TENDERNESS RELATIONSHIPS BETWEEN FOUR RAW AND COOKED BEEF MUSCLES

T. M. Plant, D. G. Taylor and J. S. Dhanda
Department of Animal Production, The University of Queensland, Gatton College 4345. Australia

SUMMARY

Tenderness measurements of the *Semimembranosus* (topside), *Longissimus dorsi* (loin), *Triceps brachii* (blade) and *Sternocephalic*(neck) muscles (when raw and after cooking) from twenty-three carcasses were taken using Warner-Bratzler shear force. For the raw samples, loin muscle was found to be the most tender followed by topside, blade and neck muscles respectively but after cooking loin became the toughest followed by neck and blade with topside being the most tender. Overall shear force values for raw and cooked samples indicated that cooking tended to reduce the variability of tenderness though it also tended to make the meat tougher. There were low correlations between the tenderness of raw and cooked muscles, when compared within and between muscles. Results indicated that measurements of tenderness on raw muscle do not give a true indication of tenderness of cooked muscle, when subjected to the cooking method and tenderness assessment procedures used in this trial.

INTRODUCTION

The ultimate assessment of tenderness of meat occurs when the consumer eats the cooked product. Tenderness varies not only between carcasses but also between muscles and even within muscles. Therefore a full understanding of the relationships between the tenderness of different muscles is essential for determining the most suitable site, or sites, to objectively measure tenderness, and to be able to relate the tenderness at the site (or sites) measured, to the tenderness of the muscles in the rest of the carcass. It is also essential that the tenderness measurements taken on raw muscle can be accurately related to the tenderness of the meat when cooked by the consumer. There has been interest recently in the development of objective measurement of tenderness of raw muscle on a carcass for use in grading and pricing decisions. This system would rely on there being a close association between the raw and cooked muscle tenderness and that the muscle sampled was representative of the tenderness of all the carcass muscles.

This study reports on the relative tenderness of muscles within a beef carcass and also the relationship between the tenderness measurements made on raw and cooked meat. With this information the aim was to determine which, if any, muscle or muscle groups could be sampled on the raw carcass to give a good representation of the tenderness of the overall carcass muscle when cooked.

MATERIALS AND METHODS

Twenty-three beef carcasses covering a range of animal ages, breeds, carcass weights and fat depths, were sampled. At 48 hours postmortem, samples weighing approximately 500g were taken from defined positions within the *Semimembranosus* (topside), *Longissimus dorsi* (loin), *Triceps brachii* (blade) and *Sternocephalic* (neck) muscles. Strips of meat (1cm wide, 1cm deep and 5cm long) were cut parallel to the muscle fibres and the force required to shear through each strip perpendicular to the muscle fibres was measured using Warner-Bratzler shear force method. The remaining portion of each whole muscle sample was individually vacuum packed and cooked in a water bath at 80^{0}C for an hour. After cooking, samples were allowed to cool for an hour and the same procedure was followed to measure tenderness as for raw samples. Six tenderness measurements were taken for each sample.

Duncan's Multiple Range Test was used to analyse differences between individual muscles and also between raw and cooked muscle samples. Correlations between raw and cooked muscle tenderness individually and overall were obtained using Pearson correlation coefficients.

RESULTS

There were significant differences in tenderness between the muscle samples and also between raw and cooked meat. Table 1 shows the mean shear force values for each muscle group, indicating that the loin was the most tender of the muscles when measured raw, followed by topside, blade and neck muscles respectively.

Table 1. Shear force values (kg) for raw and cooked samples from four muscles

	Raw		Cooked	
Muscle	Mean	Std. dev.	Mean	Std. dev.
Topside	2.7^{f}	2.0	5.3^{de}	1.5
Loin	1.4^{g}	1.0	7.2^{b}	1.9
Blade	6.5^{bc}	3.6	5.9^{cd}	1.3
Neck	8.2^{a}	4.2	6.4^{bc}	1.7
Overall Mean	4.7^{e}	3.5	6.2^{cd}	1.7

^{a,b,c,d,e,f,g}Figures with different superscripts differ ($P < 0.05$) significantly

There was little variability between measurements taken on the loin muscle but increasingly more variation associated with measurements of the topside, blade and neck respectively. When shear force was measured after cooking the order of the muscles changed with regard to tenderness. The loin became the toughest when cooked followed by neck and blade, with the topside being the most tender. The variability of tenderness measurements of the loin increased when the meat was cooked making it the most variable cut of beef measured. The other cuts became less variable after cooking. Averaged over all the muscles measured, cooking tended to reduce the variability of tenderness though it did also tend to make the meat tougher.

Table 2. Correlations between cooked and raw meat tenderness for four muscles

		Raw				
		Topside	Loin	Blade	Neck	Mean
Cooked	Topside	-0.014	0.097	-0.019	0.156	0.121
	Loin	0.001	-0.030	0.097	-0.076	0.003
	Blade	-0.026	-0.183	0.108	-0.153	-0.087
	Neck	0.078	-0.019	0.156	0.057	0.168
	Mean	0.022	-0.052	0.161	-0.003	0.103

There were low correlations between the tenderness of muscles measured raw and the tenderness of the other muscles when measured after cooking (Table 2). The correlations were also low between the tenderness of a particular muscle when raw and the tenderness of the same muscle when measured cooked. None of the raw muscles gave readings highly correlated with the mean tenderness of the muscles when cooked.

DISCUSSION

In the current study significant differences were found between the tenderness of each of the muscles, both when measurements were taken on raw meat and when the tenderness of cooked meat was measured (see Table 1). Other researchers have also found differences in tenderness between the muscles (Crouse *et al*., 1984; McKeith *et al*., 1985; Hertzman *et al*., 1993). There are many factors which may have contributed to the differences in tenderness between the muscles. Both the muscle fibre and the connective tissue contribute to the tenderness of beef (Ramsay & Wythes, 1979). It is extremely difficult to differentiate and measure the separate contributions to the muscle tenderness of each of these (Sims & Bailey, 1981).

When measured raw, the loin was found to be most tender, followed by the topside, blade and neck, respectively (see Table 1). This order approximately corresponds with the relative amount of connective tissue in each muscle. The loin is known to contain the least connective tissue of the muscle sampled (Shorthose & Harris, 1990; Dransfield, 1994) and had the lowest shear force values when tenderness was measured on the raw meat. The neck muscle contains the most connective tissue of the muscles measured (Dransfield, 1994) and also recorded the highest shear force values for raw meat of the four muscles measured in this experiment. The blade and topside contain intermediate amounts of connective tissue and correspondingly were intermediate between the loin and neck with regard to tenderness of the raw meat. This indicates that the proportion of connective tissue in the different muscles contribute largely to differences in tenderness between the muscles when raw.

Although the consumer tends to regard the loin cuts of meat to be the most tender, in this study the *Longissimus dorsi* muscle was found to be the least tender of the four muscles measured when cooked. The results shown in Table 1 indicate that the effect of cooking on meat tenderness varied between muscles. The neck improved most in tenderness though the blade improved also. The loin became drastically less tender while the topside also toughened, but to a lesser extent. The explanation for this is that cooking affects the connective tissue and the myofibrillar protein components of meat differently. The muscle fibres tend to toughen while the connective tissue tends to soften (Ramsay & Wythes, 1979). It is therefore expected that meat containing large amounts of connective tissue will become more tender while other cuts will become tougher as a result of cooking. The *Longissimus dorsi* contains a large amount of myofibrillar component and a relatively small amount of connective tissue (Shorthose & Harris, 1990; Dransfield, 1994). So, myofibrillar toughening may be responsible for reduced tenderness of loin muscle after cooking as compared to the other muscles. Correspondingly, the neck muscles are known to contain a larger amount of connective tissue (Dransfield, 1994) which will explain why the tenderness of the neck muscles improved to such a great extent. The *Semimebranosus* and *Triceps brachii* contain intermediate amounts of connective tissue (Dransfield, 1994) and the response of these two muscles with regard to tenderness was intermediate between the other two muscles.

These results were obtained by using moist heat to cook the meat at 80^{0}C for an hour. This standard method of experimental cooking was used to obtain a good comparison between muscles, however this is not how the consumers generally cook the different cuts of meat. In general, to maximise tenderness the cuts of meat with low connective tissue content are grilled while the cuts of meat containing higher amount of connective tissue are stewed or casseroled (Dransfield, 1994; Ramsay & Wythes, 1979). The variation in tenderness of muscles may be explained by the fact that the cooking method used in the trial was different to that generally used by the consumers.

Higher levels of variability were associated with the muscles which were tougher when raw (eg. neck muscle) than for the muscles which were more tender when raw (e.g. loin). Correspondingly the larger amount of variability in tenderness was associated with the muscles with higher connective tissue content. Averaged over all muscles measured , cooking tended to reduce variability of tenderness though it did also tend to make the meat tougher (Table 1). A possible explanation for this phenomenon is that connective tissue is responsible for a large amount of variation in tenderness of raw muscle between measurements and between carcasses (Sims & Bailey, 1981). Cooking softens the connective tissue (Aalhus, 1995) and therefore reduces the maximum shear force measurements likely to occur. By lowering the top end of the range this reduces the effect connective tissue has on tenderness thereby reducing the variation in tenderness of muscles once cooked.

Very low correlations were found between the tenderness of raw and the tenderness of cooked meat. Correlations between the tenderness of a muscle when measured raw and the tenderness of the same muscle when measured cooked were very low for each of four muscle sampled including the *Longissimus dorsi* which is commonly used in meat research and occasionally measured raw as an indication of tenderness (Table 2). This is consistent with the findings of Ramsay & Wythes (1979). There were low correlations between the tenderness of a certain muscle measured raw and the tenderness of other muscles measured cooked. Following on from this there were only very low correlations between the tenderness of any of the muscles measured raw and the mean of the muscles measured cooked, which was used to represent the overall tenderness of the carcass muscle.

Results indicated that measurement of tenderness on raw muscle doesn't give a true indication of tenderness of the cooked muscle, when subjected to the cooking method and tenderness assessment procedures used in this trial.

REFERENCES

Aalhus, J.L. (1995). In *Quality and Grading of Carcasses of Meat Animals.* Ed. by S.D. Morgan Jones. CRC Press, London, 51-81.

Crouse, J.D., Cross, H.R. & Seideman, S.C. (1984). *J. Anim. Sci.* 58, 619-625.

Dransfield, E. (1994). In *Advances in Meat Research,* Vol. 9. Ed. by A.M. Pearson and T.R. Dutson. Blackie Academic and Professional, London, 289-315.

Hertzman, C., Olsson, U. & Tornberg, E. (1993). *Meat Sci.* 35, 119-141.

McKeith, F.K., Savell, J.W., Smith, G.C., Dutson, T.R. & Carpenter, Z.L. (1985). *Meat Sci.* 13, 151-166.

Ramsay, W.R. & Wythes, J.R. (1979). In *Beef Carcass Composition and Meat Quality.* Ed. by J.R. Wythes and W.R. Ramsay. Queensland Department of Primary Industries, Brisbane, 47-64.

Shorthose, W.R. & Harris, P.V. (1990). *J. Food Sci.* 55, 1-8, 14.

Sims, T.J. & Bailey, A.J. (1981). In *Developments of Meat Science*, Vol. 2. Ed. by R.A. Lawrie. Applied Science Publishers, London, 29-59.