GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN SUBPOPULATIONS OF THE BONSMARA CATTLE

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Summary: Ninety bull calves of five Bonsmara strains, viz. Edelheer (E), T-49 (T), Wesselsvlei (W), Roodebos (R) and Belmont Red (BR), were fattened under intensive feeding conditions and serially slaughtered at 4 different slaughter masses. Phylogenetic relationships between strains were determined through blood typing techniques. Production and product quality characteristics were compared between strains. Determination of genetic distances among the group of animals confirmed the existence of five genetically independent subpopulations (breeding lines) with a variation in genetic distances among them. Comparisons of production and product characteristics were done on a common subcutaneous fatness level (%) by means of analyses of covariance. T gained mass faster and more efficiently on both a live and carcass mass basis and had proportionally more meat in the high-priced cuts of the carcass than W. Muscle of the W line had 7a significantly higher ($p<0.05$) myofibrillar fragmentation (MFI) than T, resulting in higher tenderness scores for W. There may therefore be a negative relationship between production potential and meat/muscle quality, which can be related to muscle enzyme activity.

INTRODUCTION

The Bonsmara is an indigenous composite breed which originated in the early 1940's from a 5/8 : 3/8 combination of the Afrikaner (indigenous Sanga) and Shorthorn/Hereford (exotic) through an initiative of the former Department of Agriculture of South Africa (Bonsma, 1980). When it was detected that the genetic structure of the breed has narrowed dangerously by 1970, four individual strains or breeding lines were developed to ensure greater genetic flexibility within the breed (Bosman, 1988). The Edelheer (E) breeding line (progenitor, the bull Edelheer) can be regarded as the main strain of the breed, since it dominated the AI industry of the Bonsmara prior to the development of the other stains. The Wesselsvlei (W) strain originated from the bull, Spanner, a 5/8 Afrikaner x 3/8 Red Poll bull, instead of the normal Afrikaner/Hereford/Shorthorn combination, while the Roodebos (R) strain was developed from an unrelated group of animals kept on a specific government farm. T-49 (T) is no formal strain, but was regarded in this study as an independent strain due to the large number of animals within the E strain that were related to a certain bull, T-49. This bull achieved exceptional growth performance indices in the National Performance Scheme (Bosman, 1996 - personal communication). The Belmont Red (BR) is an independent breed, developed in Australia from 1/2 Afrikaner, 1/4 Shorthorn and 1/4 Hereford. It was imported into South Africa and was further developed as an independent strain. In this study the phylogenetic and phenotypic relationship of these five strains are described and compared.

MATERIALS AND METHODS

Ninety bull calves of five Bonsmara strains were fattened under intensive feeding conditions and serially slaughtered at 4 different slaughter masses. The phylogenetic relationships between the strains (subpopulations) were studied using the gene frequency values obtained from the electrophoretic analysis of 8 structural gene loci, that code for blood-soluble proteins, together with 23 blood group loci. In addition, the genetic differentiation within the subpopulations was studied. Values of the genetic distances among populations, the phenograms and cladograms, as well as the goodness-of-fit statistics of those dendograms have been computed using the BIOSYS-1 program (Swofford & Selander, 1981). On reaching target masses per slaughter group, animals were slaughtered and dressed at a local research abattoir according to commercial practice and processed into 15 wholesale cuts the following day. Carcass yield (dressing percentage) as well as carcass composition and meat distribution over the carcass were determined by physical dissection of the subcutaneous fat (SCF), meat and bone and the proximate analyses of the soft tissue of the primerib for percentage protein, moisture, ash and fat (A.O.A.C., 1985; Naudé, 1972). With regard to muscle quality, collagen content and solubility (Bergman & Loxley, 1963; Hill, 1966; Weber, 1973), myofibrillar fragmentation index (MFI; Culler *et al.*, 1978 as adapted by Heinze & Bruggemann., 1994) as well as sensory quality (aroma intensity, juiciness, overall tenderness, residual amount of connective tissue, overall flavour intensity) and shear force resistance measurement were determined on samples of the *Mm. longissimus thoracis et lumborum* (LT) aged for 7 days at 0-7 °C. Muscle fibre type ratio and fibre area were determined by means of video image analysis on a sample of the LT removed directly after exsanguination and before electrical stimulation of the carcass. Sources of variation between strains were investigated by analysis of variance (ANOVA) or analysis of covariance (ANCOVA), with SCF and starting mass as covariants. Mean separation was achieved by application of the Bonferroni Multiple Comparison Method at the 5 % test level.

RESULTS AND DISCUSSION

Phylogenetic relationships: The genetic variability showed heterozygosity levels varying between 0.31 and 0.43. The lowest level was observed in T, which is in accordance with the development of this strain, being the most inbred. The highest heterozygosity level was observed in E and R, which represent the largest portion of the Bonsmara population. According to the dendogram (Figure 1), the formation of 2 large clusters were observed: the W strain and one cluster formed by the rest of the population, except the BR which separated from the hypothetical trunk very early. Within the second cluster, E and T showed a higher relationship, perfectly differentiating from R. E and R were more related than E and W. The cladogram was topologically similar to the phenogram, which corroborates the stability of the classification.

Phenotypic relationships: The W strain of the Bonsmara gained mass at a higher rate and more efficiently on both a live mass and carcass mass basis than the other strains, but in particular T and R. Differences between T/R and W of more than 30 % for carcass growth rate ($P<0.05$) and 20 % for efficiency of carcass gain ($P<0.05$) were recorded. Furthermore, both T and R showed a tendency towards higher total carcass fat yield and subsequent lower muscle yield compared to W (adjusted for carcass SCF; Table 1). In addition, T and E had a higher distribution of total carcass mass (2.3 %) and meat (1.9 %) in the high-priced cuts, with an accordingly lower distribution to the ventral cuts of the carcass, compared to W and BR (Table 3). Both Kempster *et al.* (1976) and De Bruyn (1991) reported similar findings for breeds of different maturity types, suggesting that W is an earlier maturing strain than T and R. However, according to Table 1, no significant difference in final carcass mass (maturity type) existed between the two strains.

Regarding meat quality attributes, sensory panel scores ($P<0.05$), as well as shear force resistance values ($P>0.05$), showed a 17 % advantage in meat tenderness for W compared to T. These differences coincided with a 17 % difference in MFI in favour of W. Culler *et al.* (1978) reported that MFI accounted for 50 % of the variation in loin steak tenderness and regarded myofibrillar fragmentation as a more important effector of tenderness than sarcomere length or collagen solubility. In addition, Crouse *et al.* (1991) and Seideman *et al.* (1987) reported correlation coefficients of 0.53 and 0.60 between MFI and sensory tenderness, which compared reasonably well with the 0.47 found in the current trial. Despite differences in other muscle characteristics, none of them seemed to correspond to differences in sensory tenderness or shear force between the strains.

CONCLUSION

Despite very definite phylogenetic differentiation between the strains of the Bonsmara, the only consistent differences relating to production (growth performance) as well as product quality characteristics (carcass and meat quality), were found between T and W. These differences may be coupled to the specific origins of the strains as described in the introduction of this paper, and boils down to normal variation that occurs within breeds, except that for the Bonsmara breed, some of this variation is fixed within certain strains. What seems to be more important in terms of selection criteria, is the contrast found between growth performance and meat quality between T and W. This finding may suggest that selection for fast growing, more efficient animals in a breed, which, in effect, is a selection for increased net protein gain, may be confounded by a retardation in the protein breakdown process in the muscle *post mortem*, resulting in conflicting production and product quality as found in the current trial. This process, although probably overemphasised, is clearly demonstrated by the effect of a growth promoter such as β-agonists' positive effect on growth and detrimental effect on muscle tenderness through its inhibiting effect on myofibrillar protein breakdown by the proteolytic enzyme system.

Table 1: Means and standard errors of means for production and product characteristics of five Bonsmara breeding lines

		E	T	W	B	R	Cov.
Average daily gain: (kg/day)	Live	1.35 (0.06)	1.47 (0.06)	1.28 (0.06)	1.35 (0.06)	1.51 (0.06)	NS
	Carcass	0.87^{b} (0.03)	0.90^{b} (0.04)	0.69^{a} (0.05)	0.89^{b} (0.04)	0.94^{b} (0.05)	*
Feed conversion ratio:	Live	6.71^{ab} (0.24)	6.21^{a} (0.24)	7.28^{b} (0.24)	6.75^{ab} (0.24)	6.12^{a} (0.24)	NS
(kg feed /kg gain)	Carcass	10.11^{ab} (0.38)	9.29^{a} (0.38)	11.72^{b} (0.38)	10.28^{ab} (0.38)	9.62^{a} (0.38)	NS
Carcass mass (kg)		240.8 (2.3)	241.2 (2.2)	241.8 (2.9)	236.2 (2.3)	239.3 (3.4)	$
Meat %		79.9 (0.3)	79.8 (0.3)	79.7 (0.3)	79.6 (0.3)	80.1 (0.4)	#
Muscle %		70.0 (0.7)	67.7 (0.7)	70.0 (0.7)	68.6 (0.7)	68.4 (0.7)	NS
Total carcass fat		15.0 (0.7)	17.4 (0.6)	14.8 (0.6)	16.3 (0.7)	16.6 (0.7)	#
Bone %		15.3 (0.3)	15.3 (0.3)	15.4 (0.3)	15.5 (0.3)	15.0 (0.4)	#
High-priced cuts:	Total yield	39.4 (0.3)	39.7 (0.2)	38.8 (0.2)	38.8 (0.2)	39.0 (0.3)	#
	Meat yield	42.2 (0.3)	42.3 (0.3)	41.6 (0.4)	41.6 (0.3)	41.9 (0.4)	$
Sensory attributes:	Tenderness@	5.0^{ab} (0.2)	4.6^{a} (0.2)	5.4^{b} (0.2)	4.8^{ab} (0.2)	5.0^{ab} (0.2)	NS
Shear force (N/2.5 cm ∅)		92.3 (4.0)	101.7 (4.0)	87.2 (4.0)	90.4 (4.0)	89.4 (4.0)	NS
Myofibrillar fragmentation index:		114.9 (6.6)	100.3 (6.6)	117.3 (6.6)	110.8 (6.6)	102.5 (6.6)	NS

Cov.: $ Both covariants, SCF and starting mass, were significant (P<0.05)
* Only covariant, SCF, was significant
\# Only covariant, starting mass, was significant
NS Covariants non-significant
@ Eight-point Lydard scale; 8 measuring the most tender and 1 the least tender

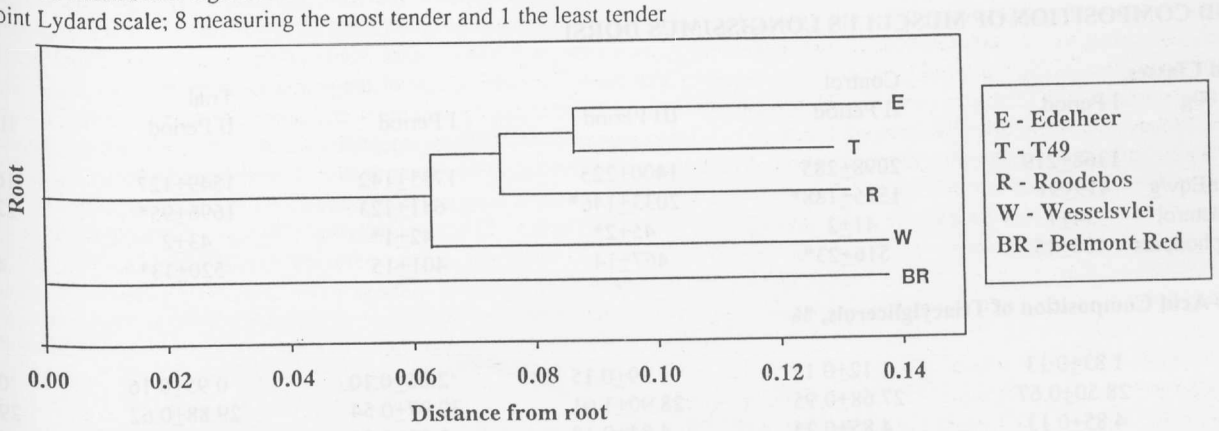

Figure 1: Dendogram obtained from Nei's distance (1978) for the different Bonsmara strains

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