COOKING HAMBURGERS ON A WEBER OUTDOOR GRILL
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Introduction
Historically, many of the hamburger *E. coli* incidents have occurred when fresh or frozen hamburgers were cooked on a family outdoor grill. The temperature of the grills is unpredictable, the thickness of the hamburgers vary, and a hamburger may be partially or fully frozen when cooking starts.

This study was conducted in order to identify the cooking time-temperature differences between fresh 4-oz. and 8-oz. hamburgers and frozen 4-oz. and 8-oz. hamburgers cooked on a Weber grill, outside, at the author's home.

Methods
A Weber grill, Silver model, was used for this experiment. It was set on a medium flame setting. It was allowed to reach a temperature of over 400ºF before the hamburgers were put on the grill. (See Figure 1, next page.) The hamburgers were made from 80% lean, 20% fat ground beef purchased from a grocery store the day prior to this study. They were formed at home in a 4-inch hamburger patty former. The 4-oz. patty was 1/2 inch thick, and the 8-oz. patty was 1 inch thick. One 4-oz. and one 8-oz. hamburger were frozen, and one 4-oz. and one 8-oz. hamburger remained fresh in the refrigerator, about 40ºF.

A Thermapen (ThermoWorks, Alpine, UT) thermocouple was used to measure temperature. The temperature was measured by pushing through the product. This is an important concept, because typically, a thermometer probe is merely stuck into the food by a cook, and the temperature is taken, which does not guarantee that the cold center temperature of the food is being measured. In order to accurately measure the center cold-spot temperature of hamburger, one must use a fast-update thermistor or thermocouple with a 0.040-inch, tip-sensitive probe. In the case of the hamburger, the hamburger is flipped, and the probe is pushed through the hamburger during a period of 3 or 4 seconds. When done correctly, one can see the hot temperature at the surface and, as the probe is pushed into the hamburger, the temperature goes down. As the probe passes through the cold spot, the temperature goes up again. There can be a difference of 20ºF within 1/8- or 3/16-inch penetration. Therefore, it is critically important that temperature not be taken with a stationary thermometer, but in a dynamic manner by pushing through the hamburger, so that a few *Salmonella* or *E. coli* in the middle of the hamburger are reduced to safe levels for children.

Solid steaks and chops are not as great a hazard, because there is virtually no chance of 100 *E. coli* being present in the center of a solid cut of meat. If one were cooking a solid piece of pork, beef, veal, etc., the only pathogen in the middle of the meat is probably a parasite, which dies quite easily at 140 to 145ºF. Furthermore, parasites are not a significant hazard, and the center temperature of solid meats is really not a critical problem.
Figure 2 shows the thermometer probing a 4-oz. hamburger. Figure 3 shows the thermometer taking a check temperature after the hamburger was removed from the grill and cut in half to see the color and check the final temperature. Figure 4 is a picture showing that a hamburger at 154°F is quite pink. Color depends very much on the pH of the beef. High-pH beef with a pH above 6.0 can be very pink at 155°F, compared with low-pH beef with a pH in the range of pH 5.7, which will be brown. If the home cook mixes any ingredients into a hamburger before cooking, such as onion, celery, mustard, etc., color is unpredictable, and a thermometer must be used.
Figure 5 shows the temperature of a cut 8-oz. hamburger and the red appearance of the hamburger. Figure 6 shows a fork-type thermistor thermometer being used to check the temperature of an 8-oz. hamburger. It is a slow thermometer for measuring temperature because of the big tips and must be used carefully to get an accurate reading. It is not recommended for the average home cook.

Results
Table 1 shows the cooking times and temperatures for the various hamburgers.

Table 1. Hamburger Cooking On Weber Grill, June 4, 2005

All hamburgers were 4 inches in diameter; 4 oz. were 1/2 thick; 8 oz. were 1" thick. They were 80/20 lean beef.

<table>
<thead>
<tr>
<th>Time (min.)</th>
<th>Temp, ºF</th>
<th>Time (min.)</th>
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<th>Time (min.)</th>
<th>Temp, ºF</th>
<th>Time (min.)</th>
<th>Temp, ºF</th>
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<td>0:00</td>
<td>30</td>
<td>0:00</td>
<td>45</td>
<td>0:00</td>
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<td></td>
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<td></td>
<td>5:18</td>
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<tr>
<td>Taken off grill</td>
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<td></td>
<td>9:00</td>
<td>Frozen core</td>
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<td></td>
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<td>12:20</td>
<td>156</td>
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<tr>
<td></td>
<td>7:00</td>
<td>100</td>
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<td>9:30</td>
<td>108</td>
<td>13:40</td>
<td>147</td>
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<td></td>
<td></td>
<td></td>
<td>Taken off grill</td>
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<tr>
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<td>18:00</td>
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<td>weight at start: 225 g</td>
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</table>
Figure 7 (next page) shows a graph of the times and temperatures for each of the four hamburgers. Note that it took about 5 minutes for the fresh 4-oz. hamburger to reach 150°F. It took about 11 minutes for the frozen 4-oz. hamburger to reach 150°F. It took about 14 minutes for the fresh 8-oz. hamburger to get to 150°F. It took almost 25 minutes for the frozen 8-oz. hamburger to get to 150°F. Note that inverted log paper is used to plot cooking, as done when plotting and calculating pasteurization and sterilization values. When cooking times and temperatures are plotted on log paper, the lines will tend to be straight. The apparent driving force-temperature for cooking is about 200°F, or the water temperature just under the surface of the hamburger.

Discussion
This experiment points out two basic problems. First, there is a dramatic difference in the time it takes a hamburger to cook, depending on its thickness and whether it is frozen or fresh. All of the hamburgers looked charred on the surface after a few minutes on the grill. Surface doneness, therefore, is no indication of center temperature. The only way one knows if a center temperature is hot enough to be pasteurized is to use a tip-sensitive thermistor or thermocouple thermometer.

Grilling on an outside grill at home is a very uncontrolled process normally done infrequently throughout the year, typically in the summer, and no hamburgers will be the same. The person cooking must use a tip-sensitive thermometer to assure safety. In a restaurant, all of the hamburgers are from the same source and are uniform in size. They go into the same cooking device every day. The cook cooks hundreds of hamburger, and so, the cook is very used to a standardized procedure that guarantees a sufficiently done hamburger, compared to a few hamburgers on a grill with unpredictable temperature at home. If after 3 days, approximately, the hamburger makes no one sick, this is a validated safe procedure in HACCP terms. As long as the cook repeats validated, safe procedures, the food is safe. Grilling at home during the summer is a completely different, high-risk event.

The frozen 4-oz. hamburger took about three times as long to cook as the fresh 4-oz. hamburger. The frozen 8-oz. hamburger took about twice as long to cook as the fresh 8-oz. hamburger. No one can predict the safety of a hamburger cooked on an outdoor grill if one does not use a proper thermometer.

Perhaps 0.1 to 1% of all commercial hamburger contains E. coli at a level that could be dangerous to a child's health. Therefore, it is particularly important that when someone at home cooks hamburgers for young children, especially on a grill, the center temperature of the hamburger be checked correctly by dynamic probing with a thin-tipped thermistor or thermocouple thermometer. An adequately cooked / pasteurized hamburger may still have a red appearance, even when pasteurized to a safe limit. As the USDA has pointed out, it can also be brown at 145°F if the beef has a low pH.

Summary
This study has shown the critical importance of using a thin-tipped thermistor or thermocouple thermometer, with a push-through procedure, to check temperatures and safety of hamburgers cooked on a home outdoor grill.
Figure 7.
Hamburger 80% / 20% cooking study data

COOKING STUDY DATA
Food item: Hamburger 80/20
Dimensions: 
Date: 6/4/2005  Time: 5pm
Description of the procedures: Cooking on Webber grill at Snyder's house

Clock Time (24 hours)  At h:m  Food Ctrl Temp.  Cooking Temp.  Other
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Center Food Temperature (°F)

Cooking Time (min)

Fresh 4 oz
Fresh 8 oz
Frozen 4 oz
Frozen 8 oz

Taken off the grill