

Meat and Fabrication-Room Temperatures for Food Safety

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Guidelines are suggested for controlling temperature of meat and meat products in fabrication rooms so as to prevent detrimental growth of meat-borne pathogens.

Common Foodborne Pathogens Associated with Meat and Meat Products

Within the last 20 years, several meat-borne pathogenic microorganisms have emerged in the United States, causing numerous outbreaks of disease and death, as well as drastic economical losses. The more common pathogenic bacteria associated with meat-borne illness are *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Salmonella* spp., and *Campylobacter* spp. Two major sources of these pathogens in meat and meat products include the living animal carrying pathogenic bacteria, and the processing environment which harbors them.

Among the above-mentioned pathogens, *E. coli* O157:H7 is a major concern in beef slaughter and fabrication operations. Recent data indicates that while ground beef is implicated in *E. coli* O157:H7 outbreaks, other sources, such as produce, person-to-person transmission and contact with animals at petting zoos and state and county fairs are also significant sources of illness. Cattle are a reservoir of *E. coli* O157:H7.

In slaughter operations, *E. coli* O157:H7 originating from the animal may contaminate the carcass, and thus, the chilled meats or trim intended for ground beef. Limiting contamination, preventing growth during fabrication and subsequent inactivation of pathogenic bacteria, such as *E. coli* O157:H7, during thermal processing or cooking are fundamental to ensuring the safety of meat and meat products.

Typical Conditions Conducive to Microbial Growth in Meat and Meat Products

Meat is a nutrient-rich medium that offers ideal conditions for microbial growth. However, extrinsic factors such as temperature, time, and oxygen availability determine the rate at which bacteria grow in the meat. *Listeria monocytogenes*, a psychrotrophic microorganism, can grow at a relatively fast rate at refrigeration temperatures (below 50°F). Other meat-borne pathogens such as *E. coli* O157:H7 and *Salmonella* spp. grow at significantly lower rates at such low temperatures.

Table 1 presents some important time-temperature relationships that affect growth of some of the meat-borne pathogens of concern. *Table 1* introduces the term “lag time,” which is the time period in which bacterial cells adjust their physiology to the environment. Consequently, bacterial growth is restricted during this phase. Therefore, a fundamental concept to ensure the safety and extend the shelf life of meat and meat products is to either prevent the growth of pathogens or spoilage organisms or to increase the lag time of pathogenic bacteria to as long as possible. In most cases, this is normally achieved by the use of low processing and storage temperatures.

As shown in *Table 1*, lag time decreases with increasing temperature. In fabrication rooms where the air temperature is above the temperature of carcasses, warming of the meat surface will occur. The rate of surface warming depends largely on the temperature and velocity of air in the fabrication room. Generally, the larger the difference between the air temperature and meat temperature, the sooner the temperature of the meat surfaces will increase and the shorter the lag time.

For example, *Figure 1* shows the predicted surface temperature of chilled beef eye of round (semitendinosus muscle) samples, of different sizes exposed to different room temperatures during fabrication into meat cuts. A finite cylinder model represented beef eye of round. Various dimensions and hence, the weights of the beef eye of round were considered

Table I. Time/temperature relationships affecting the growth of meat-borne pathogens¹.

| Pathogens | Maximum Growth Temperature | Minimum Growth Temperature | Optimum Growth Temperature | Lag Time | | | |
|--|----------------------------|----------------------------|----------------------------|-----------|--------|--------|-------|
| | | | | 40°F | 50°F | 60°F | 70°F |
| <i>E. coli</i> O157:H7 (aerobic growth) ² | 113°F | 44°F | 98.6°F | no growth | 55.4 h | 15.6 h | 5.9 h |
| <i>E. coli</i> O157:H7 (anaerobic growth) ³ | 113°F | 44°F | 98.6°F | no growth | 37.9 h | 11.4 h | 4.8 h |
| <i>L. monocytogenes</i> (aerobic growth) | 113-122°F | 34°F | 86-98.6°F | 72.5 h | 29.4 h | 13.2 h | 6.7 h |
| <i>L. monocytogenes</i> (anaerobic growth) | 113-122°F | 34°F | 86-98.6°F | 58.9 h | 22.3 h | 10.1 h | 5.6 h |
| <i>Salmonella</i> spp. (aerobic growth) | 128°F | 44°F | 98.6°F | no growth | 61.9 h | 15.0 h | 6.0 h |

¹Lag Time values were reported at a pH value typical for aged meat (pH = 5.8 – 6.2); from USDA-ARS Pathogen Modeling Program (PMP).

²Aerobic growth can be found when meat is exposed directly to air or covered with a plastic film wrapping.

³Anaerobic growth can be found when meat is vacuum packaged or modified atmosphere packaged.

to determine the surface temperature rise. Average weight and dimensions of these cylinder-shaped samples were: 5.2 lb, 3.8 in diameter and 12.2 in length. As seen in *Figure 1*, room temperature has a significant effect on the rate of increase of surface temperature of the meat cuts. If a meat sample was exposed to a room temperature of 80°F, it would take only 45 minutes to increase the surface temperature of the meat from the initial temperature of 34°F to 50°F. If the room temperatures were 75°F and 70°F, the times increased to 62 minutes and 88 minutes, respectively.

The size and shape of the meat also have significant

effects on the rate of increase of meat surface temperature. Generally, for a piece of meat, the larger the piece, the longer it takes to attain a surface temperature of 50°F (shown by different lines in *Figure 1*).

Similarly, *Figures 2* and *3* illustrate the rate of surface temperature rise from 38°F to 50°F and from 42°F to 50°F, respectively. If the same eye of round considered in *Figure 1* was subjected to a room temperature of 80°F, within 29 minutes, the surface temperature of the meat rises from 38°F to 50°F. Similarly, only 15 minutes will be required for the meat surface to warm from 42°F to 50°F when subjected to a room temperature of 80°F.

Therefore, it is hazardous to expose or store cut meat pieces in a warm fabrication room for a long time before chilled storage or transportation.

Figures 4 and *5* illustrate the effect of time and shape on the surface temperature of T-bone steaks under typical meat fabrication environments. A sequence of surface temperature profiles is provided to help visualize the variation in surface temperature for meat cuts and contrast how smaller cuts warm faster than larger cuts. As can be seen in *Figures 4a-f* and *5a-f*, portions of the surface temperature of a T-bone steak can increase from 37°F to 50°F in 36 minutes at an air temperature of 77°F. Therefore, fabrication of meat cuts in rooms with warm temperatures (e.g., 60-95°F) needs to occur more rapidly than in chilled fabrication rooms as pathogen growth is faster at warmer temperatures. Placement of fabricated meat cuts in refrigerated storage should also occur more rapidly for meat cuts prepared in rooms with elevated temperatures than for meat cuts prepared in rooms with chilled air temperatures.

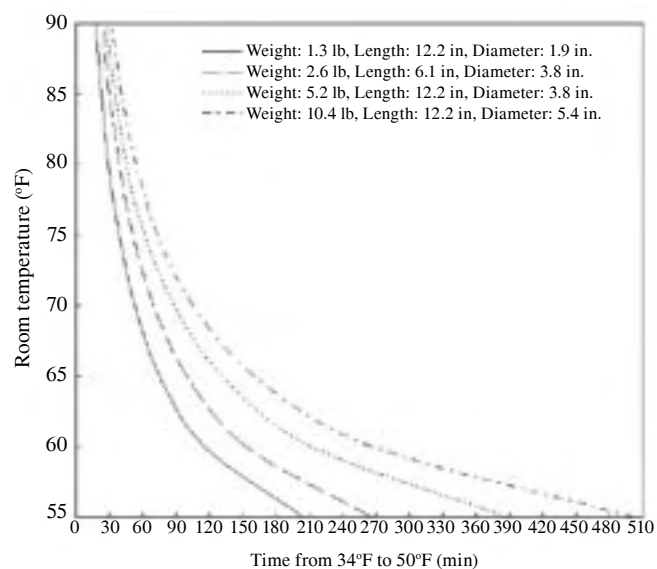


Figure 1. Effects of room temperature and size of beef eye of round on the rate of increase of meat surface temperature from 34°F to 50°F.

Good Fabrication Room Practices

The time required for fabrication of meat cuts, temperature and velocity of air in the fabrication room, and size and shape

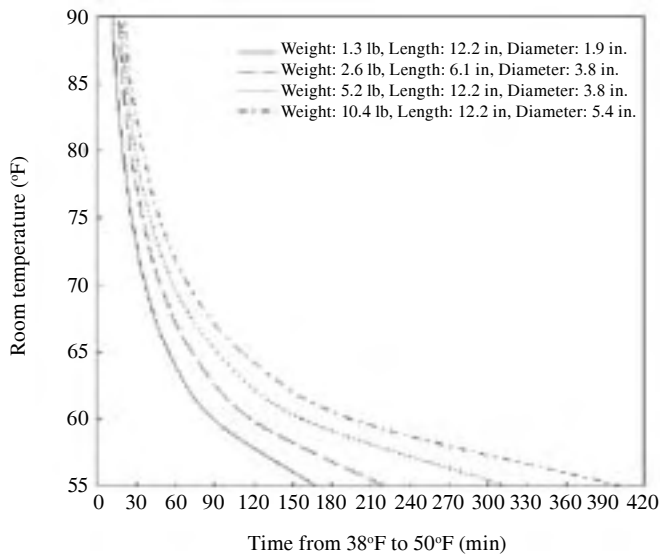


Figure 2. Effects of room temperature and size of beef eye of round on the rate of increase of meat surface temperature from 38°F to 50°F.

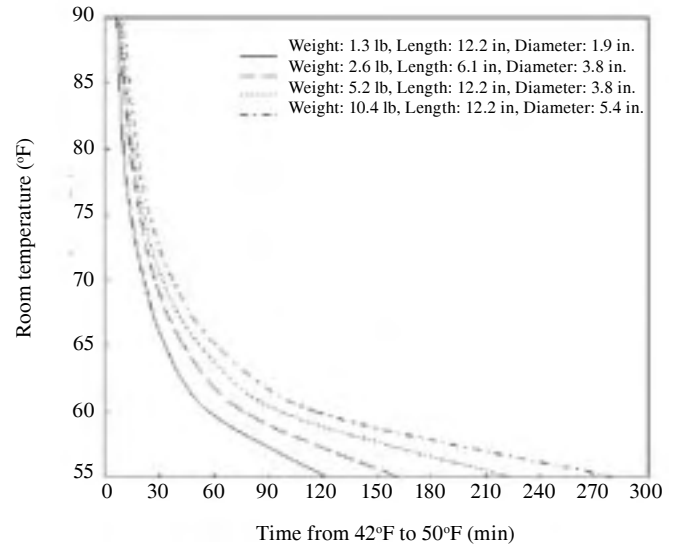


Figure 3. Effects of room temperature and size of beef eye of round on the rate of increase of meat surface temperature from 42°F to 50°F.

of the meat cuts will influence surface temperature of the cuts and lag time of microorganisms. The following guidelines are suggested as good manufacturing practices for controlling meat temperature. Processors will need to record actual meat surface temperatures for HACCP and also enhance their sanitation practices to fabricate meat in processing rooms without refrigeration for lowering air temperature.

1. Cold-storage room temperatures and the shortest time in the processing room are very important when meat has to be fabricated in processing rooms without refrigeration. Our prediction models indicate the following storage/meat temperatures and fabrication times should be considered.
 - a. Temperatures for carcasses and large subprimal cuts (> 5 lb) should be maintained below 40°F when warmer processing room temperatures are used. This will allow processors to fabricate in room temperatures of 60°F or less for approximately two hours before the meat needs to be returned to refrigeration.
 - b. Reducing the storage temperatures for carcasses and subprimals to 34°F or less will allow for fabrication room temperatures to be 70°F or less with fabrication times of up to two hours before the meat needs to be returned to refrigeration.

- c. Fabrication-room temperatures greater than 70°F require carcasses and large subprimals or meat be fabricated and moved back to refrigeration in one hour or less. In addition, frequent sanitation of food contact surfaces will be necessary.

2. Avoid single layers of steaks or roasts to prevent fast surface temperature rise on the meat products.
3. Lean trimmings for ground beef have a large surface area to volume ratio and will increase in temperature rapidly. Lean trimmings should be collected in tubs and returned to refrigerated storage more rapidly than steaks and roasts.
4. Fabrication tables and processing equipment will be chilled by constant contact with chilled meat; however, with warm processing-room temperatures, processors should plan for more frequent cleaning and sanitation of surfaces that come in contact with food.
5. Processors can use the temperature curves in this document to assist with establishment of standard operating procedures for their facility. The development of Critical Limits and Monitoring procedures for HACCP Plans will require additional documentation and validation.

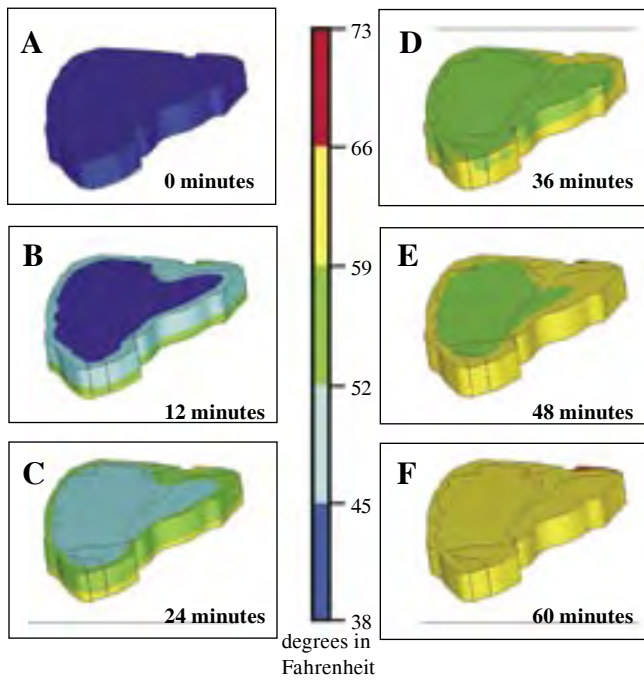


Figure 4. Effects of room temperature and stack height on the surface temperature of T-bone steaks where (a-f) depict 1 T-bone steak stored on a Teflon® surface (normal cutting board) at 77°F.

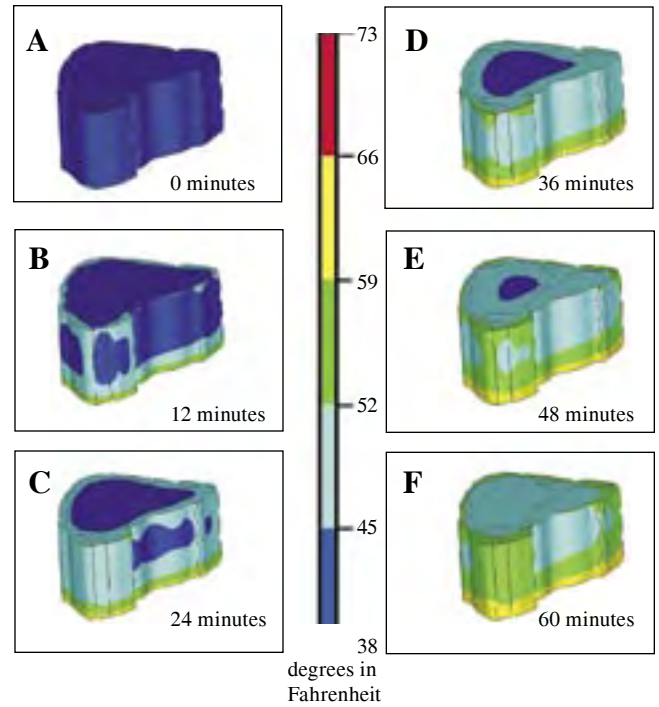


Figure 5. Effects of room temperature and stack height on the surface temperature of T-bone steaks where (a-f) depict a stack of 3 T-bone steaks stored on a Teflon® surface at 77°F.