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MEASURING THE TEMPERATURE OF HAMBURGER AS IT COOKS
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Introduction

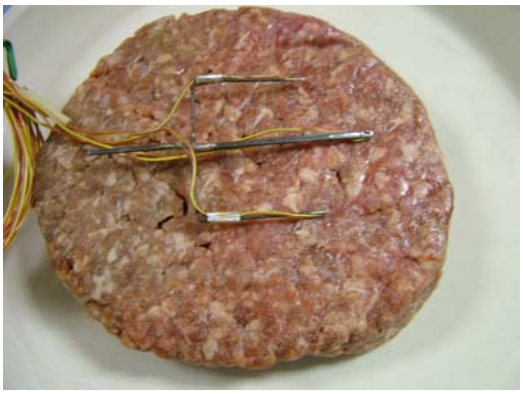
One of the more difficult cooking studies that must be done in a restaurant to validate a HACCP plan is taking the temperature of a hamburger as it cooks and then, compare a cooking curve to a survival curve of microorganisms (Juneja et al., 1997).

This research note reports on a very simple but reproducible method that can be done in a retail food operation for determining a hamburger center cooking temperature and validating a cooking process.

Method

Figure 1 shows a simple three-pronged in-food temperature-measuring device made of 0.020 stainless steel wire whereby 30-gauge type K chromal-aluminal thermocouples are soldered to the tips of the prongs in addition to the middle of the center prong (4 thermocouples). The stainless steel wire has very poor thermal conductivity, so, the wire really only functions to hold the thermocouple so that the fork can be pushed into thin food such as a hamburger, and the final position of the thermocouples will be known. The 1/2-inch-thick, 4-inch-diameter, 4-oz. hamburger in this experiment was made with 75% lean ground beef from a grocery store.

Figure 1. Three-pronged Temperature-measuring Device



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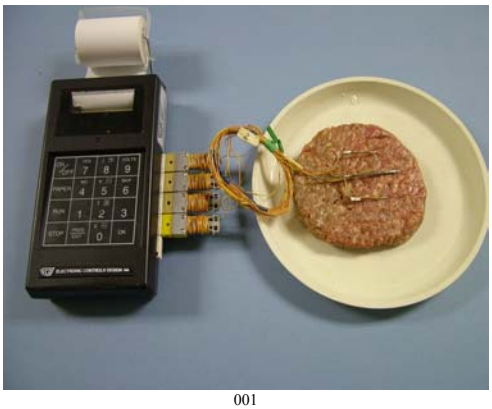
To read the voltage from the thermocouples, an ECD Model 50, four-channel data logger (Electronic Controls Design, Milwaukie, OR) was used to read and print the thermocouple temperatures as the hamburger cooked.

Figure 2 shows the data logger, the thermocouples plugged into the data logger, and the probe lying on top of the hamburger.

To insert the probe, it is put on a surface next to the hamburger and half as thick, and then, it is pushed into the hamburger.

Figure 2. Data Logger with Three-pronged Temperature-measuring Device



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Results

Table 1 shows the results of a typical hamburger cook whereby a 4-oz. hamburger, 1/2 inch in thickness and 4 inches in diameter, was cooked in a temperature-regulated electric fry pan at 325ºF.

Table 1. Hamburger Temperatures

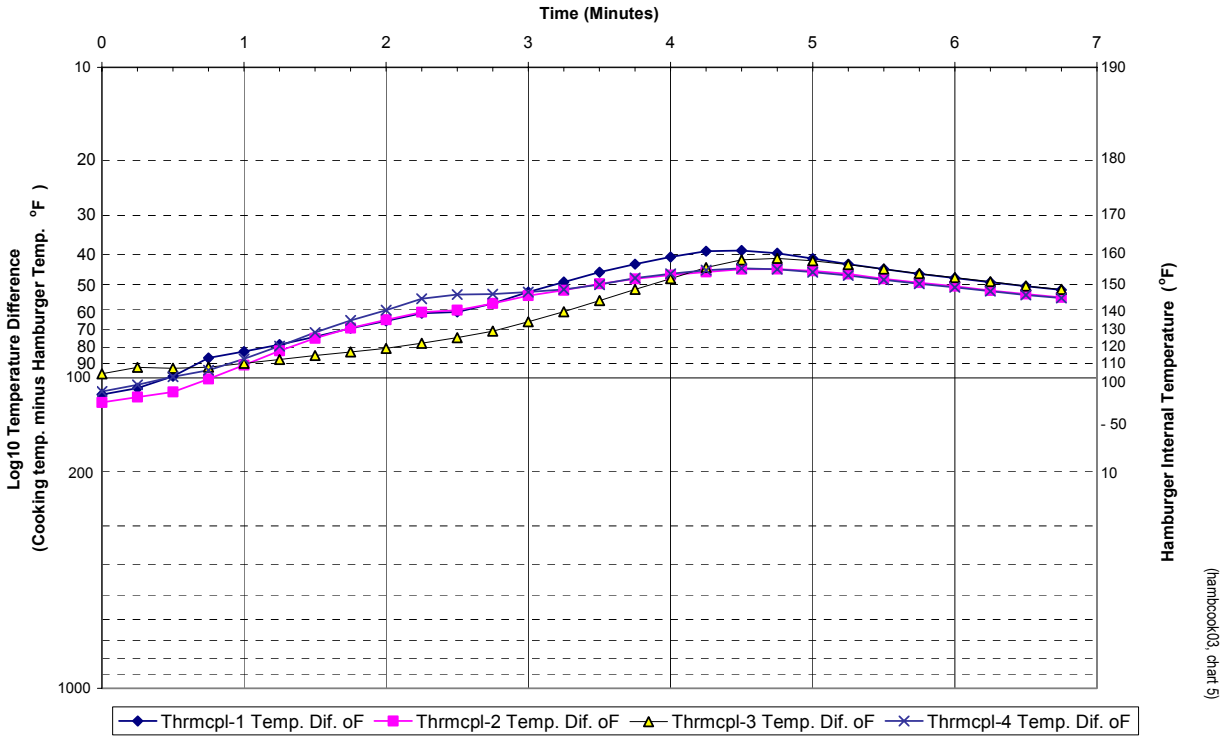
Cooking Time (min.)	Hamburger Temp. ºF	Thrmcpl-1 Temp. Dif. ΔtºF	Hamburger Temp. ºF	Thrmcpl-2 Temp. Dif. ΔtºF	Hamburger Temp. ºF	Thrmcpl-3 Temp. Dif. ΔtºF	Hamburger Temp. ºF	Thrmcpl-4 Temp. Dif. ΔtºF
0	86.8	113.2	80	120.0	102.9	97.1	89.4	110.6
0.25	92.0	108.0	84.6	115.4	107.5	92.5	94.7	105.3
0.5	101.1	98.9	89	111.0	106.8	93.2	100.9	99.1
0.75	113.7	86.3	99.1	100.9	107.7	92.3	105.5	94.5
1	117.8	82.2	109	91.0	110.2	89.8	113.1	86.9
1.25	121.9	78.1	118.1	81.9	112.7	87.3	121	79.0
1.5	126.3	73.7	125.4	74.6	115.3	84.7	128.6	71.4
1.75	130.8	69.2	130.9	69.1	117.5	82.5	134.7	65.3
2	134.5	65.5	135	65.0	119.7	80.3	139.5	60.5
2.25	138	62.0	138.6	61.4	122.6	77.4	144.4	55.6
2.5	138.7	61.3	139.5	60.5	125.8	74.2	146.1	53.9
2.75	142.4	57.6	142.4	57.6	129.3	70.7	146.3	53.7
3	147.1	52.9	145.6	54.4	134	66.0	147.1	52.9
3.25	150.9	49.1	147.8	52.2	138.8	61.2	148.1	51.9
3.5	154.3	45.7	150.2	49.8	143.6	56.4	149.9	50.1
3.75	157	43.0	152	48.0	148.1	51.9	152.3	47.7
4	159.2	40.8	153.3	46.7	152.1	47.9	153.8	46.2
4.25	160.9	39.1	154.4	45.6	155.9	44.1	155	45.0
4.5	161.1	38.9	155.3	44.7	158.3	41.7	155.6	44.4
4.75	160.3	39.7	155.4	44.6	158.8	41.2	155.3	44.7
5	158.7	41.3	154.8	45.2	158	42.0	154.3	45.7
5.25	157.0	43.0	153.7	46.3	156.8	43.2	153.2	46.8
5.5	155.4	44.6	152	48.0	155.4	44.6	151.7	48.3
5.75	153.7	46.3	150.6	49.4	153.9	46.1	150.2	49.8
6	152.3	47.7	149.3	50.7	152.5	47.5	148.9	51.1
6.25	150.8	49.2	147.7	52.3	151	49.0	147.4	52.6
6.5	149.3	50.7	146.3	53.7	149.4	50.6	145.9	54.1
6.75	147.9	52.1	144.9	55.1	148.1	51.9	144.6	55.4

(hambcook03, sheet 4)

ΔtºF = the temperature difference between the food temperature and driving force temperature, which, in this case, is about 200ºF

Figure 3 shows a semi-log graph of a typical cook curve.

Figure 3. Hamburger Cooking Curve



If the data are plotted as the difference in temperature between the hamburger and the driving force, as is done in canning, on an inverted semi-log chart, the cook line becomes virtually a straight line. All of the well-defined calculations associated with determining bacterial lethality in canning sterilization can be applied to food pasteurization cooking in retail food operations.

The driving force temperature must be chosen carefully in order to plot the difference in temperature. The driving force is the interface of the hot water in the food product as it boils just below the surface of the hamburger cooking on the griddle. The actual temperature is slightly below the boiling point and is about 200ºF. The temperature of the griddle is mostly associated with the color of the hamburger after it finishes cooking to 155ºF rather than the speed at which the hamburger cooks. Depending on the griddle temperature, this water cooking interface varies between 190 and 200ºF. This temperature difference has a very moderate effect on the time it takes a hamburger to cook on the griddle, but has a large effect on the color of the surface of the hamburger at the completion of cooking.

In this experiment, the hamburger was cooked at about 4.25 minutes, at which time it was taken from the griddle. As the data show, it did not change temperature for about 30 seconds; then, it slowly began to cool. During the next 2.25 minutes, the hamburger, sitting on a plastic plate, decreased in temperature from 160 to about 145ºF. This would be more than sufficient integrated lethality for thorough pasteurization of the meat.

Discussion and Conclusion

This simple experiment shows a method for accurately measuring the temperature of a hamburger subjected to a specified cooking process. It shows a simple way to build a small thermocouple temperature-measuring device that will allow accurate placement of thermocouples in a hamburger so that reproducible results can be obtained in hamburger cooking studies. These results can then be compared with microbiological kill measurements in order to validate in a food operation a cooking (pasteurization) process as capable of reducing pathogens to a tolerable level.

References:

Juneja, V.K., Snyder, O.P., Williams, A.C., and Marmer, B.S. 1997. Thermal destruction of *Escherichia coli* O157:H7 in hamburger. J. Food Prot. 60(10):1163-1166.