

NEW LIGHT ON TENDERNESS AND THE CALPAIN SYSTEM

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While much has been learned about the practical factors affecting tenderness of meat, investigations continue into what happens inside the cells. Scientists in CRC III are aiming for a deeper understanding of body chemistry and its genetic controls in the hope this knowledge will lead to new ways to produce more tender beef.

This article explains some of the body chemistry and the current theory on why factors such as *Bos indicus* content and hormonal growth promotants (HGP) affect tenderness.

Protein turnover

In the live animal, muscle is being synthesized and broken down in a continuous cycle referred to as protein turnover. When the animal is growing, synthesis is faster than breakdown, resulting in increasing muscle weight.

The calpains (calpain-1 and calpain-2) are the principal enzymes responsible for protein breakdown. Calpastatin is a specific natural inhibitor of calpains and the balance between calpain and calpastatin helps determine the animal's rate of muscle growth.

HGPs are thought to act by boosting the proportion of calpastatin. A relatively high proportion of calpastatin means lower rates of protein breakdown and faster growth. *Bos indicus* cattle also have naturally higher levels of calpastatin.

Calpains and tenderness

In the few hours after slaughter, the calpains continue their task of breaking down the protein bonds within the muscle fibres, helping to produce tender meat. If higher amounts of calpastatin are present, they reduce the ability of the calpains to break these

proteins down and meat is likely to be less tender.

As rigor mortis takes place and the pH (acidity) drops from around 7.0 to about 5.5, the activity of calpastatin is restricted. When beef is further aged after slaughter, the calpains slowly break down the protein bonds in muscle and make it more tender. This is thought to be the main mechanism by which beef improves with ageing.

It follows that muscles with higher levels of calpastatin will initially be less tender, but with ageing will improve substantially.

Muscles age differently

Meat from the loin muscles (cube roll and striploin, including cuts such as scotch fillet, T-bone and porterhouse) will improve significantly with ageing. These cuts have low levels of connective tissue and are known to have low levels of calpastatin, allowing the calpains to quickly break down and tenderize the meat.

Other cuts such as the oyster blade for example hardly improve at all with ageing. This is probably because their lower level of tenderness is due to more natural connective tissue, and connective tissue is not affected by the action of calpains.

At this stage there has been limited study of calpain/calpastatin levels in other cuts and muscles.

Effect of hormonal growth promotants (HGPs)

A CRC experiment in Western Australia examined both steers and heifers to study the effects of an appropriate growth implant. There were positive growth rate responses, as expected, but the study also looked closely at meat quality effects in a number of different muscles.

When the striploin was aged for 5 days and cooked, MSA taste panels reported a very significant 10-point reduction in MSA tenderness score in the HGP-treated steers and heifers. The treated animals also had a significantly lower ratio of calpain to calpastatin in the striploin at slaughter.

Samples of oyster blade from the same animals showed almost no HGP effect on tenderness, and had no difference in their calpain to calpastatin ratio.

This suggests that HGPs cause a change in the calpain to calpastatin ratio in some muscles, causing the live cattle to grow faster, but reducing the ability of the meat to tenderize after slaughter. This effect is likely to be different for different types of HGPs.

When the striploin samples were aged for 21 days, the differences were much smaller. The extra 16 days of ageing improved the striploin from HGP-treated cattle by 13 tenderness points while the more tender controls improved by only 3 points. This effectively eliminated the large HGP-induced eating quality difference present at 5 days.

It is thought that calpastatin activity stops during post-mortem ageing and the calpains are allowed to get on with the job of improving the tenderness.

Commercially, this means that extra ageing can be used to offset the toughening of prime cuts caused by the use of some types of HGPs in live cattle production.

These effects have recently been incorporated into the MSA grading model which now adjusts the estimated eating quality of each cut according to whether the animal has been treated with HGP.

Bos indicus effect and temperament

Research in CRC I showed that cattle with high *Bos indicus* content often produce beef that is less tender, with the toughening affecting some cuts more than others, particularly the high priced cuts along the back. The striploin and cube roll (scotch fillet) are high-value cuts and are the most affected.

The MSA grading model has for some time adjusted the eating quality of each cut by the appropriate amount according to the animal's *Bos indicus* content.

The research also revealed a strong genetic correlation between tenderness and flight time (a measure of temperament – see CRC fact sheet). This suggests there is a common factor in the underlying genetics of both temperament and tenderness. This intriguing concept is being explored further in CRC III.

Bos indicus carcasses also respond differently to processing and a number of theories have been advanced to help explain these differences. Tropical breeds are more sensitive to having the optimum amount of electrical stimulation. With tenderstretch hanging, their tenderness is improved more than British breed types.

To be eligible for grading, MSA now requires processors to follow best practice in electrical stimulation and chilling to minimize detrimental effects.

Links between HGPs, Bos indicus content and ageing

Cattle with a higher *Bos indicus* content are known to have a higher proportion of calpastatin. Eating quality studies have revealed that the cuts affected by *Bos*

indicus content are essentially the same ones affected by treatment of the animal with HGPs. That these are the same cuts that improve most with extended ageing.

This has led to the theory that all three phenomena are primarily caused by changes to the calpain/calpastatin mechanism in muscle.

Possible links with Net Feed Intake

Selection to improve NFI (net feed intake, a measure of feed efficiency) is already progressing in some breeds, following studies that showed substantial genetic variation exists between animals in feed efficiency. Feed intake measurement is now being used by breeders to identify feed-efficient sires.

Calpain and calpastatin have recently emerged as playing some role in NFI. It seems that more efficient cattle may also have slightly higher natural levels of calpastatin.

This suggests there will be genetic connections between meat quality and feed efficiency, and that selection for NFI could lead to tougher beef. Fortunately the correlation looks very small at this stage, and meat quality differences have not been detected in experimental cattle selected for improved feed efficiency.

DNA tests for tenderness

DNA markers for tenderness have recently been commercialised. These have been identified by screening the data from CRC's cattle experiments to find genes that are associated with differences in tenderness. The key genes that emerged were the calpain (CAPN1) and calpastatin (CAST) genes. These now form the basis of the commercial DNA marker tests.

Current research

The interactions between genetics, behaviour, biology and meat quality continue to unfold. Two large experiments underway in CRCIII have been designed to enlighten us on all these issues.

The experiments include *Bos indicus* and British breed types carrying known tenderness genes. They have been divided into groups to compare HGP/non-HGP effects, differences in temperament and stress response and tenderstretch or normal carcass hanging.

In addition to providing definitive measures of these effects, tissue and meat samples will provide a huge resource for further studies on the underlying mechanisms controlling tenderness.

Meat scientists are looking at other ways to offset the meat quality effects in cattle that are profitable to produce, but have high calpastatin levels. They may find a way to inactivate calpastatin at or shortly before slaughter, to allow the calpains to tenderize the meat.

Other breeding experiments are checking for any positive or negative genetic associations between tenderness genes and the breeding efficiency of females. This work is vital to ensure a profitable balance in genetic improvement of our production systems into the future.

