MARBLING ASSESSMENT OF MEAT

Kruk Z. A. [1], Pitchford W. S. [1], Siebert B. D. [1], Deland M. P. B. [2] and Bottema C. D. K. [1]
[1] Livestock Systems Alliance, Adelaide University, Roseworthy Campus, SA 5371, Australia
[2]South Australian Research and Development Institute, Struan Research Centre, Naracoorte SA 5271, Australia

Background

Marbling of meat is defined as the appearance of evenly distributed white flecks or streaks of fatty tissue between muscle fibers and is measured subjectively. In Australia, there are three commonly used subjective assessment systems of marbling: (i) the 7-point scale (0-6) AUS-MEAT system performed on chilled carcasses and scored against reference standards, (ii) the Meat Standards Australia (MSA) assessment using the same reference standards as AUS-MEAT (0-6) but with a finer scale of 0.1 increments, and (iii) the United States Department of Agriculture (USDA) system using different grading standards where scores range from 100 to 1000 in increments of 10. The subjective assessment of marbling can be influenced by many factors which, if properly recognized, is of great interest to the beef industry.

Objectives

The aim of this study was to investigate factors influencing estimation of marbling in cattle and the relationship between intramuscular fat percentage (IMF%) and the three systems of subjective marbling assessment used in Australia.

Methods

The animals used in this study were part of the Davies Cattle Gene Mapping Herd, ¾ Jersey (XJ) and ¾ Limousin (XL) (Kruk *et al.*, 1999). The animals comprised 50 XJ and 31 XL steers, progeny of pure Jersey and Limousin cows crossed to the three F1 (Jersey/Limousin) bulls. The steers were raised on pastures under the same management conditions, weaned at 250 days of age and fed a grain based ration for 170 days. After slaughter and on line processing, carcasses were stored in the (0-4°C) chiller. Carcass assessment was performed by accredited AUS-MEAT or MSA (Meat Standards Australia) graders. Parameters such as meat colour (MC), fat colour (FC), eye muscle area (EMA), loin temperature (LT), ossification, pH, AUS-MEAT marbling (MbAM), MSA marbling (MbMSA) and USDA marbling (MbUSA) were assessed. The left side of each carcass was boned out and eye round (*M. semitendinosus*) and strip loin (*M. longissimus dorsi*) samples were collected. A 1.5 cm thick steak was cut from the anterior part of the strip loin, placed in a sealable plastic bag and stored at -20°C until further analysis.

The methods used for lipid extraction, fatty acid analysis, including saturated fatty acids (SAF), monounsaturated fatty acids (MUFA) and melting point determination were those described by Malau-Aduli *et al*, (2000), following the method of Christie (1989).

Least squares analysis of variance was carried out using Proc GLM (SAS 1989). Two models were applied. Model 1 investigated the influence of breed of dam and sire on intramuscular fat content and included breed, sire and breed by sire interaction. Model 2 investigated the influence of various carcass traits (EMA, LT, FC, MC, IMF%) on marbling assessment and included these parameters and their interactions. The interactions were not significant (P>0.05) and were removed from the model leaving only the main effects. Correlations between variables were estimated using Proc CORR (SAS 1989).

Results and discussions

Marbling scores in each grade scheme represented the following ranges: MbAM varied from 0 to 4 with the highest score corresponding to only one animal, MbMSA varied from 0 to 2, and the MbUSA varied between 200 and 600 (Table 1A). The MbAM and MbUSA scores were very similar in IMF%, whereas MbMSA had higher percentage of intramuscular fat and a broader range of concentrations for each score. However, all grading systems ranked animals in a similar order.

The correlations between marbling scores and IMF% were high and significant (Table 2). The highest correlation was observed with MbAM and the lowest with MbMSA. The highest correlation between MbMSA and MbUSA can probably be explained by the similarity in the scale used for the estimate. The MSA assessment using the AUS-MEAT scale (expressed in finer intervals) is probably closer to that of the MbUSA scale than the AUS-MEAT assessment itself. However, as the MbMSA and MbUSA scoring was performed by the same assessor and the MbAM was performed by another assessor, the differences between assessors cannot be ruled out and requires further investigation. The MSA marbling was poorly associated with IMF% compared to the other scoring systems. The highest correlation with IMF% was with MbAM, suggesting that IMF% can be better predicted by marbling when using an integer scoring scale. The correlations with IMF% ranged from 0.67-0.79 in this study and are similar to 0.71 reported by Ferguson (2001). However, in other Australian studies, the correlations with AUS-MEAT score were lower, ranging from 0.32 to 0.57 (Reverter et al, 2001).

Table 1. 1A. Association of marbling scores and IMF%
1B. Breed differences in marbling, fat composition and intramuscular fat percentage (IMF%).

1A									1B		
#	MbAM	IMF%	#	MbMSA	IMF%	#	MbUSA	IMF%	Parameter	XJ	XL
7	0	3.4±0.82	17	0	4.4±1.16	2	200	3.0±0.95	MbAM	1.9 ± 0.09^{A}	0.8 ± 0.12^{B}
35	1	4.7±0.93	60	1	5.7±1.46	16	300	4.6±0.96	MbMSA	1.4 ± 0.05^{A}	1.1 ± 0.07^{B}
31	2	6.5±1.14	4	2	8.0±1.75	44	400	5.6±1.39	MbUSA	373 ± 8.3^{A}	313 ± 11.2^{B}
7	3	7.9±1.32	-	-	-	17	500	7.5±1.20	Mp	36.8 ± 0.44^{B}	38.9 ± 0.59^{A}
1	4	10.1	-	-	-	2	600	10.1	SFA	46.1 ± 0.57^{B}	48.9 ± 0.76^{A}
-	-	-	-	-	-	-	-	-	cMUFA	49.6 ± 0.55^{A}	47.0 ± 0.73^{B}
-	-	-	-	-	-	-	-	-	IMF%	6.4 ± 0.20^{A}	4.4 ± 0.26^{B}

Note: all abbreviations as defined in the materials and methods, # = number of animals, $^{A-B}$ within rows means of the same class followed by the same letter are not significantly different (P>0.05).

Table 2. Raw correlations between marbling and various carcass parameters

	MbAM	MbMSA	MbUSA	SFA	cMUFA	IMF%	FC	MC
MbAM		0.76***	0.81***	-0.27**	0.25*	0.79***	0.25*	0.23*
MbMSA			0.84***	ns	ns	0.67***	ns	0.23*
MbUSA				-0.24*	ns	0.71***	ns	ns
SFA					-0.98***	ns	-0.40***	ns
cMUFA						ns	0.41***	ns
IMF%							ns	0.34**
FC								0.27**
MC								

Note: ***P<0.001, **P<0.01, *P<0.05, abbreviations as described in materials and methods

Marbling was also associated with fatty acid composition. MbAM and MbUSA were negatively correlated with SFA and MbAM was positively correlated with cMUFA. The correlations were moderate. A large and highly significant negative relationship was found between SFA and cMUFA. The other traits such as FC and MC were moderately associated with MbAM. A similar association with MC was found for MbMSA. The saturation of fat was moderately correlated with fat colour (FC), which in turn was positively correlated with meat colour (MC). The low and positive correlations between some marbling scores and meat and fat colour suggests that these parameters might influence the estimation of marbling. For instance, a positive correlation with meat colour might be the result of a better contrast for marbling in a darker background. Also more yellow fat might reflect light differently to white fat. These factors are unlikely to affect marbling scores, however, since there are also positive correlations between IMF% and meat and fat colour, the correlation with marbling is likely to be real.
The influence of various carcass characteristics such as size of the eye muscle area, meat colour, fat colour, melting point of fat and loin temperature did not have a significant effect on marbling assessment (model 2). The only significant effects observed were breed and intramuscular fat percentage. Jersey steers had significantly higher marbling scores (P<0.05) than the Limousin steers by each of the three scoring systems (Table 1B). Correspondingly, IMF% was significantly higher in Jersey cattle as was mono-unsaturated fatty acids (cMUFA). Saturated fatty acids (SFA) and melting point (MPt), however, were lower. The slight discrepancy between our reports and the others in terms of IMF% per score can be accounted by the differences of IMF extraction. The method used here was based on that of Christie (1989) using a polar solvent mixture rather than neutral ether. When meat is low in fat, significantly more total lipid is extracted with polar solvents due to the phospholipid content of tissue membranes (Siebert et al., 1996).
Breed effect on marbling has been reported previously. In other studies by our group, (viz. the Southern Cross breeding experiment which consisted of seven different sire breeds), marbling was also affected by breed (Malau-Aduli et al. 2000). It is interesting to note that the significant breed difference for all three marbling scores was no longer significant for MbMSA and MbUSA when IMF% was fitted as a covariate. However, the difference between breeds was still significant for MbAM. This suggests that there may be a relationship between marbling scores and fat distribution, which is not precisely evaluated when using a coarser scale (AUS-MEAT). Additional covariates fitted in the model resulted in the conclusion that the breed differences were not due to differences in fatty acid composition (melting point) or degree of muscling (eye muscle area). On the other hand, the quality of the evaluation cannot be neglected as AUS-MEAT scores were determined by a different assessor. The influence of the assessor on the quality of testing will be a subject for further study.

Conclusion

Marbling assessment using three Australian grading systems ranked animals similarly. The highest correlation between MbAM and IMF% suggested that IMF% is better predicted by marbling when using an integer scoring scale. A number of carcass characteristics such as size of the eye muscle area, meat colour, fat colour, melting point of fat and loin temperature did not have a significant effect on marbling assessment. However, breed had an impact on marbling, although the differences between Jersey and Limousin cattle was not due to the differences in fatness or musculature but could be due to differences in fat distribution. To clarify this point, the influence of assessors on marbling requires further study.

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