

## Introduction

Meat is the edible portion of mammals—the flesh of animals used for food. “Meat” may include rabbit, venison, and other game, as well as the *nonmammals* poultry and fish. The flesh from various animals may be used as food throughout the world.

Red meat is the meat from mammals including beef and veal, lamb, mutton, and pork. White meat refers to meat from poultry. Addressing the question of pork as a white meat, it is determined that its myoglobin content is lower than beef, and yet significantly higher than chicken or turkey white meat. The USDA treats pork as a red meat. In 1987, the US National Pork Board began a successful advertising campaign stating that pork was “the other white meat.” This was intended to give the perception that, similar to chicken and turkey (white meat), it was more healthy than red meat.

Other than the red or white meats, seafood is derived from fish, and game is from nondomesticated animals. These may be sold fresh or frozen. Meat is also available in processed or manufactured products.

Meat is composed of three major parts: *muscle*, *connective tissue*, and *adipose tissue* (fat). Lean meats contain less adipose tissue than well-

marbled cuts of meat. The location of the cut of meat on the animal, muscle contraction, and postmortem changes all influence the degree of meat tenderness. Individual cuts vary in inherent tenderness, requiring different cooking methods

All meat is subject to mandatory *inspection* by the USDA and voluntary *grading*. After inspection alteration may occur due to processing methods including curing, smoking, restructuring, and tenderizing. Kosher and Halal inspections mean much more than having a religious official blessing.

*Incomplete* plant proteins of animal feed are resynthesized in meat, and it is important to know that only animal protein is a *complete* protein. Thus, if meat consumption is minimized or omitted from the diet, for any number of reasons, an individual must obtain similar nutrients from a nonmeat source, such as combination of various plants (Chap. 7).

The USDA estimates 2011 US per capita beef consumption at 57.4 lb, down 13 % from 10 years ago and down about 25 % from 1980. The 2012 USDA prediction was that Americans would eat less beef than they ate in 2011 (only 54.1 lb of beef on average). Reuters News Service reports that this low amount “an opportunity for beef companies and retailers to promote . . . higher-end cuts in supermarkets but in smaller portions (National Cattleman’s Beef Association (NCBA))”.

Beef demand has been up and down—depending on such things as health news and the economy. Yet, some individuals may have environmental, religious, vegetarian/flexitarian beliefs, or other concerns related to the consumption of meat, thus they might choose to avoid meat products, or consume meat minimally. The USDA recommends to “go lean with protein.” See your personal intake recommendation for daily consumption by utilizing [choosemyplate.gov](http://choosemyplate.gov).

Meat must satisfy the requirements of appearance, texture, and flavor, as well as nutrition, safety, and convenience. Therefore, if eating meat, in order to keep it safe, it becomes important to know the effects of storing and cooking meat on its various components.

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## Characteristics of Meat

### Physical Composition of Meat

The physical composition of meat is composed of three tissues: muscle tissue, connective tissue, and adipose or fatty tissue. Each is discussed in the text below.

**Muscle Tissue.** Muscle tissue is referred to as the *lean* tissue of meat. It includes *cardiac*, *skeletal*, and *smooth muscle*. *Cardiac* muscle is located in the heart. *Skeletal* muscle, the primary component of the carcass, provides support for the weight of the body, and its movement, or locomotion. When a muscle is used, it serves to strengthen the bone to which it is attached (true in humans too). *Smooth* muscle is the visceral muscle, located for example, in the digestive tract, reproduction system, and throughout the blood vessels of the circulatory system.

Within the muscle cell membrane (Fig. 9.1), there are *myofibrils* containing alternating thin and thick protein filaments, namely the *actin* and *myosin*, which contract and relax in the living animal. They are varied in length, perhaps 1 or 2 in. long, and are very small in diameter. Each fiber is cylindrical, with tapered ends, and is covered by a thin connective tissue sheath called *endomysium*. Small bundles of 20–40 fibers make up one primary bundle that represents the

“*grain*” of meat. This primary bundle is surrounded by *perimysium* connective tissue.

**CULINARY ALERT!** In carving meats it is often recommended to cut “across the grain,” thus shortening the fibers for enhanced tenderness.

Collectively, several primary bundles form a larger, *secondary* bundle that also contains blood vessels and nerves. As is the case with the primary bundles that make it up, each secondary bundle is also surrounded by *perimysium* connective tissue. In turn, several of the secondary bundles are surrounded by *epimysium* connective tissue dividing one skeletal muscle from another. In *between* the muscle bundles, there are blood vessels (capillaries) and small pockets of fat cells.

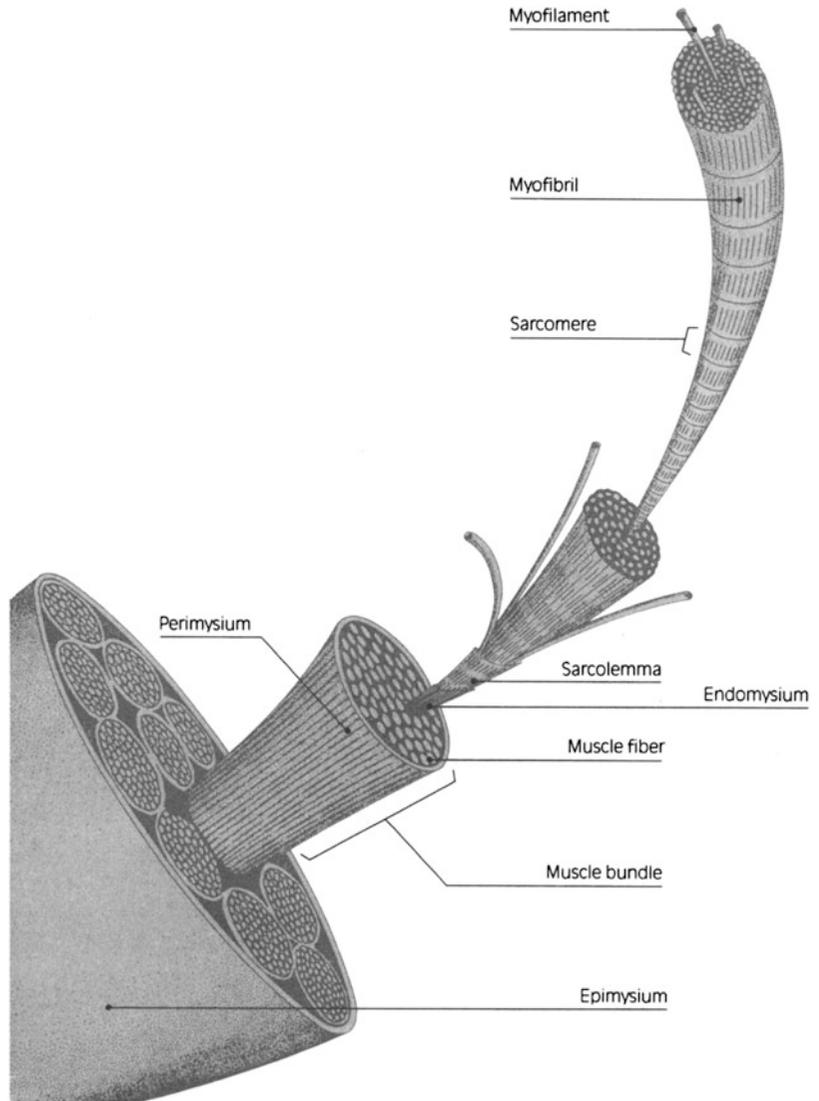
**Connective Tissue.** (mostly collagen and elastin) The connective tissue is made up of protein and mucopolysaccharides. It is located throughout the muscle (Fig. 9.1) and determines the degree of meat tenderness. Lesser amounts of connective tissue equates to meat that is more tender. Various types of connective tissue—the endomysium, perimysium, and epimysium, bind the muscle fibers in bundles to form the muscle.

The connective tissue extends beyond the muscle fibers to form *tendons*, which attach the muscle to bones and holds and connects various parts of the body. It also forms *ligaments*, attaching one bone to another. Additionally, the tough skin, or hide of an animal, is connected to underlying animal tissue by connective tissue.

It follows that meat containing a *high* degree of muscle tissue naturally has a *greater* amount of connective tissue to hold myofibrils and bundles in the muscle. **Collagen** is the most abundant protein found in mammals—in bone, cartilage, tendons, and ligament, enveloping muscle groups and separating muscle layers. It is also in horns, hooves, and skin.

Collagen is a triple-coil protein structure that is white in color and contracts to a thick mass when heated. Yet, it becomes tenderized when cooked with *moist* heat. This tenderization may be referred to in several manners. For example,

**Fig. 9.1** Diagram of a lean muscle and its connective tissue (Source: National Cattlemen’s Beef Association)



collagen may be “converted to,” “solubilized to,” or “gelatinized to” water-soluble **gelatin**. (This is the same gelatin that may in turn be used for edible gels in the diet.) In older animals, the collagen is increased and may form many cross-linkage, thus *preventing* solubilization of collagen to the more tender gelatin. The meat from older animals is therefore tough.

A second, *lesser* component of the meat’s connective tissue is the yellow-colored **elastin** protein, which is more elastic than collagen. It is found in the flexible walls of the circulatory system and throughout the animal body, assisting

in holding bone and cartilage together. Elastin is extensive in muscles used in locomotion, such as legs, neck, and shoulders. Unlike collagen, it is *not* softened in cooking.

Another minor connective tissue component is **reticulin**. This is a protein found in *younger* animals. It may be the precursor of collagen or elastin.

Usually, connective tissue is present to a greater degree in the muscle of *older* animals. Meat high in connective tissue may be mechanically *ground* to break the connective tissue and increase tenderization of the meat.

**Fatty Tissue.** A third meat component in addition to the muscle tissue and connective tissue is fatty tissue. Cuts of meat may vary substantially in composition and appearance due to the presence of *adipose* or *fatty tissue*. Animal fat stores energy, and its content is dependent on factors such as animal feed, hormone balance, age, and genetics.

Fat is held by strands of connective tissue throughout the body and is deposited in several places such as around organs, under the skin, and between and within muscles as described below.

- **Adipose tissue**—fat that is stored around the heart, kidney organs, and in the pelvic canal areas. (*Suet* refers to the hard fatty tissue around the kidneys and other glandular organs of cattle and sheep.)
- **Subcutaneous fat** (finish)—fat that is visible after the skin is removed. (This is also referred to as *cover fat*. If well trimmed, the visible fat layer is less apparent.)
- **Intermuscular fat**—fat *between* muscles (also known as seam fat).
- **Intramuscular fat**—fat *within* muscles (marbling) (Fig. 9.2).

Upon cooking, the melted fat component contributes to juiciness, the sensation of tenderness, and flavor. Thus, well-**marbled** meat with intramuscular fat may be desirable (despite the high level of fatty tissues). *Lean* meat is primarily muscle tissue and is *lower* in fat. The percentage of fat stores in an animal will generally increase with the animal's age.

## Chemical Composition of Meat

The *chemical* composition of various meat cuts varies to a large degree from one cut to another. Meat may contain a range of 45–70 % water, 15–20 % protein, and anywhere from 5 to 40 %

fat, depending on the cut and trim. Meat contains no carbohydrate (except for the liver, which stores glycogen). These meat constituents are described in the following text.

## Water

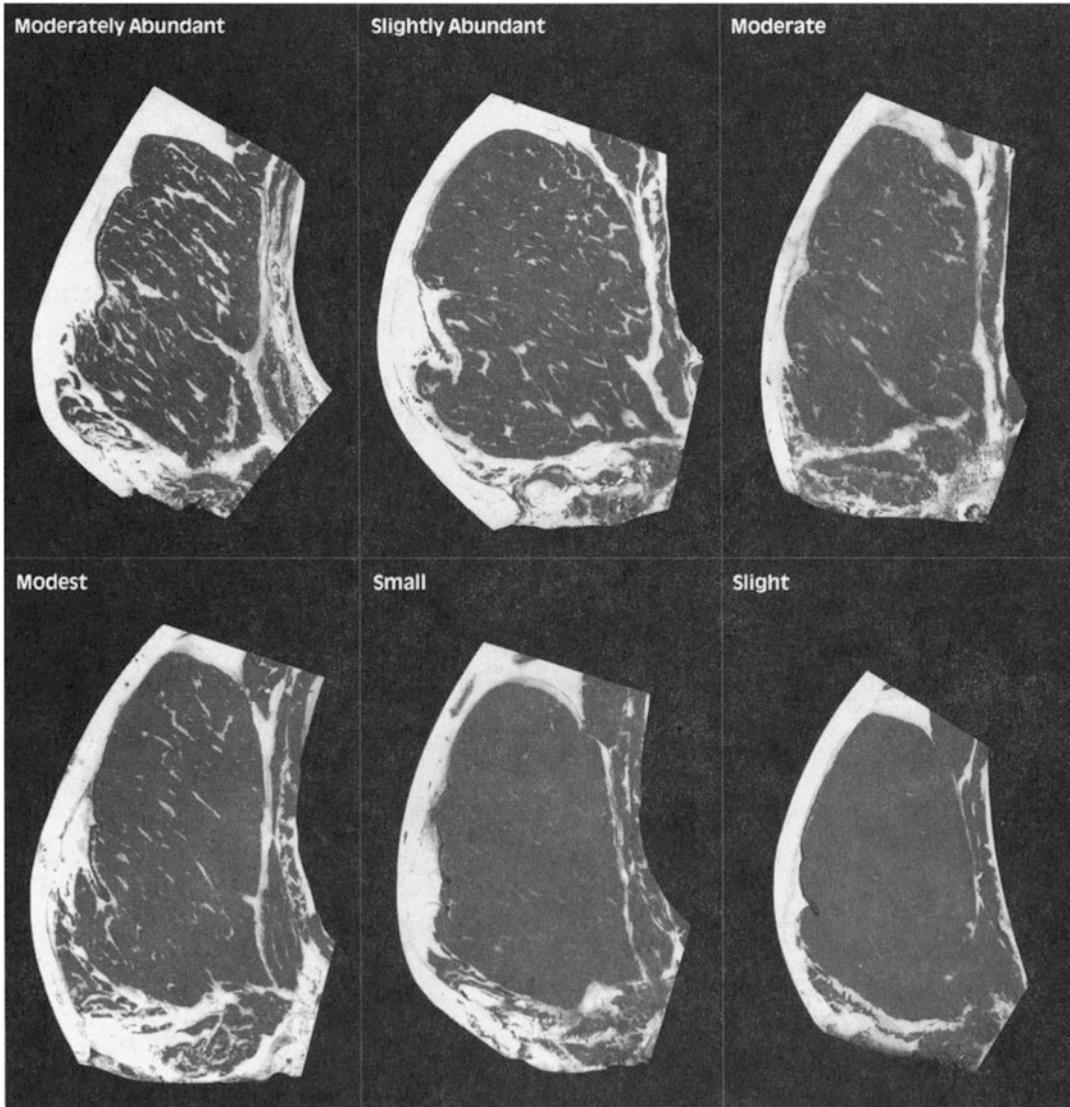
Water is the major constituent of meat, and the *greatest percentage* is found in *lean* meat and young animals where *fatty tissue* is *low*. Then, as an animal becomes more mature and fatter, with more adipose tissue, the water forms a *smaller proportion* of the entire makeup compared to young, lean animals.

Water exists in muscle fibers and, to a lesser degree, in connective tissue. It is *released* from the protein structure in a number of ways. For example, water loss occurs as the muscle coagulates during cooking. Loss occurs as muscle fibers are broken (due to chemical, enzymatic, or mechanical tenderization), by salting, and if the pH changes. Inversely, water may be *added* to meats such as cured ham, with a notation appearing by law, on the ham label.

**CULINARY ALERT!** A recent repercussion of labeling that meets the government's food safety requirements of raw meats and poultry is that an identification of water retention must be stated. Thus, according to the USDA, processors must list either the maximum percentage of absorbed water, or retained water on applicable food labels.

## Protein

Protein of *animal* sources is of *high* biological value. It is known as a *complete* protein, indicating that it contains all of the essential amino acids in amounts and proportions that can be used in synthesizing body proteins. The three primary types of proteins in meats are *myofibril*, *stromal proteins*, and *sarcoplasmic proteins* as described in the following:



**Fig. 9.2** Different levels of fat marbling (Source: National Cattlemen’s Beef Association)

**Myofibril proteins:** Muscle bundles are groups of *myofibrils* composed of several protein molecules including actin and myosin that may form an overlap complex called *actomyosin*.

**Stromal proteins (connective tissue proteins):** The watery connective tissue contains fibrils of *stromal* proteins: collagen, elastin, and reticulin (discussed earlier).

**Sarcoplasmic proteins:** *Sarcoplasmic* proteins are a third general classification of meat proteins. They include the *pigments* and *enzymes*. For example, the hemoglobin *pigment* stores oxygen in the red blood cells bringing it to tissues, including the muscles, while myoglobin stores oxygen in the muscle where it is needed for metabolism.

*Enzymes* are found in meat proteins. They may be *proteolytic*—degrading protein during the aging of meat, *amylolytic*—degrading carbohydrates, or *lypolytic*—degrading fats. There are also numerous enzymes in fluid of the muscle cell.

## Fat

Fat may be a major component of meat. Fat varies in its degree of saturation (see Fig. 9.2). For example, subcutaneous fats are generally more *unsaturated* than fat around glandular organs. *Saturated* fat promotes less oxidation, and therefore less rancidity. In the animal, fat contributes to the survival of the living animal at low environmental temperatures.

In the diet, fat allows the fat-soluble vitamins A, D, E, and K to be carried. As well, fats contain some essential fatty acids that are the precursor material used in the synthesis of phospholipids for every cell membrane

*Cholesterol*, a sterol, is present in the cell membranes of all *animal* tissue. Typically, lean meats have a lower cholesterol content than higher fat meats. An exception to this level of existence of fat and cholesterol in lean meat is veal (young, lean calf meat), which is *low* in fat, yet *high* in cholesterol.

## Carbohydrates

Carbohydrates are plentiful in *plant* tissue; however, are negligible in *animal* tissue. Approximately half of the small percentage of carbohydrates in animals is stored in the *liver* as *glycogen*. The other half exists throughout the body as glucose, especially in muscles, and in the blood. A small amount is found in other glands and organs of an animal. If an animal is exercised or not fed prior to slaughter, low stores of glycogen appear in the liver and muscles.

## Vitamins and Minerals

Both vitamins and significant minerals are present in meats. The *water-soluble* B-complex

vitamins function as cofactors in many energy-yielding metabolic reactions. The liver stores the four *fat-soluble* vitamins - vitamins A, D, E, and K. The minerals iron (in heme and myoglobin pigments), zinc, and phosphorus are present in meat.

## Muscle Contraction in Live Animals

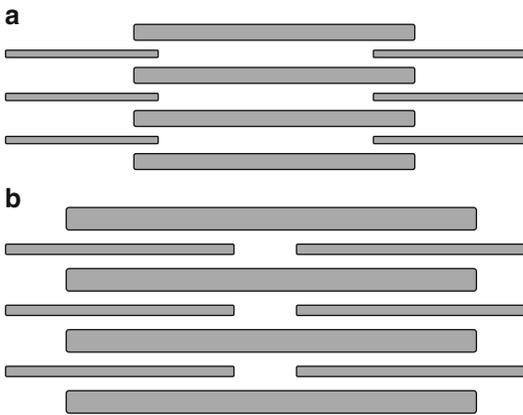
Muscle tissue of slaughtered animals undergoes several changes *after* slaughter. In order to better understand the reactions that occur in meat and their effects on tenderness and quality, it is necessary to have a basic understanding of the structure and function of muscle in a live animal.

## Structure of the Myofilaments of Muscle

As previously mentioned, muscle fibers contain bundles of myofibrils. The myofibrils themselves are composed of bundles of protein filaments as shown in Fig. 9.3. These include *thin* filaments, made mostly of *actin*, and *thick* filaments, which contain *myosin*. They are arranged in a specific pattern within a repeating longitudinal unit called a *sarcomere*.

The thin filaments occur at each end of the sarcomere, and they are held in place by **Z-lines**. The Z-lines define the ends of each sarcomere. The thick filaments occur in the center of the sarcomere, and they overlap the thin filaments. The *extent of overlap* depends on whether the muscle is contracted or relaxed. In a *relaxed* muscle, the sarcomeres are extended, and there is *not* much overlap of thick and thin filaments. However, a *contracted* muscle has a *lot* of overlap because the sarcomeres shorten as part of the contraction process.

The thin and thick filaments are interspersed between each other in the regions where they overlap. A cross-section of the myofibrils shows that each thick filament is surrounded by six of the thin filaments, and every thin filament is surrounded by three of the thick filaments. This facilitates interaction between the thin and thick filaments when contraction occurs (see “Post-mortem Changes in the Muscle” section).



**Fig. 9.3** Sarcomere and protein filaments (a) relaxed (b) contracted

## Muscle Contraction

Muscle contraction starts when a nerve impulse causes release of calcium ions from the sarcoplasmic reticulum into the sarcoplasm, which is a jelly-like substance surrounding the thin and thick filaments of the myofibrils. The calcium ions bind to a specific site on the thin filaments, causing the active site on actin to be exposed. Actin molecules are then able to react with myosin, forming actomyosin. Adenosine triphosphate (ATP) is necessary as the energy source for this reaction.

The myosin then contracts and pulls the actin-containing filaments further in toward the center of the sarcomere. The actomyosin complex then breaks, and myosin forms another cross-link with a different actin molecule. As the cycle continues, the sarcomere continues to shorten, due to the formation of more cross-links, and contraction occurs.

When the nerve impulse ceases, calcium ions are pumped out of the sarcoplasm and returned to the sarcoplasmic reticulum. Actin and myosin cannot interact without calcium ions, and so the actomyosin complex breaks. The muscle relaxes and returns to its original extended state.

## Energy for Contraction

The energy for contraction comes primarily from aerobic respiration, which enables glucose to be

broken down completely to yield  $\text{CO}_2$  and 36 molecules of ATP. In animals, glucose is stored as glycogen, which is broken down as needed to supply energy. When short bursts of extreme muscle activity are necessary, aerobic respiration does not supply adequate amounts of ATP, and so energy is also obtained by anaerobic glycolysis. This is a more rapid yet less efficient way of producing energy, as only two molecules of ATP are produced for every glucose molecule.

Glycolysis converts glucose to lactic acid, which builds up in the muscle. (It is the buildup of lactic acid that makes muscles sore and stiff after strenuous exertion. When the strenuous activity ceases, lactic acid is oxidized and removed from the muscle.)

Both aerobic respiration and glycolysis can take place in a *live* animal. *After* slaughter, aerobic respiration ceases, yet glycolysis continues for a while.

## Postmortem Changes in the Muscle

Postmortem changes in the muscle make several meat characteristics differ. Some time *after* slaughter (from 6 to 24 h), muscle *stiffens* and becomes hard and inextensible. (Perhaps you have seen this stiffness in deer or other deceased animals in roadside accidents, or hunting sites.) *Prior* to slaughter, muscle tissue in the living animal is *soft and pliable*. Then there follows a time period for stiffening. It is species-specific, and it is known as ***rigor mortis***, which literally means “the stiffness of death.” This stiffening is due to loss of extensibility by the myofibril proteins, actin, and myosin, once *energy reserves* become nonexistent, and oxygen does not reach the cells.

If meat is cooked at this stage, it is extremely *tough*. In fact, most meat is *aged or conditioned* to allow the muscles to relax and become *soft and pliable* again before it is cooked. This “*resolution of rigor*” is due to the enzymatic breakdown of proteins that hold muscle fibers together. This stiffness is temporary.

Subsequent to slaughter, a sequence of events takes place in muscle that leads to the onset of

rigor mortis. When the animal is killed, *aerobic* respiration ceases, blood flow stops, and the muscles are no longer supplied with oxygen. Therefore, *anaerobic* conditions soon prevail. Glycolysis continues, and glycogen stores are converted to lactic acid with the formation of ATP. The reaction continues until glycogen stores are depleted or until a pH of 5.5 is reached. At this pH, the enzymes that are responsible for glycolysis are denatured, and so the reaction *stops*. If glycogen is in short supply, glycolysis may stop due to depletion of glycogen, before the pH drops as low as 5.5.

When glycolysis stops, the ATP supply is quickly depleted. Lack of ATP prevents calcium ions from being pumped out of the sarcoplasm, and so the active site on the actin molecules of the thin myofilaments is available to bind with the myosin of the thick filaments. Actin and myosin unite, forming *actomyosin cross-links*. This cross-link formation is irreversible, as there is no available ATP. (In a live animal, actomyosin cross-links are formed and broken repeatedly, as part of contraction, though the cycle requires ATP.)

Formation of these irreversible *actomyosin cross-links* causes the muscle to become rigid. This is *rigor mortis*, and it correlates with the depletion of ATP in the muscle. Once formed, *actomyosin cross-links* do not break down, even during aging of meat, and their presence makes meat tough (Fig. 9.3b).

Accordingly, the stiffness of the muscle at rigor depends on the extent of actomyosin formation, which, in turn, depends on the extent of *overlap* of the thin and thick myofilaments. Recall that the *greater* is the overlap of thin and thick myofilaments, the more *extensive* the formation of actomyosin, and the *stiffer* the muscle. This results in *tough* meat:

- Little overlap—few actomyosin cross-links (tender meat)
- Substantial overlap—many actomyosin cross-links (tough meat)

Since the extent of actomyosin formation affects the toughness of meat, it is important to *minimize* the number of *cross-links* formed. This is done in two ways:

1. The meat is *hung* on the carcass after slaughter to *stretch* the muscles. This minimizes shortening of the sarcomeres and results in formation of *fewer* actomyosin cross-links. (more later).
2. *Pre-rigor temperature* is controlled to minimize fiber shortening. The optimum temperature is between 59 °F and 68 °F (15–20 °C). *Above* this temperature, increased shortening occurs. *Below* it, “cold shortening” occurs. At low temperatures, the sarcoplasmic reticulum pump is unable to pump calcium ions out of the sarcoplasm, and so contraction occurs.(more later).

Both hanging the carcass and controlling pre-rigor temperature minimize contraction before the onset of rigor mortis, result in fewer actomyosin cross-links, and increase meat tenderness.

## Ultimate pH

The *ultimate pH* is the pH that is reached when glycolysis ceases and is usually around 5.5. After slaughter, the pH drops due to the buildup of lactic acid, which is normally removed from the blood of the living animal. As mentioned already, glycolytic enzymes are close to their isoelectric point and are inactivated at this pH, thus preventing glycolysis from continuing. Therefore, a pH of 5.5 is the lowest possible ultimate pH. It is possible to obtain a higher ultimate pH if the animal is starved or stressed before slaughter. This depletes the glycogen reserves, thus glycolysis stops before sufficient lactic acid has been formed to bring the pH to 5.5.

Meat with a high ultimate pH has excellent water-holding capacity, because many of the

proteins are not as close to their isoelectric point and, therefore, are able to bind more water. However, a low ultimate pH is desirable from a microbiological point of view, because it inhibits microbial growth. A high ultimate pH results in poor resistance to microbial growth.

The *rate of change* of pH after slaughter also has a significant effect on the quality of meat. A *rapid* pH change while the temperature is still high causes considerable denaturation of contractile and/or sarcoplasmic proteins and loss of water-holding capacity. Lysozomal enzymes are also released at high temperatures, and these cause hydrolysis of proteins. Such *undesirable* changes may happen if the carcass is *not* cooled rapidly after slaughter (e.g., if the pH drops to 6.0 before the temperature of the carcass drops below 95 °F (35 °C)).

## Aging or Conditioning of Meat

Natural *aging* or conditioning of meat involves holding meat for several days, beyond rigor mortis. Under controlled storage conditions of temperature and humidity, (and perhaps light) the muscles become soft and pliable again, making the meat tender. Meat aging occurs as muscles become tender due to (protein and) actomyosin breakdown. A protease, which is active at around pH 5.5, breaks down the thin myofilaments at the Z-lines. This causes the muscle to become pliable again, and meat to be tender. The sarcoplasmic proteins denature and there is some denaturation of the myofibril proteins, with a resultant loss of water-holding capacity, and so the meat drips. Collagen and elastin do not denature significantly during aging.

**CULINARY ALERT!** Natural, proteolytic enzymes in meat may sufficiently tenderize meat in the time between slaughter and retail sale; however, controlled aging is sometimes induced.

As mentioned above, actoyosin formation affects the toughness of meat, and it is important to minimize the number of cross-links formed. This is done in two ways. Aging is achieved by

*hanging* the carcass in a cold room, at 34–38 °F (2 °C) for 1–4 weeks. Although the meat regains tenderness after about a week, the best flavor and tenderness develops in about 2–4 weeks. Humidity levels of approximately 70 % are controlled, and the meat may be wrapped in vacuum bags to minimize dehydration and weight loss.

Higher temperatures for shorter times, such as 68 °F (20 °C) for 48 h, have also been used to age beef. However, development of surface bacterial slime tends to be a problem for meat aged by such methods. It is shown that exposing the meat to ultraviolet light during the aging is of help in this regard.

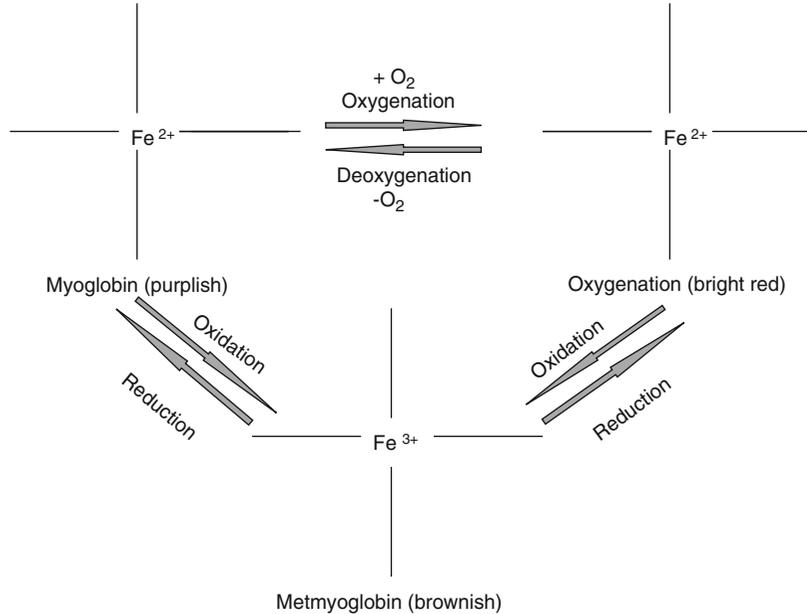
Aging requirements differ among meat types. For example, pork and lamb do *not* require aging such as occurs with beef, since the animals are slaughtered while they are young and inherently tender. They are usually processed the day following slaughter.

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## Meat Pigments and Color Changes

Various meat pigments and color changes are seen in meat tissue. Meat may appear as red meat or white meat, depending upon the predominant pigment and its concentration contained in the meat. The two major pigments in meat responsible for the red color are myoglobin and hemoglobin. *Myoglobin* (with one heme group as part of its structure) is 80–90 % of the total meat pigment (see “Chemical Composition of Meat” section). It allows oxygen to be stored in the muscles. *Hemoglobin* (with four heme groups in its structure) is present at levels of 10–20 % of well-bled meat. It carries oxygen in the bloodstream.

Myoglobin, the primary pigment contributor of meat, is purplish-red. It is present in frequently exercised portions of the animal that expend great amounts of oxygen, such as muscles of a chicken leg. It produces the “dark meat” of turkey for example. The specific myoglobin level is influenced by the species, age, sex, and specific muscle. There is *more* myoglobin in the muscles of cows than pigs, *more* in older sheep than young lambs, and *more* in bulls (adult males) than cows.

**Fig. 9.4** Pigment change

When *myoglobin* is exposed to oxygen in the air, bright red, oxygenated *oxymyoglobin* is produced. With time, *metmyoglobin* is apparent. It is the *undesirable*, brownish-red colored pigment found in meat due to oxidation of the iron molecule. This unwelcome metmyoglobin pigment is found in meat that is *not* fresh, that contains significant levels of bacteria, and in meat exposed to light or exposed to low levels of oxygen (Fig. 9.4).

In processed meats, such as lunchmeats, nitrites may be added in order to both preserve the desirable pink color and control the growth of *C. botulinum*.

## Meat-Handling Process

### USDA Inspections

“United States Inspected and Passed” and the packaging/processing plant number is specified in the round *stamp* (Fig. 9.5) found on the primal cut of inspected meat. The stamp is made of a nontoxic purple vegetable dye. Packaged, *processed* meat must show a somewhat *similar stamp* on the packaging or *carton* of the meat. It is common for specific *state* inspection

stamps (as opposed to USDA) to display a stamp with the shape of the state. Inspections for *wholesomeness* and accurate *labeling* are a service of the US government and are paid for with tax dollars.

The *Federal Meat Inspection Act* of 1906 requires inspection of all meat packing plants slaughtering and processing meat for *interstate* commerce. The Wholesome (Wholesale) Meat Act of 1967 required the same inspection program for *intrastate* transport.

Trained veterinarians and agents of the USDA **Food Safety and Inspection Service (FSIS)** inspect the *health* of the animal, as well as the *sanitation* of the physical meat plant. The inspection for meat is *mandatory* (Chap. 20). Meat’s inspection for *wholesomeness* indicates that it is safe to eat, without adulteration, and that examination of the carcass and viscera of the animal did *not* indicate the presence of *disease*. (It is *not* meant to imply freedom from all disease-causing microorganisms.)

Inspections occur *before*, *after*, and *throughout* meat processing. Diseased and unwholesome animals may *not* be used; harmful ingredients may *not* be added; misleading names or labels may *not* be used, and there must be established sanitation codes for the plant. Safety in meat processing is of

**Fig. 9.5** The USDA inspection, quality grade, and yield grade stamps  
(Source: USDA)



utmost importance to the processor and customer alike. Violations of the Meat Act are fined and persons committing violations have been imprisoned! The Meat Inspection Program also controls and monitors *imported* meat.

In view of the fact that the pathogenic microorganism *E. coli* 0157:H7 may be undetected if *only visual inspections* are used for inspection, actual *bacterial counts* are included in inspections. Meat processing inspections with the inclusion of bacterial count checks now include the *Hazard Analysis and Critical Control Point* (HACCP) method of food safety (Chap. 16). It is the current program for inspecting meat.

As far as USDA is concerned, its FSIS holds that a meat or poultry product can claim to be “natural” as long as it does not contain any artificial flavor or flavoring, color ingredient, chemical preservative or any other artificial or synthetic ingredient, and that the product and its ingredients are not more than minimally processed. Reports Hoffman at Solae regarding USDA’s stance on “natural”. (Decker 2013)

## Kosher Inspection

**Kosher** inspection indicates that the meat is “*fit and proper*” for consumption or “*properly prepared*”. Following Mosaic and Talmudic Laws, a specially trained rabbi slaughters the animal, e.g., beef, lamb, goat, and the meat is well-bled, and then salted. All processing is done under the supervision of individuals authorized by the Jewish faith. According to Mosaic Law, meat *must* come from an animal that has split hooves and chews its cud. Therefore, hogs and all

pork products *cannot* be Kosher (see “Why Americans Buy Kosher” below).

The Kosher stamp (Fig. 9.6) does not indicate grade or wholesomeness. Meat is *still* subject to federal or state inspection.

### Kosher Industry Facts

#### Why Americans Buy Kosher

- 55 %—Health and safety
  - 38 %—Vegetarians
  - 16 %—Eat halal
  - 35 %—Taste or flavor
  - 16 %—Guidelines that they were produced
  - 8 %—Good products
  - 8 %—Keep kosher all the time
  - 8 %—Looking for vegetarian products, either for religious or dietary reasons
- (Note: Respondents gave multiple answers)

**Compiled by Lubicom Marketing and Consulting (2009)**

Overall, there is an “estimated sales of kosher meat with 45 % being glatt or strictly kosher: \$550,000,000” (Lubicom Marketing and Consulting, LLC, Brooklyn, NY <http://www.lubicom.com/kosher/statistics/>). Muslims and of other religious groups comprise a large percent of the Kosher market. Of course, not all persons of Jewish faith keep Kosher in their diet.

Kosher is not considered an acceptable substitute for proper and permitted Muslim foods. Only *some* foods are acceptable in also meeting Halal certification for Muslim requirements.



**Fig. 9.6** Kosher Symbol (Source: National Cattlemen’s Beef Association)

## Halal Certification

The *Halal* certification indicates “*proper and permitted.*” Only foods prepared and processed under Halal standards are to be consumed by Muslims, although not all persons of the Muslim faith keep to a diet of solely Halal-certified foods.

Certification uses trained Muslim inspectors who assist, participate in, and supervise food production in companies complying with Halal standards. A crescent *M* symbol on the product package indicates that the product meets the Halal standards of the Islamic Food and Nutrition Council of America (Food Technol 2000).

The types of foods permitted, including use of additives, slaughtering, packaging, labeling, shipping, and other aspects of food handling, are *regulated*. For example, the halal production does *not* accept alcohol, gelatin prepared from swine (for use as a food ingredient or packaging ingredient), or meat from animals that was *not* individually blessed.

Halal does not employ the same processing as Kosher food, although some products bear certification that they *are both* Kosher and Halal (Eliasi and Dwyer 2002). As per the founder and president of a company producing both Kosher and Halal refrigeration-free meals, a Kosher or Halal food product means much more than having the product blessed by a representative religious official.

In brief, there exist over 13 million persons of the Jewish faith, and one billion Muslims in the world. Their dietary laws are *not* interchangeable, yet are *similar*. A look at dietary restrictions of other religions is included in another reference (Food Technol 2000). As is true for Kosher, the Halal Certification does not indicate grade or wholesomeness. Meat is *still* subject to federal or state inspection.



**Fig. 9.7** Halal certification (Source: Islamic Food and Nutrition Council of America)

The Halal stamp of certification (Fig. 9.7).

## Grading of Meat

*Voluntary grading* of meat is part of the processing cost and is *not* paid for by tax dollars. The task of *grading* of meat (as opposed to the inspection of carcasses) was established by the USDA in 1927. It reports on both *quality* and *yield*, as described below (Fig. 9.5).

*Voluntary quality grading* evaluates various characteristics of animals. Evaluation includes age; color of lean, external fat quality and distribution, marbling; shape of animal carcass; and firmness of the muscle and meat texture—coarseness of muscle fiber bundles. So it looks at an evaluation of marbling, maturity, texture, and appearance.

*Beef grades* are according to the grades listed below. *Other* meats have *different* standards with less categories of grades.

- Prime
- Choice
- Select
- Standard
- Commercial
- Utility
- Cutter
- Canner

Prime grades of beef are very *well*-marbled. Prime is followed by Choice, Select, and Standard rankings with *less* marbling. The younger animal is more likely to be tender and receive a grade of

Prime, Choice, Select, or Standard. Older, more mature aged beef typically qualify for Commercial, Utility, Cutter, or Canner grades.

As well as voluntary *quality* grading, meat is also graded for *yield*, which is useful at the wholesale level. The highest percentage of lean, boneless yield (usable meat) on the carcass is given an assigned yield grade of “1.” If yield of a carcass is *less*, the yield grade may be assigned a value as low as “5.” Sales and marketing of meat products are based on both grades and yields.

## Hormones and Antibiotics

Hormone and antibiotic use in animals are both monitored by the FDA. *Hormones* may be used in animal feeds to promote growth and/or to increase lean tissue growth and reduce fat content. All hormone-use in animal feeding must be *discontinued* for a specified time period prior to slaughter and must be *approved* by the FDA. A random sampling of carcasses provides tests for and monitors growth hormone residues (growth promotants).

*Antibiotics* in animal feed, when not utilized properly, may also pose a food safety concern. Antibiotics have been used for well over half of a century to treat disease and the FDA monitors their use in animal feeds to prevent their transfer to man. *Subtherapeutic* doses of antibiotics do more than treat *already-existing* diseases; such doses may be used to *prevent* disease and promote growth of animals. With this practice, the *therapeutic* administration of antibiotics to humans may be rendered ineffective if antibiotic-resistant strains of bacteria are passed from the livestock to man. The National Academy of Sciences (NAS) concluded that they were “unable to find data directly implicating the subtherapeutic use of feed antibiotics in human illness.”

In order to protect human health, the FDA (even recently) has urged that specific antibiotics used to treat animals be removed from the market, if they have been found to compromise other drugs used in treating animals or humans. “There are many countries [such as Denmark] that do not allow antibiotics as growth promoters in

farm animals” (Peregrin 2002a). See Question below:

### Question of the Week

Do Hormones and Antibiotics Cause Health Problems in Humans?

#### Myth:

The use of antibiotics and hormone growth implants in livestock production is causing hazardous residues in beef and contributing to the development of health problems in humans.

#### Fact:

1. No residues from feeding antibiotics are found in beef, and there is no valid scientific evidence that antibiotic use in cattle causes illness resulting from the development of antibiotic-resistant bacteria.
2. Scientific authorities agree that use of hormone implants results in the efficient production of beef that is safe. (Montana State University)

Antibiotics that are used *solely* for the purpose of *animal* growth have often been debated. Unfortunately, as has been reported in the press involving *human* growth hormone, a small percentage of illegal users may stay just one step ahead of regulatory inspectors.

## Animal Welfare Approval

Meat may be certified by Animal Welfare Approved, one of the leading advocates for humane livestock treatment. The first Animal Welfare Approved restaurant opened in Hudson, NY in 2011.

## Cuts of Meat

### Primal or Wholesale Cuts

A *primal cut* is also known as a *wholesale* cut of an animal. Meat cutting separates cuts into

*tender* and *less tender* cuts, and *lean* and *fatty*. Cuts differ with species, and primal cuts of *beef* are identified below. They are listed according to tenderness. *Less exercised* skeletal muscles that provide support (as in: cuts of meat along the backbone, such as the loin) are usually more tender than other skeletal muscles that are used in *locomotion*. Ultimately though, tenderness is a function of how meat is torn by the teeth, not just the cut, age, and so forth.

Most tender	Medium tender	Least tender
Rib	Chuck	Flank (<brisket)
Short loin	Round	Short plate
Sirloin		Brisket
		Foreshank
		Tip

## Subprimal Cuts

*Subprimal cuts* are divisions of *primal* cuts, often sent to the grocery market for further cutting. They may be boneless. If they are vacuum-packed, they are considered as “beef-in-a-bag”, if boxed, “boxed meat”. Subprimal cuts are further divided into individual *retail* cuts such as roasts, steaks, and chops.

## Retail Cuts

*Retail cuts* are those available in the *retail* market, cut from primal or subprimal cuts. They may be named for the primal cut in which they are located *or* for the bones they contain. (Fig. 9.8).

In most cases, the cuts from the neck, legs, and lower belly are *least tender* for the reason that, as mentioned, they are the most exercised portions of the animal. These cuts are made more palatable when cooked with *moist heat* to soften connective tissue, although the same less tender cuts may be cooked with *long*, dry heat cooking at low temperatures and produce a satisfactory product. *Tender* cuts are cooked with *dry heat*.

### CULINARY ALERT!

- Less tender cuts—best: moist heat or long, low heat cooking
- Tender cuts—best: dry heat cooking, quick

The wholesale and retail cuts of beef are identified in Fig. 9.8. In the 1970s, The National Livestock and Meat Board (now National Cattlemen’s Beef Association (NCBA)) coordinated a committee of retail and meat industry representatives and federal agencies, which standardized names for 314 retail cuts of meat. They published the *Uniform Retail Meat Identity Standards* (URMIS). URMIS labels include the kind of meat (beef, veal, pork, or lamb), the primal cut from which the meat originated (chuck, rib, loin, or round of the animal), and the name of the retail cut.

**Beef** (Fig. 9.11) is *most commonly* obtained from carcasses of the following:

- Steer: young, castrated male carcass
- Heifers: young, females before breeding, beyond veal and calf age

**Beef** is *less frequently* obtained from the carcasses of the following:

- Cows: females that have had a calf
- Bulls: adult male
- Baby beef: young cattle, 8–12 months of age
- Calves: young cattle, 3–8 months of age, beyond veal classification

**Veal** is from the carcass of:

- Beef calves, generally 3 weeks to 3 months or more.
- Veal is milk-fed, not grass-fed, thus is low in iron and pale in color.
- Young calf meat is normally lighter pin-gray than older calf meat.

**Pork** is the flesh of swine (pig).

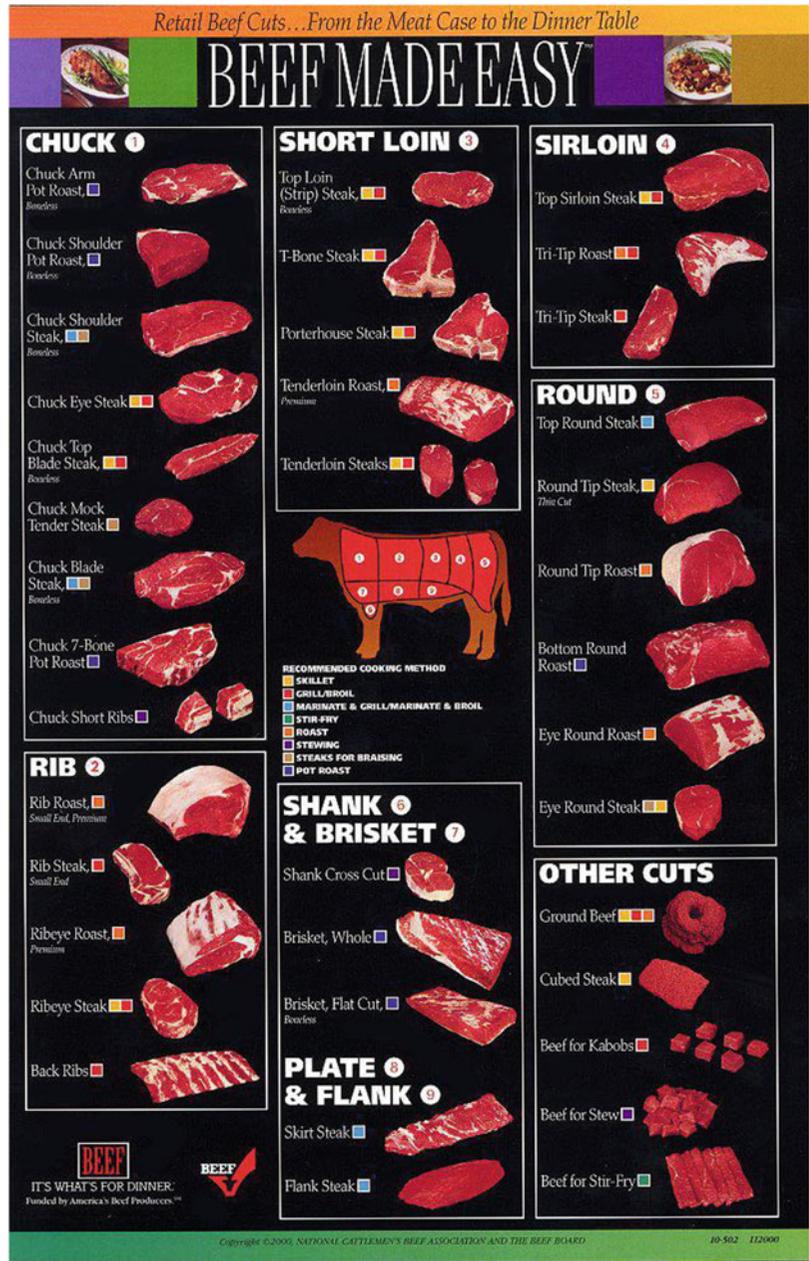
**Lamb** is the flesh of *young* sheep, not more than 14 months old.

**Mutton** is the flesh of sheep *older* than 2 years.

## Cooking Meat

To better assure a successful cooked meat product, it is critical to know the effects of cooking meat on

**Fig. 9.8** Wholesale and retail cuts of beef (Source: USDA)



its various components. The processing plant and consumer both require a familiarity with types of cuts and cooking methods for meat. Although it may be a lot to ask, meat must satisfy the requirements of appearance, texture, and flavor, as well as nutrition, safety, and convenience.

Certainly, some individuals may have environmental, religious, vegetarian, health, or other concerns related to the consumption of meat,

thus they might choose to *avoid* meat products, or consume meat minimally.

**CULINARY ALERT!** The purpose of cooking is to improve appearance, tenderness, and flavor while destroying pathogenic microorganisms.

In cooking, the peptide chains of amino acid chains uncoil (denature) and reunite or coagulate,

releasing water and melted fat (Chap. 8). Consequently, the meat shrinks. When heat is applied, muscle fibers toughen and connective tissue becomes tender. These reactions are opposing effects and the method, time, and temperature of cooking differ.

### Effects of Cooking on Muscle Proteins

Cooking has an effect, both desirable, and more negative on muscle proteins. The muscles used in locomotion (muscles for physical movement), as well as muscles of older animals each contain a large number of myofibrils in each muscle. As opposed to this, the less-used muscles and muscles of young animals have less myofibrils in each muscle. Thus, in the former case, muscle bundles are physically larger, and the large size indicates that they have a more coarse grain.

Temperatures around 131 °F (55 °C) precipitate myosin, and 158–176 °F (70–80 °C) precipitates actin. This precipitation denatures, shortens, toughens, and shrinks the surrounding connective tissue, causing a loss of water-holding capacity. The longer the cooking time, the more serious this effect will be, although at temperature of 170 °F (77 °C) tenderness may improve.

*Tender* cuts of meat contain *small* amounts of connective tissue and should be cooked for a short time at a *high* temperature with dry heat. Such cooking minimizes coagulation and shrinkage of muscle fibers and prevents loss of water-holding capacity. Toughening of the muscle fibers is minimized if tender cuts are cooked to *rare* rather than the well-done stage.

Tender meat that is *overcooked* tends to be *dry and tough* because the protein coagulates, water is squeezed out, and myofibrils toughen. Greater cooking intensity for a short time is advantageous for tender cuts of meat, and prolonged moist heat cooking is recommended for *less tender* cuts of meat.

### Effects of Cooking on Collagen

As the collagen in meat is subject to the heat of cooking, the effect is that hydrogen bonds and

some heat-sensitive cross-links are broken. Collagen, as mentioned earlier, is the major component of connective tissue. At temperatures between 122 °F and 160 °F (50–71 °C), connective tissue begins shrinking. Some of the tough-structured collagen is then solubilized and converted to gelatin. As the collagen fibers are weakened, the meat becomes more tender. Breakdown (or “melting,” solubilization, gelatinization) of collagen is faster as collagen reaches higher temperatures.

*Young* animals contain few cross-links in collagen thus, it is readily converted to gelatin and meat tends to be tender. Collagen from *older* animals, on the other hand, contains many more covalent cross-links, most of which are *not* broken down by cooking; therefore, older animals yield tough meat unless it is heated in a *moist* atmosphere.

Cuts of meat *low* in collagen, such as rib or loin steaks, are inherently tender and do *not* benefit from slow, moist heat cooking. These cuts are more tender when cooked *quickly* and served to the *rare* or *medium-rare* stage.

On the other end of the spectrum, when collagen levels in a cut of meat are *high*, slow, moist heat cooking, to achieve a *well-done* stage, is recommended as it gelatinizes the collagen. Some tenderization of the meat surface (1/4 in.) occurs as meats are placed in marinades.

### Effect of Cooking on Fat

The effect of cooking on fat is seen as fat melts throughout the meat with cooking. This melted fat produces a perception of a tender product. If a cut is high in fat content, or well-marbled, it yields a more tender cooked meat. In cooked, left-over meat, fat oxidation contributes to flavor deterioration.

### Methods of Cooking

Normally, as mentioned previously, there are various “best” methods of cooking—dry heat and moist heat.

- **Dry heat methods** of cooking include broiling, frying, pan-frying, roasting, sautéing, and stir-frying. Meat is cooked *uncovered*. Tender steaks, chops, ground meat, and thin cuts are cooked this way
- **Moist heat methods** of cooking include braising, pressure-cooking, simmering, steaming, stewing, or using a slow cooking pot to simmer. Meat is cooked *covered*. *Less tender* cuts such as chuck, flank, or round may be cooked in this manner

Meat contains water and therefore, to some extent, *all* meat if it is covered, provides moist heat cooking. This reduces surface drying that occurs with dry heat cooking and gives time for collagen to become gelatin.

The effect of *dry* heat (uncovered) and *moist* heat (covered) on two *identical*, less tender cuts of meat such as the chuck or round is seen. When the two roasts are removed from the oven at the *same* time, the *covered* roast temperature shows a lower temperature and less weight loss than the *uncovered* roast. Covering is preferable for these less tender cuts.

### Other Factors Significant in Cooking

Cooking *methods* have previously been discussed. However, additional factors are significant in cooking. For example inherent pigments, the reading of thermometers, searing, and removal temperature are important factors in cooking. They are discussed in the following:

**Pigments.** Color may be an indication of the degree of doneness. When cooked, the myoglobin pigment is denatured, and therefore meat changes color from a red or purple, to pale gray-brown.

**Use of Thermometers.** The use of a calibrated thermometer to measure temperature provides the necessary assurance that the recommended safe cooking temperature is achieved. The cooking thermometer may be designed to detect *multiple* food temperatures along its

stem and show an “average” temperature of those multiple readings. Depending upon where/how the thermometer is inserted—into the fat, muscle, or placement near a bone, the reported temperature varies and may not accurately reflect doneness.

**CULINARY ALERT!** The thermometer will give a false reading if placed in the fat or touching a bone. Thermometers provide a more accurate reading of meat doneness when they are inserted at an angle, rather than vertically where fat could drip down the stem, and again, give a false reading.

**Searing.** Initial high heat, or the short practice of “searing” with *dry* heat imparts flavor; however, further *moist* heat cooking is used for the continued cooking of less tender cuts of meat, high in collagen-containing connective tissue.

**Removal temperature.** Large roasts increase in internal temperature for 15–45 min or more *after* removal from the oven. Roasts removed from the oven at the *rare* stage (more moisture) exhibit a *greater* temperature rise following removal from the oven, than roasts removed at the drier, *well-done* stage. This should be kept in mind when a specific doneness is desired.

Specific temperatures for doneness of meat are as follows:

Doneness	Temperature
Rare	140 °F (60 °C)
Medium-rare	150 °F (65 °C)
Medium	160 °F (71 °C)
Well done	170 °F (77 °C)

**CULINARY ALERT!** Roasts increase in temperature following removal from the oven. Use a calibrated thermometer correctly.

### Alterations to Meat

#### Processed Meat

*Processed* meat is defined as meat that has been changed by any mechanical, chemical, or

enzymatic treatment, altering the taste, appearance, and often keeping the quality of the product (NCBA). It may be cured, smoked, or cooked, and it includes cold cuts (lunch meats), sausage, ham, and bacon. Processed meats may be available in low-fat formulations. Meat that has been processed is subject to the same USDA inspection as other meat.

Of all the meat produced in the United States, about one third is processed meat. Most of processed meat is *pork*, approximately one quarter of it is *beef*, and a small amount is *lamb or mutton*. If formulated with meat trimmings and variety meats, that fact must be stated on the label.

Processed meats may contain salt, phosphates, nitrate (NO<sub>3</sub>), or nitrite, which provide beneficial *microbial control*. Additionally, these ingredients supply flavor, texture, and protein-binding contributions (see Restructured Meats) to foods. Processed meats may contain a reduction or replacement of sodium. Sectors of the population watching sodium or some additives may desire to reduce their intake of processed meat. Lower sodium processed meat is also discussed under the Nutrition section of this chapter.

The FSIS allows specific additions to meat. *Carrageenan*, and locust bean gum, may be utilized as meat additives. *Xanthan* gum at maximum levels of 0.5 % to prevent escape of the brine solution added to cured pork products is allowed. *Nitrite* is added to processed meat to preserve the color of meat and control the growth of *C. botulinum*.

A health concern regarding the addition of *nitrites* is that they could combine with amines (the by-product of protein breakdown) in the stomach and form carcinogenic “nitrosamines.” This was addressed in a report by the NAS that stated that neither sodium nitrate nor nitrite was carcinogenic. Nitrites remain at levels less than 50 ppm in processed meat at the point of consumption. Many processors add ascorbic acid (vitamin C), erythorbic acid and their salts, sodium ascorbate, and sodium erythorbate, to cured meat to maintain processed meat color.

These same additives also inhibit the production of nitrosamines from nitrites.

### What Nitrite Does in Meat

Nitrite in meat greatly delays development of the botulinum toxin (which causes botulism), develops cured meat flavor and color, retards development of rancidity and off-odors and off-flavors during storage, inhibits development of warmed-over flavor, and preserves flavors of spices, smoke, etc.

Adding nitrite to meat is only part of the curing process. Ordinary table salt (sodium chloride) is added because of its effect on flavor. Sugar is added to reduce the harshness of salt. Spices and other flavorings are often added to achieve a characteristic “brand” flavor. Most, but not all, cured meat products are smoked after the curing process to impart a smoked meat flavor.

Sodium nitrite, rather than sodium nitrate, is most commonly used for curing (although in some products, such as country ham, sodium nitrate is used because of the long aging period). In a series of normal reactions, nitrite is converted to nitric oxide. Nitric oxide combines with myoglobin, the pigment responsible for the natural red color of uncured meat. They form nitric oxide myoglobin, which is a deep red color (as in uncooked dry sausage) that changes to the characteristic bright pink normally associated with cured and smoked meat (such as wieners and ham) when heated during the smoking process. (<http://www.extension.umn.edu/distribution/nutrition/DJ0974.html>, University of Minnesota Extension)

### Curing and Smoking of Meat

*Curing* is a modification of meat that increases shelf life, forms a pink color, and produces a

salty flavor. As mentioned, cured meats contain nitrite that controls the growth of *C. botulinum*. Additional color changes to the cured meat may result in fading as the pigment *oxidizes* when exposed to oxygen. Exposure to *fluorescent light* may actually give cured hams a fluorescent sheen and also causes a graying or fading of the color. Therefore, cured meats are packaged so that they are *minimally* exposed to the deleterious effects of oxygen and light.

Very popular **cured meats** include ham (pork) and corned (cured) beef as well as bacon and pastrami. Corned beef was given the name for the reason that beef was preserved with “corns” (grains) of salt.

**Smoked meats** prepared on a smoker are very popular in parts of the United States; they are relatively unheard of in other localities. Commercially or at home, beef, ham, and turkey are smoked (heat processed) to impart flavor. Liquid smoke could also be used to impart flavor.

**CULINARY ALERT!** Smoking treats meat by exposure to the aromatic smoke of hardwood and smoking also dehydrates, thus offering microbial control to the meat.

preparation of curing mixtures must be carefully controlled . . . It is important to use curing methods which achieve uniform distribution of the curing mixture in the meat or poultry product.

**FDA—Smoking**

Smoking is the process of exposing meat products to wood smoke. Depending on the method, some products may be cooked and smoked simultaneously, smoked and dried without cooking, or cooked without smoking. Smoke may be produced by burning wood chips or using an approved liquid smoke preparation. Liquid smoke preparations may also be substituted for smoke by addition directly onto the product during formulation in lieu of using a smokehouse or another type of smoking vessel. As with curing operations, a standard operating procedure must be established to prevent contamination during the smoking process.

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**FDA Ruling on Curing and Smoking**

**(A) Introduction**

Meat and poultry are cured by the addition of salt alone or in combination with one or more ingredients such as sodium nitrite, sugar, curing accelerators, and spices. These are used for partial preservation, flavoring, color enhancement, tenderizing, and improving yield of meat. The process may include dry curing, immersion curing, direct addition, or injection of the curing ingredients. Curing mixtures are typically composed of salt (sodium chloride), sodium nitrite, and seasonings. The

Ham is cured pork from the hind leg of the hog. Picnic shoulder or picnic ham is made from the front leg of the hog. Bacon is cured and/or smoked hog meat from the pig belly. The University of Georgia, Cooperative Extension Service

**Restructured Meat**

*Restructured* meat contains muscle tissue, connective tissue, and adipose tissue of a natural cut of meat; however, proportions of each may differ. In the process of restructuring, meat is (1) flaked, ground, or chunked to a small particle

size, (2) reformed, and (3) shaped—perhaps into roasts or steaks.

*Myosin* in the meat muscle may be instrumental in causing meat particles to bind together. As well, salts, phosphates, and other *nonmeat* binders such as egg albumen, gelatin, milk protein, wheat, or textured vegetable protein may be added for the purpose of holding protein particles together. Generally, the restructuring process provides a less expensive menu item that *resembles* a whole meat portion. It offers consistency in serving size and appearance. Most boneless hams and some breakfast meats are restructured meats.

### Tenderizing, Artificial Tenderizing

*Tenderizing* meats may be desirable prior to cooking. *Young* animals are *naturally* tender and do not need *artificial* tenderizing. Recall that the connective tissue of *older* animals contains more covalent cross-links, is less soluble, and less readily converted to gelatin. Therefore, meat from older animals may require tenderization. In addition to the age, the origin of the specific cut on the animal is also a factor influencing tenderness.

The less tender cuts of meat may be *artificially* tenderized to break down the proteins of muscle or connective tissue. This may be achieved by mechanical, electrical, or enzymatic treatment as discussed below.

The *mechanical* tenderization includes chopping, cubing, and grinding. Meat may be cubed, ground, or pounded prior to stuffing or rolling or use in a recipe. These techniques break the surface muscle fibers and connective tissue. A special instrument that pierces the meat with multiple thin, tenderizing needles is involved in the “needling” or “blade tenderizing” of meat.

*Electrical* stimulation such as ultrasonic vibration indirectly tenderizes meat by the physical vibrations that stimulate muscles to break down ATP to lactic acid. It also decreases the pH. The electrical stimulation of a carcass tenderizes without degrading the muscle fibers and texture of meats to a mushy state.

Natural *enzyme* tenderizers derived from tropical plants are available as powders or seasoning compounds that may be applied by dipping or spraying meat. They are more effective in tenderizing than marinades, which only penetrate approximately one fourth inch into the interior of the meat. Enzymes include papain from the papaya plant, bromelain from pineapple, and ficin from figs.

Various enzymes treat the muscle tissue, and others, the connective tissue. For example,

- The enzymes chymopapain, or papain, and ficin exert a greater effect on tenderizing *muscle fibers* than tenderizing connective tissue.
- The enzyme bromelain degrades *connective tissue* more than the myofibrils.

Any overapplication of natural enzyme tenderizers to meat surfaces, or allowing the treated meat to remain at temperatures conducive to enzymatic activity, could produce an *overly* soft meat consistency.

The natural enzyme tenderizer papain may also be injected into the jugular vein (bloodstream) of an animal a few minutes before slaughter. It is distributed throughout the animal tissue. The enzyme is heat-activated (by cooking at 140–160 °F (60–71 °C)) and eventually denatured in cooking.

**CULINARY ALERT!** With the addition of acid marinades to meat, collagen is softened to gelatin. The collagen fibers exhibit swelling and retain more water. Tomato and vinegar are acids that cause meat to respond in this manner and become tender.

There is a more *recent* development utilized in tenderizing meat without affecting appearance and taste. This is a *noninvasive process* used to tenderize meat: The process employs a 3 min cycle in a high pressure, water-filled, closed tank. A 4-ft diameter stainless steel tank, sealed with a stainless steel domed lid, creates a high-pressure wave as a small explosive charge is

detonated within *the* tank. Lower grades of meat, especially cuts that are low in fat content, may increase in value as they are made more tender for consumer use (Morris 2000).

## Poultry

Poultry (bird) sales increased in times when beef sales declined. All poultry is subject to *inspection* under the Wholesome Poultry Products Act of 1968 and is *graded* US Grade A, B, or C quality based on factors including conformation, fat, and freedom from blemishes and broken bones. The inspection, labeling, and handling of poultry products is similar to the meat inspection process (Chap. 19).

*Chicken* is the *primary* poultry consumed in the US diet. It is classified according to weight, age, and condition of the bird as follows:

Broilers/fryers	2–2.5 lb	3–5 months of age
Roasters	3–5 lb	9–12 weeks of age
Capons	4–8 lb	Less than 8 months of age
Hens, stewing hens, or fowls	2.5–5 lb	Less than 1 year
Rock Cornish game hen	1–2 lb	5–7 weeks of age

*Turkey* is the *second* most frequently consumed poultry in the United States and is classified as follows:

Fryers/roasterst	10 weeks of age
Mature roasting birds	20–26 weeks of age
Tom turkey (male)	greater than 5 months of age

Duck, geese, guinea, and pigeon provide variety to the diet; however, are consumed less frequently than chicken or turkey. Each is subject to inspection by the USDA's Food Safety and Inspection Service (FSIS).

The *dark meat* of poultry represents portions of meat from more exercised parts of the animal. Dark meat contains *more* myoglobin, and fat, and more iron and zinc than *white meat*. It also

contains *less* protein. However, regarding fat content, any poultry *without* skin on during cooking allows less drippage of fat into meat than poultry cooked with the skin. It is possible that poultry *with* skin may contain slightly more of the lipid cholesterol than an equal portion of lean beef.

In addition to the *whole bird*, individual pieces of breast meat, legs, or thighs are sold separately, and there are many *processed* poultry products on the American market. For example, many *lunch meats* contain turkey or chicken which provides the benefit of poultry in place of beef or pork and may reduce fat content. *Ground turkey* may serve as a replacement for *ground beef* in cooked dishes, and many *formed entrees* such as nuggets, patties, or rolls are available to the consumer.

Proper poultry cooking is imperative as it may carry *Salmonella* bacteria. It must be adequately cooked (165° F) to assure destruction of this living pathogen. The FSIS allows the use of trisodium phosphate as an antimicrobial agent on raw, chilled poultry carcasses that have passed inspection for wholesomeness.

## Fish

*Fish* is consumed by many people. It includes both edible *finfish* and *shellfish* (both appear in charts below) obtained from marine and freshwater sources. Fish is *softer* and *flakier* than either mammals or poultry, because muscle fibers exist as short bundles, which contain thin layers of connective tissue (see Fig. 9.9).

Worldwide, there are several thousand species of seafood, and with current processing, preservation, and marketing methods, a greater variety of species are consumed. Yet, only a few species are used as edible fish and shellfish (Fig. 9.9).

Fish are classified as follows:

**Finfish** (vertebrate with fins): Finfish are fleshy fish with a bony skeleton and are covered with scales. They may be lean or fat. For example:



**Fig. 9.9** Fish (Courtesy of SYSCO® Incorporated)

### Lean

- *Lean* saltwater fish—cod, flounder, haddock, halibut, red snapper, whiting
- *Lean* freshwater fish—brook trout and yellow pike

### Fat

- *Fat* saltwater fish—herring, mackerel, and salmon
- *Fat* freshwater fish—catfish, lake trout, and whitefish

**Shellfish** (invertebrates): Shellfish are either *crustaceans* or *mollusks*—the former with a crustlike shell and segmented bodies, the latter with soft structures in a partial or whole, hard shell. Some examples are as follows:

### Crustacea

- Crab, crayfish, lobster, and shrimp
- Crustlike shell and segmented bodies

### Mollusks

- Abalone, clams, mussels, oysters, and scallops
- Soft structures in a partial or whole, hard shell

The physical, nutritive components of fish are similar to mammals—for example,

- **Carbohydrate:** negligible content, as is the case with mammals
- **Fat:** variable percentage, primarily liquid (hence, *fish oil*) and *not* saturated.
  - Fish feed on marine and freshwater *plants* that contribute to their high content of omega-3 polyunsaturated fatty acids. (Eicosapentaenoic acid—EPA, and docosahexaenoic acid—DHA, both demonstrated to be ‘protective against diseases, such as heart disease.)
- **Protein:** high quality, complete proteins including:
  - Myofibril proteins—actin and myosin;
  - Connective tissue—collagen; and sarcoplasmic proteins—enzymes and myoglobin.

In the past, the “R-Month Rule” stated that the months of September through April indicated safe harvesting of shellfish. The letter “R” is in their spelling and these are also colder months. Today, adequate refrigeration and care dispels this belief.

Fish is classified as inherently tender because fish contains *less* connective tissue than beef, and *more* of it converts to gelatin during cooking. The *flakes* that appear in a cooked fish are due to a change in connective tissue that occurs with heating and are a sign that cooking is complete.

**CULINARY ALERT!** The appearance of flakes in cooked fish indicates doneness.

*Restructured*, or “formed” fish of various types that have been minced prior to cooking will *not* show such flakes. *Minced fish* may be

**10  
tips**  
Nutrition  
Education Series

# eat seafood twice a week



## 10 tips to help you eat more seafood

**Twice a week, make seafood—fish and shellfish—the main protein food on your plate.\*** Seafood contains a range of nutrients, including healthy omega-3 fats. According to the *2010 Dietary Guidelines for Americans*, eating about 8 ounces per week (less for young children) of a variety of seafood can help prevent heart disease.

### 1 eat a variety of seafood

Include some that are higher in omega-3s and lower in mercury, such as salmon, trout, oysters, Atlantic and Pacific mackerel, herring, and sardines.

### 2 keep it lean and flavorful

Try grilling, broiling, roasting, or baking—they don't add extra fat. Avoid breading or frying seafood and creamy sauces, which add calories and fat. Using spices or herbs, such as dill, chili powder, paprika, or cumin, and lemon or lime juice, can add flavor without adding salt.



### 3 shellfish counts too!

Oysters, mussels, clams, and calamari (squid) all supply healthy omega-3s. Try mussels marinara, oyster stew, steamed clams, or pasta with calamari.

### 4 keep seafood on hand

Canned seafood, such as canned salmon, tuna, or sardines, is quick and easy to use. Canned white tuna is higher in omega-3s, but canned "light" tuna is lower in mercury.



### 5 cook it safely

Check oysters, mussels, and clams before cooking. If shells don't clamp shut when you tap them, throw them away. After cooking, also toss any that didn't open. This means that they may not be safe to eat. Cook shrimp, lobster, and scallops until they are opaque (milky white). Cook fish to 145°F, until it flakes with a fork.

\*This recommendation does not apply to vegetarians.

### 6 get creative with seafood

Think beyond the fish fillet. Try salmon patties, a shrimp stir-fry, grilled fish tacos, or clams with whole-wheat pasta. Add variety by trying a new fish such as grilled Atlantic or Pacific mackerel, herring on a salad, or oven-baked pollock.



### 7 put it on a salad or in a sandwich

Top a salad with grilled scallops, shrimp, or crab in place of steak or chicken. Use canned tuna or salmon for sandwiches in place of deli meats, which are often higher in sodium.

### 8 shop smart

Eating more seafood does not have to be expensive. Whiting, tilapia, sardines, canned tuna, and some frozen seafood are usually lower cost options. Check the local newspaper, online, and at the store for sales, coupons, and specials to help save money on seafood.

### 9 grow up healthy with seafood

Omega-3 fats from seafood can help improve nervous system development in infants and children. Serve seafood to children twice a week in portions appropriate for their age and appetite. A variety of seafood lower in mercury should also be part of a healthy diet for women who are pregnant or breastfeeding.

### 10 know your seafood portions

To get 8 ounces of seafood a week, use these as guides: A drained can of tuna is about 3 to 4 ounces, a salmon steak ranges from 4 to 6 ounces, and 1 small trout is about 3 ounces.

produced from less popular varieties of fish, or from the fish-flesh remains of the filet process.

The washed, minced fish, coupled with heating, produces gel-like properties in the flesh and it may be “formed” for use as various products. For example, with centuries of production in Japan, and developing technology in handling, the minced fish is used in the production of fish sticks, nuggets, patties, or other unbreaded, “formed” fish items.

In the production of *surimi*, for example, minced fish such as pollack is washed to remove both oil and water-soluble substances such as colors and flavor compounds, leaving only protein fibers as the remains. The washing also removes sarcoplasmic proteins that interfere with the necessary gelling. (Thus some oil and sarcoplasmic enzyme residue remaining in the fibers.)

Subsequent to washing, the flesh (protein fibers) is mixed with salt to solubilize the myofibril proteins—actin and myosin. Other characteristic flavors and pigments, as well as ingredients that promote the elastic texture and stability of the product, are added to the fish so that it may be incorporated into chowders, resembles crabmeat, lobster meat, or sausage-type products.

If surimi is used to create these crabmeat, lobster meat, or sausage-type products, they are called “imitation” (e.g., “imitation crabmeat.”). Two of the more common raw fish dishes are sashimi and sushi. Sashimi is sliced and prepared fish and sushi is vinegared rice, rolled with raw fish, and covered with seaweed. Care in handling is required of raw fish dishes.

In addition to the aforementioned meat, poultry, and fish, other protein sources in the diet are listed below.

---

### Dry Beans and Peas (Legumes) as Meat Alternatives

Legumes offer great variety of diet. As plant material, legumes are *incomplete* proteins, while *complete* proteins are animal proteins that contain all the essential amino acids present at

superior levels—for example, meat, poultry, fish, or milk and eggs.

In order to obtain the same essential amino acid profile as complete proteins, two or more *plant* protein foods are typically *combined* and eaten in the same day. The requirement is that they are combined in a *day* (not needed in the same *meal*) in order to provide the body with *essential amino acids*.

Examples of plant foods’ amino acid composition may be seen in the chart below:

**Legumes**—for example, soybean, black-eyed peas, pinto beans; good source of lysine poor source of (limited) tryptophan and sulfur-containing (S–C) amino acids (soybeans contain tryptophan)

**Nuts–Seeds**—for example, peanuts, sesame seeds; good source of tryptophan and S–C amino acids; poor source of lysine (peanuts contain less S–C amino acids)

**Cereals–Grains** (whole grains)—corn, rice, whole grains (Chap. 4); good source of tryptophan and S–C amino acids; poor source of lysine (corn is a poor source of tryptophan and good source of S–C amino acids; wheat germ is poor in tryptophan and S–C amino acids but a good source of lysine)

“Combining” (see above—combination of two or more complementary sources of incomplete proteins in order to provide a complete amino profile) may include serving beans with rice, tofu with vegetables on rice, black-eyed peas served with cornbread, tofu and cashews stir-fry, chick peas and sesame seeds (hummus) or peanut butter on whole wheat bread. As a common example, a vegetarian diet may frequently combine legumes (beans or peas) with either nuts–seeds or grains.

*Mutual supplementation* is the name given to this combination of two or more complementary sources of incomplete proteins in order to provide a complete amino profile. The requirement is that they are combined in a *day* (not

needed in the same *meal*) in order to provide the body with *essential amino acids*.

**CULINARY ALERT!** Combine the appropriate incomplete proteins in order to create a complete protein.

## Legumes

*Legumes* (Fig. 9.10) are the seeds of a pod of the *Leguminosae* family. The seed, found inside the pod, splits into two distinct parts attached to each other at the lower edge. They include edible peas that may be green, yellow, white, or variegated in color. They include sugar peas with edible pods, black-eyed peas, and more.

Legumes may exist as elongated, flattened, spherical, or kidney-shaped beans or peas. Notable are the edible, podded string beans/snap beans or green beans, kidney beans, or soybeans. Various beans, such as mung beans, are sprouted for culinary use, and others may be used for animal fodder. Frequently, legumes may be referred to as a pulse, and part of the bean, or pea family.

In addition to beans and peas, carob pods and lentils are legumes. Peanuts, despite their name, are *not* true nuts, however, legumes. They are the high protein seeds of a brown pod that appears contracted between the seeds (humped and inverted). Their ripening occurs underground.

Conspicuous changes occur in cooking legumes such as softening due to the gelatinization of starch and flavor improvement. The protein is coagulated and its availability is higher following cooking.

Edible bean products contain both soluble and insoluble fiber which may help to slow digestion. These fibers can contribute to providing a feeling of fullness, or satiety, which can help in weight management . . . also contribute to a low glycemic index . . . a decreased level of glucose in blood following a meal. (Foster 2012)

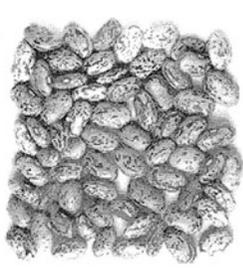
Legumes may be the origin of intestinal distress and gas in some consumers. For that reason,

an enzyme derived from *A. niger* has been processed for addition to foods such as these and is commercially available to consumers for their dietary use. As well, some individuals exhibit an *allergic* response with antibody production following ingestion of various legumes, thus Physicians and dietitians would recommend avoidance.

**CULINARY ALERT!** Beans and peas [along with cruciferous (cabbage family) vegetables and whole grains in the diet] are wholesome food choices recommended to many by physicians and dietitians for healthy eating. They are low in fat, contain no cholesterol, and are good sources of fiber.

Usually, soybeans are derived from an autumn harvest and are processed into oil, tofu, frozen dessert, “flour”, or textured vegetable protein.

- **Soybean oil**, pressed from the bean, is the highest volume vegetable oil in the United States and is commonly a constituent of margarine.
- **Tofu** is soy milk that has been coagulated to make the gel. Tofu is available in various types, ranging from soft to extra firm, depending on the water content. Extra firm tofu may be cut into small pieces and used in stir-fry cooking.
- **Frozen dessert** the curd is further processed and sweetened, it may be served as a frozen tofu- based dessert, similar to ice cream or ice milk. The soft tofu may be an ingredient of “shakes” or frozen, sweetened dessert mixtures.
- **Soy flour** is made of dehulled beans with the oil (that was 18 %) pressed out. It is useful by consumers who cannot consume wheat or flours with gluten-forming proteins. It is non-gluten. Although a soybean is not a



**PINTO**



**RED KIDNEY**



**DARK RED KIDNEY**



**PINK**



**SMALL RED**



**BLACK-EYE**



**CRANBERRY**



**YELLOW-EYE**



**PEA**



**GREAT NORTHERN**



**SMALL WHITE**



**WHITE KIDNEY**



**LIMA**



**BABY LIMA**

**Fig. 9.10** Examples of some common legumes (*Source: USDA*)

cereal, it may be a source of “flour” in recipes.

- **Textured vegetable protein (TVP)** is used by food-service establishments, including school lunch programs that use soy protein on their menus. TVP may simulate a ground form of meat or meat flakes, it resembles the texture of meat, and is a good source of protein in meatless diets. It is the principal ingredient in artificial bacon sprinkles used for salads and other foods. In combination with colors, flavors, and egg binders (for ease of fabrication), the often-unpleasant characteristic flavor of soybeans can be covered.
- **Fermented soybeans** produce soy sauce, miso, and tempeh. Soy sauce is a combination of the fermented soy and wheat; miso is fermented soybean and/or rice used in oriental sauces and soup bases. Tempeh is similar to tofu; however is inoculated with different bacteria.
  - A soy protein *concentrate* is soy that has been defatted, with soluble carbohydrate removed. It is 70 % protein. An even higher quality soy ingredient may be manufactured using a soy protein isolate.
  - An *isolate* is 90 % protein, with even more of the nonprotein material extracted, and with the addition of flavors and colors, it may be satisfactorily included in numerous foods. Nuts are addressed in the discussion of fruits and vegetables (Chap. 7).

casseroles. A former FDA food safety chief (Sanford Miller, PhD.) and senior fellow at the Center for Food and Nutrition Policy states that “This product meets what the nutrition community thinks a product should be and in addition, it tastes good! Modern science can fabricate anything. We can imitate anything, but we always run into problems on how to have it taste good. Not taste alright, but taste good. This product does that.”

The mycoprotein was approved after undergoing a 5-year approval process with extensive animal and human testing. This process included a close look at possible allergens, which showed less than the allergens of mushrooms or soy (Peregrin 2002b).

According to an earlier report by the Center for Science in the Public Interest (CSPI), claims on some labels that the key ingredient in Quorn is “mushroom in origin,” were not true. “Quorn products contain no mushrooms. Rather, the so-called “mycoprotein” in these products is actually grown in large fermentation vats from *Fusarium venenatum*, a non-mushroom fungus. On other Quorn packages, the source of mycoprotein is omitted altogether.”

CSPI executive director Michael F. Jacobson said, “But Quorn’s mycoprotein has nothing to do with mushrooms, plants, or vegetables. It is a fungus and should be labeled as such. Saying that Quorn’s fungus is in the mushroom family is like saying that jellyfish are in the human family. If an obscure term like “mycoprotein” is to be used in Quorn’s ingredient listings, says CSPI, packages should be required to disclose clearly the product’s fungal origins.” (CSPI)

## Quorn as a Meat Alternative

Quorn (pronounced “kworn”) is a meat alternative that became available to American consumers in early 2002 after being sold in Europe for over a decade. It is not a vegetable however, it is a fungus made into many meat-type products including patties and nuggets, and

## Nutritive Value of Meat, Poultry, and Fish

Selected nutritive value aspects of meats (beef, veal, pork, and lamb), poultry (chicken and turkey), and fish and shellfish are shown in Figs. 9.11, 9.12, 9.13, and 9.14. These NutriFacts figures are the most recent ones reviewed by the USDA. Nutritive values for calories, calories

## BEEF & VEAL

**NUTRI-FACTS**  
*UPDATE*

**BEEF & VEAL NUTRITION FACTS**

1/8" fat trim  
trimmed of  
visible fat

	Calories		Total Fat		Saturated Fat		Cholesterol		Sodium		Protein		Iron	
	Calories	Calories From Fat	g	g	mg	mg	mg	mg	g	g	%DV	%DV	%DV	%DV
<b>BEEF, 3 oz cooked serving</b>														
<b>Ground Beef, broiled, well done (10% fat*)</b>	210	100	11	4	85	70	27	15						
<b>Ground Beef, broiled, well done (17% fat*)</b>	230	120	13	5	85	70	24	15						
<b>Ground Beef, broiled, well done (27% fat*)</b>	250	150	17	6	85	80	23	15						
<b>Brisket, Whole, braised</b>	290	190	21	8	80	55	22	10						
<b>Chuck, Arm Pot Roast, braised</b>	260	160	18	7	85	50	24	15						
<b>Chuck, Blade Roast, braised</b>	290	190	21	9	90	55	23	15						
<b>Rib Roast, Large End, roasted</b>	300	220	24	10	70	55	20	10						
<b>Rib Steak, Small End, broiled</b>	280	190	21	9	70	55	20	10						
<b>Top Loin, Steak, broiled</b>	230	130	15	6	65	55	22	10						
<b>Loin, Tenderloin Steak, broiled</b>	240	150	16	6	75	50	22	15						
<b>Loin, Sirloin Steak, broiled</b>	210	170	12	5	75	55	24	15						
<b>Eye Round, Roast, roasted</b>	170	60	7	3	60	50	24	10						
<b>Bottom Round, Steak, braised</b>	220	110	12	5	80	40	25	15						
<b>Round, Tip Roast, roasted</b>	190	90	10	4	70	55	23	15						
<b>Top Round, Steak, broiled</b>	180	70	7	3	70	50	26	15						
<b>VEAL, 3 oz cooked serving</b>														
<b>Shoulder, Arm Steak, braised</b>	200	80	9	3	125	75	29	6						
<b>Shoulder, Blade Steak, braised</b>	190	80	9	3	130	85	27	6						
<b>Rib Roast, roasted</b>	190	110	12	5	95	80	20	4						
<b>Loin Chop, roasted</b>	180	100	10	4	85	80	21	4						
<b>Cutlets, roasted</b>	140	35	4	2	85	60	24	4						

Not a significant source of total carbohydrate, dietary fiber, sugars, vitamin A, vitamin C, and calcium. \*Before cooking

Serving Size: 3 oz. cooked portion, without added fat, salt or sauces.  
 Developed By: Food Marketing Institute, American Dietetic Association, American Meat Institute, National-American Wholesale Grocers' Association, National Broiler Council, National Fisheries Institute, National Grocers Association, National Live Stock and Meat Board, National Turkey Federation, United Fresh Fruit and Vegetable Association.  
 Reviewed By: United States Department of Agriculture  
 Data Source: USDA Handbook 8-13, revised 1990 and Bulletin Board, 1994 (beef) and USDA Handbook 8-17, 1989 (veal)

3/95

**Fig. 9.11** Nutrifacts of beef and veal in 3-ounce cooked portions (Source: Food Marketing Institute)

from fat, total fat, saturated fat, cholesterol, sodium, protein, and iron are reported for beef and veal, pork and lamb, and chicken and turkey. Similarly, calories, calories from fat,

total fat, saturated fat, cholesterol, sodium, potassium, total carbohydrate, protein, vitamin A, vitamin C, calcium, and iron are also reported for seafood.

# PORK & LAMB

**NUTRI-FACTS**  
UPDATE

PORK & LAMB NUTRITION FACTS																	
<div style="border: 1px solid black; padding: 2px; display: inline-block;">                     1/8" fat trim                      trimmed of                      visible fat                 </div>	Calories		Calories From Fat		Total Fat		Saturated Fat		Cholesterol		Sodium		Protein		Iron		
	g																
	mg																
	g																
	%DV																
<b>PORK, 3 oz cooked serving</b>																	
<b>Ground Pork, broiled</b>	250	160	18	7	80	60	22	6									
<b>Shoulder, Blade Steak, broiled</b>	220	190	14	5	80	60	22	6	8	80	65	20	23	6	23	6	8
<b>Loin, Country Style Ribs, roasted</b>	280	210	190	110	22	13	8	5	80	80	45	25	20	23	6	23	6
<b>Loin, Rib Chop, broiled</b>	220	190	120	80	13	8	5	3	70	70	55	55	24	26	4	26	4
<b>Center Chop, Loin, broiled</b>	200	170	100	60	11	7	4	3	70	70	50	50	24	26	4	26	4
<b>Top Loin, Chop, boneless, broiled</b>	200	170	90	60	10	7	3	2	70	70	55	55	25	26	4	26	4
<b>Top Loin, Roast, boneless, roasted</b>	190	170	90	60	10	6	4	2	65	65	40	40	24	26	4	26	6
<b>Loin, Tenderloin Roast, roasted</b>	150	140	45	35	5	4	2	1	65	65	45	50	24	24	6	24	6
<b>Loin, Sirloin Roast, roasted</b>	220	180	120	80	14	9	5	3	75	75	50	55	23	25	4	25	6
<b>Spareribs, braised</b>	340	230	26	9	105	80	25	8									
<b>LAMB, 3 oz cooked serving</b>																	
<b>Shoulder, Arm Chop, broiled</b>	230	170	140	70	15	8	7	3	80	80	65	70	21	24	10	24	10
<b>Shoulder, Blade Chop, broiled</b>	230	180	140	90	16	10	6	3	80	80	70	75	20	22	8	22	8
<b>Shank, braised</b>	210	160	100	45	11	5	5	2	90	90	60	65	24	26	10	26	10
<b>Rib Roast, roasted</b>	290	200	210	100	23	11	10	4	80	75	65	70	19	22	8	22	8
<b>Loin Chop, broiled</b>	250	180	160	80	18	8	7	3	85	80	65	70	22	25	10	25	10
<b>Leg, Whole, roasted</b>	210	160	110	60	12	7	5	2	80	75	55	60	22	24	10	24	10

Not a significant source of total carbohydrate, dietary fiber, sugars, vitamin A, vitamin C, and calcium.

**Serving Size:** 3 oz. cooked portion, without added fat, salt or sauces.

**Developed By:** Food Marketing Institute, American Dietetic Association, American Meat Institute, National-American Wholesale Grocers' Association, National Broiler Council, National Fisheries Institute, National Grocers Association, National Live Stock and Meat Board, National Turkey Federation, United Fresh Fruit and Vegetable Association.

**Reviewed By:** United States Department of Agriculture

**Data Source:** USDA Handbook 8-10, 1992 (pork) and USDA Handbook 8-17, 1989 and Bulletin Board, 1994 (lamb)

**Fig. 9.12** Nutrifacts of pork and lamb in 3-ounce cooked portions (Source: Food Marketing Institute)

# CHICKEN & TURKEY

**NUTRI-FACTS**  
AN UPDATE

POULTRY NUTRITION FACTS									
With skin Skinless	Calories	Calories From Fat	Total Fat	Saturated Fat	Cholesterol	Sodium	Protein	Iron	
			g	g	mg	mg	g	%DV	
<b>Chicken, 3 oz cooked serving</b>									
<b>Whole*</b> , roasted	200	100	12	3	75	70	23	6	
	130	35	4	1	75	75	23	6	
<b>Breast</b> , baked	170	60	7	2	70	60	25	6	
	120	15	1.5	.5	70	65	24	6	4
<b>Wing</b> , baked	250	150	17	5	70	70	23	6	
	150	50	6	1.5	70	80	23	6	6
<b>Drumstick</b> , baked	180	90	9	3	75	75	23	6	
	130	35	4	1	80	80	23	6	6
<b>Thigh</b> , baked	210	120	13	4	80	70	21	6	
	150	60	7	2	80	75	21	6	6
<b>Turkey, 3 oz cooked serving</b>									
<b>Whole*</b> , roasted	180	70	8	2	70	60	24	8	
	130	25	3	1	65	60	25	8	8
<b>Breast</b> , baked	160	60	6	2	65	55	24	6	
	120	10	1	0	55	45	26	6	8
<b>Wing</b> , baked	200	100	11	3	70	50	23	6	
	140	25	3	1	60	75	26	6	8
<b>Drumstick</b> , baked	170	70	8	2	70	75	23	10	
	140	40	4	1	65	80	24	10	15
<b>Thigh</b> , baked	160	60	7	2	70	70	22	10	
	140	40	5	1.5	65	70	23	10	15

\*without neck or giblets

Not a significant source of total carbohydrate, dietary fiber, sugars, vitamin A, vitamin C, and calcium.

Serving Size: 3 oz. cooked portion, without added fat, salt or sauces.

Developed By: Food Marketing Institute, American Dietetic Association, American Meat Institute, National-American Wholesale Grocers' Association, National Broiler Council, National Fisheries Institute, National Grocers Association, National Live Stock and Meat Board, National Turkey Federation, United Fresh Fruit and Vegetable Association.

Reviewed By: United States Department of Agriculture

Data Source: USDA Handbook 8-5 and research conducted in cooperation with USDA.

**Fig. 9.13** Nutrifacts of chicken and turkey in 3-ounce cooked portions (Source: Food Marketing Institute)

# SEAFOOD

## NUTRI-FACTS

UPDATE

### NUTRITION FACTS FOR COOKED SEAFOOD<sup>1</sup>

Nutrient	Calories		Calories From Fat		Total Fat	Saturated Fat	Cholesterol	Sodium	Potassium	Total Carbohydrate	Protein	Vitamin A	Vitamin C	Calcium	Iron
		% Daily Value of Nutrient	(g/%DV)	(g/%DV)	(mg/%DV)	(mg/%DV)	(mg/%DV)	(g/%DV)	(g)	(%DV)	(%DV)	(%DV)	(%DV)	(%DV)	
<b>SEAFOOD</b> (84 g/3 oz)			(g/%DV)	(g/%DV)	(mg/%DV)	(mg/%DV)	(mg/%DV)	(g/%DV)	(g)	(%DV)	(%DV)	(%DV)	(%DV)	(%DV)	
<b>Blue Crab</b>	100	10	1	0	90	30	320	13	10	0	20	0	0	8	4
<b>Catfish</b>	140	80	9	14	2	10	50	17	40	2	230	7	0	0	0
<b>Clams, about 12 small</b>	100	15	1.5	2	0	0	55	18	95	4	530	15	0	0	22
<b>Cod</b>	90	0	0.5	1	0	0	45	15	60	3	450	13	0	0	20
<b>Flounder/Sole</b>	100	14	1.5	2	0.5	3	60	20	90	4	290	8	0	0	21
<b>Haddock</b>	100	10	1	2	0	0	80	27	85	4	340	10	0	0	21
<b>Halibut</b>	110	20	2	3	0	0	35	12	60	3	490	14	0	0	23
<b>Lobster</b>	80	0	0.5	1	0	0	60	20	320	13	300	9	1	0	17
<b>Mackerel, Atlantic/Pacific</b>	210	120	13	20	1.5	8	60	20	100	4	400	11	0	0	21
<b>Ocean Perch</b>	110	20	2	3	0	0	50	17	95	4	290	8	0	0	21
<b>Orange Roughy</b>	80	10	1	2	0	0	20	7	70	3	330	9	0	0	16
<b>Oysters, about 12 medium</b>	100	35	3.5	5	1	5	115	38	190	8	390	11	4	1	10
<b>Pollock</b>	90	10	1	2	0	0	80	27	110	5	360	10	0	0	20
<b>Rainbow Trout</b>	140	50	6	9	2	10	60	20	35	1	370	11	0	0	21
<b>Rockfish</b>	100	20	2	3	0	0	40	13	70	3	430	12	0	0	21
<b>Salmon, Atlantic/Coho</b>	160	60	7	11	1	5	50	17	50	2	490	14	0	0	22
<b>Salmon, Chum/Pink</b>	130	35	4	6	1	5	70	23	65	3	410	12	0	0	22
<b>Salmon, Sockeye</b>	180	80	9	14	1.5	8	75	25	55	2	320	9	0	0	23
<b>Scallops, about 6 large or 14 small</b>	120	10	1	2	0	0	55	18	260	11	280	8	2	1	22
<b>Shrimp</b>	80	10	1	2	0	0	165	55	190	8	140	4	0	0	18
<b>Swordfish</b>	130	35	4.5	7	1	5	40	13	100	4	310	9	0	0	22
<b>Whiting</b>	110	25	3	5	0.5	3	70	23	95	4	320	9	0	0	19

**Seafood provides negligible amounts of dietary fiber and sugars.**

<sup>1</sup> Cooked, edible weight portion. Percent Daily Values are based on a 2,000 calorie diet.

Serving Size: 3 oz. skinless cooked portion, without added fat, salt or sauces.

Developed by: Food Marketing Institute, American Dietetic Association, American Meat Institute, Food Distributors International, National Broiler Council, National Cattlemen's Beef Association, National Fisheries Institute, National Grocers Association, National Turkey Federation, Produce Marketing Association, United Fresh Fruit and Vegetable Association

Data Source: U.S. Food and Drug Administration

(7/96)

**Fig. 9.14** Nutrifacts of seafood in 3-ounce cooked portions (Source: Food Marketing Institute)

Meats are excellent sources of complete protein, many B vitamins, including B<sub>12</sub> that is only found in animal products, and also the minerals

iron and zinc. For additional information on the nutritive value of meat and its many vitamins and minerals, the reader is referred to Figs. 9.11,

9.12, 9.13, and 9.14 that follow as well as other nutrition textbooks.

“Most health and nutrition authorities believe the majority of Americans consume too much sodium.” ... The CDC “believes that if manufacturers of the top-10 categories of food responsible for 44 % of people’s sodium intake were to reduce the sodium content of these foods by 25 %, they could help prevent an estimated 28,000 deaths annually. With CDC having identified cold cured cuts and cured meats as well as fresh and processed poultry as two of the top-10 categories, processed-meat manufacturers stepping up to the challenge (Berry 2013)”.

In 2000, The American Heart Association announced the organization’s official recommendation for daily consumption of soy protein. Soybeans have antioxidant properties and contain saponins noted for their disease-fighting potential.

### What Foods Are in the Protein Foods Group?

All foods made from meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, and seeds are considered part of the Protein Foods Group. Beans and peas are also part of the Vegetable Group. For more information on beans and peas, see [Beans and Peas Are Unique Foods](#).

Select a variety of protein foods to improve nutrient intake and health benefits, including at least 8 ounces of cooked seafood per week. Young children need less, depending on their age and calorie needs. The advice to consume seafood does not apply to vegetarians. Vegetarian options in the Protein Foods Group include beans and peas, processed soy products, and nuts and seeds. Meat and poultry choices should be lean or low-fat.



				
Grains Group	Vegetable Group	Fruit Group	Dairy Group	Protein Foods Group
Make at least half your grains whole.	Vary your veggies.	Focus on fruits.	Get your calcium-rich foods.	Go lean with protein.



All foods made from meat, poultry, seafood, beans and peas, eggs, processed soy products, nuts, and seeds are considered part of the Protein Foods Group. Beans and peas are also part of the Vegetable Group. For more information on beans

**10  
tips**  
Nutrition  
Education Series

# healthy eating for vegetarians



## 10 tips for vegetarians

**A vegetarian eating pattern can be a healthy option.** The key is to consume a variety of foods and the right amount of foods to meet your calorie and nutrient needs.

### 1 think about protein

Your protein needs can easily be met by eating a variety of plant foods. Sources of protein for vegetarians include beans and peas, nuts, and soy products (such as tofu, tempeh). Lacto-ovo vegetarians also get protein from eggs and dairy foods.

### 2 bone up on sources of calcium

Calcium is used for building bones and teeth. Some vegetarians consume dairy products, which are excellent sources of calcium. Other sources of calcium for vegetarians include calcium-fortified soy milk (soy beverage), tofu made with calcium sulfate, calcium-fortified breakfast cereals and orange juice, and some dark-green leafy vegetables (collard, turnip, and mustard greens; and bok choy).



### 3 make simple changes

Many popular main dishes are or can be vegetarian—such as pasta primavera, pasta with marinara or pesto sauce, veggie pizza, vegetable lasagna, tofu-vegetable stir-fry, and bean burritos.

### 4 enjoy a cookout

For barbecues, try veggie or soy burgers, soy hot dogs, marinated tofu or tempeh, and fruit kabobs. Grilled veggies are great, too!

### 5 include beans and peas

Because of their high nutrient content, consuming beans and peas is recommended for everyone, vegetarians and non-vegetarians alike. Enjoy some vegetarian chili, three bean salad, or split pea soup. Make a hummus-filled pita sandwich.



### 6 try different veggie versions

A variety of vegetarian products look—and may taste—like their non-vegetarian counterparts but are usually lower in saturated fat and contain no cholesterol. For breakfast, try soy-based sausage patties or links. For dinner, rather than hamburgers, try bean burgers or falafel (chickpea patties).

### 7 make some small changes at restaurants

Most restaurants can make vegetarian modifications to menu items by substituting meatless sauces or non-meat items, such as tofu and beans for meat, and adding vegetables or pasta in place of meat. Ask about available vegetarian options.



### 8 nuts make great snacks

Choose unsalted nuts as a snack and use them in salads or main dishes. Add almonds, walnuts, or pecans instead of cheese or meat to a green salad.

### 9 get your vitamin B<sub>12</sub>

Vitamin B<sub>12</sub> is naturally found only in animal products. Vegetarians should choose fortified foods such as cereals or soy products, or take a vitamin B<sub>12</sub> supplement if they do not consume any animal products. Check the Nutrition Facts label for vitamin B<sub>12</sub> in fortified products.

### 10 find a vegetarian pattern for you

Go to [www.dietaryguidelines.gov](http://www.dietaryguidelines.gov) and check appendices 8 and 9 of the *Dietary Guidelines for Americans, 2010* for vegetarian adaptations of the USDA food patterns at 12 calorie levels.

and peas, see [Beans and Peas Are Unique Foods](#).

Select a variety of protein foods to improve nutrient intake and health benefits, including at least 8 ounces of cooked seafood per week. Young children need less, depending on their age and calorie needs. The advice to consume seafood does not apply to vegetarians. Vegetarian options in the Protein Foods Group include beans and peas, processed soy products, and nuts and seeds. Meat and poultry choices should be lean or low-fat.

Key consumer message: Go lean with protein [View Protein Food Gallery](#)

A nutrition article on the Paleo Diet is not limited to a discussion on red meat, yet is included in this meat chapter.

### **The Paleo Diet**

#### **Should We Eat Like Our Caveman Ancestors?**

*By Lauren Innocenzi*

“The Paleolithic (Paleo) diet, also called the “Caveman” or “Stone Age” diet, centers around the idea that if we eat like our ancestors did 10,000 years ago, we’ll be healthier, lose weight and curb disease. “A quick and pithy definition of the Paleo diet is—if the cavemen didn’t eat it then you shouldn’t either,” says Academy Spokesperson Jim White, RD, ACSM/HFS. That means foods that can be hunted, fished or gathered: meat, fish, shellfish, poultry, eggs, veggies, roots, fruits, and berries. No grains, no dairy, no legumes (beans or peas), no sugar, no salt. Why? “According to proponents, our bodies are genetically predisposed to eat this way. They blame the agricultural revolution and the addition of grains, legumes and dairy to the human diet for the onset of chronic disease (obesity, heart disease, and diabetes),” says White.

On one hand, this way of eating encourages including more fruits and

vegetables and cutting out added sugar and sodium—which aligns with the 2010 *Dietary Guidelines for Americans*. The combination of plant foods and a diet rich in protein can help control blood sugar, regulate blood pressure, contribute to weight loss and prevent Type 2 diabetes, says White.

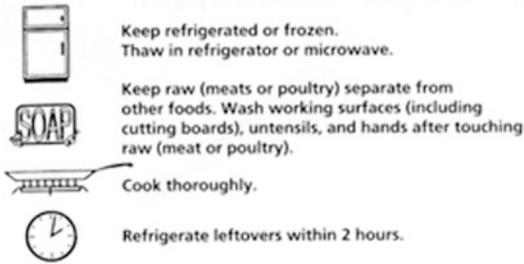
But a typical plan also exceeds the *Dietary Guidelines* for daily fat and protein intake and falls short on carbohydrate recommendations, according to a review from *US News & World Report*. The exclusion of whole grains, legumes, and dairy can be risky as well. “These foods are nutrient-rich and contain important vitamins and minerals such as calcium and vitamin D. Without these foods, supplementation is necessary,” says White. “Eating this way . . . can be very healthy but the lack of certain foods may result in certain deficiencies.”

Eliminating whole grains and dairy is not necessarily the ticket to ending disease and ensuring weight loss. Whole grains contain dietary fiber, which may help reduce your risk of heart disease, cancer and diabetes, and other health complications. And studies suggest that dairy may play a role in weight loss. “The crux of the problem, with respect to grains and dairy, stem from over consumption, and as with anything, excess quantities will become problematic,” explains White.

The Paleo diet might also be hard to sustain. “We live in a society where it is not possible to eat exactly as our ancestors ate. For example, wild game is not readily available as most of the meat we consume has been domesticated. And the plant food we eat has also been processed rather than grown and gathered in the wild,” says White. “While strict conformity is not realistic, it is possible to modify the plan, eating only wild caught fish, grass-fed meat, and organic fruits and vegetables.” But even that can be hard to follow because of lack of variety, need for planning, supplementation, and cost, White adds.

### Safe Handling Instructions

*This product was inspected for your safety. Some animal products may contain bacteria that could cause illness if the product is mishandled or cooked improperly. For your protection, follow these safe handling instructions.*



**Fig. 9.15** Safe handling instructions

*Lauren Innocenzi is an online content manager for the Academy of Nutrition and Dietetics.*

### Safety of Meat, Poultry, and Fish

The safety of meat, poultry, and fish is of utmost concern. Meat is a potentially hazardous food that supports rapid bacterial growth if contaminated and then stored at improper temperatures (Chap. 16). Because all meat contains bacteria, it should be maintained in a clean and covered condition, at temperatures that retard the growth of microorganisms which may both contaminate and spoil meat, producing changes in the color, odor, and safety. *Safe handling* instructions appearing on meat packages is shown in Fig. 9.15.

A former USDA deputy undersecretary of food safety has said “We are strongly encouraging specific interventions for raw meat and poultry in order to further reduce the level and incidence of pathogens such as *Salmonella* in these products. We feel that there is a whole arsenal of potentially effective interventions that could be utilized” (CDC).

Regarding irradiation to control pathogens, according to the USDA, “If irradiated meat is used in another product, such as pork sausage, then the ingredients statement must list irradiated pork, but the radura does not have to appear on the package.”



Restaurants are not required to disclose the use of irradiated products to their customers; however, some restaurants voluntarily provide irradiation information on menus.

#### **How should I handle irradiated meat and poultry?**

Food irradiation is not a substitute for good sanitation and does not replace safe cooking and handling. Consumers should handle irradiated foods just like any other food and always follow safe food handling practices.

“Food irradiation is a technology for controlling spoilage and eliminating foodborne pathogens. The result is similar to pasteurization. The fundamental difference between food irradiation and pasteurization is the source of the energy used to destroy the microbes. While conventional pasteurization relies on heat, irradiation relies on the energy of ionizing radiation.”

**Table 9.1** Minimum safe internal temperature for selected meats

Meat	Temperature
Beef steaks (rare)	155 °F (68 °C) (upon consumer order)
Roast beef (rare)	130 °F (54 °C) (time dependent)
Pork	155 °F (68 °C) or 170 °F (77 °C) in a microwave oven
Ground beef	155 °F (68 °C)
Poultry	165 °F (74 °C)

Source: FDA

Check your steps at FoodSafety.gov. Also see Chap. 19.

- **CLEAN.** Wash hands and surfaces often.
- **SEPARATE.** Separate raw meats from other foods.
- **COOK.** Cook food to the right temperature.
- **CHILL.** Refrigerate food promptly.

**CULINARY ALERT!** Adherence to specific temperatures is necessary for the prevention of growth and the destruction of harmful microorganisms in meat. Adequate refrigeration, cooking, and holding, as well as reheating are all important in controlling bacteria. Personal hygiene and sanitation are also important in preventing the spread of bacteria.

The bacteria, *Clostridium botulinum*, is an *anaerobic* bacteria that causes the disease botulism. It is a deadly form of food poisoning that may result from consuming improperly processed canned or vacuum-packed meats. To control this, nitrite may be added to processed meat to inhibit the reproduction of bacterial spores.

A more widespread, less deadly bacteria such as *Staphylococcus aureus* may grow in contaminated meat products. Subsequently the bacteria may be destroyed in cooking; however, the toxin that the bacteria secretes survives cooking and may cause food illness in as little as one hour after consumption of contaminated meat.

Additional bacteria and agents are problematic as well. Poultry without sufficient cooking may contain the live, infection-causing *Salmonella* bacteria, which is the most common cause of foodborne infections in the United States. Most *Salmonella* are destroyed at 161 °F (72 °C) for 16 s, or 143 °F (62 °C) for 30 min. Another *Clostridium*, *Clostridium perfringens*, is found in meats especially those that were allowed to

cool slowly following cooking. Undercooked pork may contain the parasite *Trichinella spiralis*, which is killed at temperatures of 155 °F (68 °C).

Ground beef, the *combined* meat from many cattle, is more likely to have contamination with *E. coli* 0157:H7 than is a *single* cut of meat (such as steak) coming from a *single* animal. Bacteria may spread during processing and handling, and then cooking temperatures of 155 °F (68 °C) are necessary to destroy any *E. coli* that might be in the meat. A major challenge to the safety of ready-to-eat (r.t.e.) products includes *Listeria monocytogenes*. This may grow under refrigeration, yet is destroyed by thermal processing.

The USDA gave approval for *steam pasteurization* as an antimicrobial treatment of beef carcasses (see below). This treatment reduces the risk of *E. coli* 0157:H7 by exposing the entire surface of the carcass to steam that kills the bacteria. Meat processors must avoid subsequent recontamination of the product, and the consumer must handle the meat with care. The use of steam pasteurization for *pork and poultry* is subject to further research.

The American Meat Institute Foundation (AMIF) speaks for the industry in saying that it *sanitizes* fresh meat, as well as the r.t.e meat products, including hams, and hot dogs. This sanitization is achieved either by steam pasteurization, which (1) exposes the carcass to a steam filled cabinet, or (2) uses of a handheld device in steam vacuuming, whereby steam is sprayed directly onto carcass spots where contamination is suspected. With the added food protection provided by the uses of multiple intervention strategies, sprays and organic acid (lactic and acetic acids) and hot water treatment are also used widely (Mermelstein 2000).

Further FDA-approved treatments include high-intensity pulsed-light treatment for the

control of microorganisms on the surface of food (61 FR42381-42382). Irradiation is a process often used to destroy the pathogens that are present in meat and extend refrigerator shelf life. The FDA has approved *radiation* of fresh, frozen meats.

A US patent has been awarded to a company that uses electricity as the energy source to pasteurize processed and packaged foods, including r.t.e. meats such as hot dogs and luncheon meats (Food Eng 2000). The use of *ozone* to disinfect poultry processing water is reviewed on a case-by-case basis.

**CULINARY ALERT!** Meat must be kept safe in the defrosting process. The FDA advises thawing below temperatures of 45 °F (7 °C), under cold, running water, or by microwave, if immediately cooked. Slow thawing, with intact wrappers, is the defrosting method that allows the least moisture loss. The USDA recommends refreezing only in the case of properly thawed and cooked meats.

The FDA-recommended cooking temperatures to control bacterial growth and prevent foodborne illness are listed in Table 9.1 (check local jurisdiction).

Concern exists over *Bovine Spongiform Encephalopathy* (BSE) or “*Mad Cow Disease*.” Further understanding of the disease and vigilance is needed to protect the food supply.

At this time, “meat recalls are down and safety is up” according to the data from the CDC (Decker 2012). The usual suspects include *E. coli* 0157:H7 in beef and dairy cattle, *Salmonella* and *Campylobacter* in swine and poultry, *Listeria monocytogenes* in r-t-e foods. As well, *staphylococcus aureus* is a common contaminant. “. . . ground products may have pathogens spread throughout the product”, so ordering a ‘rare’ burger may pose risk.

Handling the foods properly is also a priority, as it is reported “ultimately, the riskiest meat product is the one that’s not handled properly, but is abusively stored, handled or undercooked,

allowing pathogens to be transmitted to the consumer.”(Decker 2012)

Reported by the Meat Science Department at a leading university,

While not all lessons are easily learned, and some might come at great costs, the meat and poultry industries have actively updated their practices with new information as it has become available. (Decker 2012)

Also of current concern is the unique disease known as Alpha-Gal or *galactose alpha 1,3-galactose*. In this disease, an *IgE antibody* binds onto the *carbohydrate* present in mammal meat *galactose-alpha 1,3-galactose*. Affected persons eating this carbohydrate (not a protein) in meat show a *delayed anaphylaxis* response of several hours, instead of the typical minutes.

*Mammalian* products including beef, pork, lamb, rabbit, goat, or deer meat cause this disease. Alpha-Gal is *not* found in the nonmammalian poultry or fish.

It may be noted that previous tick bites in an individual trigger this reaction (tiny ticks are often known as chiggers).

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## Conclusion

Meat is the edible portion of animals used for food. Beef, pork, lamb, and veal are included in the definition of meat, and other animal products such as poultry and fish are commonly considered to be “meats”. The amount and type of meat consumption varies throughout the world. Meat is primarily a muscle tissue and also contains connective tissue with a greater variance in the amount of adipose tissue held inside. Water is present to a greater degree in lean meats and young animals. The protein is a complete protein and contains all the essential amino acids.

Cuts of meat include primal or wholesale, subprimal, and retail cuts, with the latter being more familiar to consumers, as it is what they may purchase at their grocery market. The inherent tenderness of a particular cut depends on such factors as location on the carcass, postmortem changes in the muscle, including the stage of

rigor mortis, aging, and the method of cooking. Meat color such as red or white, or “dark meat” is dependent on myoglobin and hemoglobin pigments. Changes in the color of meat may result from exposure to oxygen, acidity, and light.

Meat is subject to inspections and grading in order to provide the consumer with safe, more consistent, and reliable meat products. Meat is a potentially hazardous food and adherence to specific temperatures (cold and hot) is necessary for the prevention of growth and the destruction of harmful microorganisms.

Cooking meat causes the uncoiling or denaturation of peptide protein chains to occur. Tender cuts of meat remain tender when cooked by dry heat for a short time at high temperatures. Overcooking tender cuts of meat produces tough, dry meat, because water is released during denaturation. Less tender cuts of meat become increasingly tender as collagen solubilizes during lengthy exposure to moist heat cooking.

Beef, veal, pork, and lamb may be altered by various processing methods. This includes restructuring, and artificial tenderizing. Ham, corned beef, and bacon are examples of cured meat. Beef, ham, and turkey may be smoked to impart flavor and offer microbial control by dehydration. An alteration to meat occurs as meat is artificially tenderized and includes mechanical, electrical, and enzymatic treatment.

Poultry makes a significant contribution to the US diet and is classified according to age and condition of the bird. Many processed poultry products, including ground turkey, lunchmeats, and formed entrees, are available for use by consumers. Edible fish and shellfish including restructured fish such as surimi provide high-quality protein food to the diet.

Various legumes are consumed. They are incomplete proteins and when eaten in combination according to amino acid profiles, they form a complete protein and function as meat alternatives.

Make informed choices of your protein selection!

## Notes

### CULINARY ALERT!

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## Glossary

**Actin** The protein of muscle that is contained in the thin myofilaments and is active in muscle contraction.

**Actomyosin** The compound of actin and myosin that forms in muscle contraction.

**Adipose tissue** Fatty tissue; energy storage area in an animal.

**Aging** Process in which muscles become more tender due to protein breakdown.

**Collagen** Connective tissue protein; the largest component that gives strength to connective tissue; is solubilized to gelatin with cooking.

**Connective tissue** The component of animal tissue that extends beyond the muscle fibers to form tendons which attach the muscle to bones; it connects bone to bone; endomysium, perimysium, and epimysium connective tissue surrounds muscle fibers, muscle bundles, and whole muscles, respectively.

**Cured meat** Contains nitrite to form the pink color and control the growth of *Clostridium botulinum*.

**Dry heat** Method of cooking tender cuts of meat, including broiling, frying, pan-frying, and roasting.

**Elastin** Connective tissue protein; the yellow component of connective tissue that holds bone and cartilage together.

**Endomysium** Connective tissue layer that surrounds individual muscle fibers.

**Epimysium** Connective tissue layer that surrounds an entire muscle.

**Gelatin** Formed from the tenderization of collagen, used for edible gels in the human diet.

**Grain** Primary bundle containing 20–40 muscle fibrils.

**Halal** “Proper and permitted” food under jurisdiction of trained Muslim inspection.

**Kosher** “Fit and proper” or “properly prepared” food under jurisdiction of the Jewish faith; following the Mosaic or Talmudic Law.

**Marbled** Intermuscular and intramuscular fatty tissue distributed in meat.

**Moist heat** Method of cooking less tender cuts of meat, including braising, pressure-cooking, simmering, or stewing.

**Muscle tissue** The lean tissue of meat.

**Myofibril** The contractile actin and myosin elements of a muscle cell.

**Myosin** Protein of a muscle contained in the thick myofilaments that reacts with actin to form actomyosin.

**Perimysium** The connective tissue layer that surrounds muscle bundles.

**Primal cut** Wholesale cut of meat; it contains the subprimal and retail cuts.

**Retail cut** Cuts of meat available in the retail market; cut from primal cuts.

**Reticulin** Minor connective tissue found in younger animals; it may be the precursor of collagen or elastin.

**Rigor mortis** Postmortem state 6–24 h after death in which muscles stiffen and become less extensible; onset of rigor mortis correlates with depletion of ATP in the slaughtered animal.

**Sarcomere** Repeating unit of the muscle myofibrils.

**Sarcoplasmic protein** The hemoglobin and myoglobin pigments, and enzymes in the cytoplasm of a muscle fiber.

**Smoked meat** Meat that has been treated to impart flavor by exposure to aromatic smoke of hardwood; smoking preserves by dehydrating, thus offering microbial control.

**Stromal protein** Proteins including collagen, elastin, and reticulin of the connective tissue and supporting framework of an animal organ.

**Subprimal cut** Division of a primal cut.

**Wholesome** Inspection does not indicate the presence of illness.

**Z-lines** Boundaries of the sarcomere; holds thin filaments in place in the myofibril.

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