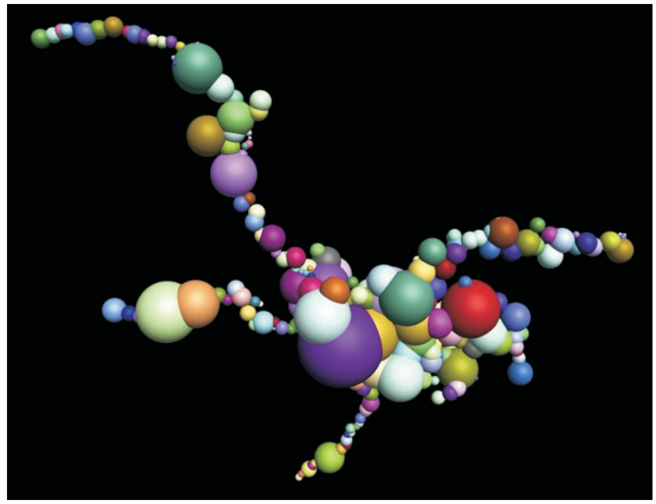
Protein Cookery

COOKING is chemistry in action. This statement is particularly true for the cooking of protein foods. The ability to manipulate proteins properly can provide the most attractive breads, the most nutritious beef, cakes that hold their structure, and sauces with perfect texture. Let's examine how proteins are handled when they are cooked.



Objectives:

1. Explain how cooking affects protein.
2. List common uses of protein in cooking.

Key Terms:

acid
amino acids
binding
broken mixtures
clot
coagulation
collagen
complete proteins
connective tissue
curdle
denaturation
digestibility
elastin
essential amino acids
gelatinization
incomplete proteins
nutrient
protein
shrinkage
tempering
texture
thickening

The Effects of Cooking on Protein

Protein is a very complex nutrient built of amino acid residues; peptide bonds; and elements of hydrogen, nitrogen, carbon, oxygen, and others (e.g., sulfur, phosphorus, and iron). A **nutrient** is a substance that nourishes, promotes growth, and/or repairs the body. **Amino acids** are the primary and the smallest unit of proteins: molecules that form long and complex protein chains. Consuming protein builds muscle mass and aids in cell renewal. Protein is the building block of muscles, skin, bone, hair, and red blood cells. Protein and amino acids are not stored by the body and must be replenished daily. Human beings require about 22 amino acids, and our bodies make all except for the following **essential amino acids** (those not produced by the body that must be replenished daily through food and drink):

- Isoleucine
- Leucine
- Lysine
- Methionine
- Phenylthalanine
- Threonine
- Valine
- Tryptophan
- Histidine
- Arginine (required for young children but not for adults)

PROTEIN VERSIONS

Dietary protein comes in two versions: complete and incomplete.

Complete Proteins

Complete proteins are nutrients that contain all the amino acids required to make new protein. Food sources are red meats, poultry, fish and shellfish, eggs, and dairy products.

Incomplete Proteins

Incomplete proteins are nutrients that lack one or more amino acids that the body cannot produce or convert from other amino acids. Food sources are vegetable (plant-based) proteins—beans, legumes, and tofu. To ensure you get enough protein when it is primarily consumed from plant sources (vegetarians), you must usually eat those foods in combination, such as rice and beans or peanut butter and whole wheat bread. Animal sources are superior in quality and quantity (ounce for ounce).

“PACKAGING”

The way in which protein is packaged makes a difference in your overall health. The protein from pork chops and steaks, for instance, is nearly the same as that from tuna and black beans. The difference is that steaks and pork chops add lots of saturated fat to your diet while tuna and black beans are low in saturated fat.

DIGESTIBILITY

Digestibility is the ease with which the body is able to access and utilize protein. Protein can be consumed raw or cooked, and the effect of cooking can be good and bad. Cooking protein, for example, can reduce digestibility because of overcooking. Yet the consumption of raw protein is harder for your body to digest, and there is the potential for you to contract a foodborne illness. Microorganisms are more likely to be present in raw animal products than in cooked animal products. For example, sushi must be of very high quality to be consumed raw. Cooking enhances digestibility.

COAGULATION

Coagulation (thickening, curdling, or clotting) is the result of the "firming" of the protein coils and is related to doneness. Think of a protein molecule as a tight spiral shape. When you add heat to the spiral coils, they tighten and make the protein denser. Coagulation is easy to see when you fry an egg. The egg turns from a loose gelatinous liquid to a solid rather quickly after heat exposure. Coagulation explains why the **texture** ("feel" in the mouth) of meats generally becomes firmer, tougher, and drier the longer meat is cooked.

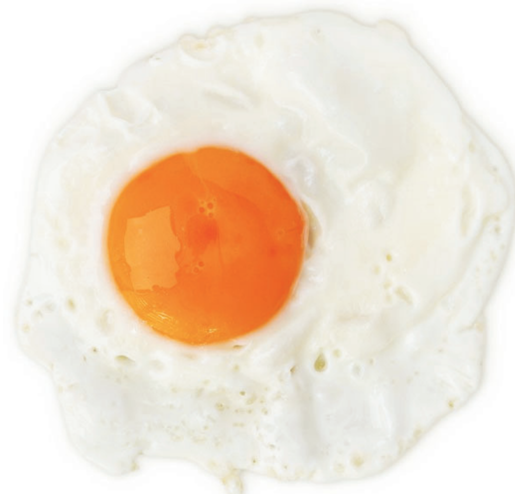


FIGURE 1. The solidifying of egg whites is a good example of protein coagulation.

DENATURATION

Denaturation is the changing of the natural shape of the protein spiral because cooking occurs. Protein molecules change from a tight spiral shape to an uncoiled and elongated "S" shape. Another way to think about denaturation is that the coils relax or separate. Denaturation occurs when proteins are subjected to cooking by exposure to heat, alcohol, acids, or bases. It changes the color and texture of foods. For example, egg whites transform from translucent to white and chicken turns from pink to white.

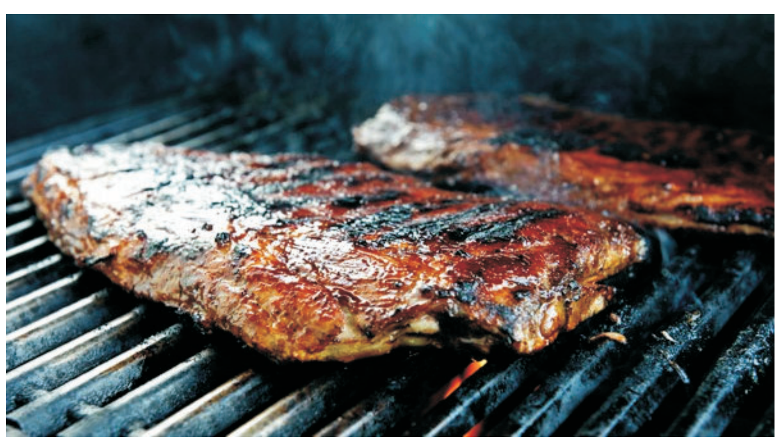


FIGURE 2. Grill marks on meat and other charring indicate over-denatured protein. Are these ribs denatured?

When excessive heat is applied to protein foods, they turn brown. Browning tells us that the protein is becoming more and more denatured. Grill lines or seared crusts on steaks, ribs, and pork chops are actually signs that the flesh is burned. While denaturing protein in food usually makes the nutrient more available to human digestion, excess denaturation (e.g., grill marks) has the opposite effect; it makes the protein nutritionally useless.

Connective Tissue and Collagen

Connective tissue provides structural support for the tissues and organs of the body in the form of collagen and fibers (reticular and elastic). **Collagen** is a long, rigid type of protein that makes up connective tissues such as bones, ligaments, and tendons. It is white in color and is composed of three separate molecules (of amino acid chains) that twist around each other and look like the fibers that make up a rope. Collagen is tenderized by low heat and moisture over time. Pot roast, ribs, and brisket are good examples of tough cuts (high in collagen) that tenderize over time under heat and moisture. They "fall off the bone" when slow cooked (at about 225°F) for several hours. As the collagen breaks down, it melts and becomes a soft gelatin.

Elastin

Elastin is a protein similar to collagen, is yellow in color, and is the major component of the elastic fibers in meat muscle. You often see elastin as a silvery membrane on the outside of some meat muscle or as thick veins running through meat. Sometimes it is called gristle. It does not tenderize under normal cooking methods. Instead, elastin must be physically tenderized by breaking of the fibers or must be cut out off the muscle before cooking. For instance, cube steak is pounded or put through a mechanical cubing machine before cooking to tenderize it. In addition, hamburger is ground before cooking to break the elastin fibers.

ACID

Acid (biting, sour, or sharp) foods (e.g., vinegar, wine, buttermilk, and citrus juices) are used to tighten the protein coils. Acids also have a denaturing affect on food. For example, adding an acid to a dairy food makes the protein **curdle** or **clot** (coagulate or congeal) to produce sour cream, crème fraîche, and clotted creams. Marinating meats in an acidic dressing helps tenderize it before cooking.

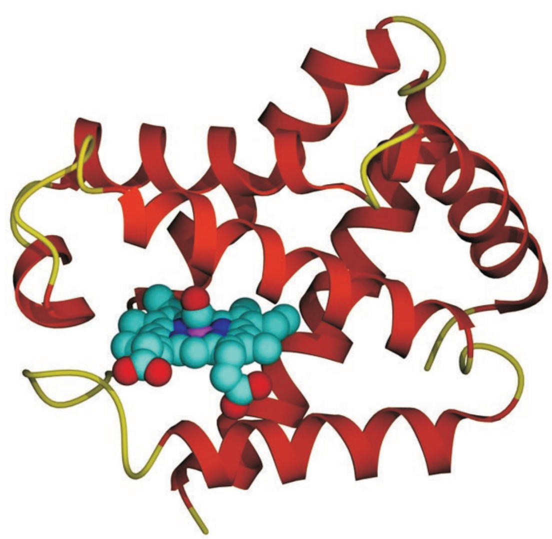


FIGURE 3. This image of blood protein shows its spiral shape. When it tightens, coagulation, denaturation, and shrinkage are occurring.

SHRINKAGE

Shrinkage is the contraction or curling of a food product as a result of protein coagulation and moisture loss. In meats, shrinkage happens first in thickness and then, as the internal temperature of the meat rises, in length. Meat is approximately 70 percent water, so as moisture is lost, it shrinks. Protein coagulation, particularly in meat, accounts for most shrinkage during cooking. You can see the shrinkage of proteins in baked goods. For example, when cakes pull away from the side of the pan, it is due to protein coagulation and moisture evaporation. Shrinkage in meats is due to moisture evaporation and the rendering of fat.

Uses of Protein in Cooking

BINDING

Binding is the ability to cause different ingredients to stick together. Eggs are a binding agent in numerous foods—meatloaf, stuffing, pudding, etc. Eggs also possess the added benefit of beginning in a liquid state—which helps initial mixing—and then solidifying when heated. Binding agents, such as eggs, are commonly included in recipes for cakes, pies, puddings, stuffing and dressings, and meatloaf. The binding quality of eggs is utilized in the bakeshop where dough needs to be "glued" together. For instance, pastries brushed with egg or egg wash help other dough stick to the pastry. Egg wash also helps seeds, sugars, and other ingredients stick to the pastry's surface. Protein provides this sticky quality.

FIGURE 4. Eggs bind ingredients together with protein coagulation. Can you identify from this picture the meatloaf ingredients that are bound together?

THICKENING

Thickening is the creation of a dense, viscous (resistant to flow) consistency from a previously liquid mixture. Egg proteins coagulate to thicken puddings, custards, pie fillings, and sauces. For example, hollandaise sauce and crème Anglaise (pronounced CREM on-glaze; the French term for English vanilla custard sauce) contain eggs that are carefully heated specifically to thicken the sauce. To thicken highly liquid mixtures, chefs commonly use a tempering technique with heated mixtures that contain eggs.

Tempering

Tempering is the gradual warming of slightly beaten eggs (off the heat). Then the egg mixture is added to the hot ingredients and is cooked just until the liquid mixture thickens. Heating egg and protein mixtures to excessive temperatures can cause the mixture to break and/or solidify.

Broken Mixtures

Broken mixtures are combinations that curdle and/or separate into solids and liquids. In most cases, broken mixtures are due to protein coagulation that occurs at high temperatures.

FIGURE 5. The crème caramel and the crème a' l'Anglaise custards—one baked until firm and the other cooked until slightly thickened—are both thickened by coagulating egg proteins.

GELATINIZATION

Gelatinization is the process of converting a liquid into a jelly-like, viscous consistency. The coagulating and thickening properties of protein are evident in gelled liquids. For example, stock that has been simmering with bones thickens when it cools into a clear and shimmering gelatinous texture. Gelatinization is a result of proteins dissolving into the cooking liquid and then gelling when cooled. The gel will liquefy again when heat is applied because the amount of liquid is far greater than the amount of protein.

When roasts are cooked and chilled, a gelled liquid forms. This gel is used in stocks, gravies, and sauces. When egg or bean proteins are added to a soup stock or sauce, the product thickens. Again, the thickening is due to protein coagulation. When

FIGURE 6. Gelatin is a product of animal protein. Notice how this clear aspic gel holds this ham, egg, and vegetable salad in suspension.

beans are added to a liquid, thickening is enhanced even more due to the amount of starch in the beans.

BROWNING

Browning increases when protein is present under heat. For instance, grilled steaks and pork chops, oven-browned roasts, and fried eggs all brown when heat is added. Eggs also increase the amount of browning of bakery items because of their protein properties. Egg proteins (in the form of beaten eggs or egg wash) add a brilliant shine to the exterior of baked goods, along with additional browning.

Summary:

Protein is a complex nutrient built of amino acids. Eating protein foods builds muscle mass and skin, bone, hair, and red blood cells. Protein and amino acids are not stored by the body and must be replenished daily. Dietary protein comes in two versions: complete and incomplete. Food sources of complete proteins include red meats, poultry, fish and shellfish, eggs, and dairy products. Food sources of incomplete proteins are vegetable (plant-based) proteins—beans, legumes, and tofu.

To ensure you get enough protein when it is primarily consumed from plant sources (vegetarians), you must usually eat those foods in combination, such as rice and beans or peanut butter and whole wheat bread. Protein foods coagulate and gelatinize under heat, help thicken food products, and help bind other ingredients together. Excessive denaturation (e.g., grill marks) make that portion of the protein nutritionally useless.

Checking Your Knowledge:

1. Which foods contain protein?
2. In what way is eating cooked protein foods a better choice than eating raw protein foods?
3. How does heat affect protein?
4. Name three uses for egg protein. (Other than cooking an egg to eat it)
5. What effect does acid have on protein?

Expanding Your Knowledge:

We have talked about protein in terms of the food we eat and have touched on the fact that we need protein for good nutrition, but protein is so much more. Our hair is made of protein, and every cell in our body grows and regenerates itself because of protein. Life is based on long spiral protein chains known as DNA: the genetic code for all life.

While protein defines and sustains us, alterations in protein chains are the cause of countless diseases, syndromes, and birth defects. So how is it that some chains of protein make up hair, others produce feathers, and others produce skin, hearts, lungs, etc.? How is it that others create deadly viruses, an inability to digest certain foods, or diseases of the blood? What is it about these variances in the molecular chains that make protein so diverse? Protein research has led to fascinating discoveries about our world and about us! Use the Internet to search for information describing the variances and their causes. Then write a short (two to three pages) paper about your findings.

Web Links:

Cooking Without Heat
http://www.dvo.com/recipe_pages/homemade/_Cooking_Without_Heat.html

Protein Damage Through Heating
http://www.innvista.com/health/nutrition/amino/pdamage.htm

The Effects on Protein Food When Heated
http://www.livestrong.com/article/59858-effects-protein-heated/

The Effects of Heat on Protein in Foods
http://www.ehow.com/facts_5566173_effects-heat-protein-foods.html

Protein
http://www.whfoods.com/genpage.php?tname=nutrient&dbid=92

Proteins: the Body's Worker Molecules
http://publications.nigms.nih.gov/structlife/chapter1.html

Science of Eggs
http://www.exploratorium.edu/cooking/eggs/eggscience.html