Investigating marbling and its relationship to meat quality in New Zealand pasture fed lamb

E.A. YOUNG[1], W.E. BAIN[1], N.J. MCLEAN[1], A.W. CAMPBELL[2] and P.L. JOHNSON[1]

[1]AgResearch Invermay, Private Bag 50-035, Mosgiel 9053, New Zealand
[2]Abacus Bio, P.O. Box 5585, Dunedin 9058, New Zealand

ABSTRACT

This is the first report of marbling in New Zealand pasture finished lamb. Marbling and meat quality data were collected on 1,056 loins from pasture finished lambs. Marbling was subjectively assessed on loin cut surfaces, using a five point visual scale (1 = Low, 5 = High), and objectively assessed using computer tomography (CT) scanning. Tenderness was objectively measured on loins that had been frozen. Corresponding loins from the lambs with the fifty highest (High) and fifty lowest (Low) subjective marbling scores were taste panelled after chilled storage. The average subjective scores were 2.94 and 0.94 for the High and Low groups respectively, with the objectively measured CT fat percentages 8.0% and 10.0% respectively, both significant differences ($P < 0.001$). Loins from the High group were significantly ($P < 0.01$) more tender than loins from the Low group as assessed objectively, however, this difference was not detected by the taste panel when assessing texture. The taste panel did not detect any significant differences in juiciness, flavour or odour between the two groups. Our findings suggest that this level of marbling in pasture fed, New Zealand chilled stored lamb is insufficient to influence meat quality as assessed by a taste panel.

Keywords: marbling; lamb; meat quality.

INTRODUCTION

Marbling of meat refers to the appearance of white flecks, or streaks of fatty tissue between bundles of muscle fibres. Although not strictly correct, it is commonly referred to as intramuscular fat (Tune, 2004). Increased marbling in beef is linked to higher tenderness, flavour and juiciness, and therefore has a positive general effect on palatability (Savell & Cross, 1988) Marbling has traditionally been assessed by subjective visual scoring or objectively by measuring ether extractable fat (Savell & Cross, 1988). Minimum levels of 2 to 3% ether extractable fat are required to achieve acceptable consumer satisfaction for grilled beef fat (Savell & Cross, 1988).

To date there has been no reports on marbling in New Zealand pasture fed lamb, Navajas (2008) and Bünger *et al.* (2009) reported between 0 and 15% of marbling in pasture fed Scottish Blackface and Texel lamb in Scotland. Observations in a trial looking at the colour of lamb loins from pasture finished New Zealand lambs visually detected marbling in the loins (A.W. Campbell, Unpublished data).

An experiment was set up in the year following the original observation to determine the level and variation in marbling in New Zealand lamb loins, using subjective visual scoring and objective estimates from X-ray computed tomography scanning, and its relationship with tenderness and taste panel assessment of quality.

MATERIALS AND METHODS

Intramuscular fat data were obtained in 2007 from 1,062 lamb loins collected from ewe and ram lambs from a progeny test of sires from a composite breed involving Suffolk, White Suffolk and Poll Dorset sheep. Details of the slaughter of these animals are in Johnson *et al.* (2008). GR measurements of the total tissue depth over the 12th rib at a point 110 mm from the midline of the carcass, were collected as a measure of fat depth on the carcass post slaughter (Kirton, 1989). At three weeks post-slaughter marbling was subjectively scored on a five point visual scale of 1 = Little or no marbling to 5 = High marbling equating to approximately 30% visual intramuscular fat on slices of loin taken from the lumbar region (*M. longissimus*). Scoring was undertaken by two independent assessors with the values averaged. The same loins were used to investigate colour stability using the CIE L* (lightness), CIE a* and (redness) CIE b* (yellowness) scale as described by Johnson *et al.* (2008). Intramuscular fat proportion was objectively measured on a corresponding half-loin using X-ray computed tomography. Two images were taken, the first at the centre of the loin and the second 30 mm along from the first image. Images were analysed through autoCAT (Jopson et al., 1995) which estimated the density in Houndsfield (Hu) units of each pixel within the image of the loin. Pixel boundaries between lean and intramuscular fat were set using a k-means clustering algorithm (Lloyd, 1982), to divide the

TABLE 1: Differences between low and high marbling groups for a range of fat traits and subjective and objective measures of meat quality. SD = Standard deviation.

Trait	Overall mean ± SD	Marbling group[1]		Significance
		Low	High	
Measures of fat (n = 1,062)				
Marbling score	1.99 ± 0.81	0.95 ± 0.09	2.94 ± 0.09	***
CT Fat %[2]	9.04 ± 2.39	8.00 ± 0.32	10.00 ± 0.34	***
Carcass GR (mm)	7.50 ± 3.22	7.12 ± 0.37	8.14 ± 0.38	†
Other traits (n = 1,062)				
Carcass weight (kg)	16.34 ± 2.73	15.36 ± 0.41	17.44 ± 0.42	***
Shear force (kgF)[3]	6.03 ± 0.24	6.47 ± 0.24	5.38 ± 0.25	**
Loin colour at 96 hours[4] (n = 1,062)				
CIE L*	43.05 ± 2.17	41.42 ± 0.26	41.85 ± 0.27	NS
CIE a*	21.40 ± 1.52	19.93 ± 0.19	20.22 ± 0.19	NS
CIE b*	10.06 ± 0.85	9.59 ± 0.10	9.79 ± 0.10	NS
Taste panel[5](n = 100)				
Raw appearance	5.10 ± 1.42	4.80 ± 0.13	5.09 ± 0.14	NS
Cooked appearance	4.45 ± 1.28	4.27 ± 0.09	4.73 ± 0.09	***
Odour	4.80 ± 1.31	4.78 ± 0.09	4.98 ± 0.09	NS
Texture	5.24 ± 1.53	5.08 ± 0.11	5.25 ± 0.11	NS
Juiciness	5.04 ± 1.43	5.09 ± 0.10	5.21 ± 0.11	NS
Flavour	5.28 ± 1.32	5.30 ± 0.06	5.45 ± 0.07	NS

[1]Carcass weight adjusted for sex and pH, all other data adjusted for sex, carcass weight and pH.
[2] CT Fat% = Loin intramuscular fat content estimated by computed tomography.
[3]Tenderness measurements were made on loins that had been frozen post slaughter processing
[4]Loins had been aged for three weeks, with measurements taken on slices 96 hours after they had been processed into slices.
[5]Taste panel measurements were made approximately five weeks post slaughter. All traits were measured on a 1 to 8 scale

pixels in the loin into two categories. Ten images with obvious visual marbling were evaluated and the mean truncation point used. Pixels with densities between -40 and +45 were classed as intramuscular fat and between +46 and +100 were classed as lean. Marbling was estimated as the proportion of total pixels that were classed as intramuscular fat (CT Fat%). The same half-loin was subsequently used to measure tenderness as described below. Colour was measured on slices of loin three week post-slaughter as described in Johnson *et al.* (2008).

Taste panel assessment was carried out on 100 loins, which represented the animals with the 50 lowest (Low) and 50 highest (High) subjective scores. The objective measurements were unavailable at this time as they were carried out at a later date. The loins were air freighted to London and trucked to Dawn Meats, Cross Hands, Carmarthenshire, Wales. A taste panel was carried out over two days at Dawn Meats using standard commercial procedures. The taste panel included 10 panelists that scored 50 pairs of samples assessing them for six sensory traits of raw appearance, cooked appearance, odour, texture, juiceness and flavour on an eight point scale. The taste panel assessment was carried out approximately five weeks post-slaughter. Tenderness measurements were made using a MIRNZ tenderometer with values converted to kg of shear force as described by McLean *et al*, (2009).

The data were analyzed using the general linear model procedure in SAS (SAS, 2004). The models fitted included fixed effects of sex and marbling group. Carcass weight and pH were fitted as covariates. Interactions between all fixed effects and covariates were tested, but were not significant and were excluded from the final model. Correlations were estimated using the correlation procedure in SAS (SAS, 2004).

RESULTS

Across the 1,200 samples the average marbling score was 1.99 with a range of 0 to 4, and an average CT intramuscular fat percentage of 9% with a range of 5% to 30%, The objective values from the two CT slices had a correlation of 95.4%, and the subjective values from the two assessors had a correlation of 86.5% . The differences between loins assigned to the Low and Hhigh marbling groups based on the visual marbling score for a variety of fat and quality traits are given in Table 1. Animals in the High marbling group had significantly ($P < 0.001$) higher marbling and CT Fat%, and were heavier but did not have a significantly greater GR

TABLE 2: Correlations between subjective marbling scores and objective computed tomography estimated loin intramuscular fat content (CT Fat%) of lamb *M. longissimus* and other estimates of fatness and subjective and objective meat quality traits.

Trait	Extent of marbling	
	Marbling score	CT fat %
Measures of fat (n = 1,062)		
CT Fat%	0.48***	
Carcass GR (mm)	0.53***	0.35***
Other traits (n = 1,062)		
Carcass weight (kg)	0.45***	0.14
Shear force (kgF)[1]	-0.08	-0.31**
Loin colour at 96 hours[2] (n = 1,062)		
CIE L*	-0.25*	-0.07
CIE a*	0.11	0.08
CIE b*	-0.08	0.02
Taste panel[3](n = 100)		
Raw appearance	0.46***	0.09
Cooked appearance	0.42***	0.23*
Odour	0.24*	0.12
Texture	0.01	0.03
Juiciness	0.10	0.01
Flavour	0.13	0.08

[1]Tendereness measurements were made on loins that had been frozen post slaughter processing.
[2]Loins had been aged for three weeks, with measurements taken on slices 96 hours after they had been processed into slices.
[3]Taste panel measurements were made approximately five weeks post slaughter. All traits were measured on a 1 to 8 scale.

measurement. No differences in objective measurements of colour were seen between the loins of the Low and High marbling groups. Loins from the High marbling group had a significantly (P <0.01) lower shear force measurement indicating they were more tender than loins from the Low marbling group. The only difference detected by the taste panel was for cooked appearance where loins from the High marbling group were scored as being slightly darker.

The correlations between the subjective and objective estimates of marbling and other quality traits are shown in Table 2. Correlations between all measures of fat were significantly (P <0.001) and ranged between 0.35 and 0.53. There was a significant correlation between carcass weight and marbling score, but not between carcass weight and CT Fat%. There was a negative correlation between shear force and CT Fat%, indicating that an increased fat percent was associated with more tender meat. The only significant correlation between estimates of marbling and colour was a negative correlation between marbling score and CIE L*, indicating that. increased marbling was associated with darker meat. Marbling score and raw appearance were positively correlated, cooked appearance was also positively correlated with marbling score and fat percent. The only correlation between estimates of marbling and taste panel assessments was a positive correlation between marbling score and odour.

DISCUSSION

The appearance of marbling on slices of loin has been verified in this study, and further supported by the detection of intramuscular fat in the CT images of the loins. The range in CT Fat% seen in this study is at the lower end of intramuscular fat reports in beef which can range as high as 16 to 39% (Okabe *et al.,* 1999). The current values are however comparable le to those reported by Navajas (2008) and Bünger *et al* (2009). Based on the conclusions of Savell and Cross (1988), only a minimum of 3% intramuscular fat is required to influence meat quality. The objective estimates of intramuscular fat in this study were based on CT images of the loin whereas the objectives estimates of intramuscular fat in other studies have been based on ether extractable fat. Given other tissue components such as connective tissue may have a similar tissue density to fat these values maybe a slight overestimate of the total intramuscular fat, but visual assessment of the pixels assigned to intramuscular fat suggest that it is likely to be a good estimate.

The correlation between the subjective and objective measurements in this study are comparable to that achieved by Reverter *et al.* (2003) which were in the order of 0.46 to 0.48, who similarly had fat percentages range between 0 and 10%. This suggests that visual scoring can be used to determine marbling content, but is not as accurate as objective measures. As discussed by Blumer *et al.* (1962) there is considerable variation in fat content between different muscles. Measurement techniques need to take account of this variation.

No significant differences were detected between the Low and High marbling groups for any of the taste panel eating quality traits, with the result that there were no significant correlations between any of the these traits. Why this is the case is unclear, but perhaps suggests that the levels of marbling were not high enough to influence the eating quality over and above the quality improvements in the meat that had occurred due to e five weeks of aging as the meat was transported to the United Kingdom. Shear force differences were detected in the meat that was frozen post-slaughter and did not have the opportunity to age.

CONCLUSION

This is the first report of detectable levels of marbling in pasture fed New Zealand lamb, detected both objectively and subjectively. The level of marbling is somewhat lower than most reports in beef but comparable to other reports in lamb. At this level of marbling there is no positive impact on eating quality as assessed by eating panels over and above the improvements in quality that likely resulted from aging during shipment to a distant destination.

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