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Food Safety Validation Study of the Effect of CVap Oven Cooking and Holding Procedures on the Reduction of *Salmonella* and in the Prevention of *Clostridium perfringens* Growth in Boneless Beef Rib Roast

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ABSTRACT

The FDA Food Code 2005 (3) roast meat cooking guidelines were used to evaluate a CVap oven (Model CAC507) processing procedure for cooking and holding six (13 to 14 lb) boneless beef rib roasts. The safety of the CVap oven-processing (cooking) procedure was based on 1) reduction of a *Salmonella* inoculum on the surface and center of beef; and 2) preventing the growth of *Clostridium perfringens* in likewise inoculated roasts. The effect of a cooling and reheating procedure on presence and growth of *C. perfringens* in inoculated product was also evaluated.

The 6-hour cooking process of large beef roasts in the CVap oven is a very safe process and meets scientific and regulatory requirements. *Salmonella* on the surface of the meat was destroyed, and the meat is safe to use at the end of 6 hours. The center temperature of the meat was always lower than the temperature of the oven by a few degrees that affected the inactivation of the *Salmonella*. This showed that meat cooking time should be based on the probe center temperature of the meat, and not on oven temperatures.

When all parts of roasts are cooked to 130°F for 112 minutes, *Salmonella* is not a food safety concern in meat that is cooked in the CVap oven. At the end of the 6-hour cook cycles, the oven effectively reduced *Salmonella* on the surface greater than 8 logs and in the center of the roasts, almost 6 logs. Vegetative cells of other bacterial pathogens would also be expected to be reduced to a safe level at the end of the 130°F – 6-hour cook cycle.

Clostridium perfringens was also controlled by the oven. At the end of cooking and then post-cook-hold at 130°F, the meat temperature was at 120°F to 125-128°F, and there was a slight increase in the count of *C. perfringens*, showing spore germination and vegetative cell growth. Vegetative cells are heat sensitive; so, at 130°F during post cook-sell-hold, *C. perfringens* was reduced to an undetectable level. However, there were still some spores remaining, because during post-cook-chill-hold and retherm, a small number of *C. perfringens* reappeared. This situation indicated that the safest handling of cooked roast beef is not to cool leftovers and reheat, but to simply keep beef hot (above 130°F).

PURPOSE

The purpose of this study was to compare FDA Food Code 2005 (3) roast meat cooking guidelines to CVap oven processing procedures. To validate the safety of CVap oven-processing (cooking) procedures: 1) reduction of a *Salmonella* inoculum on the surface and center of beef roasts was measured; and 2) preventing the growth of *C. perfringens* in likewise inoculated roasts and the effect of a cooling and reheating procedure on presence and growth of *C. perfringens* in inoculated product was also evaluated. Laboratory research was conducted by ABC Research Corp., Gainesville, FL.

EXPERIMENTAL PROCEDURE

Equipment and Product

A CVap oven (Model CAC507) was used to cook and hold six (13 to 14 lb) boneless beef rib roasts. Detailed operating instructions for the CVap oven were provided pertinent to the cooking and holding procedures used in this experiment. The beef rib roasts (USDA Good Grade) were procured from a local distributor for the project. The beef roasts were stored at 32 to 34°F until used in the experiment (within 3 to 7 days of procurement).

Test Microorganisms

Three strains of *Salmonella* were used in this study: *Salmonella* serotype *enteritidis* (ATCC 13076), *Salmonella* serotype *typhimurium* (ATCC 14028), and *Salmonella* serotype *montevideo* (ATCC 8387). All of these *Salmonella* strains are derived from clinical or animal sources and are commonly used in process validation studies with meat and poultry products. Each *Salmonella* strain was grown separately via at least 2 serial transfers at 35°C for 24 h in Tryptic Soy broth (TSB). Bacterial cells for each culture were harvested by centrifugation at 10,000 x g for 10 min. and washed with Butterfield's Phosphate Buffer, pH 7.2 (BPB). Each strain was then resuspended, concentrated, and combined in BPB to obtain a final cocktail suspension containing an equal concentration of each strain (i.e., ca. 10^{10} CFU/ml) to inoculate the product.

Three strains of *Clostridium perfringens* were used in this study: NCTC 8238 (ATCC 12916), NCTC 8239 (ATCC 12917), and NCTC 10240 (ATCC 14810). These strains are commonly used in cooking and cooling process validation studies with meat and poultry products. Each strain was individually cultured in fresh Fluid Thioglycollate broth and then transferred to (and individually cultured in) a medium designed to promote the maximum formation of spores (3). Spores from each culture were harvested by centrifugation at 10,000 x g for 10 min. and the pellets re-suspended in sterile distilled water and stored at 35 to 38ºF. Aliquots of the spore suspensions were combined to prepare a final working (cocktail) suspension containing an approximately equal number of spores of each strain (i.e., ca. 10,000 CFU/ml) to inoculate the product. The final working suspension was heat shocked (i.e., 20 min. at 75°C and immediately cooled to 4°C) just prior to inoculation to ensure that only spores were present. The final working suspension was enumerated on appropriate media.

Sample Inoculation and Preparation

Internal Inoculation. The boneless beef rib roasts were internally inoculated with the *C. perfringens* spore cocktail or the *Salmonella* cocktail using the dialysis tubing technique for containment of microbial populations inoculated into food systems (4, 11). Approximately 300 g of the raw product (beef roast) was minced/ground, inoculated with ca. 30 ml of *C. perfringens* spore cocktail, and very thoroughly mixed. Another ca. 300-g portion of raw product was minced/ground, inoculated with 3.0 ml of the *Salmonella* cocktail inoculum, and very thoroughly mixed. The respective inoculated product portions consequently had ca. 5 x 10^3 CFU/g of *C. perfringens* and ca. 2 x 10^8 CFU/g of *Salmonella*. For each pathogen, three 10-to-15 g aliquots of the inoculated minced product were microbiologically analyzed to establish "time-0" (initial) counts.

For *C. perfringens*, the remaining inoculated minced product was portioned into at least 18 sample aliquots (ca. 10 g each) that were each placed into moistened 20.4 mm diameter dialysis tubing (Spectrum) segments. For *Salmonella*, the remaining inoculated minced product was portioned into at least 9 sample aliquots (ca. 10 g each) that were each placed into moistened 20.4 mm diameter dialysis tubing (Spectrum) segments. The dialysis segments were closed at each end with thread resulting in a small tube (ca. 3 to 4 cm long) of inoculated product. The dialysis sample units were marked (e.g., color coded) to differentiate the *Salmonella* and the *C. perfringens* inocula. The dialysis sample units were kept refrigerated until insertion into the roasts and/or prior to beginning the cook.

Three roast samples were each internally inoculated with 3 *Salmonella* and 3 *C. perfringens* dialysis sample units just prior to external inoculation and/or cooking. Three additional roasts were each internally inoculated with 3 *C. perfringens* dialysis sample units just prior to cooking. For internal inoculation of the roasts, a small incision was made into the geometric center of the roast. The designated dialysis sample units were carefully inserted through the incision and placed at the approximate geometric center of the product. The incision was closed via filling with product as indicated before proceeding with cooking. The inoculated roast samples were held under refrigeration (ca. 40°F) until being cooked.

Surface Inoculation. Just prior to cooking, roast surfaces were inoculated with Salmonellae in the following manner. Three representative surface sites (10 cm^2) on each of the 3 roasts (previously inoculated internally with *Salmonella and C. perfringens*) were inoculated with 0.1 ml of the *Salmonella* suspension in 0.01 ml droplets. The inoculated surface sites were marked to aid in tracking the sites in subsequent microbial analyses. This inoculum technique delivered ca. 10^9 CFU/ cm_2 to the designated inoculation site. For time-0 (initial) counts, three representative surface sites (10 cm^2) on another roast (not internally inoculated and not subsequently cooked) were likewise inoculated. After surface inoculation, the roast samples were held refrigerated for at least 30 min. to allow for bacterial attachment and consistent temperature equilibration prior to sampling (i.e., time-0) or cooking.

Product Processing and Sampling

Experimental Cooling Cycle Development. Prior to performing the study using inoculated beef roasts, cooling procedures were developed to cool uninoculated roasts in a refrigerator according to the cooling curves (i.e., from 130 to 41°F in 15 to 24 h) provided by the author. These cooling times were chosen to be representative of cooling food items in typical retail food establishment refrigeration units with an air temperature of 38±2°F and air flow of 50 feet per minute. These cooling times are sufficient for the growth of *C. perfringens.*

For this experiment, two roasts were fitted with thermocouples (TCs) at their geometric center, heated in the CVap oven to a center temperature of 130°F (per steps 2, 3, and 4 as described below), and placed in a refrigerator/incubator set at 38°F (with an airflow to allow slow cooling). The roasts were placed in pans for cooling and one of the roasts was covered with aluminum foil. The cooling data was reviewed to determine whether the designated cooling rate has been met with one of the roasts. The preliminary cooling trials indicated that cooling the roasts without a foil cover would provide a cooling rate within the desired ranges as described in the previous paragraph.

Inoculated Study and Physical Data Recording. For the inoculated experiment, each of the six inoculated roasts was fitted with two TCs (i.e., one internal TC at the geometric center and a second TC at ca. 1/16 inches below the surface) for a total of 12 TCs. Internal and (near) surface temperatures of the designated roasts were monitored and recorded (e.g., 5-min. intervals) throughout the cooking, holding, cooling, and reheating procedures as described below. Care was taken in placing the internal TCs adjacent to the inoculated dialysis units.

The temperature and humidity in the CVap oven was electronically monitored/recorded (e.g., 5- or 10-min. intervals) during all processing steps using type K thermocouples, an Omega OMB-DAQ-55 USB data acquisition system with a OMB-PDQ1 expansion module and a humidity probe (Global Sensors' Humidity Logger DW-HS-B-16). The temperature in the refrigerator/incubator was also electronically monitored and recorded during the experimental cooling cycle and subsequent refrigerated hold step. Also, the temperature and humidity display readings on the CVap oven were manually recorded at approximately 1-hour intervals and whenever samples were collected during processing (i.e., initial cook-hold and the "retherm"). Additionally, one roast was fitted with an internal temperature probe that was integral with the CVap oven for manual recordings.

The processing and sampling steps for the beef roasts are summarized in the following table.

Procedures/Processing Steps	Sample Set	Inoculated Sample Testing	
		Salmonella	***C. perfringens***
1. Time-0: -Inoculate 7 roasts (1 roast surface w\ only *Salmonella* for time-0; 3 roasts internally & externally w\ *Salmonella* plus internally w\ *C. perfringens;* 3 roasts internally w\ only *C. perfringens*). -Set up the 6 inoculated roasts going into the oven w\ thermocouples. -Sample inoculated roast surface for *Salmonella* and inoculated minced beef samples for respective pathogen.	1) time-0 samples	3 minced 3 surface (roast)	3 minced
2. Preheat CVap oven to 130ºF+5 (170ºF cabinet temperature).	**n/a**	**n/a**	**n/a**
3. Load oven with the 6 inoculated roasts (each w\ 2 TCs). Put 3 roasts on 18"x26" sheet pans on the bottom oven rack, and 3 roasts on the pan on the middle rack in the oven. Set the oven to 130ºF-Doneness (holding) and 5-Browning (170ºF cabinet temperature) and cook time at 6 h. Set hot holding time after cook at 28 h.	**n/a**	**n/a**	**n/a**
4. Cook for 6 h to give a center temperature (CT) of 130ºF. After 6 h cook, remove 1 roast (inoculated w\ both pathogens) for sampling.	2) post-cook roast	3 internal /dialysis 3 surface	3 internal/dialysis
5. Hot hold #1: After 6 h cook, the oven was changed to 130ºF-Doneness and +1 (or cabinet temperature of 131ºF). This held the beef at CT of 130ºF for 121 min. and a surface temperature of 131ºF @ 90% humidity, to meet the FDA 6.5-log *Salmonella* reduction requirement. After this hot-hold step (i.e., 8 h & 1 min. after start of cook), remove 1 roast (inoculated w\ both pathogens) for sampling.	3) post-hot-hold #1 roast	3 internal/dialysis 3 surface	3 internal/dialysis
6. Hot hold #2: Continue to hot-hold at 130ºF (Doneness) CT + 1 cabinet temperature (131ºF, 90% humidity) for ca. 28 h more. After this hot-hold step (i.e., 36 h after start of cook), remove 1 roast (inoculated w\ both pathogens) for sampling.	4) post-hot-hold #2 roast	3 internal/dialysis 3 surface	3 internal/dialysis
7. Cool: Place remaining 3 roasts in experimental cool cycle. Cool from 130ºF CT to 41ºF in 15-24 h (including from 120° to 55°F in 6-8 h). After cooling to 41ºF CT, remove 1 roast (inoculated w\ only *C. perfringens*) for sampling.	5) post-cool roast	**n/a**	3 internal/dialysis
8. Refrigerated hold: Hold remaining 2 roasts refrigerated (i.e., 38-40°F) for 12-24 h. After refrigerated hold, remove 1 roast (inoculated w\ only *C. perfringens*) for sampling.	6) post-refrigerated hold roast	**n/a**	3 internal/dialysis
9. Retherm: Reheat remaining roast to 130ºF CT. Set Doneness at 130ºF, Brown at 5, and time at 6 h. Set Hold for 4 h, 130ºF Doneness + 1, or 131ºF, 90% humidity. After 10 h (i.e., 6-h retherm + 4-h hold), remove roast (inoculated w\ only *C. perfringens*) for sampling.	7) post-retherm & hold roast	**n/a**	3 internal/dialysis

Microbiological Analysis

Internal Inoculation. Each time-0 inoculated minced beef sub-sample (i.e., 20 g) was placed in a stomacher bag with BPB diluent to effect a 1:10 dilution. For analysis of the dialysis unit samples, the samples were aseptically removed from the dialysis tubing and placed in a stomacher bag with BPB diluent to effect a 1:10 dilution. Samples were stomached for 1 minute and the homogenate serially diluted in BPB for plating as required.

Salmonella was enumerated in designated samples via surface plating on XLT agar using the thin agar layer method (TAL) with Trypticase Soy Agar (TSA) to enhance recovery of sublethally injured bacterial cells (8). C*lostridium perfringens* was enumerated in designated samples using TSC agar (without egg yolk) and standard microbiological methods (2).

Surface Inoculation. For the surface (*Salmonella*) inoculated samples, the designated inoculation sites (10 cm^2) were sampled using a surface excision technique. The designated surface site was aseptically excised to a depth of ca. 5 mm and placed in a stomacher bag with sterile BPB diluent to effect a 1:10 dilution. Excised sample weights were recorded. Excised samples were stomached for 1 min. and the homogenates serially diluted in sterile BPB diluent as required.

Salmonella was enumerated in subject sample homogenates via surface plating on XLT4 agar using the thin agar layer method (TAL) with TSA as previously described.

General. For cooked and/or cooled samples, the inoculated sub-samples were aseptically excised from the roasts at the predetermined sampling times. For the post-cook and post-hold samples, the inoculated dialysis units and the surface samples were collected (i.e., aseptically excised) from the designated roast immediately after the cook or designated hold was completed and rapidly cooled (refrigeration). The excised sample units were then held refrigerated until analyzed.

All results were expressed as colony forming units (CFUs) per gram for internal samples and per sq. cm for surface samples. Counts of each pathogen were converted to log10 transforms for calculation of means and standard deviations. Mean *Salmonella* log reductions (as compared to time-0) were calculated for each sample set at each designated time interval (i.e., process step).

RESULTS

CVap Oven Cook, FDA Hold, and Sell Hold Temperature Data

Electronic temperature recording data for the CVap oven cook, "FDA hold", and "sell hold" processes are presented in Figures 1 and 2 as well as in Addendum Table 1. Manual (equipment) temperature and humidity recordings along with corresponding electronic recording results are also presented in Table 1.

Electronic temperature results indicated that the internal temperatures (IT) of the roasts ranged from 120 to 125°F at the end of post-cook and 123 to 128°F at the end of the FDA recommended 2 hour hold. The internal temperature of some roasts did reach 129°F during the "sell hold". Humidity readings on the oven display read only 0 or 100% RH whereas the electronic readings showed much variability during processing with the maximum RH reaching ca. 91%.

Roast Cooling after CVap Oven Cook, FDA Hold, and Sell Hold Temperature Data

Electronic temperature recording results for the roasts during the designated cooling procedure after the CVap oven cook, "FDA hold", and “sell hold” are presented in Figure 3 and in Addendum Table 2. Electronic temperature results for roasts during the cold hold period are presented in Addendum Table 2. The internal temperature of the roasts decreased from 120 to 55°F in 7 to 10 hours. The internal temperature of the roasts decreased from 120 to 80°F in 2.8 to 3 hours. The internal temperature of the roasts decreased from 80 to 55°F in 4.8 to 7 hours.

CVap Oven Re-Therm Temperature Data

Electronic temperature recording results for the CVap oven "Re-therm" process (i.e., cook, "FDA hold", and "sell hold") are presented in Figure 4 as well as in Addendum Table 3. Manual temperature and humidity recordings along with corresponding electronic recording results are also presented i Table 1. Electronic temperature results again indicated that the internal temperatures of the roast never reached 130°F as prescribed by the CVap oven program during the "Re-Therm" process. The maximum internal temperature of the test roast was 126°F during the "sell hold".

Microbiological Analysis

The microbiological results for *Salmonella* lethality delivered internally and to the surface of the boneless beef rib roasts during the CVap oven cook, "FDA hold", and "sell hold" processes are presented in Table 2.

The surface mean *Salmonella* counts were reduced by greater than 8.18 $\log_{10}$ CFU/cm^2 by the combined cook/FDA-hold process, and by the combined cook/FDA hold/ sell-hold process (i.e., from 9.18 $\log_{10}$ CFU/ cm^2 prior to processing to <1.00 $\log_{10}$ CFU/ cm^2).

The internal mean *Salmonella* counts were reduced by 5.77 $\log_{10}$ CFU/g during the cook process (i.e., from 8.35 $\log_{10}$ CFU/g prior to processing to 2.58 $\log_{10}$ CFU/g after the subject process). The internal mean *Salmonella* counts were reduced by 4.70 $\log_{10}$ CFU/g during the combined

cook and FDA hold process (i.e., from 8.35 $\log_{10}$ CFU/g to 3.65 $\log_{10}$ CFU/g). Sample-to-sample variation was also observed for each of these sample sets (i.e., post-cook and post-cook/FDA-hold), but the variation was not unusual for this type of inoculation test. The internal mean *Salmonella* counts were reduced by greater than 7.65 $\log_{10}$ CFU/g after the "sell hold" process (i.e., from 8.35 to <0.70 $\log_{10}$ CFU/g).

The microbiological results for *C. perfringens* inoculated internally into the boneless beef rib roasts subjected to the CVap oven cook, "FDA hold", and "sell hold" process steps as well as a designated cooling procedure, a cold-hold procedure and a CVap oven "Re-Therm" process are presented in Table 3. Note that the pre-cook *C. perfringens* counts were comprised of spores (due to the inocula preparation methods) whereas the counts for subsequent sampling times could be comprised of spores and/or vegetative cells of *C. perfringens*.

These results indicate that there was apparent germination and outgrowth of spores of *C. perfringens* in some samples during the cook process and during the combination cook/FDA-hold process because *C. perfringens* counts were reduced and that will not happen if *C. perfringens* is in its heat-resistant spore state. A temperature of 203°F for 52 minutes is required for spore inactivation (7). This temperature is much higher than the temperatures achieved within the roasts used in this study. Conversely, the vegetative cells of *C. perfringens* are easily inactivated at temperatures of 130°F and higher (9). Some sample-to-sample variation was observed for each of these sample sets (i.e., post-cook and post-cook/FDA-hold), but not unusual for this kind of study. There was no *C. perfringens* recovered (i.e., mean count of <10 CFU/g) after the "sell hold" process. The post-sell-hold results indicate that the *C. perfringens* spore outgrowth as vegetative cells during the previous process steps are significantly reduced during the sell-hold process.

The mean *C. perfringens* count was 1.16 $\log_{10}$ CFU/g following the designated chill procedure and 2.21 $\log_{10}$ CFU/g following the designated cold hold procedure. These results indicate that while undetectable, there were some low level of spores and there was some outgrowth of *C. perfringens s*pores during the designated chill procedure and during the designated cold hold procedure. The mean *C. perfringens* count was 3.67 $\log_{10}$ CFU/g following the CVap oven "Re-Therm" process. These results indicate *C. perfringens* growth during the CVap oven "Re-Therm" process.

DISCUSSION

Pre-Cook

An adequate number of *Salmonella* CFU (Table 2 - 8.35 log, and 9.18 log) were inoculated in and on the beef roasts to measure thermal inactivation. The counts for *C. perfringens* spores were exactly where they should be, between 1,000 and 10,000, for the inoculum (Table 3), to show control of outgrowth of spores to test for germination.

Salmonella **Analysis**

Post-Cook

Table 1 (attached) shows the time-temperature data for air temperature, evaporative temperature, etc. in the 6-hour cooking process. The cook (heating) started at 6:18 AM and was completed by 12:03 PM. The center temperature of the beef roasts, however, was only at 120 to 126°F at the end of the cook (heating), while the cabinet temperature was 130°F. At 120°F, the time for the 1-log reduction of *Salmonella* is 173 minutes and at 125°F it is 54.5 minutes (4). Some survival would be expected. Temperature at the surface was adequate for a 8.78-log reduction of *Salmonella*, as evidenced in Table 2, which shows that there were no *Salmonella* left on the surface of the beef roasts after the first 6 hours. There was a 5.77-log reduction *Salmonella* reduction in the center of the roast beef by the end of the 6-hour cook. A *Salmonella* 6.5-log reduction is required by the FDA food code. While not meeting FDA roast pasteurization exactly, the center had as much reduction as required by the FDA code for ground meat (greater

than 5 logs) at the end of the 6-hour cook. It is expected that the roast would be safe from vegetative bacterial pathogens such as *Salmonella* and easily have the 6.5-log reduction if cooked in a CVap oven to a center temperature of 130°F.

Post-Cook / FDA Hold

The center temperature of the roasts continued to rise about 1°F more during the next 2 hours, until the center temperature ranged from 123 to 128°F at 2:03 PM, and the oven completed the 2-hour FDA hold mode. The thermocouple probe within the roast indicated a temperature of 127 to 128°F when the oven was 130°F. There really was not a significantly different *Salmonella* count than at 6 hours. As mentioned previously, if the center temperature had reached 130°F, it is expected that a small number of surviving *Salmonella* in the center would have been killed giving a greater than 6.5-log reduction.

Post-Cook-Sell-Hold+28 Hours at 130°F

As expected, there was no *Salmonella* survival internally or on the surface of the roasts. This shows that the CVap oven has the capability of safely holding food at 130°F and preventing the growth of *Salmonella*. It would also kill *Salmonella* if there is a slight amount of cross-contamination that might occur when the meat is being taken in and out of the oven. Since vegetative bacterial pathogens such as *Salmonella* are killed at these temperatures, this validates that roasts, such as the beef roasts in this study, will be made safe from vegetative bacterial pathogens if the temperature of the food / meat / poultry is greater than 130°F in a CVap oven.

***Clostridium perfringens* Analysis**

Post-Cook / FDA Hold

Clostridium perfringens can multiply up to 125°F (6, 9). It is evident when the *C. perfringens* data (Table 3) in "Post-Cook/FDA Hold" is examined that there was a small amount of growth. The research studies of Willardsen et al. (12) and Shigahisa (10) indicate that this is to be expected in meat where *come-up* time to *holding* is as long as 6 hours, as is in this case. It is apparent that the oven should operate 3 to 4°F above the final center temperature to make certain that there is enough driving force (heat) to assure that the food center temperature reaches 130°F to prevent *C. perfringens* growth. The probe temperature of the center of the food, not just evaporator and oven temperature settings, should be monitored and controlled and adjustment made to the oven temperature to assure 130°F food temperature, or the equipment designed to assure a center temperature of 130°F.

Note, it is not expected to inactivate *C. perfringens* spores; the goal is simply to prevent multiplication.

Post-Cook-Sell-Hold+28 Hours at 130°F

In the post-cook mode at 130°F for 28 hours, *C. perfringens* was reduced to an undetectable level. This indicates that there was germination of spores and then, destruction of the vegetative *C. perfringens* cells produced from the spores. This apparently did not happen to all of the *C. perfringens* spores, and some undetectable spores (<10 per gram) were still present. Analysis of the post-chilling sample data indicates that there was a small amount of *C. perfringens* spore outgrowth and germination to vegetative cells that had been at such a low level it was undetectable. This research study shows that *C. perfringens* may be actually germinating a bit during come-up time and is then inactivated in the long holding at 130°F. Nonetheless, the roast is stable from the standpoint of no increase of *C. perfringens* during hot hold at 130°F. This would be true of any meat that is held in the oven at 130°F. Any hold temperature above 130°F for any meat cooked in a CVap oven anywhere in the world is safe and would prevent the survival of *Salmonella* and growth of *C. perfringens*.

Post-Chill-Hold

After chilling slowly for over 15 hours to encourage *C. perfringens* spores to germinate, if they were viable, the roasts were held for an additional 24 hours at about 38°F (Tables 2a & 2b). The *C. perfringens* count increased slightly. *Clostridium perfringens* does not multiply below 43 to 50°F (7); so this carry-over growth from the cooling process must be from nutrients generated and stored during earlier stages of the process, or simply microbiological lab variation. This is an indication that chilling any roast and then holding the roast in a refrigerator may lead to a small, but negligible, *C. perfringens* increase.

Post-Retherm Cook and Hold, An Additional + 10-Hour Retherm Cook

Table 3 shows that there were still a few *C. perfringens* that were viable and increasing in count. As mentioned above, the indications are that, even though the temperatures are beyond the range of growth of *C. perfringens*, there still seem to be a few multiplications, and this is apparently a form of carry-over growth, because the *C. perfringens* has germinated and some stored nutrients were produced. This says that cooling a roast and reheating can allow for some germination and growth of surviving *C. perfringens* spores in beef. These levels are much below the levels of 1,000,000 per gram necessary for illness (1).

SUMMARY

The 6-hour cooking process of large beef roasts in the CVap oven is a very safe process and meets scientific and regulatory requirements. The oven humidity is in the range of 20 to 40% during the first couple of hours of cooking, which is sufficient to assure the destruction of *Salmonella* on the surface of the meat. The meat surface had a greater than 6.5-log reduction at the end of 6 hours. The center temperature of the meat was always lower than the temperature of the oven by a few degrees and there was not quite as much destruction (death) of *Salmonella*. The meat holding time should be based on the probe center temperature, and not on oven temperatures. The oven temperature could be increased a few degrees to compensate for the difference between air (oven) temperature and the center temperature of the meat.

When roasts are cooked to 130°F for 112 minutes, *Salmonella* is not a food safety concern in meat that is cooked in the CVap oven anywhere in the world. The oven used in this study effectively reduced *Salmonella* 5 logs and more. Destruction of vegetative cells of other bacterial pathogens in addition to destruction of the vegetative cells of *Salmonella* is accomplished at 130°F and above.

When the meat was cooked and cooled, even though *C. perfringens* was undetectable during hot hold. After cooling and holding, a small number of vegetative cells of *C. perfringens* were detected (probably due to spore germination and outgrowth during cooling). This means that the safest use of the oven is not to remove food from the oven to cool it and then later reheat (retherm) it. The safest procedure is to simply keep the temperature at 130°F or above. The CVap oven is very capable of stable operation at 130°F, and at this temperature, the meat will remain safe. The data show that the small amount of *C. perfringens* spore outgrowth and germination that might occur in the middle of the meat is not a food safety concern.

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Figure 1. Temperature Results for CVap Oven Cook and FDA Hold.

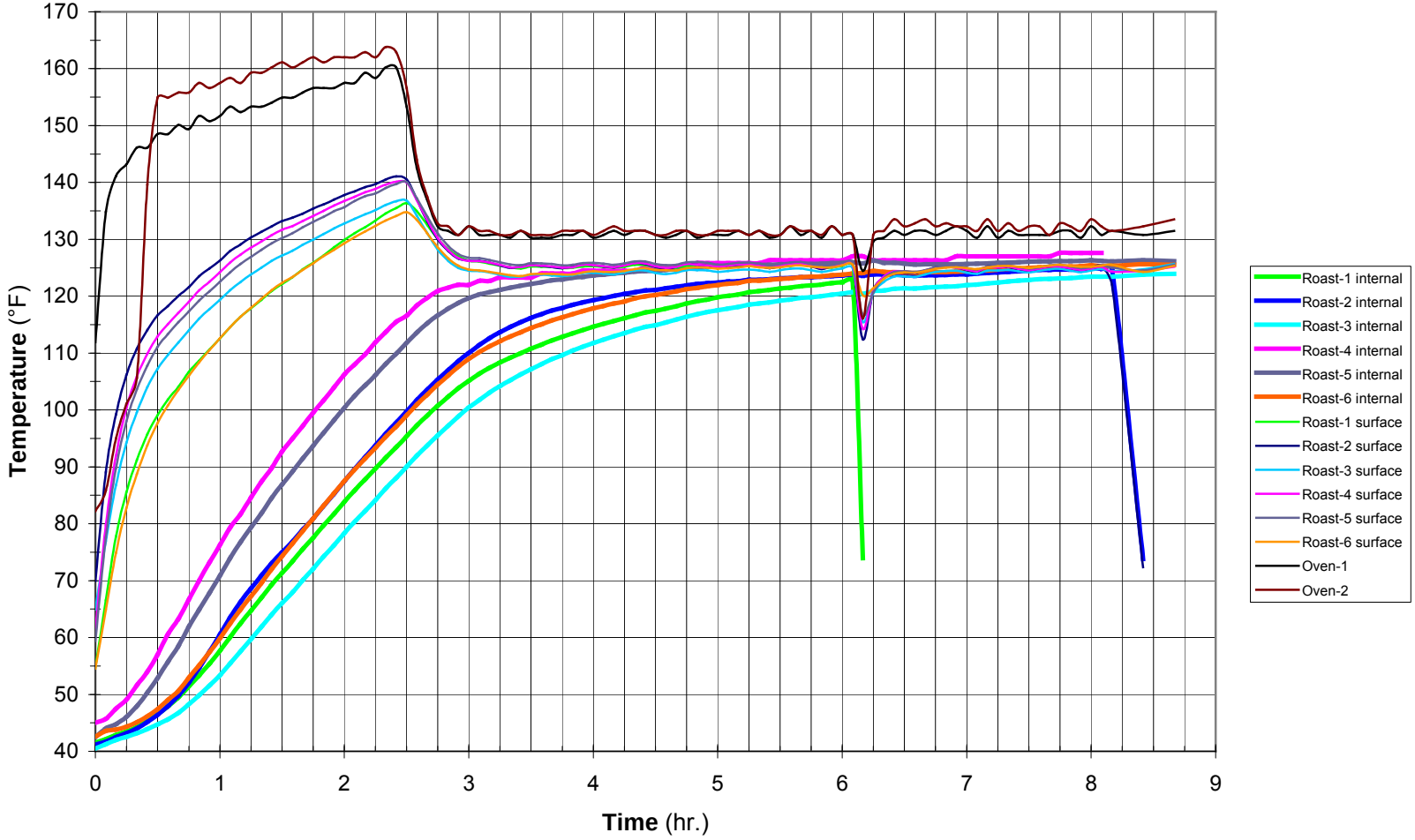

Figure 2. Temperature Results for CVap Oven Cook, FDA Hold, and "Sell" Hold .

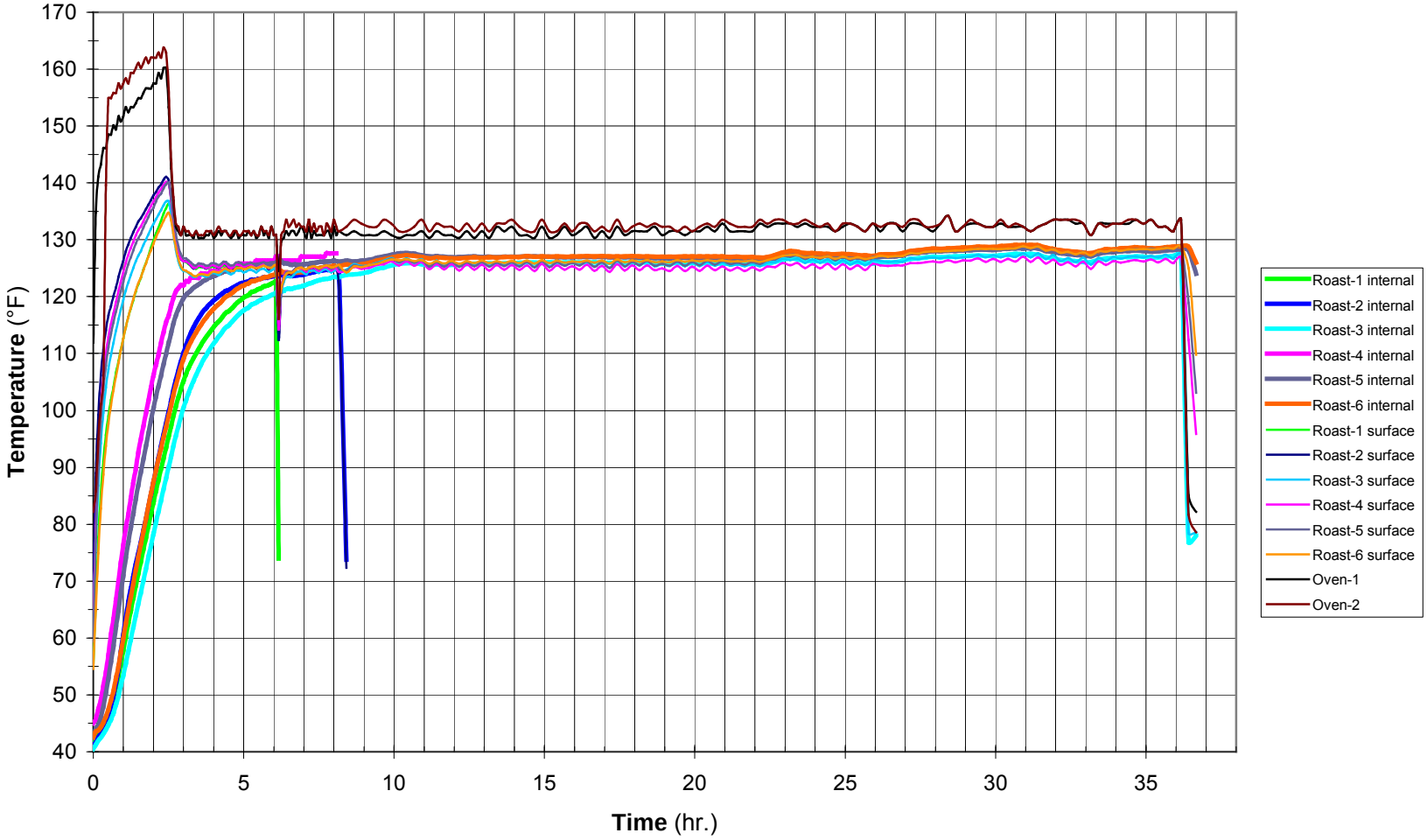

Figure 3. Temperature Results for Cooling Roasts after CVap Oven Cook, FDA Hold, and "Sell" Hold.

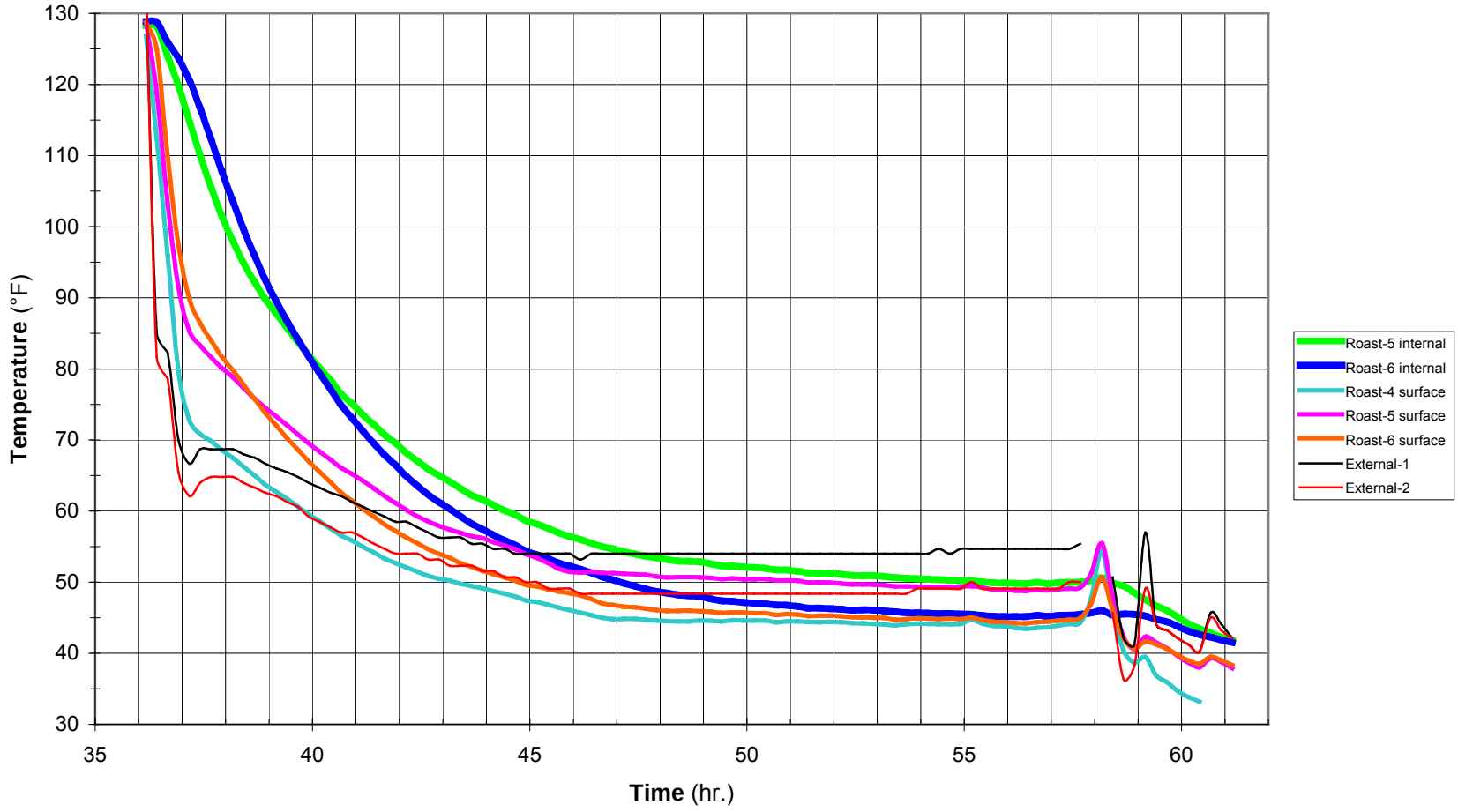

Figure 4. Temperature Results for CVap Oven Re-Therm Process.

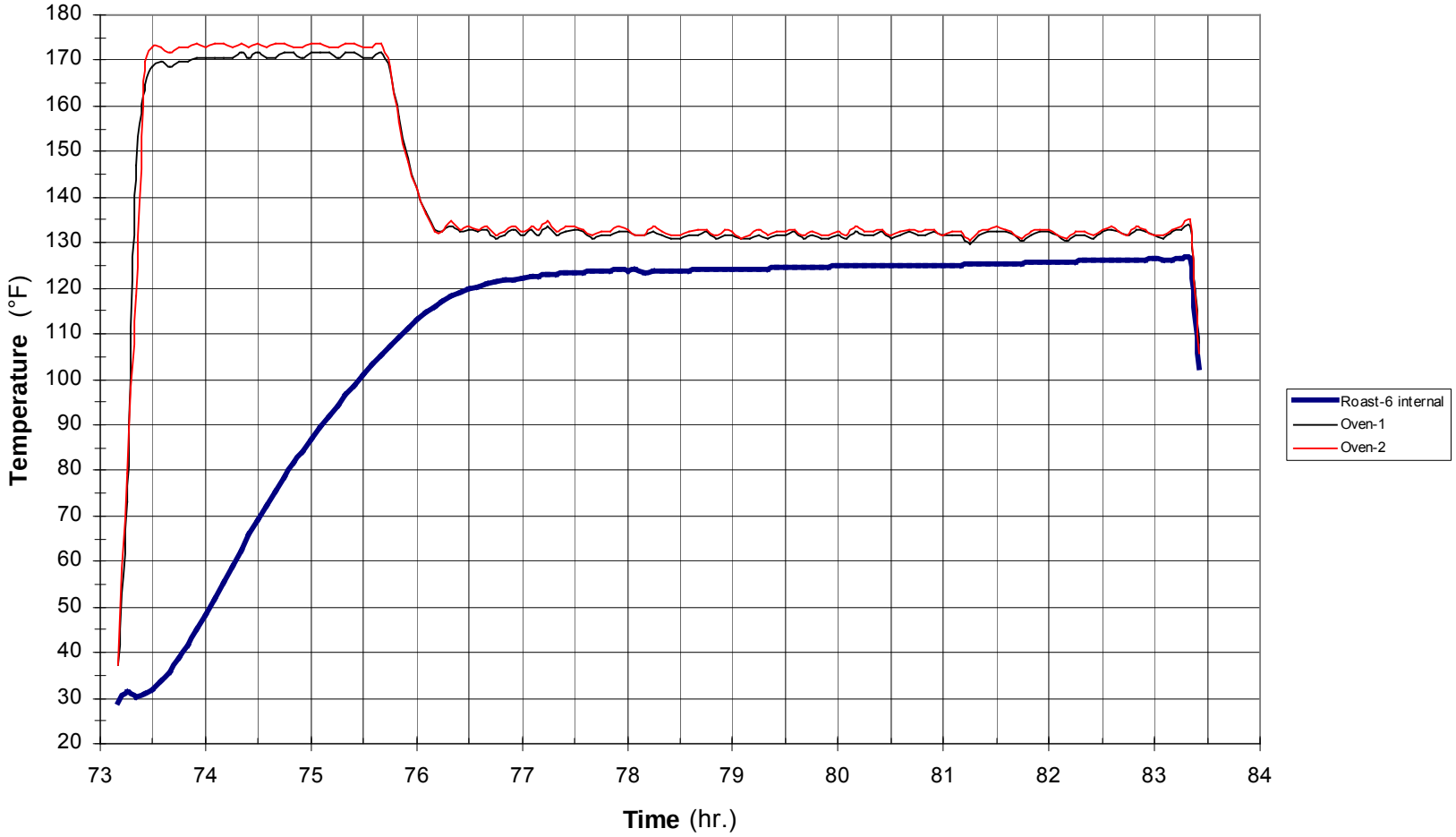

Table 1. Summary of Manual and Corresponding Electronic Temperature and Humidity Results.

			Manual Recordings					Electronic Recordings		
Date	**Time**	**Notes**	**E (evaporator)** (°F)	**D (differential air)** (°F)	**A (Actual Cabinet)** (°F)	**P (Roast Probe)** (°F)	**RH** %	**Oven** (°F)	**Roast (IT)** (°F)	**RH** %
10/2/07	5:32 AM	loading	131	39	170	145	0	--	--	--
	6:18 AM	cook	124	42	166	54	0	86-135	41-46	--
	6:30 AM	cook	128	42	170	58	0	106-146	43-52	25
	6:46 AM	cook	126	41	167	65	0	149-155	46-61	28
	7:01 AM	cook	127	43	170	73	0	152-158	50-70	33
	7:16 AM	cook	126	42	168	80	0	153-158	55-79	37
	7:31 AM	cook	127	42	169	86	0	153-159	62-87	38
	7:46 AM	cook	129	40	169	93	0	155-160	68-95	40
	8:01 AM	cook	130	39	169	100	0	160-161	74-102	43
	8:17 AM	cook	132	36	168	106	0	158-162	80-108	43
	8:32 AM	cook	133	35	168	111	0	160-164	86-114	48
	8:47 AM	cook	134	10	144	115	0	143-144	92-118	60
	9:02 AM	cook	131	0	131	117	100	132	97-122	91
	10:03 AM	cook	134	-1	133	123	100	132	110-124	82
	11:03 AM	cook	132	-2	131	126	100	130-131	117-126	82
	12:03 PM	cook	129	1	130	127	100	130-131	120-126	82
	1:03 PM	FDA hold	132	1	132	128	100	132-133	122-126	86
	2:03 PM	FDA hold	131	1	130	128	100	132	123-128	87
	3:22 PM	Sell Hold	131	1	132	128	100	131-133	124-126	84
	3:52 PM	Sell Hold	131	-1	130	129	100	132-134	125-127	84
	4:58 PM	Sell Hold	135	2	133	128	100	131-132	126-128	86
10/3/07	8:08 AM	Sell Hold	136	-5	131	130	100	133	126-127	90
	9:09 AM	Sell Hold	135	-4	131	130	100	132	126-128	86
	10:21 AM	Sell Hold	132	-1	131	130	100	133	127-128	83
	11:09 AM	Sell Hold	134	-3	131	130	100	132	127-129	86
	12:10 PM	Sell Hold	134	-3	131	130	100	132	127-129	86
	1:10 PM	Sell Hold	133	-2	131	130	100	132	128-129	87
	2:10 PM	Sell Hold	132	-1	131	130	100	134	127-128	86
	3:10 PM	Sell Hold	132	0	132	130	100	133	126-128	86
	5:10 PM	Sell Hold	129	1	130	130	100	133	127-129	82
10/5/07	8:00 AM	Re-therm	132	36	169	85	0	170-173	42	34
	9:01 AM	Re-therm	134	35	169	124	0	172-173	82	37
	10:01 AM	Re-therm	135	15	151	141	0	157-158	109	55
	11:01 AM	Re-therm	135	3	132	135	100	132	122	75
	12:01 PM	Re-therm	134	2	132	129	100	132	124	79
	1:01 PM	Re-therm	133	-1	131	129	100	131-132	124	77
	2:01 PM	FDA hold	130	0	131	130	100	131-132	125	72
	3:01 PM	FDA hold	134	2	135	130	100	132-133	125	72
	4:01 PM	Sell Hold	135	2	132	130	100	132	126	76
	5:01 PM	Sell Hold	130	1	131	131	100	133-134	126	75

Table 2. *Salmonella* Lethality Delivered to Beef Roasts During CVap Oven Processing.

Sample Variable		Internal *Salmonella* counts		Surface *Salmonella* counts	
		CFU/g	Log_{10} CFU/g	CFU/cm^2	Log_{10} CFU/cm^2
Pre-cook	rep. 1	140,000,000	8.15	1,700,000,000	9.23
	rep. 2	290,000,000	8.46	1,400,000,000	9.15
	rep. 3	280,000,000	8.45	1,500,000,000	9.18
	Mean		**8.35**		**9.18**
	Std. Dev.		0.18		0.04
Post-cook	rep. 1	6,200	3.79	<10	<1.00
(6 h to 130°F CT)	rep. 2	5	0.70	<10	<1.00
	rep. 3	1,800	3.26	<10	<1.00
	Mean		**2.58**		**<1.00**
	Std. Dev.		1.65		0.00
	Log_{10} Reduction		**5.77**		**>8.18**
Post-Cook/FDA Hold	rep. 1	22,000	4.34	<10	<1.00
(6 h to 130°F CT)	rep. 2	8,200	3.91	<10	<1.00
(plus 121 min @130°F)	rep. 3	490	2.69	<10	<1.00
	Mean		**3.65**		**<1.00**
	Std. Dev.		0.86		0.00
	Log_{10} Reduction		**4.70**		**>8.18**
Post-Cook/Sell Hold	rep. 1	<5	<0.70	<10	<1.00
(6 h to 130°F CT)	rep. 2	<5	<0.70	<10	<1.00
(plus 121 min @130°F)	rep. 3	<5	<0.70	<10	<1.00
(plus 28 h @130°F)	**Mean**		**<0.70**		**<1.00**
	Std. Dev.		0.00		0.00
	Log_{10} Reduction		**>7.65**		**>8.18**

Notes: 1) Log 10 Reduction = (pre-cook mean log_{10}/g) - (subject post-cook/hold mean log_{10}/g).
2) A "less than" (<) sign indicates no surviving *Salmonella* were detected in the subject sample.

Table 3. *Clostridium perfringens* Results in Beef Roasts during CVap Oven Processes.

Sample Variable		Internal *C. perfringens* counts	
		CFU/g	Log_{10} CFU/g
Pre-cook	rep. 1	5,300	3.72
	rep. 2	5,200	3.72
	rep. 3	4,800	3.68
	Mean		**3.71**
	Std. Dev.		0.02
Post-cook (6 h to 130°F CT)	rep. 1	<10	<1.00
	rep. 2	700	2.85
	rep. 3	97,000	4.99
	Mean		**2.94**
	Std. Dev.		2.00
Post-Cook/FDA Hold (6 h to 130°F CT) (plus 121 min @130°F)	rep. 1	2,600	3.41
	rep. 2	120,000	5.08
	rep. 3	160,000	5.20
	Mean		**4.57**
	Std. Dev.		1.00
Post-Cook/Sell Hold (6 h to 130°F CT) (plus 121 min @130°F) (plus 28 h @130°F)	rep. 1	<10	<1.00
	rep. 2	<10	<1.00
	rep. 3	<10	<1.00
	Mean		<1.00
	Std. Dev.		0.00
Post-Chill (130°F to 41°F in 15 h)	rep. 1	10	1.00
	rep. 2	<10	<1.00
	rep. 3	30	1.48
	Mean		**1.16**
	Std. Dev.		0.28
Post-Chill/Hold (130°F to 41°F in 15 h) (plus 24 h hold @38°F)	rep. 1	390	2.59
	rep. 2	160	2.20
	rep. 3	70	1.85
	Mean		**2.21**
	Std. Dev.		0.37
Post-Retherm Cook/Hold (130°F to 41°F in 15 h) (plus 24 h hold @38°F) (plus 10 h Retherm cook)	rep. 1	980	2.99
	rep. 2	8,100	3.91
	rep. 3	13,000	4.11
	Mean		**3.67**
	Std. Dev.		0.60

Note: 1) Mean Log 10 Change = (subject process variable mean log10/g) - (pre-cook mean log10/g).

Addendum-Table 1a. Temperature Results for CVap Oven Cook, FDA Hold and Sell Hold.

Date	Time	Elapsed min.	Elapsed hr.	Roast-1 internal	Roast-2 internal	Roast-3 internal	Roast-4 internal	Roast-5 internal	Roast-6 internal	Roast-1 surface	Roast-2 surface	Roast-3 surface	Roast-4 surface	Roast-5 surface	Roast-6 surface	Oven-1	Oven-2
Oct/2/2007	6:12:00	0	0.00	41.5	41.2	40.5	45.0	42.5	42.6	54.8	69.9	64.9	61.6	59.4	54.6	111.9	82.2
Oct/2/2007	6:17:00	5	0.08	42.1	41.7	41.3	45.7	44.0	43.6	66.6	89.0	76.9	79.7	77.5	64.8	134.8	85.8
Oct/2/2007	6:22:00	10	0.17	42.9	42.5	42.0	47.5	44.8	43.8	77.8	99.2	86.8	92.0	89.8	74.9	141.1	95.0
Oct/2/2007	6:27:00	15	0.25	43.5	43.2	42.5	49.1	46.1	44.3	85.6	106.2	94.2	100.4	98.0	82.8	143.2	101.1
Oct/2/2007	6:32:00	20	0.33	44.2	44.0	43.2	51.6	47.9	45.1	91.2	110.8	99.6	105.9	103.6	88.7	146.1	105.6
Oct/2/2007	6:37:00	25	0.42	45.4	45.2	43.9	54.0	50.3	46.2	95.8	114.0	104.0	109.9	107.8	93.8	146.1	139.6
Oct/2/2007	6:42:00	30	0.50	46.5	46.4	44.7	57.0	52.9	47.4	99.0	116.7	107.2	112.9	111.1	97.7	148.5	154.9
Oct/2/2007	6:47:00	35	0.58	47.9	48.0	45.6	60.6	55.7	49.0	101.9	118.3	109.7	115.1	113.4	100.8	148.5	154.9
Oct/2/2007	6:52:00	40	0.67	49.5	49.8	46.8	63.3	58.5	50.6	104.1	120.1	111.9	117.1	115.5	103.5	150.1	155.8
Oct/2/2007	6:57:00	45	0.75	51.4	52.1	48.3	66.7	61.9	53.0	106.7	121.6	114.0	119.0	117.3	106.0	149.4	155.8
Oct/2/2007	7:02:00	50	0.83	53.3	54.6	49.8	70.0	64.9	55.1	108.6	123.5	116.0	121.0	119.2	108.4	151.7	157.5
Oct/2/2007	7:07:00	55	0.92	55.4	57.5	51.6	73.2	67.9	57.4	110.6	124.9	117.7	122.6	120.9	110.5	150.8	156.6
Oct/2/2007	7:12:00	60	1.00	57.7	60.5	53.3	76.3	70.9	59.9	112.6	126.2	119.4	124.2	122.6	112.6	151.7	157.5
Oct/2/2007	7:17:00	65	1.08	60.1	63.5	55.4	79.3	74.0	62.4	114.5	127.9	121.0	125.9	124.2	114.5	153.3	158.4
Oct/2/2007	7:22:00	70	1.17	62.5	66.3	57.6	81.7	76.8	64.9	116.4	129.1	122.5	127.3	125.7	116.4	152.4	157.5
Oct/2/2007	7:27:00	75	1.25	64.7	68.7	59.7	84.6	79.4	67.2	117.9	130.3	123.8	128.5	126.9	118.0	153.3	159.3
Oct/2/2007	7:32:00	80	1.33	67.0	70.9	61.9	87.4	81.8	69.6	119.4	131.3	125.1	129.6	128.2	119.6	153.3	159.3
Oct/2/2007	7:37:00	85	1.42	69.3	73.1	64.0	89.8	84.5	72.0	120.9	132.3	126.2	130.7	129.3	121.0	154.0	160.2
Oct/2/2007	7:42:00	90	1.50	71.4	75.0	66.0	92.7	86.9	74.3	122.2	133.2	127.2	131.7	130.3	122.4	154.9	161.1
Oct/2/2007	7:47:00	95	1.58	73.4	76.9	68.0	95.0	89.2	76.5	123.3	133.8	128.0	132.3	131.1	123.4	154.9	160.2
Oct/2/2007	7:52:00	100	1.67	75.6	79.0	70.1	97.2	91.5	78.7	124.7	134.5	129.1	133.2	132.1	124.6	155.8	161.1
Oct/2/2007	7:57:00	105	1.75	77.5	80.9	72.1	99.5	93.7	80.9	125.9	135.4	130.0	134.1	133.1	125.8	156.6	162.0
Oct/2/2007	8:02:00	110	1.83	79.7	83.1	74.2	101.7	96.0	83.2	127.2	136.2	130.9	135.0	134.0	127.0	156.6	161.1
Oct/2/2007	8:07:00	115	1.92	81.7	85.2	76.2	104.0	98.2	85.4	128.6	137.0	131.9	135.9	135.0	128.1	156.6	162.0
Oct/2/2007	8:12:00	120	2.00	83.8	87.5	78.3	106.2	100.4	87.5	129.9	137.8	132.8	136.7	135.6	129.3	157.5	162.0
Oct/2/2007	8:17:00	125	2.08	85.9	89.6	80.3	108.0	102.5	89.6	131.1	138.4	133.6	137.5	136.7	130.4	157.5	162.0
Oct/2/2007	8:22:00	130	2.17	87.8	91.7	82.3	109.8	104.3	91.5	132.1	139.2	134.4	138.3	137.6	131.4	159.3	162.9
Oct/2/2007	8:27:00	135	2.25	89.7	93.8	84.2	111.9	106.1	93.3	133.3	139.7	135.2	138.9	138.1	132.4	158.4	162.0
Oct/2/2007	8:32:00	140	2.33	91.6	95.8	86.2	113.7	108.1	95.3	134.6	140.5	136.1	139.6	139.0	133.3	160.2	163.8
Oct/2/2007	8:37:00	145	2.42	93.4	97.8	88.0	115.5	109.9	97.1	135.5	141.0	136.7	140.1	139.7	134.1	160.2	162.9
Oct/2/2007	8:42:00	150	2.50	95.4	99.8	90.0	116.6	111.8	99.0	136.3	140.5	136.8	140.0	140.0	134.8	153.3	156.6
Oct/2/2007	8:47:00	155	2.58	97.3	101.8	91.9	118.4	113.6	101.0	135.0	137.0	134.1	136.9	137.3	133.4	142.5	144.0
Oct/2/2007	8:52:00	160	2.67	99.0	103.6	93.8	119.7	115.3	102.7	132.5	133.2	131.1	133.4	134.0	131.0	136.9	137.5
Oct/2/2007	8:57:00	165	2.75	100.7	105.4	95.6	120.9	116.7	104.5	130.1	130.0	128.2	130.2	131.0	128.6	132.3	132.8
Oct/2/2007	9:02:00	170	2.83	102.3	107.0	97.2	121.5	117.8	106.1	128.3	127.9	126.2	128.1	128.9	126.7	131.5	132.3
Oct/2/2007	9:07:00	175	2.92	103.8	108.6	98.9	122.0	118.8	107.6	127.0	126.6	125.0	126.7	127.4	125.4	130.8	130.8
Oct/2/2007	9:12:00	180	3.00	105.1	110.1	100.5	122.0	119.7	109.0	126.2	126.3	124.5	126.2	126.8	124.7	132.3	132.3
Oct/2/2007	9:17:00	185	3.08	106.4	111.4	101.8	122.7	120.3	110.2	126.1	126.2	124.4	126.2	126.7	124.5	130.8	131.5
Oct/2/2007	9:22:00	190	3.17	107.4	112.6	103.0	122.7	120.7	111.2	125.7	125.9	124.2	125.9	126.4	124.3	130.8	131.5
Oct/2/2007	9:27:00	195	3.25	108.3	113.7	104.2	123.3	121.1	112.1	125.4	125.4	123.8	125.5	126.0	124.0	130.8	130.8
Oct/2/2007	9:32:00	200	3.33	109.2	114.6	105.2	123.3	121.5	112.9	125.1	125.0	123.4	125.1	125.6	123.7	130.3	130.8
Oct/2/2007	9:37:00	205	3.42	110.0	115.5	106.3	123.3	121.8	113.7	124.9	125.2	123.5	125.1	125.5	123.6	131.5	131.5
Oct/2/2007	9:42:00	210	3.50	110.8	116.2	107.2	123.3	122.2	114.4	125.2	125.5	123.8	125.5	125.8	123.9	130.3	130.8
Oct/2/2007	9:47:00	215	3.58	111.5	116.9	108.1	124.0	122.4	115.0	125.2	125.3	123.8	125.4	125.8	123.9	130.3	130.8

Addendum-Table 1b. Temperature Results for CVap Oven Cook, FDA Hold and Sell Hold.

Date	Time	Elapsed min.	Elapsed hr.	Roast-1 internal	Roast-2 internal	Roast-3 internal	Roast-4 internal	Roast-5 internal	Roast-6 internal	Roast-1 surface	Roast-2 surface	Roast-3 surface	Roast-4 surface	Roast-5 surface	Roast-6 surface	Oven-1	Oven-2
Oct/2/2007	9:52:00	220	3.67	112.2	117.5	109.0	124.0	122.8	115.8	125.1	125.1	123.7	125.2	125.7	123.9	130.3	130.8
Oct/2/2007	9:57:00	225	3.75	112.9	117.9	109.6	124.0	123.0	116.3	124.9	124.9	123.5	125.0	125.4	123.8	130.8	131.5
Oct/2/2007	10:02:00	230	3.83	113.5	118.5	110.4	124.0	123.3	116.9	125.0	125.2	123.7	125.1	125.5	123.8	130.8	131.5
Oct/2/2007	10:07:00	235	3.92	114.1	118.9	111.1	124.5	123.4	117.4	125.2	125.6	124.1	125.5	125.8	124.2	131.5	131.5
Oct/2/2007	10:12:00	240	4.00	114.6	119.3	111.8	124.5	123.6	117.9	125.3	125.5	124.1	125.5	125.9	124.4	130.3	130.8
Oct/2/2007	10:17:00	245	4.08	115.2	119.7	112.4	124.5	123.8	118.3	125.1	125.2	124.0	125.3	125.7	124.3	130.8	131.5
Oct/2/2007	10:22:00	250	4.17	115.6	120.1	113.0	124.5	124.0	118.7	125.1	125.1	123.8	125.1	125.5	124.3	131.5	132.3
Oct/2/2007	10:27:00	255	4.25	116.1	120.4	113.5	124.5	124.1	119.1	125.2	125.5	124.2	125.4	125.8	124.4	130.8	131.5
Oct/2/2007	10:32:00	260	4.33	116.6	120.7	114.1	124.5	124.3	119.6	125.5	125.9	124.5	125.8	126.1	124.8	131.5	131.5
Oct/2/2007	10:37:00	265	4.42	117.1	121.0	114.6	125.1	124.5	120.0	125.5	125.7	124.5	125.8	126.1	124.9	131.5	131.5
Oct/2/2007	10:42:00	270	4.50	117.4	121.1	114.9	125.1	124.5	120.2	125.2	125.2	124.1	125.3	125.7	124.6	130.8	130.8
Oct/2/2007	10:47:00	275	4.58	117.8	121.4	115.4	125.1	124.6	120.5	125.0	124.8	123.9	125.0	125.5	124.6	130.3	130.8
Oct/2/2007	10:52:00	280	4.67	118.2	121.6	115.9	125.1	124.8	120.9	125.0	125.2	124.1	125.2	125.5	124.5	130.8	131.5
Oct/2/2007	10:57:00	285	4.75	118.7	121.9	116.4	125.1	125.0	121.2	125.3	125.7	124.6	125.7	126.0	124.9	131.5	131.5
Oct/2/2007	11:02:00	290	4.83	119.1	122.1	116.8	125.8	125.1	121.5	125.5	125.5	124.6	125.5	126.0	125.1	130.3	130.8
Oct/2/2007	11:07:00	295	4.92	119.4	122.3	117.2	125.8	125.2	121.8	125.5	125.4	124.5	125.4	125.9	125.0	130.8	130.8
Oct/2/2007	11:12:00	300	5.00	119.8	122.4	117.5	125.8	125.3	121.9	125.2	125.0	124.3	125.2	125.6	124.8	130.8	131.5
Oct/2/2007	11:17:00	305	5.08	120.1	122.6	117.8	125.8	125.3	122.2	125.1	125.3	124.4	125.4	125.7	124.9	130.8	131.5
Oct/2/2007	11:22:00	310	5.17	120.3	122.7	118.1	125.8	125.4	122.3	125.2	125.5	124.6	125.6	125.8	125.1	131.5	131.5
Oct/2/2007	11:27:00	315	5.25	120.7	122.9	118.5	125.8	125.5	122.7	125.3	125.4	124.7	125.6	125.9	125.3	130.8	130.8
Oct/2/2007	11:32:00	320	5.33	120.9	122.9	118.7	125.8	125.5	122.7	125.2	125.3	124.5	125.4	125.7	125.1	131.5	131.5
Oct/2/2007	11:37:00	325	5.42	121.1	123.0	118.9	126.3	125.5	122.9	125.0	124.9	124.3	125.0	125.5	125.0	130.3	130.8
Oct/2/2007	11:42:00	330	5.50	121.4	123.1	119.2	126.3	125.6	123.0	125.2	125.3	124.6	125.4	125.7	125.1	130.8	130.8
Oct/2/2007	11:47:00	335	5.58	121.5	123.2	119.4	126.3	125.6	123.1	125.3	125.8	124.8	125.7	125.9	125.3	132.3	132.3
Oct/2/2007	11:52:00	340	5.67	121.8	123.4	119.7	126.3	125.7	123.3	125.5	125.6	124.9	125.7	126.0	125.4	130.8	131.5
Oct/2/2007	11:57:00	345	5.75	121.9	123.3	119.8	126.3	125.7	123.4	125.2	125.3	124.6	125.3	125.7	125.2	131.5	131.5
Oct/2/2007	12:02:00	350	5.83	122.0	123.4	120.0	126.3	125.7	123.5	125.0	124.8	124.3	125.0	125.4	125.1	130.3	130.8
Oct/2/2007	12:07:00	355	5.92	122.3	123.5	120.2	126.3	125.8	123.7	125.0	125.2	124.6	125.3	125.5	125.1	132.3	132.3
Oct/2/2007	12:12:00	360	6.00	122.5	123.7	120.5	126.3	125.9	123.8	125.3	125.5	124.9	125.6	125.9	125.4	130.8	130.8
Oct/2/2007	12:17:00	365	6.08	122.7	123.8	120.7	127.0	126.0	124.0	125.5	125.5	124.9	125.6	125.9	125.5	130.8	130.8
Oct/2/2007	12:22:00	370	6.17	74.0	123.6	120.4	127.0	125.8	124.1	74.8	112.4	115.5	114.3	116.7	120.2	124.5	116.1
Oct/2/2007	12:27:00	375	6.25		123.9	120.9	126.3	126.2	124.4		121.0	120.5	121.0	120.7	121.4	129.6	130.8
Oct/2/2007	12:32:00	380	6.33		123.8	121.0	126.3	125.9	124.3		123.4	122.5	123.4	123.1	123.1	130.3	131.5
Oct/2/2007	12:37:00	385	6.42		123.8	121.3	126.3	125.8	124.2		124.3	123.4	124.4	124.2	123.9	131.5	133.5
Oct/2/2007	12:42:00	390	6.50		123.7	121.4	126.3	125.7	124.2		124.1	123.5	124.3	124.4	124.2	130.8	132.3
Oct/2/2007	12:47:00	395	6.58		123.6	121.4	126.3	125.6	124.1		124.0	123.4	124.1	124.3	124.1	131.5	132.8
Oct/2/2007	12:52:00	400	6.67		123.7	121.5	126.3	125.6	124.2		124.5	123.8	124.5	124.6	124.4	131.5	133.5
Oct/2/2007	12:57:00	405	6.75		123.7	121.6	126.3	125.6	124.2		125.1	124.3	125.0	125.1	124.8	130.8	132.3
Oct/2/2007	13:02:00	410	6.83		123.8	121.7	126.3	125.6	124.3		125.1	124.4	125.1	125.3	125.0	131.5	132.8
Oct/2/2007	13:07:00	415	6.92		123.8	121.8	127.0	125.6	124.3		125.0	124.5	125.0	125.3	125.1	132.3	132.3
Oct/2/2007	13:12:00	420	7.00		123.9	121.9	127.0	125.7	124.4		124.6	124.1	124.7	125.0	124.9	131.5	132.3
Oct/2/2007	13:17:00	425	7.08		124.0	122.1	127.0	125.7	124.5		124.2	123.9	124.4	124.7	124.8	130.3	131.5
Oct/2/2007	13:22:00	430	7.17		124.1	122.3	127.0	125.8	124.6		125.2	124.5	125.1	125.2	125.1	132.3	133.5
Oct/2/2007	13:27:00	435	7.25		124.2	122.4	127.0	125.9	124.7		125.1	124.6	125.1	125.4	125.3	130.3	131.5
Oct/2/2007	13:32:00	440	7.33		124.3	122.6	127.0	125.9	124.8		125.1	124.6	125.2	125.4	125.3	131.5	132.8
Oct/2/2007	13:37:00	445	7.42		124.4	122.7	127.0	126.0	124.9		124.7	124.4	124.8	125.1	125.2	130.8	131.5

Addendum-Table 1c. Temperature Results for CVap Oven Cook, FDA Hold and Sell Hold.

Date	Time	Elapsed min.	Elapsed hr.	Roast-1 internal	Roast-2 internal	Roast-3 internal	Roast-4 internal	Roast-5 internal	Roast-6 internal	Roast-1 surface	Roast-2 surface	Roast-3 surface	Roast-4 surface	Roast-5 surface	Roast-6 surface	Oven-1	Oven-2
Oct/2/2007	13:42:00	450	7.50		124.5	122.9	127.0	126.1	125.0		124.4	124.2	124.6	124.9	125.0	130.8	132.3
Oct/2/2007	13:47:00	455	7.58		124.6	123.0	127.0	126.1	125.1		124.9	124.5	124.9	125.1	125.2	130.8	132.3
Oct/2/2007	13:52:00	460	7.67		124.6	123.1	127.0	126.1	125.1		125.2	124.8	125.2	125.4	125.4	130.8	130.8
Oct/2/2007	13:57:00	465	7.75		124.7	123.1	127.6	126.2	125.2		125.3	124.8	125.2	125.5	125.5	131.5	132.8
Oct/2/2007	14:02:00	470	7.83		124.7	123.2	127.6	126.2	125.2		124.8	124.5	124.9	125.2	125.3	131.5	132.3
Oct/2/2007	14:07:00	475	7.92		124.8	123.3	127.6	126.2	125.3		124.4	124.2	124.6	124.9	125.2	130.3	131.5
Oct/2/2007	14:12:00	480	8.00		124.9	123.5	127.6	126.3	125.4		125.0	124.5	124.9	125.1	125.2	132.3	133.5
Oct/2/2007	14:17:00	485	8.08		124.8	123.4	127.6	126.2	125.3		125.2	124.8	125.2	125.4	125.4	130.8	132.3
Oct/2/2007	14:22:00	490	8.17		124.9	123.4		126.1	125.3		122.0	124.4	124.4	125.1	125.5	131.5	131.5
Oct/2/2007	14:37:00	505	8.42		73.8	123.8		126.3	125.6		72.4	124.7	124.5	124.6	124.3	130.8	132.3
Oct/2/2007	14:52:00	520	8.67			123.9		126.2	125.5			125.7	125.2	125.5	125.3	131.5	133.5
Oct/2/2007	15:07:00	535	8.92			124.1		126.3	125.7			125.4	124.9	125.3	125.2	130.8	132.8
Oct/2/2007	15:22:00	550	9.17			124.3		126.4	125.9			125.5	125.0	125.5	125.5	130.8	132.3
Oct/2/2007	15:37:00	565	9.42			124.8		126.8	126.3			125.9	125.5	125.8	125.7	130.8	132.3
Oct/2/2007	15:52:00	580	9.67			125.1		127.1	126.6			126.3	125.7	126.1	126.2	131.5	133.5
Oct/2/2007	16:07:00	595	9.92			125.5		127.3	126.9			126.8	126.2	126.6	126.5	130.8	132.8
Oct/2/2007	16:22:00	610	10.17			125.7		127.6	127.1			126.1	125.5	126.0	126.4	130.3	131.5
Oct/2/2007	16:37:00	625	10.42			125.9		127.6	127.2			126.7	126.2	126.6	126.6	130.8	131.5
Oct/2/2007	16:52:00	640	10.67			125.9		127.5	127.2			126.1	125.4	126.0	126.3	130.8	132.3
Oct/2/2007	17:07:00	655	10.92			125.7		127.3	127.0			126.6	126.0	126.3	126.4	131.5	133.5
Oct/2/2007	17:22:00	670	11.17			125.5		127.0	126.7			125.4	124.8	125.3	125.8	130.3	131.5
Oct/2/2007	17:37:00	685	11.42			125.6		127.1	126.9			126.3	125.7	126.1	126.2	131.5	132.8
Oct/2/2007	17:52:00	700	11.67			125.6		127.0	126.8			125.4	124.8	125.3	125.8	130.8	132.3
Oct/2/2007	18:07:00	715	11.92			125.6		126.9	126.7			126.3	125.7	126.1	126.3	130.8	132.3
Oct/2/2007	18:22:00	730	12.17			125.6		126.9	126.7			125.3	124.6	125.2	125.8	130.3	131.5
Oct/2/2007	18:37:00	745	12.42			125.7		127.0	126.8			126.2	125.6	126.0	126.2	131.5	132.8
Oct/2/2007	18:52:00	760	12.67			125.8		127.0	126.9			125.5	124.7	125.3	125.9	130.3	131.5
Oct/2/2007	19:07:00	775	12.92			125.8		127.0	126.8			126.3	125.6	126.1	126.3	131.5	132.8
Oct/2/2007	19:22:00	790	13.17			125.8		127.0	126.9			125.4	124.6	125.3	125.9	130.3	131.5
Oct/2/2007	19:37:00	805	13.42			125.8		126.9	126.9			126.1	125.5	126.0	126.2	132.3	132.8
Oct/2/2007	19:52:00	820	13.67			125.8		127.0	126.9			125.5	124.8	125.4	125.9	131.5	132.8
Oct/2/2007	20:07:00	835	13.92			125.9		127.0	127.0			126.1	125.5	126.0	126.3	132.3	133.5
Oct/2/2007	20:22:00	850	14.17			125.9		127.0	127.0			125.4	124.7	125.3	125.9	130.8	132.3
Oct/2/2007	20:37:00	865	14.42			126.0		127.0	127.1			126.1	125.5	126.1	126.3	130.8	131.5
Oct/2/2007	20:52:00	880	14.67			126.0		127.0	127.0			125.2	124.5	125.1	125.8	130.3	131.5
Oct/2/2007	21:07:00	895	14.92			126.0		127.0	127.0			126.4	125.7	126.2	126.4	132.3	133.5
Oct/2/2007	21:22:00	910	15.17			126.0		127.0	127.0			125.3	124.6	125.2	125.9	130.3	131.5
Oct/2/2007	21:37:00	925	15.42			126.0		126.9	127.1			126.1	125.5	126.0	126.3	130.8	131.5
Oct/2/2007	21:52:00	940	15.67			126.0		126.9	127.0			125.5	124.7	125.4	126.0	132.3	132.8
Oct/2/2007	22:07:00	955	15.92			126.0		126.9	127.1			126.0	125.3	125.9	126.2	130.8	131.5
Oct/2/2007	22:22:00	970	16.17			126.0		127.0	127.1			125.6	124.8	125.5	126.1	131.5	132.8
Oct/2/2007	22:37:00	985	16.42			126.0		127.0	127.1			126.1	125.6	126.2	126.3	132.3	132.8
Oct/2/2007	22:52:00	1000	16.67			126.0		127.0	127.1			125.3	124.5	125.2	126.0	130.3	131.5
Oct/2/2007	23:07:00	1015	16.92			126.0		127.0	127.1			126.0	125.4	126.0	126.3	131.5	132.3
Oct/2/2007	23:22:00	1030	17.17			125.9		126.9	127.0			125.1	124.3	125.1	125.8	130.3	131.5
Oct/2/2007	23:37:00	1045	17.42			125.9		126.9	127.1			126.4	125.7	126.3	126.5	132.3	133.5

Addendum-Table 1d. Temperature Results for CVap Oven Cook, FDA Hold and Sell Hold.

Date	Time	Elapsed min.	Elapsed hr.	Roast-1 internal	Roast-2 internal	Roast-3 internal	Roast-4 internal	Roast-5 internal	Roast-6 internal	Roast-1 surface	Roast-2 surface	Roast-3 surface	Roast-4 surface	Roast-5 surface	Roast-6 surface	Oven-1	Oven-2
Oct/2/2007	23:52:00	1060	17.67			126.0		126.9	127.1			125.3	124.6	125.4	126.0	130.8	131.5
Oct/3/2007	0:07:00	1075	17.92			126.0		126.9	127.1			126.1	125.5	126.1	126.4	131.5	132.3
Oct/3/2007	0:22:00	1090	18.17			126.0		126.9	127.1			125.5	124.7	125.5	126.1	131.5	132.8
Oct/3/2007	0:37:00	1105	18.42			126.0		126.8	127.1			126.2	125.5	126.3	126.4	131.5	132.3
Oct/3/2007	0:52:00	1120	18.67			125.9		126.8	127.0			125.4	124.6	125.4	126.0	132.3	132.8
Oct/3/2007	1:07:00	1135	18.92			125.9		126.7	127.0			125.7	124.9	125.8	126.2	130.8	132.3
Oct/3/2007	1:22:00	1150	19.17			125.9		126.7	127.0			125.4	124.5	125.5	126.0	131.5	132.3
Oct/3/2007	1:37:00	1165	19.42			125.9		126.8	127.0			126.0	125.4	126.2	126.4	131.5	131.5
Oct/3/2007	1:52:00	1180	19.67			125.9		126.8	127.1			125.3	124.5	125.4	126.1	130.8	132.3
Oct/3/2007	2:07:00	1195	19.92			125.9		126.7	127.1			126.0	125.2	126.1	126.4	131.5	131.5
Oct/3/2007	2:22:00	1210	20.17			125.9		126.8	127.1			125.4	124.6	125.6	126.2	131.5	132.3
Oct/3/2007	2:37:00	1225	20.42			125.9		126.7	127.1			126.1	125.4	126.3	126.4	132.3	132.8
Oct/3/2007	2:52:00	1240	20.67			125.8		126.7	127.0			125.4	124.6	125.6	126.2	131.5	132.3
Oct/3/2007	3:07:00	1255	20.92			125.8		126.7	127.0			126.0	125.3	126.3	126.4	132.8	133.5
Oct/3/2007	3:22:00	1270	21.17			125.8		126.7	127.0			125.5	124.6	125.7	126.2	131.5	132.8
Oct/3/2007	3:37:00	1285	21.42			125.8		126.6	127.0			125.7	125.1	126.0	126.2	131.5	132.3
Oct/3/2007	3:52:00	1300	21.67			125.8		126.6	126.9			125.4	124.5	125.6	126.2	131.5	132.3
Oct/3/2007	4:07:00	1315	21.92			125.7		126.6	127.0			125.8	125.1	126.1	126.3	131.5	132.3
Oct/3/2007	4:22:00	1330	22.17			125.7		126.5	126.9			125.3	124.6	125.7	126.1	132.8	133.5
Oct/3/2007	4:37:00	1345	22.42			125.7		126.6	127.0			126.0	125.3	126.4	126.4	132.3	132.8
Oct/3/2007	4:52:00	1360	22.67			126.1		127.0	127.3			126.0	125.2	126.5	126.8	132.8	133.5
Oct/3/2007	5:07:00	1375	22.92			126.5		127.4	127.7			126.6	125.9	127.1	127.2	132.8	133.5
Oct/3/2007	5:22:00	1390	23.17			126.7		127.6	128.0			126.4	125.6	127.0	127.3	132.8	132.8
Oct/3/2007	5:37:00	1405	23.42			126.6		127.5	127.9			126.7	125.9	127.2	127.3	132.3	132.8
Oct/3/2007	5:52:00	1420	23.67			126.3		127.2	127.6			125.9	125.0	126.6	126.9	132.8	133.5
Oct/3/2007	6:07:00	1435	23.92			126.3		127.2	127.6			126.5	125.7	127.0	127.0	132.3	132.8
Oct/3/2007	6:22:00	1450	24.17			126.2		127.1	127.5			125.9	125.0	126.6	126.8	132.3	132.3
Oct/3/2007	6:37:00	1465	24.42			126.2		127.1	127.5			126.5	125.7	127.1	127.1	132.3	132.8
Oct/3/2007	6:52:00	1480	24.67			126.1		127.1	127.5			125.7	124.8	126.4	126.7	131.5	131.5
Oct/3/2007	7:07:00	1495	24.92			126.2		127.0	127.5			126.4	125.7	127.0	127.0	132.3	132.8
Oct/3/2007	7:22:00	1510	25.17			126.0		127.0	127.4			125.6	124.8	126.4	126.7	132.8	132.8
Oct/3/2007	7:37:00	1525	25.42			126.0		126.9	127.3			126.2	125.5	126.8	126.9	132.3	132.3
Oct/3/2007	7:52:00	1540	25.67			125.9		126.8	127.3			125.5	124.7	126.4	126.6	131.5	131.5
Oct/3/2007	8:07:00	1555	25.92			125.8		126.7	127.2			126.3	125.7	127.0	126.9	132.8	132.8
Oct/3/2007	8:22:00	1570	26.17			126.0		127.0	127.4			126.3	125.5	127.0	127.2	131.5	132.3
Oct/3/2007	8:37:00	1585	26.42			126.0		127.0	127.4			126.1	125.4	126.9	127.0	132.8	132.8
Oct/3/2007	8:52:00	1600	26.67			126.0		127.0	127.5			126.2	125.5	127.0	127.1	132.8	132.8
Oct/3/2007	9:07:00	1615	26.92			126.3		127.2	127.7			126.1	125.5	127.0	127.2	131.5	132.3
Oct/3/2007	9:22:00	1630	27.17			126.6		127.6	128.0			126.7	125.9	127.6	127.7	132.8	133.5
Oct/3/2007	9:37:00	1645	27.42			126.7		127.7	128.1			126.5	125.9	127.5	127.6	132.8	133.5
Oct/3/2007	9:52:00	1660	27.67			126.9		127.8	128.3			126.8	126.0	127.8	127.9	132.3	132.3
Oct/3/2007	10:07:00	1675	27.92			127.0		128.0	128.4			126.9	126.2	127.9	127.9	131.5	132.3
Oct/3/2007	10:22:00	1690	28.17			126.9		127.9	128.4			126.8	126.0	127.8	127.9	132.8	132.8
Oct/3/2007	10:37:00	1705	28.42			127.0		128.0	128.5			127.0	126.4	128.0	128.0	134.2	134.2
Oct/3/2007	10:52:00	1720	28.67			127.0		128.1	128.5			126.8	126.0	127.9	128.1	131.5	131.5
Oct/3/2007	11:07:00	1735	28.92			127.1		128.1	128.6			126.9	126.4	128.0	128.1	132.3	132.3

Addendum-Table 1e. Temperature Results for CVap Oven Cook, FDA Hold and Sell Hold.

Date	Time	Elapsed min.	Elapsed hr.	Roast-1 internal	Roast-2 internal	Roast-3 internal	Roast-4 internal	Roast-5 internal	Roast-6 internal	Roast-1 surface	Roast-2 surface	Roast-3 surface	Roast-4 surface	Roast-5 surface	Roast-6 surface	Oven-1	Oven-2
Oct/3/2007	11:22:00	1750	29.17			127.2		128.2	128.6			127.0	126.3	128.2	128.3	132.8	133.5
Oct/3/2007	11:37:00	1765	29.42			127.2		128.2	128.8			127.3	126.7	128.4	128.4	132.8	132.8
Oct/3/2007	11:52:00	1780	29.67			127.2		128.2	128.7			126.9	126.1	128.2	128.4	132.3	132.3
Oct/3/2007	12:07:00	1795	29.92			127.2		128.2	128.7			127.2	126.6	128.4	128.4	132.3	132.3
Oct/3/2007	12:22:00	1810	30.17			127.3		128.4	128.9			126.9	126.1	128.1	128.4	132.8	133.5
Oct/3/2007	12:37:00	1825	30.42			127.4		128.4	128.9			127.2	126.6	128.4	128.4	132.3	132.3
Oct/3/2007	12:52:00	1840	30.67			127.5		128.5	129.1			127.0	126.2	128.3	128.5	132.3	132.8
Oct/3/2007	13:07:00	1855	30.92			127.5		128.4	129.1			127.6	127.0	128.8	128.8	132.3	132.3
Oct/3/2007	13:22:00	1870	31.17			127.5		128.6	129.1			126.9	126.1	128.2	128.5	131.5	131.5
Oct/3/2007	13:37:00	1885	31.42			127.4		128.4	129.0			127.6	126.9	128.8	128.8	132.3	132.3
Oct/3/2007	13:52:00	1900	31.67			126.9		128.0	128.6			126.6	125.8	127.9	128.1	132.8	132.8
Oct/3/2007	14:07:00	1915	31.92			126.7		127.8	128.4			127.3	126.5	128.3	128.3	133.5	133.5
Oct/3/2007	14:22:00	1930	32.17			126.4		127.6	128.2			126.3	125.6	127.5	127.7	133.5	133.5
Oct/3/2007	14:37:00	1945	32.42			126.4		127.4	128.0			126.7	126.0	127.8	127.9	133.5	133.5
Oct/3/2007	14:52:00	1960	32.67			126.2		127.3	127.9			126.1	125.3	127.3	127.4	132.8	133.5
Oct/3/2007	15:07:00	1975	32.92			126.1		127.2	127.8			126.8	126.1	127.9	127.8	132.8	132.8
Oct/3/2007	15:22:00	1990	33.17			126.1		127.1	127.7			125.7	124.9	126.9	127.2	130.8	130.8
Oct/3/2007	15:37:00	2005	33.42			126.5		127.5	128.0			126.8	126.2	127.9	127.9	132.8	132.8
Oct/3/2007	15:52:00	2020	33.67			126.7		127.8	128.3			126.3	125.6	127.7	127.9	132.8	132.3
Oct/3/2007	16:07:00	2035	33.92			126.7		127.8	128.3			126.9	126.2	128.2	128.2	132.8	132.8
Oct/3/2007	16:22:00	2050	34.17			126.9		128.0	128.5			126.7	126.0	127.9	128.0	132.8	132.8
Oct/3/2007	16:37:00	2065	34.42			127.0		128.0	128.5			127.0	126.2	128.2	128.3	132.8	133.5
Oct/3/2007	16:52:00	2080	34.67			127.1		128.1	128.7			127.1	126.4	128.3	128.3	133.5	133.5
Oct/3/2007	17:07:00	2095	34.92			127.0		128.0	128.6			126.9	126.2	128.3	128.4	132.8	132.8
Oct/3/2007	17:22:00	2110	35.17			126.9		127.9	128.5			127.2	126.5	128.4	128.3	133.5	133.5
Oct/3/2007	17:37:00	2125	35.42			126.9		128.0	128.5			126.9	126.0	128.2	128.4	132.3	132.3
Oct/3/2007	17:52:00	2140	35.67			127.0		128.1	128.7			127.3	126.6	128.6	128.6	132.3	132.3
Oct/3/2007	18:07:00	2155	35.92			127.1		128.2	128.8			126.7	125.9	128.1	128.4	131.5	131.5
Oct/3/2007	18:22:00	2170	36.17			127.2		128.3	128.9			127.5	126.9	128.8	128.8	133.5	133.5
Oct/3/2007	18:37:00	2185	36.42			76.9		128.1	128.7			78.5	112.4	118.9	125.0	85.1	81.7
Oct/3/2007	18:52:00	2200	36.67			78.0		124.0	126.0			78.7	95.9	103.2	109.8	82.2	78.6

Addendum-Table 2a. Temperature Results for Chilling and Cold Hold of Roasts after CVap Oven Processing.

Date	Time	Elapsed min.	Elapsed hr.	Roast-5 internal	Roast-6 internal	Roast-4 surface	Roast-5 surface	Roast-6 surface	External-1	External-2
Oct/3/2007	18:22:00	2170	36.17	128.3	128.9	126.9	128.8	128.8	133.5	133.5
Oct/3/2007	18:37:00	2185	36.42	128.1	128.7	112.4	118.9	125.0	85.1	81.7
Oct/3/2007	18:52:00	2200	36.67	124.0	126.0	95.9	103.2	109.8	82.2	78.6
Oct/3/2007	19:07:00	2215	36.92	119.8	123.7	79.7	91.5	97.4	70.0	65.5
Oct/3/2007	19:22:00	2230	37.17	114.8	120.6	72.8	85.3	89.8	66.7	62.1
Oct/3/2007	19:37:00	2245	37.42	110.0	116.7	70.9	83.3	86.4	68.7	64.0
Oct/3/2007	19:52:00	2260	37.67	105.5	112.2	69.8	81.6	84.0	68.7	64.8
Oct/3/2007	20:07:00	2275	37.92	101.5	107.8	68.6	80.2	81.7	68.7	64.8
Oct/3/2007	20:22:00	2290	38.17	98.0	103.6	67.5	78.8	79.8	68.7	64.8
Oct/3/2007	20:37:00	2305	38.42	94.9	99.6	66.2	77.3	77.8	68.0	64.0
Oct/3/2007	20:52:00	2320	38.67	92.2	95.9	65.0	75.8	75.8	67.5	63.3
Oct/3/2007	21:07:00	2335	38.92	89.8	92.5	63.7	74.5	73.8	66.7	62.6
Oct/3/2007	21:22:00	2350	39.17	87.8	89.4	62.7	73.3	72.0	66.0	62.1
Oct/3/2007	21:37:00	2365	39.42	85.7	86.7	61.7	72.1	70.3	65.5	61.3
Oct/3/2007	21:52:00	2380	39.67	83.8	84.1	60.7	70.8	68.7	64.8	60.6
Oct/3/2007	22:07:00	2395	39.92	81.9	81.7	59.5	69.5	67.0	64.0	59.2
Oct/3/2007	22:22:00	2410	40.17	80.2	79.4	58.6	68.4	65.5	63.3	58.5
Oct/3/2007	22:37:00	2425	40.42	78.4	77.2	57.5	67.2	64.1	62.6	57.7
Oct/3/2007	22:52:00	2440	40.67	76.5	74.9	56.5	66.1	62.6	62.1	57.0
Oct/3/2007	23:07:00	2455	40.92	75.1	73.0	55.8	65.2	61.4	61.3	57.0
Oct/3/2007	23:22:00	2470	41.17	73.6	71.2	55.0	64.3	60.3	60.6	56.3
Oct/3/2007	23:37:00	2485	41.42	72.2	69.5	54.2	63.2	59.2	59.9	55.4
Oct/3/2007	23:52:00	2500	41.67	70.7	67.9	53.3	62.1	58.1	59.2	54.7
Oct/4/2007	0:07:00	2515	41.92	69.5	66.4	52.7	61.1	57.2	58.5	54.0
Oct/4/2007	0:22:00	2530	42.17	68.2	64.9	52.1	60.2	56.3	58.5	54.0
Oct/4/2007	0:37:00	2545	42.42	67.0	63.5	51.5	59.3	55.5	57.7	54.0
Oct/4/2007	0:52:00	2560	42.67	65.9	62.3	50.9	58.6	54.7	57.0	53.2
Oct/4/2007	1:07:00	2575	42.92	65.0	61.3	50.5	57.9	54.0	56.3	53.2
Oct/4/2007	1:22:00	2590	43.17	64.1	60.3	50.2	57.4	53.4	56.3	52.3
Oct/4/2007	1:37:00	2605	43.42	63.2	59.2	49.8	56.9	52.7	56.3	52.3
Oct/4/2007	1:52:00	2620	43.67	62.2	58.2	49.5	56.5	52.2	55.4	52.3
Oct/4/2007	2:07:00	2635	43.92	61.6	57.4	49.1	56.2	51.6	55.4	51.6
Oct/4/2007	2:22:00	2650	44.17	60.8	56.6	48.7	55.7	51.1	54.7	51.6
Oct/4/2007	2:37:00	2665	44.42	60.1	55.9	48.4	55.2	50.7	54.7	50.7
Oct/4/2007	2:52:00	2680	44.67	59.5	55.2	48.0	54.7	50.2	54.0	50.7
Oct/4/2007	3:07:00	2695	44.92	58.7	54.4	47.4	53.9	49.6	54.0	50.0
Oct/4/2007	3:22:00	2710	45.17	58.2	53.9	47.2	53.4	49.4	54.0	50.0
Oct/4/2007	3:37:00	2725	45.42	57.6	53.3	46.8	52.7	49.0	54.0	49.1
Oct/4/2007	3:52:00	2740	45.67	57.0	52.7	46.4	51.9	48.7	54.0	49.1
Oct/4/2007	4:07:00	2755	45.92	56.4	52.3	46.1	51.5	48.5	54.0	49.1
Oct/4/2007	4:22:00	2770	46.17	56.0	51.8	45.7	51.3	48.1	53.2	48.4
Oct/4/2007	4:37:00	2785	46.42	55.5	51.3	45.4	51.5	47.6	54.0	48.4
Oct/4/2007	4:52:00	2800	46.67	55.0	50.8	45.0	51.3	47.0	54.0	48.4
Oct/4/2007	5:07:00	2815	46.92	54.7	50.3	44.8	51.3	46.8	54.0	48.4
Oct/4/2007	5:22:00	2830	47.17	54.3	49.9	44.9	51.2	46.6	54.0	48.4
Oct/4/2007	5:37:00	2845	47.42	54.0	49.4	44.9	51.1	46.5	54.0	48.4
Oct/4/2007	5:52:00	2860	47.67	53.7	49.1	44.7	51.0	46.3	54.0	48.4
Oct/4/2007	6:07:00	2875	47.92	53.4	48.7	44.6	50.8	46.1	54.0	48.4
Oct/4/2007	6:22:00	2890	48.17	53.2	48.4	44.5	50.7	45.9	54.0	48.4
Oct/4/2007	6:37:00	2905	48.42	53.0	48.2	44.5	50.7	46.0	54.0	48.4
Oct/4/2007	6:52:00	2920	48.67	52.9	48.1	44.5	50.7	46.0	54.0	48.4
Oct/4/2007	7:07:00	2935	48.92	52.9	48.0	44.6	50.7	45.9	54.0	48.4
Oct/4/2007	7:22:00	2950	49.17	52.6	47.7	44.6	50.6	45.8	54.0	48.4
Oct/4/2007	7:37:00	2965	49.42	52.3	47.4	44.5	50.4	45.7	54.0	48.4
Oct/4/2007	7:52:00	2980	49.67	52.3	47.3	44.6	50.5	45.8	54.0	48.4
Oct/4/2007	8:07:00	2995	49.92	52.1	47.2	44.6	50.4	45.7	54.0	48.4
Oct/4/2007	8:22:00	3010	50.17	52.1	47.1	44.6	50.4	45.6	54.0	48.4
Oct/4/2007	8:37:00	3025	50.42	51.9	46.9	44.6	50.4	45.6	54.0	48.4
Oct/4/2007	8:52:00	3040	50.67	51.8	46.8	44.4	50.2	45.4	54.0	48.4
Oct/4/2007	9:07:00	3055	50.92	51.7	46.8	44.5	50.2	45.5	54.0	48.4

Addendum-Table 2b. Temperature Results for Chilling and Cold Hold of Roasts after CVap Oven Processing.

Date	Time	Elapsed min.	Elapsed hr.	Roast-5 internal	Roast-6 internal	Roast-4 surface	Roast-5 surface	Roast-6 surface	External-1	External-2
Oct/4/2007	9:22:00	3070	51.17	51.6	46.6	44.5	50.2	45.4	54.0	48.4
Oct/4/2007	9:37:00	3085	51.42	51.3	46.4	44.4	50.0	45.3	54.0	48.4
Oct/4/2007	9:52:00	3100	51.67	51.2	46.3	44.4	50.0	45.3	54.0	48.4
Oct/4/2007	10:07:00	3115	51.92	51.2	46.3	44.4	49.9	45.3	54.0	48.4
Oct/4/2007	10:22:00	3130	52.17	51.1	46.2	44.4	49.8	45.2	54.0	48.4
Oct/4/2007	10:37:00	3145	52.42	51.0	46.1	44.2	49.7	45.1	54.0	48.4
Oct/4/2007	10:52:00	3160	52.67	50.9	46.1	44.2	49.7	45.0	54.0	48.4
Oct/4/2007	11:07:00	3175	52.92	50.9	46.1	44.1	49.6	45.0	54.0	48.4
Oct/4/2007	11:22:00	3190	53.17	50.8	46.0	44.1	49.6	45.0	54.0	48.4
Oct/4/2007	11:37:00	3205	53.42	50.6	45.8	43.9	49.4	44.7	54.0	48.4
Oct/4/2007	11:52:00	3220	53.67	50.5	45.7	44.1	49.4	44.8	54.0	48.4
Oct/4/2007	12:07:00	3235	53.92	50.5	45.7	44.2	49.4	44.9	54.0	49.1
Oct/4/2007	12:22:00	3250	54.17	50.4	45.7	44.1	49.4	44.9	54.0	49.1
Oct/4/2007	12:37:00	3265	54.42	50.4	45.6	44.1	49.3	44.8	54.7	49.1
Oct/4/2007	12:52:00	3280	54.67	50.3	45.6	44.1	49.4	44.9	54.0	49.1
Oct/4/2007	13:07:00	3295	54.92	50.2	45.5	44.1	49.3	44.8	54.7	49.1
Oct/4/2007	13:22:00	3310	55.17	50.2	45.5	44.7	49.4	45.0	54.7	50.0
Oct/4/2007	13:37:00	3325	55.42	50.0	45.3	44.2	49.2	44.7	54.7	49.1
Oct/4/2007	13:52:00	3340	55.67	49.9	45.2	43.9	49.0	44.5	54.7	49.1
Oct/4/2007	14:07:00	3355	55.92	49.9	45.2	43.8	48.9	44.4	54.7	49.1
Oct/4/2007	14:22:00	3370	56.17	49.9	45.2	43.6	48.8	44.3	54.7	49.1
Oct/4/2007	14:37:00	3385	56.42	49.8	45.2	43.5	48.8	44.2	54.7	49.1
Oct/4/2007	14:52:00	3400	56.67	50.0	45.3	43.6	48.9	44.4	54.7	49.1
Oct/4/2007	15:07:00	3415	56.92	49.8	45.2	43.7	48.8	44.4	54.7	49.1
Oct/4/2007	15:22:00	3430	57.17	49.9	45.3	43.9	49.0	44.6	54.7	49.1
Oct/4/2007	15:37:00	3445	57.42	50.0	45.4	44.1	49.1	44.7	54.7	50.0
Oct/4/2007	15:52:00	3460	57.67	50.0	45.5	44.3	49.3	45.0	55.4	50.0
Oct/4/2007	16:07:00	3475	57.92	50.3	45.7	47.6	51.2	46.9	60.6	54.0
Oct/4/2007	16:22:00	3490	58.17	50.6	46.0	54.4	55.4	50.6	76.8	85.1
Oct/4/2007	16:37:00	3505	58.42	49.9	45.4	46.0	47.9	46.1	50.7	45.7
Oct/4/2007	16:52:00	3520	58.67	49.4	45.5	40.4	42.3	42.1	42.1	36.3
Oct/4/2007	17:07:00	3535	58.92	48.5	45.5	38.7	40.6	40.7	41.2	38.3
Oct/4/2007	17:22:00	3550	59.17	47.5	45.3	39.5	42.3	41.6	57.0	49.1
Oct/4/2007	17:37:00	3565	59.42	46.7	44.8	36.9	41.5	41.2	44.1	44.1
Oct/4/2007	17:52:00	3580	59.67	46.0	44.4	35.9	40.7	40.6	43.2	43.2
Oct/4/2007	18:07:00	3595	59.92	45.1	43.8	34.7	39.6	39.8	42.1	42.1
Oct/4/2007	18:22:00	3610	60.17	44.1	43.1	33.8	38.7	39.0	41.2	41.2
Oct/4/2007	18:37:00	3625	60.42	43.5	42.6	33.2	38.1	38.6	40.3	40.3
Oct/4/2007	18:52:00	3640	60.67	42.8	42.3		39.3	39.5	45.7	45.0
Oct/4/2007	19:07:00	3655	60.92	42.3	41.9		38.8	39.0	44.1	43.2
Oct/4/2007	19:22:00	3670	61.17	41.8	41.5		37.9	38.4	42.1	42.1
Oct/4/2007	20:22:00	3730	62.17	39.1	39.3		34.1	35.3	37.4	36.3
Oct/4/2007	21:22:00	3790	63.17	36.5	37.3		31.5	32.9	34.2	33.1
Oct/4/2007	22:22:00	3850	64.17	34.3	35.1		36.0	35.5	49.1	48.4
Oct/4/2007	23:22:00	3910	65.17	34.4	34.8		32.4	33.2	39.4	39.4
Oct/5/2007	0:22:00	3970	66.17	33.6	34.5		30.1	31.4	34.2	34.2
Oct/5/2007	1:22:00	4030	67.17	31.7	32.9		29.2	30.5	35.2	35.2
Oct/5/2007	2:22:00	4090	68.17	30.3	31.7		27.6	28.9	33.1	33.1
Oct/5/2007	3:22:00	4150	69.17	29.2	30.6		27.0	28.3	33.1	33.1
Oct/5/2007	4:22:00	4210	70.17	27.7	29.2		25.9	27.3	32.0	32.0
Oct/5/2007	5:22:00	4270	71.17	27.1	28.6		26.8	27.5	36.3	35.2
Oct/5/2007	6:22:00	4330	72.17	27.0	28.0		32.3	31.4	49.1	49.1
Oct/5/2007	7:22:00	4390	73.17	28.7	29.2		28.4	29.2	37.4	37.4

Addendum-Table 3a. Temperature Results for CVap Oven Re-Therm Process

Date	Time	Elapsed min.	Elapsed hr.	Roast-6 internal	External-1	External-2
Oct/5/2007	7:22:00	4390	73.17	29.2	37.4	37.4
Oct/5/2007	7:27:00	4395	73.25	31.3	73.2	79.3
Oct/5/2007	7:32:00	4400	73.33	30.2	147.0	118.4
Oct/5/2007	7:37:00	4405	73.42	30.8	164.7	169.7
Oct/5/2007	7:42:00	4410	73.50	31.9	168.6	172.8
Oct/5/2007	7:47:00	4415	73.58	33.7	169.7	172.8
Oct/5/2007	7:52:00	4420	73.67	35.9	168.6	171.7
Oct/5/2007	7:57:00	4425	73.75	38.7	169.7	172.8
Oct/5/2007	8:02:00	4430	73.83	41.7	169.7	172.8
Oct/5/2007	8:07:00	4435	73.92	45.0	170.6	173.8
Oct/5/2007	8:12:00	4440	74.00	48.4	170.6	172.8
Oct/5/2007	8:17:00	4445	74.08	52.0	170.6	173.8
Oct/5/2007	8:22:00	4450	74.17	55.4	170.6	173.8
Oct/5/2007	8:27:00	4455	74.25	59.0	170.6	172.8
Oct/5/2007	8:32:00	4460	74.33	62.5	171.7	173.8
Oct/5/2007	8:37:00	4465	74.42	65.8	170.6	172.8
Oct/5/2007	8:42:00	4470	74.50	69.1	171.7	173.8
Oct/5/2007	8:47:00	4475	74.58	72.4	170.6	172.8
Oct/5/2007	8:52:00	4480	74.67	75.6	170.6	173.8
Oct/5/2007	8:57:00	4485	74.75	78.7	171.7	173.8
Oct/5/2007	9:02:00	4490	74.83	81.5	171.7	172.8
Oct/5/2007	9:07:00	4495	74.92	84.2	170.6	172.8
Oct/5/2007	9:12:00	4500	75.00	86.9	171.7	173.8
Oct/5/2007	9:17:00	4505	75.08	89.4	171.7	173.8
Oct/5/2007	9:22:00	4510	75.17	91.9	171.7	172.8
Oct/5/2007	9:27:00	4515	75.25	94.2	170.6	172.8
Oct/5/2007	9:32:00	4520	75.33	96.6	171.7	173.8
Oct/5/2007	9:37:00	4525	75.42	98.8	171.7	173.8
Oct/5/2007	9:42:00	4530	75.50	101.0	170.6	172.8
Oct/5/2007	9:47:00	4535	75.58	103.2	170.6	172.8
Oct/5/2007	9:52:00	4540	75.67	105.3	171.7	173.8
Oct/5/2007	9:57:00	4545	75.75	107.3	167.7	168.6
Oct/5/2007	10:02:00	4550	75.83	109.4	157.5	156.6
Oct/5/2007	10:07:00	4555	75.92	111.3	148.5	147.7
Oct/5/2007	10:12:00	4560	76.00	113.0	141.8	141.8
Oct/5/2007	10:17:00	4565	76.08	114.6	136.9	136.2
Oct/5/2007	10:22:00	4570	76.17	116.0	132.8	132.3
Oct/5/2007	10:27:00	4575	76.25	117.2	132.3	132.3
Oct/5/2007	10:32:00	4580	76.33	118.2	133.5	134.8
Oct/5/2007	10:37:00	4585	76.42	119.0	132.3	132.8
Oct/5/2007	10:42:00	4590	76.50	119.7	132.8	133.5
Oct/5/2007	10:47:00	4595	76.58	120.3	132.3	132.8
Oct/5/2007	10:52:00	4600	76.67	120.9	132.8	133.5
Oct/5/2007	10:57:00	4605	76.75	121.3	130.8	131.5
Oct/5/2007	11:02:00	4610	76.83	121.7	131.5	132.3
Oct/5/2007	11:07:00	4615	76.92	122.0	132.8	133.5
Oct/5/2007	11:12:00	4620	77.00	122.3	131.5	132.3
Oct/5/2007	11:17:00	4625	77.08	122.4	132.8	133.5
Oct/5/2007	11:22:00	4630	77.17	122.7	131.5	132.8
Oct/5/2007	11:27:00	4635	77.25	122.8	133.5	134.8
Oct/5/2007	11:32:00	4640	77.33	123.1	131.5	132.3
Oct/5/2007	11:37:00	4645	77.42	123.3	132.3	133.5
Oct/5/2007	11:42:00	4650	77.50	123.4	132.8	133.5
Oct/5/2007	11:47:00	4655	77.58	123.5	132.3	132.8
Oct/5/2007	11:52:00	4660	77.67	123.7	130.8	131.5
Oct/5/2007	11:57:00	4665	77.75	123.9	131.5	132.3
Oct/5/2007	12:02:00	4670	77.83	124.0	131.5	132.3
Oct/5/2007	12:07:00	4675	77.92	124.1	132.3	133.5
Oct/5/2007	12:12:00	4680	78.00	124.0	132.3	132.8
Oct/5/2007	12:17:00	4685	78.08	124.0	131.5	131.5
Oct/5/2007	12:22:00	4690	78.17	123.6	131.5	131.5
Oct/5/2007	12:27:00	4695	78.25	123.7	132.3	133.5

Addendum-Table 3b. Temperature Results for CVap Oven Re-Therm Process

Date	Time	Elapsed min.	Elapsed hr.	Roast-6 internal	External-1	External-2
Oct/5/2007	12:32:00	4700	78.33	123.8	131.5	132.3
Oct/5/2007	12:37:00	4705	78.42	123.9	130.8	131.5
Oct/5/2007	12:42:00	4710	78.50	124.0	130.8	131.5
Oct/5/2007	12:47:00	4715	78.58	124.0	131.5	132.3
Oct/5/2007	12:52:00	4720	78.67	124.1	131.5	132.8
Oct/5/2007	12:57:00	4725	78.75	124.1	132.3	132.8
Oct/5/2007	13:02:00	4730	78.83	124.1	130.8	131.5
Oct/5/2007	13:07:00	4735	78.92	124.1	131.5	132.8
Oct/5/2007	13:12:00	4740	79.00	124.1	131.5	132.3
Oct/5/2007	13:17:00	4745	79.08	124.1	130.8	130.8
Oct/5/2007	13:22:00	4750	79.17	124.3	130.8	131.5
Oct/5/2007	13:27:00	4755	79.25	124.2	131.5	132.8
Oct/5/2007	13:32:00	4760	79.33	124.3	130.8	131.5
Oct/5/2007	13:37:00	4765	79.42	124.4	131.5	132.3
Oct/5/2007	13:42:00	4770	79.50	124.5	131.5	132.3
Oct/5/2007	13:47:00	4775	79.58	124.6	132.3	132.8
Oct/5/2007	13:52:00	4780	79.67	124.6	130.8	131.5
Oct/5/2007	13:57:00	4785	79.75	124.7	131.5	132.3
Oct/5/2007	14:02:00	4790	79.83	124.7	130.8	131.5
Oct/5/2007	14:07:00	4795	79.92	124.7	130.8	131.5
Oct/5/2007	14:12:00	4800	80.00	124.8	131.5	132.3
Oct/5/2007	14:17:00	4805	80.08	124.8	130.8	131.5
Oct/5/2007	14:22:00	4810	80.17	124.8	132.3	133.5
Oct/5/2007	14:27:00	4815	80.25	124.9	131.5	132.3
Oct/5/2007	14:32:00	4820	80.33	124.8	131.5	132.3
Oct/5/2007	14:37:00	4825	80.42	125.0	132.3	132.8
Oct/5/2007	14:42:00	4830	80.50	125.1	130.8	131.5
Oct/5/2007	14:47:00	4835	80.58	125.1	131.5	132.3
Oct/5/2007	14:52:00	4840	80.67	125.0	132.3	132.8
Oct/5/2007	14:57:00	4845	80.75	125.1	131.5	132.3
Oct/5/2007	15:02:00	4850	80.83	125.0	131.5	132.8
Oct/5/2007	15:07:00	4855	80.92	125.1	132.3	132.8
Oct/5/2007	15:12:00	4860	81.00	125.1	131.5	131.5
Oct/5/2007	15:17:00	4865	81.08	125.1	131.5	132.3
Oct/5/2007	15:22:00	4870	81.17	125.1	131.5	132.3
Oct/5/2007	15:27:00	4875	81.25	125.2	129.6	130.3
Oct/5/2007	15:32:00	4880	81.33	125.2	131.5	132.3
Oct/5/2007	15:37:00	4885	81.42	125.3	132.3	132.8
Oct/5/2007	15:42:00	4890	81.50	125.3	132.3	133.5
Oct/5/2007	15:47:00	4895	81.58	125.4	132.3	132.8
Oct/5/2007	15:52:00	4900	81.67	125.4	131.5	131.5
Oct/5/2007	15:57:00	4905	81.75	125.5	130.3	130.8
Oct/5/2007	16:02:00	4910	81.83	125.6	131.5	132.3
Oct/5/2007	16:07:00	4915	81.92	125.6	132.3	132.8
Oct/5/2007	16:12:00	4920	82.00	125.8	132.3	132.8
Oct/5/2007	16:17:00	4925	82.08	125.8	131.5	131.5
Oct/5/2007	16:22:00	4930	82.17	125.9	130.3	130.8
Oct/5/2007	16:27:00	4935	82.25	125.9	131.5	132.3
Oct/5/2007	16:32:00	4940	82.33	126.0	131.5	132.3
Oct/5/2007	16:37:00	4945	82.42	126.1	130.8	131.5
Oct/5/2007	16:42:00	4950	82.50	126.1	132.3	132.8
Oct/5/2007	16:47:00	4955	82.58	126.2	132.8	133.5
Oct/5/2007	16:52:00	4960	82.67	126.2	132.3	132.3
Oct/5/2007	16:57:00	4965	82.75	126.3	131.5	131.5
Oct/5/2007	17:02:00	4970	82.83	126.3	132.8	133.5
Oct/5/2007	17:07:00	4975	82.92	126.3	132.3	132.8
Oct/5/2007	17:12:00	4980	83.00	126.4	131.5	131.5
Oct/5/2007	17:17:00	4985	83.08	126.3	130.8	131.5
Oct/5/2007	17:22:00	4990	83.17	126.3	132.3	132.8
Oct/5/2007	17:27:00	4995	83.25	126.5	132.8	133.5
Oct/5/2007	17:32:00	5000	83.33	126.5	133.5	134.8
Oct/5/2007	17:37:00	5005	83.42	102.6	108.0	105.6