



Meat Tenderness

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Meat tenderness is the most studied aspect of meat science. Even so, there is a lack of complete understanding of the interactions and intricacies of meat tenderness. Generally, there are four main categories that have been identified as the main factors contributing to tenderness: contractile state, degradation state, connective tissue, and fat content. All four categories play a role in determining the tenderness of a muscle.

Contractile state of the muscle – The contractile state of the muscle relates to the degree of contraction in a muscle. Muscles are composed of thick and thin filaments, which serve as the functional units of contraction. Relaxed (i.e., stretched) muscles have a minimal amount of overlap of the thick and thin filaments. This results in a more open striation pattern and reduces the instances of shearing across both filaments. The tenderloin is an example of a muscle that is stretched post-mortem and thus very tender. Contracted muscles have greater overlap of the thick and thin filaments, hence there is a greater incidence of shearing across both filaments. Cold-shortened muscles, where rapid chilling induces severe muscle contractions resulting in extremely tough meat, are the best example of the negative impact that contraction can have on meat tenderness. The most common measurement of contractile state is sarcomere length, with a more contracted muscle having shorter sarcomeres.

Degradative state of the muscle – The degradative state of the muscle involves the post-mortem proteolytic enzymes. Calpains (the calcium activated proteases) are responsible for most of the post-mortem tenderization, by breaking down some of the structural components of muscle, relieving inherent muscle tension and resulting in fragmentation. Calpastatin is an antagonistic regulator of the calpains. If calpastatin levels are high, calpain activity will be inhibited and less post-mortem degradation will occur. Factors that influence the degree of post-mortem proteolysis include: breed, temperature, and time. It is recommended to age all beef a minimum of 14 days to allow sufficient time for the calpains to work. Calpain and calpastatin activity, and muscle fragmentation are ways to measure degradation.

Connective tissue – The amount and solubility of connective tissue greatly influences the tenderness of muscle. In general, our concern is with the amount of collagen and the degree of cross-linking. Collagen has the unique ability to form cross-linkages within itself and with other collagen filaments. The more cross-linkages in a collagen fiber, the more insoluble it becomes. Greater insolubility means that collagen cannot be dissolved during the cooking process. As an animal ages, the amount of connective tissue, and the degree of cross-linking increases, resulting in greater amounts of connective tissue that is highly insoluble. This is why there are such large differences in tenderness of young animals versus older animals. The most common measurements of collagen are hydroxyproline content and collagen solubility.

Fat Content – The amount and distribution of fat in a muscle also influences tenderness. Fat in muscle is thought to function as a lubricant on the teeth or in the mouth and decrease the amount of frictional force. The bulk density of marbling is also thought to aid in tenderness. As fat melts during cooking, it leaves “pockets” between the muscle bundles leaving more compressive spaces in the muscle. It can be likened to Swiss cheese where it takes less force to cut through than a solid block of cheddar. Marbling deposits are closely associated with connective tissue and have been shown to “stretch” connective tissues, making it more thin. Intramuscular fat acts as an insulator during cooking, making it more difficult to overcook muscle proteins. Marbling or intramuscular fat is used as the method to measure fat content.

