



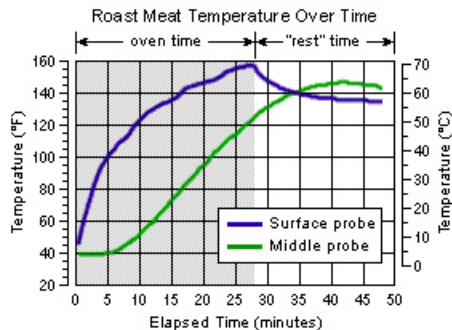
Le livret de température des viandes, or The Little Book of Meat Temperatures, was created to provide a more complete explanation than is usually presented in other information sources as to what internal temperature meat should reach during cooking in order to destroy any harmful bacteria. Click the book title to open the book or click *à la carte* to return to the home page.

In May, 2000, I watched the kitchen staff at Le Château d'Amondans prepare *gigot d'agneau* for 230 people. The lamb legs were trimmed minimally, dusted with coarse salt, and placed on a bed of lamb trimmings in oval roasting pans. A couple of hours before serving, they were roasted in a 230°C (450°F) convection oven. The cooks used a high-speed, digital thermometer to test the legs for proper doneness. When the right temperature was reached, they were transferred to a holding cabinet set to 70°C (158°F). At the moment of service, the legs were removed from the cabinet and carved. Each slice was a gorgeous, even shade of pink with a thin brown border at the edge. While the legs were resting, the trimmings had been turned into a stock that was reduced and combined with a copious amount of roasted shallots and some Madeira wine for flavoring. The lamb was served with this simple sauce and with some simple vegetables on the side. I tasted a few scraps. It was possibly the best lamb I had ever tasted. I asked the chef, Frédéric Médigue, at what internal temperature the legs were removed from the oven. His response was 46°C. That's a mere 115°F! That answer sent me on a two-year quest for further knowledge about roasting meat.

In my journey I learned a number of things, some helpful, some not. I've searched for a French government document listing cooking temperatures for various foodstuffs, but so far I've not found such a document. This doesn't mean one doesn't exist, it just means I haven't found it. I have found U.S. government documents — lots of them — specifying suggested or required temperatures that, at times, seem to conflict with each other. Consumer oriented, government documents assume a large degree of user error and thus suggest higher temperatures. Suggested cooking

temperatures in cookbooks often exceed the government requirements — attempting to err further on the side of safety, I assume.

The majority of these documents say to cook the piece of meat to a particular internal temperature. I have learned that these documents should be specifying two temperatures, not just one. The first temperature is the internal temperature that the piece of meat reaches in the oven. The second temperature is the internal temperature that the meat reaches after being removed from the oven, but before it is served. In order to achieve the best effect for roasting meats, it is necessary to let the meat "rest" outside of the oven. During this time, the temperature in the middle of the meat will continue to rise while the temperature at the surface



begins to fall. The heat at the surface will continue to move into the piece of meat, as well as into the surrounding environment. The preceding graph shows the surface temperature and internal temperature of a pork loin as it is cooked. When the roast is removed from refrigeration and placed in the oven, the meat is at a uniform temperature. As one would expect, the surface of the meat cooks faster than the center. When removed from the oven, the surface begins to cool while the center of the piece of meat continues to increase in heat until there is no residual heat differential. At this point the meat in the center starts to cool, too.

I have been told that the general practice should be that the bigger the piece of meat, the lower the oven temperature and the longer the resting time, but in France, I have only observed ovens being used in the range of 210 to 230 °C — that's 410 to 446°F. The U.S. government\* specifies a minimum oven temperature and a minimum time that the meat must be held at its maximum temperature. The minimum oven temperatures are shown in the table on the following page.

Minimum hold time — the time that a piece of meat must be at or above a certain temperature — is illustrated in the following graph. Note that the holding time may include both time in the oven and post oven heat rise. Based on the graph, a piece of meat must be at or above 140°F (60°C) for 12 minutes, 145°F (63°C) for 4 minutes, and 150°F (66°C) for about a minute.

\* Food Code, 2001 Recommendations of the United States Public Health Service, Food and Drug Administration, National Technical Information Service Publication PB-2002-100819, § 3-401.11 ¶ (B).

Oven type	Min. oven temperature based on roast weight	
	Less than 4.5kg(10lb)	4.5kg(10lb) or more
Still, dry (conventional)	177°C (350°F)	121°C (250°F)
Convection	163°C (325°F)	121°C (250°F)
High humidity*	121°C (250°F)	121°C (250°F)

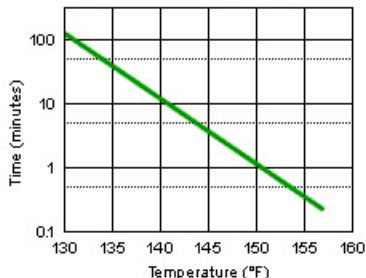
\* Relative humidity greater than 90% for at least 1 hour as measured in the cooking chamber or exit of the oven; or in a moisture-impermeable bag that provides 100% humidity.

Working with the above information and knowing that the center temperature of the roast will continue to rise after it is removed from the oven, it is possible to see how the center of a roast removed from the oven at 130°F and allowed to rest for 10 to 15 minutes, can easily be at 145°F or above for 4 minutes and thus be "safe" to eat.

Other food guides, such as the *Codex Alimentarius*,\* simply state: "The time and temperature of cooking should be sufficient to ensure the destruction of non-sporing pathogenic micro-organisms."

\* The Code of Hygienic Practice for Precooked and Cooked Foods in Mass Catering, Codex Alimentarius, CAC/RCP 39-1993, World Health Organization, 1993, §7 ¶ 7.5.1.

Minimum Safe "Hold" Time vs. Maximum Attained Temperature in Roasted Meats



It is not uncommon to brown some cuts of meat on top of the stove before placing them in the oven. This process ensures that the outer surface of the meat is browned and its surface temperature exceeds 63°C (145°F). Cooked in this manner, "raw or undercooked whole-muscle, intact beef steak may be served."\* In other words, the meat can be cooked on the surface and raw in the center.

\* Food Code, 2001 Recommendations of the United States Public Health Service, Food and Drug Administration, National Technical Information Service Publication PB-2002-100819, §3-401.11 (C)

Unfortunately, the publication referenced provides less detail for the safe cooking of poultry and fish. It states that poultry should be cooked to 74°C (165°F) or above for 15 seconds, but no differentiation is made between just cooking pieces of the bird or the whole carcass. It states that fish should be cooked to 63°C (145°F) or above for 15 seconds. In other U.S. government publications written for the consumer, the proper cooking temperature for poultry is often given as 82°C (180°F) and for fish, the advice is to cook the fish until it easily "flakes," *i.e.*, falls apart.

As one who believes that life is full of risks, I have to admit that I often do not cook food, especially fish and poultry to the temperatures recommended by my government. I place a high degree of faith in my suppliers — that they will provide me with food products that are reasonably free of bacterial and parasitic contamination. I also place more emphasis on cooking a piece of meat to the point to which it is tender, juicy, and flavorful than I place on following the government's advice — advice that is often based as much on politics as it is on physical reality.

During a recent period I decided to monitor the temperatures that I used for various meats during cooking. The results are listed in the following table. One of two methods were used for the cooking. In some cases, the portion being cooked was placed directly on a baking sheet or roasting pan, seasoned, and cooked in a 425°F (215°C) oven. In other cases, the portion was first browned in a frying pan in either butter or olive oil or a combination of the two. The frying pan was then placed in a 425°F (215°C) oven to finish the cooking. In each case, the first temperature listed is the temperature measured in the middle of the thickest part of the cut when removed from the oven. The second

Roll cursor over item description in list to display a picture of the item.

Description and approximate weight (grams)	Cooking time in a 425°F (220°C) oven (minutes)	Internal temperature at removal from oven (°F / °C)	Surface temperature at removal from oven (°F / °C)	Time to reach maximum internal temperature (minutes)	Maximum internal temperature achieved (°F / °C)
<i>pavé de saumon</i> 225	15	110 / 43	151 / 66	10	136 / 58
<i>filet de porc</i> 400	27	125 / 52	157 / 69	13	147 / 64
<i>pavé de rumsteck</i> 450	18	115 / 46	135 / 57	8	140 / 60
<i>blanc de volaille*</i> 220	10	135 / 57	150 / 66	9	163 / 73
<i>filet mignon de dinde</i> 450	31	135 / 57	161 / 72	11	150 / 66
<i>gigot d'agneau</i> 450	35	125 / 52	155 / 68†	12	145 / 63

\* Oven time includes browning in oil in a very hot frying pan for one minute before placing in oven.

† Surface temperature of meat. Surface temperature of fat was 190°F (88°C).

temperature is the surface temperature measured at the same time. The piece of meat, fish, or poultry is then transferred to a plate, covered with aluminum foil, and allowed to rest for about 10 minutes. The internal temperature is then monitored continuously until it no longer is rising.

These temperatures and times have been developed through experience in my kitchen and do not represent any statement of safe cooking. Each person has to make his or her own decisions in that regard. Remember that individual variations in size, weight, configuration, fat content, and oven temperatures and type will cause variations in cooking time. For that reason I find that cooking to specific temperatures yield a more consistent result and reliable outcome.

But what about safety? If *salmonella enteritidis*, *campylobacter jejuni*, *escherichia coli* 0157:H7, and *listeria monocytogenes*, the most important food borne pathogens\* in the United States, are your only concern then overcooking may be your best course of action. But if flavor and texture are important to you, proper food handling along with reasonable cooking methods may provide sufficient, if not absolute safety. Section 3.1 of *Kinetics of Microbial Inactivation for Alternative Food Processing Technologies*† lays out the conditions under which the pathogens

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\* Healthy People 2000 Food Safety Objectives, U. S. Food and Drug Administration, 1998.

† Kinetics of Microbial Inactivation for Alternative Food Processing Technologies, Center for Food Safety and Applied Nutrition, U. S. Food and Drug Administration, June 2, 2002.

become inactive. In brief, all of these pathogens can be inactivated by heat. The conditions listed are as follows:

- Salmonella: "considered to be sensitive to heat and is killed easily by pasteurization of milk equivalent to 71.7°C (161°F) for 15 seconds."
- Campylobacter jejuni: "extremely sensitive to heat and ... inactivated at temperatures as low as 55°C (131°F)."
- Escherichia coli: "inactivation of this bacterium is best accomplished by ... adequate cooking of all meat products to a center point temperature of 165 to 180°F (74 to 82°C)."
- Listeria monocytogenes: "heating equivalent to milk pasteurization (71.7°C [161°F] for 15 seconds) or heating to 62.8 °C [145°F] for 30 minutes or above should inactivate the microorganism in milk or other foods."

Often, the point of introduction of these pathogens is during the slaughter and processing of meat. Still, it is up to the consumer to ensure that meat and seafood are stored properly before cooking, *i.e.*, below 5°C (41°F). When the cooking time arrives, the item being cooked should be moved quickly from the refrigerator to the heat.

The ultimate internal temperature reached during cooking for proper taste and texture may, in the end, be below that required to deactivate all the possible pathogens. This is a risk that each cook must decide whether to take or not.