AG-FO-0856-B
Revised 1992

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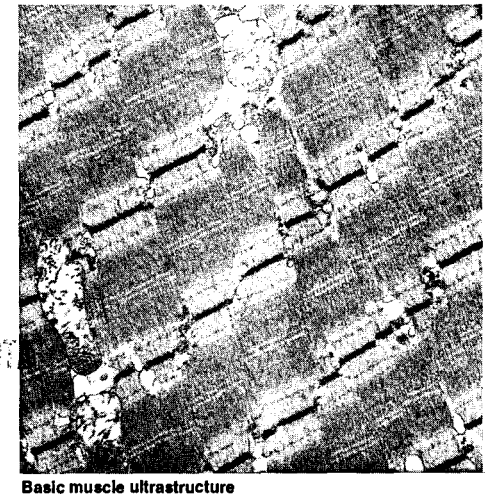
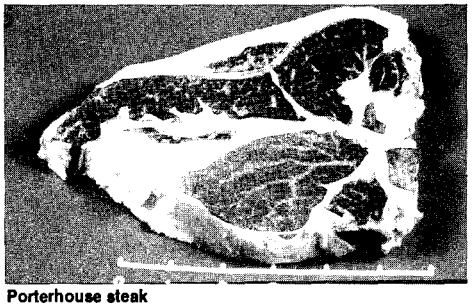
AGRICULTURE

Meat Tenderness

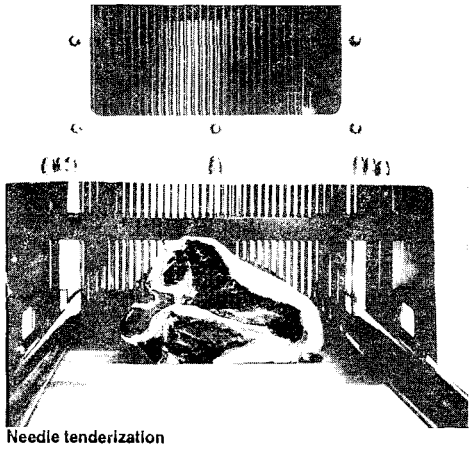


Basic muscle ultrastructure



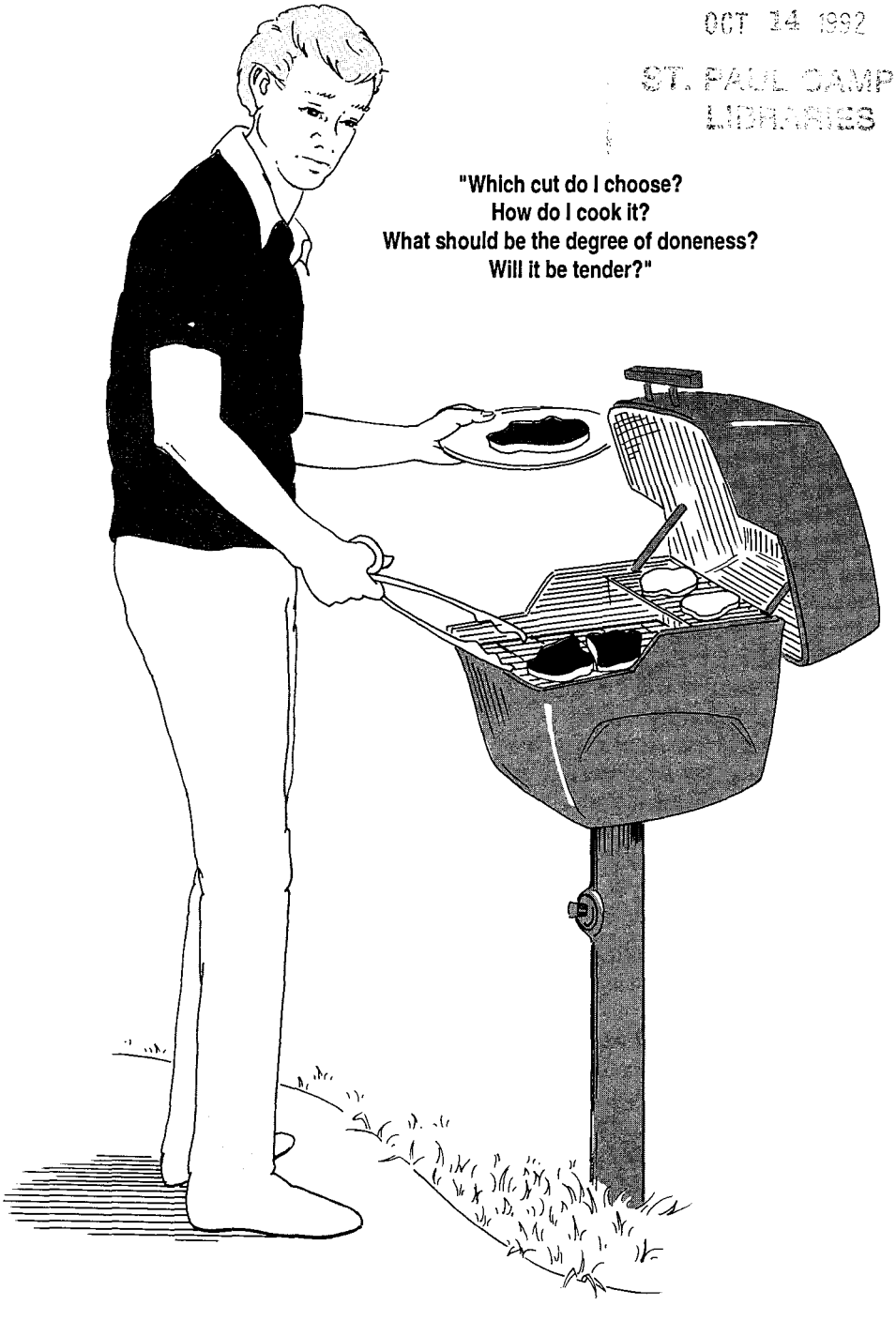
Porterhouse steak

Round steak



Needle tenderization

"Which cut do I choose?
How do I cook it?
What should be the degree of doneness?
Will it be tender?"



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Tenderness, juiciness, and flavor are components of meat palatability. Although juiciness and flavor normally do not vary a great deal, tenderness can vary considerably from one cut to the next. This folder will discuss some of the most common causes of variation in tenderness of beef, pork, lamb, and veal.

Genetics

The heritability of tenderness in beef is approximately 45 percent, which means that 45 percent of the observed variation in tenderness of cooked beef is due to the genetics or parents of the animal from which the beef came.

A consumer can purchase a USDA Choice rib roast, cook it to a medium degree of doneness, and end up with a very tender product. The same consumer can then go back to the same store, buy the same grade and type of cut, cook it the same way, and it could be less tender. Although there are many other factors involved in tenderness, as discussed below, genetics is one of the main reasons such a wide difference in tenderness often exists among identical grades and cuts of meat.

Species and Age

Beef usually is the most variable in tenderness followed by lamb, pork, and veal. The tenderness variation from species to species is due primarily to the chronological age of the animal at time of slaughter. Beef normally is processed at approximately 20 months of age, lamb at 8 months, pork at 5 months, and veal at approximately 2 months of age.

Within a given species such as beef, age of the animal at slaughter also influences tenderness. Beef normally is slaughtered between 9 and 30 months of age. Usually the meat from the animals is fairly tender; however, if a female beef animal has been used for breeding purposes, meat from such an animal becomes progressively less tender as the animal gets older. Cows up to 15 years of age may be processed for beef steaks and roasts, but ideally these should be tenderized because of the increased probability of less tender meat in older animals.

The decrease in tenderness with increasing age is due to the changing nature of collagen (gristle), the connective tissue protein found in meat. Collagen becomes more complex and stronger with advancing age and thus is more resistant to tenderization from moist-heat cooking. Pork and lamb from older animals normally are processed into sausage items, so toughness due to age usually is not a problem.

Feeding

Contrary to popular belief, what the animal is fed does not directly influence tenderness. In the case of beef, an indirect effect of feeding on tenderness may be observed. Animals that are finished with grain tend to reach a given slaughter weight sooner than animals that are finished to the same slaughter weight on pasture. Thus, grain-fed animals usually are slightly more tender because they are slaughtered at a slightly younger age.

Muscle to Muscle

Within any species, there is a considerable variation in tenderness among muscles. For example, tenderloin is much more tender than the fore shank or heel of round in beef. This difference is due in part to the amount of connective tissue in the various cuts. The tenderloin usually has a small amount of connective tissue compared with the fore shank or heel of round. The amount of connective tissue present is due to the function of the muscles in the live animal. The fore shank and heel of round are used quite heavily in locomotion (movement) and therefore have relatively large amounts of connective tissue. Conversely, the tenderloin provides a support function in the animal and therefore has less connective tissue.

Another source of muscle-to-muscle variation in tenderness is the amount of stretch or tension applied to each muscle while the carcass is being chilled. This stretching is due to the weight of the carcass and prevents shortening (contraction) of the muscle, which in turn results in more tender meat. The major muscle in the rib and the loin is stretched more during the chilling process than are the major muscles in the round; therefore, cuts from the rib and loin are more tender than cuts from the round. This is the major reason the tenderloin is the most tender muscle in the carcass.

Suspension of Carcass

As mentioned above, stretching of the muscle during chilling of the carcass affects tenderness. This has different effects on different muscles according to their anatomical location in the carcass. Although most carcasses are hung from the hind leg, a new method of hanging the carcass from the pelvic or hip bone changes the tension applied to some muscles. This method has been shown to increase tenderness of muscles in the round; however, it decreases the stretch and consequently the tenderness of the tenderloin. Pelvic suspension of beef carcasses is not used widely in industry because it requires changes in plant layout and cutting procedures. It is a procedure, however, than can be used in home slaughtered animals or wild game such as deer.

Electrical Stimulation

Electrical stimulation of the hot carcass immediately after slaughter is an innovation being used in the meat industry to increase tenderness. Beef carcasses are subjected to approximately one minute of high voltage electrical current. The result is an improvement in tenderness of many cuts of the carcass. An improvement in tenderness of cuts from carcasses of older cows also has been observed when electrical stimulation has been applied. Electrical stimulation speeds up the post-mortem conversion of muscle to meat and thus reduces the incidence of "cold shortening" (discussed below). The use of electrical stimulation in the beef industry is widespread.

Chilling Rate

Immediately after slaughter, many changes take place in muscle that convert muscle to meat. One of the changes is the contraction and stiffening of muscle known as rigor mortis. Muscle is very tender at the time of slaughter. However, as rigor mortis begins, muscle becomes progressively less tender until rigor mortis is complete. In the case of beef, 6 to 12 hours are required for the

completion of rigor mortis, whereas in the case of pork, only 1 to 6 hours are required .

The carcass is chilled immediately after slaughter to prevent spoilage. If the carcass is chilled too rapidly, the result is "cold shortening" and subsequent toughness. Cold shortening occurs when the muscle is chilled to less than 60° F before the completion of rigor mortis. If the carcass is frozen before completion of rigor mortis, the result is "thaw rigor" and subsequently extremely tough meat. Under normal chilling conditions, it appears that unprotected carcasses with less than 0.50 inch of fat over the rib eye probably will have some reduced tenderness because of cold shortening. Aging a carcass affected by cold shortening or thaw rigor will not alleviate the detrimental effects on tenderness caused by these two conditions. To ensure more tender meat, home slaughtered animals and wild game should be protected from very rapid cooling during the first 6-12 hours after death.

Aging

After the completion of rigor mortis, changes take place in beef that result in the beef becoming progressively more tender. This holding of beef in a cooler (carcass or vacuum packaged subprimal) or beef in the refrigerator is commonly referred to as the "aging period." The increase in tenderness is due to natural enzymatic changes taking place in the muscle. The increase in beef tenderness continues only for approximately 7 to 10 days after slaughter when the beef is held at approximately 35° F. Beef held at higher temperatures will tenderize more rapidly, but it also may spoil and develop off-flavors.

Lamb and pork are rarely aged. A lack of tenderness usually is not encountered because of lamb and pork's relatively young age when slaughtered.

Quality Grade

Age of the animal also plays a major role in tenderness as it applies to quality grading in beef. The quality grades of beef are USDA Prime, Choice, Select, Standard, Utility, and Commercial. Carcasses from young animals (up to 40 months of age) are eligible for USDA Prime, Choice, Select, Standard, and Utility grade designations. Carcasses from beef animals older than 40 months are eligible for USDA Commercial and Utility grade designations. Normally beef in the young grade designations is more tender than beef from USDA Commercial or Utility grade carcasses and, therefore, is much more common in the marketplace.

Marbling, the visible specks of fat in the lean, also is a factor used in determining the USDA quality grade. However, information in the last decade indicates that marbling exerts only a small influence on tenderness of meat, primarily by acting as a lubricant during chewing.

Texture of the lean has a small influence on tenderness. Lean that has a fine, smooth, velvety texture generally is somewhat more tender when cooked than lean that has a coarse, open, or rough texture.

Lean that is pale, soft, and exudative or watery (most often found in pork) may have a tendency to be less tender when cooked than normal, bright-colored lean. Part of this effect may be due to the fact that pale, soft, and watery lean loses more moisture upon cooking. Meat that is less juicy usually is perceived to be less tender when eaten, especially when cooked to a high degree of doneness, as frequently occurs with pork.

Mechanical

Grinding is a very popular means of increasing tenderness of meat, especially beef. The popularity of hamburger and ground beef is due in part to the fact that texture and tenderness is more uniform than tenderness of steaks and roasts. Cubing is another means of mechanically tenderizing meat. The small blades of a cuber simply sever connective tissue in boneless retail cuts so that the connective tissue is broken into smaller pieces.

Blade or needle tenderization of cuts recently has increased in popularity. This method of tenderization is employed on wholesale cuts that are in turn processed in the normal manner into retail cuts. Blade tenderization cuts and punctures some of the connective tissue contained in the lean.

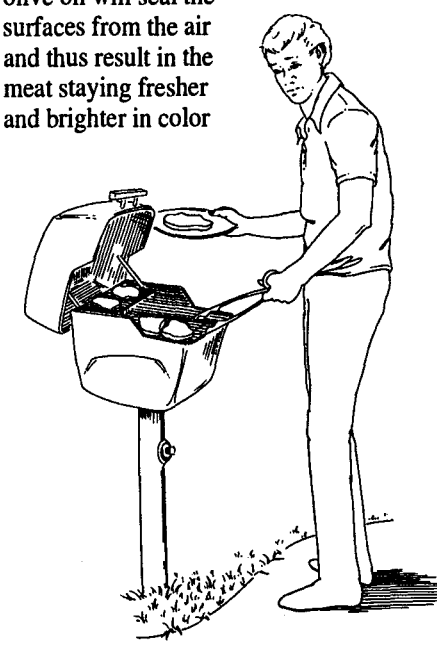
Chemical

Salt is a chemical that at certain concentrations increases the tenderness of meat. The presence of salt is one of the reasons that cured meats such as ham are more tender than uncured meats. Salt apparently exerts its influence on tenderness by softening the connective tissue protein, collagen, into a more tender form.

There are a number of vegetable enzymes such as papain (papaya), bromelin (pineapple), and ficin (fig) used to tenderize meat both commercially and in the home. These tenderizers can be applied either in liquid form or in powder form. Their primary effect is to dissolve or degrade the connective tissues collagen and elastin. The limitation of vegetable enzymes is that their action is sometimes restricted to the surface of meat. Also, on occasion, they can impart a characteristic "tenderized" flavor to meat.

Marinading

Marinading is a way consumers can improve tenderness and add taste variety to the meat component of meals. The basic ingredients of a marinade include salt (or soy sauce), acid (vinegar, lemon, Italian salad dressing, or soy sauce), and enzymes (papain, bromelin, ficin, or fresh gingerroot). Some marinade recipes call for addition of an alcohol source (wine or brandy) for flavor. The addition of several tablespoonfuls of olive oil will seal the surfaces from the air and thus result in the meat staying fresher and brighter in color



for a longer period of time. The tenderizing action of marinades occurs through the softening of collagen by the salt, the increased water uptake, and the hydrolysis and breakage of the cross links of the connective tissue by the acids and alcohols. Mix the desired marinade components in an earthenware dish (acid will affect a metal container and give an off-flavor). Cut the meat into thin strips or pieces to get a more complete penetration of the marinade into the center of the meat. Place the meat in the dish, add some water only if necessary, and refrigerate for a minimum of 4-8 hours. (Less than 4 hours is an insufficient amount of time for the tenderizing action of the marinade to be completed.) Do not overcook. It should be noted that marination results in substantial losses of iron, zinc, and magnesium, but increases the sodium content of meat.

Freezing

Freezing rate plays a small role in tenderness. When meat is frozen very quickly, small ice crystals form; when meat is frozen slowly, large ice crystals are formed. While the formation of large crystals may serve to disrupt components of the muscle fibers in meat and thereby increase tenderness very slightly, the large ice crystals result in an increased loss of juices upon thawing. This increase in loss of juices results in meat that is less juicy upon cooking and therefore usually is perceived as being less tender.

Thawing

Thawing meat slowly in the refrigerator generally results in greater tenderness compared with cooking from the frozen state. Slow thawing minimizes the toughening effect from cold shortening (when present) and reduces the amount of moisture loss. Thawing in a microwave is accomplished by using a lower power setting or by manually alternating cooking and standing times. During the standing time, some of the heat from the thawed areas moves toward the frozen area.

Cooking

As cooking progresses, the contractile proteins in meat become less tender, and the major connective tissue protein (collagen) becomes more tender. Thus, for cuts that are low in connective tissue—such as steaks and chops from the rib and loin—the recommended method of cooking is dry heat, including pan frying, broiling, roasting, or barbecuing. Dry heat raises the temperature very quickly and the flavor of meat will develop before the contractile proteins have the opportunity to become significantly less tender.

For cuts with a high amount of connective tissue—such as those from the fore shank, heel of round, and chuck—the recommended method of cooking is long and slow at low temperatures using moist heat such as braising. The application of moist heat for a long time at low temperatures (275°-325° F) results in conversion of tough collagen into tender gelatin and makes this type of cut more tender compared with dry heat cooking of one of the less tender cuts of meat.

Degree of doneness significantly affects tenderness. As the lean is heated, the contractile proteins toughen and moisture is lost. Both decrease tenderness. Tender cuts of meat cooked to a rare degree of doneness (140° F) are more tender than when cooked to medium (155° F), and medium in turn is more tender than well-done (170° F). Degree of doneness is especially important in the case of beef. Some people, however, do not like the flavor of rare beef and thus choose to cook their beef well-done. They should be aware that by doing so, tenderness is greatly reduced in what normally are tender cuts of meat (tenderness will be improved in less tender cuts when cooked well-done by moist heat).

When consumers switch to a grade of beef with less marbling than what they have been accustomed to, care should be taken not to overcook. In most cases, beef with little marbling requires less cooking time than higher grade beef. However, consumers often fail to make this time adjustment and the result is overcooked beef that lacks tenderness. Some consumers cook low fat beef in the frozen state for the same time as they would higher fat, thawed beef. This procedure helps prevent overcooking.

It is recommended that pork be cooked to approximately 160° F or 170° F internal temperature for desirable flavor. Although this temperature range corresponds to well-done in beef, pork still may be slightly pink. Since *Trichinella spiralis* (trichina) is destroyed at 137° F, an internal temperature of 160°-170° F for pork is definitely safe. Therefore, it is not necessary to cook pork beyond this stage of doneness; further cooking will result in dehydration, loss of juiciness, and unnecessary toughening. It usually is recommended to cook lamb to well-done (approximately 160°-170° F internal temperature) because the flavor is more desirable compared with lower temperatures.

Carving

Muscles, muscle bundles, and muscle fibers are all surrounded by connective tissue. When cuts are made from carcasses and wholesale cuts, the normal procedure is to cut at right angles to the length of the muscle. This procedure severs the maximum amount of connective tissue and distributes the bone more evenly among all cuts in that area. Likewise, consumers should carve cooked meat at right angles to the length of the muscle fibers or "against the grain" to achieve maximum tenderness. Cutting with the grain results in "stringiness" and thus less tenderness.

Summary

Many factors influence meat tenderness. The most important factors are genetics, age of the animal, location of the cut on the carcass, processing, method of cooking, and degree of doneness.

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