

# Heat in Cooking

**Heat naturally moves from hot surfaces to cooler surfaces. The movement of heat is commonly referred to as heat transfer. There are three methods of heat transfer: conduction, convection, and radiation. Cooking of food usually uses a combination of these methods.**

## Conduction

Conduction transfers the heat using direct contact; food is heated directly in a metal pan, in a liquid, or surrounded by air. Dropping an egg into a pan of boiling water is a good example. The heat from the water is transferred to the egg. As the outside of the egg becomes warm, the heat moves into the center of the egg, continuing inward until the entire egg is heated to the desired temperature. The efficiency of the heat transfer depends on the conductivity of materials in contact with the food. Copper is one of the best conductors of heat. Heat transfers quickly from the heat source into the food through the copper cookware. In contrast, water, stainless steel, and the food itself, are poor conductors of heat.

## Convection

Convection heat transfer occurs faster than conduction. Convection occurs by the movement of air, liquid, or steam around the food. For example, as a pan of soup heats up on the stove, heat moves from the bottom of the pan. This movement of hot and cool liquids or gases combines. Stirring the pan redistributes the heat from the bottom of the pan throughout the other ingredients. Convection is the reason frozen foods thaw more quickly when placed under cold running water. Convection can also occur mechanically by means of a fan that circulates the air in an oven. A convection oven can reduce the cooking time by 25 percent over standard ovens. It also increases browning of the food because of the concentrated heat on the surface of the food.

## Radiation

Radiation heat transfer occurs when microwave (light waves) or infrared energy (heat waves) are spread into the food. As the microwaves penetrate the food, they bump into molecules of water and fat, causing them to vibrate rapidly. This vibration creates friction, which creates heat that cooks the food. The larger the piece of food, the more unevenly the microwaves penetrate, so microwave cooking has some limitations.

## Effects of Heat

When heat is added to food, it causes changes in color, texture, flavor, shape, and nutritional value. Heat affects protein, carbohydrates (sugars and starches), fats, and water in different ways. Careful selection of the cooking method based on the contents of the food and the desired outcome will lead to the best quality product.

## Coagulation

Proteins are denatured or coagulated by heat or a change in pH. The proteins change from a semisolid to a solid state during cooking. An example includes cooking an egg white. This process occurs between 160° to 185°F. The heat causes the unfolded protein chains to become entangled and lump together. The same coagulation occurs when an acid such as lemon juice or vinegar is added to milk. The pH is altered and the casein (milk protein) denatures and coagulates into spongy lumps. In meats, excessive heat will cause meat proteins to lose moisture and become tough.

## **Gelatinization**

Gelatinization is the thickening of liquids. Starch, in the presence of water, gelatinizes when heated. The starch granules absorb water. When heated, the starch granules swell and then burst, leaking starch into the surrounding liquid. Swelling is usually complete at 190 to 195°F. Excessive or prolonged heat, not enough heat, inadequate dispersion of dry starch in melted fat or cold water, and excessive agitation may interrupt proper starch gelatinization.

## **Caramelization**

Caramelization or browning occurs when sugar and proteins are combined and exposed to high heat. This applies to both natural sugars in food and sugar added to foods. Excessive caramelization may result in an unappealing dark color or burned flavor.

## **Evaporation**

Most foods contain water. As the water in foods reach 212°F, the water turns to steam and evaporates. Heat that is too high or prolonged cooking may dry out the product through excessive evaporation of moisture.

## **Cooking Methods**

Basic cooking methods can be categorized as dry heat methods and moist heat methods.

### **Dry Heat Cooking**

Dry heat cooking includes roasting, broiling, barbecuing, and grilling. These techniques cook food using direct or radiant heat from a heat source that is below or above the food. Frying is also a dry heat method with the food placed in a varying amount of fat.

During roasting, the food is surrounded with hot air, usually between temperatures of 325° to 425°F. Baking is essentially the same as roasting but generally refers to baking fish, pastries, fruits, and vegetables. The transfer of heat by convection to the food's surface causes it to have a brown exterior and a moist interior. Low, constant temperatures aid in browning and tenderizing. Thus, less tender cuts of meat should be cooked at a low temperature for a longer period of time to help dissolve the connective tissues in tougher cuts of meat.

Grilling and barbecuing are used interchangeably, but the primary distinction between the two is the heat source. Grilling cooks food over a direct flame or high heat source. Barbecuing uses indirect heat at a low temperature. A tender cut of meat is often grilled because most food can be cooked in 10 to 20 minutes over a direct heat source. Barbecuing can take a full day or even up to two or three days to reach the desired product outcome.

Frying is a general term used for any food cooked in oil or fat over a heat source. The name of the frying technique depends on the amount of fat used. Sautéing requires only a small amount of fat and is cooked in a frying pan or wok. Pan frying requires more fat than sautéing but only one-third or one-half of the food is covered in the fat while cooking. Another technique, deep frying, requires the entire piece of food to be immersed in hot oil. All forms of frying allow for quick cooking and provide a crispy finished product. The key to preventing excessive fat absorption is to keep the oil at the required temperature. Place the food in the hot oil only after it has reached the right temperature.

### **Moist Heat Cooking**

Moist heat cooking includes blanching, boiling, poaching, simmering, steaming, stewing, and braising. Food cooked by these techniques surround the food with steam or liquid. Cooking temperatures are lower in moist heat cooking methods and can be anywhere between 140°F and 212°F.

Blanching is a food preparation technique used to keep vegetables or fruit flavorful and crisp. Vegetables or fruit are boiled for a short period of time and then immediately chilled in ice water.

This stops enzymatic browning and ripening, setting the color for future preservation or cooking methods.

Poaching, simmering, and boiling all require the food to be in hot water, broth, stock, or wine. The differing factor is the actual temperature of the liquid. Poaching uses the range of 140°F to 180°F and is used for fragile items such as eggs and fish. There are usually no visible signs of bubbling when poaching, but a thermometer can be used to check the temperature. Increasing to a range of 180°F to 205°F changes the cooking method to simmering. Bubbles form and gently rise during simmering. This method is good for soups and pastas. Lastly, boiling occurs when cooking at the highest temperature of 212°F. This temperature causes a rolling boil where the food becomes agitated, causing some foods to fall apart.

Braising is a method used to cook tough meats and crunchy vegetables. The meat is usually browned over high direct heat initially and then placed in a liquid that covers about half of the meat. A pan is then used to slowly cook the food until it is tender. Braising can be done on top of the stove or in the oven. Stewing is similar to braising but usually calls for smaller pieces of food to be covered with a liquid. A stew is cooked just under the boiling point for an extended period of time.

**Choosing the correct cooking method will determine the quality of the end product. In addition to quality, the color, flavor, texture, and nutrient content will also be affected by the cooking method chosen. The length of time that foods cook will depend on the cooking temperature, size, and shape of food, whether bone is present, the quality of the food itself, how much you are cooking at one time, and the degree of doneness desired.**

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