Anim. Prod. Aust. 2002 Vol. 24: 177-180

ARE THERE MEAT QUALITY DIFFERENCES BETWEEN CATTLE BREEDS IN SOUTHERN AUSTRALIA?

W.S. PITCHFORD [A], Z.A. KRUK [A], E.M. STEPHENS [A,C], P.A. SPECK [B,D] and M.P.B. DELAND [B]

[A] Livestock Systems Alliance, Adelaide University, Roseworthy SA 5371, Australia
[B] South Australian Research and Development Institute, Struan Agricultural Centre, Naracoorte SA 5271
[C] Present address: PIRSA Rural Solutions, Struan Agricultural Centre, Naracoorte SA 5271
[D] Present address: Meat and Livestock Australia, Locked Bag 991, North Sydney NSW 2059

SUMMARY
The Southern Crossbreeding Project was designed to examine a range of *Bos taurus* cattle breeds for production and beef quality traits. Jersey, Wagyu, Angus, Hereford, South Devon, Limousin and Belgian Blue sires were mated to Hereford cows with calves born over four years (1994-97). By testing two cohorts (1995-drop steers and 1996-drop heifers) representing 50 sires, it was concluded that there were no breed differences in tenderness or pH but there were differences in juiciness. Breeds high in intramuscular fat (Jersey and Wagyu) and the double-muscled Belgian Blue had less cooking loss than the other breed combinations.

Keywords: cattle breeds, tenderness, cooking loss, meat quality

INTRODUCTION
Tenderness and juiciness are key factors affecting consumer decision to purchase beef.. The Southern Crossbreeding (SXB) Project aimed to help beef producers to consistently produce beef to a range of market specifications. This is being achieved by studying genetic aspects of the many traits associated with beef production, using a range of sire breeds. The Project progressively evaluated carcass development of the progeny using liveweight, ultrasound and biopsy sampling followed by slaughter at weights required by Australia's major domestic and export markets. Previous publications have dealt with the fertility (Deland *et al.* 2001), calving (Rutley *et al.* 1997), growth and carcass composition (Ewers *et al.* 1999), fat quality (Pitchford *et al.* 2001) and flavour (Stephens *et al.* 1999) aspects of the study. This paper concentrates on the meat tenderness and juiciness.

MATERIALS AND METHODS
Animals and management
In June 1993-6, sires from seven breeds (Angus, Belgian Blue, Poll and Horned Hereford, Jersey, Limousin, South Devon and the Japanese Wagyu) were mated to mature Hereford cows. There were generally three sires per year for Angus and Hereford and four sires per year for the remaining breeds. The calves were born in March-April and weaned each year (1994-97) in December at approximately 250 days of age. Calves were born at two locations (Struan and Wandilo) in the south east of South Australia. At weaning, all calves were transported to Struan Research Centre where they were randomly allocated to three management groups. Thus, there were six combinations of pre and post-weaning management although not all of these combinations were present for both cohorts reported herein: the 1995-drop steers (173) and 1996-drop heifers (145) representing 50 sires.

Cattle were trucked for only two hours, arriving at the abattoir 20 hours prior to slaughter. They were slaughtered at endpoints equivalent to Japanese feedlot steers and domestic feedlot heifers as defined for the Cattle and Beef Quality CRC (Robinson *et al.* 2001). Steers were slaughtered at Murray Bridge (Metro Meats, now T&R Pastoral) during May 1997 (approximately 750 days of age) after 180 days in a feedlot. Heifers were slaughtered at Gepps Cross (SAMCOR) during June 1997 (approximately 420 days days of age) after 90 days in a feedlot.

Measurements
Cattle were stunned with a captive bolt before carotid arteries were severed. Within five minutes, all carcasses were electrically stimulated using extra low voltage (<45V). Carcasses were trimmed to Australian minimum standards (AUSMEAT®), then the hot standard carcass weight (HSCW) and fat depth on the rump (P8 fat) were measured before entering the chiller (0-4°C). After being chilled overnight to a deep butt temperature <20°C, the carcasses were split at various rib sites according to market specifications. The cross-sectional area of the *M. longisimus dorsi* (eye muscle area or EMA,

cm^2) was measured and the carcasses were scored (not reported) for meat colour, fat colour and marbling. Full striploin primals (*M. longisimus dorsi*) were then individually wrapped and transported to the University where they were frozen (-18°C) and stored until being analysed (Stephens *et al.* 1999) for intramuscular fat content (IMF, %), pH, loss of moisture during cooking (%) and tenderness or toughness (Warner-Bratzler peak shear force, WBSF kg). A summary of the data (mean, min, max, CV) is presented in Table 1.

Statistical analysis

Since EMA was measured at a number of sites, adjustment equations developed by D.L. Rutley (unpublished) were used to adjust all values to $10/11^{th}$ rib site. This was done by assuming the $9/10^{th}$ rib is 91%, $11/12^{th}$ is 104%, and $12/13^{th}$ is 102% of the EMA at $10/11^{th}$ rib. The distribution of all traits was examined for deviations from normality. Two of the traits (pH and WBSF) comprised small numbers of high values. However, for both traits, a log transformation had no effect on conclusions so for simplicity only the original data is presented.

Differences between ages of animals were tested by forming four birth groups of animals; the first 25% of those born, second 25%, etc. A linear regression of day of birth within each of these groups was tested but removed because it was not significant for any of the traits reported. Cohort by birth group interactions were also tested but deleted because they were not significant.

Cohort effects were a function of sex confounded with year and target market and considered to be largely a function of animal size and age rather than due to sex *per se*. As described above, there were six pre- and post-weaning management groups. These management groups were nested within cohort since the effects were not expected to be consistent across years. There were some missing subclasses so there were nine (four for heifers and five for steers) rather than 12 combinations.

Sire breed and the breed by cohort interaction were included in the model. Sire was fitted as a random effect and nested within the breed by cohort interaction. The sire variance was used as the error term (38df) for testing the significance of cohort, sire breed and breed by cohort interaction effects. The residual error term (255df) was used for the significance of birth and management group effects. Significance is defined as P<0.05 based on type III SS using the Mixed procedure (SAS 1992).

RESULTS

Age effects (within cohort) were significant only for carcass weight and cooking loss (Table 1). For cooking loss, the trend was that younger animals had more loss. The oldest calves (first 25% born) lost 15±2% during cooking whereas the youngest group lost 21±2%. For carcass weight, the trend was less clear with the four age groups weighing 253±13, 273±3, 265±4, and 256±12kg respectively.

Table 1. Summary of data, analyses of variance and tests of significance

	HSCW (kg)	P8 fat (mm)	EMA (cm^2)	IMF (%)	pH	Toughness (kg F)	Cook Loss (%)
Mean	276	13	71	3.8	5.6	3.0	16
Minimum	149	2	105	1.0	5.4	1.8	9
Maximum	427	32	41	10.9	6.4	6.9	27
CV (%)	24	42	17	45	3	20	23
Mean Sq's.							
Birth Group	3.0*	2.6	0.1	2.5	0.5	0.7	2.8*
Cohort	362.2***	40.9***	1.3	18.9***	0.9	5.0*	0.1
LP[a] Group	5.1***	5.0***	2.3*	1.7	0.5	1.1	1.1
Breed	10.8***	9.3***	16.8***	10.9***	0.5	1.4	4.2**
Br'd. x C't.	0.3	1.4	0.4	2.8*	0.3	0.9	3.4**
Variances							
Sire[B]	122	0.00	12.7	0.00	.0002	.035	0.00
Residual	685	17.8	78.0	1.99	.0344	.328	12.3

[A]LP Group combination of birth location and postweaning management group.
[B]Sire nested within breed of sire by cohort interaction.
*P<0.05 **P<0.01 ***P<0.001

The cohort effect (combination of year and sex or market) was significant for most traits (Table 1). Steers were 54% heavier, 63% fatter (P8), had 36% higher IMF, and were 6% more tender (lower WBSF) than heifers (Table 2). Management group effects (within cohort) were significant for carcass weight, P8 fat depth, and eye muscle area (Table 1). Generally calves born at Wandilo were heavier and fatter than those at Struan. The post-weaning effects were variable but also important.

Table 2. Least squares means for Cohort and Sire Breed main effects

	HSCW (kg)	P8 fat (mm)	EMA (cm^2)	IMF (%)	pH	Toughness (kg F)	Cook Loss (%)
Cohort	***	***		***		*	
1996 Heifers	206±6	8±1	69±2	3.3±0.3	5.64±0.04	3.2±0.1	17.6±0.8
1995 Steers	317±5	13±1	72±2	4.5±0.3	5.61±0.04	3.0±0.1	17.4±0.7
Sire breed	***	***	***	***			**
Angus	275±7	14±1	69±2	4.5±0.3	5.64±0.05	3.2±0.2	17.8±0.9
Belgian Blue	273±7	8±1	80±2	2.9±0.3	5.60±0.05	3.2±0.2	17.6±0.9
Hereford	254±8	11±1	66±2	4.0±0.3	5.63±0.05	3.2±0.2	18.5±0.9
Jersey	229±7	11±1	59±2	4.7±0.3	5.59±0.05	2.9±0.2	15.3±0.9
Limousin	272±7	10±1	78±2	2.9±0.3	5.63±0.04	3.1±0.1	18.2±0.8
South Devon	280±7	10±1	76±2	3.9±0.3	5.64±0.05	3.1±0.2	18.4±0.9
Wagyu	247±7	13±1	66±2	4.3±0.3	5.64±0.04	3.0±0.1	16.8±0.8

*P<0.05 **P<0.01 ***P<0.001

Sire breed effects were highly significant for all traits except tenderness and pH. Sire breed effects were generally consistent for heifers and steers (Table 1). However, there was a significant interaction for intramuscular fat content and cooking loss. Over all traits, the two most extreme breeds were the Jersey and Belgian Blue. The Belgian Blue sired calves were 19% heavier, had 27% less subcutaneous fat, 36% larger eye muscle area, 38% lower intramuscular fat, and lost 15% more moisture during cooking than Jersey calves (Table 2). Although not significant, Jersey calves also had the most tender (lowest shear force) meat.

DISCUSSION

The steers differed from heifers by having more greater marbling (4.5 versus 3.3%), as expected for older (750 vs. 420 days) and fatter (13 vs. 8mm at P8 site) cattle (Trenkle *et al.* 1978). However, the steers were less heavily muscled than the heifers as evidenced by the small difference in eye muscle areas (4%, Table 2) despite much greater (54%) carcass weights. It is possible that this is a function of the heifers being finished younger. The heifers only experienced a slowed growth rate (<0.5kg/d) for, at most, 2 months (February-March 1997) whereas the steers gained negligible weight for at least 7 months (February-September 1996). From September until November, the growth of the steers on pasture was rapid (common for spring in Mediterranean environments) before entering the feedlot (eight months of rapid gain). However, lifetime growth rate was approximately 16% faster for the heifers than steers. An alternative hypothesis could be that cross-sectional area of the *M. longisimus dorsi* matures (reaches adult size) earlier than overall weight of the animal.

There was no difference between steers and heifers in pH or cooking loss, but beef from steers was more tender than from heifers. This was unexpected because of the large age difference and the well-documented effects of age on decreasing tenderness (Ferguson *et al.* 2001). However, the muscle tested has very low levels of connective tissue, which is the primary cause of age-related toughness. Of the 173 steers the maximum shear force was 4.1kg, and of the 145 heifers, two were between 5-6kg and one was above 6kg. Thus, in the whole study, consumers would have considered only 1% marginally tough (Perry *et al.* 2001). In addition, if pH values above 5.8 were considered undesirable, then none of the steers had high pH but 14 of the 145 heifers did have high pH. It is likely that this was due to either differences in pre-slaughter handling between the two abattoirs or cold shortening occurring in some of the leaner heifer carcasses. Neither of these effects can be quantified as the trial is now complete.

Despite large differences between breeds in size, fat and muscle, there were no breed differences in tenderness. Generally, shear forces less than 5kg are associated with high levels of consumer acceptability (Perry *et al.* 2001) and the breed averages were all well below that level (around 3kgF). The phenotypic variation in tenderness ($0.035+0.328=0.363kg^2$, Table 1) was much less than that reported by Robinson *et al.* ($0.54kg^2$, 2001) for temperate breeds and both studies had values lower

than commonly experienced by industry (Ferguson *et al.* 2001). It is likely that this is due to cattle being treated close to "best-practice" which included extra low voltage electrical stimulation.

The values for cooking loss were similar to the lowest values reported by the Cattle and Beef Quality CRC (Perry *et al.* 2001). Differences between breeds were reasonably large and suggest that for juiciness, the breeds tested ranked: Jersey, Wagyu, then Belgian Blue, Angus, Limousin, South Devon and Hereford. Cooking loss could have been associated with intramuscular fat content since fat cells have a lower moisture content than muscle cells. While Jersey and Wagyu were breeds with greater intramuscular fat content (Table 2), this was unlikely to be the cause of the low cooking loss since IMF was not a significant covariate. Furthermore, the Belgian Blue was also on the low side as found by other studies (e.g. Burrow *et al.* 2001). Thus, it is likely that the breed differences in cooking loss were a function of maintaining cell integrity during storage and cooking. Genetic effects on cell integrity have not been reported but nutritional effects have. An example is Mistumoto *et al.* (1995) who showed that cell integrity could be improved by vitamin E supplementation.

The management system utilised in this project is common to the high rainfall zones of southern Australia and this project indicates that high quality meat can be produced from a wide range of breed types. The study confirms the conclusion by Burrow *et al.* (2001) that within *Bos taurus*, there is negligible genetic variation in tenderness especially with "best practice" operations.

ACKNOWLEDGEMENTS

The contribution from farm staff at Struan and abattoir staff at both locations especially Metro was invaluable. In addition, we thank Austral Meats for access to their boning room, Heather Bray for conducting some of the tenderness measurements, Andrew Ewers, David Rutley and many other Adelaide University students for help with slaughters. AW&PR Davis (feedlot phase), SA Cattle Compensation Fund (project establishment), Elders Ltd. and the Australia Research Council (meat quality measurements) supplied funding.

REFERENCES

BURROW, H.M., MOORE, S.S., JOHNSTON, D.J., BARENDSE, W. and BINDON, B.M. (2001). *Aust. J. Exp. Agric*. **41**, 893-920.

DELAND, M.P.B., ROSS, R.A., ABRAHAM, E.A. and PITCHFORD, W.S. (2001) *Proc. Ass. Adv. Anim. Breed. Genet.* **14**, 333-6.

EWERS, A.L., DELAND, M.P.B., PITCHFORD, W.S., RUTLEY, D.L. and PONZONI, R.W. (1999). *Proc. Assoc. Adv. Anim. Breed. Genet.* **13**, 393-6.

FERGUSON, D.M., BRUCE, H.L., THOMPSON, J.M., EGAN, A.F., PERRY, D. AND SHORTHOSE, W.R. (2001). *Aust. J. Exp. Agric.* **41**, 879-92.

MITSUMOTO M. ARNOLD R.N. SCHAEFER D.M. and CASSENS RG. (1995). *J. Anim. Sci.* **73**, 2289-94.

PERRY, D., THOMPSON, J.M., HWANG, I.H., BUTCHERS, I., and EGAN, A.F. (2001). *Aust. J. Exp. Agric.* **41**, 981-9.

PITCHFORD, W.S., DELAND, M.P.B., SIEBERT, B.D. MALAU-ADULI, A.E.O. and BOTTEMA, C.D.K (2001). *Proc. Assoc. Adv. Anim. Breed. Genet.* **14**, 477-80.

ROBINSON, D.L., FERGUSON, D.M., ODDY, V.H., PERRY, D. AND THOMPSON, J.M. (2001). *Aust. J. Exp. Agric*. **41**, 997-1004.

RUTLEY, D.L. AND PITCHFORD, W.S. (1997). *Proc. Ass. Adv. Anim. Breed. Genet.* **12**, 194-7.

SAS (1992) Technical report P-229. SAS/STAT Software: Changes and Enhancements.

STEPHENS, E.M., PITCHFORD, W.S. AND SIEBERT, B.D. (1999). *Proc. Int. Cong. Meat Sc. Tech.* **45**, 446-7.

TRENKLE, A., DEWITT, D.L., TOPEL, D.G. (1978). *J. Anim. Sci.* **46**, 1597-1603.

Email:wayne.pitchford@adelaide.edu.au