The influence of the genotype of the sire and dam on beef tenderness

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SUMMARY: The meat tenderness of certain sire (Afrikaner-A, Brahman-B, Charolais-C, Hereford-H & Simmentaler-S) and dam (A & Bonsmara-Bo and BA, CA, HA & SA two-way crosses) genotypes were evaluated. Weaner steers of these genotypes were slaughtered immediately post weaning (±210 kg) and, after intensive feeding, at 340, 380 and 440 kg live masses respectively. Meat tenderness evaluations included shear force determinations on meat samples subjected to a moist (one hour at 60, 70 and 80 °C respectively) and dry cooking method (160 °C to internal temperature of 70 °C) respectively. The latter oven-roasted sample was also evaluated by a sensory panel (five point scale) for tenderness. Significant (P<0,05 & P<0,01) meat tenderness differences were only due to sire effect. These sire differences were primarily the result of the less tender meat of S- and B-sired genotypes. When including the B and S respectively in crossbreeding systems with the A, the most favourable heterosis responses were observed in the BA backcrossing to the A-sire (ABA-25 % B) and SA two-way cross (50 % S) respectively.

INTRODUCTION: Meat tenderness is the characteristic that the consumer in South Africa (NEL *et al*., 1989) as well as internationally (LAWRIE, 1985) considers to be the most important for the palatability of beef. It is therefore important to note that meat tenderness is also the quality characteristic that reveals the largest within-population variation, primarily due to the influence of the genotype, sex and age of the animal. In studies on the influence of genotype on beef tenderness, it became evident that the largest between-genotype variation in meat tenderness was due to the negative influence of the Brahman (RAMSEY *et al*., 1963; MCKEITH *et al*., 1985). In a consumer survey, MARCHELLO *et al*. (1979) also found that cuts from cattle with Brahman infusion consistently scored lower for tenderness and overall acceptance.

According to CUNDIFF *et al.* (1987), adverse effects, e.g. the lack of tenderness in meat, could be reduced to a large extent by means of crossbreeding through the utilization of, *inter alia*, heterosis. Considering the important role of the Brahman in the South African beef industry, it was therefore inevitable that the meat tenderness characteristics of this genotype together with those of other major genotypes such as the Afrikaner, Charolais, Bonsmara, Hereford and Simmentaler should be investigated. Such a comparative evaluation would of necessity, also include consideration of crossbreeding as a possible means of overcoming any undesirable characteristics (e.g. less tender meat) which were anticipated in certain genotypes.

MATERIALS AND METHODS: Six purebreds, eight two-way crosses and 20 three-way crosses were evaluated with the Afrikaner (A) as the predominant dam genotype and the A, Brahman (B), Charolais (C), Hereford (H) and Simmentaler (S) as the respective sire genotypes. The Bonsmara (Bo) was also included, both as a purebred and a dam genotype in combination with the above-mentioned sire genotypes (except with A). From each sire genotype between 11 - 17 bulls were used. Weaner steers of these genotypes (34) were intensively fed (average: ME = 10,50 MJ/kg & CP = 11,86 %) in individual feeding pens and slaughtered immediately post weaning (±210 kg) and at 340, 380 and 440 kg live masses respectively for further analysis. Meat tenderness evaluations included the following:

a) Three equal portions of the left *M. longissimus thoracis* (LT: 8, 9 & 10th ribcut - seven days cold storage at 0-5 °C) were cooked in a plastic bag in waterbaths for one hour at 60, 70 and 80 °C respectively. A 25,4 mm diameter cylindrical core from each sample was tested for tenderness with the aid of an Instron Universal Testing Machine Model 1140 (shear force: Newton/25,4 mm), fitted with a Warner Bratzler shearing device.
b) After a 7-day ageing period (0-5 °C) the bone-in wingrib (11, 12 & 13th rib cut - left side) of each carcass was oven-roasted (160 °C) to an internal temperature of 70 °C. Cubes (15x15x15 mm) of the LT in this cut were subsequently evaluated by a sensory panel, using a five point measuring scale (1 = least and 5 = most favourable) for tenderness, *inter alia*. Shear force determinations (LT) were also carried out on this meat sample (25,4 mm core).

Meat tenderness results were analysed by least-square analysis of variance (HARVEY, 1988), with significant (P<0,05) group and genotypic differences separated by the Student's t-test. For the purpose of this presentation, the 34 genotypes were combined in common sire (A, B, C, H & S) and dam groups (A & Bo and BA, CA, HA & SA) and analyzed. The degrees of heterosis were determined for the two-way and backcrosses when combining the A respectively with the B, C, H and S in crossbreeding. The degrees of heterosis were also calculated for the Bo two-way crosses when sired by the B, C, H and S respectively.

RESULTS: The analysis of variance and least-square means of the different meat tenderness characteristics for the respective sire/dam groups are presented in Table 1. A significant (P<0,05 & P<0,01) sire effect was evident for the sensory tenderness score and the four shear force determinations respectively (Table 1). Shear force results (70 & 80

°C and sensory sample) highlight especially the less tender meat of B- and S-sired genotypes (Table 1). For these three shear force determinations, the A-, C- and H-sired genotypes had significantly (P<0,05) more tender meat (LT) than the B- and S-sired genotypes. The shear force determination on the lowest waterbath cooking temperature (60 °C) again favoured the H-, A- and especially the C-sired genotypes (Table 1). In the sensory tenderness evaluation, the A- and C-sired genotypes gave significantly (P<0,05) higher scores than the B- & S- and B-sired genotypes respectively. It is thus evident that the most favourable tenderness results were obtained from genotypes sired by either an A-, C- or H-bull, while the B- and S-sire were responsible for the least tender meat to approximately the same extent.

When considering the effect of the respective dam groups, both the A/Bo- and two-way cross dams had a non-significant effect on all meat tenderness characteristics (Table 1), with the result that meat tenderness differences within a crossbred population depended primarily on the specific sire(s) utilised. In this study, the extent to which heterosis could be utilized for an improvement in meat tenderness is illustrated in Table 2 and discussed as follows:

B-crosses: With the exception of the sensory tenderness score, the backcrossing of the BA-dam to the A-sire (ABA) was the only cross that consistently showed positive heterosis for these characteristics. When considering all meat tenderness characteristics, only the ABA (25 % B) compared favourably with the A. When the A- or Bo-dam was used for terminal crossbreeding with the B-sire, the BBo showed a high degree of positive heterosis for the sensory meat tenderness score and the BA showed a consistently positive heterosis response for the shear force determinations at 60 and 70 °C (Table 2).

C-crosses: The backcrosses of the CA two-way cross to either of the parent genotypes (ACA & especially CCA), resulted in high degrees of heterosis for the different tenderness determinations. The CA two-way cross showed a favourable heterosis response for the sensory determinations only. In contrast to the inconsistent heterosis effect of the CA (A-dam), the CBo (Bo-dam) demonstrated a consistently favourable degree of heterosis for all meat tenderness characteristics (Table 2).

H-crosses: Although no fixed pattern favouring a specific cross could be deduced from the heterosis results, it became evident that, for almost all meat tenderness characteristics, one of the backcrosses (AHA or HHA) rather than the two-way cross (HA), showed the highest degrees of heterosis. In the A/Bo-dam comparison (two-way crosses), the only distinct differences were in the higher degrees of heterosis of the HBo for shear force (60, 70 & 80 °C) (Table 2).

TABLE 1: ANALYSIS OF VARIANCE AND LEAST-SQUARE SIRE/DAM MEANS AND STANDARD ERRORS OF THE MEAT TENDERNESS CHARACTERISTICS

SIRE/DAM GROUP	SHEAR FORCE (N/25,4 mm)			SENSORY TENDERNESS SCORE	SENSORY SHEAR FORCE (N/25,4 mm)
	60 °C	70 °C	80 °C		
F-VALUE:					
SIRES	6,98**	7,27**	12,3**	3,21*	10,2**
A/Bo-DAM	0,10	0,38	0,44	0,23	0,13
TWO-WAY DAM	1,14	1,61	0,46	0,67	1,29
SIRE:					
A	$51,4 \pm 1,47^{ab}$	$82,6 \pm 2,94^{a}$	$91,9 \pm 3,47^{a}$	$3,02 \pm 0,10^{a}$	$130 \pm 5,29^{a}$
B	$55,1 \pm 1,50^{bd}$	$92,5 \pm 2,92^{b}$	$109 \pm 3,52^{b}$	$2,59 \pm 0,10^{b}$	$155 \pm 5,26^{b}$
C	$47,0 \pm 1,60^{c}$	$79,0 \pm 3,17^{a}$	$87,8 \pm 3,75^{a}$	$2,91 \pm 0,11^{ac}$	$132 \pm 5,67^{a}$
H	$49,3 \pm 1,56^{ac}$	$78,0 \pm 3,17^{a}$	$90,5 \pm 3,54^{a}$	$2,81 \pm 0,10^{abc}$	$136 \pm 5,33^{a}$
S	$56,6 \pm 1,44^{d}$	$95,9 \pm 2,87^{b}$	$115 \pm 3,38^{b}$	$2,66 \pm 0,09^{cb}$	$168 \pm 5,08^{b}$
OVERALL MEAN	51,9 ± 0,68	85,7 ± 1,34	98,9 ± 1,58	2,78 ± 0,04	144 ± 2,38
A/Bo DAM:					
A	52,0 ± 1,62	84,9 ± 3,12	98,3 ± 3,84	2,88 ± 0,11	145 ± 6,05
Bo	51,3 ± 1,57	87,5 ± 2,95	102 ± 3,81	2,81 ± 0,10	148 ± 5,94
OVERALL MEAN	51,7 ± 1,13	86,2 ± 2,15	100 ± 2,70	2,84 ± 0,08	147 ± 4,24
TWO-WAY DAM:					
BA	54,7 ± 1,61	92,4 ± 3,23	104 ± 3,96	2,79 ± 0,10	139 ± 5,98
CA	51,9 ± 1,51	84,0 ± 2,99	100 ± 3,70	2,71 ± 0,10	144 ± 5,42
HA	50,7 ± 1,78	83,4 ± 3,51	97,1 ± 4,34	2,88 ± 0,11	143 ± 6,40
SA	51,3 ± 1,49	86,2 ± 2,97	99,4 ± 3,67	2,69 ± 0,10	154 ± 5,42
OVERALL MEAN	52,1 ± 0,80	86,5 ± 1,59	100 ± 1,96	2,77 ± 0,05	145 ± 2,91

a,b,c,d -Means within columns of each sire/dam group with different superscripts differ significantly (P<0,05)
* - P<0,05 ** - P<0,01

TABLE 2: LEAST-SQUARE GENOTYPIC MEANS AND ESTIMATED HETEROSIS EFFECT (%) OF THE DIFFERENT MEAT TENDERNESS CHARACTERISTICS

	SHEAR FORCE (N/25,4 mm)			SENSORY TENDERNESS SCORE	SENSORY SHEAR FORCE (N/25,4 mm)
	60 °C	70 °C	80 °C		
B-CROSSES:					
A (0 % B)	51,7^{a}	82,5^{a}	89,4^{a}	3,09^{a}	140
ABA (25 % B)	52,9^{a} (+7,1)	88,0^{ab}(+2,6)	93,7^{ab}(+5,5)	2,74^{ab}(-2,8)	129(+11,6)
BA (50 % B)	54,0^{a}(+13,1)	91,2^{ab}(+7,2)	109^{bc}(-0,2)	2,50^{bc}(-2,1)	158 (-3,6)
BBA (75 % B)	59,6^{a}(+11,6)	104^{bc}(+2,4)	127^{c} (-7,2)	2,22^{bc}(-2,7)	161 (-1,0)
B (100 % B)	72,6^{b}	114^{c}	129^{c}	2,01^{c}	166
C-CROSSES:					
A (0 % C)	51,7	82,5	89,4	3,09^{a}	140^{ab}
ACA (25 % C)	52,5 (-3,1)	80,2 (+2,0)	89,0 (+2,4)	3,22^{a}(+11,4)	125^{a} (+13,3)
CA (50 % C)	53,0 (-5,4)	84,5 (-4,1)	93,7 (-0,9)	3,05^{a}(+13,4)	136^{ab} (+9,0)
CCA (75 % C)	43,8(+11,6)	76,0 (+5,5)	87,1 (+8,0)	2,65^{ab}(+6,4)	138^{ab}(+10,2)
C (100 % C)	48,9	79,7	96,4	2,30^{b}	158^{b}
H-CROSSES:					
A (0 % H)	51,7	82,5	89,4	3,09	140
AHA (25 % H)	46,0 (+8,3)	75,4 (+5,5)	90,2 (-2,1)	2,86 (-8,0)	120(+12,6)
HA (50 % H)	49,1 (-0,7)	76,8 (+0,4)	86,9 (+0,3)	3,07 (-1,8)	127 (+5,9)
HHA (75 % H)	49,1 (-3,7)	68,7 (+7,6)	75,6(+12,1)	3,20 (+1,8)	120(+10,1)
H (100 % H)	45,9	71,6	84,9	3,17	131

a,b,c -Means within columns of each genetic group with different superscripts differ significantly ($P<0,05$)
+/- -Positive sign indicates an improved effect, e.g. a decrease in shear force and an increase in sensory tenderness score. Negative sign indicates an opposite effect.

TABLE 2 cont.: LEAST-SQUARE GENOTYPIC MEANS AND ESTIMATED HETEROSIS EFFECT (%) OF THE DIFFERENT MEAT TENDERNESS CHARACTERISTICS

	SHEAR FORCE (N/25,4 mm)			SENSORY TENDERNESS SCORE	SENSORY SHEAR FORCE (N/25,4 mm)
	60 °C	70 °C	80 °C		
S-CROSSES:					
A (0 % S)	51,7^{a}	82,5^{a}	89,4^{a}	3,09^{a}	140^{a}
ASA (25 % S)	52,3^{a} (+4,3)	85,4^{a} (+4,8)	93,4^{a} (+6,2)	3,10^{a} (+8,2)	130^{a}(+14,4)
SA (50 % S)	51,8^{a} (+9,9)	86,4^{a}(+11,0)	102^{ab}(+7,0)	2,97^{ab}(+12,7)	156^{ab}(+5,4)
SSA (75 % S)	53,5^{a}(+11,5)	93,8^{a}(+11,5)	113^{bc}(+5,4)	2,46^{bc} (+2,0)	180^{bc}(-1,4)
S (100 % S)	63,4^{b}	112^{b}	130^{c}	2,19^{c}	190^{c}
Bo TWO-WAY:					
BBo (50 % B)	+7,3	-3,3	-0,7	+12,3	-3,9
CBo (50 % C)	+9,5	+6,7	+6,9	+22,3	+9,3
HBo (50 % H)	+9,1	+4,8	+4,8	-14,9	-3,0
SBo (50 % S)	+12,3	+3,4	+5,3	+4,9	+12,5

a,b,c -Means within columns of each genetic group with different superscripts differ significantly ($P<0,05$)
+/- -Positive sign indicates an improved effect, e.g. a decrease in shear force and an increase in sensory tenderness score. Negative sign indicates an opposite effect.

S-crosses: Shear force (60, 70 & 80 °C) showed a positive heterosis response for all three crosses. The SA and also the ASA (A-sire) showed higher positive responses for the evaluations on the sensory sample. Similar to the SA (A-dam), the SBo (Bo-dam) demonstrated a positive heterosis response for all meat tenderness characteristics. This positive heterosis effect in the SA especially, resulted in this cross (50 % S blood) comparing favourably in meat tenderness with the purebred A. Thus, in order to ensure a general meat tenderness similar to the purebred A, the B- and S-crosses should possess not more than 25 % B- and 50 % S-blood respectively (Table 2).

DISCUSSION: A general consideration of meat tenderness characteristics in this study points primarily towards a significant sire effect on meat tenderness (Table 1), with these sire differences mainly due to the comparatively less tender meat of the B- and S-sired genotypes (Table 1). This specific effect of the B has been investigated intensively world-wide and confirmed as being less tender (KELLAWAY, 1973; RILEY *et al.*, 1986). WILLIAMS *et al.* (1988) further emphasized the meat toughening effect of the B by indicating that a gradual decrease in tenderness existed with a concomitant increase in the percentage B-genes. A similar response was observed in this study with a prominent effect evident especially in shear force (80 °C) and the sensory tenderness score (Table 2).

Although these results could point towards a general *Bos indicus* effect on meat tenderness (less tender), meat tenderness results of the alternative *Bos indicus* genotype, viz. the A, were amongst the most favourable (Table 1). The favourable results of the A were confirmed by VON LA CHEVALLERIE (1964) and BOCCARD *et al.* (1979). In the work of VON LA CHEVALLERIE (1964) the A did not differ significantly in meat tenderness from the Brown Swiss, Drakensberger, Friesian and H, while BOCCARD *et al.* (1979) found that the A produced more tender meat than the Friesian. Important factors could be the fact that the B is *Bos indicus* zebu (origin India) and the A is *Bos indicus* Sanga (origin Africa).

Contrary to the general consensus in the literature regarding the less tender meat of the B, the less tender meat of the S-sired genotypes (Table 1) is not supported to the same extent. A few studies only reported less tender meat for S-associated genotypes (e.g. KOCH *et al.*, 1976), while the majority indicated favourable meat tenderness for the S (e.g. MAY *et al.*, 1977; MILLER *et al.*, 1987).

The use of the A (dam or sire) and the Bo-dam in crossbreeding programmes with the B and S proved to be important aids in reducing the less favourable effects of the latter genotypes. A sufficient degree of heterosis was, however, obtained only when the B two-way cross was crossed back to the alternative genotype (A) (Table 2). This deduction is supported by WILLIAMS *et al.* (1988) in a crossbreeding study with the B and Angus. High degrees of heterosis in the S two-way crosses allowed these genotypes to show favourable tenderness results. In general, the high degrees of heterosis observed when utilizing the indigenous A (preferably as sire) and Bo in crossbreeding programmes (Table 2), contrasted with the general finding in the literature that meat quality characteristics (including tenderness) showed low positive or negative degrees of heterosis (URICK *et al.*, 1974).

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