An evaluation of the lamb and mutton carcase grading system in the Republic of South Africa. 4. The influence of age, carcase mass and fatness on meat quality characteristics

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A sample of 104 lamb and mutton carcases was selected on the market at an abattoir in three age groups and four mass classes representing five of the six fat classes of the classification system. The loin cut of the left side was used to evaluate the organoleptic characteristics. The *M. longissimus thoracis* was dissected from the left side to study the influence of age, carcase mass and fatness on collagen solubility, total collagen and pigment content of the muscle. As the age of lamb/sheep increased a decline was observed in the tenderness, juiciness, flavour, residue and collagen solubility of the meat. Results from a growth expriment indicated that after 4 months of age there was a marked decline in muscle collagen solubility. Carcase fatness was found to have an influence on certain meat quality characteristics and should not be ignored completely in a classification system. The influence of carcase mass on meat quality was in most instances negligible. As age of the animal plays such a predominany role on meat quality characteristics, age should be included as a parameter in any carcase classification or grading system. The current age grouping in the classification system should therefore remain unchanged, namely 0 tooth, 1 – 6 tooth and more than 6 tooth.

'n Monster van 104 lam- en skaapkarkasse is op die mark by 'n abattoir geselekteer in drie ouderdomsgroepe en vier massagroepe waarin vyf van die ses vetheidsklasse van die klassifikasiestelsel verteenwoordig was. Die lendesnit van die linkersy is gebruik om sekere eetkwaliteitseienskappe te evalueer. Die *M. longissimus thoracis* van die linkersy is uitgedissekteer ten einde die invloed van ouderdom, karkasmassa en vetheid op kollageenoplosbaarheid, totale kollageen en pigmentinhoud van die spier te bestudeer. Met 'n toename in ouderdom was daar 'n afname in sagtheid, sappigheid, smaaklikheid, residu en kollageenoplosbaarheid. Resultate van 'n groeiproef het aangedui dat daar na 4-maande-ouderdom 'n merkbare afname in kollageenoplosbaarheid was. Daar is ook gevind dat vetheid 'n rol speel by sekere vleiskwaliteitseienskappe en dié verband nie heeltemal geïgnoreer kan word in'n klassifikasiesisteem nie. Die invloed van karkasmassa op vleiskwaliteitseienskappe was weglaatbaar klein. Omdat ouderdom van die dier dus so 'n opmerklike invloed het op vleiskwaliteitseienskappe, behoort ouderdom dus as 'n parameter in klassifikasie- of graderingstelsels ingesluit te word. Die huidige klassifikasie van karkasse afkomstig van lammers en skape van drie ouderdomsgroepe behoort onveranderd te bly, naamlik 0 tand, 1 – 6 tand en meer as 6 tande.

Keywords: Lamb, mutton, carcase grading, meat quality, age, carcase mass and fatness.

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Introduction

The quality of a meat animal is determined by the quality of the carcase as well as the quality of the meat. It is difficult to define quality, but according to Naudé (1982) the appearance, palatability, nutritional value, processing ability and consumer acceptance of meat are the main constituents of meat quality. Factors that influence meat quality have been reviewed in many articles (Yeates, Edey & Hill, 1975; Macfarlane, Harris & Shorthose, 1974; Kirton, 1976; Lawrie, 1979). Tenderness appears to be the single most important sensory characteristic of meat quality. The predominant factor prior to slaugther influencing tenderness of meat is the age of the animal (Kirton, 1976). Therefore age classes are often included in carcase classification systems. The appearance of the carcase is influenced by the colour and the firmness of the fat cover (Weniger, 1966). There appears to be some discrimination against soft, greasy, and yellow fat amongst buyers in the trade (Yeates, *et al.*, 1975; Naudé, 1982). Optimal carcase fatness as assessed by fat cover is not only an important factor to determine carcase composition but is also an indicator of carcase and meat quality.

The purpose of this study was to determine the influence of animal age, carcase fatness and carcase mass on meat quality characteristics and to ascertain whether the age classification successfully groups carcases with similar meat tenderness levels together.

Procedure

Carcases (104) were selected on the market as was described by Bruwer, Naudé, Vosloo, Du Toit & Cloete (1987). Age was determined according to the number of permanent incisors counted prior to dressing the carcase. This is a standard procedure in the grading system in South Africa. Carcases are then seperately grouped into three age groups, namely A-age group (Lamb, 0 p.i.); B-age group (1–6 p.i.) and C-age group (>6 p.i.).

Carcases were selected at an abattoir from four mass groups within each age group, i.e. 10,1 – 15,0 kg; 15,1 –

20,0 kg; 20,1 – 25,0 kg and more than 25,0 kg. Within these mass groups carcases within the following fatness classes were obtained, i.e. 2^-, 2^+, 3, 4, 5 and 6. All carcases were electrically stimulated for 35 sec, 4,5 minutes post stunning, with a current of 800V. No rams were included in this study as it was not the objective to study the influence of sex on meat quality. Each carcase was split with a handsaw. The left side was used for meat quality determinations. From the left side the loin cut, the *M. longissimus lumborum* included, was dissected and vacuumpacked in a heat shrink film, frozen at –18°C and stored for 3 weeks. Thereafter it was thawed (4°C) and roasted in an oven (160°C) until an internal endpoint meat temperature of 70°C was attained. Total cooking loss was determined by calculating the percentage difference in the mass of the loin cut before thawing and after cooking.

Samples of the roasted loin cuts were evaluated by a six member taste panel, for tenderness, juiciness, flavour and residue on a five-point scale according to the method of De Beer (personal communication). A physical evaluation of the tenderness of the meat was performed on chilled cooked samples (+5°C) from the same loin cuts as those used for the taste panel. The Instron Materials Testing Machine with a Warner Bratzler attachment was used for this purpose. Core samples with a diameter of 13 mm were used for shear force (N) measurements.

The *M. longissimus thoracis* was dissected from the left side and the total collagen content (measurement of hydroxyproline content), collagen solubility (%) (using method A of Bergman & Loxley, 1963) and pigment content (μg Fe/g muscle) were determined (Cronjé, 1976) on this muscle.

Because of the incomplete block design and to incorporate all data it was necessary to perform various variance analyses using the program of Harvey (1977). The following variance analyses were carried out, i.e.

Three way analyses of variance:
Table 1 — three age groups (A, B and C), two mass groups (15,1 – 20,0 kg and 20,1 – 25,0 kg) and four fatness classes (2^-, 2^+, 3 and 4).
Table 2 — two age groups (B and C), two mass groups (20,1 – 25,0 kg and >25,0 kg) and six fatness classes (2^-, 2^+, 3, 4, 5 and 6).
Table 3 — two age groups (B and C), three mass groups (15,1 – 20,0 kg; 20,1 – 25 kg and >25,0 kg) and four fatness classes (2^-, 2^+, 3 and 4).
Two way analyses of variance:
Table 4 — three age groups (A, B and C) and six fatness classes (2^-, 2^+, 3 4, 5 and 6) of the mass group 20,1 – 25,0 kg.
Table 5 — three mass groups (10,1 – 15,0 kg; 15,1 – 20,0 kg and 20,1 – 25,0 kg) of the A-age group.

Simple correlations between certain carcase and meat quality characteristics were also calculated.

Results and Discussion

Intramuscular fat percentage ('marbling')

With an increase in age as well as fatness, the intramuscular fat content increased (Tables 1 – 5). Kauffman & Safanie (1967) reported that as carcase fatness increases more intramuscular fat is deposited in the perimysium layers. This corresponds with the above results. It is also reflected in the results of Table 6 with *r*-values of 0,28, 0,43 and 0,41 between intramuscular fat and age, carcase mass and fatness respectively. The relationship between intramuscular fat content and other meat quality characteristics was low, although there was some indication that as the intramuscular fat content increases the percentage total cooking loss also increases (r = 0,43). Batcher, Dawson, Pointer & Gilpin (1962) found that neither marbling nor intramuscular fat percentage was significantly associated with tenderness, juiciness, or flavour of cooked lamb roasts. Thus the inclusion of

Table 1 Least square means for meat quality characteristics (n = 48)

	Age groups			Carcase mass groups (kg)		Fatness classes				Interactions (*F* values)		
	A	B	C	15,1–20,0	20,1–25,0	2^-	2^+	3	4	A×M	A×F	M×F
Intramuscular fat (%)	2,29^{a}	3,66^{b}	3,63^{b}	3,68	2,71	2,41^{a}	2,84^{ab}	3,31^{ab}	4,21^{b}	0,223	0,558	1,237
Shear force (Instron: N)	32,65^{a}	35,17^{ab}	39,61^{b}	33,99	37,63	39,29^{a}	36,50^{ab}	36,82^{ab}	30,63^{b}	0,231	1,439	5,237**
Tenderness (1 – 5)	3,59^{a}	3,47^{a}	2,74^{b}	3,41	3,13	2,93^{a}	3,16^{ab}	3,37^{ab}	3,62^{b}	1,422	1,061	2,111
Juiciness (1 – 5)	3,54	3,61	3,13	3,62	3,23	3,07	3,38	3,51	3,74	0,037	0,104	1,119
Flavour (1 – 5)	3,54	3,56	3,56	3,49^{a}	3,68^{b}	3,39	3,33	3,62	3,63	0,162	0,232	2,083
Residue (1 – 5)	4,29^{a}	4,27^{a}	3,63^{b}	4,10	4,03	3,90	3,97	4,13	4,24	0,509	0,302	1,565
Total cooking loss (%)	11,57^{a}	11,56^{a}	13,05^{b}	11,71	12,41	11,34^{a}	10,76^{ab}	12,45^{ac}	13,69^{c}	8,149*	0,713	0,380
Collagen solubility (%)	21,16^{a}	20,31^{a}	18,12^{b}	20,43^{a}	19,31^{b}	20,13	20,42	20,28	18,62	1,767	0,492	0,517
Total collagen (Hypro N/N)×1000	2,58	2,51	2,66	2,53	2,63	2,73^{a}	2,58^{ab}	2,62^{abc}	2,40^{bd}	4,782*	4,021**	1,938
Pigment content (μg Fe/g)	53,78^{a}	57,94^{ab}	62,95^{b}	57,24	59,20	59,01^{a}	57,59^{ab}	51,34^{bc}	64,95^{abd}	4,164*	2,482*	0,918

*P<0,05; **P<0,01; A = Age; M = Mass; F = Fatness class;
[a,b,c,d] Means in the same row respectively for age groups, carcase mass groups and fatness classes with different superscripts differ significantly (P<0,05)

Table 2 Least square means for meat quality characteristics (n = 48)

	Age groups		Carcase mass groups (kg)		Fatness classes						Interactions (F values)		
	B	C	20,1–25,0	>25,0	2^{-}	$\mathbf{2}^{-}$	3	4	5	6	A×M	A×F	M×F
Intramuscular fat (%)	4,20	3,73	3,43^{a}	4,50^{b}	2,60^{a}	2,55^{a}	3,57^{ab}	4,94^{bc}	5,26^{c}	4,89^{bc}	7,211*	0,911	1,414
Shear force (Instron: N)	33,84	38,56	36,59	35,81	38,24	35,90	39,73	35,28	34,25	33,80	1,333	0,152	3,374*
Tenderness (1 – 5)	3,27^{a}	2,61^{b}	3,03	2,85	2,23^{a}	2,49^{ab}	2,94^{bc}	3,51^{c}	3,28^{c}	3,20^{c}	0,695	0,314	2,444
Juiciness (1 – 5)	3,28	2,98	3,32	2,94	2,39^{a}	3,03^{ab}	3,15^{b}	3,41^{b}	3,26^{b}	3,54^{b}	0,100	0,275	0,904
Flavour (1 – 5)	3,52	3,30	3,42	3,40	3,06^{a}	3,31^{ab}	3,50^{b}	3,50^{b}	3,53^{b}	3,55^{b}	0,270	1,075	1,195
Residue (1 – 5)	4,30^{a}	3,80^{b}	4,05	4,05	3,60^{a}	3,70^{a}	4,04^{ab}	4,34^{b}	4,43^{b}	4,20^{b}	0,485	0,704	1,814
Total cooking loss (%)	13,43	11,69	11,95	13,16	6,92^{a}	6,07^{a}	15,39^{b}	16,75^{b}	17,21^{b}	13,00^{b}	5,549*	1,446	16,313
Collagen solubility (%)	19,38^{a}	17,29^{b}	19,03^{a}	17,66^{b}	28,18^{a}	18,70^{ac}	18,03^{aa}	18,42^{b}	18,26^{b}	18,47^{bcd}	0,255	1,130	2,187
Total collagen (Hypro N/N)×1000	2,51^{a}	2,67^{b}	2,58	2,60	2,88	2,72	2,73	2,42	2,28	2,52	2,550	2,673*	2,325
Pigment content (μg Fe/g)	67,67	62,13	63,12	66,68	65,37^{ab}	65,85^{ab}	59,19^{a}	61,99^{ab}	67,04^{ab}	69,97^{b}	0,694	1,382	1,255

*P<0,05; **P<0,01;

^{a,b,c,d} Means in the same row respectively for age groups, carcase mass groups and fatness classes with different superscripts differ significantly (P<0,05)

Table 3 Least square means for meat quality characteristics (n = 48)

	Age groups		Carcase mass groups (kg)			Fatness classes				Interactions (F values)		
	B	C	15,1–20,0	20,1–25,0	>25,0	2^{-}	$\mathbf{2}^{-}$	3	4	A×M	A×F	M×F
Intramuscular fat (%)	3,91	3,46	4,24^{a}	3,05^{b}	3,77^{ab}	3,02^{a}	3,04^{a}	4,04^{ab}	4,66^{b}	0,826	0,320	1,617
Shear force (Instron: N)	4,47	39,30	36,08	38,71	35,86	36,31	34,51	42,13	34,59	0,062	0,145	2,282
Tenderness (1 – 5)	3,34^{a}	2,60^{b}	3,34^{a}	2,88	2,71^{b}	2,68^{a}	2,75^{a}	3,05^{ab}	3,41^{b}	0,912	0,046	2,930*
Juiciness (1 – 5)	3,40^{a}	2,69^{b}	3,55^{a}	3,19^{ab}	2,80^{b}	2,83^{a}	3,19^{ab}	3,26^{ab}	3,44^{b}	0,067	0,244	1,490
Flavour (1 – 5)	3,51	3,38	3,65^{a}	3,39^{ab}	3,29^{b}	3,23	3,52	3,53	3,51	0,378	0,311	1,190
Residue (1 – 5)	4,25^{a}	3,66^{b}	4,02	3,88	3,96	3,78	3,87	3,98	4,18	0,529	0,502	2,118
Total cooking loss (%)	12,94^{a}	12,08^{b}	11,92^{a}	12,69^{a}	16,23^{b}	12,19^{a}	11,84^{a}	14,57^{b}	15,84^{b}	8,721**	1,087	29,501**
Collagen solubility (%)	19,78^{a}	17,63^{b}	19,44^{a}	19,00^{a}	17,67^{b}	18,56	19,26	18,63	18,36	0,390	0,133	1,729
Total collagen (Hypro N/N)×1000	2,50^{a}	2,73^{b}	2,48^{a}	2,69^{b}	2,68^{b}	2,82^{a}	2,62^{b}	2,61^{b}	2,42^{c}	3,911*	6,933**	3,318*
Pigment content (μg Fe/g)	63,00	61,93	61,20^{ab}	59,68^{a}	66,51^{b}	63,64^{a}	66,05^{a}	56,75^{b}	63,43^{a}	9,721**	0,084	1,262

*P<0,05; **P<0,01;

^{a,b,c} Means in the same row respectively for age groups, carcase mass groups and fatness classes with different superscripts differ significantly (P<0,05)

intramuscular fat content as a grading principle, as is done in the USA (Kempster, Cuthbertson & Harrington, 1982) does not seem justified from the results of this study, reflecting the situation in the meat industry in South Africa.

Tenderness

Only in one analysis a statistical difference (P<0,05) was found in shear force values of meat of A and C age group carcases (Table 1). Taste panel results for tenderness, showed that there was no significant differences between age groups A and B in Table 1 (3,59 vs 3,47), but in Table 4 significant differences (P<0,05) were found between these two age groups (3,91 vs 3,28). Significant differences (P<0,05) were found between age groups B and C in Table 1, 2 and 3 but not in Table 4. Age groups A and C also differed significantly in Table 1 and 4. There was, however, a clear tendency that the meat of age group C had lower values than that of the B-age group and the B-age group meat had lower values than that of the A-age group.

Results from Weller, Galgan & Jacobsen (1962); Carpenter & King (1965a) and Kirton (1970) showed that there was insufficient evidence to prove that meat of lambs was more tender than that of two-teeth sheep. Wenham, Fairbairn, McLeod, Carse, Pearson & Locker (1973) on the other hand found that if the negative effects of rapid chilling or early freezing were removed,

Table 4 Least square means for meat quality characteristics (n = 36)

	Age groups			Fatness classes						Interactions (F values)
	A	B	C	2^-	2^+	3	4	5	6	A×F
Intramuscular fat (%)	2,81^{a}	3,03^{ab}	3,83^{b}	1,73^{a}	2,31^{a}	2,32^{a}	4,47^{b}	4,43^{b}	4,09^{b}	2,972*
Shear force (Instron: N)	32,51	35,63	37,55	44,88	43,35	32,13	30,15	32,45	28,40	0,996
Tenderness (1 – 5)	3,91^{a}	3,28^{b}	2,78^{b}	2,50^{a}	2,77^{ab}	3,45^{bc}	3,78^{c}	3,60^{c}	3,85^{c}	1,714
Juiciness (1 – 5)	3,65^{a}	3,50^{ab}	3,13^{b}	2,60^{a}	3,17^{ab}	3,38^{bc}	3,78^{bc}	3,67^{bc}	3,97^{c}	0,688
Flavour (1 – 5)	3,58	3,50	3,34	3,05^{a}	3,33^{ab}	3,63^{bc}	3,55^{bc}	3,40^{ab}	3,87^{c}	1,116
Residue (1 – 5)	4,93^{a}	4,25^{ab}	3,84^{b}	3,63^{ac}	3,80^{ab}	4,27^{ab}	4,40^{abc}	4,60^{bc}	4,55^{c}	1,127
Total cooking loss (%)	12,54^{a}	13,90^{ab}	10,00^{b}	12,15	10,90	12,74	13,85	15,35	16,02	1,748
Collagen solubility (%)	20,60^{a}	20,18^{a}	17,87^{b}	19,88	19,64	19,30	18,54	19,49	20,46	0,985
Total collagen (Hypro N/N)×1000	2,43^{a}	2,55^{ab}	2,61^{b}	2,75^{a}	2,75^{a}	2,59^{ab}	2,50^{bd}	2,25^{c}	2,35^{cd}	4,209**
Pigment content (μg Fe/g)	57,67	64,79	61,46	62,71^{ab}	56,41^{ab}	53,49^{a}	63,84^{ab}	64,62^{ab}	66,94^{b}	1,232

*P<0,05; **P<0,01;

^{a,b,c,d} Means in the same row respectively for age groups and fatness classes with different superscripts differ significantly (P<0,05)

Table 5 Least square means for meat quality characteristics (n = 36)

	Carcase mass groups			Fatness classes						Interactions (F value)
	10,1–15,0	15,1–20,0	20,1–25,0	2^-	2^+	3	4	5	6	M×F
Intramuscular fat (%)	2,52	2,88	2,81	1,81^{a}	2,20^{a}	2,18^{a}	2,56^{a}	4,02^{b}	3,66^{b}	1,388
Shear force (Instron: N)	29,70	31,68	32,51	36,55^{a}	32,53^{a}	26,53^{b}	25,33^{b}	34,20^{a}	32,63^{a}	4,369
Tenderness (1 – 5)	3,76	3,45	3,91	3,52	3,90	3,60	3,92	3,55	3,72	1,833
Juiciness (1 – 5)	3,78	3,65	3,65	3,47^{ab}	3,50^{ab}	3,52^{ab}	3,90^{ab}	3,87^{a}	3,90^{b}	2,422*
Flavour (1 – 5)	3,42	3,58	3,58	3,45	3,37	3,65	3,70	3,23	3,73	1,883
Residue (1 – 5)	4,33	4,19	4,52	4,32	4,25	4,23	4,48	4,33	4,47	1,512
Total cooking loss (%)	11,36	12,09	12,54	10,55^{ab}	11,25^{ab}	11,63^{a}	11,67^{ab}	12,77^{ab}	14,11^{b}	0,366
Collagen solubility (%)	22,27	21,67	20,60	20,73^{ab}	21,53^{bc}	24,75^{a}	21,01^{bcd}	19,54^{ad}	21,52^{c}	4,737**
Total collagen (Hypro N/N)×1000	2,46	2,65	2,43	2,59^{a}	2,39^{a}	2,72^{b}	2,45^{a}	2,64^{a}	2,29^{a}	2,939
Pigment content (μg Fe/g)	52,64	54,20	57,76	55,51^{abc}	46,06^{a}	48,68^{ab}	60,25^{bc}	60,39^{c}	58,32^{bc}	1,339

*P<0,05; **P<0,01;

^{a,b,c,d} Means in the same row respectively for age groups, mass groups and fatness classes with different superscripts differ significantly (P<0,05)

differences in tenderness were evident between the meat from lambs, two-teeth sheep and ewes up to 9 years.

Barwick & Thwaites (1980) also found that the meat of lamb carcases have significantly lower shear values than that of mutton carcases. The research of other workers such as Pearson (1966) and Smith, Carpenter, King & Hoke (1970) supported the last results. Results of this study showed a consistent tendency for the meat of lambs (A-age group) to be more tender than that of the B- and C-age groups, and the B-age group meat was more tender than that of the C-age group both in sheer force and panel tenderness values. Thus it is quite evident that tenderness is influenced by age and therefore age or some indication of maturity is usually included in most of the grading/classification systems in lamb and mutton marketing countries (Kirton, 1976).

A general tendency, although not always statistically significant, was established that as carcases increased in fatness the meat became more tender (shear force as well as taste panel) (Tables 1 – 5). In the literature no clear evidence was found to indicate that an increase in carcase fatness is correlated with an increase in tenderness (Batcher, Dawson, Pointer & Gilpin, 1962; Naudé, 1983 unpublished). Carpenter & King (1965b) and Oldfield, Fox, Bahn, Bickoff & Kohler (1966) reported positive but low relationships between tenderness and fat deposition. Woodhams, Kirton & Jury (1966), Batcher, *et al.* (1962) and Carpenter, King, Ortes & Cunningham

Table 6 Simple correlations between various carcase and meat characteristics(n = 104)

	Age 1	Carcase mass (kg) 2	Fat-ness (1–18) 3	Intramus-cular fat (%) 4	Tenderness (Instron) 5	Tenderness (taste panel) (1–5) 6	Juici-ness (1–5) 7	Flavour (1–5) 8	Residue (1–5) 9	Total cooking loss (%) 10	Collagen solubi-lity (%) 11	Total collagen (HyPro N/N) ×1000 12	Pigment content (µg Fe/g) 13
1	1,00	0,44	0,01	0,28	0,28	–0,050	–0,36	–0,12	–0,40	0,43	–0,61	0,16	0,35
2		1,00	0,33	0,43	0,02	–0,15	–0,22	0,04	0,07	0,65	–0,43	–0,06	0,36
3			1,00	0,41	–0,12	0,16	0,28	0,16	0,26	0,53	–0,08	–0,34	0,25
4				1,00	–0,18	0,23	0,24	0,27	0,29	0,43	–0,23	–0,25	0,21
5					1,00	–0,58	–0,36	–0,37	–0,56	0,09	–0,24	0,28	0,07
6						1,00	0,69	0,63	0,84	–0,18	0,41	–0,47	–0,27
7							1,00	0,59	0,60	–0,30	0,28	–0,42	–0,13
8								1,00	0,59	–0,03	0,24	–0,41	–0,50
9									1,00	–0,05	0,23	–0,48	–0,14
10										1,00	–0,41	–0,08	0,40
11											1,00	–0,19	–0,43
12												1,00	–0,08
13													1,00

(1964) have found no relationship between fatness and tenderness. From the results of this study and the literature that was cited it appears that there is still no agreement whether a relationship exists between fatness and tenderness. Simple correlations between fatness on the one hand and shear force and taste panel values on the other were respectively –0,12 and 0,16 (Table 6).

The influence of carcase mass on meat tenderness is shown in Tables 1 – 6. No statistically significant differences between the different mass groups were found for meat tenderness, with the exception in Table 3, of one comparison where the carcase group 15,1 – 20,0 kg had more favourable taste panel results than the >25,0 kg carcase mass group. These results regarding the influence of carcase mass support the results of Woodhams, *et al.* (1966); Purchas, Williamson, Barton & Rae (1969); Solomon, Kemp, Moody, Ely & Fox (1980) and Crouse, Busboom, Field & Ferrell (1981) that carcase mass has almost no influence on meat tenderness. The simple correlation (r) between carcase mass and meat tenderness was also very low (0,02 and –0,15 respectively for Instron and taste panel).

The relationship between taste panel scores and shear force values was found to be acceptable (r = –0,58). This is in agreement with results of Paul, Torten & Spurlock (1964) and Klingbiel (1984). High relationships between taste panel scores for tenderness and meat quality characteristics were found, namely between tenderness on the one hand and juiciness (r = 0,69), flavour (r = 0,63), residue (r = 0,84), collagen solubility (r = 0,41) and total collagen (r = –0,47) on the other hand. Therefore the more tender the meat, the more rapidly juices are released by chewing, the less residue remains in the mouth after the chewing and the higher the solubility and lower the content of the collagen.

Juiciness

No statistically significant differences were found between age groups for juiciness in Tables 1 and 2. In Tables 3 and 4 however significant differences (P<0,05) were found between age groups. Meat from the younger animals obtained higher juiciness scores. The possible reason for this is that meat from young animals leaves a watery impression during initial chewing (Price & Schweigert, 1971). Conflicting results are found in the literature regarding the influence of age on juiciness. Some results indicate no relationship (Campion, Field, Riley & Smith, 1976; Pinkas, Marinova, Toinov & Monin, 1982), whilst others such as Paul, *et al.* (1964) report increases in juiciness with increased maturity. Smith, *et al.* (1969; 1970) found that carcases from younger animals were associated with higher panel juiciness ratings. The results of this study support the work of Smith, *et al.* (1970). The main possible reason why some of the researchers quoted were unable to demonstrate the consistent effect of age on meat quality could be that the range of their age groups might have been very narrow.

No statistically significant differences in juiciness were found among carcase mass and juiciness except in Table 3. The lighter carcase mass groups tended to achieve higher juiciness scores than the heavier carcase mass groups. Kemp, Mahyuddin, Ely, Fox & Moody (1981) found no significant differences between slaughter mass and juiciness. However, in one experiment there was also a tendency for the smaller slaughter mass group to achieve a higher juiciness score than the heavier slaughter mass group. This result is supported by those of Solomon, *et al.* (1980).

In most of the analyses (Tables 1 – 4) the very lean car cases (fatclasses 2^- and 2^+) had statistically significant lower juiciness scores than the fatter carcases (fatclasses 4, 5 and 6). This agrees with the results of Oldfield, *et al.* (1966); Smith, Galgan & Weller (1964) and Smith & Carpenter (1970) indicating that meat produced by more heavily finished lambs was more juicy than meat containing less fat.

The relationships between juiciness and age, carcase mass and fatness were low, $r = -0{,}36$; $-0{,}22$ and $0{,}28$ respectively, and correspond with most of the results that were described previously. High relationships were obtained between juiciness, on the one hand and flavour and residue, on the other hand, i.e. $r = 0{,}59$ and $0{,}60$ respectively.

Flavour

There are a number of contributing factors influencing the flavour of lamb and mutton. According to Sink & Caporosa (1977); Crouse (1983) and Crouse, Ferrel & Cross (1983) the factors that have the most pronounced effect on flavour are age, sex, breed, slaughter mass and nutrition. The low consumption of both lamb and mutton in the USA has been attributed in part, to its intense flavour (Sink & Caporosa, 1977). Unfortunately not all these factors have been studied in this experiment and only the influence of age, carcase mass and fatness will be discussed.

No statistically significant differences were obtained (Tables 1 – 4) between the three age groups in meat flavour. There was, however, a tendency that the meat from the younger animals obtained a higher flavour score than the meat of animals in the older age groups. A low and negative relationship was also found between age and meat flavour ($r = -0{,}12$). The above results correspond with the results of Sink & Caporosa (1977).

Results illustrating the influence of carcase mass on meat flavour were inconsistent among the various mass groups. In Table 1 there was a significant difference ($P<0{,}05$) between mass groups 15,1 – 20,0 kg and 20,1 – 25,0 kg. The latter group had a more desirable meat flavour. This tendency, although not statistically significant, was also found in Table 5 while in Tables 2 and 3 meat from carcases in the lighter mass groups had higher flavour scores than the meat from carcases in the heavier mass groups. Contradicting results were also reported in the literature. Weller, *et al.* (1962) and Kemp, Johnson, Stewart, Ely & Fox (1976) reported that there was a decrease in flavour intensity scores as live mass of the animal increased. Mendenhall & Erconbrach (1979) and Crouse, *et al.* (1981), observed no effect of mass on lamb flavour. Field, Williams, Ferrell, Crouse & Kunsman (1978) found that flavour scores were less desirable from rib roasts of 68 kg ram lambs than that of lighter 41 kg ram lambs. Thus it seems there is still uncertainty of the influence of mass on meat flavour. The results of this study contribute to the uncertainty.

From Tables 1 – 5 it appeared that as carcases increased in fatness, flavour scores became more desirable. Significant differences ($P<0{,}05$) between the different fat classes were found only in Table 2 and Table 4. The relationship between flavour and fatness was very low ($r = 0{,}16$) (Table 6). These results support the findings of Paul, *et al.* (1964); Woodhams, *et al.* (1966) and Smith, *et al.* (1970).

High relationships were found between meat flavour and residue ($r = 0{,}59$) total collagen content ($r = -0{,}41$) and pigment content ($r = -0{,}50$). Smith & Carpenter (1970) found a high relationship between rib chop flavour score and total collagen ($-0{,}49$), while the relationship between loin chop flavour score and total collagen was $-0{,}16$. Romans, Tuma & Tucker (1965) reported a significant ($P<0{,}05$) correlation between haemoglobin concentration and the flavour of cooked beef. According to Yeates, *et al.* (1975) the increasing depth of colour in meat is associated with an increase in meat flavour. The results of the present study correspond well with those of other workers.

Residue

It is clear from the results of Tables 1 – 5 that as age increased more residue was left in the mouth after the chewing process. In most cases significant differences ($P<0{,}05$) were found between age groups A and C and B and C. No significant differences were found between age groups A and B, although there was a tendency that the A-age groups obtained more satisfactory residue scores than the B-age groups. In the same tables it is indicated that as carcase fat increases, residue scores became more favourable. In Tables 2 and 4, however, only minor significant differences ($P<0{,}05$) were found between the different fat classes. Carcase mass had no influence on the amount of residue and no clear pattern was found for the different mass groups. A negative relationship between the residue score and total collagen content ($r = -0{,}48$) was also found.

Total cooking loss

The influence of age on total cooking loss was statistically significant ($P<0{,}05$) in most cases (Table 1 – 5), however no clear tendency was found between the different age groups. The results of Pinkas, *et al.* (1982) showed that older animals have lower cooking losses. The overall impresions from the results of this study were in agreement with the findings of the above researchers. Paul, *et al.* (1964) and Smith, *et al.* (1970) however found that cooking losses were higher for roasts from carcases of advanced maturity. The results of this study were further complicated by the fact that as carcase mass increased the total cooking loss also increased. The latter was also found by Kemp, Shelley, Ely & Moody (1972). Quite a high relationship was found between total cooking loss and age ($r = 0{,}43$) and between total cooking loss and carcase mass ($r = 0{,}65$) (Table 6). As carcase fatness increased, total cooking loss also increased (Tables 1 – 5; $P>0{,}05$) with a positive correlation of $r = 0{,}53$ (Table 6). The results of Purchas, *et al.* (1969) and Solomon, *et al.* (1980) were similar to those found in this study.

Collagen solubility and total collagen

The main protein influencing the tenderness of electrically stimulated meat is collagen. Much research has been done on this subject (Hill, 1966; Smith, *et al.* 1970; Boccard, 1973 and Barwick, 1977), but the results are still contradictory. However, it is well known that with an increase in the age of the animal, there is also an increase in the cross linkages in the connective tissue which stabalizes at a later stage (Bailey, 1972). It is also important to note that older animals do not have greater amounts of connective tissue per muscle unit in comparison with younger animals, but it is the extent of cross linking that increases with age and therefore influences the tenderness of the meat (Price & Schweigert, 1971).

This study has shown that no statistically significant differences were found in muscle collagen solubility and total collagen content among carcases of age groups A and B (Tables 1 and 4). Significant differences (P<0,05) in collagen solubility were found between age groups A and C and B and C (Tables 1 – 4). Significant differences (P<0,05) in total collagen content were found between age groups B and C (Tables 2 & 3) and between A and C (Table 4). Even though no significant differences were found between age groups A and B, collagen solubility was higher in meat from A than from B-age group carcases. These results confirm the results of Bailey (1972) and Yeates, *et al.* (1975). A high and negative relationship was also found between age of animal and muscle collagen solubility (–0,61). There is currently strong pressure from South African lamb and mutton producers that carcases of two-tooth sheep should be grouped with those of lamb carcases (0 tooth) in the same grade. Differences in collagen solubility between age groups A and B in this study were not found to be statistically significant even though the values for A-animals were always higher than those for B-animals. Heinze, Smit, Naudé & Boccard (1986) analysed collagen in Dorper, Merino and Mutton Merino slaughtered at three different ages, namely 1, 4 and 18 months (Figure 1). It was shown that there was a marked decline in the percentage collagen solubility as the age of the animal increased; especially between the 1 and 4 months age groups. Therefore it should be clear that if the full benefit of the meat quality characteristics are to be obtained by the consumer, lambs should be slaughtered as close to 4 months of age as possible. A possible explanation why no significant differences were found between age groups A and B in this study, is that carcases in the B-age group were carcases from sheep with between one and six permanent incisors and in the A-age group 0-tooth lamb. When selecting the carcases on the market it was impossible to get a representative sample of each 'tooth' or monthly chronological age. A separate A (lamb) class therefore seems justified in the carcase grading system.

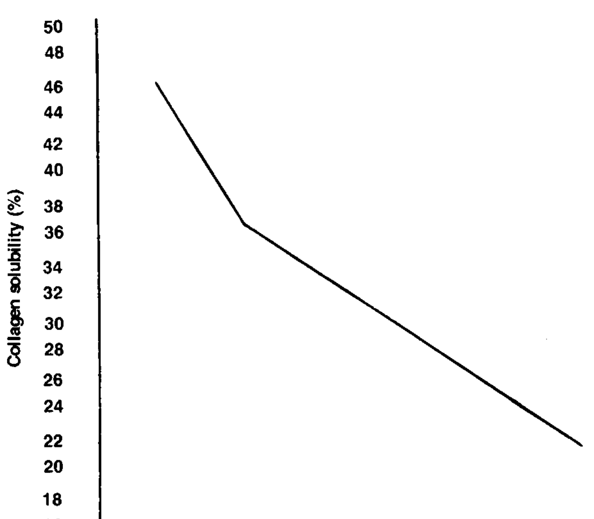

Figure 1 The influence of age on collagen solubility (%) for three different sheep breeds (Heinze *et al.*, 1986)

Carcase mass had the same influence on collagen solubility and total collagen content in the muscle as the age of an animal. Meat from the lighter mass groups had a higher percentage collagen solubility and a lower total collagen content than that of the heavier mass groups which were in most cases statistically significant (P<0,05) (Tables 1, 2 & 3). The relationship between carcase mass and percentage collagen solubility was negative (r = –0,43). It was also found that with increasing levels of fatness the total collagen content decreases. This could possibly be attributed to the dilution effect of intramuscular fat. The influence of fatness on collagen solubility was not quite clear from the results of this study.

Pigment content

The red colour of fresh muscle is due to the presence of the respiratory pigments myoglobin and haemoglobin. Apart from the oxidative changes the colour of fresh meat is also influenced by age, sex, exercise and in young animals, by the type of feed (Yeates, *et al.*, 1975). Muscle colour intensity increases with advances in the chronological age of the animal (Price & Schweigert, 1971). From the results in Tables 1 – 4 no significant differences (P<0,05) were found between age groups B and C. It is interesting to note that the B-age group meat had higher pigment content values than that of age group C, except in Table 1. Although no significant differences (P<0,05) between age groups A and B (Table 1) and A, B and C (Table 4) were found, there was a clear tendency that the carcases of the A age-group had lower values than carcases in the B- and C-age groups.

The relationship between age and pigment content was positive but not very high (r = 0,35). Pinkas, *et al.* (1982) found no difference in meat reflectance due to the age of the animals. However the range of their age groups was not very wide (22 and 33 weeks of age). No significant differences (P<0,05) between the various carcase mass groups were obtained, except in Table 3. There was a clear tendency that the heavier mass groups obtained higher pigment content values. This supports the results of Jacobs, Field, Botkin, Riley & Roehrkasse (1972). The influence of fatness on pigment content is difficult to explain in this study.

Conclusion

The results of this study show that age is the predominant factor affecting meat quality characteristics of lamb and mutton. The influence of carcase mass was in most cases somewhat similar to that of age because of the relationship between mass and age. Although not as direct as the influence of age, carcase fatness was shown to have an important bearing on meat quality. According to the results of this study the current age grouping in the classification and grading system of lamb and mutton in South Africa contributes significantly in grouping carcases with similar meat quality characteristics together, and should remain unchanged.

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