THE EFFECT OF EXTREME CROSS BREEDING (CHAROLAIS X NGUNI) ON GROWTH PERFORMANCE AND MEAT AND CARCASS QUALITY

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Abstract – Growth, carcass, meat quality and muscle characteristics of Charolais (Ch) and Charolais x Nguni bulls (ChNg) were evaluated to add to a reference data base of production and product characteristics of various South African cattle breeds. Data recorded on growth performance and carcass yield confirmed common knowledge that the Charolais is a later maturing and the Charolais x Nguni a medium maturing beef breed. Over the same duration and conditions of feeding, the Charolais had a better feed conversion and growth rate and produced larger carcasses than Charolais x Nguni. The Charolais x Nguni performed better than pure Ngunis from previous trials and was similar to Bonsmara types. Due to the large difference in carcass size, the Charolais dressed out higher at slaughter and also had a better meat to bone ratio than the Charolais x Nguni. Both breeds produced meat of good eating quality and considering the fact that much attention was given to slaughter procedures, it is evident that breed plays a minor role in meat quality.

Key Words – ADG (average daily gain), Dressing percentage, FCR (feed conversion ratio), tenderness.

I. INTRODUCTION

Efficiency of meat production is continuously under pressure for different reasons but similar outcomes. On the one hand the exponential estimated human population growth (to 8.9 billion in 2050) coupled with increased per capita consumption due to a growing middle class in developing countries will lead to an increase in demand of 32% in developing countries and 14% in developed countries by 2030 [1]. On the other hand agriculture, and meat production in particular, is accused of contributing to a large proportion of total anthropogenic greenhouse gasses (GHG) or the so-called carbon foot print [2]. Capper [3] and others have reported how advancements in genetics, nutrition, animal health and reproductive performance could reduce GHG. Under reproductive performance the economy of the cow-calf unit is also considered. Africa has a large numbers of indigenous breeds that have adapted to the continent's diverse and often challenging climatic conditions [4]. However, when considering the need for increased slaughter animal weight in intensive feeding conditions as propagated by Capper [3], the low mature size of the most numbered indigenous breed in southern Africa, the Nguni, negates this breed's other favourable characteristics. To solve this problem, while considering the environmental challenges in the region it was proposed by Scholtz *et al.* [4] that the Nguni cow should be used in terminal cross-breeding programs using larger beef breeds as sire lines. Off-spring should then be finished in grain fed systems. They recorded no calving difficulties when Chianina, Charolais, Simmental or Hereford was used as sire lines on Nguni cows. The ratio of weaning weight of the calf to the dam weight, the estimate of cow herd productivity, was 57.2 for the Charolais-Nguni cross compared to 49.3 for the pure Nguni and 43.8 of the national average of all breeds in South Africa. Considering all efficiency parameters used by Scholtz *et al*. [4], the Charolais came out superior when utilized as a terminal sire in cross-breeding, which agrees with the work of Olentine *et al.* [5] and Baker *et al.* [6]. The Charolais breed is generally regarded as a late maturing beef breed. Due to climatic challenges, the pure breed is not suitable for large parts of Southern Africa and considering the challenge to improve efficiency, the size of the Charolais cow may disqualify the breed on the basis weaned calf to the dam weight ratio under these conditions.

While yield and efficiency is of paramount importance in the challenge to meet the increased demand for meat over the next decades, the consumer still have the final say with regards appearance and palatability of the product [7]. In this study we attempt to demonstrate the suitability

of the Nguni cow in an extreme crossbred system with the Charolais, by characterising the growth performance, yield and meat quality of the Nguni-Charolais cross bred calf under grain fed conditions. Pure Charolais bulls were used as control.

II. MATERIALS AND METHODS

Treatment groups consisted of 10 intact male animals of pure Charolais (Ch) origin and 10 intact male Charolais x Nguni crosses (ChNg). Feed intake was monitored on a group basis. After initial processing, live weights were recorded weekly to determine average daily gain (ADG).

Carcasses were electrically stimulated (500 V, 2A output and 15 oscillations per second) after exsanguinations. Warm carcass weights were recorded to calculate total yield and dressing percentage. Cold carcass weights were also recorded. One side of each carcass was processed into 15 retail cuts. Each cut was separated into meat (muscle and intermuscular fat), subcutaneous fat and bone.

All samples were collected from the M. longissimus thoracis et lumborum (LD) after rigor mortis. Aged samples for Warner-Bratzler shear force (WBSF) were frozen at -20°C and then processed into 30 mm steaks. The frozen steaks were thawed at 2 ± 1 °C for 24 h and cooked using an oven-broiling (Mielé, model H217, Mielé & Cie, Gütersloh, Germany) method with direct radiant heat [8]. The steaks were broiled at 200°C to 70 °C internal temperature and cooled down to 18 °C. Six round cores (12.7 mm diameter) were removed from the steaks parallel to the muscle fibres [8]. Each core was sheared once through the centre, perpendicular to the fibre direction, by a Warner-Bratzler shear device mounted on an Universal Instron apparatus (Model 4301, Intsron Ltd, Buckinghamshire, England;.cross head speed = 20 mm/min) and the mean value of the 6 recordings were used as a shear value.

Samples for sarcomere lengths of a fresh LL samples (24 h post mortem), were prepared according the method of Hegarty *et al*. [9], by using distilled water instead of Ringer Locke solution. Fifty sarcomeres per sample were measured by means of a video image analyses (VIA) using an Olympus B x 40 system microscope at a 1 000 x magnification equipped with CC12 video camera (Olympus, Tokyo, Japan). AnalySIS Life Science software package (Soft Imaging Systems Gmbh, Münster, Germany) was used to process and quantify measurements. Myofibril fragment lengths (MFL) aged for 3 and 14 days post mortem were measured by means of VIA. Myofibrils were extracted according to Culler *et al*. [10] as modified by Heinze *et al*. [11]. One hundred myofibril fragments per sample were examined and measured with an Olympus B x 40 system microscope at a 400 x magnification.

Data of WBSF were subjected to analysis of variance for a split-plot design (GenStat® VSN International, Hemel Hempstead, UK; Payne *et al*. [12]) with the 2 breed groups (Ch and ChNg) as whole plots and the 2 ageing periods (3 and 14 days post mortem) as sub-plots. The rest of the data were subjected to normal analysis of variance with breed as main effect. Means were separated using Fisher's protected t-test least significant difference (LSD) at the 5% level (Snedecor *et al*., [13]).

III. RESULTS AND DISCUSSION

The Ch and Ch-Ng started the trial at average live weights of 236 and 171 kg (Table 1), respectively which coincide with the national average weaning weight of the Ch and is almost 20 kg heavier than the average Nguni (Ng) weaning weight according to National Beef Cattle Improvement Scheme (NBCIS) statistics. The Ch

Table 1 Means (±s.e.) for growth performance and carcass characteristics of the Charolais and Charolais x Nguni

	Ch	ChNg	*P* value	s.e.
Starting weight (kg)	236	171	< 0.001	4.59
Final weight (kg)	527	379	< 0.001	7.53
ADG (kg/day)	2.38	1.49	< 0.001	0.06
FCR (kg/day- dry matter basis	4.7	5.2		
Final carcass weight (kg)	320	224	< 0.001	4.58
Dressing %	60.6	59.0	< 0.001	0.27

gained 800 g/day more weight (P<0.001) than the Ch-Ng and needed 0.5 kg less feed per kg weight gain. The Ch gained 291 kg and the Ch-Ng 208 kg. Ch produced a carcass of 320 kg, 96 kg heavier than the ChNg on average and dressed out 1.6% points higher than the Ch-Ng (P<0.001) due to higher slaughter weight [14]. Larger animals at the same carcass fat level will dress out higher than smaller animals. Jones *et al*. [15] confirmed this maturity type effect, accounting for the differences in dressing percentage to significantly lower proportional yields of the fifth quarter parts for the larger animals. ADG of the ChNg was lower (200 g/day) but the FCR better (1.1 kg feed per kg gain) than data recorded by Scholtz *et al*. [4]. While the latter study showed a better performance for ChNg, our study recorded much better performances for Ch. Strydom *et al*. [16] reported on feedlot performances of pure Ng steers implanted twice with anabolic growth promoters and raised on the same diet as the present trial. In 2 trials Ng gained 1.3 and 1.5 kg on average with FCR's of 5.2 to 5.9 kg/kg over a 97 and 132 day period, respectively. The animals started the trial at 151 kg and 169 kg, respectively which was higher in the second trial than the breed's standard weaning weight of 151 kg. In the light of this evidence, the growth potential of the ChNg group was expected to be better but could probably be ascribed to a low weaning weight and poorer adaptation to the feedlot conditions. Carcass weights of ChNg bulls were higher than the first group of Ng steers (188 kg) but the same as the second group, while the ChNg dressed out higher than both groups (55% and 58% vs. 59%). More important, both Ng groups were fatter than the animals in the present trial at slaughter (7 mm vs. 2.9 mm rib fat).

According to Table 2, the carcass of the Ch had slightly less subcutaneous fat (SCF; non-significant P = 0.08), but significantly less bone (1.5% units) and more meat (meat = muscle + intermuscular fat; 2.3 % units) (P<0.001) than the ChNg carcass. Based on the fact that the % subcutaneous fat (SCF: visible fat on the dressed carcass) was almost the same, it means that for every kg bone the Ch and ChNg had 5.3 and 4.7 kg meat, a difference of 0.6 kg. Berg *et al*. [14] and De Bruyn [17] reported that carcasses of larger breeds (later maturing) should have more meat to bone at the same fatness, although there exceptions to this rule that tend to complicate such study results.

Table 2 Means (±s.e.) for carcass characteristics of the Charolais and Charolais x Nguni

	Ch	ChNg	*P* value	s.e.
Carcass tissue				
SCF%	4.06	4.90	0.08	0.296
Meat%	80.7	78.3	< 0.001	0.333
Bone%	15.2	16.8	< 0.001	0.275
Kidney and channel fat %	2.44	3.27	< 0.001	0.145
Meat to bone ratio		4.7	< 0.001	0.099
Total SCF (kg)	6.08	5.15	0.137	0.411
Total meat (kg)	121.1	81.5	< 0.001	1.430
Total bone (kg)	22.8	17.4	< 0.001	0.410

Shear force values for Ch and Ch-Ng were similar at 2 and 14 days post mortem (Table 3). Considering the threshold values for consumer acceptability of Shackelford *et al*. [18] viz. 4.6 kg and 3.9 kg for "retail" and "food service" beef, respectively 2 days aging was not sufficient to ensure consumer satisfaction irrespective of breed. Prolonged ageing (14 days) will satisfy the consumer. The myofibrillar lengths were shorter after 7 days compared to day 1, indicating that proteolysis caused significant weakening of the cytoskeletal structure and coincided with improved tenderness at 14 days ageing. However, in correspondence with shear force tenderness, no differences in MFL were found between the breeds. With regards to rigor shortening, Marsh *et al*. [19] stated that post mortem sarcomere length changes of less than 20% produced almost negligible effects on beef tenderness. If resting sarcomere length of bovine muscle were taken as 2.1µm (Marsh *et al*. [20]), then mean percentage shortening for the Ch and ChNg would have been 9.0% and 18 %,

Table 3 Means (±s.e.) of meat quality characteristics of the loin muscle of the Charolais and Charolais x Nguni bulls

	Ch	ChNg	*P* value	s.e.
WBSF (kg)				
2 days	5.14	5.30	0.723	0.321
14 days	3.00	2.92	0.763	0.192
Histology				
Sarcomere length	1.91	1.72	< 0.001	0.028
MFL 1 day	34.6	32.2	0.206	1.277
MFL 7 day	25.8	24.0	0.416	1.500

respectively. Therefore, shortening differences between the two groups in this low range (<20%) would be expected to exert no effect at all.

IV. CONCLUSION

Considering the unique intrinsic qualities of the Nguni, the option of diversification for both breed societies seems to be very attractive. The larger part of the industry seems to be fixed in their views regarding carcass size; both the lower and upper limits of carcass weight. Through this cross, the Nguni can benefit with regards to intensive production suitability, final carcass weight and yield, while the pure Charolais can benefit from the reduced carcass weight and earlier fat deposition.

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REFERENCES

1. FAO 2006 World Agriculture: Towards 2030/2050. Interim Report: Prospects for Food, Nutrition, Agriculture and Major Commodity Groups (Rome: Global Perspective Studies Unit, Food and Agriculture Organization of the United Nations).
2. Steinfeld, H., Gerber, P., Wassenaar, T., Castel, V., Rosales, M., & de Haan, C. (2006). Livestock's Long Shadow — Environmental issues and options. Rome: Food and Agriculture Organization of the United Nations.
3. Capper, J. L. (2011). The environmental impact of beef production in the United States: 1977 compared with 2007. Journal of Animal Science, 89, 4249–4261.
4. Scholtz,, M.M. & Theunissen,, A. (2010). The use of indigenous cattle in terminal cross-breeding to improve beef cattle production in Sub-Saharan Africa. Animal Genetics Resources, 46, 33-39.
5. Olentine, C.G., Bradley, N.W., Boling, J.A. & Moody, W.G. (1976). Comparison of Charolais-crossbred and Angus yearling steers finished on pasture. J. Anim. Sci., 42(6): 1375.
6. Baker, J.F., Bryson,W.L. & Knutson, R. (1987). Feed intake and growth during finishing of Angus-, Charolais- and Piedmontese-sired calves when slaughtered at similar measurements of subcutaneous fat. J. Anim. Sci., 65(Suppl.): 10–12.
7. Grunert, K. G., Bredahl, L., & Brunsø, K. (2004). Consumer perception of meat quality and implications for product development in the meat sector—A review. Meat Science, 66, 259−272.
8. AMSA (1978) Guidelines for cooking and sensory evaluation of meat. American Meat Science Association, National Livestock and Meat Board, Chicago, IL.
9. Hegarty, P.V.J. & Naudé, R.T., 1970. The accuracy of measurement of individual skeletal muscle fibres separated by a rapid technique. Laboratory Practice 19, 161.
10. Culler, R.D., Parrish, F.C. Jr., Smith G.C. & Cross, H.R., 1978 Relationship of myofibril fragmentation index to certain chemical, physical and sensory characteristics of bovine longissimus muscle. J. Food Sci. 43, 1177.
11. Heinze, P.H. & Bruggemann, D., 1994. Ageing of beef: Influence of two ageing methods on sensory properties and myofibrillar proteins. Sciences Des Aliments. 14, 387.
12. Payne, R. W., Murray, D. A., Harding, S. A., Baird, D. B. & Soutar, M. (2007). GenStat for Windows® (10th Edition) introduction. Hemel Hempstead, UK: VSN International.
13. Snedecor, G.W. & Cochran, W.G., 1980. Statistical methods (7th Ed.). Iowa State University Press.
14. Berg, R.T. & Butterfield, R.M., 1978. New Concepts of Cattle Growth. 2nd ed., Sydney University Press, Sydney, Australia.
15. Jones, S.D.M., Rompala, R. E. & Jeremiah, L. E. (1984). Growth and Composition of the Empty Body in Steers of Different Maturity Types Fed Concentrate or Forage Diets. J. Anim. Sci, 60, 427-433.
16. Strydom, P. E. (2008). Do indigenous Southern African cattle breeds have the right genetics for commercial production of quality meat? Meat Science, 80, 86-93.
17. De Bruyn, J.F. (1991). Production and product characteristics of different cattle genotypes under feedlot conditions. D.Sc.-thesis, University of Pretoria, Pretoria, South Africa.
18. Shackelford, S.D., Koohmaraie, M., Cundiff, L.V., Gregory, K.E., Rohrer, G.A. & Savell, J.W., 1994. Heritabilities and phenotypic and genetic correlations for bovine post rigor calpastatin activity, intramuscular fat content, Warner-Bratzler shear force, retail product yield, and growth rate. J. Anim. Sci. 72, 857-863.
19. Marsh, B.B. & Leet, N.G. (1966). Studies in meat tenderness: III The effects of cold shortening on tenderness. Food Sci.ence, 31, 450.
20. Marsh, B.B. & Carse, W.A. (1974). Meat tenderness and the sliding-filament hypothesis Journal of Food Technology., 9, 129.