GENETIC AND PHENOTYPIC RELATIONSHIPS BETWEEN FOUR METHODS OF ASSESSING INTRAMUSCULAR FAT IN BEEF CARCASES

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SUMMARY

A total of 4263 carcases were measured for chemically extracted intramuscular fat percent (CHEM) and AUS-MEAT chiller assessed marbling score (A_MS). A sub-set of these animals (N=897) were part of the Meat Standards Australia (MSA) program and were scored using two additional visual marbling scoring systems (MSA_1 and MSA_2). The data were used to estimate genetic and phenotypic correlations between the four measures of intramuscular fat and, for the larger dataset, between domestic and export markets and for the two lines (temperate and tropical breeds). The heritability for CHEM was 0.43 and 0.15 for A_MS, with a genetic correlation of 0.96. Similar estimates were found for the lines for these two traits. The two MSA marbling scores were moderately heritable (h^2=0.32), with very high genetic correlations with all other measures. The heritability of A_MS from the domestic market carcases was very low (h^2=0.06) but moderate in the export carcases (h^2=0.27). Corresponding heritabilities for CHEM were 0.38 and 0.54 for the domestic and export markets. The genetic correlations between markets and traits were high (0.67 to 0.98). Intramuscular fat was heritable, however the method of measurement affected the magnitude of this heritability. CHEM appears most useful in a genetic evaluation, however marbling scores (using the methods in the MSA program) may prove more cost effective. AUS-MEAT marbling scores from domestic market weight carcases do not appear useful for genetic evaluation.
Keywords: Beef carcase, intramuscular fat, marbling score, genetic correlation

INTRODUCTION

There is increasing interest within the breeding sector of the Australian beef industry to improve marbling by selection. This is being driven primarily by premiums paid for higher marbled product into the Japanese market. However, to include marbling in a breeding program, a suitable selection criterion must exist. The trait measured must be heritable, cost effective to measure, and correlated to the trait in the breeding objective. This paper uses data from the Cooperative Research Centre for the Cattle and Beef Industry (CRC) to estimate genetic parameters for four measures of intramuscular fat to determine the one more suitable for use in an industry breeding program.

MATERIALS AND METHODS

Data from the CRC straightbreeding project were used, the design and management of which were outlined by Robinson (1995). In brief, the project entailed a progeny test for carcase and meat quality traits from four temperate breeds (Angus, Hereford, Shorthorn, Murray Grey) and three tropical

[K] AGBU is a joint institute of NSW Agriculture and The University of New England breeds (Brahman, Belmont Red and Santa Gertrudis). The data in this study were from 4263 carcases representing 34 herds, three market endpoints and three finishing systems, and slaughtered at six abattoirs.

Four measures of intramuscular fat were investigated. All carcases in the dataset had an AUS-MEAT marbling score and a chemically extracted fat percentage. The AUS-MEAT marbling scores were given by an accredited assessor on carcases quartered between the 12th and 13th ribs. The data spanned the change in the AUS-MEAT scoring procedure (AUS-MEAT 1996). However the change in scoring method (i.e. old and new) was completely confounded with the fixed effect of slaughter day and therefore scoring method was accounted for in the analysis by the modelling of slaughter day. Chemically extracted fat percent was predicted from a sample of the *m. longissimus dorsi* muscle between the 12/13th ribs using either near infra-red (NIR) spectroscopy (for all of the temperate and some of the tropical cattle) or Soxhlet extraction (for the reminder of the tropical cattle). The slightly different laboratory procedure used, as with the marbling scores, was confounded with, and therefore accounted for by, line and slaughter day.

For a sub-set of the carcases (N=897) two additional visual marbling scoring systems were used. This data was collected as part of the CRC involvement in the Meat Standards Australia (MSA) program. The scores (MSA_1 and MSA_2) were given in the chiller by trained MSA operators. Both scoring systems used a scale with an increased number of score gradations compared to the AUS-MEAT marbling scoring method. MSA_1 used the AUS-MEAT scale with an additional ten units per whole score (i.e. scoring to 0.1). MSA_2 used the USDA marbling scoring system.

Variance components were estimated by REML using VCE4.0 (Groeneveld and García Cortés 1998). The same model was fit for each of the four measures of intramuscular fat (A_MS, MSA_1, MSA_2 and CHEM). The model included two fixed effects, random additive genetic and residual effects. The first fixed effect was herd of origin||sex||kill code, where kill code grouped all animals from same CRC intake, finish-market destination, killed on the same day at the same abattoir. The second fixed effect grouped animals according to their pre-finishing management regime, and included background nutrition level||year||season||market. The analysis included a relationship matrix using up to five generations of pedigree. The full dataset contained progeny records from 337 sires (131 tropical, 206 temperate). Variance components were also estimated for the lines separately (i.e. temperate and tropical breeds) and also for the different markets. For this work the Japanese and Korean market data were grouped into a single export class due to the relatively small number of Japanese carcases. Data were from 325 sires for the domestic and 299 for the export market, with 289 sires with progeny in both.

RESULTS AND DISCUSSION

Trait statistics are presented in Table 1. The data were not adjusted for fixed effects, so care should be taken when interpreting differences between groups (e.g. temperate vs. tropical).

Table 1. Raw trait statistics for four measures of intramuscular fat

Dataset	Trait	Number	Mean	Std	Min.	Max.
All	A_MS	4263	0.95	0.86	0	6
	CHEM	4263	3.75	2.13	0.1	18.9
	MSA_1	897	0.85	0.67	0	3.4
	MSA_2	860	273	75.79	110	560
Temperate	A_MS	2203	1.21	0.85	0	5
	CHEM	2203	4.64	2.22	1.2	18.9
Tropical	A_MS	2060	0.67	0.79	0	6
	CHEM	2060	2.79	1.54	0.1	12.6
Domestic	A_MS	1849	0.65	0.66	0	4
	CHEM	1849	2.65	1.31	0.1	10.1
Export	A_MS	2414	1.18	0.93	0	6
	CHEM	2414	4.58	2.25	0.4	18.9

Heritabilities and correlations for the four measurements of intramuscular fat are presented in Table 2. For the complete dataset the heritability was 0.15 for A_MS and 0.43 for CHEM. Both additional visual marbling scores (MSA_1 and MSA_2), from the reduced MSA dataset, had heritabilities of 0.32. The genetic correlations between all traits were very high (>0.95) suggesting all were measurements of the same trait. However differences existed in the precision of the measure, which in turn affected the magnitude of the additive and residual variances. It appeared that of the visually scored marbling traits the MSA_1 and MSA_2 were more useful than the AUS-MEAT score (A_MS).

Table 2. Heritabilities (diagonals), genetic (above) and phenotypic (below) correlations for the four measures of intramuscular fat

	A_MS	MSA_1	MSA_2	CHEM
A_MS	**0.15**	0.99	0.99	0.96
MSA_1	0.61	**0.32**	0.95	0.97
MSA_2	0.59	0.85	**0.32**	0.97
CHEM	0.43	0.55	0.59	**0.43**

Splitting the data into lines showed similar variances and heritabilities for A_MS in each line (Table 3). For CHEM, the heritabilities were similar but tropical breeds had about half the additive variance, which may reflect differences in the chemical extraction methods and reduced trait expression. The genetic correlation between A_MS and CHEM was 0.92 and 1.0 for temperate and tropical breeds, respectively.

When the full dataset was examined by market the results showed a difference between Domestic and Export (Table 3). The variances and heritabilities were smaller for measures in the domestic market, with the heritability of A_MS being only 0.06. This means that AUS-MEAT marbling scores on domestic cattle are of little use in a genetic evaluation for intramuscular fat. The genetic correlation between A_MS for the export market was highly correlated with CHEM (r_g=0.92) indicating AUS-MEAT marbling scores on export cattle may be useful.

Table 3. Variance components[1] for A_MS and CHEM, by line and market

	Line				Market			
	Temperate		Tropical		Domestic		Export	
	A_MS	CHEM	A_MS	CHEM	A_MS	CHEM	A_MS	CHEM
Va	0.05	0.80	0.04	0.35	0.01	0.28	0.12	1.24
Vp	0.36	2.10	0.27	1.06	0.17	0.74	0.43	2.28
h^2	0.15	0.38	0.15	0.33	0.06	0.38	0.27	0.54
se	0.04	0.05	*	*	0.03	0.06	0.04	0.03
r_g	0.92		1.0		0.98		0.92	

[1]Va=additive genetic variance; Vp=phenotypic variance; h^2=heritability; se=standard error ;r_g=genetic correlation

The genetic correlation between A_MS for domestic and export markets was 0.72 and for CHEM of 0.81. The genetic correlation between domestic A_MS and export CHEM was 0.67 and domestic CHEM and export A_MS of 0.84. The high genetic correlation (r_g=0.81) between domestic and export for CHEM suggests a similar trait in light and heavy carcases. Further data are required to estimate the correlation for market within line.

From a genetic view point chemically measured intramuscular fat appears to be the most useful trait and is that currently used in the new version of BREEDPLAN. However at present it is an expensive test and requires a sample taken from the carcase for laboratory analysis. Scoring of marbling offers a cheaper measure but the AUS-MEAT marbling score generally had a lower heritability and variation, particularly for domestic finished cattle. Development of an on-line measure based on NIR technology to measure intramuscular fat would overcome these problems. The preliminary estimates from the scoring methods implemented by MSA appear to be useful measurements but more data is required to determine whether they can adequately score the reduced marbling in domestic carcases.

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