MEAT TECHNOLOGY UPDATE
Cutting edge technology for the meat processing industry

Meat technology update

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Production factors affecting beef eating quality

Previous *Meat Technology Update* Newsletters (99/4 and 99/6—see Further Reading) have dealt with the influence of pre- and post-slaughter factors on beef eating quality. This final newsletter in a series of four focuses on the on-farm, or production-based, factors that have been shown to affect beef palatability.

There are a lot of misconceptions about what governs beef palatability. Most relate to the relevance of the on-farm factors (e.g. breed, nutrition, growth path, fatness etc.) that, historically, have generally been overstated. That is not to say that factors like breed and growth path do not have a bearing on palatability traits like tenderness. Rather, some of the previous estimates of the magnitude of these effects were often confounded, owing to a lack of control of the post-slaughter environment. Only recently have these effects been more accurately defined through the research of the Cattle and Beef Industry Co-operative Research Centre (CRC) and Meat Standards Australia (MSA).

With the aim to predict eating quality, a logical approach is to identify which factors are relevant to each muscle. The eating quality of each muscle will be determined by a number of factors, including:

- the amount of connective tissue;
- fat content;
- muscle-fibre shortening/stretching during rigor mortis;
- post-rigor ageing/tenderisation.

Given these variables, it follows that there will be fundamental differences in the palatability of different muscles within the carcase and that these relationships will vary, depending on the production, pre-slaughter and post-slaughter conditions. Moreover, it is important to recognise that the influence of any single production factor may not be constant across all muscles.

The production factors covered in this newsletter include:

- within-breed and between-breed variation;
- sex;
- fatness;
- age;
- nutrition and growth path.

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Breed

Within-breed variation

Initial estimates from the CRC indicate that under the slaughter protocol used by the CRC there is limited genetic variation in tenderness (shear force) for *Bos taurus* breeds, although there appears to be much more genetic variation in the tropically adapted breeds (e.g. Belmont Reds, Santa Gertrudus, and Brahman). These results therefore suggest that there is little opportunity for genetic improvement in tenderness within *Bos taurus* breeds. Greater scope for change exists in the case of the tropically adapted breeds.

Between-breed variation

The debate regarding the significance of breed in relation to beef eating quality has attracted considerable controversy. Most has centred on the issue of *Bos indicus* content, with the debate intensifying following the initial decision by MSA to exclude cattle with greater than 25 per cent Brahman content. Whilst the new MSA cuts-based system is far less restrictive in that the full range of *Bos indicus* content is eligible for grading, there is still a negative association between *Bos indicus* content and eating quality within the prediction model.

A number of researchers (both overseas and Australian) have reported that as *Bos indicus* percentage increases, tenderness or palatability of the meat decreases. The magnitude of the breed effect tends to vary considerably between studies and is probably linked to differences in the management or the processing conditions during slaughter. Certainly individual studies by the CRC show that under carefully controlled conditions, *Bos indicus* content up to 75% may have only a small impact on palatability.

Another joint CRC/MSA study has also shown that the *Bos indicus* effect is not constant across all muscles in the carcase. Notably, the effect was more pronounced in the high quality loin cuts (striploin, cube roll and tenderloin), suggesting that the effect is more myofibrillar in origin. These muscles, being predominantly postural, are typically low in connective tissue.

Various suggestions have been made as to why *Bos indicus* cattle have less tender meat. These include the effect of the production environment given that *Bos indicus* cattle are typically raised in harsher environments. This, in turn, results in variable growth rates (possible direct effect on muscle structure and composition), increased age at slaughter (increased collagen-related toughness) and leaner and lighter carcases (increased risk of cold shortening if not controlled). Other theories have arisen from observed breed differences in the intrinsic properties of the muscle. Prominent amongst these is the difference in activities of enzymes responsible for the tenderising effect when meat is aged. More precisely, the inhibitor to these enzymes, calpastatin, is higher in activity in the muscles of *Bos indicus* cattle, thus retarding the ageing process. However, even though differences in the protein-breakdown (proteolytic) activity have been found, they haven't always coincided with different rates of tenderisation as measured by consumer panels or by shear-force measurements, particularly when the post-slaughter environment has been controlled.

Sex

Small differences in palatability have been observed between the sexes. Beef from bulls can be more variable and this is often associated with the higher variability in ultimate pH. Consequently, male cattle showing secondary sex characteristics—physical characteristics of a bull—have been excluded under the MSA system. Past comparisons between steers and heifers suggest that the beef quality was similar. However, preliminary analyses of the MSA data indicate a small, yet consistent, sex effect, with heifers having lower eating quality scores than steers. Reasons for this effect are not clear at this stage.

Fatness

The fatness of the carcase can exert indirect and direct effects on beef eating quality. The indirect effect is associated with the inverse relationship between the fatness of the carcase and the rate at which the carcase cools (i.e. fatter carcases will cool at slower rates compared to leaner carcases). Any variances in cooling rate relative to the pH decline (refer *Meat Technology Update* Newsletter 99/1) will lead to differences in the degree of muscle shortening and consequently, tenderness/toughness.

The direct effect of marbling on eating quality has attracted considerable debate in the past. Much of this centred on the contention that greater marbling always resulted in more tender meat. Whilst this could be demonstrated, this was largely due to the indirect effect of carcase fatness on tenderness rather than marbling *per se*. In other words, marbled beef was typically derived from heavy, fat carcases in which the likelihood of cold shortening was minimal, in view of the slower cooling rates observed for these carcases. In stimulated carcases (where cold shortening did not occur) marbling had only a small effect on tenderness. Recent results from consumer panels indicate that the direct link between marbling and palatability is through enhanced juiciness and flavour.

Animal age

The chronological age of the animal is important in the context of meat tenderness. Typically, with increasing animal age, the connective tissue contribution to tenderness/ toughness increases as a result of the increased crosslinking within the connective tissue. Dentition scores relating to the eruption of permanent incisor teeth is used to estimate, albeit crudely, animal age.

Ossification

Physiological age can be estimated by the degree of ossification (calcification) that occurs in the chine bones and during fusion of the vertebrae. As the animal ages, the soft cartilage tips of the spinous processes of the vertebrae (chine bones) calcify or harden. However, like dentition, the relationship between the degree of ossification and age can vary considerably. This, to a large degree, is related to the growth history of the animal and ossification is believed to provide a more informative perspective on the physiological maturity of the animal. Animals that endure restricted growth show advanced ossification at the same age compared with animals that have been raised on a good plane of nutrition. Therefore, by knowing the ossification score and the weight of the animal, it is possible to draw some conclusions about the production history of the animal.

Why is this important? The data indicates that at the same carcase weight, there is an inverse relationship between ossification score and eating quality. The nature of this relationship will vary, depending on how the carcase was processed, but it shows that, as the ossification score increases, there is a slight loss in eating quality. There are a number of plausible reasons for this effect; however they have not been validated at this stage.

The MSA scale of ossification goes from 100 to 200 in 10-point increments. With the present system, a maturity score of 200 is the cut-off as a means to exclude older animals. In cattle that have followed a normal growth path, an MSA ossification score of 200 would generally refer to an animal of about 30 months of age.

The vertebrae of the backbone—specifically the cartilage between and on the dorsal edges of the sacral, thoracic (called buttons), and lumbar vertebrae —are assessed (the cervical vertebrae are not considered). All of these cartilage areas are considered in arriving at a level of maturity. The sacral and lumbar cartilages are least ossified in the youngest carcases, as are the buttons, which are also prominent and soft. Ribs can also be used to assess physiological age. They tend to be round and narrow in young animals and flat and wide in older ones. Young animals have red-coloured ribs because they are involved in marrow, red-blood-cell manufacture. As the animals get older, this activity decreases and their ribs become correspondingly whiter.

As an example, a maturity score of 100 indicates a carcase with no ossification of the cartilage and clearly defined spinous processes in all regions, including the sacral chine bones. Figure 1 shows the degree of ossification in a carcase with an ossification score of 100. Note that there was no ossification in the cartilage that was present both between the vertebrae and above the spinous processes. A more detailed view of the sacral region of an MSA ossification score of 100 is shown in Figure 2.

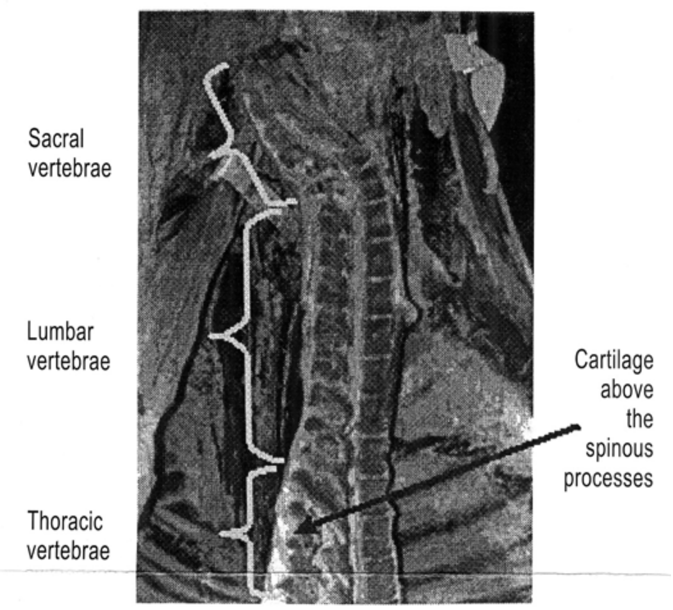

FIGURE 1 MSA ossification score of 100 (vertebral column)

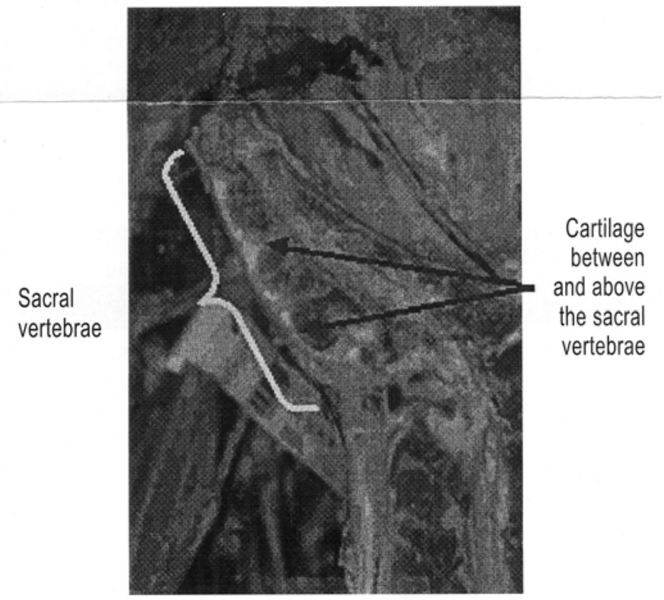

FIGURE 2 MSA ossification score of 100 (sacral vertebrae)

In the absence of other influences, the younger the physiological age of the animal, the more tender the meat will be. As an animal gets older, the connective tissues become more resistant to breakdown during cooking. This manifests as toughness. With increased physiological age, the transition from tender meat to tough meat is gradual and occurs at different rates in different muscles.

Nutrition and growth path

It is often very difficult to estimate the ‘true’ effects of the type of nutrition an animal receives and its rate of growth, as these are generally confounded. In other words, animals on higher quality feed will generally grow at faster rates and vice versa. Moreover, these factors will also impact on the degree of carcase fatness and animal age at slaughter, which, as stated earlier, will have both indirect and direct effects on palatability.

Results from the CRC and MSA indicate that the rate and pattern of growth impacts on meat tenderness/toughness. However, it must be emphasised that the relationship between growth rate and eating quality could not be classed as strong. Rather, there is considerable variation surrounding this relationship and much of this can be linked to the fact that growth rate does not necessarily describe the growth pattern of animals. Cattle rarely grow at constant rates: there are often periods of no growth, slow growth and rapid growth, depending on the nutritional quantity and quality of feed. The timing and duration of these changes are believed to have a significant impact on the ultra-structural components within muscle, which, in turn, manifests as changes in the meat tenderness/toughness. Changes in the relative rates of both muscle protein synthesis and degradation, and connective tissue structure have been implicated as reasons for this effect. These mechanisms and the overall effect of growth pattern on meat tenderness/toughness will be further characterised following the completion of forthcoming investigations within the Cattle and Beef Quality CRC. However, generally speaking, a high plane of nutrition is desirable.

Conclusion

There have been a lot of misconceptions about what governs beef eating quality. Clearly, the pre- and post-slaughter conditions are still paramount. However, when these have been controlled, we can now quantify the real magnitude of the production or on-farm factors on eating quality. Genetic improvement in tenderness is feasible but predominantly for the tropically adapted breeds. Changes in the rate and pattern of growth will influence not only carcase composition with respect to fatness but also the physiological age at slaughter. However, the issue of growth path is far from being fully understood and is the subject of further research.

Acknowledgements

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Further Reading

Meat Technology Update Newsletter 99/1, 'A Critical Control Point approach to beef eating quality'

Meat Technology Update Newsletter 99/4, 'Post-slaughter aspects of beef eating quality'

Meat Technology Update Newsletter 99/6, 'Pre-slaughter aspects of beef eating quality'

Meat Technology Update Newsletter 99/7, 'Beef fat quality'

Contact us for additional information

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