



# **Beef Quality:**

## **Effect of Meat pH, Marbling and Doneness**

*For consumer satisfaction, meat must be of consistent, good eating quality. Many factors, however, can affect meat quality, leading to quality variability. Variations in the degree of cooking add further variation to the final product. This Bulletin discusses how meat pH, amount of marbling and degree of doneness (end-point cooking temperature) affect some aspects of meat quality.*

### **INTRODUCTION**

Most of the material in this Bulletin is based on a recent study examining quality attributes of steaks cut from aged beef striploins (aged for 2 or 3 weeks at 0°C) that had been stored frozen (-35°C) for a short period before assessment (Scott *et al.*, 1999).

One part of the study examined how pH affects the eating quality of meat cooked on a grill to an internal temperature of either 60, 70 or 80°C, corresponding to rare, medium or well done. The striploins in this part of the study fell into one of four pH categories:

- 5.5-5.6 (average pH = 5.54)
- 5.6-5.7 (average pH = 5.66)
- 5.8-6.0 (average pH = 5.91)
- >6.2 (average pH = 6.47).

The other part of the study used other striploins to examine how the degree of marbling affects the eating quality of meat cooked to either 70 or 80°C. The rare end-point (60°C) was not studied because the effect of marbling on eating quality was expected to be greatest at the higher cooking temperatures. The three degrees of marbling were

- Trace - mean of <3% fat in the lean
- Moderate - mean of approx. 8% fat in the lean
- High - mean of just over 12% fat in the lean.

The rest of this Bulletin discusses how pH, marbling and cooking-end-point interact to affect meat quality.

### **MOISTURE LOSS DURING THAWING AND COOKING**

As meat ultimate pH increased, less moisture was lost during thawing (drip loss) and cooking (cook-out loss). This tendency of high pH meat to "hold onto" water is well known and has been demonstrated in other studies.

### **APPEARANCE**

#### **Raw Meat Appearance**

High pH meat is darker, and this was confirmed by both instrumental colour measurements and sensory colour assessment. Panellists considered that the high pH lean had a less acceptable colour than normal pH lean.

The degree of marbling also affected acceptability, in terms of whether panellists would buy the steak in question. As the amount of marbling increased, panellist desire to purchase decreased, particularly for the highly marbled steaks. Almost all panellists who stated they would not buy the highly marbled steaks said they disliked the high fat content of these steaks. However, some panellists also disliked the very lean steaks, saying they would prefer a bit more marbling than was present in these steaks.

#### **Cooked Meat Appearance**

When steaks were cooked to a given end-point temperature, the high pH steaks (pH > 6.2) looked less done (more rare) than lower pH steaks. Therefore high pH meat needs to be cooked to a higher end-point temperature to achieve the same level of visual doneness.

### **SENSORY ATTRIBUTES**

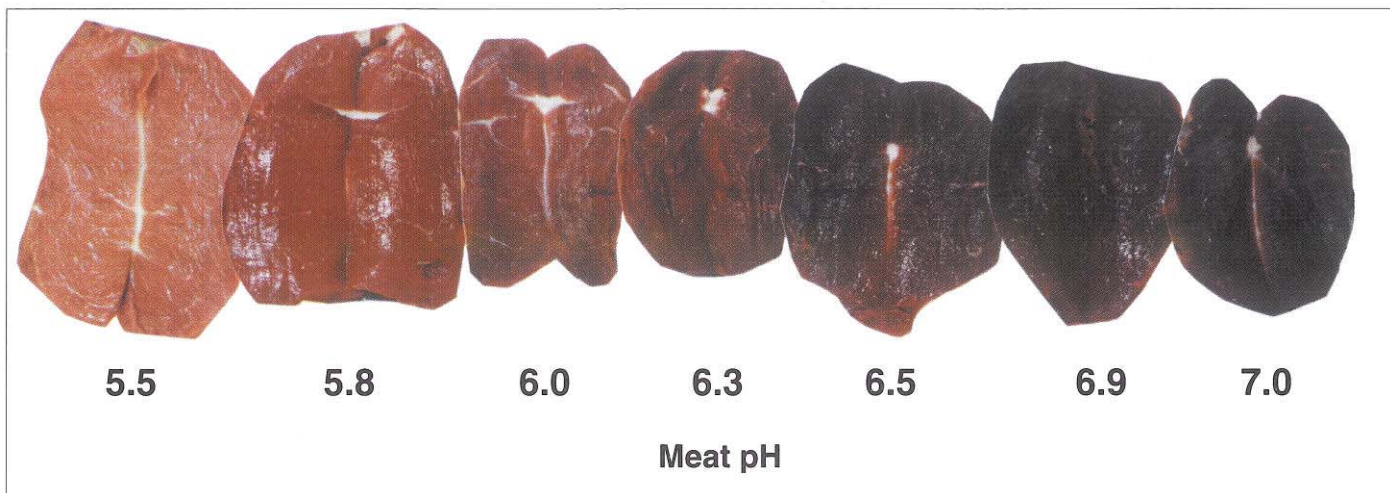
#### **Odour**

The degree of doneness had little effect on odour intensity.

High pH steaks (>6.2) had a lower odour intensity regardless of degree of cooking. Panellists disliked the odour of intermediate pH steaks (pH 5.8-6.0) compared to that of either normal pH or very high pH steaks.







*Example of how meat pH affects meat colour.  
Note: This example is NOT to be used as a colour standard.*

In the marbling study, the highly marbled steaks cooked to the lower temperature (70°C) had the most intense and the most preferred odour, although differences were small. Fat acts as a storage depot for volatile substances that are released on cooking, so the increased fat content of the highly marbled steaks probably explains the more intense odour of these steaks.

#### Flavour

The highest pH steaks (>6.2) had the lowest overall flavour intensity, regardless of level of doneness. This finding confirms the results of other studies done at MIRINZ, which found a markedly reduced flavour for high pH beef and lamb.

Rare, low pH (5.5-5.6) steaks had the most intense overall flavour and beef flavour, although as degree of doneness increased, differences in overall and beef flavour due to pH fell. The production of volatile chemicals that are responsible for flavour peaks at between 52 and 68°C, and decreases after 77°C, helping to explain why steaks cooked to lower end point temperatures had a more intense overall flavour.

“Livery” flavour was always highest in the high pH samples, regardless of degree of doneness. Doneness itself did not affect “livery” flavour intensity. Intermediate pH steaks had the least acceptable flavour, mirroring the odour results.

As would be expected, “bloody” flavour was strongest for rare steaks, and decreased as doneness increased. High pH steaks had the highest “bloody” flavour. Thus, high pH steaks not only looked less cooked than steaks of normal pH cooked to the same internal end-point temperature, they also tasted less cooked. Therefore, very high pH steaks need more cooking to achieve the same level of visual and flavour “doneness” as lower pH steaks.

The degree of marbling, interacting with end-point temperature, had various effects on flavour, but no trends were evident.

#### Juiciness

As would be expected, as degree of doneness increased, both the initial juiciness and the sustained juiciness (juiciness just before swallowing) fell.

For each degree of doneness, the highest pH (>6.2) steaks were the most juicy (both initial and sustained), and the juiciness was the most preferred. Meat pH had little effect on juiciness for the other pH categories.

Highly marbled steaks were the most juicy, and their juiciness was the most preferred, at each end-point temperature.



*Three degrees of marbling in this study: trace, moderate, high (left to right).*



The findings supported the work of others, that initial juiciness is more affected by the degree of doneness, and sustained juiciness is more affected by the degree of marbling.

### Tenderness

In both studies, well-done steaks were less tender than their rarer counterparts.

In this work, meat pH had interesting and contradictory effects on tenderness.

Analytical taste panellists, who scored tenderness level, found that the highest pH steaks were the most tender, and that steaks in the other pH groups were all of similar tenderness. These findings were supported by tenderometer measurements of these samples.

In contrast, in-house consumer panellists, who scored how well they liked the meat tenderness of different samples from the same treatments, downrated the tenderness of the intermediate pH samples (pH 5.8-6.0), although they agreed with the analytical panel that the high pH samples had a high (most acceptable) tenderness. These findings were also supported by tenderometer measurements of these (different) samples.

Therefore the sensory and tenderometer findings for samples assessed by the two panels were contradictory, for the intermediate pH samples.

Many studies have shown that intermediate pH meat tends to be tougher than meat of normal or very high pH, and this certainly was the case for the samples assessed by the in-

house panel. Other work indicates that some of this toughness can reduce on aging. There are therefore a number of possibilities regarding the pH-toughness issue in beef.

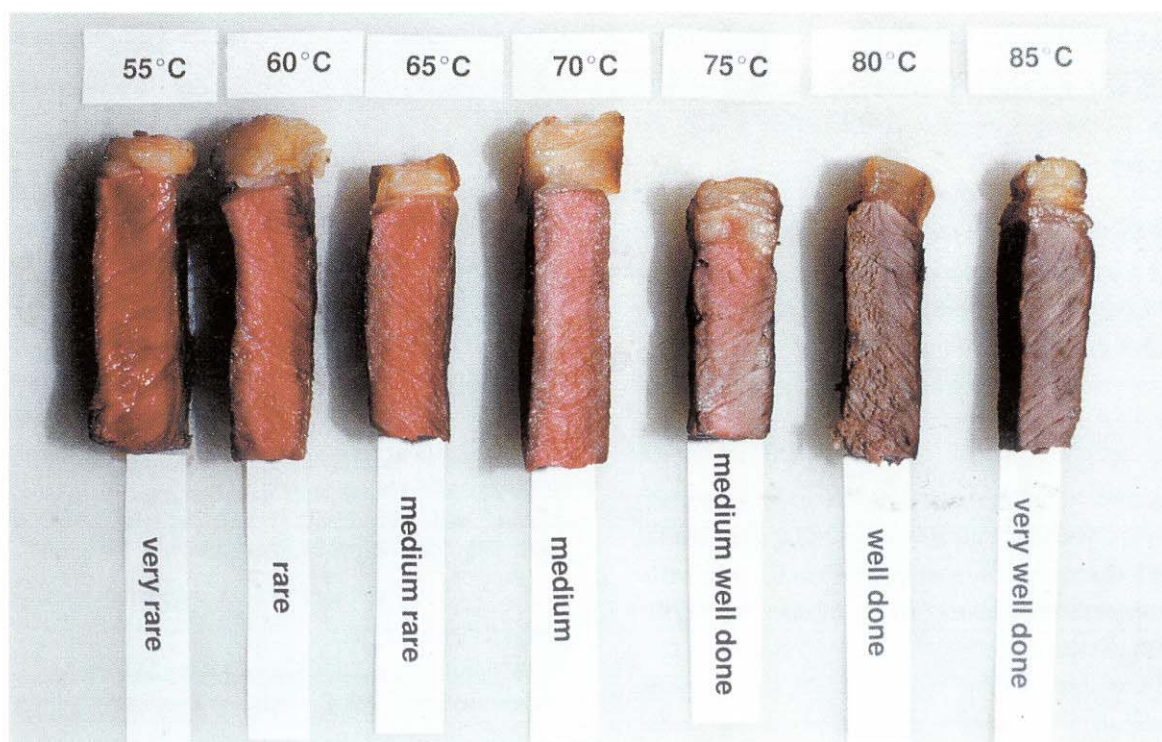
- Some intermediate pH beef is tough while other intermediate pH beef is not.
- Of the tough beef, some ages to become more tender while some does not, despite long-term chilled storage. (This is in contrast to lamb, where intermediate pH toughness will invariably “age out”.)

It is likely that some of the intermediate pH samples underwent some degree of tenderisation, and that by chance, the analytical panel was allotted a disproportionate number of these. For both panels, the intermediate pH samples had a very high tenderness variability.

Therefore, intermediate pH meat, while tougher just after slaughter than higher or lower pH meat, can improve in tenderness to a variable extent if it is aged, so that aged intermediate pH meat tends to be variably tough. Why this happened is not known, but is under study at MIRINZ.

Both the analytical and in-house panels agreed on the effect of marbling on tenderness – a high degree of marbling resulted in more tender meat.

Marbling could improve tenderness in one of several ways. Physically, it could “dilute” the muscle tissue. It also is associated with the thinning of connective tissue, making this tissue easier to break. Fat also provides lubrication during chewing and may change the water holding capacity of the meat.



Examples of steaks cooked to a range of end-point temperatures.





## OVERALL ACCEPTABILITY

The analytical panel did not assess overall acceptability, but did assess the level of “succulence”. Succulence is defined as the sum of all characteristics that define how “mouthwatering” the meat is. Therefore this term reflects the overall eating quality of the samples. The panellists gave rare steaks the highest score for succulence.

In-house consumer panellists considered that the high pH steaks had the most acceptable eating quality overall, and that the intermediate pH steaks had the least acceptable eating quality.

The consumer panellists found the highly marbled steaks cooked to the lower temperature had the most acceptable eating quality overall. At the lower cooking temperature, very lean and moderately marbled steaks had a similar overall acceptability, but at the higher cooking temperature very lean steaks were the least acceptable.

This finding reinforces previous work at MIRINZ, which has shown that very lean beef can be of excellent eating quality, so long as it is not overcooked.

### General Comments

One interesting finding relating to cooking temperature and eating quality was whether people truly understand what terms like “rare” or “medium well” truly mean.

To find this out, researchers asked over 75 MIRINZ staff members how they liked their steaks cooked. A week later, the staff members were shown steaks cooked to various degrees of doneness and asked to select the one cooked the way they like it.

Surprisingly, only one-third were able to pick the steak cooked to the level of doneness they had said was their preference a week before.

The most popular level of doneness was medium rare – almost half of the people surveyed said they liked their steaks cooked this way. But when shown the cooked steaks, most of those who said they liked their steaks cooked “medium rare” actually chose steaks cooked to a higher level of doneness.

The discrepancies between what people believe they like (terminology) and what they truly like (actuality) could be due to several factors, not the least of which is the very wide variability in actual doneness of steaks cooked to “medium rare” in restaurants.

Clearly, education is needed in what the various doneness terms truly mean.

## CONCLUSIONS

- Very high pH beef is darker. When cooked, high pH steaks tend to be more juicy and tender. They also taste and look more rare for a given degree of cooking, and therefore need to be cooked to a higher end-point to achieve a given level of “doneness”.
- Intermediate pH steaks tend to be tougher than higher or lower pH steaks. Aging can reduce some of this toughness, but only to a variable extent.
- Lower cooking treatments result in juicier, more flavourful, more tender and more succulent meat. For good eating quality, it is essential not to overcook very lean meat.
- Although consumers may not want to buy highly marbled meat, highly marbled steaks have a more acceptable overall eating quality over a range of cooking temperatures.
- Consumers tend not to understand what the various terms mean that are used to indicate degree of doneness.

## FURTHER READING

The Effect of Meat pH, Marbling and Cooking Temperature on Sensory Attributes of Beef Striploin Steaks (1999), by T.L. Cummings, S.M. Scott and C.E. Devine MIRINZ Technical Report No. 992.

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For more information please contact:  
AgResearch MIRINZ  
Private Bag 3123  
Hamilton 3240  
New Zealand

Phone: +64 7 838 5576  
MIRINZ@agresearch.co.nz