

Technical Information from the Food Safety and Inspection Service

Color of Cooked Ground Beef and Juices As It Relates to Doneness

Because meat and poultry products may contain harmful bacteria, the Food Safety and Inspection Service (FSIS) of the U.S. Department of Agriculture (USDA) has conducted a longstanding consumer education program on safe cooking and handling of meat and poultry. Proper food safety practices prevent situations that promote bacterial growth, cross-contamination, and foodborne illness. Thorough cooking destroys bacteria.

E. coli O157:H7 is a strain of bacteria that has caused numerous outbreaks of foodborne disease resulting in hundreds of illnesses and several deaths. This pathogen can survive both refrigerator and freezer storage.

The majority of *E. coli* O157:H7 outbreaks recorded since 1982 have been linked to undercooked ground beef as the primary source of infection. Future outbreaks may be prevented if food handlers - in food service institutions and in the home - understand and act on a simple fact: Thorough cooking kills *E. coli* O157:H7.

FSIS advises consumers to use a meat thermometer when cooking meat and poultry to assure that a safe internal temperature has been reached, as well as to verify doneness. Whole beef roasts and steaks should be cooked to an internal temperature of 145 F in the center, other cuts of meat and ground beef to 160 , ground poultry to 165 , and poultry to 180 F internally.

To accurately measure the internal temperature of a ground beef patty, a food preparer must insert the thermometer through the side of the patty to the center. Even consumers who routinely use meat thermometers rarely use them when grilling or frying ground beef patties. Consumers who do not use a meat thermometer have been advised to cook meat and poultry until the center and the cooked-out juices are no longer pink. Consumers should also look for a firm "cooked" texture rather than a softer "raw or rare" texture in the meat.

However, recent research results have raised questions regarding the suggestions for the visual checks for doneness.

Color as an indicator of doneness

FSIS has recently recognized two divergent problems with its advice about using the color of ground beef to test for doneness and guarantee the destruction of pathogens:

1. One problem occurs because some ground beef may appear to have lost all pink color before it is fully cooked. If raw ground beef is somewhat brown already, it may look fully cooked before it reaches a safe temperature. The product may have turned brown before cooking because it has been temperature-abused or stored for an extended period of time.
2. The other problem occurs because some lean ground beef, or ground beef that contains approved seasonings or flavorings, such as spices and spice extractives, may remain pink temperatures well above the 160 F final cooking temperature recommended for consumers.

Browning Too Soon

Cooked ground beef patties may appear brown before they have reached a safe internal temperature because the raw product turned brown or because the meat was ground from the carcasses of older animals.

When ground beef is exposed to the air (oxygenation), its pigment, myoglobin (normally a purplish-red color in the absence of oxygen), combines with oxygen to form oxymyoglobin, which is red. This is what gives fresh beef its red color. But if meat is stored for long periods of time, is stored above proper temperatures, or is exposed to too much air, oxidation takes place, causing the meat to turn brown.

To prevent premature browning, ground beef should be tightly wrapped and either frozen or stored for no more than two days in a 40 F refrigerator.

Consumers associate bright red color with high quality (Lynch et al, 1986) and are frequently concerned when ground beef appears red on the outside and brown on the inside. Different levels of oxygenation at different locations inside and on the surface of the meat can account for this coloration (the grinding process allows air to contact more surface area of the meat). If ground beef loses contact with the air, as with the inside of the package of ground beef, it will turn greyish-brown. Likewise, as ground beef is stored for extended periods of time the outside will also turn brown.

As ground beef is cooked, it changes color from red to pink to brown. If the meat is already brown, it will not change color during cooking. Recent research has shown some ground beef patties to look well-done at internal temperatures as low as 131 F (Hague et al, 1994; Hunt et al, 1995).

Raw meat from older carcasses can also be less red, or darker in color, and can appear to be adequately cooked when it is actually still undercooked. When ground beef patties are made from a mixture of meat taken from a combination of older and younger carcasses, as well as imported trimmings (also reported to be darker in color), it has been found that patties cooked to 131 F are similar in color to patties cooked to 140 F. Patties cooked to 150 F have been shown to be visually indistinguishable from those cooked to 160 F (Hague et al, 1994).

There is considerable variation both between and within beef patty formulations in endpoint temperature and color, even when controlled cooking procedures are followed. When cooking hamburger patties, a consumer would not be able to determine whether the patties were thoroughly cooked unless a meat thermometer was used.

Persistent Pink Color in Cooked Meat Patties

There are several reasons why ground beef may remain pink at temperatures above 160 F. This phenomenon is most commonly associated with the pH and the level of pigment in the meat, as well as the fat content. amounts of total pigment, there are significant differences in cooked internal color, indicating that the pH is responsible. But when pH is held constant, the concentration of total pigment contributes to the abnormal internal color. It was further shown that when cooked bull meat (pH 6.2) is compared to a mixture of bull meat, chuck, and trim (pH 6.2), the bull meat patty is significantly redder

due to the higher concentration of pigment.

A third factor affecting cooked ground beef color is the amount of fat in beef patties. Low-fat beef appears to have less conduction of heat than high-fat beef. Consequently, low-fat beef patties - including those that contain water, oat bran, carrageenan, and/or isolated soy protein - require longer cooking times and higher cooking temperatures to reach a certain internal temperature. Furthermore, patties can remain pink even though they have reached internal temperatures higher than the recommended 160 F. In some cases, low-fat beef patties have not only taken longer than expected to reach the targeted end-point temperature but also maintained a pink color at temperatures of 160 to 165 F (Berry, 1994; Troutt et al, 1992).

Again, there is considerable variation both between and within beef patty formulations in endpoint temperature and color even when controlled cooking procedures are followed.

Color of Meat Juices

Although ground beef, for various reasons, may either never or prematurely turn brown, the cooked-out juices may be a reliable indicator of doneness. Meat juices from normal as well as oxidized (prematurely brown) ground beef look red when the meat is raw, then change to pink and then tan with higher cooking temperatures. When studying the color of ground beef and its juices as they are cooked, researchers noted that meat juices lose their red or pink color and become tan or yellow-colored (Hague et al, 1994; Hunt et al, 1995). However, contrary to longstanding consumer advice, the juices from beef never become clear in the way that juices from poultry do. Thus, it is now recommended that the instructions "cook until juices run clear" be replaced by "cook until juices are no longer pink."

Advice for Consumers

To avoid foodborne illness, USDA recommends that meat and poultry be cooked thoroughly. Thorough cooking is most accurately measured by use of a meat thermometer. The thermometer should penetrate the thickest part of the food. For a meat loaf or a casserole, it would be in the center. If a beef patty is thick enough, the thermometer should also be placed in the thickest area. If the patty is not thick enough to check this way, the thermometer may be inserted sideways. Ground beef should be cooked to an internal temperature of 160 F.

In the absence of a food thermometer to measure the internal temperature, a consumer should judge doneness by several factors:

Color of cooked-out juices: the juices should have no trace of pink, red, or cloudiness

Color of cooked meat: ground beef should be brown in the center

Texture of cooked meat: cooked meat has a firm or flaky texture, raw meat has a soft, mushy texture, regardless of the color

Fresh or thawed meat should be used quickly, within one to two days. To prevent premature browning, ground beef should be tightly wrapped and frozen, or stored for no more than two days in a 40 F refrigerator.

Focus Group Testing

FSIS tested consumer understanding of descriptive terms for doneness factors using focus groups. The various factors used to indicate doneness were tested for clarity and accuracy of understanding. The goal was to develop precise wording to enable FSIS to educate consumers on determin

Normal fresh muscle has a pH ranging from 5.3 to 5.7. When thoroughly cooked, the myoglobin, oxymyoglobin, and metmyoglobin pigments of normal meat are converted (i.e. denatured) to globin ferrihemochrome, the grey pigment of cooked meat. Meat with a pH of 6.0 or higher can remain pink at 159.8 F. The rate at which normal muscle pigments change to form the grey globin ferrihemochrome is affected by pH. The higher the pH, the longer the cooking time and/or higher the final internal temperature required for denaturation to be complete (Mendenhall, 1989). A high pH reduces the amount of myoglobin denatured by cooking, resulting in a pink color rather than the expected grey cooked color created by globin ferrihemochrome (Trout, 1989).

A high concentration of pigment also contributes to a red color in cooked meat. Meat coming from bulls typically exhibits both a higher pH and high concentrations of pigment. According to Mendenhall (1989), when patties are formulated from bull meat, chuck, and beef trim with similar doneness in ground beef. Of the phrases tested, "brown in the middle" was the one preferred by consumers and was the least open to individual interpretation. Educators may wish to modify or expand the above message.

REFERENCES

Berry, B.W. 1994. Fat Level, High Temperature Cooking and Degree of Doneness Affect Sensory, Chemical, and Physical Properties of Beef Patties. *J. Food Science*. 59(1): 10-14, 19.

Cornforth, D., C.R. Calkins, C. Faustman. 1991. Methods for Identification and Prevention of Pink Color in Cooked Meat. *Reciprocal Meat Conference Proceedings*, AMSA 44:53-58.

Hague, M.A., K.E. Warren, M.C. Hunt, D.H. Kropf, C.L. Kastner, S.L. Stroda, and D.E. Johnson. 1994. Endpoint Temperature, Internal Cooked Color, and Expressible Juice Color Relationships in Ground Beef Patties. *J. Food Sci*. 59(3): 465-470.

Hunt, M.C., K.E. Warren, M.A. Hague, D. H. Kropf, C.L. Waldner, S.L. Stroda, and C.L. Kastner. 1995. Cooked Ground Beef Color is Unreliable Indicator of Maximum Internal Temperature. Department of Animal Sciences, Kansas State University, Manhattan, KS 66506-0201. Presentation to American Chemical Society April 6, 1995.

Mendenhall, V.T. 1989. Effect of pH and Total Pigment Concentration on the Internal Color of Cooked Ground Beef Patties. *J. Food Sci*. 54(1): 1-2.

Trout, G.R. 1989. Variation in Myoglobin Denaturation and Color of Cooked Beef, Pork, and Turkey Meat as Influenced by pH, Sodium Chloride, Sodium Tripolyphosphate, and Cooking Temperature. *J. Food Sci*. 54(3): 536-544.

Trout, E.S., M.C. Hunt, D.E. Johnson, J.R. Claus, C.L. Kastner, and D.H. Kropf. 1992.

Characteristics of Low-fat Ground Beef Containing Texture-modifying Ingredients. J. Food Sci. 57(1): 19-24.

Lynch, N.M., C.L. Kastner, and D.H. Kropf. 1986. Consumer Acceptance of Vacuum Packaged Ground Beef as Influenced by Product Color and Educational Materials. J. Food Sci. 51(2): 253-255, 272.

For More Information:

Food Safety and Inspection Service

Information and Legislative Affairs:
Office of the Director (202) 720-7943

Media Inquiries: (202) 720-9113

Consumer Inquiries: Call USDA's Meat and Poultry Hotline:
1-800-535-4555

In the Washington, D. C., area, call: (202) 720-3333