Meat studies of indigenous Southern African cattle. II. Textural evaluation of ribcut samples from carcasses of Afrikaner, Nguni and Pedi bulls fed intensively

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Textural evaluations were conducted on the *longissimus thoracis* muscles from carcasses of young Afrikaner, Nguni and Pedi bulls fed intensively and slaughtered at 160, 290, 340 and 390 kg. Carcasses were stimulated electrically (500 V, 12,5 Hz) for 2 min, and chilled for 19 h at 0—5 °C. Ribcut samples (11, 12 and 13th ribcut) were removed 24 h post-slaughter and evaluated by a taste panel for tenderness, juiciness, flavour and residue on an unstructured five-point scale, ranging from least to most acceptable. Shear tests were performed on an Instron apparatus. Percentage cooking loss and free water were measured. The Afrikaner was found to be slightly more tender and flavoursome with less residue than the Nguni ($P < 0,10$). The Pedi did not differ from the Afrikaner or the Nguni. No breed differences occurred in juiciness, cooking loss, free water or shear force. Mass affected juiciness ($P < 0,05$), residue ($P < 0,01$) and free water ($P < 0,01$). Shear force correlated highly with tenderness (–0,61**) and residue (0,74**). Juiciness correlated negatively with percentage cooking loss (–0,57**), though poorly with percentage free water (0,28). Compared with published results of textural evaluation of steer meat, the meat from the young Afrikaner, Nguni and Pedi bulls fell into a superior category.

Die tekstuur van ribsnitmonsters afkomstig van intensief-gevoerde, ongewisselde Afrikaner-, Nguni- en Pedi-bulle, geslag op teikenmassas van 160, 290, 340 en 390 kg, is geëvalueer. Karkasse is elektries gestimuleer (500 V, 12,5 Hz) vir 2 min, en verkoel teen 4 °C vir 19 h. Ribsnitte (ribbes 11, 12, 13) is 24 h na slagting verwyder. Monsters is voorberei en deur 'n proepaneel volgens 'n ongestruktureerde vyfpuntskaal vir sagtheid, sappigheid, smaaklikheid en residu geëvalueer. Snyweerstandtoetse is met behulp van 'n Instron-apparaat bepaal. Persentasies kookverlies en ongebonde water is gemeet. Die Afrikaner se vleis was meer sappig en smaakvol ($P < 0,10$) as die Nguni. Die Pedi het nie van die Afrikaner of die Nguni verskil nie. Geen rasverskille het ten opsigte van sappigheid, kookverlies, ongebonde water of snyweerstand voorgekom nie. Massa het 'n invloed op sappigheid ($P < 0,05$), residu ($P < 0,01$) en ongebonde water ($P < 0,01$) gehad. Snyweerstand was hoogs gekorreleer met sagtheid (–0,61**) en residu (0,74**). Sappigheid was negatief gekorreleer met persentasie kookverlies (–0,57**), maar nie betekenisvol met ongebonde water (0,28) nie. Die gehalte van die vleis van jong Afrikaner-, Nguni- en Pedi-bulle, in vergelyking met dié van jong osse in gepubliseerde resultate oor tekstuurevaluasie, is baie goed en sal vir die verbruiker aanvaarbaar wees.

Keywords: Bulls, meat texture, ribcut.

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Meat texture is a multi-dimensional quality (Szczesniak, 1986), being influenced by muscle locality (Segars, Nordstrom & Kapalis, 1974; Lepetit & Sale, 1985), breed and age (Naudé, Mentz, Venter, Nel, Botha, Stiemie & Argo, 1980), sex, degree of finish, ante-mortem treatment of animals and post-mortem treatment of carcasses and meat (Harris & Shorthouse, 1988), including cooking method and presentation. Determining texture and quantifying differences between sources (breed, sex, treatment and muscle) require that a standard, representative sample be evaluated under standardized conditions in terms of chemical, physical and sensory attributes. Although totally standardized methodologies for textural evaluation of meat have yet to be evolved, certain procedures yielding consistent and replicate results have emerged and have been applied in this study. Furthermore, the multi-dimensional character of meat texture must be taken into account with as many parameters as possible being tested. However, for some applications, quantification of a limited number of parameters may be sufficient (Szczesniak, 1986). This study assesses the comparative tenderness, juiciness, flavour, residue, percentage cooking loss, percentage free water and shear force value of intensively fed Afrikaner, Nguni and Pedi bulls slaughtered at 160, 290, 340 and 390 kg.

Analyses of the growth performance and carcass characteristics of these bulls (Swanepoel, Casey, de Bruyn & Naudé, 1990) indicated that growth rates did not differ, although the Nguni yielded the heavier carcass ($P < 0,05$), the greater dressing percentage ($P < 0,05$) (and lighter hide) and the more compact carcass and hind quarter ($P < 0,01$). Breed effects occurred in certain parameters that may influence texture; the Pedi carcass was the fattest with the most intramuscular fat and least muscle content ($P < 0,05$), whereas the Afrikaner had significantly more subcutaneous fat (SCF) than the Nguni, which was also the leanest of the three breeds.

Table 1 Two-way analysis of variance of tenderness, juiciness, flavour, residue, % cooking loss, % free water and shear force

									Least significant differences					
		Mean and SD				*F* value			Breed			Mass		
Parameter	Group	Afrikaner	Nguni	Pedi	CV %	Breed	Mass	B×M	A:N	A:P	N:P	290:340	290:390	340:390
Tenderness	Initial	3,83	3,19	3,53										
		0,37	0,87	0,42										
	290	3,50	2,97	3,47										
		0,76	0,67	0,55										
	340	3,43	3,10	2,90										
		0,29	0,56	0,45										
	390	3,07	2,88	3,10										
		0,74	0,48	0,82										
	$\bar{x}$	3,46	3,04	3,25	18,65	2,34	1,91	0,45	*	NS	NS	NS	NS	NS
Juiciness	Initial	3,67	3,53	3,40										
		0,41	0,46	0,61										
	290	3,25	2,95	3,30										
		1,02	0,72	0,96										
	340	2,71	2,80	2,58										
		0,28	0,54	0,33										
	390	2,67	2,42	2,50										
		0,64	0,39	0,49										
	$\bar{x}$	3,08	2,93	2,95	20,22	0,35	8,58***	0,25	NS	NS	NS	NS	**	NS
Flavour	Initial	3,97	3,20	3,47										
		0,14	0,14	0,40										
	290	3,50	3,54	3,57										
		0,30	0,30	0,15										
	340	3,44	3,23	3,37										
		0,20	0,15	0,38										
	390	3,37	3,25	3,40										
		0,40	0,34	0,34										
	$\bar{x}$	3,57	3,31	3,45	8,40	4,06**	2,29*	1,94*	*	NS	NS	NS	NS	NS
Residue	Initial	4,70	4,33	4,47										
		0,25	0,55	0,27										
	290	4,50	4,27	4,47										
		0,36	0,45	0,52										
	340	4,21	3,87	4,05										
		0,37	0,27	0,31										
	390	3,73	3,45	3,58										
		0,35	0,44	0,44										
	$\bar{x}$	4,29	3,98	4,14	9,56	2,92*	16,36***	0,06	*	NS	NS	*	***	**
Cooking loss (%)	Initial	12,15	13,99	13,68										
		1,88	3,11	2,90										
	290	14,47	15,18	14,33										
		2,94	1,76	1,21										
	340	16,19	15,68	17,01										
		1,48	1,24	1,97										
	390	17,12	15,59	15,84										
		1,92	0,73	2,72										
	$\bar{x}$	14,98	15,11	15,22	13,92	0,06	6,90***	0,84	NS	NS	NS	NS	NS	NS
Free water (%)	Initial	55,43	54,29	54,55										
		1,97	5,03	5,77										
	290	53,67	53,16	50,85										
		2,84	5,11	3,03										
	340	51,64	50,44	51,19										
		3,90	4,62	2,71										
	390	45,76	47,85	45,12										
		4,94	6,21	1,67										
	$\bar{x}$	51,63	51,44	50,43	8,34	0,45	10,70***	0,30	NS	NS	NS	NS	***	**
Shear force	Initial	71,61	85,87	80,72										
		10,22	21,71	13,37										
	290	105,29	107,26	86,58										
		37,86	14,57	12,77										
	340	97,95	112,55	108,18										
		22,60	13,94	17,10										
	390	102,11	104,79	93,51										
		11,52	15,27	15,86										
	$\bar{x}$	94,24	102,62	92,25	18,74	1,86	6,30***	0,75	NS	NS	NS	NS	NS	NS

NS: not significant; * $P < 0{,}10$; ** $P < 0{,}05$; *** $P < 0{,}01$.

Procedure

The pre- and post-mortem procedure, including carcass composition and other evaluation procedures, have been described by Swanepoel *et al.* (1990). Carcasses were stimulated electrically (500 V 12,5 Hz for 2 min, polarity changes per 30 s). The right wingrib (ribs 11, 12, 13) was removed for determining the intramuscular fat of the *longissimus thoracis*. Cooking loss (Naudé, 1974), shear force and free water were determined on the *longissimus thoracis* of the left primerib (ribs 8, 9, 10).

Cooking loss was measured in a 2,54 cm^3 sample cut perpendicular to the direction of muscle fibres. The cubes were heated in a polyethylene bag immersed in water, 70°C for 1 h. Mass differences between before and after cooking were expressed as a percentage loss. Shear force was measured using the blades of the Warner–Bratzler apparatus on an Instron meter with 2,54 cm (1 inch) diameter core samples of meat (Naudé, 1974). The free water or expressible fluid content was measured by applying a pressure of 900 kg on a 0,5 g sample of product between sheets of Whatman no. 2 filter paper (Sanderson & Vail, 1963) at room temperature of 25°C, and expressing the mass loss as a percentage.

Sensory evaluation was performed on the wingrib of the left side. The entire wingrib was roasted in an oven at 160°C until a core temperature of 70°C was attained. Ten minutes after removing the joint from the oven, the meat (*longissimus thoracis* only) was cut into 1 cm^3 portions, wrapped in foil and served warm to the members of the taste panel (De Bruyn, 1983). Evaluations were made on an unstructured five-point scale, ranging from least to most acceptable, for tenderness, juiciness, flavour and residue.

The results were analysed statistically in one- or two-way analyses of variance and breed differences were measured in *F* tests. Least significant differences (LSD) were determined between means. Significances are quoted at the $P < 0{,}01$, $P < 0{,}05$ and $P < 0{,}10$ levels.

Results and Discussion

In this comparison of the textural characteristics of the meat of young Afrikaner, Nguni and Pedi bulls, the multi-dimensional nature of meat quality has been taken into account with seven parameters being tested. Tenderness is most probably the most important quality parameter affecting consumer acceptance of meat (Cross, Durland & Seideman, 1986). Tenderness has been defined as the initial impression of softness (Ginger & Weir, 1958). The results (Table 1) show that no significant breed or mass effect was found in the taste panel evaluation of tenderness, although tenderness decreased in all three breeds as growth proceeded. The LSD tests showed the Afrikaner to have slightly more tender meat than the Nguni ($P < 0{,}10$). These results, compared with those of Naudé *et al.* (1980), would indicate tenderness of meat to be an inherent characteristic of the Afrikaner breed. The shear tests did not show any breed effect, although a mass effect did appear to be significant ($P < 0{,}01$). This did not interact with breeds. Shear force and tenderness were correlated inversely and highly significantly (Table 2) ($r = -0{,}61$), illustrating the reliability of both the subjective taste panel evaluation and the objective mechanical measurement of tenderness in this analysis. The tenderness values obtained in this trial, from the initial slaughter group to the 390 kg group, correspond with the values obtained for A age (0 permanent teeth) steers by Klingbiel (1984). The relative low rating of the 390 kg group of the Nguni bulls (2,88 ± 0,48) is closer to that of the B age group. The possibility of cold shortening affecting tenderness, as reported by Klingbiel (1984), was minimized by electrically stimulating the carcasses (Swanepoel *et al.*, 1990) and chilling moderately at 4°C for 19 h.

In terms of residue, defined as the amount of residual material remaining after chewing (Ginger & Weir, 1958), a slight breed effect was found ($P < 0{,}10$), with meat from the Afrikaner bulls leaving less residue than the Nguni ($P < 0{,}05$). The mass effect was highly significant ($P < 0{,}01$) due to increasing residues with growth. No breed × mass interaction occurred. Residue was highly correlated with tenderness ($r = 0{,}74$) and with shear force ($r = -0{,}49$) on the pooled data. Individually, the correlations between residue and shear force were significant only at the $P < 0{,}10$ level in the Afrikaner ($r = -0{,}42$) and Pedi ($r = -0{,}42$). The Nguni, however, showed a highly significant correlation ($r = -0{,}58$).

Juiciness applies to both raw and cooked meat. In raw meat, juiciness is determined primarily by the water-binding capacity of the sarcoplasmic proteins, muscle fibre integrity, and to a small degree by the intramuscular fat (Lawrie, 1985). In cooked meat, juiciness is due to both the rapid release of meat fluid and the stimulatory effect of fat on salivation (Weir, 1960). In this study, juiciness was determined on the *longissimus dorsi* muscle of the wingrib roasted to a core temperature of 70°C. The results (Table 1) indicate no differences between the breeds, but a loss of juiciness between 290 and 390 kg ($P < 0{,}05$). Juiciness *per se* is also a multi-dimensional trait being influenced by cooking loss and free water, which in turn are influenced by the denaturing effect of heat on the myofibrillar proteins. The correlation between cooking loss and juiciness was $r = -0{,}57^{**}$ (Table 2), indicating a decrease in juiciness due to cooking loss. No breed differences occurred in percentage cooking loss and free water. The cooking loss of A age steers reported by Klingbiel (1984), was in the region of 20% (primerib fat content 18,3%), with a significant increase with age, compared with the 12—17% reported here (primerib fat content 20%). The correlation between free water and juiciness was positive, though non-significant, whereas thát between cooking loss and free water was negative (also non-significant), reiterating the correlation between cooking loss and juiciness. The percentage free water decreased with age in association with the increase in percentage intramuscular fat reported by Swanepoel *et al.* (1990). The possible effect of heating the wingrib to a core temperature of 70°C on juici-ness and free water cannot be ignored. Myofibrillar and sarcoplasmic proteins begin to denature between 40°C and 60°C, and gradually decrease their solubility, with the exception of actomyosin which loses its solubility at 80°C plus. Denaturation by heating causes myofibrillar proteins to contract, decreasing the immobilized water and increasing the expressible fluid (Ritchey & Hostetler, 1965; Hamm, 1969; Hostetler & Landman, 1968; Cheng, 1976). The shrinkage of collagen may be responsible also for squeezing

Table 2 Linear regressions between textural parameters

Correlants			Regression			
x	y	Breed	a	b	r^2	r
Shear force	Tenderness	A	4,9818	−0,0163	0,4522	−0,67
		N	5,0367	−0,0195	0,3361	−0,58
		P	5,0373	−0,0194	0,3151	−0,56
		Pooled	5,0303	−0,0186	0,3768	−0,61
Residue	Tenderness	A	−0,3500	0,8905	0,5355	0,73
		N	−0,2581	0,8284	0,5257	0,73
		P	−0,0702	0,8019	0,4986	0,71
		Pooled	−0,3373	0,8675	0,5437	0,74
Shear force	Residue	A	5,0655	−0,0085	0,1803	−0,42
		N	5,0367	−0,0195	0,3361	−0,58
		P	5,3276	−0,0129	0,1793	−0,42
		Pooled	5,3383	−0,0126	0,2393	−0,49
Cooking loss (%)	Juiciness	A	5,7335	−0,1778	0,4679	−0,69
		N	5,5289	−0,1728	0,2576	−0,51
		P	5,1916	−0,1477	0,2613	−0,51
		Pooled	5,4868	−0,1661	0,3277	−0,57
Cooking loss (%)	Free water	A	64,0996	−0,8384	0,2066	−0,45
		N	71,4026	−1,3213	0,2105	−0,46
		P	56,4086	−0,3931	0,0415	−0,20
		Pooled	62,9626	−0,7835	0,1334	−0,37
Free water (%)	Juiciness	A	−0,0953	0,0808	0,3282	0,57
		N	1,9189	0,0196	0,0275	0,17
		P	2,4934	0,0090	0,0036	0,06
		Pooled	1,0147	0,0384	0,0791	0,28

Degrees of freedom: Afrikaner (A), 18; Nguni (N) and Pedi (P), 19; pooled, 58.

hydrated water from muscle to its free form (Cross *et al.*, 1986), and lost during the cooking process.

Flavour is the complex combination of olfactory and gustatory attributes perceived during tasting and may be affected by tactile, thermal, pain and even kinaesthetic effects (Cross *et al.*, 1986). The flavour of cooked meat is mainly due to the release of flavorous juices, including fat and volatile aromatic compounds (Patterson, 1975; Cross *et al.*, 1986). The flavour ratings given indicate a slight preference ($P < 0{,}10$) for the Afrikaner over the Nguni, but no different from the Pedi. A slight mass effect ($P < 0{,}10$) and breed × mass interaction also occurred.

Conclusion

In terms of textural attributes of the meat, no overall differences could be established between young Afrikaner, Nguni and Pedi bulls. Considering these results with the breed comparisons reported by Naudé *et al.* (1980), the Afrikaner has an inherent advantage of having tender meat. These results also indicate that the palatability of meat of young indigenous bulls compares favourably with that of purebred and crossbred steers and A age carcasses drawn from the market (Naudé, *et al.*, 1980; Klingbiel, 1984), and would be acceptable to the consumer.

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