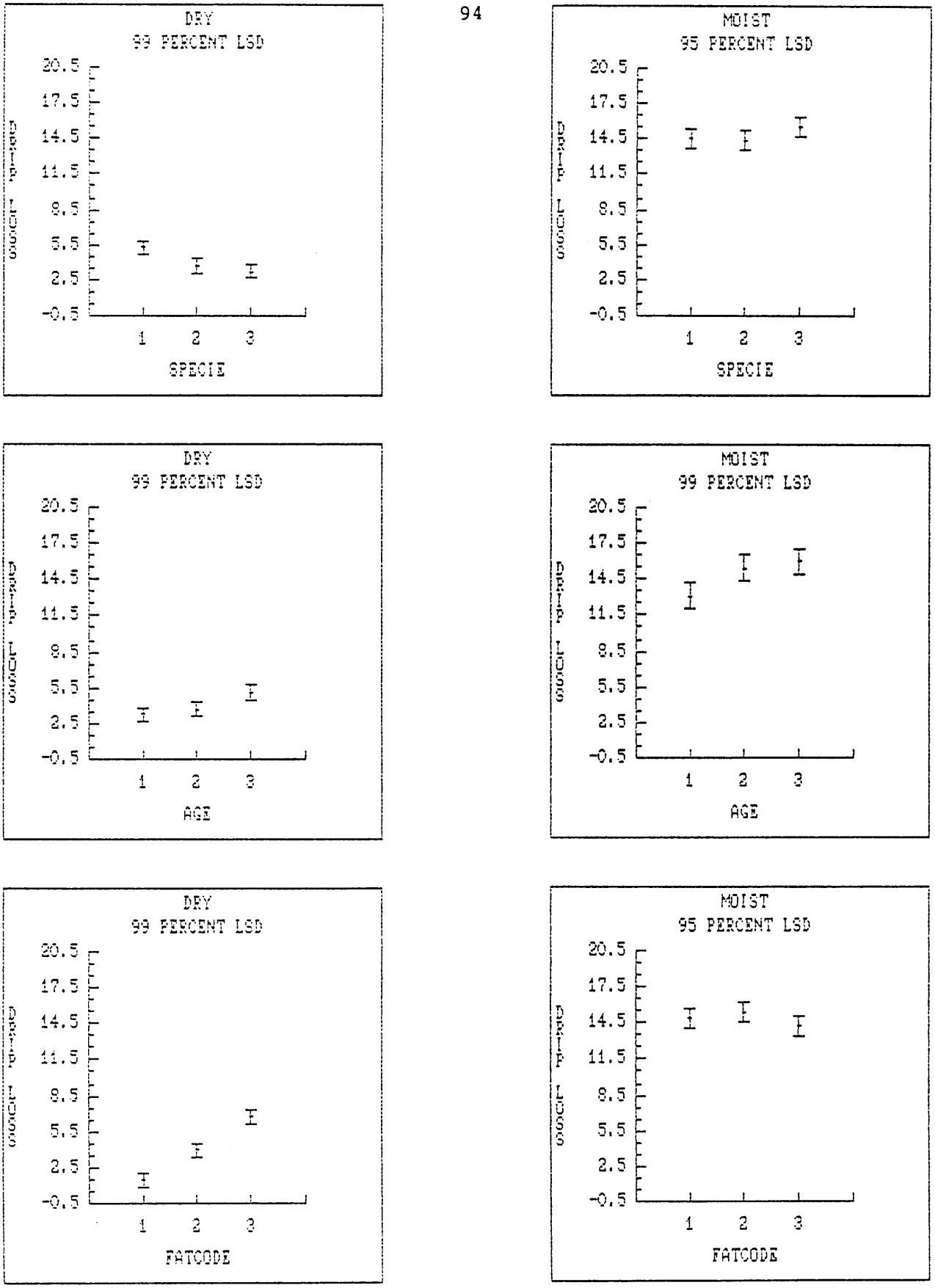

FIGURE 27: GRAPHIC REPRESENTATIONS OF VARIANCE WITH DRIP LOSS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The three-way analyses of variance for drip losses (Table 28) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 27) the *M. semimembranosus* cuts of the B and C age groups had significantly ($p \leq 0,01$) more drip losses than the corresponding cuts from the A age group. Therefore, the hypothesis that there will not be a significant difference between the drip losses of the *M. semimembranosus* cuts of the A age group, and that of the *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the drip losses of the *M. semimembranosus* cuts of the B age group, and that of the *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for the drip losses (Table 27) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 27) the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly ($p \leq 0,01$) more drip losses than the corresponding cuts with a fat code of two, which in turn had significantly ($p \leq 0,01$) more drip losses than for the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the drip losses of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 99 % level of significance.

The three-way analyses of variance for the drip losses show no significant differences (Table 28) between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the drip losses of the *M. semimembranosus* cuts with a fat code of either one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 27 and Figure 28) shows no significant effect on the drip losses of the *Mm. longissimus thoracis et lumborum* cuts.

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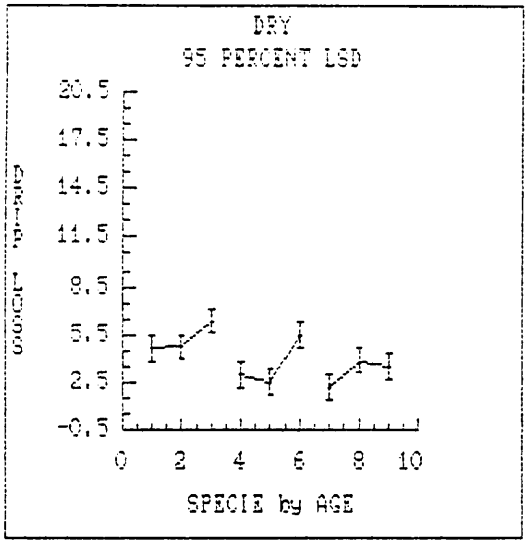

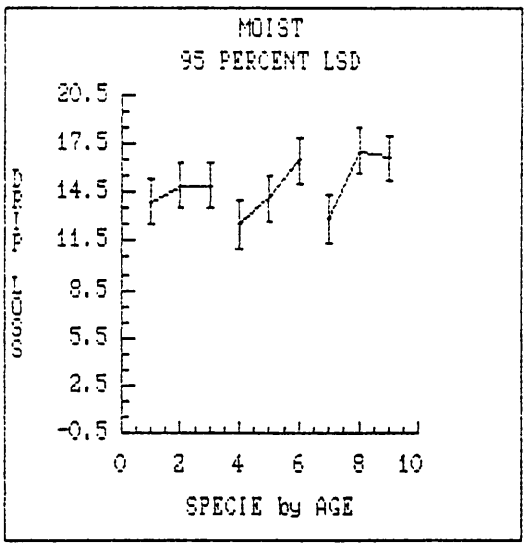

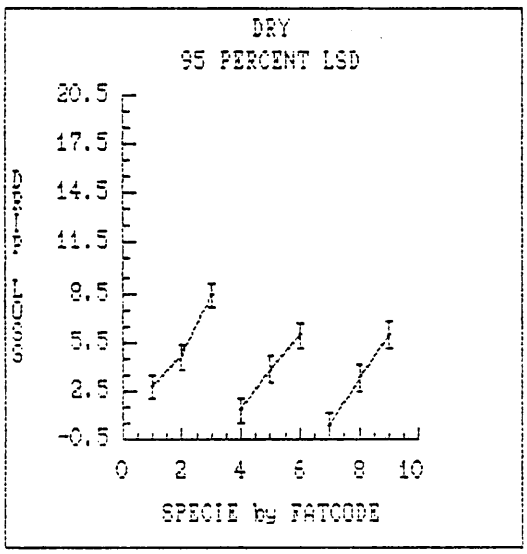

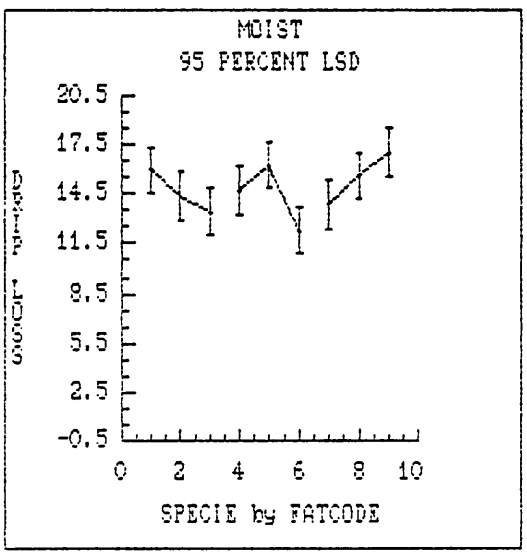

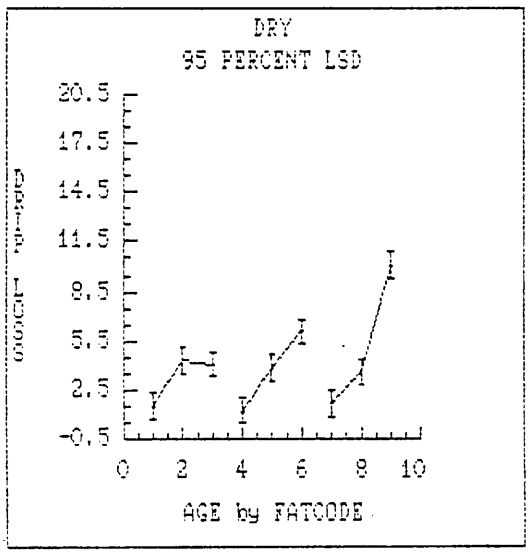

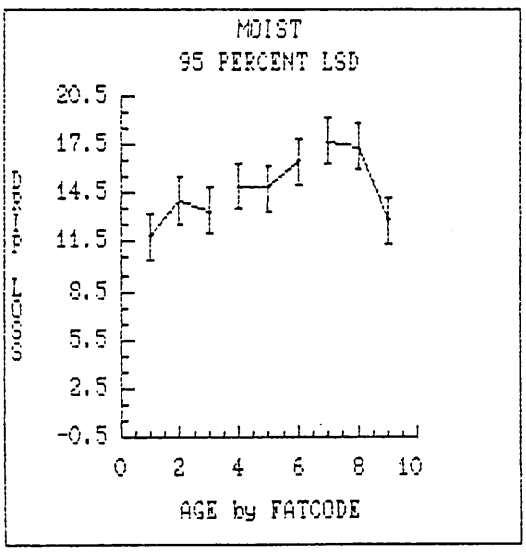

FIGURE 28: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE WITH DRIP LOSS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of species and age (Table 28 and Figure 28) shows no significant effect on the drip losses of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 27 and Figure 28) shows no significant effect on the drip losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 28) shows a significant ($p \leq 0,01$) effect on the drip losses of the *M. semimembranosus* cuts. According to the t-test (Figure 28) the drip losses of the Boer goat *M. semimembranosus* cuts with a fat code of three was significantly ($p \leq 0,05$) higher than that of the corresponding sheep and Angora goat cuts of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 27) shows a significant effect ($p \leq 0,01$) on the drip losses of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 28) the drip losses of the *Mm. longissimus thoracis et lumborum* cuts of the C age group with a fat code of three was significantly ($p \leq 0,01$) higher than that of the corresponding cuts of the B age group of the identical fat code, which in turn was significantly ($p \leq 0,05$) higher than that of the corresponding cuts of the A age group of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 28) shows a significant effect ($p \leq 0,01$) on the drip losses of the *M. semimembranosus* cuts. According to the t-test (Figure 28) the drip losses of the *M. semimembranosus* cuts of the C age group with a fat code of one was significantly ($p \leq 0,05$) higher than that of the corresponding cuts of the A age group of the identical fat code. The drip losses of the *M. semimembranosus* cuts of the C age group with a fat code of two was significantly ($p \leq 0,05$) higher than that of the corresponding cuts of the A age group of the identical fat code. The drip losses of the *M. semimembranosus* cuts of the B age group with a fat code of three was significantly ($p \leq 0,05$) higher than that of the corresponding cuts of the A and C age groups of the identical fat code.

Evaporation loss The three-way analyses of variance for evaporation

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losses (Table 29) show no significant differences in evaporation losses between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for evaporation losses (Table 30) show significant differences ($p \leq 0,05$) in evaporation losses between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 29) the sheep *Mm. longissimus thoracis et lumborum* cuts had significantly ($p \leq 0,05$) more evaporation losses than the corresponding cuts from the Angora goat cuts. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of the Angora goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the evaporation losses of the Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for evaporation losses (Table 29) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the *Mm. longissimus thoracis et lumborum* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for evaporation losses (Table 30) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 29) the *M. semimembranosus* cuts of the C age group had significantly ($p \leq 0,01$) higher evaporation losses than the corresponding cuts from the A age group. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of the *M. semimembranosus* cuts of the A age group, and that of the *M. semimembranosus* cuts of the C age group, is

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TABLE 29: THREE-WAY VARIANCE OF EVAPORATION LOSS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation		Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS		659.30177	6	109.88363	1.794	.1149
SPECIE1		93.61710	2	46.80855	.764	.4700
AGE1		68.26462	2	34.13231	.557	.5756
FATCODE1		497.42005	2	248.71003	4.061	.0220
2-FACTOR INTERACTIONS		556.05250	12	46.33771	.757	.6912
SPECIE1	AGE1	83.38370	4	20.84593	.340	.8497
SPECIE1	FATCODE1	40.36801	4	10.09200	.165	.9554
AGE1	FATCODE1	432.30079	4	108.07520	1.765	.1474
RESIDUAL		3797.1101	62	61.243712		
TOTAL (CORR.)		5012.4644	80			

0 missing values have been excluded.

TABLE 30: THREE-WAY VARIANCE OF EVAPORATION LOSS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation		Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS		319.33967	6	53.223279	7.200	.0000
SPECIE		48.23439	2	24.117194	3.262	.0450
AGE		101.25846	2	50.629231	6.849	.0021
FATCODE		169.84682	2	84.923412	11.488	.0001
2-FACTOR INTERACTIONS		115.97397	12	9.664498	1.307	.2375
SPECIE	AGE	37.13469	4	9.283673	1.256	.2970
SPECIE	FATCODE	45.43609	4	11.359022	1.537	.2027
AGE	FATCODE	33.40319	4	8.350798	1.130	.3508
RESIDUAL		458.33794	62	7.3925475		
TOTAL (CORR.)		893.65159	80			

0 missing values have been excluded.

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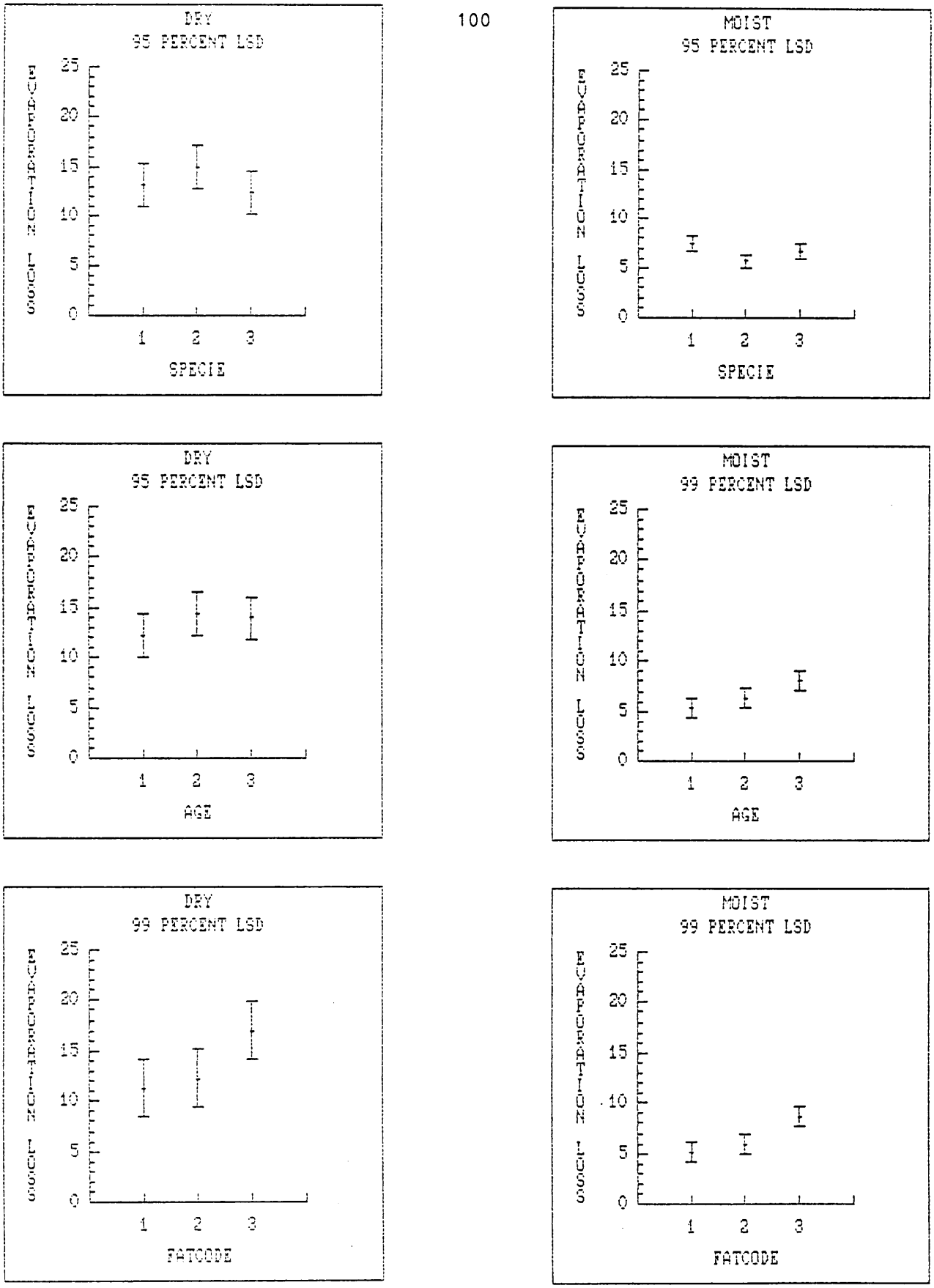

FIGURE 29: GRAPHIC REPRESENTATIONS OF VARIANCE WITH EVAPORATION LOSS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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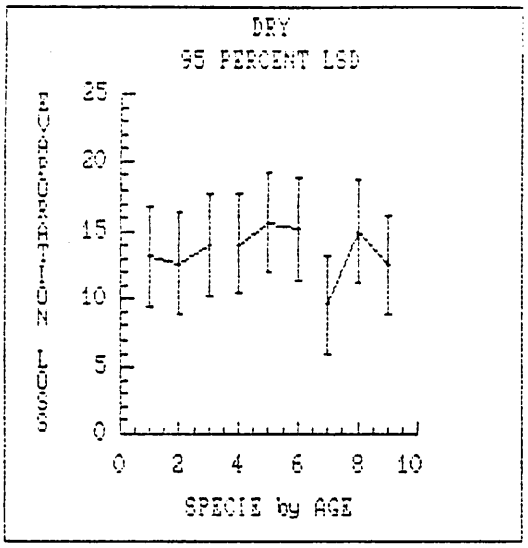

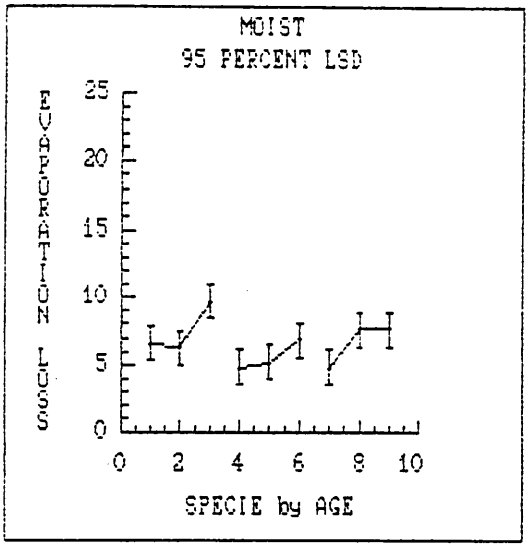

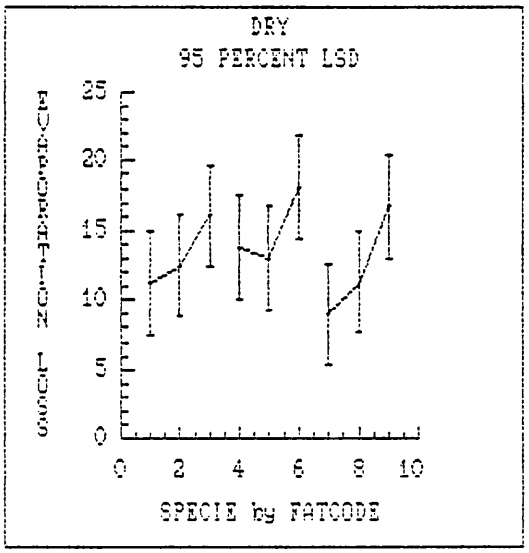

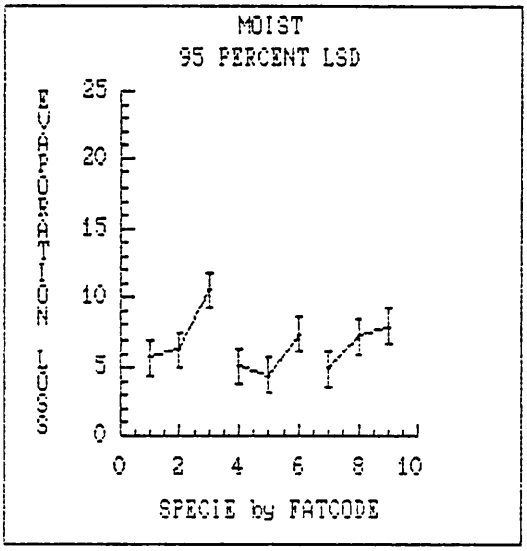

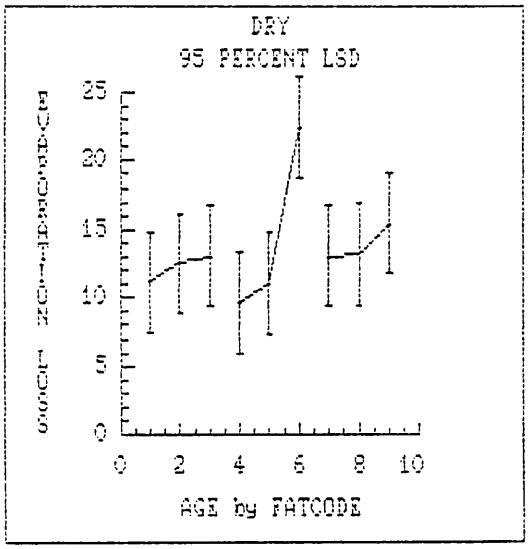

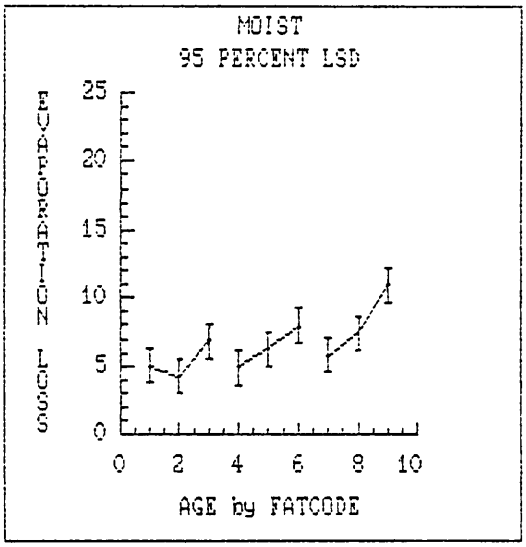

FIGURE 30: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE WITH EVAPORATION LOSS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the evaporation losses of the *M. semimembranosus* cuts of the B age group, and that of the *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for evaporation losses (Table 29) show significant differences ($p \leq 0,05$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 29) the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly ($p \leq 0,01$) higher evaporation losses than the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of one, and that of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of two, and that of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for evaporation losses (Table 30) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 29) the *M. semimembranosus* cuts with a fat code of three had significantly ($p \leq 0,01$) higher evaporation losses than the corresponding cuts with a fat code of one and two. Therefore, the hypothesis that there will not be a significant difference between the evaporation losses of the *M. semimembranosus* cuts with a fat code of either one or two, and that of the *M. semimembranosus* cuts with a fat code of three, is rejected at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 29 and Figure 30) shows no significant effect on the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 30 and Figure 30) shows no significant effect on the evaporation losses of the

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M. semimembranosus cuts.

The two-factor interaction analysis of species and fat code (Table 29 and Figure 30) shows no significant effect on the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 30 and Figure 30) shows no significant effect on the evaporation losses of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 29 and Figure 30) shows no significant effect on the evaporation losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 30 and Figure 30) shows no significant effect on the evaporation losses of the *M. semimembranosus* cuts.

Total cooking loss The three-way analyses of variance for total cooking losses (Table 31) show no significant differences in total cooking losses between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for total cooking losses (Table 32) show significant differences ($p \leq 0,05$) in total cooking losses between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 31) the sheep and Boer goat *Mm. longissimus thoracis et lumborum* cuts had significantly ($p \leq 0,05$) higher total cooking losses than the corresponding Angora goat cuts. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of the Angora goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the total cooking losses of the Boer goat *M. semimembranosus* cuts, and that

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TABLE 31: THREE-WAY VARIANCE OF TOTAL COOKING LOSS OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1975.0755	6	329.17925	4.941	.0003
SPECIE	172.2681	2	86.13405	1.293	.2818
AGE	156.9850	2	78.49250	1.178	.3146
FATCODE	1645.8224	2	822.91121	12.352	.0000
2-FACTOR INTERACTIONS	780.89973	12	65.07498	.977	.4805
SPECIE AGE	174.45381	4	43.61345	.655	.6258
SPECIE FATCODE	53.13606	4	13.28401	.199	.9378
AGE FATCODE	553.30986	4	138.32746	2.076	.0946
RESIDUAL	4130.4752	62	66.620567		
TOTAL (CORR.)	6886.4504	80			

0 missing values have been excluded.

TABLE 32: THREE-WAY VARIANCE OF TOTAL COOKING LOSS OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	610.15581	6	101.69264	10.310	.0000
SPECIE	80.42829	2	40.21414	4.077	.0217
AGE	423.95450	2	211.97725	21.492	.0000
FATCODE	105.77303	2	52.88651	5.362	.0071
2-FACTOR INTERACTIONS	304.44293	12	25.370244	2.572	.0078
SPECIE AGE	112.03239	4	28.008098	2.840	.0315
SPECIE FATCODE	131.14019	4	32.785048	3.324	.0157
AGE FATCODE	61.27034	4	15.317585	1.553	.1981
RESIDUAL	611.51981	62	9.8632228		
TOTAL (CORR.)	1526.1186	80			

0 missing values have been excluded.

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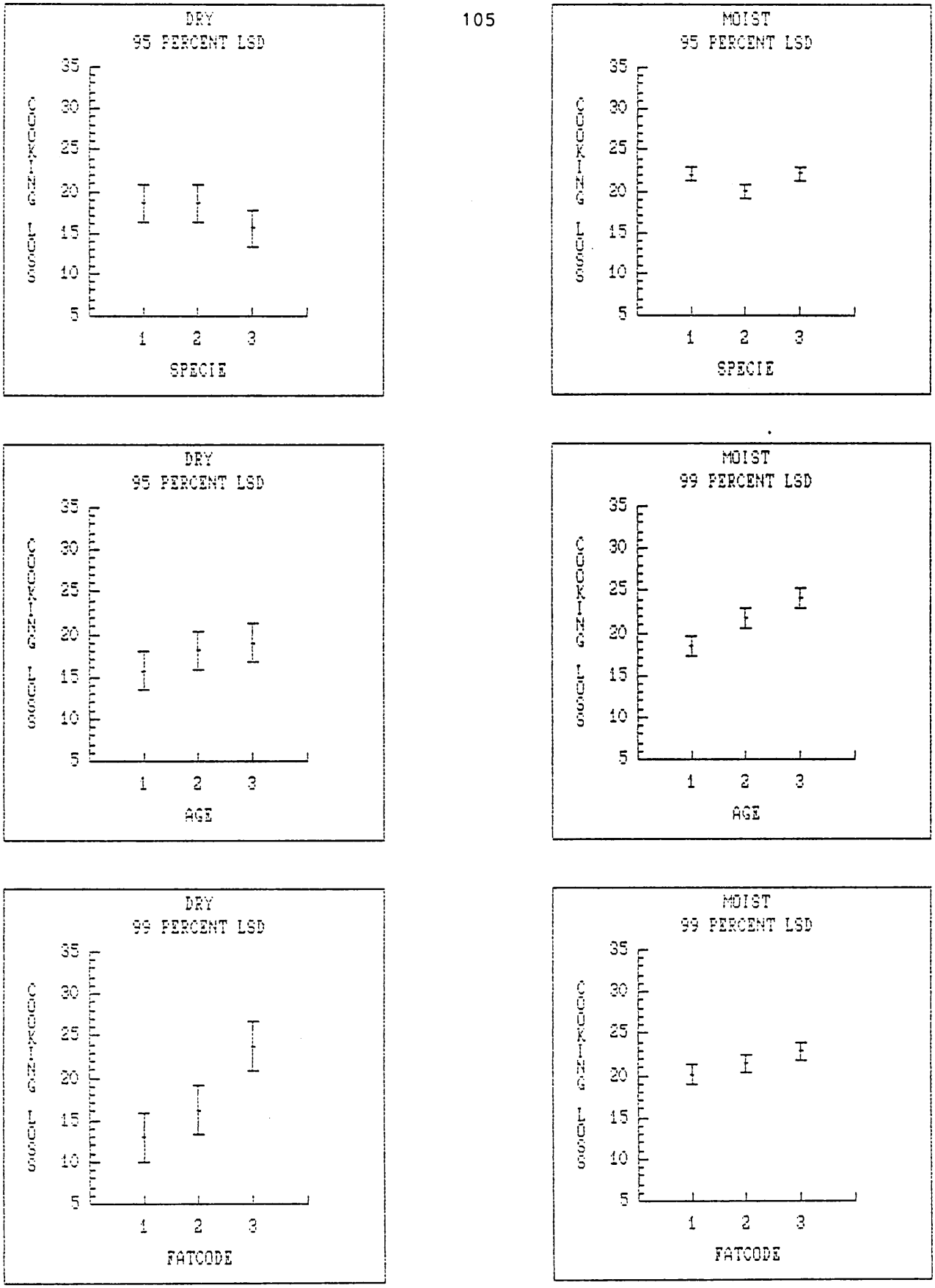

FIGURE 31: GRAPHIC REPRESENTATIONS OF VARIANCE WITH TOTAL COOKING LOSS AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for total cooking losses (Table 31) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the *Mm. longissimus thoracis et lumborum* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for total cooking losses (Table 32) shows significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 31) the *M. semimembranosus* cuts of the C age group had significantly ($p \leq 0,01$) higher total cooking losses than the corresponding cuts from the B age group, which in turn had significantly ($p \leq 0,01$) more total cooking losses than the corresponding cuts from the A age group. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of the *M. semimembranosus* cuts of either the A or B age groups, and that of the *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance.

The three-way analyses of variance for total cooking losses (Table 31) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 31) the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly ($p \leq 0,01$) higher total cooking losses than the corresponding cuts with a fat code of one and two. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 99 % level of significance.

The three-way analyses of variance for total cooking losses (Table 32) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 31) the *M. semimembranosus* cuts with a fat code of three had significantly

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(p ≤ 0,01) higher total cooking losses than for the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the total cooking losses of the *M. semimembranosus* cuts with a fat code of one, and that of the *M. semimembranosus* cuts with a fat code of three, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the total cooking losses of the *M. semimembranosus* cuts with a fat code of two, and that of the *M. semimembranosus* cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 31 and Figure 32) shows no significant effect on the total cooking losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 32) shows a significant (p ≤ 0,05) effect on the total cooking losses of the *M. semimembranosus* cuts. According to the t-test (Figure 32) the total cooking losses of the sheep *M. semimembranosus* cuts of the A age group was significantly (p ≤ 0,05) higher than that of the corresponding Angora and Boer goat cuts of the identical age group. The total cooking losses of the Boer goat *M. semimembranosus* cuts of the B age group was significantly (p ≤ 0,05) higher than that of the corresponding sheep and Angora goat cuts of the identical age group.

The two-factor interaction analysis of species and fat code (Table 31 and Figure 32) shows no significant effect on the total cooking losses of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 32) shows a significant (p ≤ 0,05) effect on the total cooking losses of the *M. semimembranosus* cuts. According to the t-test (Figure 32) the total cooking losses of the sheep and Boer goat *M. semimembranosus* cuts with a fat code of three was significantly (p ≤ 0,01) higher than that of the corresponding Angora goat cuts of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 31) shows no significant effect on the total cooking losses of the *Mm. longissimus thoracis et lumborum* cuts.

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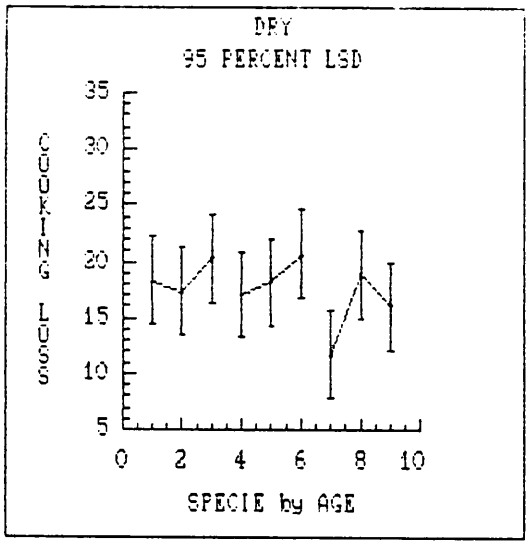

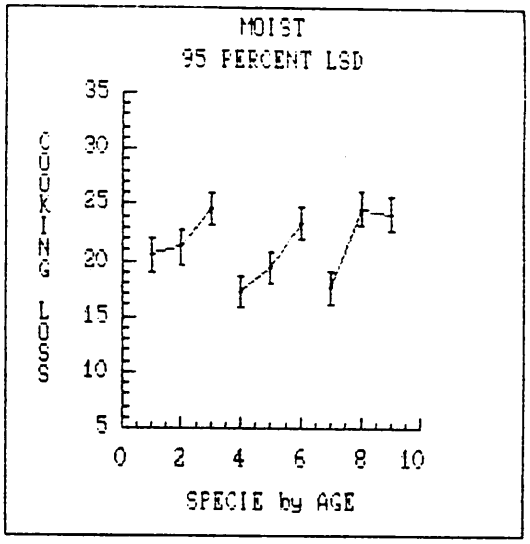

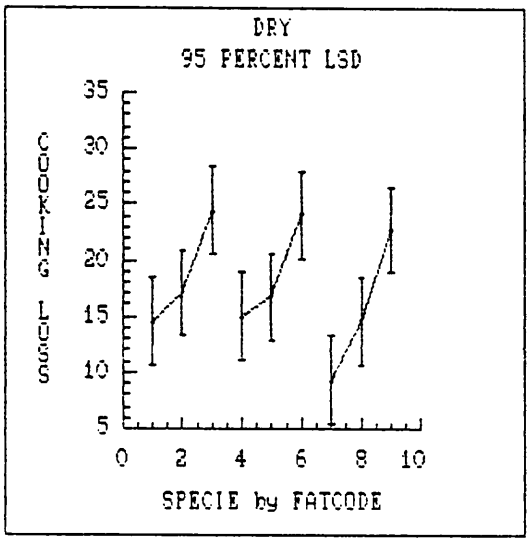

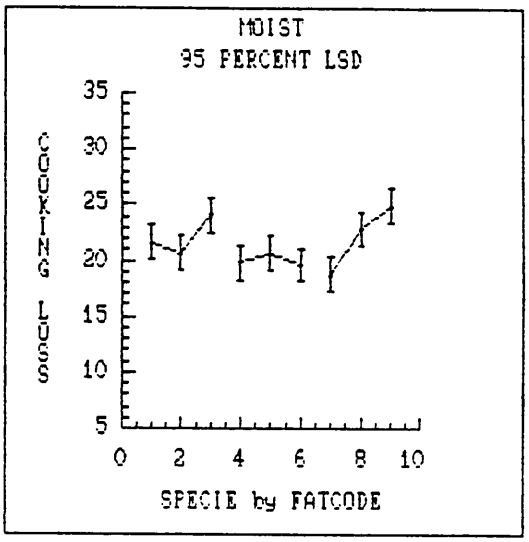

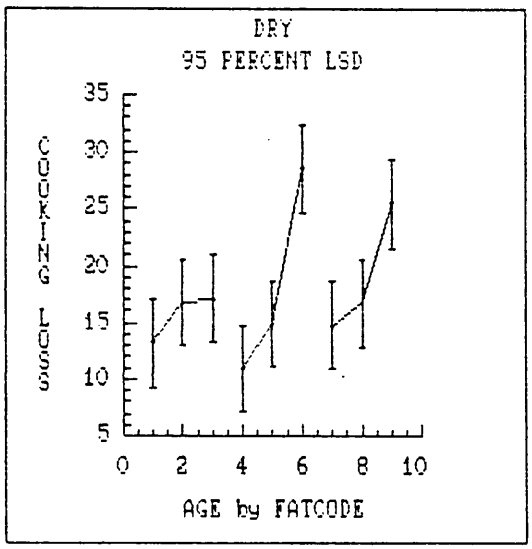

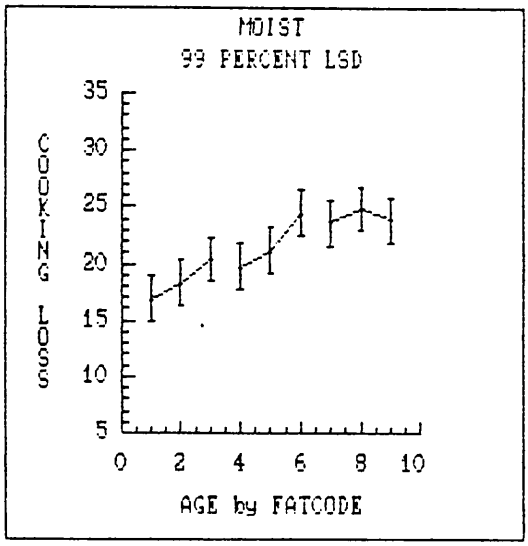

FIGURE 32: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE WITH TOTAL COOKING LOSS OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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The two-factor interaction analysis of age and fat code (Table 32) shows no significant effect on the total cooking losses of the *M. semimembranosus* cuts.

Press fluid

The three-way analyses of variance for press fluid (Table 33) show no significant differences between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the expressible moisture of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for press fluid (Table 34) show no significant differences between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the expressible moisture of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for the press fluid (Table 33) show significant differences ($p \leq 0,01$) between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 33) the expressible moisture of the *Mm. longissimus thoracis et lumborum* cuts of the A age group was significantly higher ($p \leq 0,05$) than that of the corresponding cuts of the B age group, which was in turn significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the C age group. Therefore, the hypothesis that there will not be a significant difference between the expressible moisture of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the *Mm. longissimus thoracis et lumborum* cuts of the C age group, is rejected at the 99 % level of significance.

The three-way analyses of variance for the press fluid (Table 34) show no significant differences between the *M. semimembranosus* cuts from the three age groups. Therefore, the hypothesis that there will not be a

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TABLE 33: THREE-WAY VARIANCE OF PRESS FLUID OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	481.38081	6	80.23014	4.418	.0009
SPECIE	85.76062	2	42.88031	2.361	.1027
AGE	258.75614	2	129.37807	7.124	.0016
FATCODE	136.86405	2	68.43203	3.768	.0285
2-FACTOR INTERACTIONS	618.39326	12	51.53277	2.838	.0037
SPECIE AGE	59.18797	4	14.79699	.815	.5206
SPECIE FATCODE	92.61850	4	23.15463	1.275	.2895
AGE FATCODE	466.58679	4	116.64670	6.423	.0002
RESIDUAL	1125.9665	62	18.160750		
TOTAL (CORR.)	2225.7406	80			

0 missing values have been excluded.

TABLE 34: THREE-WAY VARIANCE OF PRESS FLUID OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	171.31122	6	28.551870	1.347	.2503
SPECIE	109.05335	2	54.526675	2.572	.0845
AGE	56.90763	2	28.453816	1.342	.2687
FATCODE	5.35024	2	2.675120	.126	.8817
2-FACTOR INTERACTIONS	372.78223	12	31.065186	1.465	.1620
SPECIE AGE	129.77805	4	32.444512	1.530	.2044
SPECIE FATCODE	133.40178	4	33.350444	1.573	.1926
AGE FATCODE	109.60240	4	27.400601	1.293	.2827
RESIDUAL	1314.3195	62	21.198702		
TOTAL (CORR.)	1858.4130	80			

0 missing values have been excluded.

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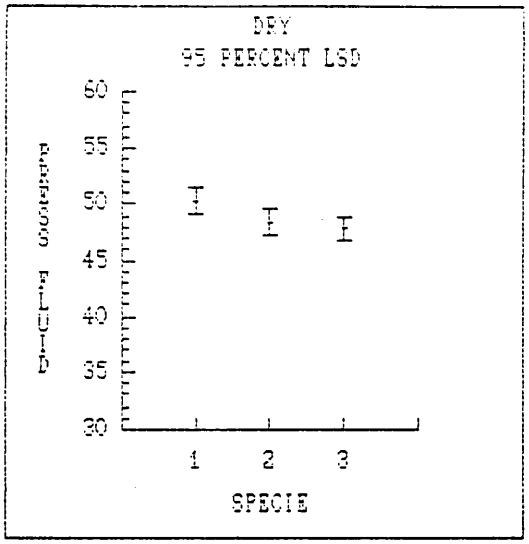

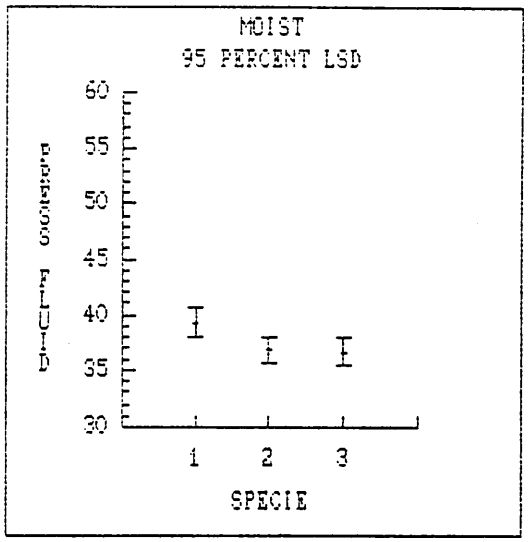

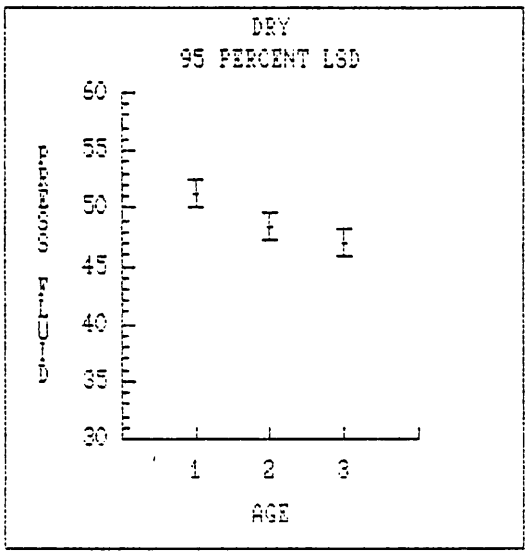

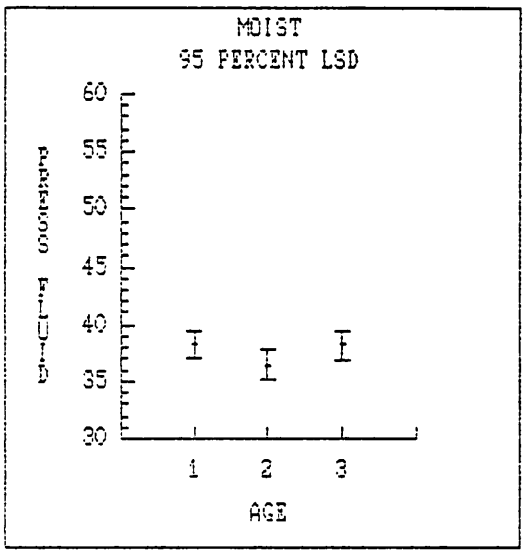

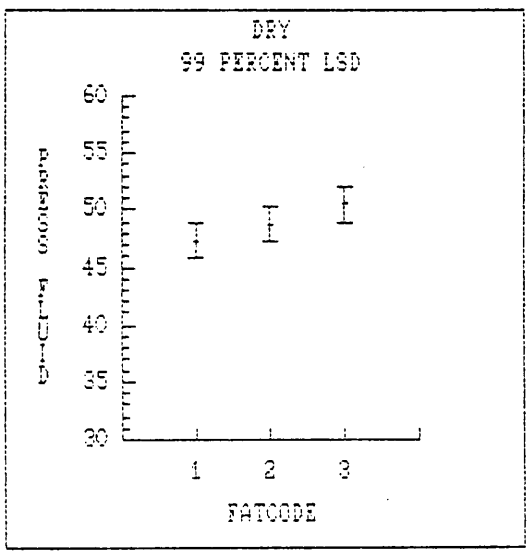

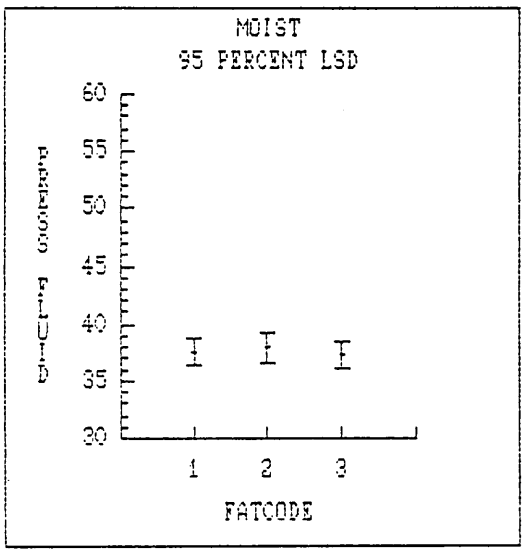

FIGURE 33: GRAPHIC REPRESENTATIONS OF VARIANCE WITH PRESS FLUID AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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significant difference between the expressible moisture of the *M. semimembranosus* cuts of either the A or B age groups, and that the expressible moisture of the corresponding cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for press fluid (Table 33) show significant differences ($p \leq 0,05$) between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 33) the expressible moisture of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly more ($p \leq 0,01$) expressible moisture than that of the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the expressible moisture of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of one, when compared with that of the corresponding cuts with a fat code of three, is rejected at the 95 % level of significance. The hypothesis that there will not be a significant difference between the expressible moisture of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for press fluid (Table 34) show no significant differences between the *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the expressible moisture of the *M. semimembranosus* cuts with either a fat code of one or two, and that of the corresponding cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 33 and Figure 34) shows no significant effect for the press fluid of the *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 34 and Figure 34) shows no significant effect for the press fluid of the *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 33 and Figure 34) shows no significant effect for the press fluid of the

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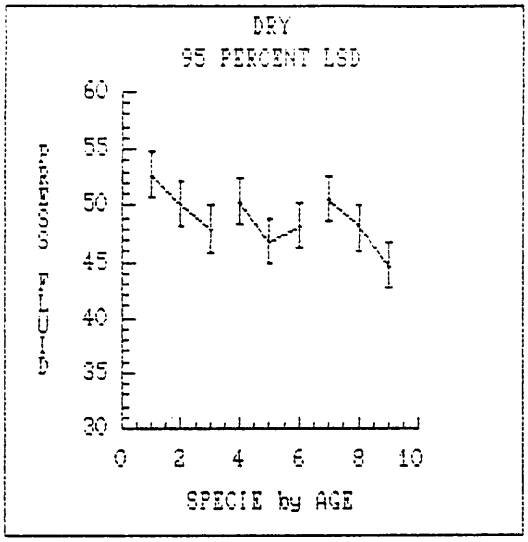

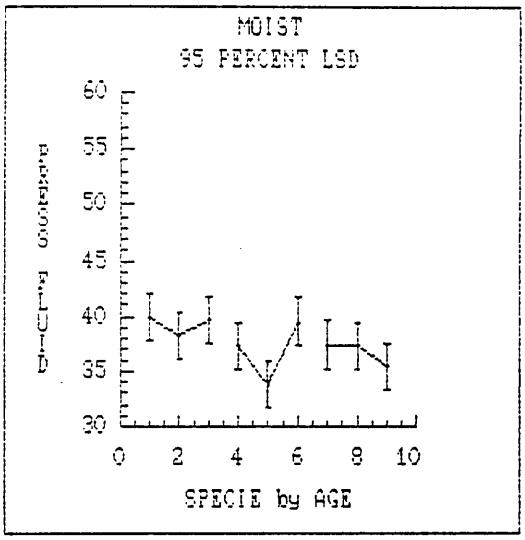

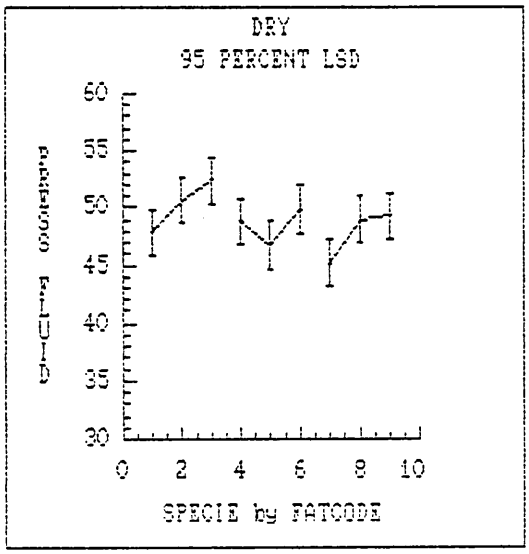

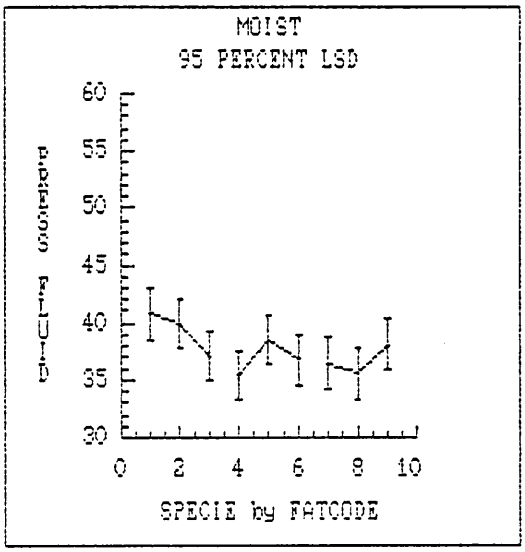

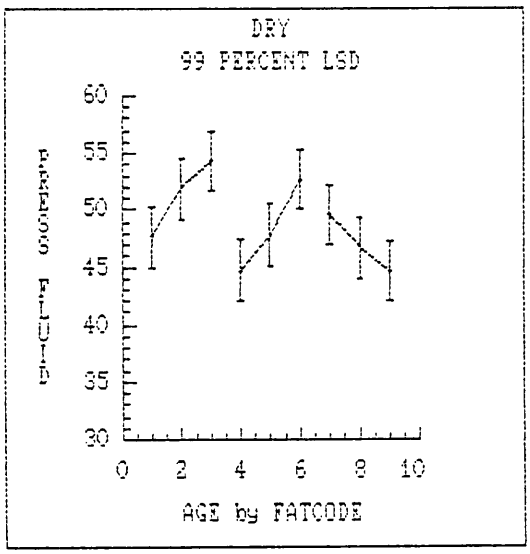

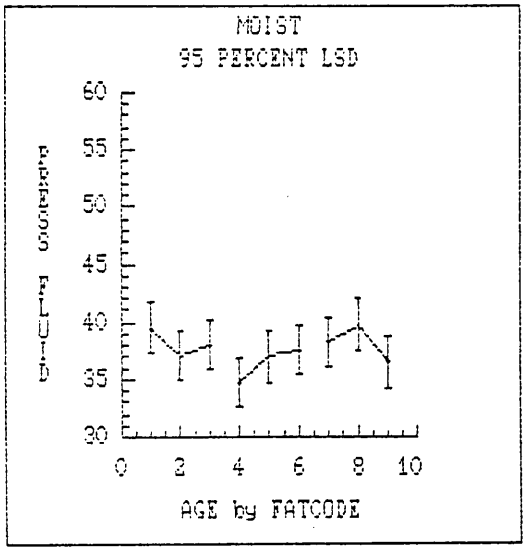

FIGURE 34: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE WITH PRESS FLUID OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Mm. longissimus thoracis et lumborum cuts.

The two-factor interaction analysis of species and fat code (Table 34 and Figure 34) shows no significant effect for the press fluid of the *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 33 and Figure 34) shows a significant effect ($p \leq 0,01$) for the press fluid of the *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 34) the *Mm. longissimus thoracis et lumborum* cuts of both the A and B age groups with a fat code of three had significantly ($p \leq 0,01$) more expressible moisture than that of the corresponding cuts of the C age group of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 34) shows no significant effect on the press fluid of the *M. semimembranosus* cuts.

Shear force

The three-way analyses of variance for shear force (Table 35) show significant differences ($p \leq 0,01$) between sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 35) the Boer goat *Mm. longissimus thoracis et lumborum* cuts showed significantly ($p \leq 0,01$) more resistance to shear force than the corresponding Angora goat cuts, which in turn showed significantly ($p \leq 0,01$) more resistance to shear force than the corresponding cuts of the sheep cuts. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of either the Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the sheep *Mm. longissimus thoracis et lumborum* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for shear force (Table 36) show significant differences ($p \leq 0,01$) between sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 35) the Boer goat *M. semimembranosus* cuts showed significantly ($p \leq 0,05$) more resistance to shear force than the corresponding Angora goat cuts, which in turn showed significantly ($p \leq 0,01$) more resistance to shear

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TABLE 35: THREE-WAY VARIANCE OF SHEAR FORCE OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	13076.769	6	2179.4614	7.195	.0000
SPECIE	12755.216	2	6377.6082	21.055	.0000
AGE	19.771	2	9.8855	.033	.9679
FATCODE	373.866	2	186.9331	.617	.5428
2-FACTOR INTERACTIONS	2508.3653	12	209.03045	.690	.7545
SPECIE AGE	625.4619	4	156.36549	.516	.7241
SPECIE FATCODE	273.7099	4	68.42748	.226	.9229
AGE FATCODE	1628.7907	4	407.19767	1.344	.2639
RESIDUAL	18476.871	61	302.89952		
TOTAL (CORR.)	34062.005	79			

1 missing values have been excluded.

TABLE 36: THREE-WAY VARIANCE OF SHEAR FORCE OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	12679.675	6	2113.2792	17.079	.0000
SPECIE	6570.710	2	3285.3552	26.551	.0000
AGE	4917.853	2	2458.9265	19.872	.0000
FATCODE	1191.112	2	595.5559	4.813	.0114
2-FACTOR INTERACTIONS	2847.5121	12	237.29267	1.918	.0492
SPECIE AGE	1265.2907	4	316.32267	2.556	.0474
SPECIE FATCODE	606.4956	4	151.62389	1.225	.3093
AGE FATCODE	975.7258	4	243.93146	1.971	.1099
RESIDUAL	7671.6132	62	123.73570		
TOTAL (CORR.)	23198.801	80			

0 missing values have been excluded.

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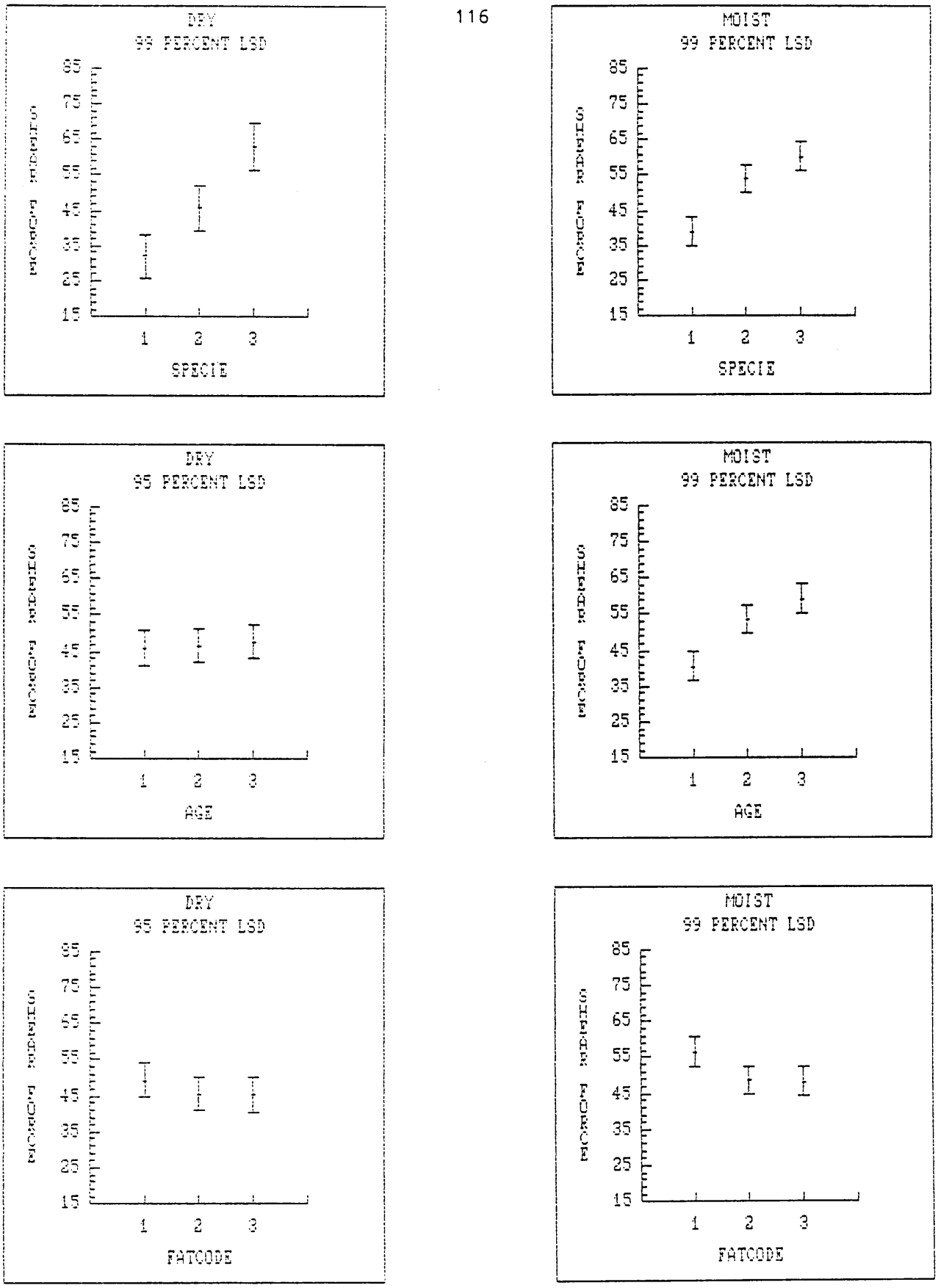

FIGURE 35: GRAPHIC REPRESENTATIONS OF VARIANCE WITH SHEAR FORCE AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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force than the corresponding cuts of the sheep cuts. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of either the Angora or Boer goat *M. semimembranosus* cuts, and that of the sheep *M. semimembranosus* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for shear force (Table 35) no show significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of the *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the *Mm. longissimus thoracis et lumborum* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for shear force (Table 36) show significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 36) the *M. semimembranosus* cuts of the C age group showed significantly more ($p \leq 0,01$) resistance to shear force than the corresponding cuts of the A age group. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of the *M. semimembranosus* cuts of the A age group, when compared with the resistance to shear force of the *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the resistance to shear force of the *M. semimembranosus* cuts of the B age group, and that of the *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for shear force (Table 35) show no significant differences between the *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of the *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for shear force (Table 36) show

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significant differences ($p \leq 0,01$) between the *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 36) of the *M. semimembranosus* cuts with a fat code of one showed significantly more ($p \leq 0,01$) resistance to shear force than the corresponding cuts with a fat code of two and three. Therefore, the hypothesis that there will not be a significant difference between the resistance to shear force of the *M. semimembranosus* cuts with a fat code of one, and that of the *M. semimembranosus* cuts with a fat code of three, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the resistance to shear force of the *M. semimembranosus* cuts with a fat code of two, and that of the *M. semimembranosus* cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 35 and Figure 37) shows no significant effect on the resistance of the *Mm. longissimus thoracis et lumborum* cuts to shear.

The two-factor interaction analysis of species and age (Table 36) shows a significant effect ($p \leq 0,05$) on the resistance of the *M. semimembranosus* cuts to shear. According to the t-test (Figure 37) the Boer goat *M. semimembranosus* cuts of the B age group showed significantly ($p \leq 0,01$) more resistance to shear force than that of the corresponding Angora and sheep cuts of the identical age group. The Angora and Boer goat *M. semimembranosus* cuts of the C age group showed significantly ($p \leq 0,01$) more resistance to shear force than that of the corresponding sheep cuts of the identical age group.

The two-factor interaction analysis of species and fat code (Table 35 and Figure 37) shows no significant effect on the resistance of the *Mm. longissimus thoracis et lumborum* cuts to shear.

The two-factor interaction analysis of species and fat code (Table 36 and Figure 37) shows no significant effect on the resistance of the *M. semimembranosus* cuts to shear.

The two-factor interaction analysis of age and fat code (Table 35 and Figure 37) shows no significant effect on the resistance of the

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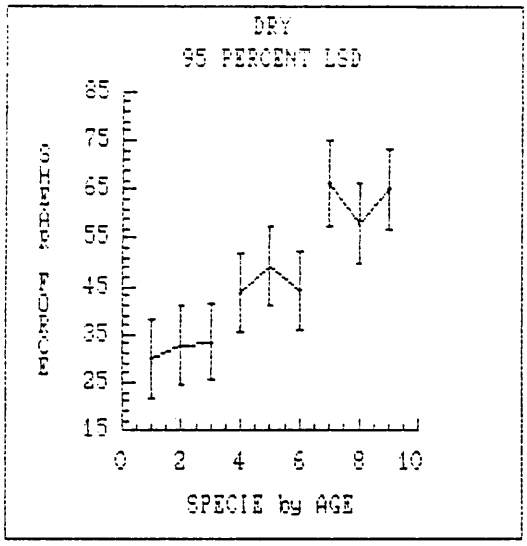

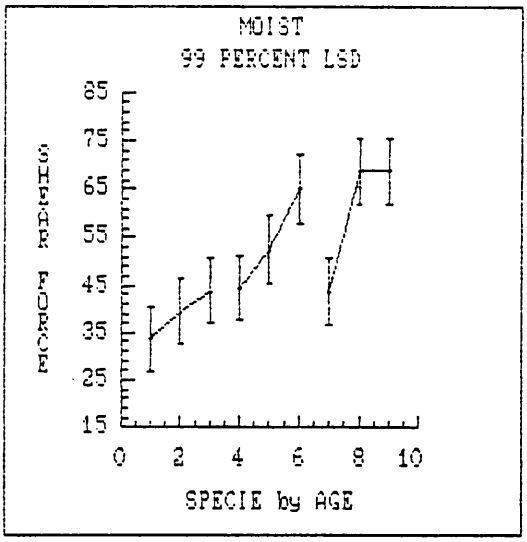

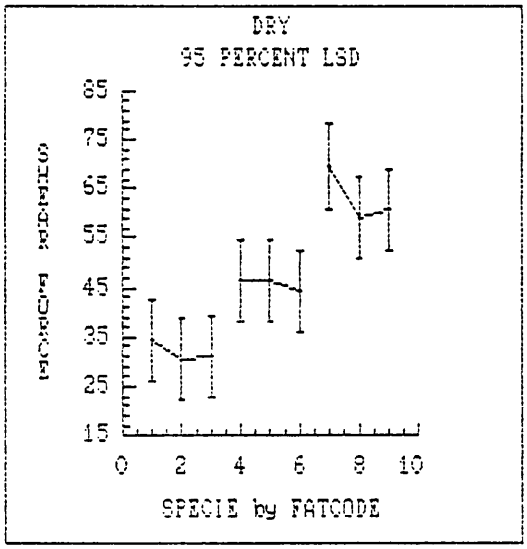

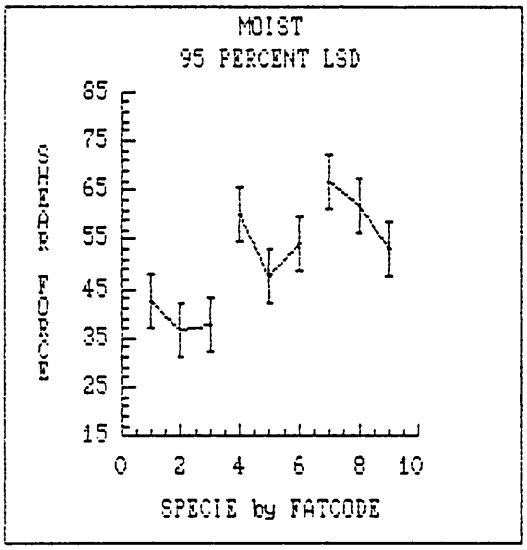

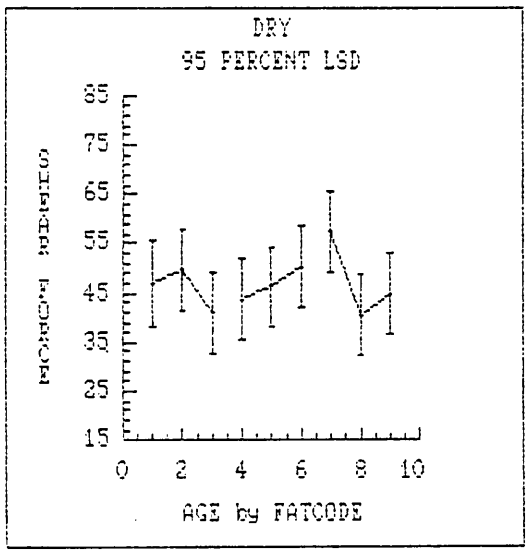

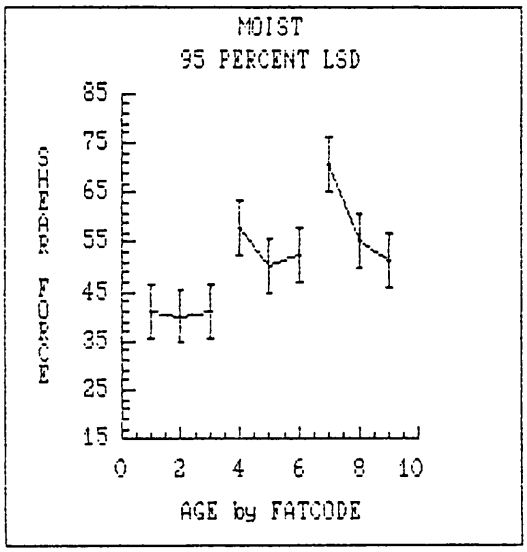

FIGURE 36: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE WITH SHEAR FORCE OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Mm. longissimus thoracis et lumborum cuts to shear.

The two-factor interaction analysis of age and fat code (Table 36) shows no significant effect on the resistance of the *M. semimembranosus* cuts to shear.

Proximate chemical analysis

These analyses were done on the cooked *Mm. longissimus thoracis et lumborum* cuts cooked according to a dry heat cooking method and the cooked *M. semimembranosus* cuts cooked according to a moist heat cooking method.

Moisture

The three-way analyses of variance for moisture content (Table 37) show no significant differences between cooked sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the moisture content of either the cooked Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the cooked sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for moisture content (Table 38) show no significant differences between cooked sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the moisture content of either the cooked Angora or Boer goat *M. semimembranosus* cuts, and that of the cooked sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for moisture content (Table 37) show significant differences ($p \leq 0,05$) between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 37) the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts of the A and B age groups was significantly higher ($p \leq 0,05$) than that of the corresponding cuts of the C age group. Therefore, the hypothesis that there will not be a significant difference between the moisture content of the cooked *Mm. longissimus thoracis et*

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TABLE 37: THREE-WAY VARIANCE OF MOISTURE CONTENT OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	127.07618	6	21.179363	6.034	.0001
SPECIE	8.88871	2	4.444357	1.266	.2891
AGE	25.70075	2	12.850375	3.661	.0314
FATCODE	92.48671	2	46.243357	13.175	.0000
2-FACTOR INTERACTIONS	59.980363	12	4.9983636	1.424	.1794
SPECIE AGE	11.017086	4	2.7542716	.785	.5395
SPECIE FATCODE	9.139235	4	2.2848086	.651	.6284
AGE FATCODE	39.824042	4	9.9560105	2.837	.0317
RESIDUAL	217.61674	62	3.5099475		
TOTAL (CORR.)	404.67328	80			

0 missing values have been excluded.

TABLE 38: THREE-WAY VARIANCE OF MOISTURE CONTENT OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	91.165600	6	15.194267	5.270	.0002
SPECIE	1.973936	2	.986968	.342	.7115
AGE	61.957017	2	30.978509	10.744	.0001
FATCODE	27.234647	2	13.617323	4.723	.0123
2-FACTOR INTERACTIONS	44.977296	12	3.7481080	1.300	.2417
SPECIE AGE	20.947894	4	5.2369735	1.816	.1370
SPECIE FATCODE	15.706331	4	3.9265827	1.362	.2575
AGE FATCODE	8.323072	4	2.0807679	.722	.5804
RESIDUAL	178.76126	62	2.8832462		
TOTAL (CORR.)	314.90416	80			

0 missing values have been excluded.

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lumborum cuts of either the A or B age groups, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts of the C age group, is rejected at the 95 % level of significance.

The three-way analyses of variance for moisture content (Table 38) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 37) the moisture content of the cooked *M. semimembranosus* cuts of the A age group was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the B and C age groups. Therefore, the hypothesis that there will not be a significant difference between the moisture content of the cooked *M. semimembranosus* cuts of the A age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the moisture content of the cooked *M. semimembranosus* cuts of the B age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for moisture content (Table 37) show significant differences ($p \leq 0,01$) between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 37) the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of one was significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of two, which in turn was significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of three. Therefore, the hypothesis that there will not be a significant difference between the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts with either a fat code of or and two, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 99 % level of significance.

The three-way analyses of variance for moisture content (Table 38) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 37) the moisture content of the cooked *M. semimembranosus* cuts with a fat code of one and two was significantly higher ($p \leq 0,01$ and $p \leq 0,05$ respectively) than that of the corresponding cuts with a fat code of three. Therefore, the hypothesis that there will not be a significant difference between the

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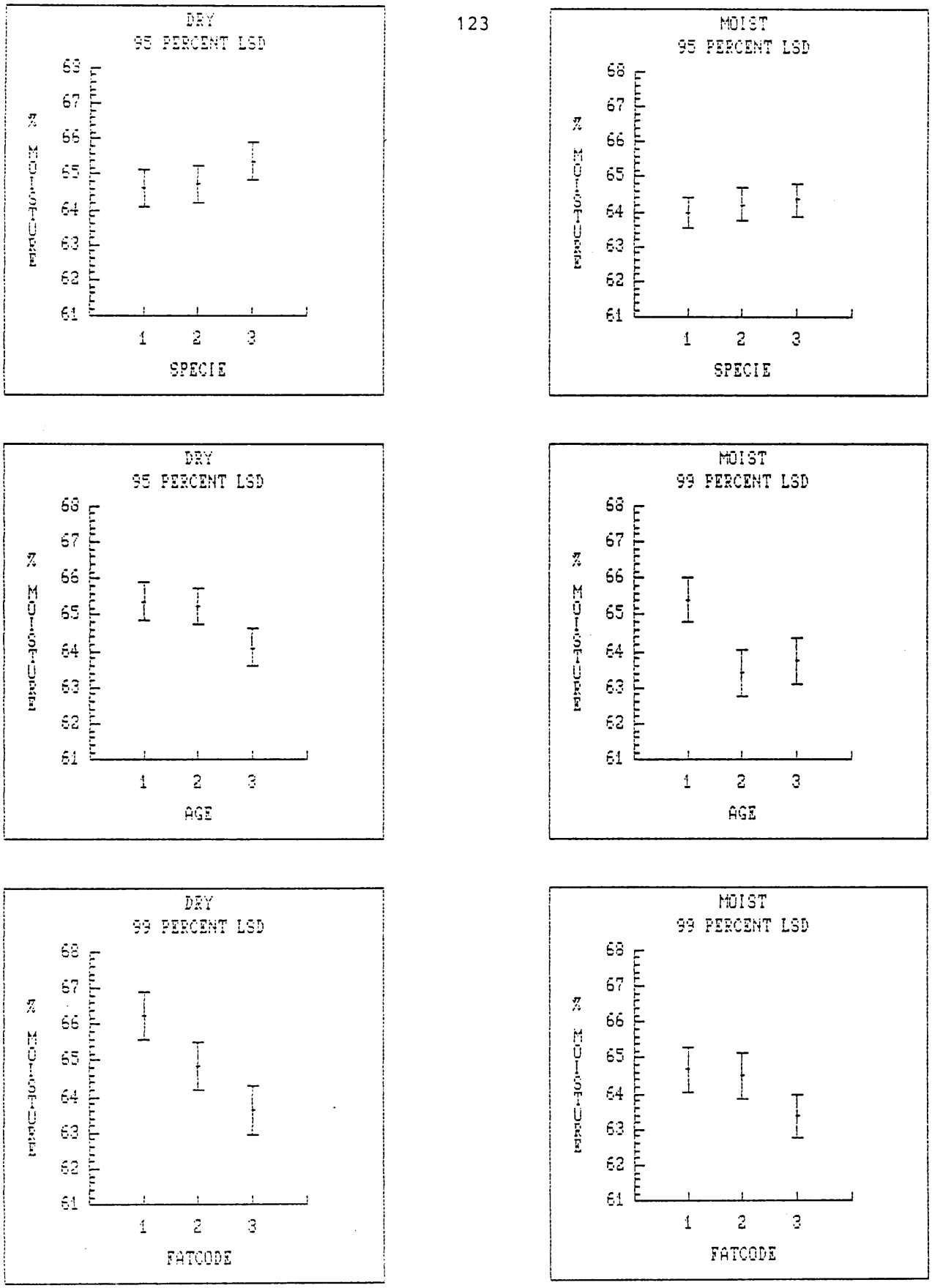

FIGURE 37: GRAPHIC REPRESENTATIONS OF VARIANCE WITH MOISTURE CONTENT AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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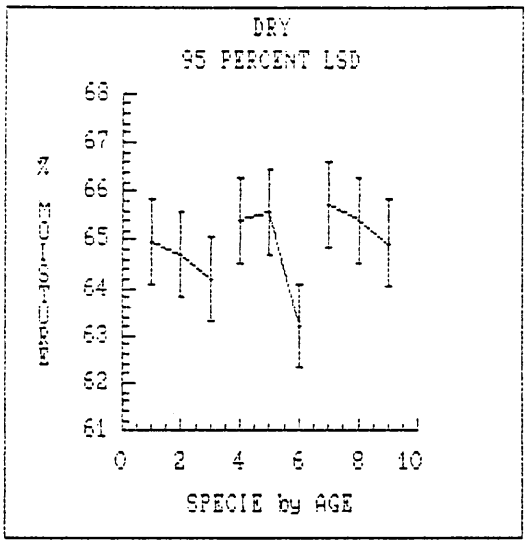

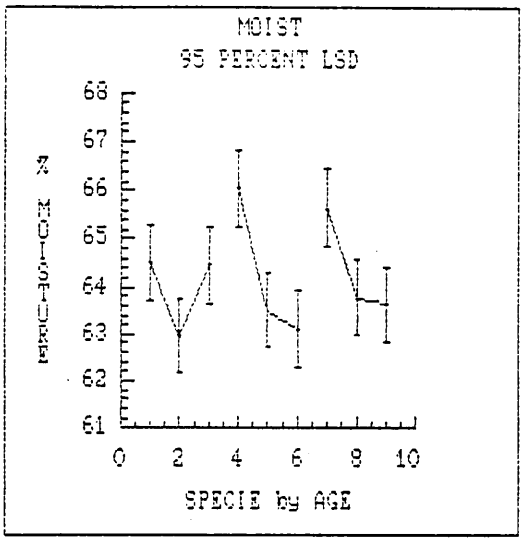

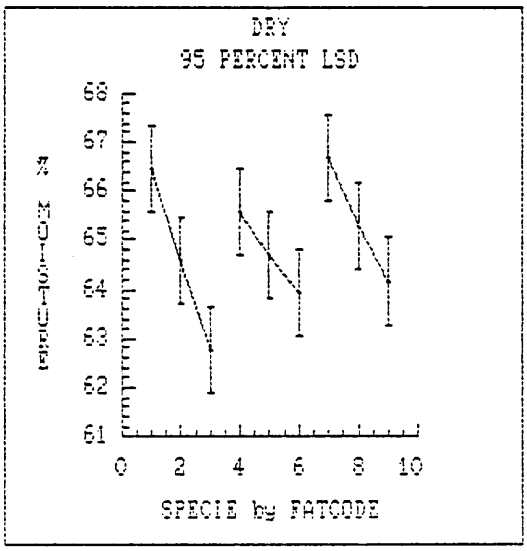

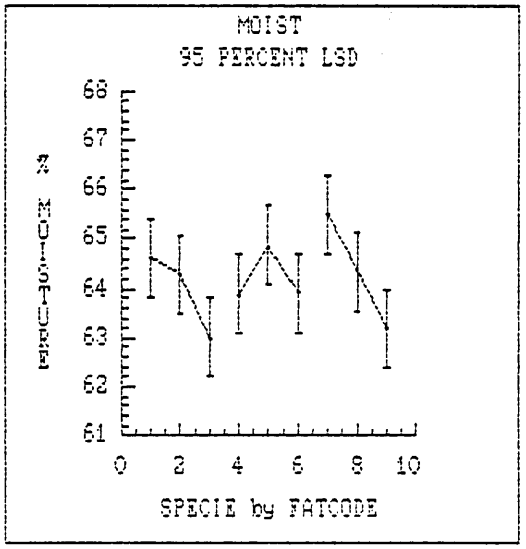

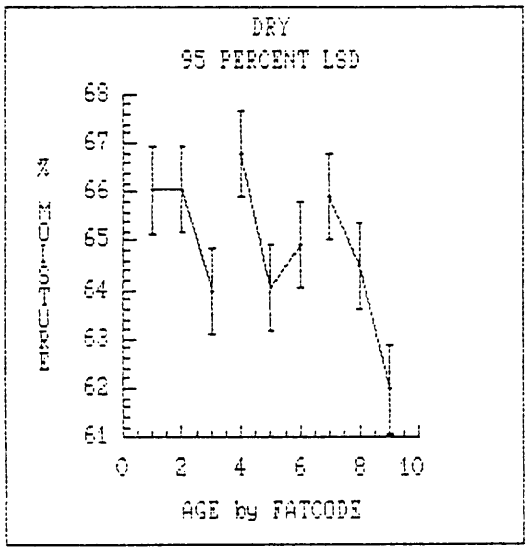

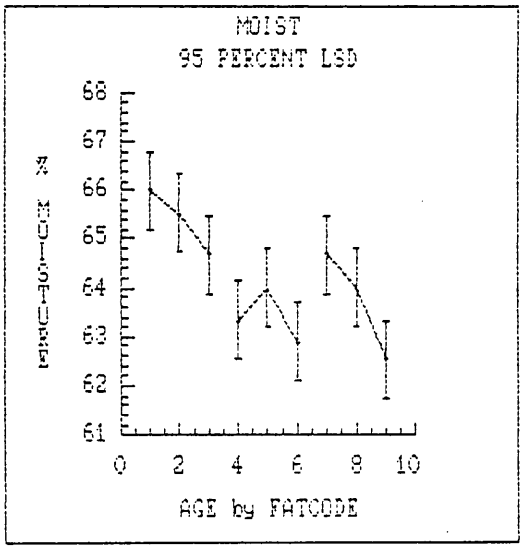

FIGURE 38: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF MOISTURE CONTENT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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moisture content of the cooked *M. semimembranosus* cuts with either a fat code of one or two, and that of the cooked *M. semimembranosus* cuts with a fat code of three, is rejected at the 99 % level of significance.

The two-factor interaction analysis of species and age (Table 37 and Figure 38) shows no significant effect on the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 38 and Figure 38) shows no significant effect on the moisture content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 37 and Figure 38) shows no significant effect on the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 38 and Figure 38) shows no significant effect on the moisture content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 37) shows a significant effect ($p \leq 0,05$) on the moisture content of the cooked *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 38) the *Mm. longissimus thoracis et lumborum* cuts of the A age group with a fat code of two had a significantly ($p \leq 0,05$) higher moisture content than that of the corresponding cuts of the B age group of the identical fat code. The *Mm. longissimus thoracis et lumborum* cuts of the A and B age groups with a fat code of three had a significantly ($p \leq 0,05$) higher moisture content than that of the corresponding cuts of the C age group of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 38) shows no significant effect on the moisture content of the cooked *M. semimembranosus* cuts.

Protein

The three-way analyses of variance for protein content (Table 39) show no

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significant differences between cooked sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the protein content of either the cooked Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the cooked sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for protein content (Table 40) show no significant differences between cooked sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the protein content of either the cooked Angora or Boer goat *M. semimembranosus* cuts, and that of the cooked sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for protein content (Table 39) show no significant differences between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the protein content of the cooked *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for protein (Table 40) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 39) the protein content of the cooked *M. semimembranosus* cuts of the B and C age groups was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the A age group. Therefore, the hypothesis that there will not be a significant difference between the protein content of the cooked *M. semimembranosus* cuts of the A age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the protein content of the cooked *M. semimembranosus* cuts of the B age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for protein (Table 39) show no significant

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TABLE 39: THREE-WAY VARIANCE OF PROTEIN CONTENT OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	8.1648963	6	1.3608160	.376	.8918
SPECIE	5.0852914	2	2.5426457	.702	.4995
AGE	2.6786469	2	1.3393235	.370	.6924
FATCODE	.4009580	2	.2004790	.055	.9462
2-FACTOR INTERACTIONS	20.645504	12	1.7204586	.475	.9219
SPECIE AGE	3.309175	4	.8272938	.228	.9215
SPECIE FATCODE	9.413664	4	2.3534160	.650	.6292
AGE FATCODE	7.922664	4	1.9806660	.547	.7020
RESIDUAL	224.57487	62	3.6221753		
TOTAL (CORR.)	253.38527	80			

0 missing values have been excluded.

TABLE 40: THREE-WAY VARIANCE OF PROTEIN CONTENT OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	55.776170	6	9.296028	5.328	.0002
SPECIE	1.214314	2	.607157	.348	.7075
AGE	53.964388	2	26.982194	15.465	.0000
FATCODE	.597469	2	.298735	.171	.8430
2-FACTOR INTERACTIONS	23.708111	12	1.9756759	1.132	.3516
SPECIE AGE	9.315472	4	2.3288679	1.335	.2671
SPECIE FATCODE	8.665168	4	2.1662920	1.242	.3026
AGE FATCODE	5.727472	4	1.4318679	.821	.5169
RESIDUAL	108.17087	62	1.7446914		
TOTAL (CORR.)	187.65515	80			

0 missing values have been excluded.

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differences between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the protein content of the cooked *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for protein content (Table 40) show no significant differences between the cooked *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the protein content of the cooked *M. semimembranosus* cuts with either a fat code of one or two, and that of the cooked *M. semimembranosus* cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 39 and Figure 40) shows no significant effect on the protein content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 40 and Figure 40) shows no significant effect on the protein content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 39 and Figure 40) shows no significant effect on the protein content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 40) shows no significant effect on the protein of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 39 and Figure 40) shows no significant effect on the protein of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 40) shows no significant effect on the protein content of the cooked *M. semimembranosus* cuts.

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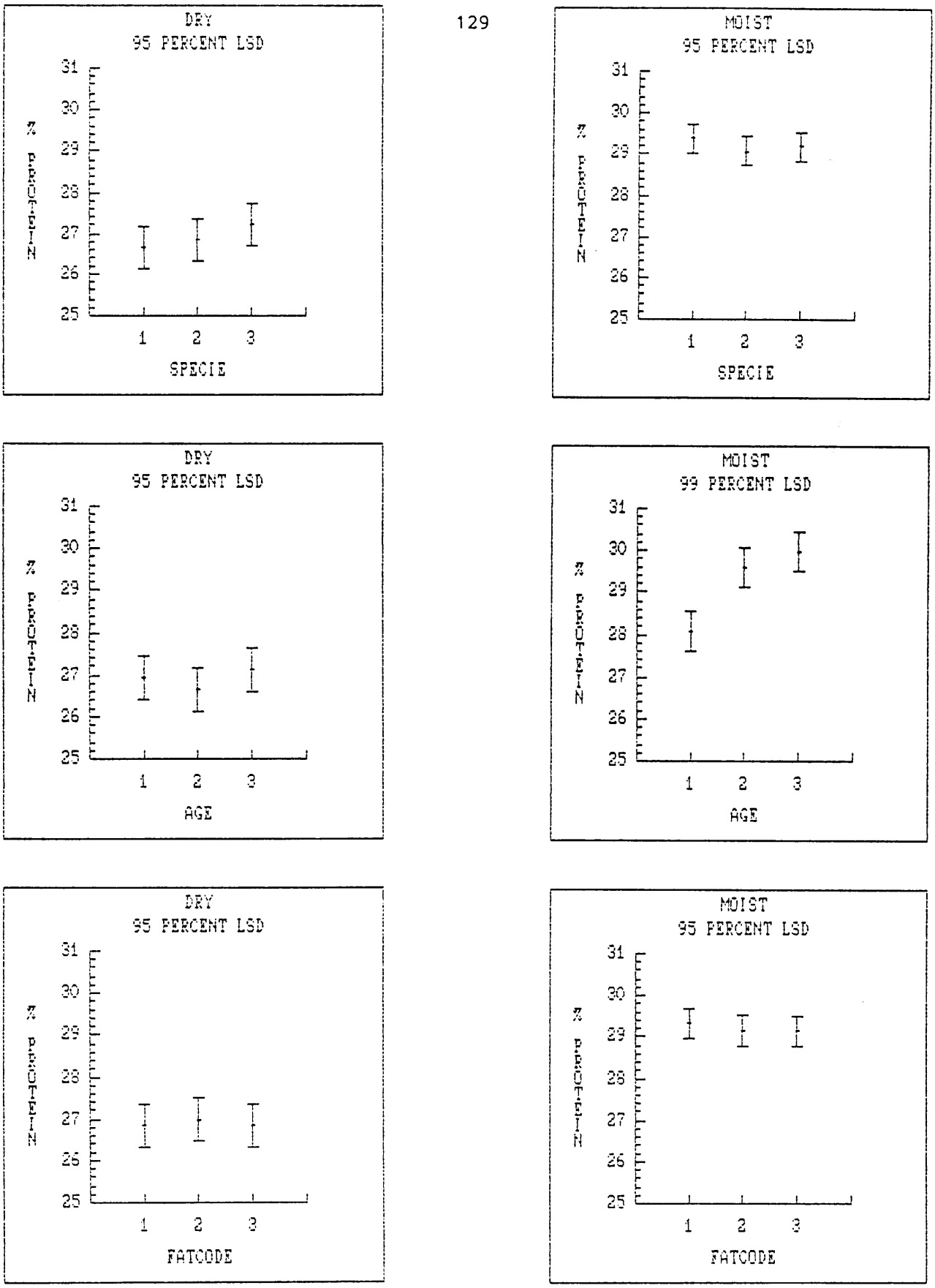

FIGURE 39: GRAPHIC REPRESENTATIONS OF VARIANCE WITH PROTEIN CONTENT AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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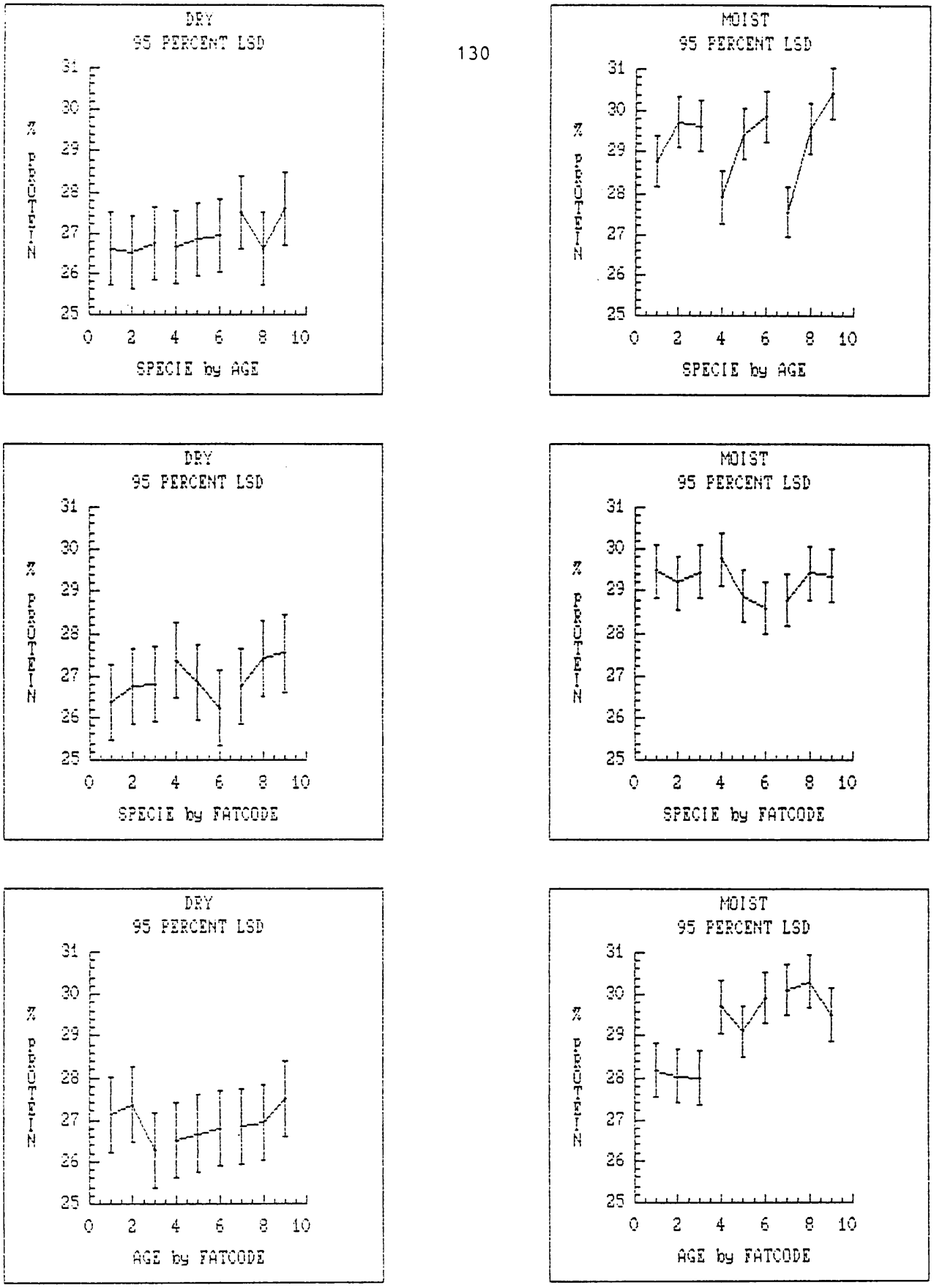

FIGURE 40: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF PROTEIN CONTENT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Fat

The three-way analyses of variance for fat content (Table 41) show no significant differences between cooked sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the fat content of either the cooked Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, when respectively compared with the fat content of the cooked sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for fat content (Table 42) show no significant differences between cooked sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the fat content of either the cooked Angora or Boer goat *M. semimembranosus* cuts, and that of the cooked sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for fat content (Table 41) show no significant differences between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for fat content (Table 42) show no significant differences between the cooked *M. semimembranosus* cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the fat content of the cooked *M. semimembranosus* cuts of either the A or B age groups, and that of the cooked *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for fat content (Table 41) show significant differences ($p \leq 0,01$) between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the

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TABLE 41: THREE-WAY VARIANCE OF FAT CONTENT OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	91.699748	6	15.283291	5.487	.0001
SPECIE	12.401662	2	6.200831	2.226	.1165
AGE	3.669106	2	1.834553	.659	.5211
FATCODE	75.628980	2	37.814490	13.577	.0000
2-FACTOR INTERACTIONS	66.290911	12	5.524243	1.983	.0411
SPECIE AGE	8.242790	4	2.060698	.740	.5684
SPECIE FATCODE	6.734005	4	1.683501	.604	.6609
AGE FATCODE	51.314116	4	12.828529	4.606	.0025
RESIDUAL	172.67752	62	2.7851213		
TOTAL (CORR.)	330.66818	80			

0 missing values have been excluded.

TABLE 42: THREE-WAY VARIANCE OF FAT CONTENT OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	15.749244	6	2.6248741	1.993	.0801
SPECIE	1.564158	2	.7820790	.594	.5553
AGE	.606314	2	.3031568	.230	.7950
FATCODE	13.578773	2	6.7893864	5.156	.0085
2-FACTOR INTERACTIONS	19.156385	12	1.5963654	1.212	.2953
SPECIE AGE	8.573746	4	2.1434364	1.628	.1785
SPECIE FATCODE	2.699042	4	.6747605	.512	.7268
AGE FATCODE	7.883598	4	1.9708994	1.497	.2141
RESIDUAL	81.641743	62	1.3168023		
TOTAL (CORR.)	116.54737	80			

0 missing values have been excluded.

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t-test (Figure 41) the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three was significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of two, which in turn was significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 99 % level of significance.

The three-way analyses of variance for fat content (Table 42) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 41) the fat content of the cooked *M. semimembranosus* cuts with a fat code of three was significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of two and one ($p \leq 0,01$). Therefore, the hypothesis that there will not be a significant difference between the fat content of the cooked *M. semimembranosus* cuts with either a fat code of one or two, and that of the cooked *M. semimembranosus* cuts with a fat code of three, is rejected at the 99 % level of significance.

The two-factor interaction analysis of species and age (Table 41 and Figure 42) shows no significant effect on the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 42 and Figure 42) shows no significant effect on the fat content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 41 and Figure 42) shows no significant effect on the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 42 and Figure 42) shows no significant effect on the fat content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 41 and

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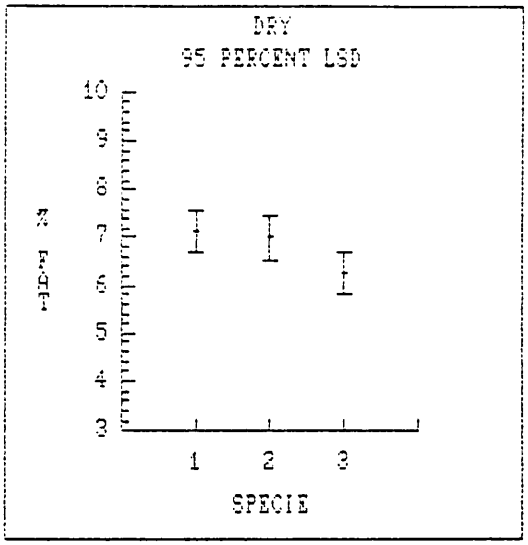

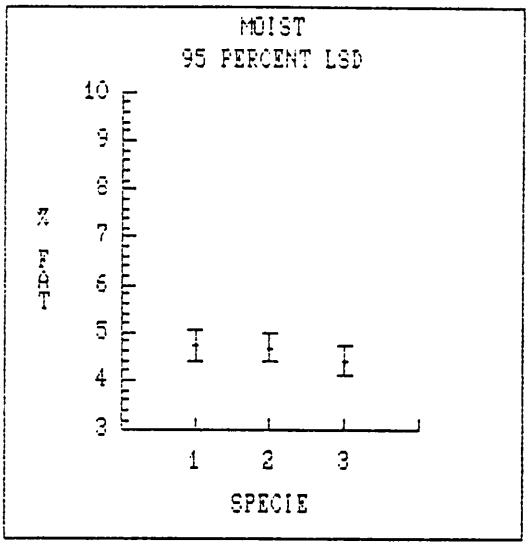

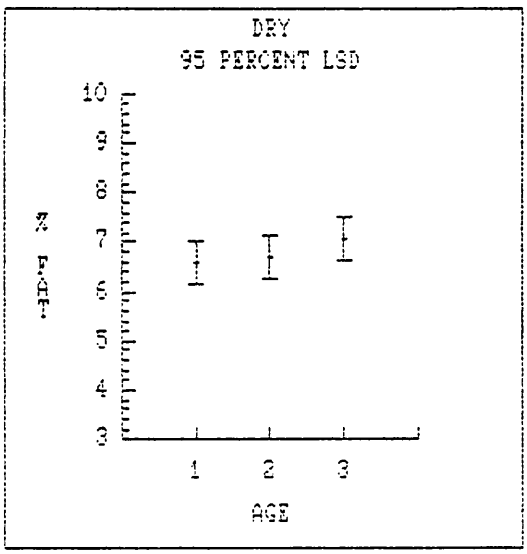

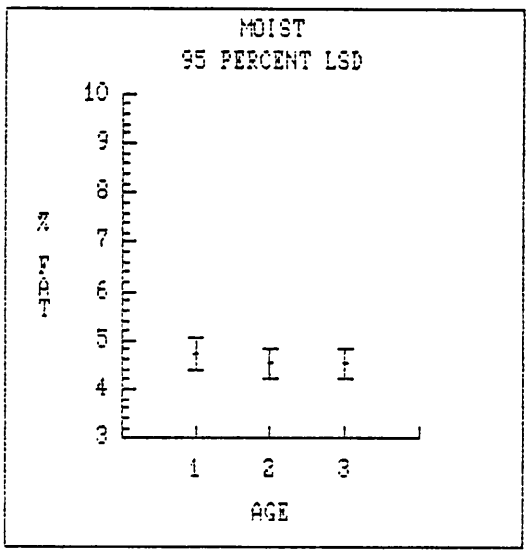

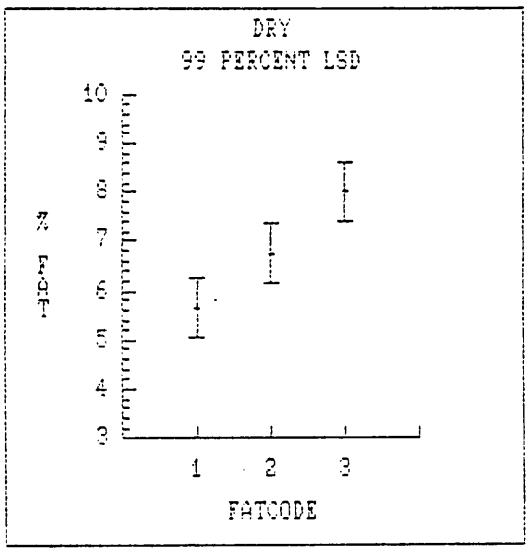

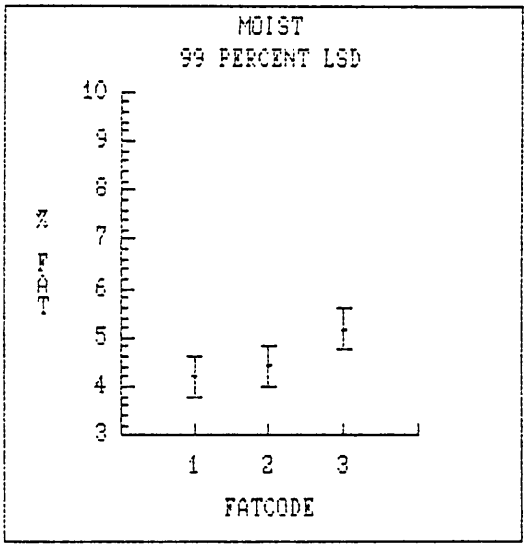

FIGURE 41: GRAPHIC REPRESENTATIONS OF VARIANCE WITH FAT CONTENT AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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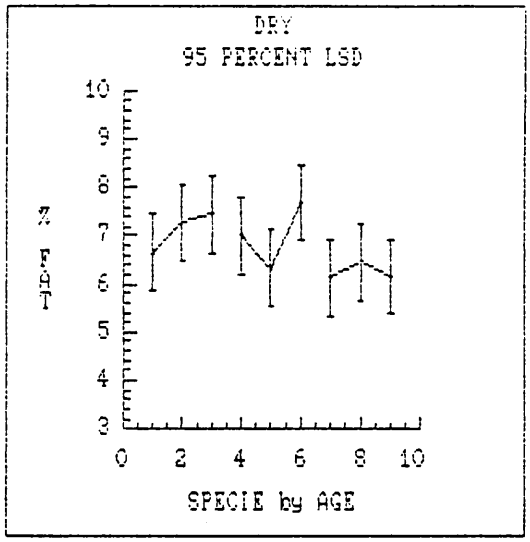

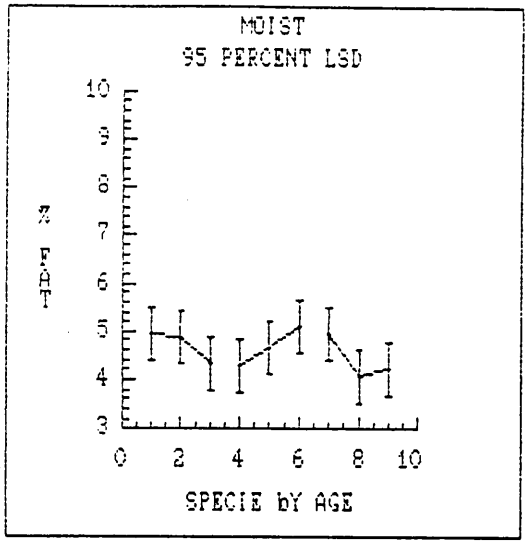

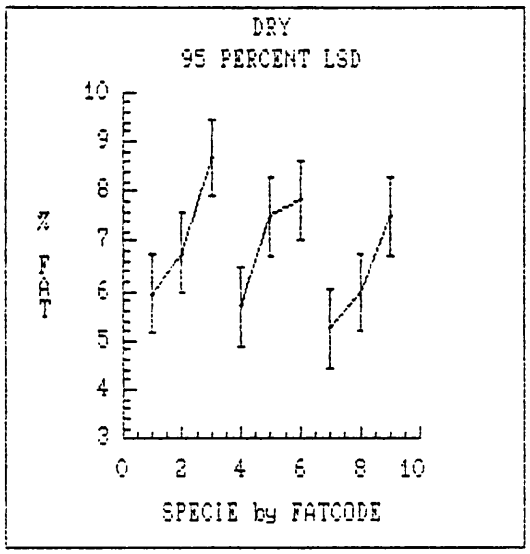

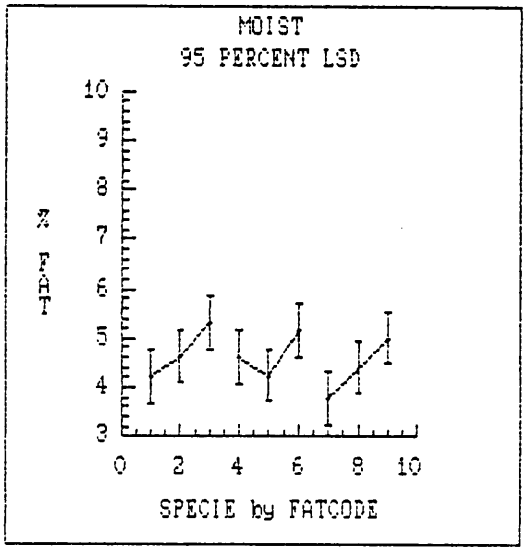

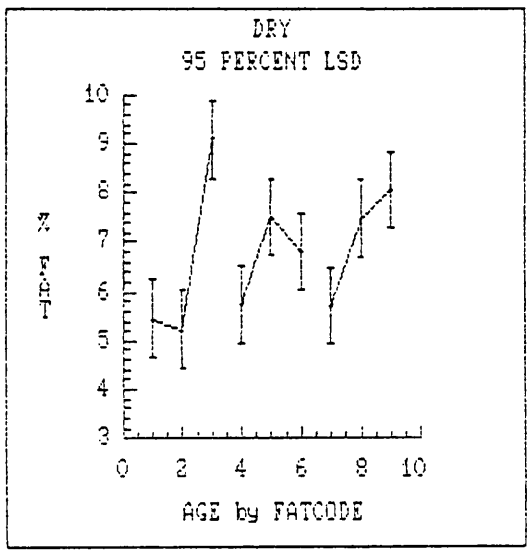

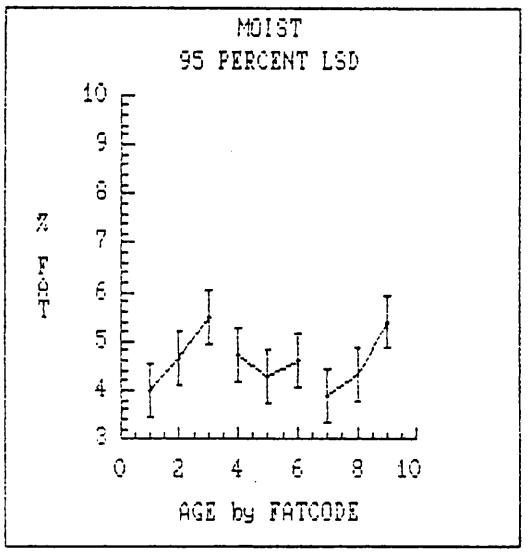

FIGURE 42: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF FAT CONTENT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Figure 42) shows a significant effect ($p \leq 0,01$) on the fat content of the cooked *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 42) the *Mm. longissimus thoracis et lumborum* cuts of the A age group with a fat code of two had a significantly ($p \leq 0,05$) lower fat content than that of the corresponding cuts of the B and C age groups of the identical fat code. The *Mm. longissimus thoracis et lumborum* cuts of the A age group with a fat code of three had a significantly ($p \leq 0,01$) higher fat content than that of the corresponding cuts of the B age group of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 42 and Figure 42) shows no significant effect on the of fat content of the cooked *M. semimembranosus* cuts.

Ash

The three-way analyses of variance for ash content (Table 43) show no significant differences between cooked sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the ash content of either the cooked Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the cooked sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for ash content (Table 44) show no significant differences between cooked sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the ash content of either the cooked Angora or Boer goat *M. semimembranosus* cuts, and that of the cooked sheep *M. semimembranosus* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for ash content (Table 43) show no significant differences between the cooked *Mm. longissimus thoracis et lumborum*cuts from the three age groups. Therefore, the hypothesis that there will not be a significant difference between the ash content of the cooked *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts

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TABLE 43: THREE-WAY VARIANCE OF ASH CONTENT OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	.0132160	6	.0022027	.727	.6302
SPECIE	.0027047	2	.0013523	.446	.6426
AGE	.0070693	2	.0035346	1.166	.3199
FATCODE	.0015970	2	.0007985	.263	.7695
2-FACTOR INTERACTIONS	.0695192	12	.0057933	1.911	.0555
SPECIE AGE	.0443184	4	.0110796	3.655	.0109
SPECIE FATCODE	.0111302	4	.0027826	.918	.4609
AGE FATCODE	.0286100	4	.0071525	2.360	.0659
RESIDUAL	.1515517	50	.0030310		
TOTAL (CORR.)	.2342870	68			

12 missing values have been excluded.

TABLE 44: THREE-WAY VARIANCE OF ASH CONTENT OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	.1178222	6	.0196370	4.816	.0004
SPECIE	.0198247	2	.0099123	2.431	.0963
AGE	.0866099	2	.0433049	10.621	.0001
FATCODE	.0113877	2	.0056938	1.396	.2552
2-FACTOR INTERACTIONS	.0389407	12	.0032451	.796	.6530
SPECIE AGE	.0099309	4	.0024827	.609	.6577
SPECIE FATCODE	.0149086	4	.0037272	.914	.4615
AGE FATCODE	.0141012	4	.0035253	.865	.4903
RESIDUAL	.2528025	62	.0040775		
TOTAL (CORR.)	.4095654	80			

0 missing values have been excluded.

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of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for ash content (Table 44) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 43) the ash content of the cooked *M. semimembranosus* cuts of the B and C age groups was significantly ($p \leq 0,01$) lower than that of the corresponding cuts of the A age group. Therefore, the hypothesis that there will not be a significant difference between the ash content of the cooked *M. semimembranosus* cuts of the A age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the ash content of the cooked *M. semimembranosus* cuts of the B age group, and that of the cooked *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for ash content (Table 43) show no significant differences between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the ash content of the cooked *Mm. longissimus thoracis et lumborum* cuts with either a fat code of one or two, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is accepted at the 95 % level of significance.

The three-way analyses of variance for ash content (Table 44) show no significant differences between the cooked *M. semimembranosus* cuts from the three fat codes. Therefore, the hypothesis that there will not be a significant difference between the ash content of the cooked *M. semimembranosus* cuts with either a fat code of one or two, and that of the cooked *M. semimembranosus* cuts with a fat code of three, is accepted at the 95 % level of significance.

The two-factor interaction analysis of species and age (Table 43) shows a significant ($p \leq 0,01$) effect on the ash content of the cooked *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 44) the Boer goat *Mm. longissimus thoracis et lumborum* cuts of the A age group had a significantly ($p \leq 0,05$) higher ash content than that

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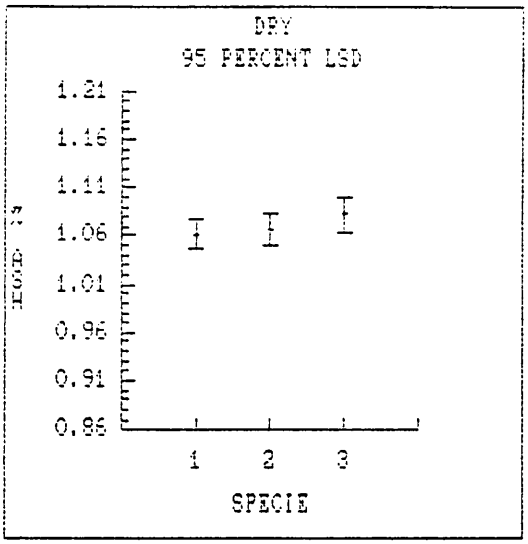

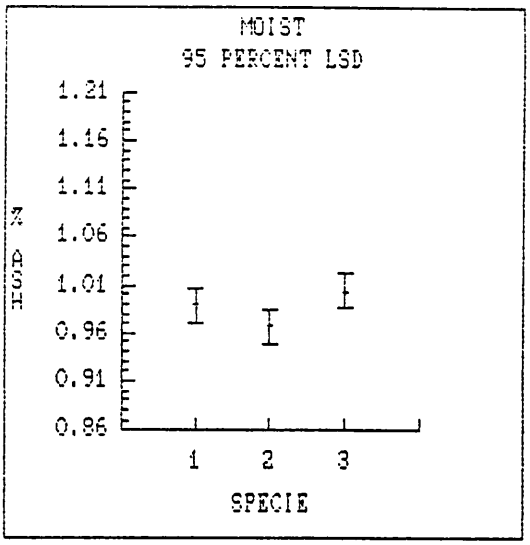

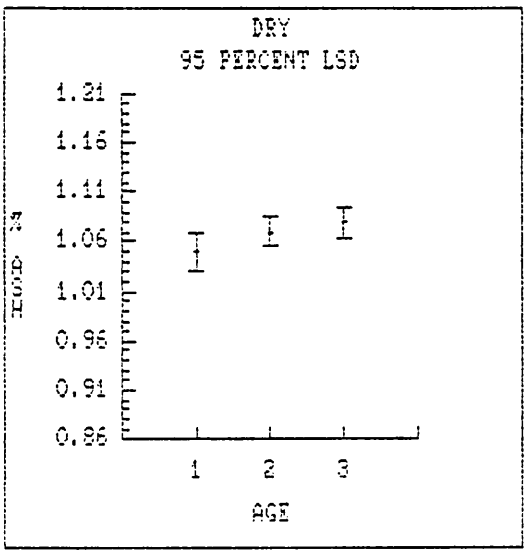

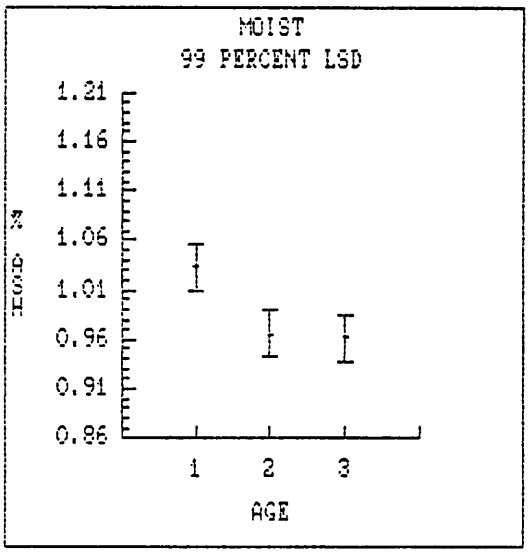

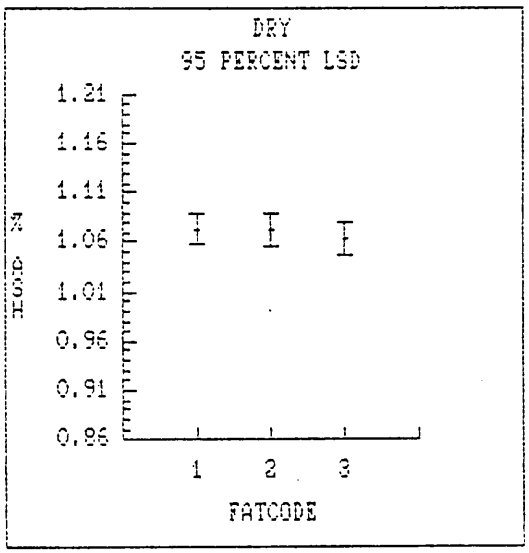

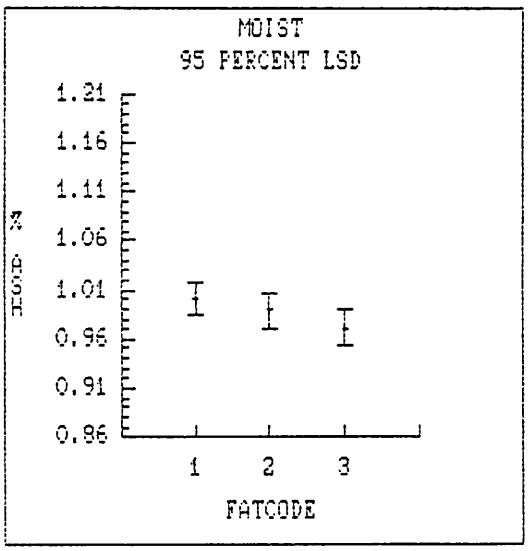

FIGURE 43: GRAPHIC REPRESENTATIONS OF VARIANCE WITH ASH CONTENT AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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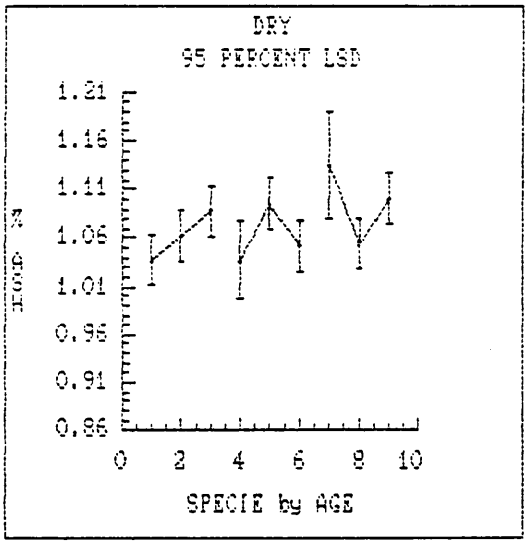

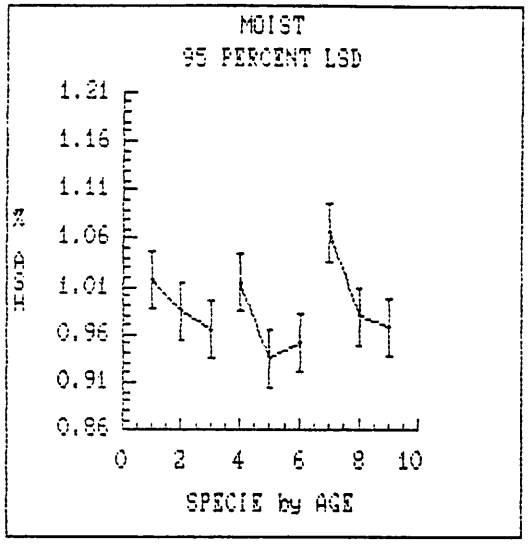

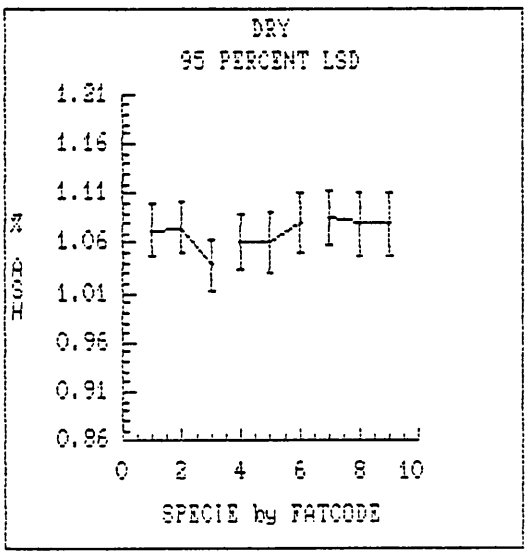

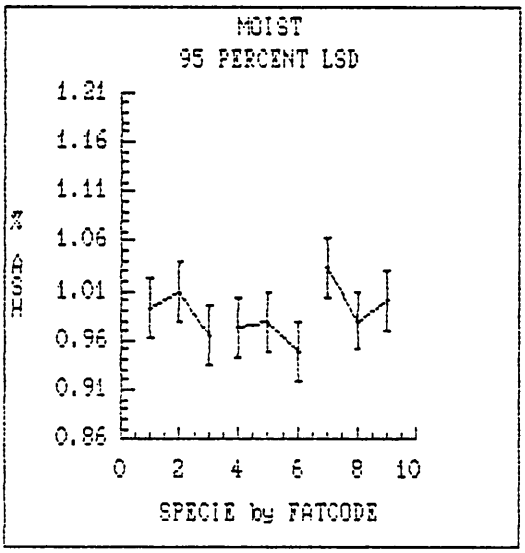

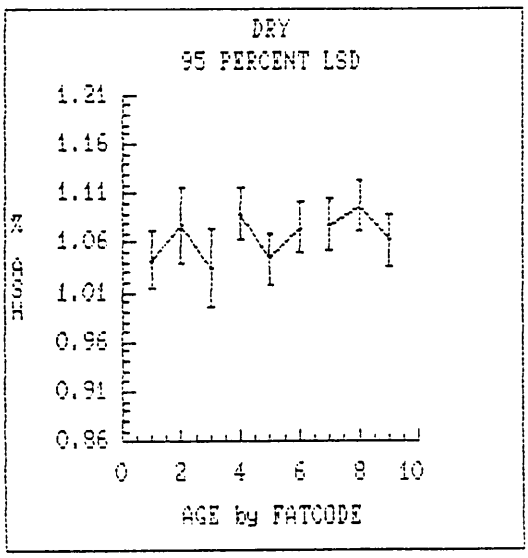

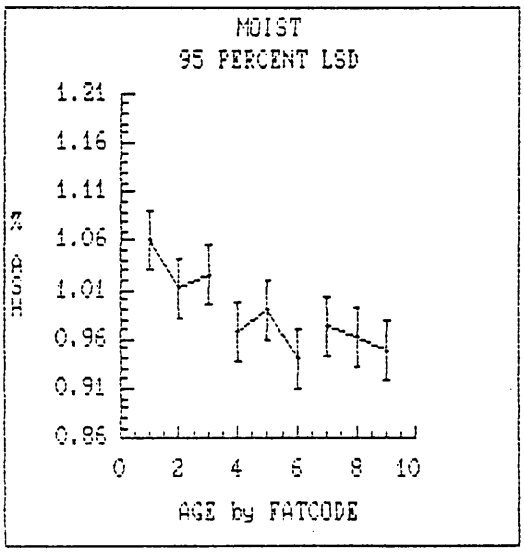

FIGURE 44: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF ASH CONTENT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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of the corresponding sheep and Angora goat cuts of the identical age group.

The two-factor interaction analysis of species and age (Table 44 and Figure 44) shows no significant effect on the ash content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 43 and Figure 44) shows no significant effect on the ash content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 44 and Figure 44) shows no significant effect on the ash content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 43 and Figure 44) shows no significant effect on the ash content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of age and fat code (Table 44 and Figure 44) shows no significant effect on the ash content of the cooked *M. semimembranosus* cuts.

Dry matter

The three-way analyses of variance for dry matter content (Table 45) show no significant differences between cooked sheep *Mm. longissimus thoracis et lumborum* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of either the cooked Angora or Boer goat *Mm. longissimus thoracis et lumborum* cuts, and that of the cooked sheep *Mm. longissimus thoracis et lumborum* cuts, is accepted at the 95 % level of significance.

The three-way analyses of variance for dry matter content (Table 46) show no significant differences between cooked sheep *M. semimembranosus* cuts and the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of either the cooked Angora or Boer goat *M. semimembranosus* cuts, and that of the cooked sheep *M. semimembranosus* cuts, is accepted at the 95 %

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level of significance.

The three-way analyses of variance for dry matter content (Table 45) show significant differences ($p \leq 0,05$) between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three age groups. According to the t-test (Figure 45) the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts of the C age group was significantly higher ($p \leq 0,05$) than that of the corresponding cuts of the A and B age groups. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts of either the A or B age groups, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts of the C age group, is rejected at the 95 % level of significance.

The three-way analyses of variance for dry matter content (Table 46) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three age groups. According to the t-test (Figure 45) the dry matter content of the cooked *M. semimembranosus* cuts of the B and C age groups was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the A age group. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of the cooked *M. semimembranosus* cuts of the A age group, when compared with the dry matter content of the cooked *M. semimembranosus* cuts of the C age group, is rejected at the 99 % level of significance. The hypothesis that there will not be a significant difference between the dry matter content of the cooked *M. semimembranosus* cuts of the B age group, when compared with the dry matter content of the cooked *M. semimembranosus* cuts of the C age group, is accepted at the 95 % level of significance.

The three-way analyses of variance for dry matter content (Table 45) show significant differences ($p \leq 0,01$) between the cooked *Mm. longissimus thoracis et lumborum* cuts from the three fat codes. According to the t-test (Figure 45) the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three was significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of two, which in turn was significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of the cooked

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TABLE 45: THREE-WAY VARIANCE OF DRY MATTER CONTENT OF *Mm. longissimus thoracis et lumborum* COOKED ACCORDING TO A DRY COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	121.40996	6	20.234993	5.736	.0001
SPECIE	14.95674	2	7.478372	2.120	.1286
AGE	30.75290	2	15.376449	4.359	.0169
FATCODE	75.70031	2	37.850157	10.730	.0001
2-FACTOR INTERACTIONS	78.021563	12	6.501797	1.843	.0603
SPECIE AGE	9.902331	4	2.475583	.702	.5937
SPECIE FATCODE	13.186094	4	3.296523	.935	.4499
AGE FATCODE	54.933138	4	13.733285	3.893	.0069
RESIDUAL	218.70381	62	3.5274808		
TOTAL (CORR.)	418.13533	80			

0 missing values have been excluded.

TABLE 46: THREE-WAY VARIANCE OF DRY MATTER CONTENT OF *M. semimembranosus* COOKED ACCORDING TO A MOIST COOKING METHOD

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	83.130131	6	13.855022	4.885	.0004
SPECIE	1.765587	2	.882793	.311	.7337
AGE	57.142802	2	28.571401	10.074	.0002
FATCODE	27.022289	2	13.511144	4.764	.0120
2-FACTOR INTERACTIONS	48.538274	12	4.0448562	1.426	.1795
SPECIE AGE	21.211871	4	5.3029678	1.870	.1275
SPECIE FATCODE	18.489075	4	4.6222687	1.630	.1785
AGE FATCODE	9.251387	4	2.3128468	.816	.5203
RESIDUAL	170.16240	60	2.8360400		
TOTAL (CORR.)	301.83081	78			

2 missing values have been excluded.

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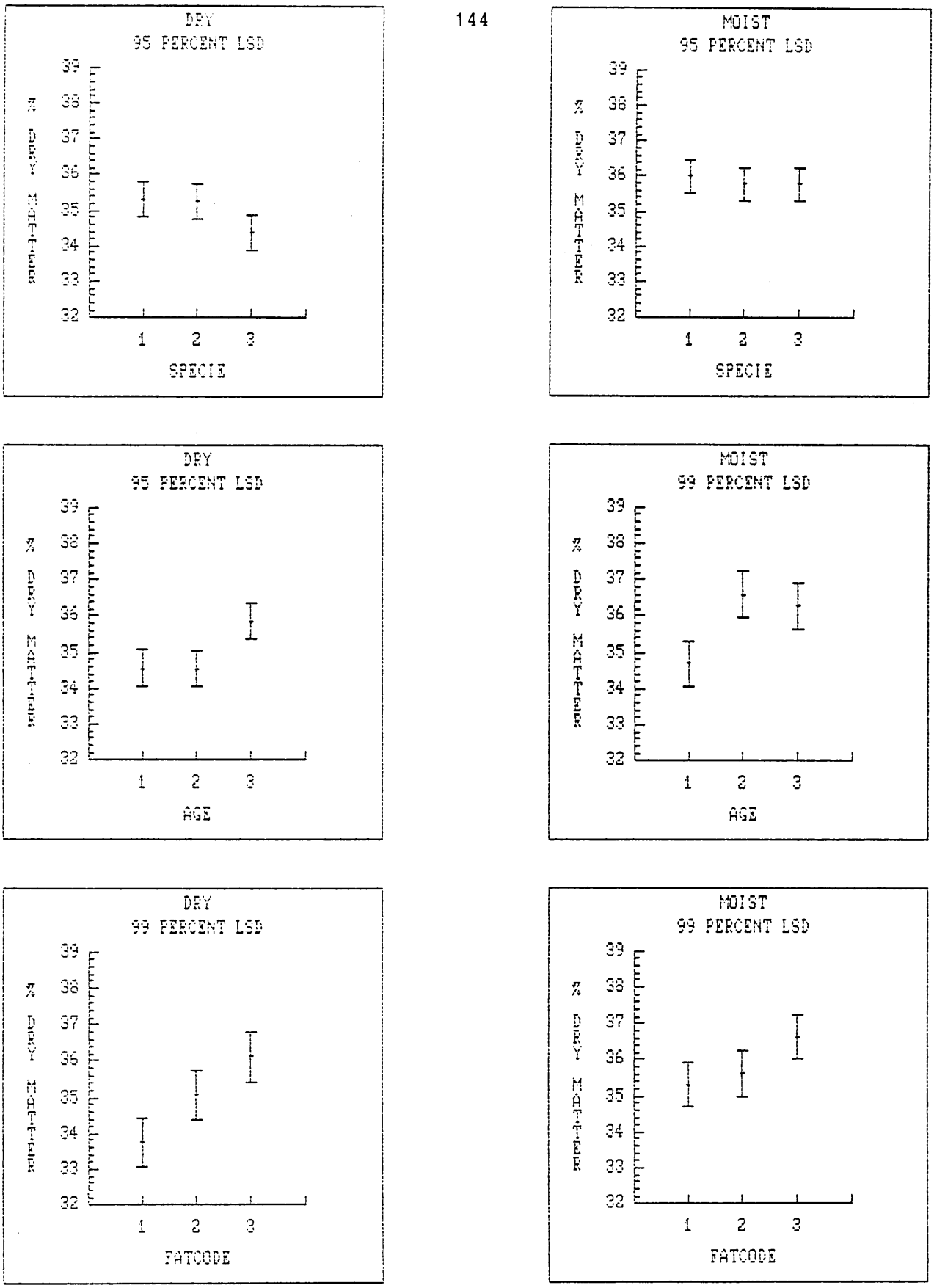

FIGURE 45: GRAPHIC REPRESENTATIONS OF VARIANCE WITH DRY MATTER CONTENT AS MAIN EFFECT OF DRY (*Mm. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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Mm. longissimus thoracis et lumborum cuts with either a fat code of one or two, and that of the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of three, is rejected at the 99 % level of significance.

The three-way analyses of variance for dry matter content (Table 46) show significant differences ($p \leq 0,01$) between the cooked *M. semimembranosus* cuts from the three fat codes. According to the t-test (Figure 46) the dry matter content of the cooked *M. semimembranosus* cuts with a fat code of three was significantly higher ($p \leq 0,05$ and $p \leq 0,01$ respectively) than that of the corresponding cuts with a fat code of two and one. Therefore, the hypothesis that there will not be a significant difference between the dry matter content of the cooked *M. semimembranosus* cuts with either a fat code of one or two, and that of the cooked *M. semimembranosus* cuts with a fat code of three, is rejected at the 99 % level of significance.

The two-factor interaction analysis of species and age (Table 45 and Figure 46) shows no significant effect on the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and age (Table 46 and Figure 46) shows no significant effect on the dry matter content of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of species and fat code (Table 45 and Figure 46) shows no significant effect on the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts.

The two-factor interaction analysis of species and fat code (Table 46 and Figure 46) shows no significant effect on the dry matter of the cooked *M. semimembranosus* cuts.

The two-factor interaction analysis of age and fat code (Table 45) shows a significant effect ($p \leq 0,01$) on the dry matter content of the cooked *Mm. longissimus thoracis et lumborum* cuts. According to the t-test (Figure 46) the *Mm. longissimus thoracis et lumborum* cuts of the B and C age groups with a fat code of two had a significantly ($p \leq 0,01$ and $p \leq 0,05$ respectively) higher dry matter content than that of the corresponding cuts of the A age group of the identical fat code. The *Mm. longissimus*

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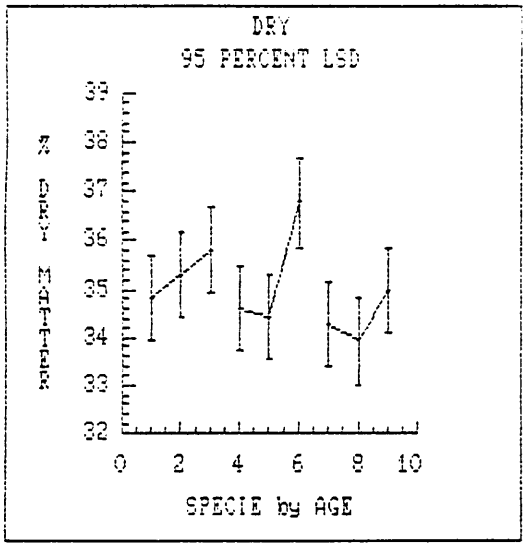

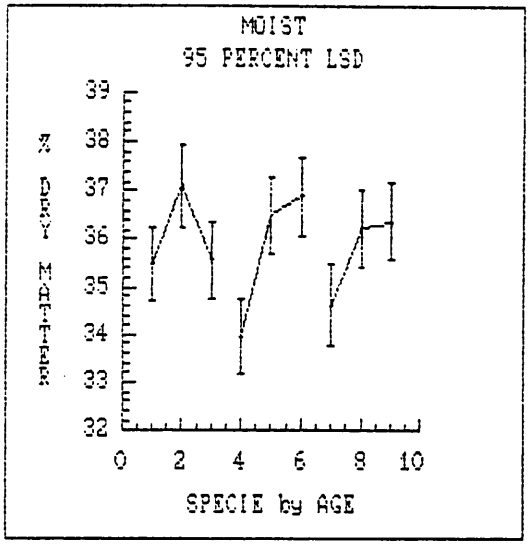

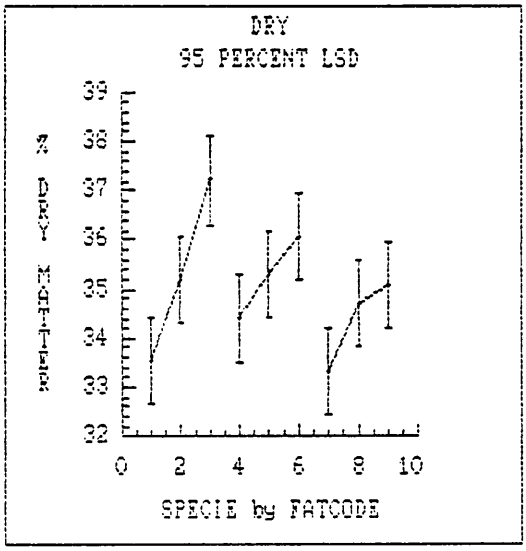

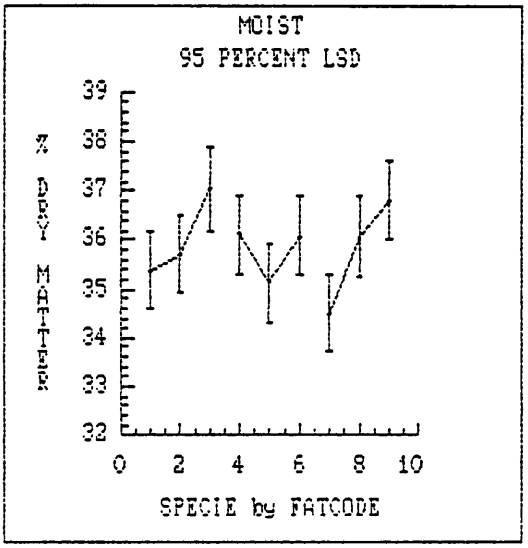

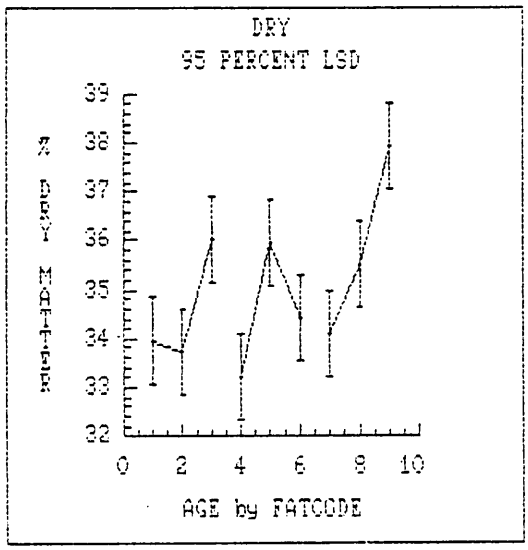

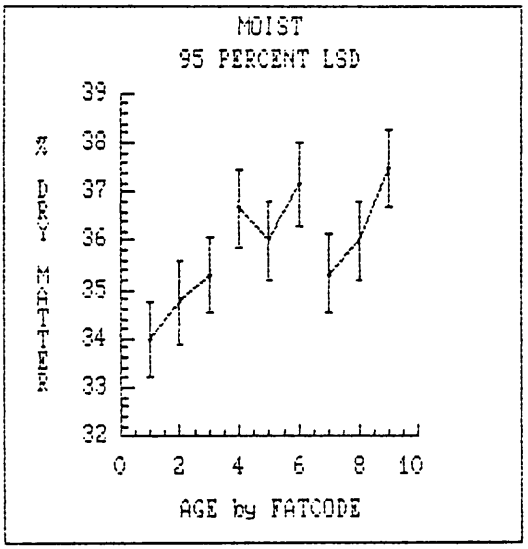

FIGURE 46: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF DRY MATTER CONTENT OF DRY (*M. longissimus thoracis et lumborum*) AND MOIST (*M. semimembranosus*) HEAT COOKING METHODS

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thoracis et lumborum cuts of the C age group with a fat code of three had a significantly ($p \leq 0,05$ and $p \leq 0,01$) higher dry matter content than that of the corresponding cuts of the A and B age groups of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 46 and Figure 46) shows no significant effect on the dry matter content of the cooked *M. semimembranosus* cuts.

Collagen solubility

The three-way analyses of variance for collagen solubility (Table 47) show significant differences ($p \leq 0,01$) between sheep *M. longissimus thoracis* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 47) the collagen solubility of the sheep *M. longissimus thoracis* cuts was significantly higher ($p \leq 0,01$) than that of the corresponding Angora and Boer goat cuts. Therefore, the hypothesis that there will not be a significant difference between the collagen solubility of either the Angora or Boer goat *M. longissimus thoracis* cuts, and that of the sheep *M. longissimus thoracis* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for collagen solubility (Table 47) show significant differences ($p \leq 0,01$) between the *M. longissimus thoracis* cuts from the three age groups. According to the t-test (Figure 47) the collagen solubility of the *M. longissimus thoracis* cuts of the A age group was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the B age group, which was in turn significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the C age group. Therefore, the hypothesis that there will not be a significant difference between the collagen solubility of the *M. longissimus thoracis* cuts of either the A or B age groups, when respectively compared with the collagen solubility of the *M. longissimus thoracis* cuts of the C age group, is rejected at the 99 % level of significance.

The three-way analyses of variance for collagen solubility (Table 47) show significant differences ($p \leq 0,01$) between the *M. longissimus thoracis* cuts from the three fat codes. According to the t-test (Figure 47) the

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TABLE 47: THREE-WAY VARIANCE OF COLLAGEN SOLUBILITY OF *M. longissimus thoracis*

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	1867.0555	6	311.17592	52.013	.0000
SPECIE	90.3286	2	45.16428	7.549	.0012
AGE	1506.9892	2	753.49458	125.947	.0000
FATCODE	269.7378	2	134.86889	22.543	.0000
2-FACTOR INTERACTIONS	262.64737	12	21.887281	3.658	.0004
SPECIE AGE	31.33772	4	7.834431	1.310	.2763
SPECIE FATCODE	34.54790	4	8.636975	1.444	.2303
AGE FATCODE	196.76175	4	49.190436	8.222	.0000
RESIDUAL	370.92212	62	5.9826149		
TOTAL (CORR.)	2500.6250	80			

0 missing values have been excluded.

collagen solubility of the *M. longissimus thoracis* cuts with a fat code of three was significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of two, which was in turn significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of one. Therefore, the hypothesis that there will not be a significant difference between the collagen solubility of the *M. longissimus thoracis* cuts with either a fat code of one or two, and that of the *M. longissimus thoracis* cuts with a fat code of three, is rejected at the 99 % level of significance.

The two-factor interaction analysis of species and age (Table 47 and Figure 48) shows no significant effect on the collagen solubility of the *M. longissimus thoracis* cuts.

The two-factor interaction analysis of species and fat code (Table 47 and Figure 48) shows no significant effect on the collagen solubility of the *M. longissimus thoracis* cuts.

The two-factor interaction analysis of age and fat code (Table 47) shows a

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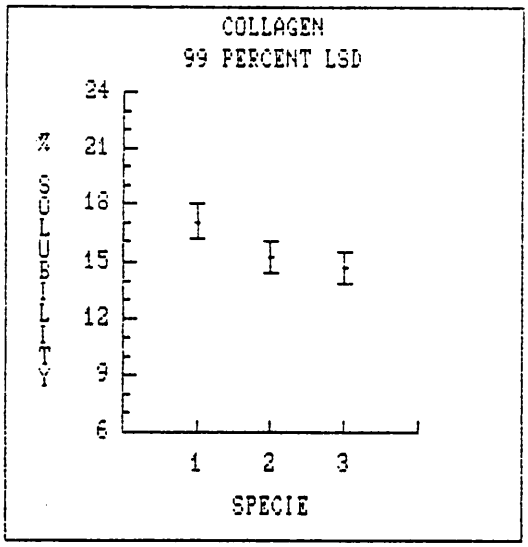

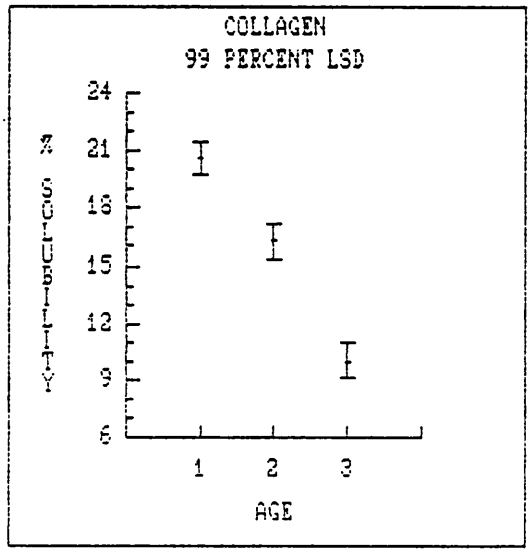

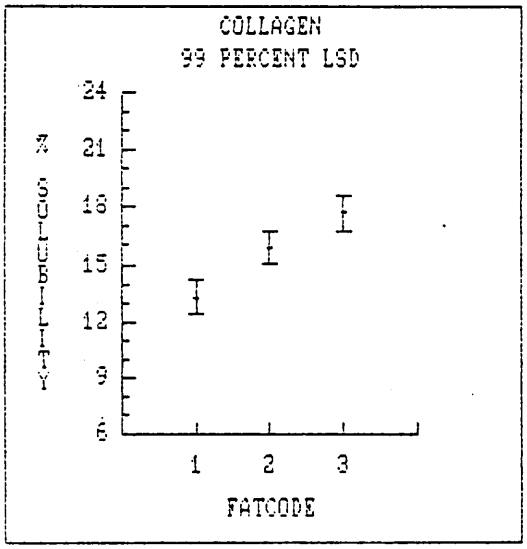

FIGURE 47: GRAPHIC REPRESENTATIONS OF VARIANCE WITH COLLAGEN SOLUBILITY AS MAIN EFFECT FOR *M. longissimus thoracis*

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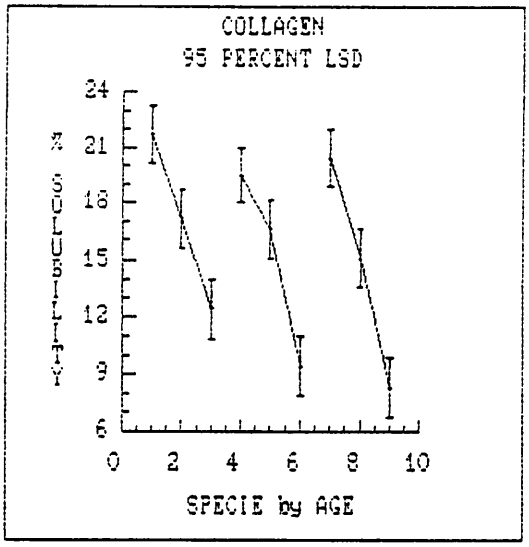

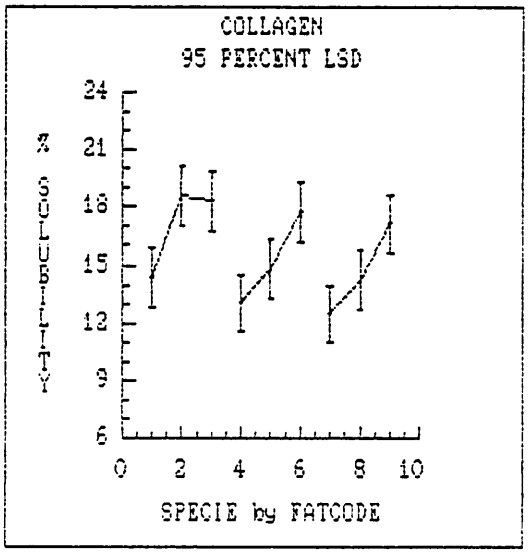

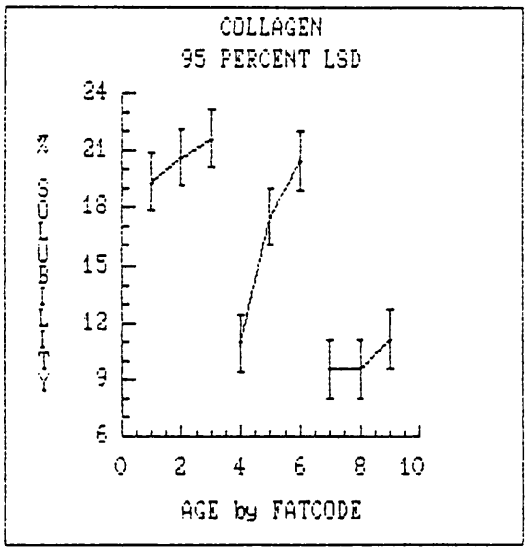

FIGURE 48: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF COLLAGEN SOLUBILITY OF *M. longissimus thoracis*

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significant effect ($p \leq 0,01$) on the determination of collagen solubility of the *M. longissimus thoracis* cuts. According to the t-test (Figure 48) the collagen solubility *M. longissimus thoracis* cuts of the A age group with a fat code of one was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the B and C age groups of the identical fat code. The collagen solubility *M. longissimus thoracis* cuts of the A age group with a fat code of two was significantly higher ($p \leq 0,05$) than that of the corresponding cuts of the B age group of the identical fat code, which in turn was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the C age group of the identical fat code. The collagen solubility *M. longissimus thoracis* cuts of the A and B age groups with a fat code of three was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the C age group of the identical fat code.

Collagen content

The three-way analyses of variance for collagen content (Table 48) show significant differences ($p \leq 0,01$) between sheep *M. longissimus thoracis* cuts and the corresponding Angora and Boer goat cuts. According to the t-test (Figure 49) the collagen content of the Angora and Boer goat *M. longissimus thoracis* cuts was significantly higher ($p \leq 0,01$) than that of the corresponding sheep cuts. Therefore, the hypothesis that there will not be a significant difference between the collagen content of either the Angora or Boer goat *M. longissimus thoracis* cuts, and that of the sheep *M. longissimus thoracis* cuts, is rejected at the 99 % level of significance.

The three-way analyses of variance for collagen content (Table 48) show significant differences ($p \leq 0,01$) between the *M. longissimus thoracis* cuts from the three age groups. According to the t-test (Figure 49) the collagen content of the *M. longissimus thoracis* cuts of the A and C age groups was significantly higher ($p \leq 0,01$) than that of the corresponding cuts of the B age group. Therefore, the hypothesis that there will not be a significant difference between the collagen content of the *M. longissimus thoracis* cuts of the A age group, and that of the *M. longissimus thoracis* cuts of the C age group, is accepted at the 99 % level of significance. The hypothesis that there will not be a significant difference between the collagen content of the *M. longissimus thoracis* cuts of the B

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TABLE 48: THREE-WAY VARIANCE OF COLLAGEN CONTENT OF *M. longissimus thoracis*

Source of variation	Sum of Squares	d.f.	Mean square	F-ratio	Sig. level
MAIN EFFECTS	17.779099	6	2.9631831	7.241	.0000
SPECIE	4.685284	2	2.3426419	5.724	.0055
AGE	4.731476	2	2.3657378	5.781	.0052
FATCODE	8.066335	2	4.0331675	9.855	.0002
2-FACTOR INTERACTIONS	7.5184659	12	.6265388	1.531	.1406
SPECIE AGE	1.2828054	4	.3207013	.784	.5406
SPECIE FATCODE	5.0386414	4	1.2596603	3.078	.0232
AGE FATCODE	1.2111618	4	.3027904	.740	.5688
RESIDUAL	22.917590	56	.4092427		
TOTAL (CORR.)	48.215155	74			

6 missing values have been excluded.

age groups, and that of the *M. longissimus thoracis* cuts of the C age group, is rejected at the 99 % level of significance.

The three-way analyses of variance for collagen content (Table 48) show significant differences ($p \leq 0,01$) between the *M. longissimus thoracis* cuts from the three fat codes. According to the t-test (Figure 49) the collagen content of the *M. longissimus thoracis* cuts with a fat code of one was significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of two, which was in turn significantly higher ($p \leq 0,05$) than that of the corresponding cuts with a fat code of three. The collagen content of the *M. longissimus thoracis* cuts with a fat code of one was significantly higher ($p \leq 0,01$) than that of the corresponding cuts with a fat code of three. Therefore, the hypothesis that there will not be a significant difference between the collagen content of the *M. longissimus thoracis* cuts with either a fat code of one and two, and that of the *M. longissimus thoracis* cuts with a fat code of three, is rejected at the 99 % level of significance.

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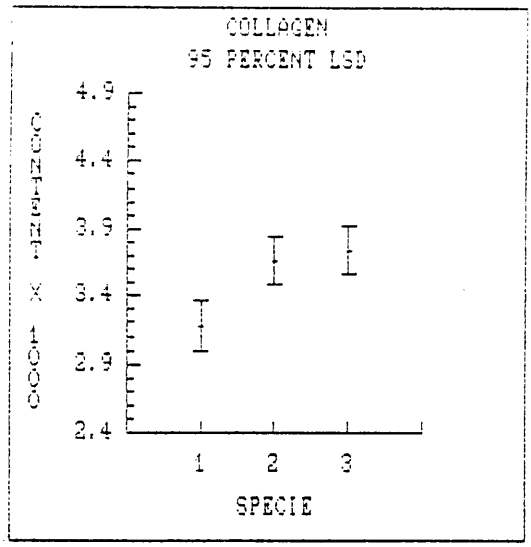

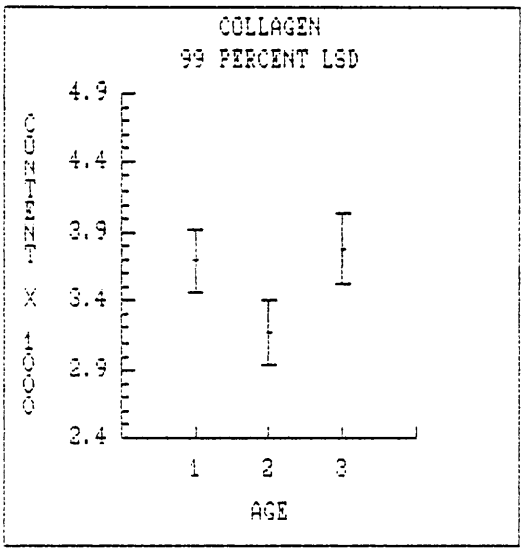

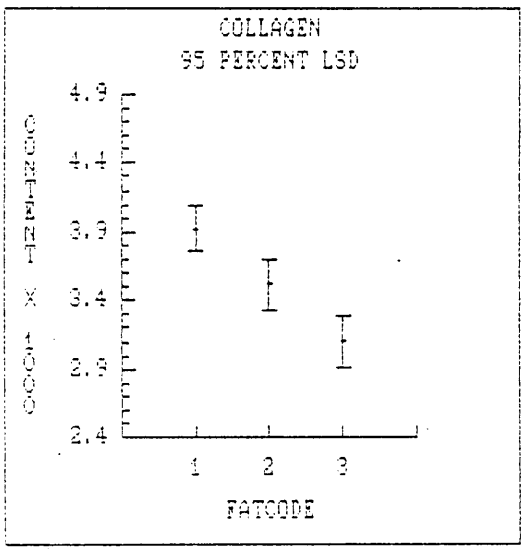

FIGURE 49: GRAPHIC REPRESENTATIONS OF VARIANCE WITH COLLAGEN CONTENT AS MAIN EFFECT FOR *M. longissimus thoracis*

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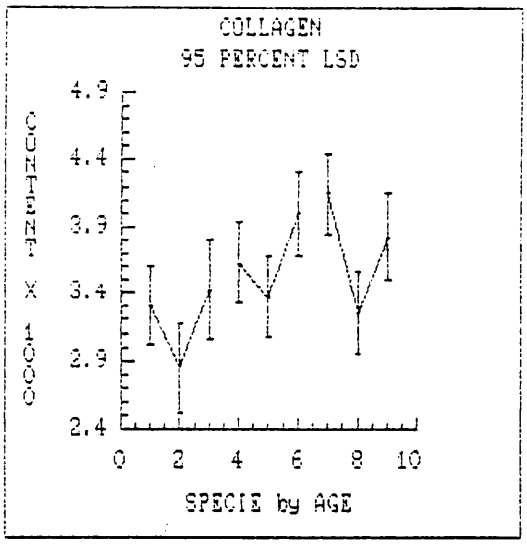

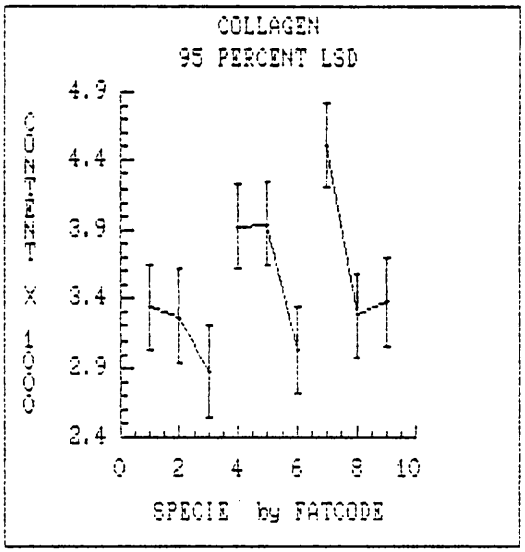

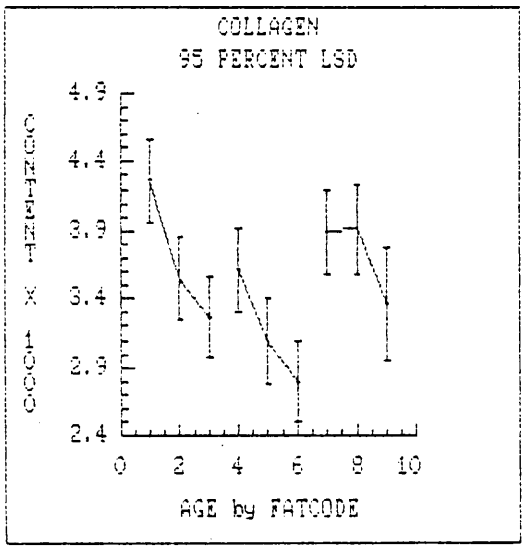

FIGURE 50: GRAPHIC REPRESENTATIONS OF TWO-FACTOR INTERACTIONS SHOWING VARIANCE OF COLLAGEN CONTENT OF *M. longissimus thoracis*

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The two-factor interaction analysis of species and age (Table 48 and Figure 50) shows no significant effect on the collagen content of the *M. longissimus thoracis* cuts.

The two-factor interaction analysis of species and fat code (Table 48) shows a significant effect ($p \leq 0,05$) on the collagen content of the *M. longissimus thoracis* cuts. According to the t-test (Figure 50) the collagen content of the Boer goat *M. longissimus thoracis* cuts with a fat code of one was significantly higher ($p \leq 0,01$) than that of the corresponding sheep cuts of the identical fat code. The collagen content of the Angora goat *M. longissimus thoracis* cuts with a fat code of two was significantly higher ($p \leq 0,05$) than that of the corresponding sheep and Boer goat cuts of the identical fat code.

The two-factor interaction analysis of age and fat code (Table 48 and Figure 50) shows no significant effect on the collagen content of the *M. longissimus thoracis* cuts.

Correlation analysis

A correlation matrix was used to investigate the relationships between various attributes and to ascertain whether or not they were significant. The correlation between two specific attributes is described using the correlation coefficient (r), coefficient of determination (R^2 - expressed as a percentage), significance level (p) and sample size (n).

The correlation matrices for the evaluation of thawing and cooking-related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are supplied in Appendices D.1 and D.2. There was a significant positive ($p \leq 0,01$) correlation (Table 49) between drip loss and fat code of the *Mm. longissimus thoracis et lumborum* cuts. There was no significant correlation (Table 49) between drip loss and fat code of the *M. semimembranosus* cuts.

There was no significant correlation (Table 49) between total cooking losses and age of the *Mm. longissimus thoracis et lumborum* cuts. There was a significant positive correlation ($p \leq 0,01$) between total cooking losses and age of the *M. semimembranosus* cuts.

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TABLE 49: ANALYSIS OF THE CORRELATION OF THE THAWING AND COOKING RELATED MEASUREMENTS FROM *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS (n = 81)

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	r	R^2	P	r	R^2	P
Drip Loss *vs* Fat code	0,6778	45,9400	**	-0,0666	0,4400	NS
Total cooking loss *vs* Age	0,1457	2,1200	NS[a]	0,5246	27,5200	**
Total cooking loss *vs* Fat code	0,4759	22,6500	**	0,2632	6,9300	NS
Total cooking loss *vs* Drip loss	0,5645	31,8700	**	0,6645	44,1600	**
Total cooking loss *vs* Evaporation loss	0,9428	88,8900	**	0,5867	34,4200	**

[a] = NS = not significant

There was a significant positive ($p \leq 0,01$) correlation (Table 49) between total cooking loss and the fat code of the *Mm. longissimus thoracis et lumborum* cuts. There was no significant correlation (Table 49) between total cooking loss and fat code of the *M. semimembranosus* cuts.

There was a significant positive ($p \leq 0,01$) correlation (Table 49) between total cooking loss and drip loss of the *Mm. longissimus thoracis et lumborum* and of the *M. semimembranosus* cuts.

There was a significant positive ($p \leq 0,01$) correlation (Table 49) between total cooking loss and evaporation loss of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts.

The correlation matrices of the sensory evaluation of aroma, species flavour and flavour of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts are supplied in Appendices D.3 and D.4

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respectively. There was a significant negative ($p \leq 0,01$ and $p \leq 0,05$ respectively) correlation (Table 50) between the species and the species flavour of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts, as evaluated by the sensory panel.

There was a significant positive ($p \leq 0,01$) correlation (Table 50) between the species flavour and the aroma of the species of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts, as evaluated by the sensory panel.

There was a significant positive ($p \leq 0,01$) correlation (Table 50) between the flavour and the species flavour of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts, as evaluated by the sensory panel.

The correlation matrices of the evaluation of juiciness-related characteristics of the *Mm. longissimus thoracis et lumborum* cuts and the *M. semimembranosus* cuts are supplied in Appendices D.5 and D.6 respectively. There was a significant positive ($p \leq 0,01$) correlation (Table 51) between the sustained juiciness and the initial impression of

TABLE 50: ANALYSIS OF THE CORRELATION OF THE SENSORY EVALUATION OF AROMA, SPECIES FLAVOUR AND FLAVOUR OF THE *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS (n = 81)

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	r	R^2	P	r	R^2	P
Species flavour *vs* Species	-0,4407	19,4200	**	-0,2164	4,6800	*
Species flavour *vs* Aroma	0,4682	21,9200	**	0,3035	9,2100	**
Flavour *vs* Species flavour	0,4635	21,4800	**	0,3480	0,1200	**

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juiciness of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts, as evaluated by the sensory panel.

There was a significant negative ($p \leq 0,01$ and $p \leq 0,05$ respectively) correlation (Table 51) between the moisture content and the fat code of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

There was a significant positive ($p \leq 0,01$) correlation (Table 51) between the fat content and the fat code of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

There was no significant correlation (Table 51) between the expressible moisture and moisture content of the *Mm. longissimus thoracis et lumborum* cuts. There was a significant positive ($p \leq 0,05$) correlation (Table 51) between the expressible moisture and moisture content of the *M. semimembranosus* cuts, as evaluated by the sensory panel.

There was a significant negative ($p \leq 0,01$) correlation (Table 51) between the fat content and moisture content of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

The correlation matrix of the evaluation of tenderness-related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are supplied in Appendix D.6 and D.7 respectively. There was a significant negative ($p \leq 0,01$) correlation (Table 52) between the species and tenderness of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts, as evaluated by the sensory panel.

There was a significant positive ($p \leq 0,01$) correlation (Table 52) between the species and shear force resistance of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

There was no significant correlation (Table 52) between age and shear force resistance of the *Mm. longissimus thoracis et lumborum* cuts. There was a significant positive ($p \leq 0,01$) correlation (Table 52) between the age and shear force resistance of the *M. semimembranosus* cuts.

There was a significant negative ($p \leq 0,01$) correlation (Table 52) between

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TABLE 51: ANALYSIS OF THE CORRELATION OF JUICINESS RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS (n = 81)

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	r	R^2	P	r	R^2	P
Sustained juiciness *vs* Initial impression of juiciness	0,7175	51,4800	**	0,7902	62,4400	**
Moisture content *vs* Fat code	-0,4778	22,8300	**	-0,2702	7,3000	*
Fat content *vs* Fat code	0,4780	22,8500	**	0,3266	10,6700	**
Expressible moisture *vs* Moisture content	-0,0273	0,0700	NS	0,2634	51,3200	*
Fat content *vs* Moisture content	-0,7225	52,2000	**	-0,5295	35,1100	**

tenderness and shear force resistance of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

There was a significant negative ($p \leq 0,01$) correlation (Table 52) between collagen solubility and age of the *Mm. longissimus thoracis et lumborum* cuts.

There was a significant negative ($p \leq 0,01$) correlation (Table 52) between the species and residue of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

There was a significant positive ($p \leq 0,01$) correlation (Table 52) between the residue and tenderness of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

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TABLE 52: ANALYSIS OF THE CORRELATION OF TENDERNESS RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* CUTS (n= 81)

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	r	R^2	P	r	R^2	P
Tenderness *vs* Species	-0,7979	63,6600	**	-0,4664	21,7500	**
Species *vs* Shear force resistance	0,6089	37,0800	**	0,5182	26,8500	**
Age *vs* Shear force resistance	0,0354	0,1300	NS	0,4488	20,1400	**
Tenderness *vs* Shear force resistance	-0,6333	40,1100	**	-0,6302	39,7200	**
Collagen solubility *vs* Age	-0,7717	59,5500	**			
Residue *vs* Species	-0,7820	61,1500	**	-0,4936	24,3600	**
Residue *vs* Tenderness	0,9697	94,0300	**	0,9378	87,9500	**
Residue *vs* Shear force resistance	-0,6747	45,5200	**	-0,6303	39,7700	**

There was a significant negative ($p \leq 0,01$) correlation (Table 52) between the residue and shear force resistance of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts.

Summary of results

In Table 53 a summary of the three-way analyses of variance of the different quality characteristics tested is given according to the various attributes that are in a direct relationship to each other. Refer to Table 54 for a

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summary of the two-factor interaction analyses.

TABLE 53: SUMMARY OF THE THREE-WAY ANALYSES OF VARIANCE OF THE *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus* OF THE DIFFERENT QUALITY CHARACTERISTICS EVALUATED

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	Species	Age	Fat code	Species	Age	Fat code
Thawing Loss	NS	NS	NS	*	NS	NS
Drip Loss	**	**	**	NS	**	NS
Evaporation Loss	NS	NS	*	*	**	**
Cooking Loss	NS	NS	**	*	**	**
Aroma	**	NS	NS	**	NS	NS
Flavour	**	NS	NS	NS	**	*
Species Flavour	**	NS	NS	**	*	*
Initial Impression of Juiciness	NS	*	NS	**	NS	NS
Sustained Juiciness	**	**	**	**	**	NS
Press Fluid	NS	**	*	NS	NS	NS
Tenderness	**	**	*	**	**	**
Residue	**	**	NS	**	**	NS
Shear Force	**	NS	NS	**	**	**
Collagen Solubility	**	**	**			
Collagen Content	**	**	**			
Moisture %	NS	*	**	NS	**	**
Protein %	NS	NS	NS	NS	**	NS
Fat %	NS	NS	**	NS	NS	**
Ash %	NS	NS	NS	NS	**	NS
Dry Matter %	NS	*	**	NS	**	**

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TABLE 54: SUMMARY OF THE TWO-FACTOR ANALYSES OF THE DIFFERENT QUALITY CHARACTERISTICS EVALUATED OF THE *Mm. longissimus thoracis et lumborum* AND *M. semimembranosus*

Attributes	*Mm. longissimus thoracis et lumborum*			*M. semimembranosus*		
	Species: age	Species: Fat code	Age: Fat code	Species: age	Species: Fat code	Age: Fat code
Thawing Loss	NS	NS	NS	NS	*	NS
Drip Loss	NS	NS	**	NS	**	**
Evaporation Loss	NS	NS	NS	NS	NS	NS
Cooking Loss	NS	NS	NS	*	*	NS
Aroma	NS	NS	NS	*	*	NS
Flavour	*	NS	**	NS	NS	**
Species Flavour	NS	NS	NS	NS	NS	NS
Initial Impression of Juiciness	NS	NS	**	NS	NS	**
Sustained Juiciness	NS	NS	NS	*	NS	**
Press Fluid	NS	NS	**	NS	NS	NS
Tenderness	**	**	NS	NS	**	NS
Residue	**	*	NS	NS	**	NS
Shear Force	NS	NS	NS	*	NS	NS
Collagen Solubility	NS	NS	**			
Collagen Content	NS	*	NS			
Moisture %	NS	NS	*	NS	NS	NS
Protein %	NS	NS	NS	NS	NS	NS
Fat %	NS	NS	**	NS	NS	NS
Ash %	**	NS	NS	NS	NS	NS
Dry Matter %	NS	NS	**	NS	NS	NS

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CHAPTER 6

DISCUSSION OF RESULTS

Introduction

Both phases will be considered concurrently for a balanced appraisal. Note that the *Mm. longissimus thoracis et lumborum* cuts were cooked according to a dry heat and the *M. semimembranosus* cuts according to a moist heat cooking method. The three main sources of variation, namely species, age and fat code will be discussed separately. Due to the fact that no contradictory results were obtained in the two-factor analyses of the data and that the differences that occurred were similar to those of the main effects, the two-factor analyses will only be discussed in the conclusion at the end of the chapter.

The effect of species

Results obtained and analyzed by the three way analysis of variance for cooking loss measurements are summarized in Table 55. It is evident that the sheep *Mm. longissimus thoracis et lumborum* cuts had significantly ($p \leq 0,01$) greater drip loss than the corresponding Angora and Boer goat cuts. The sheep *M. semimembranosus* cuts showed significantly ($p \leq 0,05$) more evaporation loss than the corresponding Angora cuts. On the other hand, the sheep and Boer goat *M. semimembranosus* cuts had significantly ($p \leq 0,05$) greater total cooking losses than the corresponding Angora goat cuts. The Angora *M. semimembranosus* cuts showed significantly ($p \leq 0,05$) greater thawing losses compared to the corresponding Boer goat cuts. The differences in drip loss of the *Mm. longissimus thoracis et lumborum* cuts between the species can be attributed to the fact that, goat carcases with the same total fat content as sheep have a lesser subcutaneous fat deposit. However, this is compensated for by larger deposits of internal carcase fat which is easily removed from the carcase, hence leaner cuts are obtained from goat carcases than from sheep carcases (French, 1980:142). Gaili, et al (1972:354) also describe sheep as having a good cover of subcutaneous fat, which is very thin or even lacking in goats.

The results of the sensory evaluation of the three species are summarized in Table 56. The sheep *Mm. longissimus thoracis et lumborum* were

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TABLE 55: AVERAGE COOKING AND THAWING LOSSES (%) SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Species	Sheep	Angora goat	Boer goat	Sheep	Angora goat	Boer goat
Drip loss	$5,24^{a}$	$3,68^{b}$	$3,19^{b}$**	14,59	14,41	15,51
Evaporation loss	13,25	14,95	12,35	$7,52^{a}$	$5,64^{b}$	$6,69^{ab}$*
Total cooking loss	18,66	18,61	15,54	$22,12^{a}$	$20,04^{b}$	$22,20^{a}$*
Thawing loss	0,72	0,69	0,25	$0,30^{ab}$	$0,47^{b}$	$0,16^{a}$*

** $p \leq 0,01$
* $p \leq 0,05$
a b Means in the same row with different superscripts differ significantly

significantly ($p \leq 0,01$) more easily recognizable than the corresponding Angora and Boer goat cuts. The sheep *M. semimembranosus* were significantly ($p \leq 0,01$) more easily recognizable than the corresponding Boer goat cuts. Smith, et al (1974:1145) described the flavour intensity of Angora goat meat as lower in flavour than meat from pork carcases, and less desirable than that of either beef or lamb.

The higher proportion of saturated fatty acids in lamb's fat has been associated with an undesirable flavour. It was shown that the characteristic aroma of heated lamb is obtained from the fat. A major portion of the odour, obtained upon heating, is contributed by carbonyl compounds. These flavour compounds, or their precursors are apparently present only in trace amounts in the fat (Vesely, 1973:673). It was confirmed by Brennard and Lindsay (1982:251) that adipose tissue is the source of ovine-specific flavour. Compounds found in lean meat do not have a strong role in the species flavour and odour of lamb.

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TABLE 56: AVERAGE SENSORY EVALUATION SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Species	Sheep	Angora goat	Boer goat	Sheep	Angora goat	Boer goat
Aroma (6=Extremely intense) (1=Extremely bland)	$4,58^{a}$	$4,32^{b}$	$4,33^{b}$**	$4,50^{a}$	$4,20^{b}$	$4,35^{ab}$**
Initial impression of juiciness (6=Extremely juicy) (1=Extremely dry)	4,45	4,33	4,32	$4,36^{a}$	$4,17^{b}$	$3,97^{c}$**
Sustained juiciness (6=Extremely juicy) (1=Extremely dry)	$4,08^{a}$	$3,86^{b}$	$3,74^{b}$**	$3,98^{a}$	$3,71^{b}$	$3,42^{c}$**
Tenderness (6=Extremely tender) (1=Extremely tough)	$4,75^{a}$	$3,07^{b}$	$2,42^{c}$**	$3,84^{a}$	$3,28^{b}$	$2,94^{c}$**
Residue (6=none) (1=abundant)	$4,40^{a}$	$3,12^{b}$	$2,45^{c}$**	$3,77^{a}$	$3,26^{b}$	$3,00^{c}$**
Flavour (6=excellent) (1=unacceptable)	$4,29^{a}$	$4,02^{b}$	$3,88^{b}$**	4,13	4,09	4,06
Species flavour (6=extremely typical) (1=extremely a-typical)	$4,49^{a}$	$4,27^{b}$	$4,15^{b}$**	$4,41^{a}$	$4,22^{ab}$	$4,18^{b}$**

** $p \leq 0,01$
* $p \leq 0,05$
a b c Means in the same row with different superscripts differ significantly

Brennard and Lindsay (1982:252) indicated that both 4-methyloctanoic and 4-methylnonanoic acid are associated with ovine specific flavours. These components have been identified as the characteristic "sweaty-sour" odour in mutton (Wong, et al, 1975:261). In other words branched chain and unsaturated

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acids having 8 to 10 carbon atoms contributed to the undesirable aroma and flavour of cooked mutton.

According to Misock, et al (1976:1442) aroma and flavour are most important in determining palatability of cooked lamb. The aroma or odour of meat is the sensory quality attribute ascribed to certain volatile substances as perceived by the olfactory organ (Cross, et al, 1986:289). Cross, et al (1986:279) describes flavour as the complex sensation from the combination of the olfactory and gustatory attributes perceived during tasting, which may be influenced by tactile, thermal, pain, and even kinaesthetic effects. The "meat" odour and flavour of a sample (species flavour), or its "meatiness" are the natural odour and flavour one would expect in meat from a particular species (Ford & Park, 1977:221).

The aroma of the sheep cuts was significantly ($p \leq 0,01$) more intense than that of the goat cuts, bar that of the Boer goat *M. semimembranosus* where the difference was only significant on the 95 % level of confidence. These results were surprising in view of the general belief that Boer goat has a very strong characteristic aroma especially in meat of older animals when cooked according to a moist heat cooking method.

The flavour of the sheep *Mm. longissimus thoracis et lumborum* cooked according to a dry heat cooking method was significantly ($p \leq 0,01$) more acceptable to the sensory panel, than the flavour of the Angora and Boer goat cuts. No significant difference was found for the *M. semimembranosus* cooked according to a moist heat cooking method.

The high aroma intensity of sheep meat may explain, to some degree, the low consumption of sheep meat by the American people, as noted by Sink and Caporaso (1977:119), if a high aroma intensity is seen as less desirable. Carpenter (1966:1232) stated that according to consumer studies done in the United States, lamb was described as being more undesirable in odour than any other meat.

The low consumption of both lamb and mutton overseas has been attributed to the flavour of these meats (Vesely, 1973:673). Kirton (1970:167) and Smith, et al (1978:1235) reported that most of the sensory panel discrimination against goat meat was due to lack of tenderness. No indication of any strong

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odour or flavour associated with cooked goat meat was considered to have been a factor.

According to Kirton (1970:178) the slight preference of the sensory panel for sheep meat above goat meat was due to flavour. The researcher noted that there was no suggestion of the presence of any off flavour or odour from the goat meat. Gaili, et al (1972:357) could not find any significant differences in flavour between male Sudan desert sheep and goats.

In this regard the South African consumer is unique, in respect of the red meat consuming world, in that these consumers are prepared to pay appreciably more for sheep meat than for either beef or pig meat on a market where there is usually a shortage of both lamb and mutton.

Although odour and flavour have already briefly been discussed as being important in determining palatability, Vesely (1973:673) is not sure that the "characteristic aroma" of heated lamb is identical to that of undesirable lamb flavour. The low consumption of both lamb and mutton overseas has been attributed to the flavour of these meats (Sink & Caporaso, 1977:119; Vesely, 1973:673). Crouse (1983:264) stated that these consumers tend to consistently eat beef or pork in preference to lamb. The main reason given is that the majority of consumers do not accept the flavour of either lamb or mutton.

In a review of the chemistry of mutton flavour Sink and Caporaso (1977:119) described the precursor of flavour in lean lamb meat as low in molecular mass, water soluble and producing characteristic meat aromas on heating. The presence of glutathione in water extracts of lamb muscle and a low total carbohydrate content are also mentioned flavour contributors.

As shown in Table 56, there was no significant difference in the initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* between the three species. However the sheep *M. semimembranosus* was significantly ($p \leq 0,01$) more juicy than the corresponding Angora cuts, which were more juicy than the Boer goat cuts.

The sustained juiciness of the sheep *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* was significantly ($p \leq 0,01$) higher in comparison to the corresponding Angora and Boer goat cuts. The sheep *M. semimembranosus*

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TABLE 57: AVERAGE EXPRESSIBLE MOISTURE AND SHEAR FORCE RESISTANCE SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Species	Sheep	Angora goat	Boer goat	Sheep	Angora goat	Boer goat
Expressible moisture (%)	50,27	48,50	47,83	39,29	36,91	36,75
Shear force resistance (Newton)	$32,50^{a}$	$45,76^{b}$	$62,94^{c}$**	$38,96^{a}$	$54,05^{b}$	$60,44^{c}$**

** $p \leq 0,01$
* $p \leq 0,05$
a b c Means in the same row with different superscripts differ significantly

was more juicy in comparison with that of the Angora goat, which in turn was more juicy than that of the Boer goat. Although not significant a similar trend was observed for expressible moisture determinations (Table 57).

These results are similar to those of Smith, et al (1974:1146) who concluded that meat from Angora and Spanish goats was equivalent in juiciness ratings to beef and pork, more juicy than horse meat but less juicy than lamb. Pike, et al (1973:269) described lamb leg cutlets as more flavourful, juicy, tender and better overall than cutlets from goat legs ($p \leq 0,01$). However Kirton (1970:179) did not find any significant difference in juiciness between sheep and New Zealand feral goats.

The sheep, Angora and Boer goat *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* differed significantly ($p \leq 0,01$) in tenderness. The sheep cuts were more tender than the Angora goat cuts, which in turn were more tender than the Boer goat cuts. This difference in tenderness was supported by the shear force measurements (Table 57) and collagen measurements (Table 58).

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TABLE 58: AVERAGE COLLAGEN MEASUREMENTS SCORES OF THE *M. longissimus thoracis* FROM SHEEP, ANGORA AND BOER GOATS

Species	Sheep	Angora goat	Boer goat
Collagen solubility (%)	$17,09^{a}$	$15,19^{b}$	$14,62^{b}$**
Collagen content (Hypro N/ Total N x 10^{3})	$3,18^{a}$	$3,65^{b}$	$3,74^{b}$**

** p≤0,01
* p≤0,05
a b Means in the same row with different superscripts differ significantly

This difference in tenderness was also reported by other workers. According to Kirton (1970:180) the meat from New Zealand feral goats is significantly less tender (p≤0,01) than that of sheep. Smith, et al (1974:1146) reported that meat from Angora and Spanish goats is less tender than lamb, beef or pork. Gaili, et al (1972:356) described a tendency for sheep to be more tender than Sudan goats as yearlings. Pike, et al (1973:269) reported that lamb loin chops and leg chops were significantly more tender than similar cuts from goats. They concluded that chops from goat carcases could not substitute those from lambs of similar age, and were generally less tender and less palatable to consumers than meat from sheep.

The collagen content of the sheep *M. longissimus thoracis* was significantly (p≤0,01) lower and the collagen was significantly (p≤0,01) more soluble than that of the Angora and Boer goats. In general, the higher the insoluble collagen content the tougher the meat. Boccard, et al (1979:276) found that collagen content affected toughness of meat, although shear force values seem to have been influenced to a larger extent by the solubility than by the content of muscle collagen.

These results are similar to that of Heinze, et al (1986:171). They reported

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the collagen content of the Boer goat as similar to the Pedi and Merino sheep breeds, but significantly ($p \leq 0,01$) higher than the Dorper and South African Mutton Merino. Significant differences ($p \leq 0,05$) in collagen solubility were found between breeds. The collagen of the South African Mutton Merino was significantly more soluble than that of the Pedi and Dorper sheep breeds, with the Boer goat and Merino breeds containing collagen that was least soluble.

There was a significant difference in the amount of residue (Table 56) between the three species for both the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus*. The sheep cuts contained significantly ($p \leq 0,01$) less residue than the Angora cuts, which contained significantly ($p \leq 0,01$) less residue than the Boer goat cuts. The correlation between tenderness and residue as evaluated by the sensory panel was significant ($r = 0,97$ and $r = 0,94$ respectively; $p \leq 0,01$).

There were no significant differences between the three species for the percentage moisture, protein, fat, ash and dry matter for the cooked cuts (Table 59).

Kirton (1970:175) described protein and water content as indicative of red meat or muscular tissue, and percentage water on a fat-free basis as a "biological constant" in body and carcase composition for most animal species. Although no differences were found in the proximate analysis of sheep and goat meat (cooked samples, without subcutaneous fat) in this research project, Gaili, et al (1972:351) reported less chemical fat, more moisture and protein in goat meat than in sheep. They ascribed it to the fact that fat usually replaces water in carcases as animals become more finished.

Summary

In Figures 51 and 52 schematic presentations of the juiciness and cooking related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are supplied. The flavour and tenderness related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are schematically presented in Figure 53 and 54.

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TABLE 59: AVERAGE PROXIMATE ANALYSIS SCORES (%) OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Species	Sheep	Angora goat	Boer goat	Sheep	Angora goat	Boer goat
Moisture	64,62	64,74	65,37	63,97	64,22	64,35
Protein	26,64	26,82	27,24	29,37	29,19	29,07
Fat	7,13	7,00	6,24	4,71	4,67	4,40
Ash	1,06	1,07	1,08	0,99	0,97	1,00
Dry Matter	35,31	35,26	34,38	36,00	35,78	35,78

** p≤0,01
* p≤0,05
a b Means in the same row with different superscripts differ significantly

The effect of age

The effect of differences in age on the quality characteristics of sheep, Angora and Boer goat meat seen as a whole will be discussed. The A age group consists of animals with no permanent incisor teeth (Grades Super lamb or kid, lamb or kid 1, and lamb or kid 3), the B age group animals with 1 to 6 permanent incisor teeth (Grades Prime B, B1 and B3) and the C age group animals with more than 6 permanent incisor teeth (Grades Top C, C1 and C3).

Results obtained and analyzed by the three way analysis of variance for cooking loss measurements are summarized in Table 60. It is evident that the *Mm. longissimus thoracis et lumborum* cuts of the C age group had significantly (p≤0,01) greater drip loss than the corresponding cuts from the A and B age groups. The *M. semimembranosus* cuts of the B and C age groups

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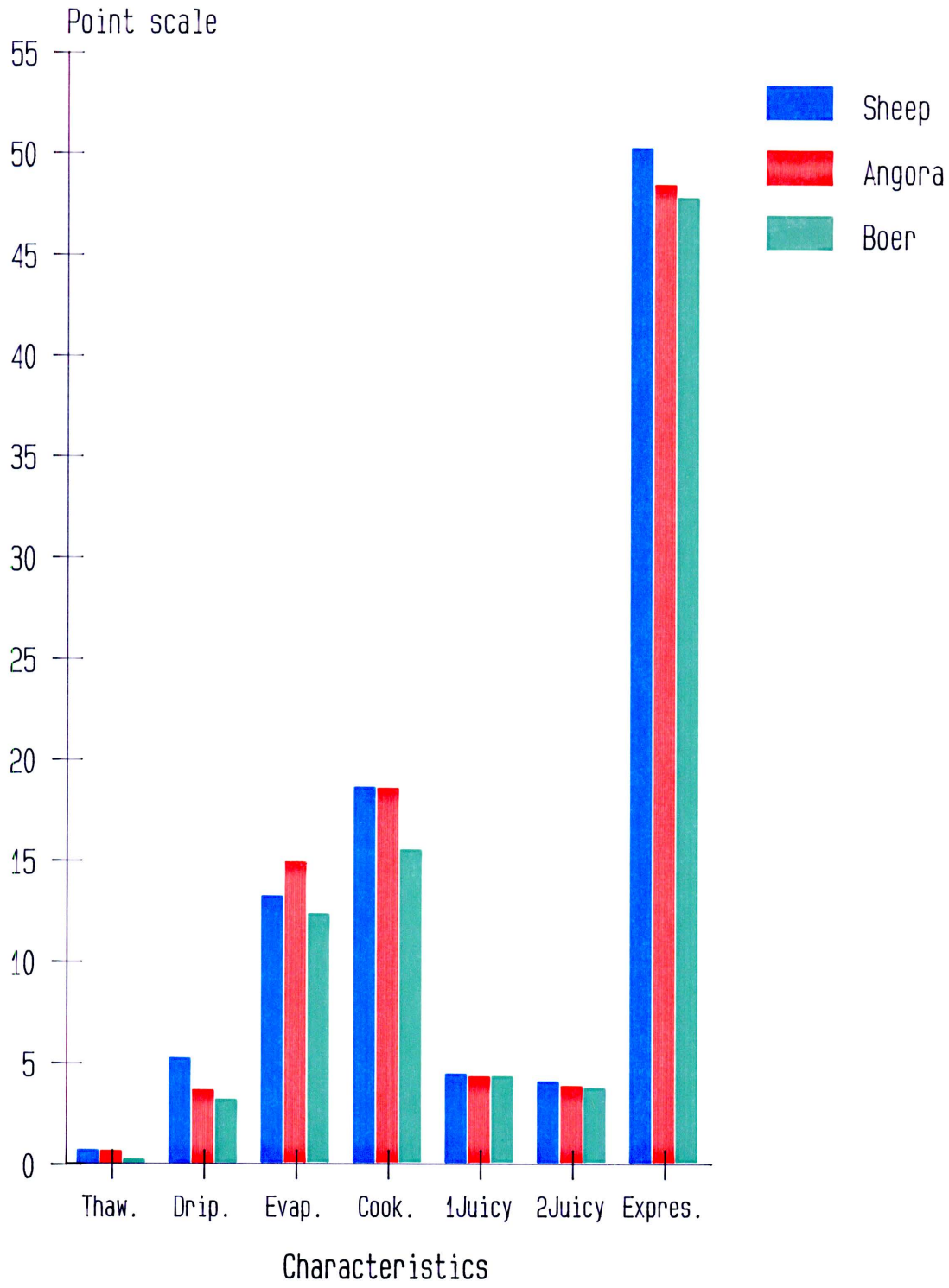

FIGURE 51: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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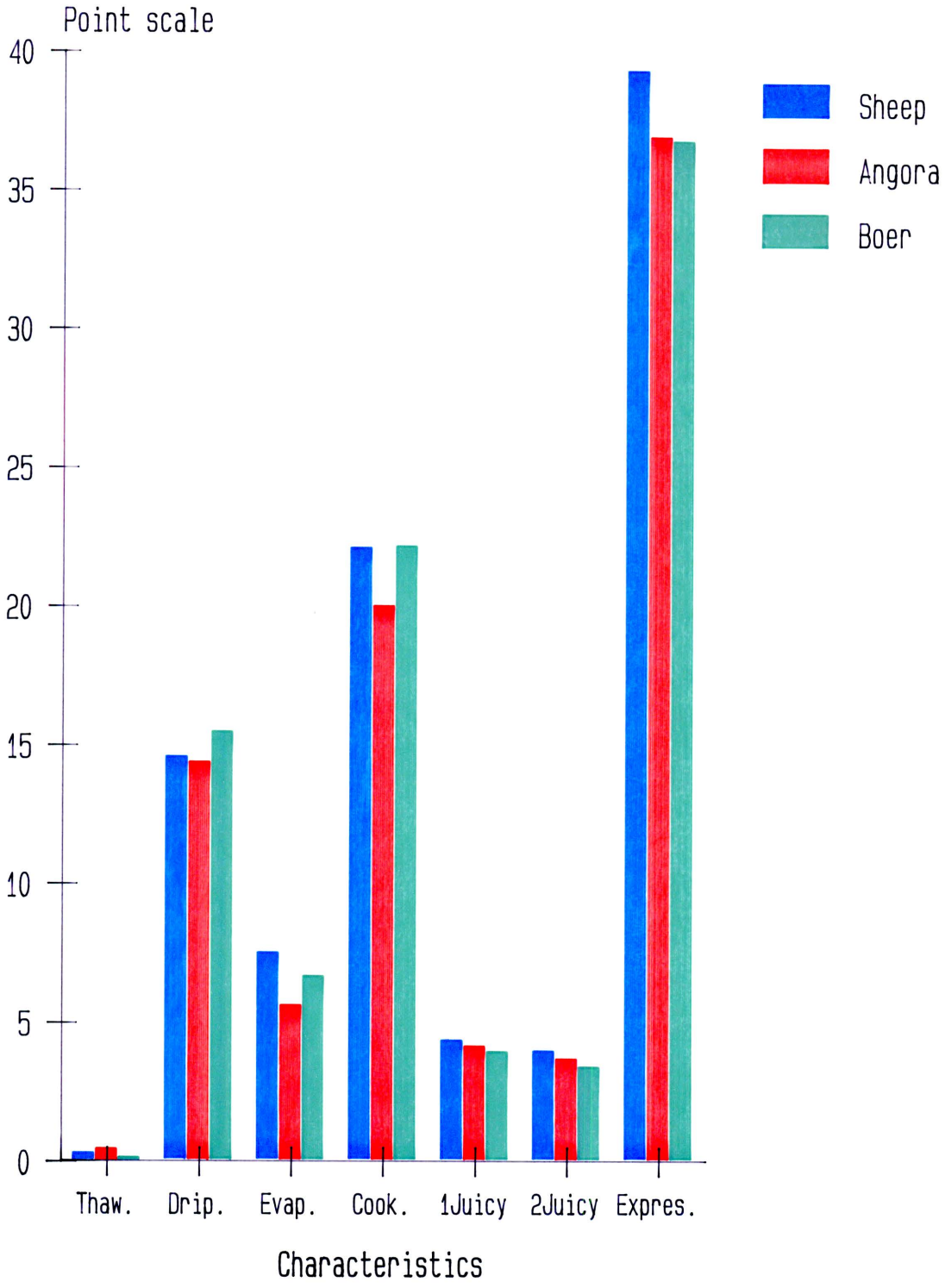

FIGURE 52: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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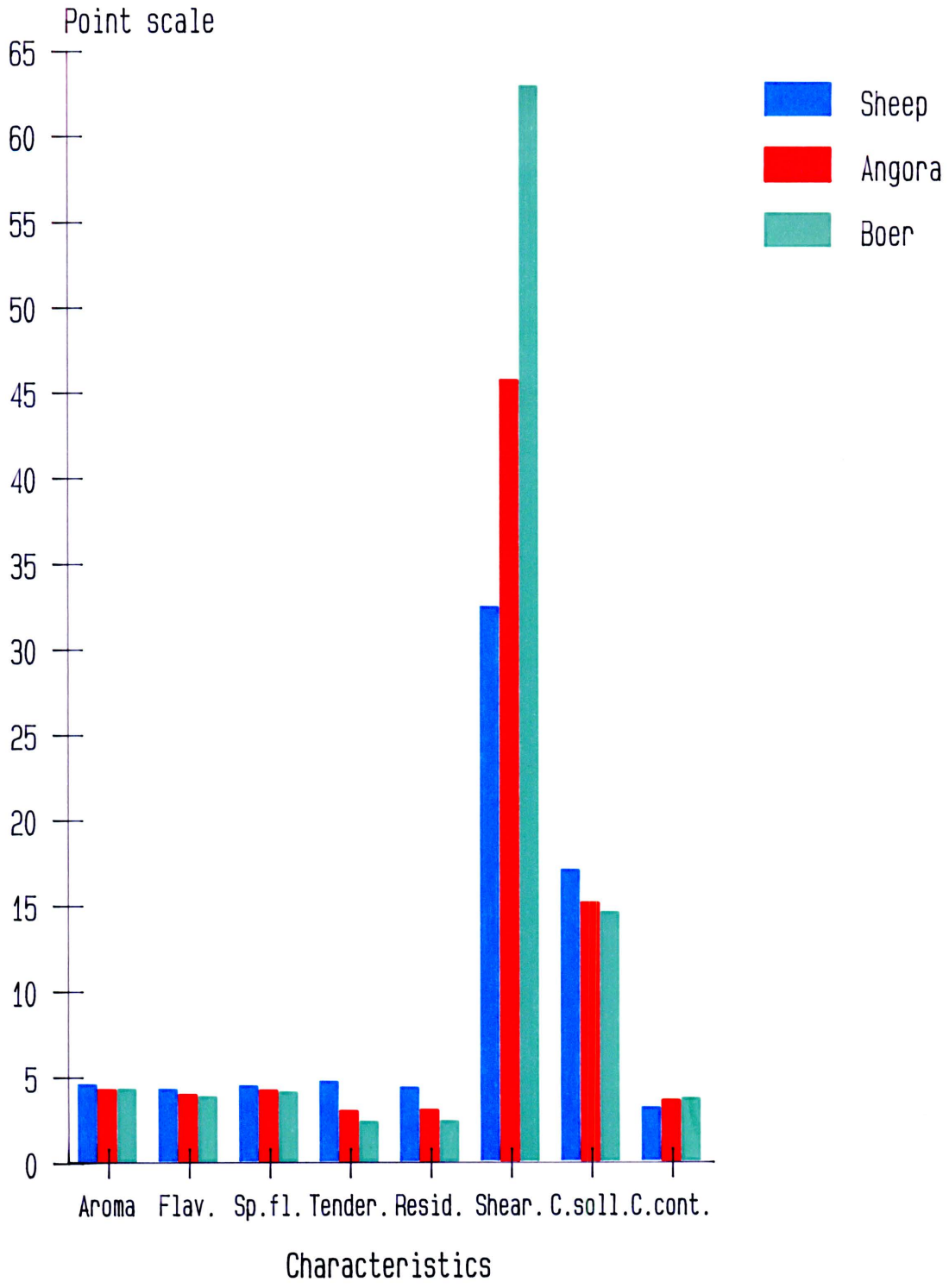

FIGURE 53: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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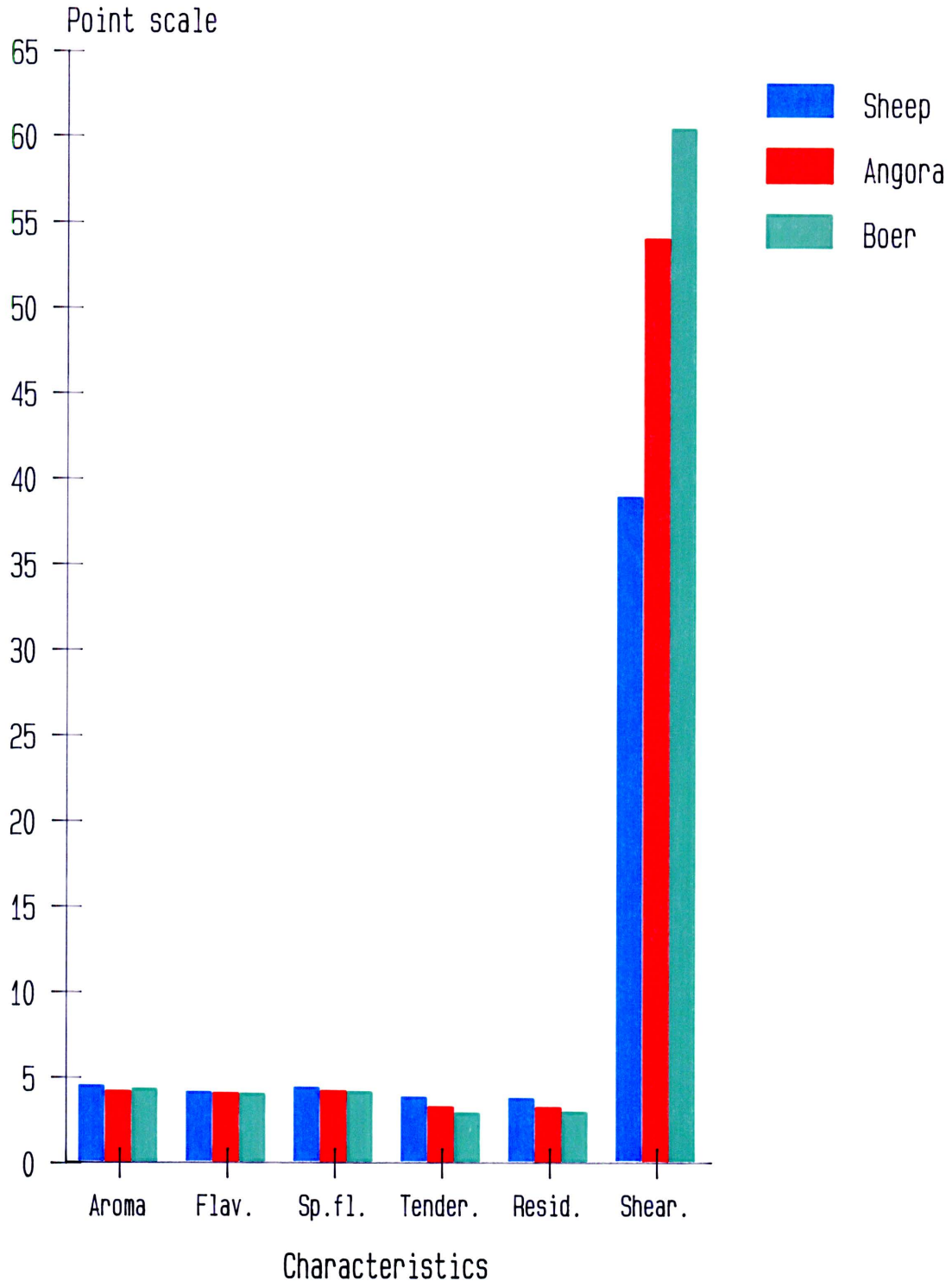

FIGURE 54: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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TABLE 60: AVERAGE COOKING AND THAWING LOSSES (%) OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE AGE CLASSES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Age group	A	B	C	A	B	C
Drip loss	3,28^{a}	3,72^{a}	5,11^{b}**	13,13^{a}	15,39^{b}	16,00^{b}**
Evaporation loss	12,25	14,41	13,89	5,38^{a}	6,37^{ab}	8,09^{b}**
Total cooking loss	15,70	18,12	18,99	18,51^{a}	21,76^{b}	24,09^{c}**
Thawing loss	0,83	0,46	0,37	0,41	0,20	0,32

** p≤0,01
* p≤0,05
a b c Means in the same row with different superscripts differ significantly

had significantly (p≤0,01) greater drip loss than the corresponding cuts from the A age group. The *M. semimembranosus* cuts of the C age group showed significantly (p≤0,01) more evaporation loss than the corresponding cuts from the A age group. The *M. semimembranosus* cuts of the C age group showed significantly (p≤0,01) more total cooking loss than the corresponding cuts from the B age group, which showed significantly (p≤0,01) more total cooking loss than the corresponding cuts from the A age group. These differences in cooking losses can be attributed to the fact that during the post-natal growth of the animal, the muscle grows initially faster than the fat, but as growth continues fat growth will exceed muscle growth. The rate of fat deposition will continue and further growth is mainly due to the growth of fat depots, with only a small increase in lean body mass (Leat & Cox, 1980:43).

The results of the sensory evaluation for the three age groups are summarized

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in Table 61. There were no significant differences in aroma between the three age groups. No significant differences in flavour between the three age groups were found for the *Mm. longissimus thoracis et lumborum* cuts. The

TABLE 61: AVERAGE SENSORY EVALUATION SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE AGE CLASSES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Age group	A	B	C	A	B	C
Aroma (6=Extremely intense) (1=Extremely bland)	4,48	4,40	4,35	4,31	4,42	4,32
Initial impression of juiciness (6=Extremely juicy) (1=Extremely dry)	$4,49^{a}$	$4,32^{ab}$	$4,29^{b}$*	4,16	4,09	4,25
Sustained juiciness (6=Extremely juicy) (1=Extremely dry)	$4,04^{a}$	$3,71^{ab}$	$3,92^{b}$**	$3,64^{ab}$	$3,60^{a}$	$3,87^{b}$**
Tenderness (6=Extremely tender) (1=Extremely tough)	$3,87^{a}$	$3,22^{b}$	$3,16^{b}$**	$3,83^{a}$	$3,21^{b}$	$3,03^{b}$**
Residue (6=none) (1=abundant)	$3,62^{a}$	$3,18^{b}$	$3,18^{b}$**	$3,63^{a}$	$3,27^{b}$	$3,14^{b}$**
Flavour (6=excellent) (1=unacceptable)	4,18	4,02	3,99	$4,27^{a}$	$4,03^{b}$	$3,97^{b}$**
Species flavour (6=extremely typical) (1=extremely a-typical)	4,33	4,28	4,31	$4,16^{a}$	$4,38^{b}$	$4,27^{ab}$*

* p≤0,01
p≤0,05
b c Means in the same row with different superscripts differ significantly

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flavour of the *M. semimembranosus* cuts from the A age group was significantly ($p \leq 0,01$) more acceptable to the sensory panel, than the flavour of the cuts from the B and C age group.

No significant differences in species flavour between the three age groups were found for the *Mm. longissimus thoracis et lumborum* cuts. The species flavour of the *M. semimembranosus* cuts from the B age group were significantly more easily recognizable than the corresponding cuts from the A age group.

Crouse (1983:265) considering the lamb flavour - age association reported, ascribed the variation in observed association (i.e. positive, zero, or negative), to the interactions of age with breed, sex condition, or diet. Although differences in flavour and aroma of meat samples have been documented, consumers tend to be divided in their preference for a strong flavour. He proposes that flavour and aroma should rather be evaluated by trained sensory panels using an intensity scale. This may be the reason why such clear differences were found in the present study.

Sink and Caporaso (1977:119) describe the flavour of meat from young animals as more desirable than that from older ones. According to them it is a generally accepted fact that the "animal" flavour intensity of meat increases with chronological age. It seems as if there is an age effect upon the flavour of sheep meat, with older animals yielding a more intense meat flavour. According to Ford and Park (1977:224) the natural meat flavour of a particular species is not fully developed until the animal reaches maturity. Twelve months appears to be the age by which most sheep produce flavoursome meat. The characteristic flavour of mutton has been cited as one reason for the low consumption of sheep meat in the United States. Mutton may have an entirely different flavour from that of lamb, or may merely represent a change in concentration (Sink & Caporaso, 1977:119). Smith, et al (1978:1234) found that loin chops from young goats were less intense in flavour than yearling goats. This supports the findings in this research report that the flavour of animals from the A age group (both lamb and kid meat) are less intense in flavour than those of the B and C age groups (mutton and goat meat).

The fact that the *M. semimembranosus* cuts (moist heat) showed more significant differences between the various age groups for flavour than the

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Mm. longissimus thoracis et lumborum cuts (dry heat) may be explained by an observation of Bratzler (1971:337). He describes lamb cooked according to a moist heat cooking method as having a predominant animal flavour, a greasy mouth-coating effect and an after taste, the reason being that the nature and intensity of meat flavours are dependent on the type, length of time, and temperature of cooking.

The *Mm. longissimus thoracis et lumborum* cuts of the A age group were significantly more juicy in comparison to the corresponding cuts from the C age group. This was true for both the initial impression of juiciness and sustained juiciness ($p \leq 0,05$ and $p \leq 0,01$) respectively. A similar trend was observed for expressible moisture determinations (Table 62). The *Mm. longissimus thoracis et lumborum* cuts of the A age group contained significantly ($p \leq 0,01$) more expressible moisture than the corresponding cuts from the B and C age groups. However, the sustained juiciness of the *M. semimembranosus* cuts of the C age group were significantly ($p \leq 0,01$) higher, in comparison to the corresponding cuts from the B age group.

TABLE 62: AVERAGE EXPRESSIBLE MOISTURE AND SHEAR FORCE RESISTANCE SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE AGE CLASSES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Age group	A	B	C	A	B	C
Expressible moisture (%)	$51,26^{a}$	$48,37^{b}$	$46,97^{b}$**	38,25	36,46	38,23
Shear force resistance (Newton)	45,86	46,61	47,65	$40,61^{a}$	$53,61^{b}$	$59,22^{b}$**

** $p \leq 0,01$
* $p \leq 0,05$
a b Means in the same row with different superscripts differ significantly

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The results of the *Mm. longissimus thoracis et lumborum* cuts for juiciness are further supported by the chemical analysis for moisture of the cooked cuts (Table 63). The *Mm. longissimus thoracis et lumborum* cuts of the A and B age groups contained significantly ($p \leq 0,05$) more moisture than the corresponding cuts from the C age group. The *M. semimembranosus* cuts of the A age group contained significantly ($p \leq 0,01$) more moisture than the corresponding cuts from the B and C age groups. These results are supported by Forrest, et al (1975:296). They describe the water remaining in the cooked product as the major contributor to the sensation of juiciness. Therefore differences in juiciness must relate to the sensation of juiciness. This is the reason for the gradual reduction of juiciness in cooked meat with an increase in the age of the animal. Gaili, et al (1972:357) found that young goats had juicier meat than older ones, while they found no difference between ages in sheep meat.

TABLE 63: AVERAGE PROXIMATE ANALYSIS SCORES (%) OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE AGE CLASSES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Age group	A	B	C	A	B	C
Moisture	$65,37^{a}$	$65,24^{a}$	$64,12^{b}*$	$65,40^{a}$	$63,73^{b}$	$63,41^{b}**$
Protein	26,66	26,93	27,11	$28,08^{a}$	$29,58^{b}$	$29,97^{b}**$
Fat	6,59	6,69	7,09	4,72	4,54	4,53
Ash	1,05	1,07	1,08	$1,03^{a}$	$0,97^{b}$	$0,96^{b}**$
Dry Matter	$34,55^{a}$	$34,54^{a}$	$35,85^{b}*$	$34,68^{a}$	$36,59^{b}$	$36,28^{b}**$

** $p \leq 0,01$
* $p \leq 0,05$
a b Means in the same row with different superscripts differ significantly

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The *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts of the A age group were significantly ($p \leq 0,01$) more tender than the cuts from the B and C age groups. This difference in tenderness was supported by the shear force measurement (Table 62). The *M. semimembranosus* cuts from the A age group were significantly ($p \leq 0,01$) more tender than the cuts from the B and C age groups.

The tenderness values were further supported by the collagen measurements (Table 64). The collagen of the *M. longissimus thoracis* cuts of the A age group was significantly ($p \leq 0,01$) more soluble than that of the B age group, which was in turn significantly ($p \leq 0,01$) more soluble than that of the C age group. The collagen content of the *M. longissimus thoracis* cuts of the A and C age groups was significantly ($p \leq 0,01$) greater than that of the B age group. In general, the higher the insoluble collagen content the tougher the meat. The correlation ($r = 0,77$) between age and collagen solubility was significant ($p \leq 0,01$).

TABLE 64: AVERAGE COLLAGEN MEASUREMENTS SCORES OF THE *M. longissimus thoracis* FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE AGE CLASSES

Age group	A	B	C
Collagen solubility (%)	$20,55^{a}$	$16,30^{b}$	$10,05^{c}$**
Collagen content (Hypro N/ Total N x 10^{3})	$3,69^{a}$	$3,17^{b}$	$3,78^{a}$**

** $p \leq 0,01$
* $p \leq 0,05$
a b c Means in the same row with different superscripts differ significantly

Kirton (1970:179) found that a sensory panel preferred the meat from young

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feral goats to the meat from yearlings, which in turn scored higher than the meat from old animals. He reported the meat from the young animals very much more tender than that from the yearlings and older animals and that the flavour was also slightly preferred to the meat from the younger animals.

Forrest, et al (1975:291) describes growth and development in the animal after 30 months of age, as a gradual toughening process of the muscle, although the rate of change becomes progressively slower with advanced age. The quantity of connective tissue apparently changes very little after maturity. The decrease in tenderness seems to be largely due to the increased number of crosslinks in the collagen fibrils, resulting in the decreased solubility of the collagen and increased resistance to shearing and chewing. In a research project on the South African beef carcase grading scheme Klingbiel (1984:9.24) also found that the collagen solubility of the A age group was significantly higher, than that from the older age groups. These results are confirmed by Bruwer, et al (1987:98). They reported a consistent tendency for the meat of lambs (A age group) to be more tender than that of the B and C age groups. Meat of the B age group was more tender than that of the C age group in shear force and taste panel tenderness values.

According to Boccard (1973:353) many workers have found high correlations between collagen content, measured by hydroxyproline or other methods, and tenderness of different muscles within a carcase. However, considerable controversy seems to exists because many workers have found no correlation or very low correlations. For instance Mc Keith, et al (1985:871) determined the collagen content of thirteen muscles and found that collagen content was not a good predictor of tenderness. They proposed that the percent soluble collagen may be more important to meat tenderness. The total variation of toughness at a given age cannot be explained in terms of the amount of connective tissue alone. Other factors such as the nature, structure and distribution of the connective tissue may play a role.

Heinze, et al (1986:171) stated that age had a significant influence ($p \leq 0,01$) on the collagen content and collagen solubility of four sheep breeds as well as of Boer goat. Boccard, et al (1979:265) found in bovine animals a decrease in collagen content from birth to the older ages, although a slight increase was found after eight months, whereas a constant level was reached and maintained from the age of 16 months. This was not found by Heinze, et al

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(1986:170) in sheep and goat breeds from one month to 18 months. They found a general tendency to decrease in collagen solubility as well as content with age. They do seem to agree that the collagen content is a poor indicator of tenderness, with the solubility of collagen a more accurate predictor. Boccard, et al (1979:278) concluded that at a given age, differences in collagen solubility of different muscles within a carcase are small, but differences in collagen content are significant and hence correlated to differences in tenderness of different muscles. With an increase in age of the animal the collagen content of a specific muscle increased, while collagen solubility decreased, with a concomitant decrease in the tenderness of the muscle.

Boccard (1973:359) found higher correlations between collagen solubility and tenderness with moist heat cooking methods, than with dry cooking methods. The explanation was given that as more water molecules are introduced between the collagen chains, more collagen can swell and be removed, and hence the more tender the meat.

Although a decrease in collagen content with an increase in age of the animal was found, this phenomenon could easily be explained by the increase of muscle fibre volume during the growth of the animal, rather than by direct decline in the absolute content of collagen.

There was a significant ($p \leq 0,01$) difference in the amount of residue (Table 61) between the A age group on the one hand, and the B and C age groups on the other for both the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts. Cuts from the A age group contained significantly ($p \leq 0,01$) less residue than the cuts from the B and C age groups.

According to Table 63 the cooked *M. semimembranosus* cuts from the A age group contained significantly ($p \leq 0,01$) less protein, more ash and less dry matter than the corresponding cuts from the B and C age groups. The cooked *Mm. longissimus thoracis et lumborum* cuts from the A and B age groups contained significantly ($p \leq 0,05$) less dry matter than the corresponding cuts from the C age group.

Gonzalez, et al (1983:305) also reported a steady decrease in the moisture content of goat meat with increasing slaughter mass. They too found a

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decrease in the ash content, an increase in the fat content and a decrease in the protein content. Owen, et al (1978:70) found that in goat and sheep meat the levels of dissectable fat tended to increase with age, thus reducing lean content. Gaili, et al (1972:355) also reported a higher ash content in the meat of young animals (for both sheep and goat meat) compared to older ones. They described a general trend of an increase in fat content with increasing age and fattening, and a reduction in the moisture and protein content of meat. Kirton (1970:177) indicated that as with other species the percentage water on a fat-free basis in sheep and goat carcases was lower in older animals. A concomitant increase in protein and ash content was noted.

Summary

In Figures 55 and 56 schematic presentations of the juiciness and cooking related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are supplied. The flavour and tenderness related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are schematically presented in Figure 57 and 58.

The effect of fat code

The effect of different fat codes on the quality characteristics of sheep, Angora and Boer goat meat seen as a whole will be discussed. Animals with a fat code of one are from the A3, B3 and C3 grades, those with a fat code of two from the A1, B1 and C1 grades and those with a fat code of three are from the Super, Prime and Top grades.

Results obtained and analyzed by the three way analysis of variance for cooking loss measurements are summarized in Table 65. It is evident that the *Mm. longissimus thoracis et lumborum* cuts of fat code three had significantly ($p \leq 0,01$) greater drip loss than the corresponding cuts of fat code two, which in turn had significantly ($p \leq 0,01$) greater drip loss than the corresponding cuts of fat code one. The *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly ($p \leq 0,05$) more evaporation losses than the corresponding cuts with a fat code of one. The *M. semimembranosus* cuts with a fat code of three had significantly ($p \leq 0,01$) more evaporation losses than the corresponding cuts with a fat code

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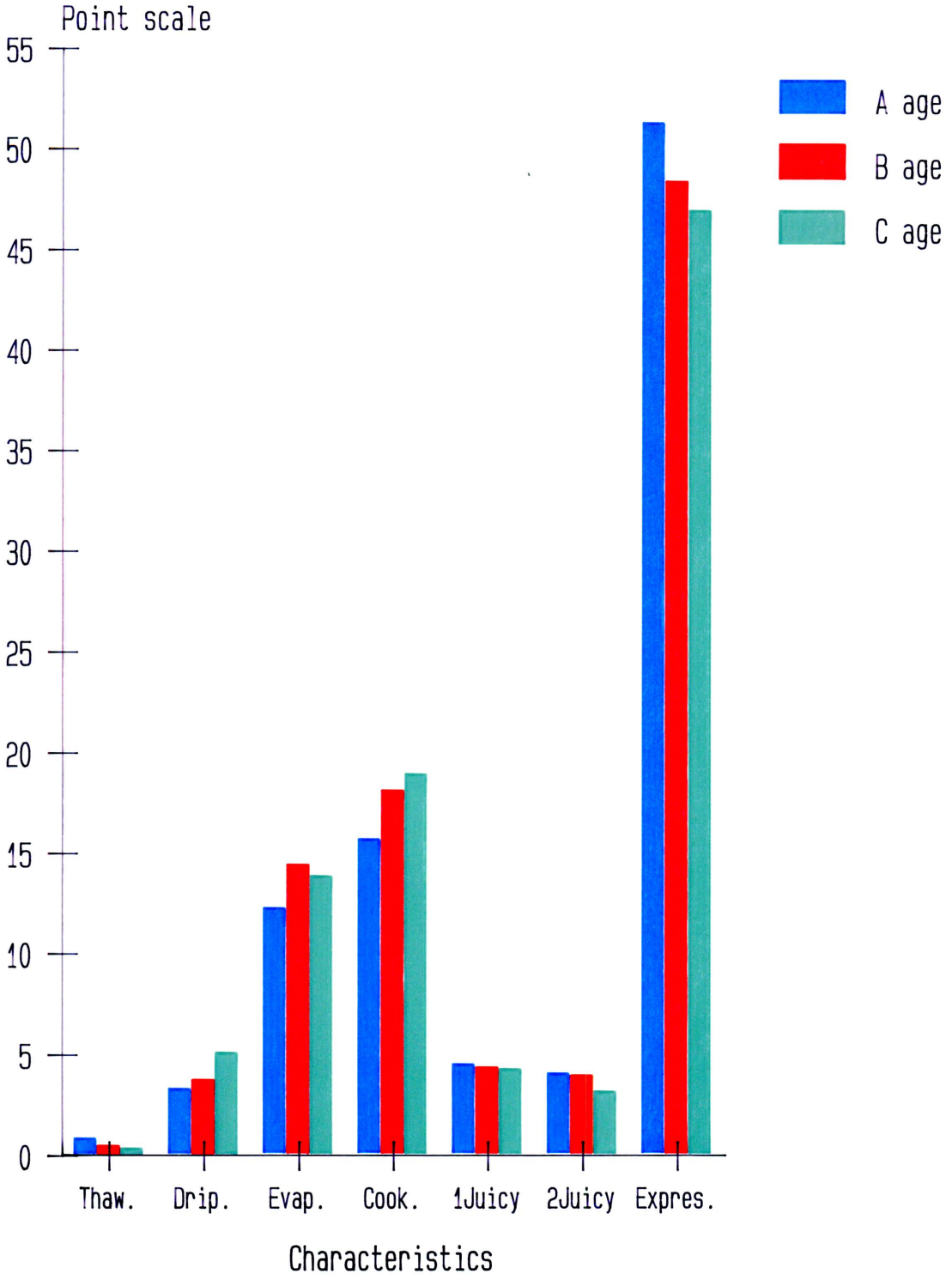

FIGURE 55: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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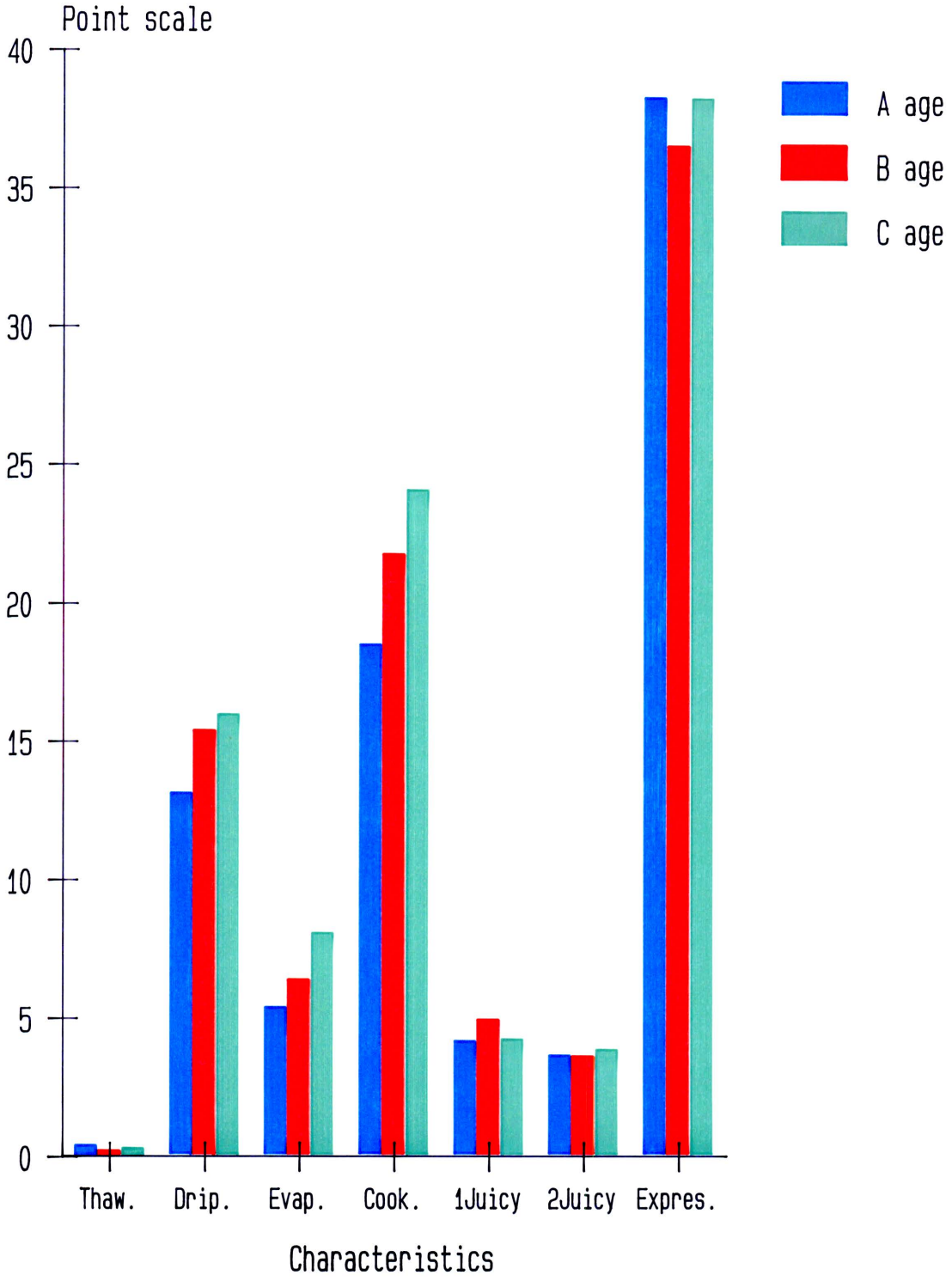

FIGURE 56: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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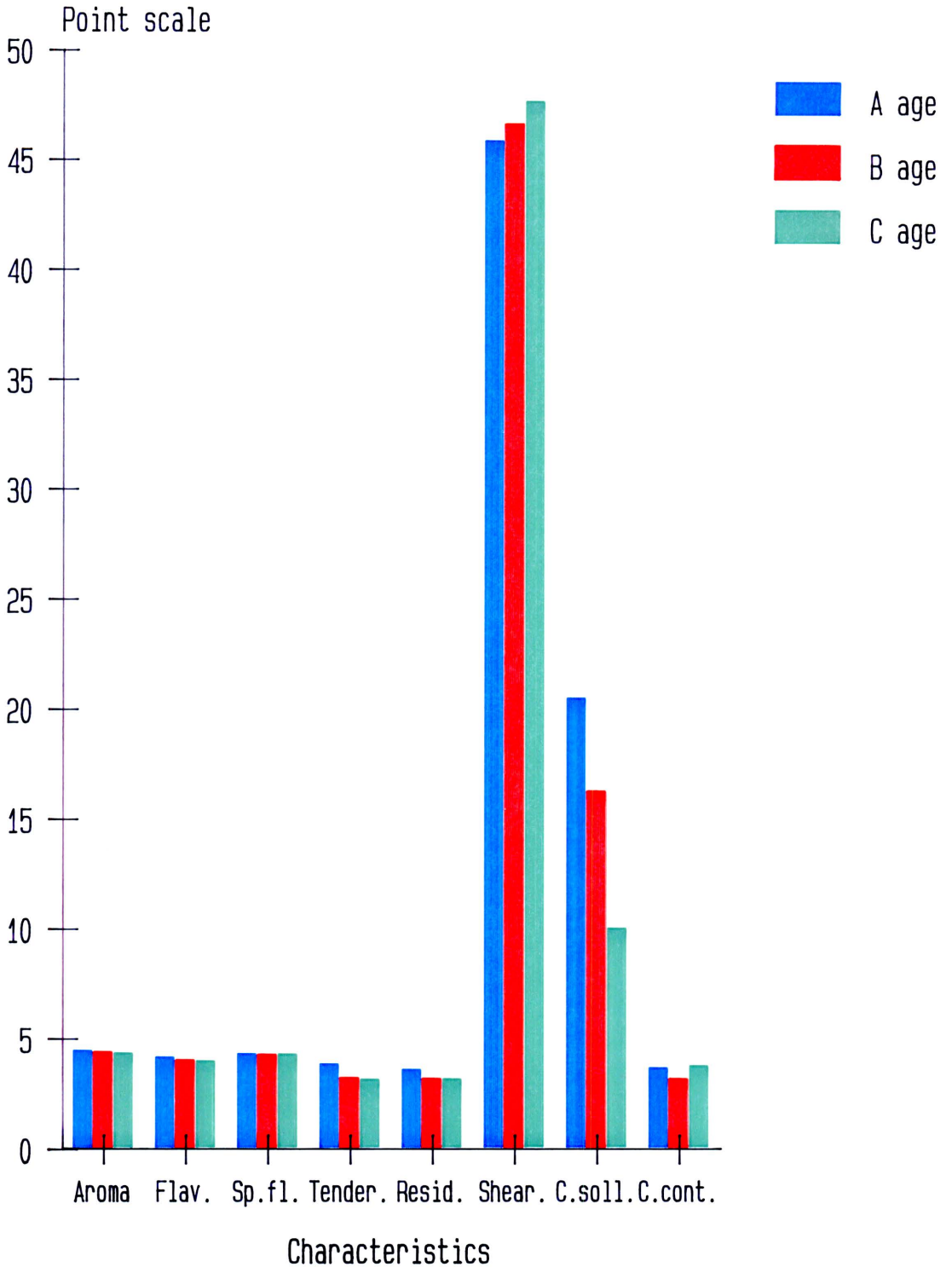

FIGURE 57: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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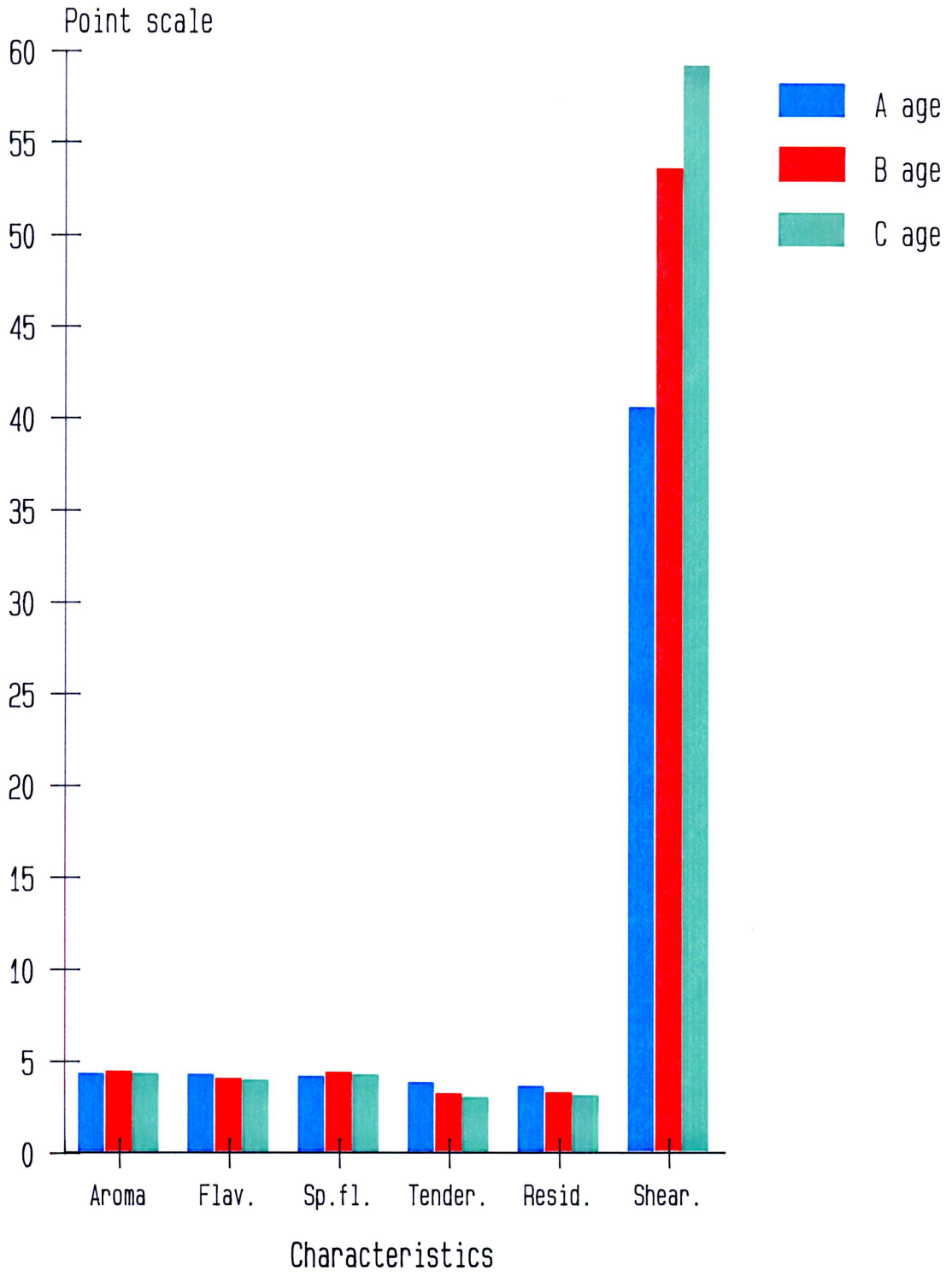

FIGURE 58: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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TABLE 65: AVERAGE COOKING AND THAWING LOSSES (%) OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE FAT CODES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Fat code	1	2	3	1	2	3
Drip loss	$1,46^{a}$	$3,91^{b}$	$6,73^{c}$**	14,84	15,41	14,25
Evaporation loss	$11,31^{a}$	$12,36^{ab}$	$16,98^{b}$*	$5,23^{a}$	$6,01^{a}$	$8,61^{b}$**
Total cooking loss	$12,96^{a}$	$16,14^{a}$	$23,71^{b}$**	$20,07^{a}$	$21,42^{ab}$	$22,87^{b}$**
Thawing loss	0,70	0,56	0,40	0,36	0,29	0,27

** $p \leq 0,01$
* $p \leq 0,05$
a b c Means in the same row with different superscripts differ significantly

of two and one. The *Mm. longissimus thoracis et lumborum* cuts with a fat code of three had significantly ($p \leq 0,01$) higher total cooking losses than the corresponding cuts with a fat code of two and one. The *M. semimembranosus* cuts with a fat code of three had significantly ($p \leq 0,01$) higher total cooking losses than the corresponding cuts with a fat code of one. The correlation between the fat code and drip loss was, although relatively low, significant ($r = 0,68$; $p \leq 0,01$) for the *Mm. longissimus thoracis et lumborum* cuts.

Although Parrish (1974:118) found that the degree of marbling had little effect on the flavour, tenderness, juiciness, overall acceptability and Warner Bratzler shear force, they reported a higher percentage cooking loss, with increased marbling. Carpenter and King (1965:103) also reported higher cooking losses with increased marbling or fat content. Although Cross (1977:184) did not find any relationship between the degree of marbling and

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total cooking losses, or percentage fat or moisture, they did report a higher percentage drip loss with increased marbling. It may be interesting to note that they found that cooking times were significantly affected by the amount, distribution and texture of marbling. It was highest for steaks that were low in marble fat, uneven in distribution and coarse in the texture of marbling. Solomon, et al (1980:1106) describe differences in cooking losses among rib roasts cooked under similar conditions as primarily due to differences in fatness. Leaner roasts generally had more evaporative loss, while fatter roasts had more drip loss. Ockerman, et al (1982:1371) also found a positive relationship between cooking yield as affected by fat content.

The results of the sensory evaluation for the three age groups are summarized in Table 66. No significant differences were found in aroma between the three age groups. Misock, et al (1976:1442) reported that heated fat aroma did not closely follow the results for panel flavour evaluation, with increased age and mass of rams and wethers.

The flavour of the *M. semimembranosus* cuts with a fat code of one and three cooked according to a moist heat cooking method were significantly ($p \leq 0,05$) less intense to the sensory panel, than the flavour of the cuts with a fat code of two. In addition, the flavour of the *M. semimembranosus* cuts with a fat code of one were significantly ($p \leq 0,05$) less easily recognizable than the corresponding cuts with a fat code of two.

Wasserman and Talley (1968:221) stated that fat increased the flavour of meat. Lean meat of the various species seems to have essentially the same basic aroma and that species-specific aroma is due to fat, although this statement may not always hold true. Crouse (1983:267) observed that with increased carcase fatness, lamb flavour intensity increased. Mc Keith, et al (1985:872) observed a trend for muscles with a higher % of fat to be more flavourful and tender. Species flavour and aroma are thought to arise from some components in fat that are volatilized upon heating, although future research is required to validate these concepts (Forrest, et al, 1975:296).

According to Table 66, there were no significant differences in the initial impression of juiciness of the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts between the three fat code groups. The sustained

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TABLE 66: AVERAGE SENSORY EVALUATION SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE FAT CODES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Fat code	1	2	3	1	2	3
Aroma (6=Extremely intense) (1=Extremely bland)	4,36	4,48	4,40	4,34	4,32	4,39
Initial impression of juiciness (6=Extremely juicy) (1=Extremely dry)	4,47	4,32	4,31	4,20	4,25	4,05
Sustained juiciness (6=Extremely juicy) (1=Extremely dry)	$4,11^{a}$	$3,82^{b}$	$3,74^{b}$**	3,81	3,70	3,60
Tenderness (6=Extremely tender) (1=Extremely tough)	$3,29^{a}$	$3,51^{b}$	$3,45^{ab}$*	$3,19^{a}$	$3,41^{ab}$	$3,46^{b}$**
Residue (6=none) (1=abundant)	3,24	3,40	3,34	3,29	3,39	3,35
Flavour (6=excellent) (1=unacceptable)	3,96	4,11	4,11	$4,05^{a}$	$4,21^{b}$	$4,01^{a}$*
Species flavour (6=extremely typical) (1=extremely a-typical)	4,27	4,37	4,28	$4,19^{a}$	$4,39^{b}$	$4,23^{ab}$*

** $p \leq 0,01$
* $p \leq 0,05$
a b c Means in the same row with different superscripts differ significantly

juiciness of the *Mm. longissimus thoracis et lumborum* cuts with a fat code of one were significantly ($p \leq 0,01$) higher in comparison to the corresponding cuts with a fat code of two and three. There were no significant differences in the sustained juiciness of the *M. semimembranosus* cuts between the

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three fat code groups. Exactly the opposite was observed for expressible moisture determinations (Table 67). The *Mm. longissimus thoracis et lumborum* cuts with a fat code of one contained significantly ($p \leq 0,05$) less expressible moisture than the corresponding cuts with a fat code of three. Mc Keith, et al (1985:869) describe a study in which no relationship was found between water holding capacity values and intramuscular fat content.

TABLE 67: AVERAGE EXPRESSIBLE MOISTURE AND SHEAR FORCE RESISTANCE SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE FAT CODES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Fat code	1	2	3	1	2	3
Expressible moisture (%)	$47,33^{a}$	$48,77^{ab}$	$50,51^{b}$*	37,57	37,99	37,38
Shear force resistance (Newton)	49,42	45,53	45,30	$56,57^{a}$	$48,61^{ab}$	$48,27^{b}$**

** $p \leq 0,01$
* $p \leq 0,05$
a b Means in the same row with different superscripts differ significantly

According to Bratzler (1971:334) the sensation of juiciness in cooked meat is closely related to intramuscular fat content. Thus, well-marbled meat of mature animals with a relatively high degree of finish is juicier than that from young animals with less marbling. Meat from young animals gives a watery effect on first chewing but a final impression of dryness.

Forrest, et al (1975:295) maintain that the principal sources of juiciness in meat, as detected by the consumer, are the intramuscular lipids and moisture content. In combination with water, the melted lipid constitutes a broth, which is released upon chewing. This broth may also stimulate the flow of saliva, and thus improve the meat's apparent juiciness. The fat content of

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the muscle may also enhance juiciness in an indirect way. During cooking the melted fat apparently becomes translocated along the band of the perimysial connective tissue. This may act as a barrier to moisture loss during cooking, thus less shrinkage and less moisture loss, resulting in a juicier product. In this research project the correlation between the proximate evaluation of moisture and fat content was significant ($r = 0,72$; $p \leq 0,01$) for the *Mm. longissimus thoracis et lumborum* cuts.

The *Mm. longissimus thoracis et lumborum* cuts with a fat code of one were significantly ($p \leq 0,05$) less tender (Table 66) in comparison to the corresponding cuts with a fat code of two. On the other hand the *M. semimembranosus* cuts with a fat code of one were significantly ($p \leq 0,01$) less tender in comparison to the corresponding cuts with a fat code of three. This difference in tenderness was supported by the shear force measurements (Table 67). According to these measurements the *M. semimembranosus* cuts with a fat code of one were significantly ($p \leq 0,01$) more resistant to shearing than the cuts with a fat code of three.

The tenderness values as evaluated by the sensory panel and shear force measurements were further supported by the collagen values (Table 68). The collagen content of the *M. longissimus thoracis* muscles with a fat code of three was significantly ($p \leq 0,01$) lower than that of the corresponding cuts with a fat code of two, which in turn was significantly ($p \leq 0,01$) lower than that of the corresponding cuts with a fat code of one. The collagen of the muscles with a fat code of one was significantly ($p \leq 0,01$) more soluble than that of the corresponding cuts with a fat code of two, which was in turn significantly ($p \leq 0,01$) more soluble than that of the corresponding cuts with a fat code of three. In general, the higher the soluble collagen content the more tender the meat.

Much controversy seems to exist around the effects of marbling (or percent fat) and tenderness. Although it is an accepted fact that intramuscular fat content affects the palatability of meat, the specific relationship does not seem to be clear at this stage. According to Mc Keith, et al (1985:869) some researchers have reported positive relationships between percent fat and tenderness, while others have found virtually no relationship. For instance Carpenter and King (1965:103) found significant correlations between chops with variations in marbling score and tenderness, while Parrish (1974:120)

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TABLE 68: AVERAGE EXPRESSIBLE MOISTURE AND SHEAR FORCE RESISTANCE SCORES OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE FAT CODES

Fat code	1	2	3
Collagen solubility (%)	$13,28^{a}$	$15,91^{b}$	$17,72^{c}$**
Collagen content (Hypro N/ Total N x 10^{3})	$3,92^{a}$	$3,52^{b}$	$3,10^{c}$**

** p≤0,01
* p≤0,05
a b c Means in the same row with different superscripts differ significantly

found no relationship.

Results in this study suggest that fatness has a positive relation to the tenderness of muscle and to associated muscle characteristics.

There was no significant difference in the residue score (Table 66) between the three fat codes for both the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts.

According to Table 69 the cooked *Mm. longissimus thoracis et lumborum* cuts with a fat code of one contained significantly (p≤0,01) more moisture and less dry matter than the corresponding cuts with a fat code of two, which in turn contained significantly (p≤0,01) less fat than the corresponding cuts with a fat code of three. The cooked *M. semimembranosus* cuts with a fat code of one contained (p≤0,01) significantly more moisture, less fat and less dry matter than the corresponding cuts with a fat code of three.

Gonzales, et al (1983:308) also reported similar trends. As the fat content of goats increased, the total moisture content decreased gradually but significantly. Apparently this inverse relationship between intramuscular fat and moisture has been shown to hold true for other animals over a range

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TABLE 69: AVERAGE PROXIMATE ANALYSIS SCORES (%) OF MUSCLES FROM SHEEP, ANGORA AND BOER GOATS SHOWN IN THREE FAT CODES

Attribute	*Mm. longissimus thoracis et lumborum* cuts			*M. semimembranosus* cuts		
Fat code	1	2	3	1	2	3
Moisture	66,24^{a}	64,86^{b}	63,63^{b}**	64,67^{a}	64,51^{ab}	63,37^{b}**
Protein	26,84	26,86	27,00	29,33	29,16	29,14
Fat	5,63^{a}	6,74^{a}	8,00^{b}**	4,20^{a}	4,43^{ab}	5,16^{b}**
Ash	1,09	1,07	1,07	1,00	0,99	0,99
Dry Matter	33,76^{a}	35,07^{b}	36,12^{b}**	35,33^{a}	35,62^{ab}	36,64^{b}**

** p≤0,01
 * p≤0,05
a b c Means in the same row with different superscripts differ significantly

of breed, body types, ages and nutritional regimes. According to Klingbiel (1984:9.16) the main effect of an increase in fatness is that of a decrease in the proportion of moisture, protein and ash content. According to Owen, et al (1978:61) the intermuscular and subcutaneous fat of sheep carcases showed a tendency to increase with increasing age, while the intramuscular fat content of individual muscles of the goat carcases tend to increase gradually with age.

Although such clear differences were found between the various parameters, it may be interesting to the reader to note that Jeremiah, et al (1971:43) apparently found no significant differences for the palatability attributes among cuts from carcases differing in fatness. They therefore question the validity of the USDA yield grading system.

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Summary

In Figures 59 and 60 schematic presentations of the juiciness and cooking related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are supplied. The flavour and tenderness related characteristics of the *Mm. longissimus thoracis et lumborum* and the *M. semimembranosus* cuts are schematically presented in Figure 61 and 62.

Résumé

The influence of species, age and fat code on 20 variables of *Mm. longissimus thoracis et lumborum* was tested. The influence of species, age and fat code on 18 variables of *M. semimembranosus* was tested.

Due to species, ten of these variables differed significantly ($p \leq 0,01$) in the *Mm. longissimus thoracis et lumborum* cuts and ten in the *M. semimembranosus* cuts, seven at the 99 % level of significance. Aroma, flavour and tenderness related attributes were affected the most. Juiciness was affected to a lesser extent.

Considering the influence of age, ten of these variables differed significantly for the *Mm. longissimus thoracis et lumborum* cuts, three at the 95 % level and seven at the 99 % level of significance. Thirteen variables in the case of the *M. semimembranosus* cuts differed significantly. One at the 95 % level and twelve at the 99 % level of significance. Variation was particularly noticeable in cooking losses and flavour, as well as juiciness and tenderness related attributes, and proximate analyses.

Considering the influence of fat code, eleven of these effects differed significantly for the *Mm. longissimus thoracis et lumborum* cuts. Three at the 95 % level and eight at the 99 % level of significance. Nine variables in the case of the *M. semimembranosus* cuts differed significantly. Two at the 95 % level and seven at the 99 % level of significance. Variation was particularly noticeable in cooking losses and flavour, as well as some of the juiciness and tenderness related attributes, as well as some of the proximate

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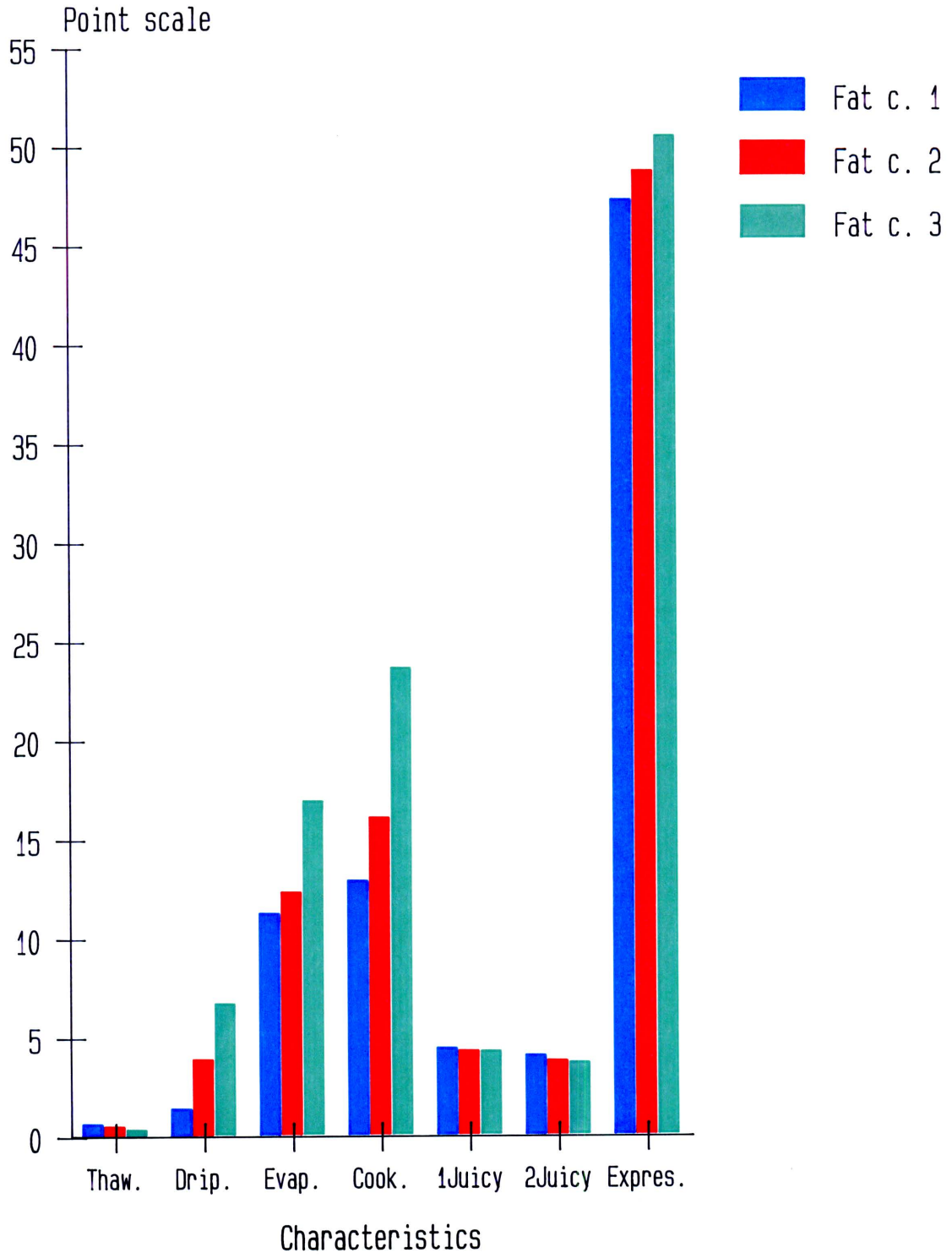

FIGURE 59: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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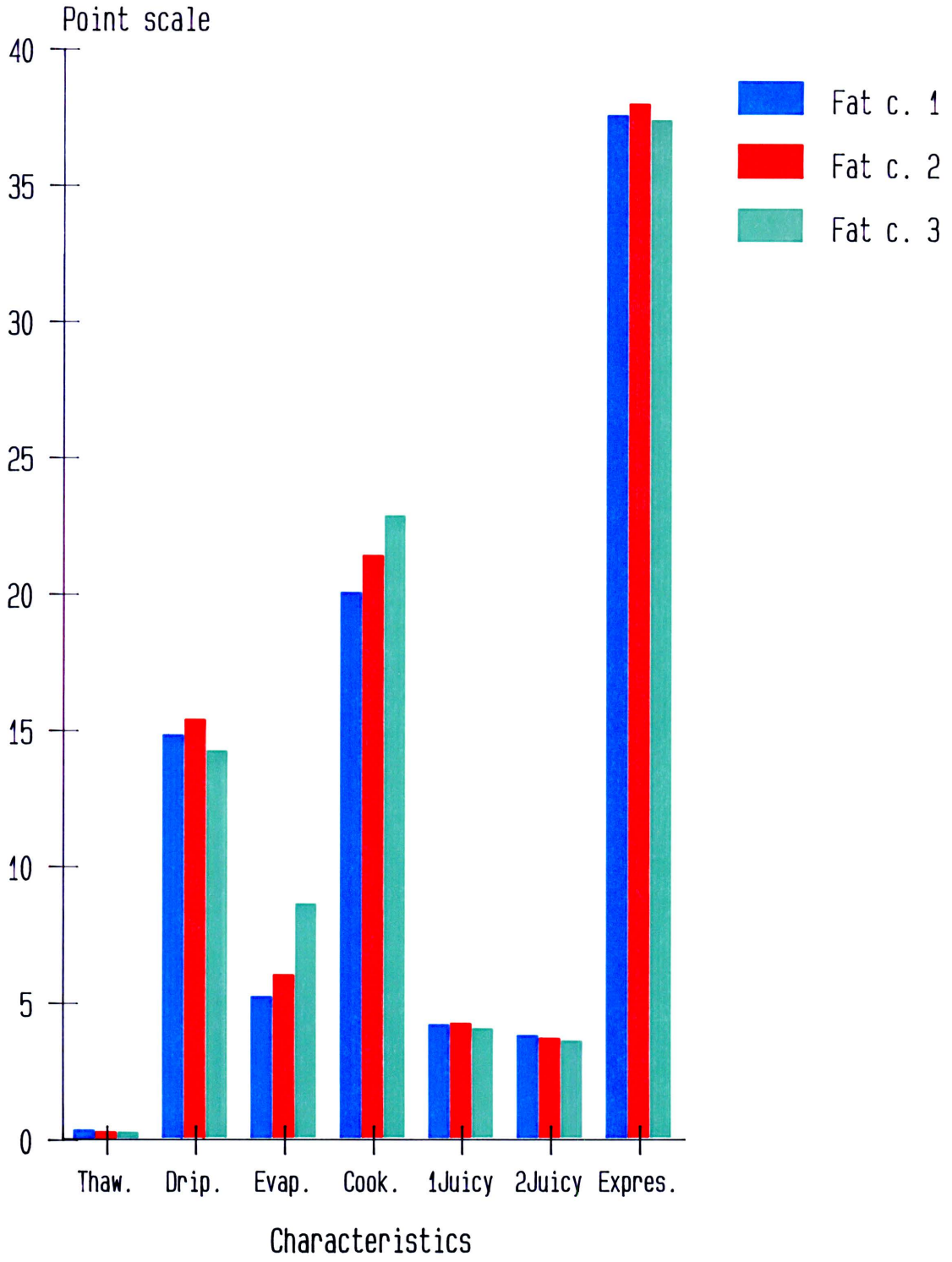

FIGURE 60: SCHEMATIC DIAGRAM OF JUICINESS AND COOKING RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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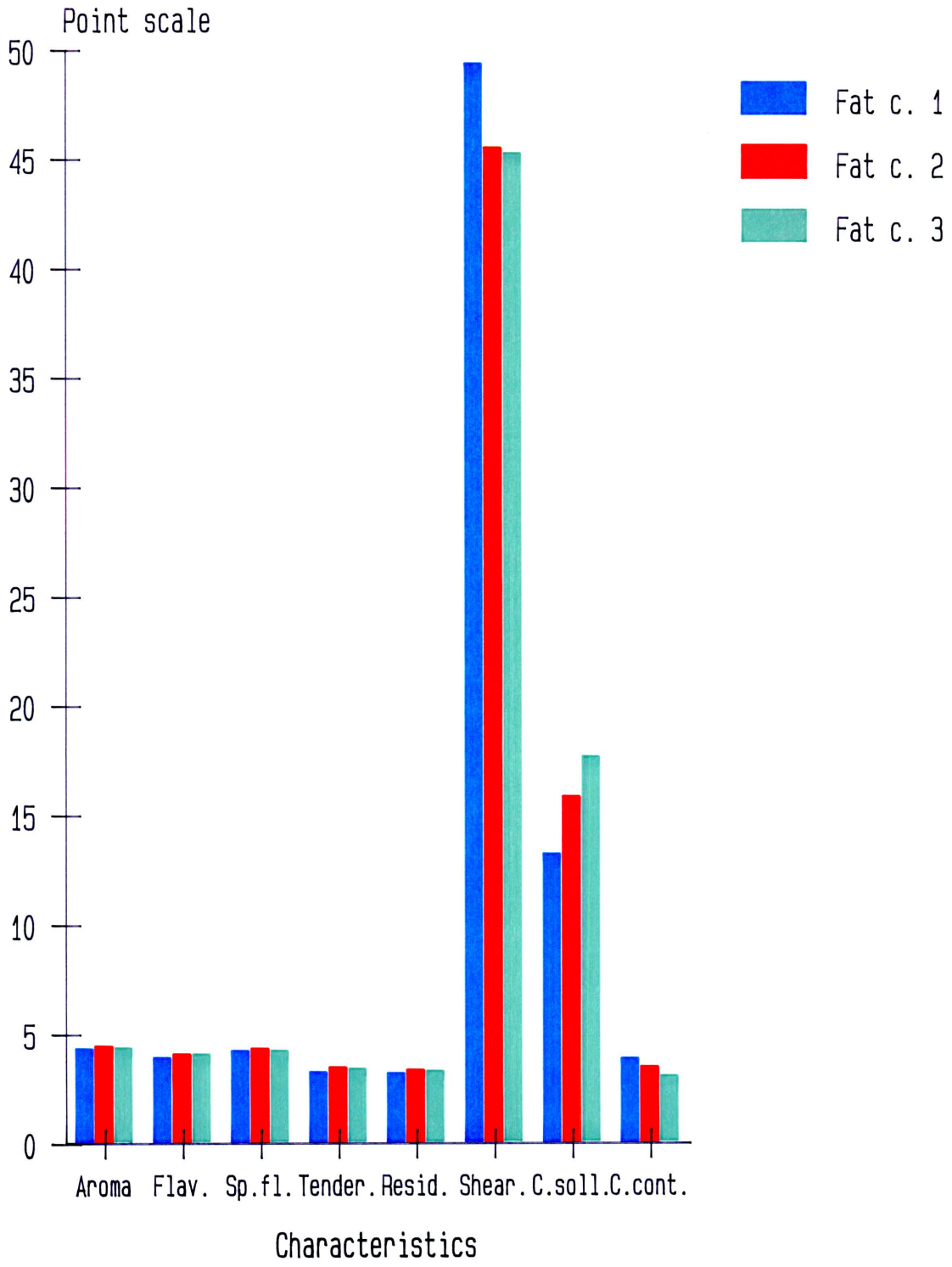

FIGURE 61: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *Mm. longissimus thoracis et lumborum* CUTS

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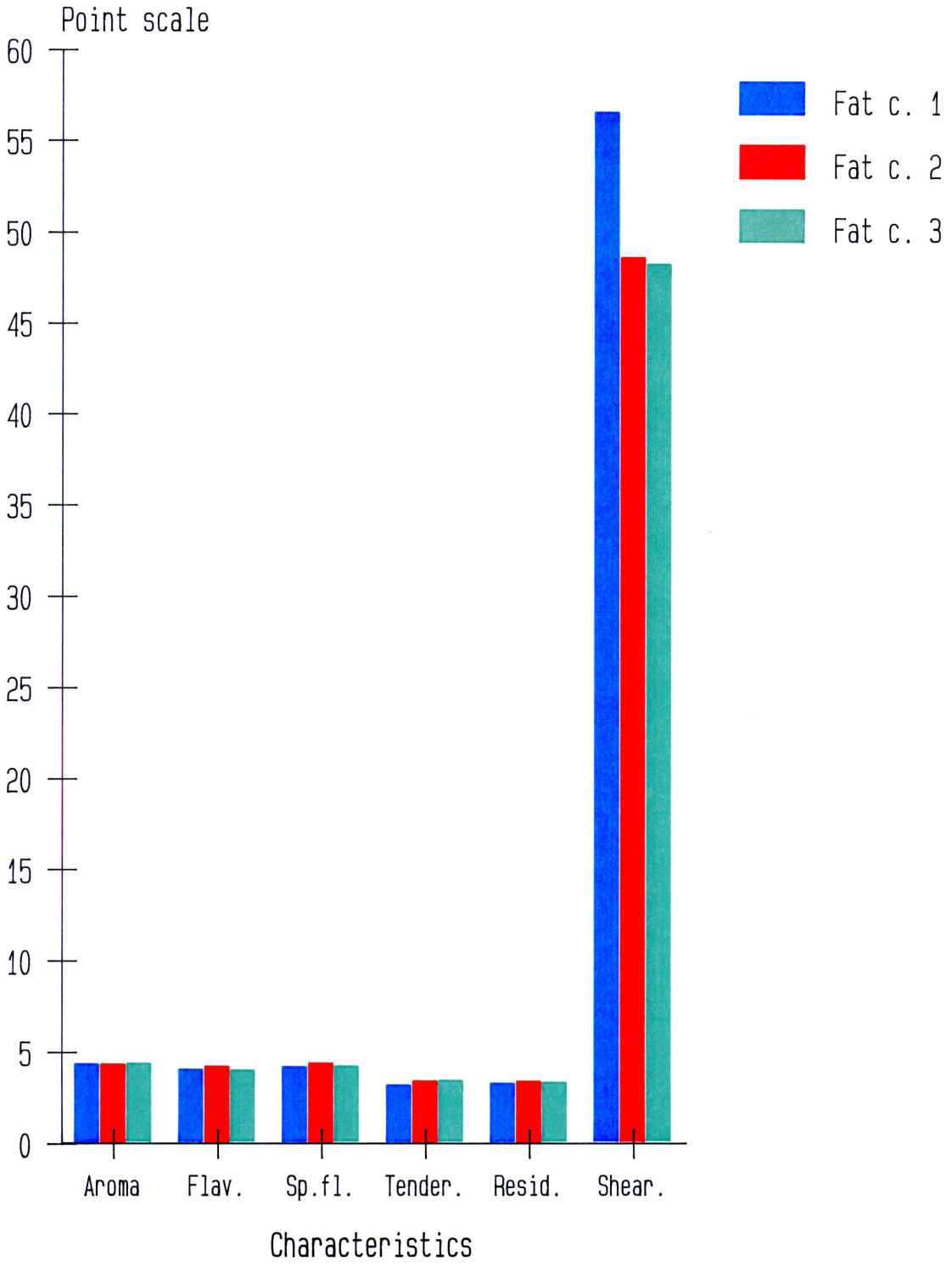

FIGURE 62: SCHEMATIC DIAGRAM OF FLAVOUR AND TENDERNESS RELATED CHARACTERISTICS OF THE *M. semimembranosus* CUTS

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analyses.

The species versus age, species versus fat code and age versus fat code two-factor interactions with 20 variables for the *Mm. longissimus thoracis et lumborum* were tested. The species versus age, species versus fat code and age versus fat code two-factor interactions with 18 variables for the *M. semimembranosus* were tested. Due to the species versus age interaction, four of these variables were significantly affected in the case of the *Mm. longissimus thoracis et lumborum* cuts. One at the 95 % level and three at the 99 % level of significance. Four variables in the case of the *M. semimembranosus* cuts differed significantly at the 95 % level of significance. Variation was particularly noticeable in the tenderness and residue of the cuts.

Due to the species versus fat code interaction, three of these effects were significantly affected in the case of the *Mm. longissimus thoracis et lumborum* cuts. Two at the 95 % level and one at the 99 % level of significance. Six variables in the case of the *M. semimembranosus* cuts differed. Three at the 95 % level and three at the 99 % level of significance. Variation was particularly noticeable in the tenderness, residue and drip loss of the cuts.

Due to the age versus fat code interaction, eight of these effects were significantly affected in the case of the *Mm. longissimus thoracis et lumborum* cuts. One at the 95 % level and seven at the 99 % level of significance. Four variables in the case of the *M. semimembranosus* cuts differed significantly ($p \leq 0,01$). Variation was particularly noticeable in drip loss, flavour, juiciness related attributes, collagen solubility, fat and dry matter content.

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CHAPTER 7

REVIEW OF THE STUDY AND RECOMMENDATIONS

Introduction

The ability of goats to survive and even reproduce under adverse environmental conditions was possibly one of the reasons why goats were among the first domestic animals kept by man for the production of meat, milk, skins and fibre (Gall, 1981:1). According to Salmon (1987:17) more people in the world eat goat meat than any other meat.

On a worldwide scale, economic and health pressures have obligated livestock producers to produce leaner products (Breidenstein, 1987:43). Baker (1987:16) reports a global increase in the production of meat goats on a commercial scale. Goats have leaner carcases than sheep and a particularly low subcutaneous fat content. The large fat deposit in the abdominal region may be removed when the carcase is dressed.

According to Naudé and Hofmeyr (1981:305), both kid and goat meat is quite acceptable to the consumer and, in certain cases, may even replace mutton, lamb or beef. It was pointed out, however, that sensory panels found goat meat less tender than either lamb or mutton. Results from a comparative study of carcasses obtained from kids and lambs of similar ages of up to 18 months, did not indicate a markedly lower collagen solubility in kids when compared to certain breeds of lamb (Heinze, et al, 1986:170). They indicated that the collagen content of Boer goat muscles was similar to that of the Pedi and Merino sheep muscles. However, collagen solubility and total collagen content may only account for part of the variation found in tenderness. Little scientific information about goat meat is available, yet it may become an important source of good quality animal protein in the future.

The similarity between the solubility of muscle collagen of Boer goats and certain sheep breeds was discussed at a National Sheep Committee Meeting on 23 March 1983 and this led to a request by the Meat Board, for a comparative study of the eating quality characteristics, to be done at the Animal and Dairy Science Research Institute (ADSRI) on sheep and goat meat. The National

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Small Stock Executive of the Red Meat Producers Organization also requested that the ADSRI re-evaluate the validity of a different grading and roller marking system for goat carcases as compared to that for sheep carcases, to aptly reflect possible differences in meat quality characteristics of goat and sheep carcases. An orange marking ink is used for the roller marking of goat carcases. Consumers are said to be confused by the orange colour of roller marks identifying the goat meat grades, because they only associate the colour purple with the optimal grades of good quality meat. Goat farmers feel their product is being discriminated against even though it is included in the current official grading system.

A further request was to investigate the possible differences between the meat of Boer and Angora goat breeds. A grading system, however, must relate to eating quality (palatability) as well as carcase quality. In order to comply with this requirement, the meat as well as carcase characteristics of goats should first of all be determined and described accurately.

Purpose of the study

The purpose of this study was, therefore, to ascertain how the quality characteristics of two species of goat meat compare with those of sheep meat. To this end the following goals were formulated: firstly, to determine how the quality characteristics of the *Mm. longissimus thoracis et lumborum* of the various grades of Angora and Boer goat meat, prepared according to a dry heat cooking method, compare with those of the identically prepared *Mm. longissimus thoracis et lumborum* of the corresponding grades of sheep meat; and, secondly, to ascertain how the quality characteristics of the *M. semimembranosus* of the various grades of Angora and Boer goat meat, prepared according to a moist heat cooking method, compare with those of the identically prepared *M. semimembranosus* of the comparable grades of sheep meat.

Materials and method

The basic experimental design incorporated 27 carcases of each of the following breeds: Angora goats, Boer goats and sheep. Three age groups consisting of three fat classes (nine in total) were compared. The specific fat code as well as the ranges for the cold mass of the carcases were

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specified. Three replications within the nine groups were performed (9 classes x 3 species x 3 replications - 81 carcases). Castrates and ewes were used to exclude the possible negative hormonal effect of intact or entire rams on flavour.

The Angora and Boer goat carcases were procured according to standardized specifications, by the Meat Board representatives at the Port Elizabeth and Cato Ridge abattoirs. All carcases were electrically stimulated to prevent toughening caused by rapid chilling, hence cold-shortening, then aged for seven days at between 1 and 7 °C, then finally wrapped in stockinette and plastic bags, labeled and stored at -20 °C until transportation in frozen state to the ADSRI, Irene. At Irene the carcases were repacked in thick plastic bags in order to exclude as much air as possible and stored at -20 °C until subdivision (still in the frozen state), coding and vacuum packaging. "Bone guard" was used to prevent damage to packaging material and consequent loss of vacuum. All the carcases were subdivided into seven wholesale cuts (Bruwer, 1984:89).

The required sheep carcases procured from City Deep in Johannesburg or Chamdor in Krugersdorp, were also electrically stimulated. They were then transported by road to the ADSRI at Irene in a refrigerated truck, where they were aged for seven days at 1 to 7 °C, labelled, unwrapped and stored at -20 °C until all the carcases had been obtained. Consequently these samples were subdivided, packaged and stored exactly as the goat carcases were treated.

A preliminary study was executed to refine, standardize and evaluate all the techniques and equipment used in the final study.

The final study consisted of two phases. Phase one was the evaluation of the *Mm. longissimus thoracis et lumborum* cuts cooked according to a dry cooking method (The cuts were roasted uncovered on an oven pan at 160 °C to an internal temperature of 75 °C). Phase two consisted of the evaluation of the *M. semimembranosus* cuts cooked by a moist heat cooking method (The cuts were placed in individual cooking bags, closed with a string and cooked in an oven at 160 °C, to an internal temperature of 75 °C).

A set of three samples representing the three species within a single age and fat code group was cooked and evaluated together. This procedure was repeated

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three times. The same approach was followed for every age and fat code combination for the various species.

The following measurements were made during the study:

Total cooking losses

All the *Mm. longissimus thoracis et lumborum* and *M. semimembranosus* cuts were weighed (using a Mettler PE 16 electronic balance) pre- and post-thawing as well as after roasting or braising respectively, for the determination of the moisture loss during the cooking process. Percentage thawing, drip, evaporation and total cooking losses were calculated.

Sensory evaluation

Aroma intensity, initial impression of juiciness, sustained juiciness, tenderness, residue, flavour and characteristic species flavour were evaluated for each sample. A six point Likert-type measuring scale was used; one denoting the least favourable condition and six the most favourable. Sensory evaluation was carried out by a trained ten-member sensory panel of the Meat Science Centre of the ADSRI.

Tenderness determination

Tenderness was measured as the maximum force required to shear a 12,5 mm diameter cylindrical core of cooked meat perpendicular to the grain. The shear force was generated with a Warner Bratzler shear attachment and recorded using an Instron Universal Testing Machine Model 1140. The higher the reading obtained, the greater the shear force required hence the tougher the meat.

Press fluid

A direct indication of the water holding capacity of the cooked meat was obtained from the amount of expressible moisture measured as a percentage of the initial unpressed mass of sample subjected to a compressive force of 1 metric ton for 60 sec using a Carver Model C laboratory Press. A quadruplicate test was performed on each sample using a Mettler AE 160

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electronic balance to weigh the aluminium foil and sample. Whatman no 4 filter paper was used to absorb all expressed moisture.

Biochemical analysis

The total collagen content and hydroxyproline of the *M. longissimus thoracis* was determined, as well as the solubility of the collagen. Collagen solubility was expressed as the percentage hydroxyproline in the filtrate as compared to total amount of hydroxyproline (filtrate plus residue).

Statistical analysis

Three way analysis of variance with species, age and fat code as the main effects on variation, was performed on every one of the dependent variables. This test included analysis of interactions between each factor of the three way analysis of variance. If the main effects or the two-factor interactions were significant on a 5 % level, the variable was analyzed further at the 1 % significance level. The three way analysis of variance procedure analyzes the effect of the three factors namely species, age and fat code on each response variable. The intervals for factor means for the main effects and the two factor interactions were then plotted. A correlation matrix was constructed to test for the correlations between different variables.

Results and discussion

Both phases will be considered concurrently for a balanced appraisal. Note that the *Mm. longissimus thoracis et lumborum* cuts were cooked according to a dry heat and the *M. semimembranosus* cuts according to a moist heat cooking method.

The effect of species

Cooking yield was affected by the subcutaneous fat content of the various species. Sheep meat showed significantly greater drip loss than goat meat and more evaporation loss than Angora goat meat. On the other hand, sheep and Boer goat meat had greater total cooking losses than Angora meat. The relationship between cooking yield and fat was also found by Ockerman, et al

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(1982:1371). Higher thawing losses were reported for Angora goats in comparison to Boer goat cuts.

There were significant differences in the palatability attributes of the three species. The aroma of the sheep meat was more intense, it was more juicy, more tender, contained less tissue residue, the flavour was more acceptable and the species flavour more typical than that of the Angora and Boer goat meat. The Angora meat was more juicy, more tender and contained less connective tissue residue than the Boer goat cuts. This was confirmed by the shear force resistance measurements. Sheep meat also showed less resistance to shear force than Angora meat, which in turn showed less resistance than Boer goat meat. Goat meat also contained more collagen and the collagen was less soluble than that of sheep meat.

This is similar to the results of Pike, et al (1973:269) who described lamb leg chops as more flavourful, juicy, tender and satisfactory overall than chops from goat legs.

The effect of age

Cooking losses of cuts were affected by the age of the animal. Drip loss increased significantly with increased age. Evaporation and total cooking losses also showed a tendency to increase with age. This was particularly noticeable in the *M. semimembranosus* cuts.

The meat of animals of the A age group was more juicy, more tender, contained less tissue residue, the flavour was more acceptable and the species flavour more typical than that of the B and C age groups. This was confirmed by the expressible moisture and shear force resistance measurements. Meat of animals of the A age group showed more expressible moisture than meat from the B and C age groups. Meat from animals of the A age group also showed less resistance to shear force than those of the B and C age groups.

The study confirms the fact that, during growth and development, significant changes occur in the composition of the body of the animal which have a direct effect on the palatability attributes of the end-product as evaluated by the final consumer. This is in agreement with results from a study performed by Forrest, et al (1975:291). They describe growth and development

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in the animal after the age of 30 months as a gradual toughening process of the muscle.

In this study a significant decrease in collagen solubility was found with increased age. These results can be ascribed to the age associated increase in the number of cross links between collagen fibrils thus reducing solubility and increasing resistance to shearing and chewing.

The protein and dry matter content of the cooked cuts increased, while the moisture and ash content decreased with increased age. These results are similar to those of Gonzales, et al (1983:305), although they reported an increase in fat and decrease in protein content.

The effect of fat code

Cooking yields were closely related to the fat code measurements of the various carcases. Higher drip, evaporation and total cooking losses were reported when carcases had increased fat content. Carpenter and King (1965:103) also reported higher cooking losses with increased marbling or fat content.

With increased fatness, significant differences in the palatability attributes of the cuts studied were found. With increased fatness, the juiciness of the cooked cuts tended to decrease and the tenderness and species flavour to increase. The expressible moisture content of the meat increased with the fatness of the animal. The collagen solubility tended to increase and content to decrease with increased fatness. The decrease in collagen content is probably due to the increase of muscle fibre volume relative to muscle connective tissue during the growth of the animal, and not directly by a decline in the absolute content of collagen.

A decrease in the resistance to shear force with increased fatness was found. This too may be attributed to the increased muscle volume relative to the structural component. However, the mechanism of toughening is not yet understood.

With increasing level of fatness, the cuts contained less moisture, more fat and increased amounts of dry matter. Gonzales, et al (1983:308) also reported this inverse relationship between fat and moisture content.

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Conclusions

The data of the present study confirms that goat meat is unique and is not interchangeable with meat from sheep (of the same approximate maturity and fatness levels) with regard to palatability attributes. The study shows that significant differences exist between the quality characteristics of sheep on the one hand, and Angora and Boer goat meat on the other. The sheep meat was juicier, more tender, contained less connective tissue residue, had a more intense aroma and the species aroma is more typical than that of either the Angora or Boer goat meat. In general, the meat of goat carcases was found to be significantly less acceptable than that of sheep carcases, the Angora to a lesser extent, however, than the Boer goat.

The study confirms the fact that the meat of younger animals (irrespective of species) is juicier, more tender, contains less connective tissue residue and the species aroma is less typical than that of older animals, contains collagen with higher solubility resulting in lower shear force values of cooked meat.

Significant differences in the palatability attributes with an increase in the fat thickness of the animals were found. With increased fatness, the juiciness of the cooked cuts tended to decrease and the tenderness, species flavour and solubility of collagen to increase.

Recommendations

This study showed very clearly that although both kid and goat meat are acceptable to the consumer, they are clearly distinguishable from lamb or mutton from a eating quality point of view. Although goat meat may become an important source of good quality animal protein in the future, it will have to be appreciated by the consumer for its own specific characteristics.

Due to the differences in the meat quality characteristics, it is therefore a valid practice to differentiate between goat and sheep carcases, with regard to the current official grading system of South Africa, by using different colours of marking ink for the roller marking of sheep and goat carcases and using the words goat and kid in the roller mark.

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The present study also identified significant differences between the meat of Boer and Angora goat carcases. Angora meat was found to be less acceptable, to a lesser extent however than the Boer goat, when compared to sheep meat. This may imply orientation in the marketing of these breeds of goat meat.

In conclusion it may be significant to note that although the *Mm. longissimus thoracis et lumborum* cooked according to a dry cooking method is recognized worldwide as the determinant of carcase eating quality, the *M. semimembranosus* may be an even more accurate parameter. For the prediction of specific carcase attributes, the *M. semimembranosus* cuts cooked according to a moist heat cooking method showed, during this study, clearer differences between the various attributes tested. Whether it can be attributed to the specific muscle or the moist heat cooking method, is not clear. Future research on this specific topic is needed.

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APPENDIX A: SCORE CARD

Name: ..... Session: ..... Date: ..... Time: .....
Any health comments? .....

CHARACTERISTICS	SCORE	SAMPLE NUMBERS		
		748	606	917
1. AROMA INTENSITY Take a few short sniffs as soon as you remove the foil	6 Extremely intense			
	5 Intense			
	4 Slightly intense			
	3 Slightly bland			
	4 Bland			
	5 Extremely bland			
2.1 INITIAL IMPRESSION OF JUICINESS It is the amount of fluid excreted on the cut surface when pressed	6 Extremely juicy			
	5 Juicy			
	4 Slightly juicy			
	3 Slightly dry			
	2 Dry			
	1 Extremely dry			
2.2 SUSTAINED JUICINESS It is the impression that you form as you start chewing	6 Extremely juicy			
	5 Juicy			
	4 Slightly juicy			
	3 Slightly dry			
	2 Dry			
	1 Extremely dry			
3. TENDERNESS Chew sample with a light chew action	6 Extremely tender			
	5 Tender			
	4 Slightly tender			
	3 Slightly tough			
	2 Tough			
	1 Extremely tough			
4. RESIDUE This is the chewiness of the meat	6 None			
	5 Practically none			
	4 Slight			
	3 Moderate			
	2 Slightly abundant			
	1 Abundant			
5.1 FLAVOUR This is a combination of taste while chewing and swallowing	6 Excellent			
	5 Good			
	4 Acceptable			
	3 Fair			
	2 Very poor			
	1 Unacceptable			
5.2 SPECIES FLAVOUR How typical is the flavour during the process of smelling, chewing and swallowing	IDENTIFY			
	6 Extremely typical			
	5 Typical			
	4 Slightly typical			
	3 Neutral			
	2 Slightly A-typical			
	1 Extremely A-typical			

GENERAL COMMENTS .....
.....

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APPENDIX B: GENERAL INFORMATION ABOUT THE EXPERIMENTAL MATERIAL

B.1 Sheep

Cerial number	Carcase number	Abattoir of slaughter	Age (teeth)	Date of slaughter	Fat Code	Cold Mass (kg)	Area of origin
1	SSL1	C.D. Jhb	0	01/7/85	3	22	Christiana
2	SSL2	C.D. Jhb	0	01/7/85	3	22	Christiana
3	SSL3	C.D. Jhb	0	01/7/85	3	22	Christiana
4	SL11	C.D. Jhb	0	28/6/85	2	15	Migdol
5	SL12	C.D. Jhb	0	28/6/85	2	16	Migdol
6	SL13	C.D. Jhb	0	01/7/85	2	16	Christiana
7	SL31	C.D. Jhb	0	28/6/85	1	13	Hopetown
8	SL32	C.D. Jhb	0	28/6/85	1	13	Migdol
9	SL33	C.D. Jhb	0	28/6/85	1	12	Upington
10	SPB1	C.D. Jhb	6	01/7/85	3	21	Christiana
11	SPB2	C.D. Jhb	6	01/7/85	3	21	Christiana
12	SPB3	C.D. Jhb	6	01/7/85	3	21	Christiana
13	SB11	C.D. Jhb	6	01/7/85	2	14	Christiana
14	SB12	C.D. Jhb	6	28/6/85	2	15	Migdol
15	SB13	C.D. Jhb	6	28/6/85	2	15	Migdol
16	SB31	C.D. Jhb	2	10/3/87	1	19	Williston
17	SB32	C.D. Jhb	6	10/3/87	1	17	Kroonstad
18	SB33	C.D. Jhb	4	26/8/86	1	14	Olifantshoek
19	STCI	C.D. Jhb	8	01/7/85	3	22	Carnarvan
20	STC2	C.D. Jhb	8	09/3/87	3	25	Olifantshoek
21	STC3	C.D. Jhb	8	09/3/87	3	20	Olifantshoek
22	SC11	C.D. Jhb	8	26/6/85	2	16	Migdol
23	SC12	C.D. Jhb	8	28/6/85	2	16	Migdol
24	SC13	C.D. Jhb	8	28/6/85	2	16	Migdol
25	SC31	C.D. Jhb	8	26/8/86	1	13	Upington
26	SC32	C.D. Jhb	8	26/8/86	1	13	Upington
27	SC33	C.D. Jhb	8	28/6/86	1	16	Heidelberg

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B.2 Angora goats

Cerial number	Carcase number	Abattoir of slaughter	Age (teeth)	Date of slaughter	Fat Code	Cold Mass (kg)	Area of origin
1	ABLS1	P.E.	0	28/6/85	3	13	Middelburg CP
2	ABLS2	P.E.	0	28/6/85	3	13	Middelburg CP
3	ABLS3	P.E.	0	28/6/85	3	14	Middelburg CP
4	ABL11	P.E.	0	28/6/85	2	14	Middelburg CP
5	ABL12	P.E.	0	28/6/85	2	13	Middelburg CP
6	ABL13	P.E.	0	28/6/85	2	13	Middelburg CP
7	ABL31	P.E.	0	28/6/85	1	8	Middelburg CP
8	ABL32	P.E.	0	28/6/85	1	10	Middelburg CP
9	ABL33	P.E.	0	28/6/85	1	8	Middelburg CP
10	ABPB1	CATO R.	6	26/1/87	3	17	Lady Brand
11	ABPB2	CATO R.	6	26/1/87	3	23	Colesberg
12	ABPB3	CATO R.	6	26/1/87	3	24	Colesberg
13	ABB11	CATO R.	6	20/1/87	2	12	Marquard
14	ABB12	CATO R.	6	20/1/87	2	12	Marquard
15	ABB13	CATO R.	6	22/1/87	2	14	Dealsville
16	ABB31	P.E.	2	8/10/85	1	13	Kammadga
17	ABB32	P.E.	6	8/10/85	1	13	Kammadga
18	ABB33	P.E.	4	8/10/85	1	15	Kammadga
19	ABTC1	P.E.	8	28/6/85	3	20	Middelburg CP
20	ABTC2	P.E.	8	28/6/85	3	20	Middelburg CP
21	ABTC3	P.E.	8	28/6/85	3	18	Middelburg CP
22	ABC11	P.E.	8	28/6/85	2	15	Middelburg CP
23	ABC12	P.E.	8	28/6/85	2	18	Middelburg CP
24	ABC13	P.E.	8	28/6/85	2	14	Middelburg CP
25	ABC31	P.E.	8	28/6/85	1	12	Middelburg CP
26	ABC32	P.E.	8	28/6/85	1	12	Middelburg CP
27	ABC33	P.E.	8	28/6/85	1	13	Middelburg CP

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B.3 Boer goats

Cerial number	Carcase number	Abattoir of slaughter	Age (teeth)	Date of slaughter	Fat Code	Cold Mass (kg)	Area of origin
1	BBLS1	CATO R.	0	23/1/87	3	18	Aliwal N.
2	BBLS2	CATO R.	0	23/1/87	3	21	Aliwal N.
3	BBLS3	CATO R.	0	23/1/87	3	16	Aliwal N.
4	BBL11	CATO R.	0	22/1/87	2	14	Britstown
5	BBL12	CATO R.	0	22/1/87	2	19	Britstown
6	BBL13	CATO R.	0	29/1/87	2	18	Vic. West.
7	BBL31	CATO R.	0	22/1/87	1	11	Upington
8	BBL32	CATO R.	0	22/1/87	1	9	Upington
9	BBL33	CATO R.	0	22/1/87	1	6	Upington
10	BPB1	P.E.	6	26/6/85	3	22	Grahamstad
11	BPB2	P.E.	6	26/6/85	3	22	Grahamstad
12	BPB3	P.E.	6	26/6/85	3	23	Grahamstad
13	BBB11	P.E.	6	26/6/85	2	22	Grahamstad
14	BBB12	P.E.	6	26/6/85	2	19	Grahamstad
15	BBB13	P.E.	6	26/6/85	2	20	Grahamstad
16	BBB31	CATO R.	2	22/1/87	1	16	Upington
17	BBB32	CATO R.	6	22/1/87	1	14	Upington
18	BBB33	CATO R.	4	22/1/87	1	18	Upington
19	BBTC1	CATO R.	8	26/1/87	3	26	Colesberg
20	BBTC2	CATO R.	8	26/1/87	3	25	Colesberg
21	BBTC3	CATO R.	8	26/1/87	3	28	Colesberg
22	BBC11	CATO R.	8	22/1/87	2	19	Upington
23	BBC12	CATO R.	8	22/1/87	2	16	Britstown
24	BBC13	CATO R.	8	22/1/87	2	26	Britstown
25	BBC31	CATO R.	8	22/1/87	1	17	Upington
26	BBC32	CATO R.	8	22/1/87	1	16	Upington
27	BBC33	CATO R.	8	22/1/87	1	15	Upington

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APPENDIX C: COOKING DATA FORMS

C.1 Cooking data form - Phase 1

TASTE PANEL LEADER:			
Project:		Project leader:	
Slaughter date:		Sample code:	
Panel date:		Panel code:	
* THAWING DATA *			
* Mass raw + thawing loss + bag (g)			.....
* Mass bag + drip (g)			.....
* Mass bag without drip (g)			.....
* COOKING DATA *			
* Time in:		Cooking time (h):	
* Time out:		(calculated)	
Thermocouples			
	Number	Start	End
Oven	.....	.....	.....
Sample	.....	.....	.....
Cooking tempo (calculated):			
			Mass (g)
* Mass of pan + rack			.....
* Mass pan + rack + raw meat			.....
Mass raw meat (g) - calculated			
* Mass pan + rack + drip + cooked meat			.....
* Mass pan + rack + drip + fat			.....
Mass total drip (g) - calculated			
Mass cooked meat (g) - calculated			
* Mass pan + rack + residue drip			.....
Mass drip left in pan (g) - calculated			
CHARACTERISTICS OF DRIP REMARKS			Volume (ml)
* Drip			.....
* "Stock"			.....
Total volume of fat (ml) - calculated			
Mass of fat (g) - calculated			
% Total cooking loss (calculated)			
% Drip loss (calculated)			
% Evaporation loss (calculated)			
% Thawing loss (calculated)			

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C.2 Cooking data form - Phase 2

TASTE PANEL LEADER:	
Project: ..... Project leader:	
Slaughter date: ..... Sample code: ..... Panel date: ..... Panel code:	
* THAWING DATA *	
* Mass raw + thawing loss + bag (g) ..... * Mass bag + drip (g) ..... * Mass bag without drip (g)	....
* COOKING DATA *	
* Time in: ..... Cooking time (h): * Time out: ..... (calculated) Thermocouples Number Start End Oven .... Sample .... Cooking tempo (calculated):	
	Mass (g)
* Mass of pan + rack + bag + wire ..... * Mass pan + rack + bag + wire + raw meat ..... Mass raw meat (g) - calculated * Mass pan + rack + bag + wire + drip + cooked meat .... * Mass pan + rack + bag + wire + drip + fat ..... Mass total drip (g) - calculated Mass cooked meat (g) - calculated * Mass pan + rack + bag + wire + residue drip ..... Mass drip left in pan (g) - calculated	....
CHARACTERISTICS OF DRIP REMARKS	Volume (ml)
* Drip ..... * "Stock" ..... Total volume of fat (ml) - calculated Mass of fat (g) - calculated	....
% Total cooking loss (calculated) % Drip loss (calculated) % Evaporation loss (calculated) % Thawing loss (calculated)	

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C.3 Formulas of cooking data form - Phase 1

TASTE PANEL LEADER:			
Project:		Project leader:	
Slaughter date:		Sample code:	
Panel date:		Panel code:	
* THAWING DATA *			
* Mass raw + thawing loss + bag (g)			...A.....
* Mass bag + drip (g)			...B.....
* Mass bag without drip (g)			...C.....
* COOKING DATA *			
* Time in:	...D.....	Cooking time (h):	E - D
* Time out:	...E.....	(calculated)	
Thermocouples			
	Number	Start	End
Oven	.....	.....	.....
Sample	.....	...F....	...G....
Cooking tempo (calculated): ...(G - F) ÷ (E - D)... (min)			
			Mass (g)
* Mass of pan + rack			...H....
* Mass pan + rack + raw meat			...I....
Mass raw meat (g) - calculated			I - H
* Mass pan + rack + drip + cooked meat			...J....
* Mass pan + rack + drip + fat			...K....
Mass total drip (g) - calculated			K - H
Mass cooked meat (g) - calculated			J - K
* Mass pan + rack + residue drip			...L....
Mass drip left in pan (g) - calculated			L - H
CHARACTERISTICS OF DRIP REMARKS			Volume (ml)
* Drip			...M.....
* "Stock"			...N.....
Total volume of fat (ml) - calculated			M - N
Mass of fat (g) - calculated			(M - N)x0,9
% Total cooking loss (calculated)			(I-H) - (J-K) ÷ (I-H) x 100 = O
% Drip loss (calculated)			(K-H) ÷ (I-H) x 100 = P
% Evaporation loss (calculated)			O - P
% Thawing loss (calculated)			(B-C) ÷ Mass of meat before freezing x 100

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C.4 Formulas of cooking data form - Phase 2

TASTE PANEL LEADER:		
Project: ..... Project leader:		
Slaughter date: ..... Sample code:		
Panel date: ..... Panel code:		
* THAWING DATA *		
* Mass raw + thawing loss + bag (g)		...A.....
* Mass bag + drip (g)		...B.....
* Mass bag without drip (g)		...C.....
* COOKING DATA *		
* Time in: ...D.....	Cooking time (h):	E - D
* Time out: ...E.....	(calculated)	
Thermocouples		
	Number Start End	
Oven		
Sample ....F.... ...G....		
Cooking tempo (calculated): ...(G - F) ÷ (E - D)... (min)		
		Mass (g)
* Mass of pan + rack		...H....
* Mass pan + rack + bag + wire + raw meat		...I....
Mass raw meat (g) - calculated		I - H
* Mass pan + rack + bag + wire + drip + cooked meat		...J....
* Mass pan + rack + bag + wire + drip + fat		...K....
Mass total drip (g) - calculated		K - H
Mass cooked meat (g) - calculated		J - K
* Mass pan + rack + bag + wire + residue drip		...L....
Mass drip left in pan (g) - calculated		L - H
CHARACTERISTICS OF DRIP REMARKS		Volume (ml)
* Drip		...M.....
* "Stock"		...N.....
Total volume of fat (ml) - calculated		M - N
Mass of fat (g) - calculated		(M - N)x0,9
% Total cooking loss (calculated)		(I-H) - (J-K) ÷ (I-H) x 100 = O
% Drip loss (calculated)		(K-H) ÷ (I-H) x 100 = P
% Evaporation loss (calculated)		O - P
% Thawing loss (calculated)		(B-C) ÷ Mass of meat before freezing x 100

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C.5 Press fluid and shear force form

PRESS FLUID (Indication of water-holding capacity)

S.E. Code: ..... Date: ..... Time: .....

Mass of foil (g)	Mass of foil and sample before press	Mass of foil and sample after press	% Expressible moisture
1) 0,.....	0,.....	0,.....	Calculated
2) 0,.....	0,.....	0,.....	Calculated
3) 0,.....	0,.....	0,.....	Calculated
4) 0,.....	0,.....	0,.....	Calculated

Average % of moisture loss: ..... (Calculated)

SHEAR FORCE RESISTANCE (Indication of tenderness)

Core Diameter: 13 mm Internal temp (sample): 25°C

Setting	Reading	Force(N)
5	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
10	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
20	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated
	.....	Calculated

Average force (N): ..... (Calculated)

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APPENDIX D: CORRELATION MATRIX

D.1: Correlation analysis of thawing and cooking related measurements of *Mm. longissimus thoracis et lumborum* cuts (n = 81)

	Species	Age	Fat code	Drip loss	Evapora-tion loss	Total cooking loss	Thawing loss
Species	1,0000[a] 100,0000[b] 0,0000[c]						
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000					
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000				
Drip loss	-0,2637 6,9500 0,0174	0,2366 5,6000 0,0335	0,6778* 45,9400 0,0000	1,0000 100,0000 0,0000			
Evapora-tion loss	-0,0463 0,2100 0,6813	-0,0850 0,7200 0,4506	0,2940 8,6400 0,0077	0,2633 6,9300 0,0175	1,0000 100,0000 0,0000		
Total cooking loss	-0,1380 1,9000 0,2191	0,1457 2,1200 0,1944	0,4759* 22,6500 0,0000	0,5645* 31,8700 0,0000	0,9428* 88,8900 0,0000	1,0000 100,0000 0,0000	
Thawing loss	-0,2024 4,1000 0,0700	-0,1997 3,9900 0,0739	-0,1263 1,6000 0,2611	-0,1031 1,0600 0,3595	0,1009 1,0200 0,3701	0,890 0,7900 0,4295	1,0000 100,0000 0,0000

[a] = 1,0000 = r = correlation coefficient
[b] = 100,0000 = R^2 = coefficient of determination (expressed as a %)
[c] = 0,0000 = p = significance level
* Significant correlation

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D.2: Correlation analysis of thawing and cooking related measurements of *M. semimembranosus* cuts (n = 81)

	Species	Age	Fat code	Drip loss	Evapora-tion loss	Total cooking loss	Thawing loss
Species	1,0000 100,0000 0,0000						
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000					
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000				
Drip loss	0,1039 1,0800 0,3561	0,3257 10,6100 0,0030	-0,0666 0,4400 0,5547	1,0000 100,0000 0,0000			
Evapora-tion loss	-0,1030 1,0600 0,3603	0,3327 11,0700 0,0024	0,4162 17,3200 0,0001	-0,2153 4,6400 0,0536	1,0000 100,0000 0,0000		
Total cooking loss	0,0072 0,0052 0,9491	0,5246* 27,5200 0,0000	0,2632 6,9300 0,0176	0,6645* 44,1600 0,0000	0,5867* 34,4200 0,0000	1,0000 100,0000 0,0000	
Thawing loss	-0,1299 1,6900 0,2479	-0,0947 0,9000 0,4004	-0,0911 0,8300 0,4185	0,0197 0,0900 0,8615	-0,0494 0,2400 0,6615	-0,0216 0,0500 0,8483	1,0000 100,0000 0,0000

* Significant correlation

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D.3: Correlation analysis of the sensory evaluation of aroma, species flavour and flavour of the *Mm. longissimus thoracis et lumborum cuts* (n = 81)

	Species	Age	Fat code	Aroma	Species flavour	Flavour
Species	1,0000					
	100,0000					
	0,0000					
Age	0,0000	1,0000				
	0,0000	100,0000				
	1,0000	0,0000				
Fat code	0,0000	0,0000	1,0000			
	0,0000	0,0000	100,0000			
	1,0000	1,0000	0,0000			
Aroma	-0,2792	-0,1398	0,0438	1,0000		
	7,8000	1,9500	0,1900	100,0000		
	0,0116	0,2131	0,6980	0,0000		
Species flavour	-0,4407*	-0,0065	0,0130	0,4682*	1,0000	
	19,4200	0,0042	0,0169	21,9200	100,0000	
	0,0000	0,9539	0,9080	0,0000	0,0000	
Flavour	-0,3273	-0,1534	0,1221	0,1422	0,4635*	1,0000
	10,7100	2,3500	1,4900	2,0200	21,4800	100,0000
	0,0029	0,1716	0,2774	0,2054	0,0000	0,0000

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D.4: Correlation analysis of the sensory evaluation of aroma, species flavour and flavour of the *M. semimembranosus* cuts (n = 81)

	Species	Age	Fat code	Aroma	Species flavour	Flavour
Species	1,0000					
	100,0000					
	0,0000					
Age	0,0000	1,0000				
	0,0000	100,0000				
	1,0000	0,0000				
Fat code	0,0000	1,0000	1,0000			
	0,0000	0,0000	100,0000			
	1,0000	1,0000	0,0000			
Aroma	-0,1786	0,0087	0,0523	1,0000		
	3,1900	0,0080	0,2700	100,0000		
	0,1107	0,9385	0,6431	0,0000		
Species flavour	-0,2164*	0,1389	0,0074	0,3035*	1,0000	
	4,6800	1,9300	0,0055	9,2100	100,0000	
	0,0523	0,2163	0,9480	0,0059	0,0000	
Flavour	-0,0908	-0,2656	-0,593	-0,542	0,3480*	1,0000
	0,8200	7,0500	0,3500	0,2900	0,1200	100,0000
	0,4199	0,0166	0,5987	0,6311	0,0015	0,0000

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D.5: Correlation analysis of the evaluation of juiciness related characteristics of the *Mm. longissimus thoracis et lumborum cuts (n = 81)*

	Species	Age	Fat code	Initial impres. of juiciness	Sustained juiciness	Moisture content	Expres. moisture	Fat content	Evaporation loss	Thawing loss
Species	1,0000 100,0000 0,0000									
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000								
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000							
Initial impression of juiciness	-0,1414 2,0000 0,2079	-0,2029 4,1200 0,6930	-0,1574 2,4800 0,1605	1,0000 100,0000 0,0000						
Sustained juiciness	-0,2653 7,0400 0,0167	-0,0987 9,8700 0,3807	-0,3061 9,3700 0,0055	0,7175* 51,4800 0,0000	1,0000 100,0000 0,0000					
Moisture content	0,1378 1,9000 0,2199	-0,2295 5,2700 0,0393	-0,4778* 22,8300 0,0000	0,2356 5,5500 0,0342	0,2922 8,5400 0,0081	1,0000 100,0000 0,0000				
Expressible moisture	-0,1899 3,6100 0,0896	-0,3344 11,1800 0,0023	0,2476 6,1300 0,0258	0,2582 6,6700 0,0199	0,1460 2,1300 0,1933	-0,0273 0,0700 0,8090	1,0000 100,0000 0,0000			
Fat content	-0,1788 3,2000 0,1103	0,0992 0,9800 0,3781	0,4780* 22,8500 0,0000	0,0638 0,4100 0,5718	-0,0468 0,2200 0,6779	-0,7225* 52,2000 0,0000	0,1512 2,2900 0,1780	1,0000 100,0000 0,0000		
Evaporation loss	-0,0463 0,2100 0,6813	0,0850 0,7200 0,4506	0,2940 8,6400 0,0077	-0,2469 6,1000 0,0263	-0,3076 9,4600 0,0052	-0,3793 14,3900 0,0005	0,1257 1,5800 0,2635	0,2294 5,2600 0,0394	1,0000 100,0000 0,0000	
Thawing loss	-0,2024 4,1000 0,0700	-0,1997 3,9900 0,0739	-0,1263 1,6000 0,2611	0,0213 0,0500 0,8504	0,0314 0,1000 0,7807	0,1199 1,4400 0,2865	0,1749 3,0600 0,1185	-0,1452 2,1100 0,1958	0,1009 1,0200 0,3701	1,0000 100,0000 0,0000

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D.6: Correlation analysis of the evaluation of juiciness related characteristics od the *M. semimembranosus* cuts (n = 81)

	Species	Age	Fat code	Initial impres. of juiciness	Sustained juiciness	Moisture content	Expres. moisture	Fat content	Evaporation loss	Thawing loss
Species	1,0000 100,0000 0,0000									
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000								
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000							
Initial impression of juiciness	-0,3493 12,2000 0,0014	-0,0838 0,7000 0,4568	-0,1677 2,8100 0,1346	1,0000 100,0000 0,0000						
Sustained juiciness	-0,4231 17,9000 0,0001	-0,1785 3,1900 0,1109	-0,1612 2,6000 0,1505	0,7902* 62,4400 0,0000	1,0000 100,0000 0,0000					
Moisture content	0,0781 0,6100 0,4885	-0,3463 11,9900 0,0015	-0,2702* 7,3000 0,0147	0,2337 5,4600 0,0357	0,0985 0,9700 0,3815	1,0000 100,0000 0,0000				
Expressible moisture	-0,2162 4,6700 0,0526	-0,0019 0,0036 0,9864	-0,0164 0,0300 0,8848	0,1789 3,2000 0,1101	0,2380 5,6700 0,0324	0,2634* 51,3200 0,0175	1,0000 100,0000 0,0000			
Fat content	-0,1061 1,1300 0,3457	-0,0600 0,3600 0,5947	0,3266* 10,6700 0,0029	-0,0407 0,1700 0,7181	0,0116 0,0100 0,9181	-0,5925* 35,1100 0,0000	-0,0256 0,0700 0,8203	1,0000 100,0000 0,0000		
Evaporation loss	-0,1030 1,0600 0,3603	0,3327 11,0700 0,0024	0,4162 17,3200 0,0001	-0,0944 0,8900 0,4019	-0,0228 0,0500 0,8397	-0,1442 2,0800 0,1989	-0,0289 0,0800 0,7976	-0,0118 0,0100 0,9171	1,0000 100,0000 0,0000	
Thawing loss	-0,1299 1,6900 0,2479	-0,0947 0,9000 0,4004	-0,0911 0,8300 0,4185	-0,1929 3,7200 0,0844	-0,0599 0,3600 0,5954	-0,0256 0,0700 0,8204	0,1494 2,2300 0,1831	0,0683 0,4700 0,5448	-0,0494 0,2400 0,6615	1,0000 100,0000 0,0000

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D.6: Correlation analysis of the evaluation of tenderness related characteristics of the *Mm. longissimus thoracis et lumborum* cuts (n = 81)

	Species	Age	Fat code	Tender-ness	Shear force resis-tance	Collagen solubi-lity	Residue	Collagen content	Protein content
Species	1,0000 100,0000 0,0000								
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000							
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000						
Tenderness	-0,7979* 63,6600 0,0000	-0,2429 5,9000 0,0289	0,0585 0,3400 0,6040	1,0000 100,0000 0,0000					
Shear force resistance	0,6089* 37,0800 0,0000	0,0354 0,1300 0,7550	-0,0809 0,6500 0,4756	-0,6333* 40,1100 0,0000	1,0000 100,0000 0,0000				
Collagen solubility	-0,1815 3,2900 0,1050	-0,7717* 59,5500 0,0000	0,3266 10,6700 0,0029	0,3538 12,5200 0,0012	-0,1589 2,5200 0,1592	1,0000 100,0000 0,0000			
Residue	-0,7820* 61,1500 0,0000	-0,1803 3,2500 0,1073	0,0380 0,1400 0,7360	0,9697* 94,0300 0,0000	-0,6747* 45,5200 0,0000	0,3092 9,5600 0,0050	1,0000 100,0000 0,0000		
Collagen content	0,2772 7,6800 0,0160	0,0228 0,0500 0,8459	-0,4162 17,3200 0,0002	-0,3108 9,6600 0,0066	0,2175 4,7300 0,0627	-0,2531 6,4100 0,0284	-0,2837 8,0500 0,0136	1,0000 100,0000 0,0000	
Protein content	0,1383 1,9100 0,2181	0,0404 0,1600 0,7206	0,0039 1,5210 0,9722	-0,2145 4,6000 0,0545	0,2416 5,8400 0,0308	-0,0883 0,7800 0,4329	-0,2735 7,4800 0,0135	0,1131 1,2800 0,3339	1,0000 100,0000 0,0000

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D.7: Correlation analysis of the evaluation od tenderness related characteristics of the *M. semimembranosus* cuts (n = 81)

	Species	Age	Fat code	Tender-ness	Shear force resis-tance	Residue	Protein content
Species	1,0000 100,0000 0,0000						
Age	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000					
Fat code	0,0000 0,0000 1,0000	0,0000 0,0000 1,0000	1,0000 100,0000 0,0000				
Tenderness	-0,4664* 21,7500 0,0000	-0,4256 18,1100 0,0289	0,1341 1,8000 0,6040	1,0000 100,0000 0,0000			
Shear force resistance	0,5182* 26,8500 0,0000	0,4488* 20,1400 0,0000	-0,2002 4,0100 0,0732	-0,6302* 39,7200 0,0000	1,0000 100,0000 0,0000		
Residue	-0,4936* 24,3600 0,0000	-0,3209 10,3000 0,0035	0,0486 0,2400 0,6664	0,9378* 87,9500 0,0000	-0,6306* 39,7700 0,0000	1,0000 100,0000 0,0000	
Protein content	-0,0489 0,2400 0,6648	0,5079 0,2580 0,0000	-0,0512 0,2600 0,6501	-0,3340 11,1600 0,0023	0,2834 8,0300 0,0103	-0,3246 10,5400 0,0031	1,0000 100,0000 0,0000

* Significant correlation

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