

Beef Tenderness Explained

Some processing factors affecting the eating quality of beef - pre-slaughter stress, pH, tenderstretch, electrical stimulation and ageing

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Introduction

Consumers of beef are concerned with price, hygiene, nutrition and eating quality. Eating quality, especially tenderness, is the attribute of beef which gains and retains markets and consumers for the beef industry. Inconsistency in eating quality ultimately reduces consumption levels by red meat eaters. This short article is not a discussion of “meat quality” because that would include topics such as hygiene, nutrition, retail prices, carcass quality and fat colour. It concentrates on the attributes of beef steak that people tell us are important to their enjoyment of beef. If consumers do not enjoy beef then they just do not bother eating it. Vegetarians and chicken lickers do not care whether beef is healthy, nutritious or economical because they are not having any.

Eating Quality Measurements

The most important attribute in all surveys of customers’ attitudes to beef is tenderness. Presented here is background information on eating quality attributes such as tenderness. How is it measured? What are the components of meat which determine its tenderness? What is the relationship between tenderness and production and processing factors such as pH, electrical stimulation, ageing, pre-slaughter stress and breed?

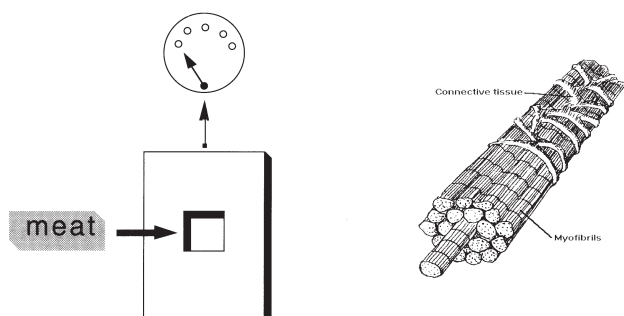
Toughness can be measured using mechanical devices which mimic the functions of the mouth and teeth.

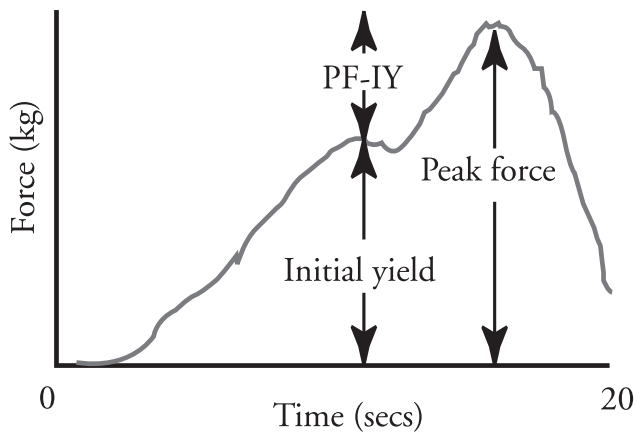
Most common is a machine called a Warner-Bratzler Shear Force machine. It consists of a steel plate with a square hole in it. A square sample of cooked meat is placed in the hole and the plate is pulled through the meat while the ends of the meat are held in some sort of clamp.

The forces needed to pull the plate through the meat are plotted on a graph as shown on the next page. Note that there is an increase in force, then a break. This break is called the initial yield. The force then continues to build up until it reaches the peak force. At this point the meat breaks in half and the force collapses.

The two forces, the initial yield and the (peak force minus the initial yield) can be related to two structures in meat which contribute to toughness. One component of muscle is long bundles of protein rods. These are the myofibrils. They are the bulk of the muscle and they are the bits that make the muscle work. When they shorten the muscle contracts and so pulls on things. “Myo” means muscle and “fibril” is a fibre-like thing.

The other component is the network-like material. This is connective tissue. It holds the myofibrils together. It is similar to the stuff that makes up tendons and sinews. It is spread throughout the muscle or meat in a crosslinked network structure. If we refer back to the diagram of Warner-Bratzler forces we can equate the toughness of the myofibrils with the initial yield and the build up from the initial yield to the peak force is due to the connective tissue.





There are other ways of measuring toughness. **Instron compression** is a method where the force required to drive a blunt probe into the meat is measured. It is the connective tissue which offers the most resistance to the probe.

Adhesion involves measuring how hard it is to rip the meat apart. This is done by gripping the meat with clamps and measuring the force required to tear it apart.

Myofibrillar Fragmentation Index measures how much damage a homogenizer does to the myofibrils.

Collagen Solubility measures how easily the connective tissue falls apart when heated.

Taste Panel Testing

The most relevant test is where real people taste the meat and tell us whether it is tough or not. **Sensory Evaluation** or **Taste Panel Testing** has the added advantage that we also get other important results such as juiciness, flavour and overall acceptability. The disadvantages of this method are that it is slow and hard to organize and the fact that people often do not agree with each other. Taste tests can be done by presenting the meat to consumers in a supermarket or restaurant and asking ordinary people to fill in a response sheet. This method is not reliable unless you assess a huge number of samples. Another approach is to train people very thoroughly so that they can reproduce the results obtained with the Warner-Bratzler machine. This is pointless since the machine results are easier to obtain.

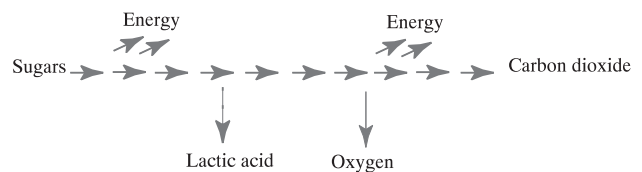
An alternate approach to the sensory evaluation or taste panel testing of meat is to use ordinary people who have been made aware of the sorts of things to look for when tasting. They are given a wide range of experience in tasting and their results are statistically checked to ensure everyone is performing with the others. Each sample is tested by a number of different people. They assess the tenderness of the meat,

its juiciness and flavour and finally they judge its overall acceptability.

pH?

You must have a low pH to have tender meat. What is low pH and how do you get it?

Metabolism, which is all the chemical reactions that go on in a living thing, is aimed at supplying energy for the living body. Sugars are broken down in a number of steps which release energy. The early steps do not require oxygen, but the later ones do.



When oxygen is available the end result is carbon dioxide which animals breathe out. Consider yourself taking a brisk walk. You can go on for miles. This is because you are using sugars and oxygen to produce energy and breathing out the carbon dioxide. During a fast sprint, you cannot breathe the oxygen in fast enough and you cannot get rid of the carbon dioxide fast enough. Only the first part of the energy production chain functions. After a while you cannot go any further. The reason is that if there is not enough oxygen, a new product is formed, lactic acid. This is an acid and it stays in your blood stream. It lowers the pH, more acid means lower pH, and stops everything from working. You are fatigued and you must stop, breathe in oxygen and allow your body to remove the lactic acid.

The same process happens in cattle muscles when they are killed. There is no oxygen supply after death but the other processes keep working until the sugars run out. Therefore, the pH in fresh meat drops and this is good because it allows ageing to occur. pH in live muscle is about 7 (neutral, the same as water). In meat, the pH should be less than 5.8; this means the meat is more acid than live muscle. You must have a low pH to have tender meat.

Electrical Stimulation

What happens if you chill a freshly killed carcass very quickly? Firstly, the muscles contract as they always do in a process called *rigor mortis*. Thus the muscles are cold shortened. Unless this is prevented as in the tenderstretch process or reversed later by the ageing process the meat will be very tough. When freshly killed meat becomes too cold, too quickly, the enzymes that use up the sugars cannot work properly

and the pH does not drop. Without a pH drop, ageing does not occur and the myofibrils stay shortened. The meat is tough, cold shortened.

How do you prevent this problem? Chilling slowly is not allowed because of hygiene problems. A good fat cover helps slow the chilling within the muscle, but having too much subcutaneous fat is wasteful and it does not work very well for the more exposed muscles like the striploin. The best solution is to electrically stimulate. When you electrically stimulate the muscle, the muscle uses up all the sugars very quickly. Because no oxygen is going to the muscles, a large quantity of lactic acid is produced. The pH drops and ageing can occur. Since this all happens before chilling, even a fast chill has no permanent detrimental effect.

Stress

In some situations, there is not enough sugar in the muscle in the first place. Without enough sugar in the muscle the pH cannot drop far enough. The meat will be tough and there is nothing that can be done about it. The meat has a dark colour and is dry and firm. These carcasses are known as dark cutters. This problem costs the Australian meat industry over \$40 million a year.

If the pH does not drop at all, then all the wrong enzymes go to work and the meat will be pale, soft and mushy. This is more of a problem with pigs than cattle.

When are there not enough sugars in the muscle? This happens when the cattle are stressed pre-slaughter. Sugars can be used up during acute stress such as when animals are mixed and they run around butting and mounting each other. It can also be used up by slow stress such as during transport, in heat or cold and due to dehydration. Because cattle are slow to replace the sugars, any pre-slaughter stress means that the animals will die with insufficient sugars in their muscle. The pH will not drop and the meat will be tough.

What Happens During Ageing?

Ageing is when you let meat stand for a period of time after slaughter, usually eight days to several weeks, so that it becomes more tender. Ageing is usually done at low temperature to avoid spoilage due to bacteria and in special plastic bags to prevent off-flavours due to oxygen.

In the muscle diagram, bands are drawn across the myofibrils. Under the microscope you can actually see these bands. They are there because the relatively long fibres of the myofibrils are

made up of shorter units (sarcomeres) joined together at flat plates depicted by the bands. During ageing, enzymes called calpains cut the long fibres up by snipping the short sections away from the plates. The bundles still remain intact, but they have breaks in them. This means that the meat is more tender but it still has texture. It is not mince or mush.

Other changes also occur during ageing. The effect of low pH and free calcium (released by electrical stimulation), change the way muscle proteins fold and bind together. The overall effect of these changes and the enzyme action is to produce tender meat.

What is the Answer?

The answer lies in understanding exactly what consumers regard as tenderness. This varies from person to person and from situation to situation. Many people expect a steak in a restaurant to be better than one they have at home. People like their steaks done to different degrees. It is all in the mind. We do not yet have all the answers, but we do know that there are some steaks that nearly everyone agrees are very tender. These are the product we should aim to produce.

Further Information

For further information on estimating meat quality see "Laboratories, Taste Panels and Palatability" by Diana Perry in these proceedings.



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