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A Case Study of a School Foodservice Cook-Chill Operation to Develop a Hazard Analysis Critical Control Point Program

Karen M. Blakeslee and Karen P. Penner*

SUMMARY

A case study was conducted of a school foodservice cook-chill operation to establish a Hazard Analysis Critical Control Point (HACCP) program for four ground beef entrees. Focus groups assessed employee knowledge and attitudes about cook-chill production, food safety, and HACCP. Managers were knowledgeable about food safety but cited lack of time as an impediment to implementation. Time and temperature measurements documented cooking, chilling, reheating, and serving functions. Product internal temperatures reached 184.5 ± 5.9°F prior to chilling. Blast chilling cooled products to 40°F within 2.0 ± 0.8 h. On reheating, product temperature reached 184.9 ± 10.6°F in 40.0 ± 17.9 min. A holding temperature of >140°F was sustained for 71.4 ± 4.5 min. Environmental sanitation was analyzed using adenosine triphosphate bioluminescence. Inconsistencies signified the need to establish standard sanitation practices. Microbiological tests included aerobic plate count (APC), total coliforms, *Escherichia coli* spp., *E. coli* O157:H7, *Salmonella* spp., *Staphylococcus aureus*, and *Clostridium perfringens*. All tests were negative for *E. coli* O157:H7. Raw ground beef contained *Salmonella* spp., *S. aureus*, *C. perfringens*, an APC of $2.4 \times 10^5 \pm 4.3 \times 10^5$ CFU/g, a total coliform count of $3.6 \times 10^2 \pm 5.3 \times 10^2$ CFU/g, and an *E. coli* count of $3.3 \times 10^2 \pm 6.9 \times 10^2$ CFU/g. Cooking reduced the APC by 3 to 4 log cycles and eliminated total coliforms and *E. coli*. *Salmonella* spp., however, survived processing or reappeared through recontamination.

INTRODUCTION

In 1995, Unified School District (USD) 383 in Manhattan, KS, broke ground to build a new central kitchen to service 6,274 students in 15 schools (11 elementary, 2 middle, and 2 high) serving 3,200 lunches and 700 breakfasts each day. The kitchen also services HeadStart, summer feeding, and a day-care center. The central kitchen replaced base kitchens that prepared hot meals that were transported to the remaining schools on the same day. One of the base kitchens, which was only 4 years old, produced 2,500 meals in a facility designed to produce 2,000 meals. With the addition of two new middle schools, another base kitchen would have been needed. Based on the advice of consultants, the central kitchen was identified as the best option to replace the four base kitchens and save money as well as increasing product quality, product safety, and customer service *(12)*. The design of the central and satellite kitchens included a cook-chill production system to prepare products, chill them rapidly, transport them to the schools, reheat them, and serve them to the students. A decision was made to incorporate a Hazard Analysis Critical Control Point (HACCP) plan to ensure the safety of the food prepared at the central kitchen and schools. This project was a case study to design a HACCP program for USD 383, using four ground beef products, and to incorporate the HACCP procedures into the recipes being produced in the central kitchen cook-chill facility and served at the schools. This article focuses on the cook-chill operation, microbiological analysis, and the effectiveness of cleaning and sanitation.

MATERIALS AND METHODS

Procedures were performed in the central kitchen cook-chill operation and one elementary school. Focus groups were conducted with all school managers and central kitchen managers to determine attitudes and knowledge about HACCP, food safety, and the cook-chill system. We assumed that the data gathered at the school are representative of all schools, so that general recommendations can be made. For the initial HACCP study, four products were chosen: spaghetti sauce, taco meat, chili, and sloppy joe meat. These products all contain ground beef, which has been the source of several outbreaks of foodborne illness. Ground beef products were evaluated at these points: raw meat prior to cooking, preparation, chilling, reheating, and service. Variables measured were time, temperature, microbiological growth in the products, and environmental sanitation effectiveness. All numerical data were analyzed with SPSS 7.5 for Windows® Student Version.

Focus groups

Two focus group sessions were conducted, the first of which was prior to the opening of the central kitchen. The purpose of this session was to determine perceptions of the central kitchen managers and satellite kitchen managers about food safety, HACCP, and the new cook-chill system following methods outlined by RIVA Market Research, Inc. *(9)*. A moderator's guide, developed in consultation with two faculty members, served as a script. The session was recorded on tape to obtain an accurate record of the discussion.

At the beginning of the focus group session, each participant responded to a questionnaire on knowledge of food safety and HACCP. They evaluated themselves on their use and frequency of some basic food safety practices, using a Likert scale *(8)* of 1 to 5 (1 = never; 5 = always). Participants also rated their level of knowledge of microorganisms and potential hazards in school foodservice on a Likert scale of 1 to 5 (1 = no knowledge; 5 = complete knowledge). They also provided demographic data and information about their foodservice experience and training in HACCP.

A second focus group was conducted to determine the managers' knowledge, practices and attitudes about food safety, HACCP, and the cook-chill system after 7 months experience with the new system. The same questionnaire was used to determine whether any self-reported change had occurred in food handling practices and knowledge about food safety and HACCP.

Cook-chill

Ground beef was received frozen in boxes of 5-pound chubs from a local meat wholesaler before the start of the school year. It was stored at the central kitchen in a freezer (0 to 10°F). Canned products were purchased in cases of six #10 cans. These and all dry ingredients were kept in dry storage.

Based on the menu, schools placed food orders 2 weeks in advance of scheduled service. From these orders, production was scheduled to make the product 2 days in advance of serving. Two days prior to production, ground beef was taken from the freezer to the thawing cooler (33 to 39°F), removed from boxes and placed in a single layer on trays on a rolling cart. One day prior to production, dry ingredients were measured and canned items were removed from storage.

On the day of production, the kettle and pump-fill station (Groen CAPKOLD®, Elk Grove Village, IL) were sanitized with a solution of 8 fluid ounces of 5.25% sodium hypochlorite chlorine solution (Nugget® Brand Bleach, Stockton, CA) in 60 gallons of 140°F water for approximately 30 min and then pumped out. The steam in the kettle jacket kept the sanitizing solution at the proper temperature. The ground beef was precooked in tilting fry pans (Groen, Elk Grove Village, IL). The amount of ground beef used varied depending on production needs. When the meat was cooked to at least 165°F, the grease was removed by straining the meat through a hand strainer. The meat was then transferred to a 100-gallon cooking kettle and heated with agitation to ensure that all pieces of meat were cooked thoroughly. The dry and liquid ingredients were added. The entire mixture was agitated and heated to an

internal temperature of 180°F for 15 s, using the thermometer located inside the shaft of the kettle agitator. The product temperature was recorded on a continuous circular recording chart (Honeywell, York, PA). The quantities prepared varied.

The product was pumped through a 4-inch transfer hose from the bottom of the kettle to the pump-fill station. The pump-fill station was programmed to pump 1-gallon quantities. Plastic bags sealed with a metal clip on one end were held up to the filler head. Each bag was filled with 1 gallon of product. As much air as possible was removed from the bag, and the bag was sealed with a metal clip. The bag was tagged with the product name and Julian date of production. The bags, designed especially for cook-chill operations, are made from a multi-layered, coextruded material combining nylon and linear low-density polyethylene (LLDPE) with a thickness of 4.5 ml. They can withstand temperatures up to 250°F, are highly durable, and provide extended shelf life for several weeks (C & K Mftg, West Lake, OH).

The filled bags were placed in single layers no more than 2 inches thick on rolling wire racks. When filled, the rack was rolled into a blast chiller (Cross-Cool™ by OmniTemp, Downey, CA). A Dickson Data Logger was used to monitor the time and temperature required to chill the bagged product from 180°F to below 40°F in the blast chiller. The temperature probe was placed so that the bagged product surrounded the probe but maintained the same thickness as other bagged product. The chiller was turned on and the starting time and temperature were recorded. When the product reached a minimum chill temperature of 40°F, the rack was rolled into refrigerated storage units (Kolpak, Parsons, TN). This product was ready to be trucked to satellite schools on the following day.

Two transportation routes were used for delivering food. The bags of product were transported in insulated food carts (Food Warming Equipment, Crystal Lake, IL), one cart per school with the number of bags per cart varying depending on the quantity ordered. The carts which were not refrigerated during delivery were loaded by central kitchen employees early in the morning and kept in refrigerated storage until time to load the truck. At the school, the product was removed from the cart by the driver and placed into the refrigerator at 28 to 32°F (Beverage-Air®, Spartanburg, SC). The Dickson Data Logger was used on one occasion to record product temperature during transport from the central kitchen to the satellite schools, beginning when the cart was loaded and ending at the final delivery stop. The two-channel logger recorded ambient air temperature and product temperature.

Heating

On the day of service at the satellite school, the bags to be reheated were removed from the refrigerator, an average of 2.5 h prior to service. Several methods were utilized to heat the product to determine the best method for the school. One method consisted of removing the cold product from the bags, placing it into a 4 inch-deep pan, and heating it in a convection oven (Blodgett, Burlington, VT) at 350°F for 1 to 2 hours. In another method, bags were placed in a 4 inch-deep pan with water surrounding and covering the bag. Two pans of product were placed in a HyPerSteam Atmospheric steamer Model HY-3E (Groen, Elk Grove Village, IL) and heated for 30 min, after which the temperature of the product was verified by wrapping the bag around a Taylor Type K model 9800 thermocouple digital thermometer. This thermometer has a temperature range of -40°F to 500°F, with accuracy of ± 1.6°F. If the temperature did not reach 180°F, the product was returned to the steamer to continue heating. When at 180°F, the pan of bagged product was placed into the convection oven at 250°F to keep warm. After all bagged product had been heated, it was poured from the bags into 4 inch-deep counter pans, covered with foil, and placed into a preheated hot cart (Precision Industries Inc., USA).

At the time of service, one pan at a time was removed from the hot cart and placed in the hot food serving station (Seco®, Washington, VT). The temperature was verified to ensure that it was above 140°F. During service, the temperature was verified again. Lunch service lasted for 1 h and 10 min. Any product to be kept for the next day was covered with foil and placed in the refrigerator to cool (28 to 32°F).

Microbial analysis

Samples were obtained for microbiological testing before, during, and after processing at the central kitchen and at the school. Five different food samples were taken for microbial testing. For each of four different products (spaghetti sauce, taco meat, chili, and sloppy joe meat), samples for microbial analyses included raw ground beef, cooked product after blast chilling, reheated product at the time of serving at school, and cooked product after 5 and 10 days of storage. The 5- and 10-day samples were taken to determine shelf-life stability. The product samples, except for the sample obtained after serving, were bagged product. From the entire amount of ground beef used for each product, portions of raw ground beef were randomly collected, using aseptic techniques and placed in sterile bags. The raw portions were commingled to get a uniform sample for analysis. The school sample was taken by use of the serving spoon and was transferred to a sterile bag. All samples were transferred and kept at 28 to 32°F and analyzed on the day of sampling.

For each of the five samples, aerobic plate count (APC), coliforms/ *Escherichia coli* count, *E. coli* O157: H7, *Salmonella* spp., *Staphylococcus aureus*, and *Clostridium perfringens* were determined. Environmental samples taken with sterile swabs from the drains in the central kitchen were analyzed for *Listeria monocytogenes.*

All tests were conducted following the FDA Bacteriological Analyti-

cal Manual *(3)* and the Compendium of Methods for the Microbiological Examination of Foods *(11)*. Rapid methods for microbial analysis were used when possible. These included 3M Petrifilm™ APC and coliform/ *E. coli* plates (3M Petrifilm™, St. Paul, MN); Remel RIM *E. coli* O157:H7 latex test (Remel, Lenexa, KS) for presumptive identification of *E. coli* serogroup O157:H7; and Fung's double tube system for recovery and enumeration of *Clostridium perfringens (1)*.

The counts for APC, total coliforms, and *E. coli* were determined in duplicate with 3M Petrifilm Plates (3M Petrifilm™, St. Paul, MN). A 50 g subsample was taken from the commingled sample, placed in a filtered stomacher bag with 450 ml of 1% sterile peptone water, and stomached for 2 min. Serial dilutions were made for each sample. Coliform/*E. coli* plates were incubated at 32°C for 24 h and APC plates at 37°C for 48 h.

Fung's double tube method was used to detect *C. perfringens (1)*. A 25 g sample was placed in a stomacher bag along with 75 ml sterile 1% peptone dilution water. The sample was stomached for 2 min, and serial dilutions were made. A 1 ml sample was transferred to 22.5 ml of Shahidi Ferguson perfringens agar with 0.1 ml of D-cycloserine in a large tube. An inner tube was inserted, and the tube system was capped and incubated at 37°C for 48 h. Black colonies were picked up with a needle and stabbed into motility test medium and lactose-gelatin media, which were incubated at 37°C for 24 h. Gelatin samples that changed color from red to yellow were chilled for 1 h at 5°C, and any sample that gelled was incubated for another 24 h at 37°C. Motility-negative samples and liquefied gelatin in 48 h were considered presumptive positive for *C. perfringens (3)*.

To determine the presence of *E. coli* O157:H7, a 25 g sample was placed in modified EC broth with novobiocin, stomached 2 min, and incubated at 37°C for 24 h. Serial dilutions were made and streaked on MacConkey sorbitol agar plates, which were incubated at 42°C overnight *(11)*. Sorbitol negative colonies (white) were tested using the Remel RIM *E. coli* O157:H7 latex test.

To determine *Staphylococcus aureus* count, a 25 g sample was placed in 75 ml sterile 1% peptone and stomached for 2 min. Serial dilutions were made and a 1 ml sample was transferred to 3 plates of Baird-Parker agar at 0.4 ml, 0.3 ml, and 0.3 ml per plate. Plates were incubated at 37°C for 48 h. Typical colonies were transferred to small tubes containing 0.3 ml brain heart infusion broth and 0.5 ml reconstituted coagulase plasma. Firmly clotted tubes were considered positive for *S. aureus (3)*.

Salmonella spp. were detected by placing a 25 g sample in 225 ml lactose broth and incubating at 37°C for 24 h. One ml aliquots were transferred to sterile selenite cystine broth and tetrathionate broth, and broths were incubated at 37°C for 24 h. After enrichment, a sample from each broth was streaked onto bismuth sulfite agar, xylose lysine desoxycholate agar, and hektoen enteric agar. All plates were incubated at 37°C for 24 h. Suspected colonies of *Salmonella* were inoculated in triple sugar iron slants and lysine iron agar slants. All slants were incubated at 37°C for 24 h. Suspected cultures of *Salmonella* were tested serologically with somatic (O) test and biochemically with phenol red lactose broth, MR-VP broth, urease, and Simmons citrate agar *(3)*.

Listeria monocytogenes was analyzed by swabbing the drain with a sterile swab moistened in *Listeria* enrichment broth (LEB). The swab was placed in 100 ml LEB broth and incubated at 30°C for 48 h. The broth was streaked onto modified oxford medium plates with a sterile cotton swab and incubated at 35°C for 24 to 48 h *(11)*. Because no typical colonies developed, no further tests were conducted.

Adenosine triphosphate bioluminescence

Equipment sanitation was monitored using the adenosine triphosphate (ATP) bioluminescence assay technique. This assay measures the total residue, including microbes and food, that contains ATP. Assays were performed using the UNI-LITE® XCEL monitoring kit and single-shot hygiene swabs from Biotrace™ Inc. (Biotrace™, Inc., Plainsboro, NJ). Results were given in relative light units (RLU). The sample points were primarily food-contact surfaces and utensils that affected the four products being monitored. Samples also were taken from the drains. These assays were conducted at the central kitchen and at the school. Sample area size was 4 in^2 where possible. Swabs were taken using standard microbial swabbing technique. A total of 11 samples was taken at the central kitchen prior to beginning production; sample areas were the 100 gallon kettle, kettle beaters, kettle air valve, transfer hose, pump-fill rotors, pump-fill filler head, tilting fry pan, floor drain, can opener, cutting board, and hand stirring paddle. A total of 5 samples was taken at the school; sample areas were the preparation table, floor drain, 4-inch counter pan, serving ladle, and lid. An RLU reading of $\leq$ 100 indicated clean, 101 to 299 indicated the need for caution, and $\geq$ 300 indicated contamination. The ATP method is a proactive technique in that the assays can be performed on site. If results showed contamination, immediate corrective action could be taken.

Food safety checklist

A Food Safety Checklist for Foodservice Operations developed by KSU Cooperative Extension Specialists utilizing HACCP principles *(2)* was used four times in the central kitchen and twice in the school to audit employee practices. The areas observed were receiving, storage, employee preparation, prepreparation (thawing) and preparation, serving and reusing prepared foods, cleaning, and sanitizing. The information obtained was used in taking corrective action and to improve practices.

TABLE 1. Self-reported food handling practices and knowledge level of food-service managers (N = 14)

Variable	Pretest mean (Std Dev)	Post-test mean (Std Dev)	*t* value	*P* value
Frequency of practice[a]				
Use of thermometer	4.39 (0.70)	4.64 (0.63)	1.472	0.165
Employees wash hands	4.83 (0.38)	4.86 (0.36)	0.563	0.583
Keep PHF[c] out of TDZ[d]	4.67 (0.77)	4.79 (0.58)	1.38	50.189
Check sanitizers	4.50 (0.51)	4.21 (0.80)	1.000	0.336
Level of knowledge[b]				
Microorganisms that cause foodborne illness	3.33 (0.69)	3.64 (0.63)	1.587	0.136
Conditions that affect microbial growth	3.21 (0.65)	3.71 (0.47)	2.876	0.013*
Potential hazards in school foodservice	3.56 (0.70)	4.00 (0.39)	3.606	0.003**

[a]1 = Never, 5 = Always

[b]1 = NO knowledge, 5 = COMPLETE knowledge

[c]PHF = Potentially Hazardous Foods

[d]TDZ = Temperature Danger Zone

* $P \leq 0.05$

** $P \leq 0.01$

RESULTS

Focus group

The participants, 16 women and two men, included three central kitchen managers and 15 school kitchen managers of USD 383. The average age of the employees was 45 years. The average length of employment with USD 383 was 10.25 years. Formal education levels included at least a high school education for 61.1% and some vocational training for 22.2%. Over half (55.7%) had been employed in school foodservice for at least 10 years. Many had held other positions in school foodservice. One-third (33.3%) had been general foodservice workers, 27.8% had been cashiers, and 22.2% had worked primarily in the main-dish department. Other types of foodservice employment included positions in family style restaurants (44.4%) and hospitals (22.2%). Some (27.8%) had not worked in any other foodservice establishment. Primary sources for food safety advice and food safety training cited by 83.3% were the county health inspector and school foodservice management. Most of the participants (72.2%) had received food sanitation training on the job, and some (55.6%) had training in HACCP.

Practices and knowledge. For all questions on safe food handling practices, no significant differences in responses occurred between the first and second sessions (Table 1). Significant differences between the first and second evaluations were noted ($P \leq 0.05$) for knowledge about conditions that affect microbial growth. Significant differences also were noted ($P \leq 0.01$) for knowledge about potential hazards in school foodservice. In both cases, knowledge increased from the first session to the second session (Table 1). Although mean scores for food safety practices ranged from 3 (half the time) to 5 (always), observation by the researcher in the elementary school indicated that these practices were not always followed.

Focus group discussion. In the first focus group session, employees identified as common the following practices: washing hands, checking temperatures of products, proper dishwashing temperatures, wearing hair nets, and using plastic gloves. Participants indicated their belief that food safety education should be required for all new employees, and refresher courses should be offered for everyone more often; many even felt that lunch room supervisors should have a food safety education course. The primary impediment to following food safety procedures was lack of time to perform the procedures properly. Employees were aware of the types of foods considered potentially hazardous; examples cited were chicken, fish, dairy products, lunch meat, and various salad bar items. Controlling temperature was cited as the critical factor in preventing foodborne illness. Employees indicated that they kept equipment washed and sanitized and that they washed hands frequently.

Regarding knowledge of HACCP, some employees knew that it involved following a product from receiving of ingredients to serving of meals to students. Many were intimidated by the amount of paperwork potentially involved in tracking products. Temperatures of products were mentioned as primary critical control points.

All employees indicated that they were apprehensive, yet excited, about the cook-chill system and were afraid of the major changes that would occur. Initial concerns mentioned included the problems of inadequate equipment and insufficient help at the schools. Many employees were concerned that communication would diminish and that the numbers of employees would be reduced. Some school managers were adjusting from a full cooking kitchen to a satellite kitchen, which changed their responsibilities and routines. Expected advantages mentioned included less waste, fresher food, and improved quality of food.

All employees realized that mistakes were going to happen and that they would learn from the mistakes. School managers hoped administrators would come to the schools and observe how meals are prepared. Everyone agreed that they needed to work as a team to make the cook-chill system a success.

In the second focus group session, the primary concerns were: improperly functioning equipment, insufficient equipment to prepare meals efficiently, and lack of time to complete all responsibilities while at work. Employees noted that some equipment used for reheating and holding products did not function properly. Many school managers performed more functions in preparing meals and also were required to do more paperwork. They noted that food safety practices, such as taking temperatures, were being performed but they indicated that temperatures were not always recorded. Employees felt transportation and delivery of food were critical points in the operation. Because the transport carts were not refrigerated, managers perceived a potential for temperature abuse. The timing of delivery of food was not always convenient for employees to receive and store food properly. Many times, deliveries occurred during lunch service. The truck driver emptied the cart and left all products at room temperature, which created the potential for temperature abuse.

Overall, employees believed the cook-chill production system was improving. Central kitchen managers noted that a change to use of larger bags for cook-chill products had decreased the time required to chill the product efficiently. The central kitchen had requested feedback from schools by use of critique sheets for various products. School managers liked the cook-chill products because of the greater control over the amount of product that needed to be heated. Managers of some satellite schools expressed concern about their personal safety in handling the hot bagged product. In some schools, managers did not heat the product in the bag. How products were heated depended on the menu each day and on the number of different items to be heated. Heating equipment was a limiting factor. The central kitchen managers felt less pressure to get product to the schools with the new system. Any rush deliveries could be made in adequate time prior to service at the schools.

Although many school managers indicated that they felt busier than before, all said they would not return to the previous production system. They also realized that many functions need improvement and would change over time.

Food safety checklist for foodservice operations

Central Kitchen. The Food Safety Checklist was administered four times in the central kitchen. Product receiving was not observed, because a majority of products were received at the beginning of the school year. We observed during preparation, however, that some canned products were slightly too severely dented, but had been accepted anyway at the central receiving center. The severely dented cans were discarded at the preparation site, resulting in loss of product. Upon receipt, boxes should be opened randomly to check for damaged cans and products should be rejected if not acceptable.

Storage practices were excellent. All items put in storage were labeled with dates and rotated using first in-first out (FIFO) procedures. Storage temperatures, for all conditions (dry storage, refrigerated storage, and frozen storage) were monitored daily and recorded. All chemicals were kept in their original containers and stored away from food.

Employee preparation practices were satisfactory overall. Employees were conscientious about washing their hands before beginning work, during work as needed, and after any possible contamination. At one observation, an employee sneezed, covered her mouth and nose with her hand, and did not wash her hands before handling product. Lack of hand washing can lead to the spread of many infections, viral as well as bacterial, such as staphylococcal infections, and the nose is a source of *Staphylococcus aureus (6)*. Another time, an employee who was ill refused to go home although encouraged to do so; such employees may contaminate food and infect other employees. Ready-to-eat foods were handled safely, but plastic gloves needed to be utilized more often in handling food that was to have no further preparation before being served *(4)*.

Thawing and preparation practices were excellent. All frozen raw meat was thawed appropriately in the refrigerator. Meat was placed in pans on rolling carts, reducing the potential for cross contamination with any cooked products in the refrigerator. The meat was cooked to an internal temperature of at least 155°F for 15 s, meeting established standards set by the 1995 FDA Food Code *(4)*.

Cleaning and sanitizing procedures were inconsistent over the four observations. After each use, all equipment was washed with a mild detergent (Old Faithful, Meyer Laboratory, Blue Springs, MO), rinsed, and sanitized with an aqueous 5.25% sodium hypochlorite solution (Nugget® Brand Bleach, Stockton, CA).

TABLE 2. ATP bioluminescence results for cook-chill and preparation equipment at the central kitchen and serving equipment at the school

Data Point	Valid N	Missing N	RLU[a] Mean[b]	RLU[a] Standard Deviation	RLU[a] Min	RLU[a] Max
Kettle						
100 gal kettle	11	1	401.0	794.6	1.0	2734.0
Kettle beaters	11	1	559.0	794.0	13.0	2049.0
Kettle air valve	11	1	370.0	381.0	11.0	1139.0
Transfer hose	11	1	935.0	2872.1	13.0	9593.0
Pump-fill rotor	11	1	1134.0	3576.8	11.0	11918.0
Pump-fill filler head	11	1	418.0	1104.2	19.0	3741.0
Drain	11	1	4345.0	7648.5	10.0	21330.0
Preparation						
Can opener	10	2	1417.0	1903.1	63.0	5633.0
Tilting fry pan	11	1	182.0	410.6	13.0	1414.0
Cutting board	10	2	247.0	348.2	53.0	1218.0
Hand stirring paddle	10	2	963.0	2849.0	18.0	9069.0
Serving						
Pan	11	1	121.3	138.1	17.0	443.0
Lid	11	1	166.6	290.6	17.0	1013.0
Spoon	11	1	1238.1	2016.8	73.0	6744.0
Table	10	2	219.5	478.7	22.0	1577.0
Drain	10	2	1975.8	3963.1	65.0	12932.0

[a]RLU = Relative Light Units

[b]= 0-99 = clean, 100-299 = caution, ≥ 300 = contaminated

Concentration of the sanitizing agent was not verified, however. At the first observation, sanitizing of cook-chill equipment after washing did not occur, although results of ATP bioluminescence tests showed that sanitizing was a necessary step. All fixed equipment with removable parts was dismantled after each use, and all parts and equipment were washed in the mild detergent, rinsed manually, and sanitized by immersing in the 5.25% sodium hypochlorite sanitizing solution. This concentration was not measured or verified. Table 2 shows results from ATP bioluminescence assays, which reflect wide variations in effectiveness of cleaning and sanitation.

Satellite school. The Food Safety Checklist *(2)* was administered twice in the satellite school. Deliveries from the central kitchen to the elementary school arrived during lunch service.

TABLE 3. Presence of indicator organisms including aerobic plate count (APC), total coliforms, and *E. coli* for all products

Sample	APC (CFU/g) Mean (Std Dev)	Total Coliform (CFU/g) Mean (Std Dev)	*E. coli* (CFU/g) Mean (Std Dev)
Raw ground meat	2.4×10^5 4.3×10^5	3.6×10^2 5.3×10^2	3.3×10^2 6.9×10^2
After blast chill	3.5×10^2 5.2×10^2	<10 <10	<10 <10
Serving	2.0×10^1 3.0×10^1	<10 <10	<10 <10
5 days after production	1.9×10^2 1.8×10^2	<10 <10	<10 <10
10 days after production	6.3×10^2 1.6×10^3	<10 <10	<10 <10

This was a poor delivery time for kitchen employees who could not stop serving lunch to check and receive deliveries. Thus, the preferred delivery and receiving procedures were not maintained. Potentially hazardous foods were not checked for temperature abuse during delivery. Products were not always marked to show delivery date.

Employee preparation practices were acceptable most of the time. At times, an employee handled ready-to-eat foods without using plastic gloves during preparation, although gloves were used during service.

ATP bioluminescence results in the school identify inconsistencies in the effectiveness of cleaning and sanitizing procedures of some equipment (Table 2). Sanitizer concentrations were not verified during these observation periods.

Other functions, including preparation and serving, were performed according to acceptable standards defined by the Food Safety Checklist for Foodservice Operations *(2)*. Employees were conscientious and worked hard to serve a safe, healthy meal and maintain a clean kitchen and clean equipment.

Cooking, blast chilling, heating, and holding

The meat was cooked to an average temperature of 199.7 ± 12.7°F for 15 s, well above the recommended standard of 155°F for 15 s for ground beef. The high cooking temperature was because employees were responsible for other duties and thus let the meat cook for longer than necessary because they could not attend to it.

After cooked meat was transferred to the kettle, the mean starting cooking temperature was 117.6 ± 33.6°F. The kettle temperature was set to reach 180°F, a standard recommended by the Groen company, manufacturer of the kettle. Cooking and agitation continued until internal product temperature reached 180°F, which was maintained for 15 s to pasteurize the product. This cooking process was completed in a mean time of 61.3 ± 23.4 min, but varied from 51.3 ± 13.8 min to 78.3 ± 25.2 min. The variation was due to other responsibilities of the cooks that took them away from their primary job, as well as to differences in batch size.

The mean product temperature was 131.3 ± 19.4°F prior to blast chilling and at the end of blast chilling was 40.3 ± 10.3°F. The mean time to reach 45°F for all 12 samples was 2.6 ± 1.7 h, and the mean time to reach 40°F was 3.2 ± 2.9 h. These two mean times include data on two samples that took an unusally long time to complete the cooling process. With cooling parameters corrected, the mean chilling time to 45°F was 1.9 ± 0.8 h and the mean chilling time to 40°F was 2.0 ± 0.8 h. A reduction in chilling time greatly increases the shelf life of the product.

Figure 1 shows the temperature data obtained every 30-min for all products except the two aforementioned cases. Temperature was reduced by 38.9°F in the first 30-min of cooling. Temperature reduction slowed in each subsequent 30 min time interval. Figure 2 shows temperature data for the two cases (spaghetti and taco) with extremely long cooling times. Prior to heating, which took place at the satellite school, the mean product temperature was 46.3 ± 18.6°F, (one sample had a temperature of 99°F; the cook had preheated the product to remove it from the bag prior to getting an initial temperature reading). After heating, final mean product temperature was 184.9 ± 10.6°F; recommended final temperature to repasteurize the product was 180°F. The mean time required to reach the final temperature was 40.0 ± 17.9 min. All heated product was kept hot in the oven or in the hot cart until service.

Lunch was served during an interval of 1 h and 10 min. The heated product was served from the hot serving line. The mean temperature at the beginning of service was 165.9 ± 15.3°F. The mean temperature during service, taken at an average of 29.5 ± 8.2 min into service was 160.8 ± 16.3°F. The mean temperature at the end of service was 153.2 ± 19.5°F. All temperatures, except for sloppy joes during service, are well above state and FDA regulations of temperatures at least 140°F for holding and serving hot food. The mean for this sample was 147.0 ± 25.5°F, but the

Figure 1. Temperatures during blast chilling for all products except spaghetti 10/9/96 and taco 10/16/96

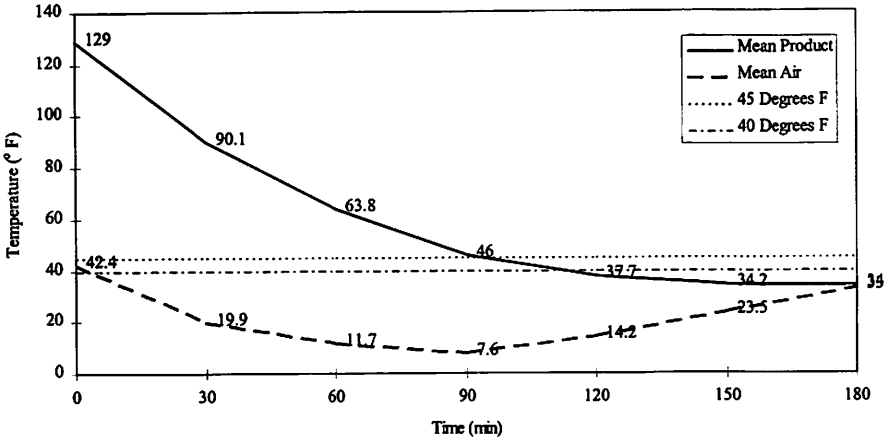
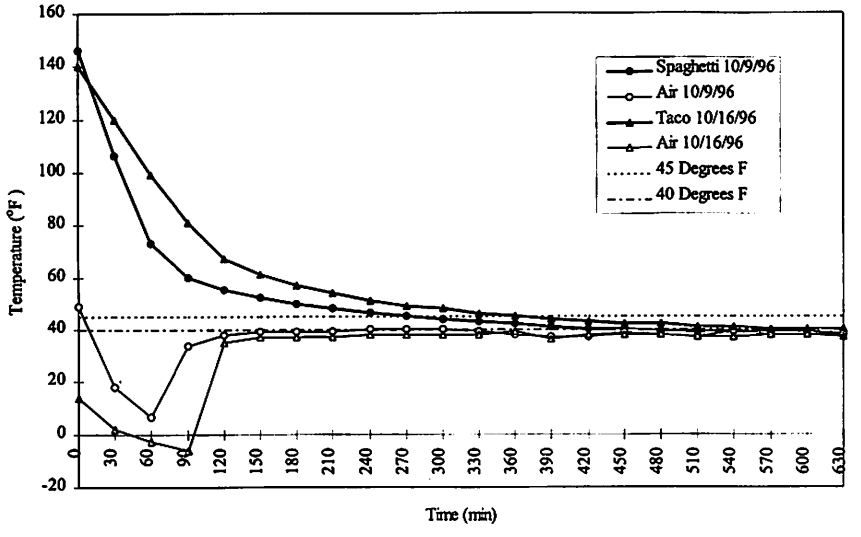


Figure 2. Temperatures during blast chilling for spaghetti 10/9/96 and taco 10/16/96



low temperature, 121.5°F, was not a safe serving temperature. The product should have been removed from the serving line and reheated to 165°F.

ATP bioluminescence

Means and standard deviations for ATP bioluminescence results were calculated on each sample point at the central kitchen and satellite school (Table 2). At the central kitchen, the means for two samples (tilting fry pan and cutting board) were below the 300 Relative Light Units (RLU) level that indicates contamination. Overall, readings deviated widely for all sample points, some of which indicated effective and others of which indicated ineffective cleaning and sanitizing. This wide deviation can be attributed to inconsistencies in cleaning and sanitizing as identified when employee practices were observed with the Food Safety Checklist for Food Service Operations *(2)*.

At the school, mean values for three sample points (the serving pan, the serving lid, and the preparation table) were below the 300 RLU level. The pan and lid were washed in the automatic dishwasher and air dried with minimal handling, and the table was washed frequently throughout the day. In 5 out of 11 samples, the serving spoon was contaminated, which could be attributed to inadequate washing in the automatic dishwasher, handling of the spoon with contaminated hands, or contact with other contaminated utensils. In some cases, the high ATP values may have indicated the presence of *Salmonella* spp. in the product.

Microbial analysis

The effectiveness of the cooking, chilling, and serving processes and product shelf life were evaluated by analysis for APC, total coliform, and *E. coli* as indicator organisms (Table 3). Mean results for APC in the raw ground beef were $2.4 \times 10^5 \pm 4.3 \times 10^5$ CFU/g, which is classified as high. Following cooking, a 3 log reduction occurred in APC counts, to $3.5 \times 10^2 \pm 5.2 \times 10^2$ CFU/g, which is classified as low. The APC was further reduced following heating and serving, to $2.0 \times 10^1 \pm 3.0 \times 10^1$ CFU/g. Shelf-life analysis showed a 1 log mean increase. The total coliform and *E. coli* counts for the raw ground beef were $3.6 \times 10^2 \pm 5.3 \times 10^2$ CFU/g and $3.3 \times 10^2 \pm 6.9 \times 10^2$ CFU/g, respectively. These organisms were completely eliminated upon cooking and were not detected at any time in cooked products. These results indicate that the cook-chill process of heating the product to 180°F was effective in destroying indicator organisms.

Results of analyses for *E. coli* O157:H7, *Clostridium perfringens*, *Salmonella* spp. and *Staphylococcus aureus* are in Table 4. *E. coli* O157:H7 was not detected in any sample tested. *Clostridium perfringens* and *S. aureus* were found only in raw ground beef, in 41.7% and 33.3% of samples, respectively. *Salmonella* spp. found at each sample point, was detected in 41.7% of raw ground beef samples but in only 8.3% of blast chilled samples. Even though cooking caused a reduction, the product could not be considered safe. The presence of this bacterium increased following serving (33.3%) and in the samples after 5 and 10 days of storage (25.0% and 16.7%), respectively. Three samples taken from a drain below the kettle contained no *Listeria monocytogenes*.

TABLE 4. *E. coli* O157:H7, *C. perfringens*, *Salmonella* spp., and *S. aureus* in raw ground beef, after blast chilling the final product, after serving the product at the school, 5 days after production, and 10 days after production

Sample	*E. coli* O157:H7			*C. perfringens*			*Salmonella* spp.			*S. aureus*		
	N*	Pos N (%)	Neg N (%)	N*	Pos N (%)	Neg N (%)	N*	Pos N (%)	Neg N (%)	N*	Pos N (%)	Neg N (%)
Raw ground beef	12	0 (0)	12 (100)	12	5 (41.7)	7 (58.3)	12	5 (41.7)	7 (58.3)	12	4 (33.3)	8 (66.7)
After blast chill	12	0 (0)	11 (91.7)	12	0 0	11 (91.7)	12	1 (8.3)	10 (83.3)	12	0 0	11 (91.7)
Serving	12	0 (0)	12 (100)	12	0 0	12 (100)	12	4 (33.3)	8 (66.7)	12	0 0	12 (100)
5 days after production	12	0 (0)	8 (66.7)	12	0 0	8 (66.7)	12	3 (25.0)	5 (41.7)	12	0 0	8 (66.7)
10 days after production	12	0 (0)	11 (91.7)	12	0 0	11 (91.7)	12	2 (16.7)	9 (75.0)	12	0 0	11 (91.7)

*Total sample size is 12. Because sample values were missing, percentages will not always add to 100

DISCUSSION AND RECOMMENDATIONS

The Kansas Department of Health and Environment (KDHE) regulation for final product chill temperature is 45°F *(7)* and the 1995 FDA Food Code recommends 41°F *(4)*. For a cook-chill system, the recommended final chill temperature is 40°F *(5)*. Final temperatures recorded for two of the 12 products were above 45°F because the data logger probe was removed from the product too soon. These high values account for the large variation in final blast chilling temperature. One spaghetti sample and one taco sample took 5 h and 7 h, respectively, to reach the 45°F standard. An additional 3 h and 3 1/2 h, respectively, were required to reach the 40°F recommendation. In both cases, the extreme time requirement was due to improper chilling by the blast chiller and an ineffective method of placing the product into the blast chiller; the product had been placed in 2-inch pans, one bag per pan, and placed on rolling racks, so that the pans placed an extra barrier between product and air, thus impeding the effectiveness of the blast chilling. This situation was corrected before the next product was prepared. *Salmonella* spp. found at several points in the process may have been due to postprocessing contamination or to initial high loads of bacteria on the raw product.

Implementation of HACCP into the cook-chill operation of USD 383 Manhattan school foodservice is an important addition to this new food production system. The cook-chill production system is effective for producing mass quantities of food while maintaining high quality of products. This system also increases the safety of the food, primarily by increasing control of time and temperature.

Commitment to a project must take place at all levels of the organization; when employees know that upper management supports a project, everyone works to achieve a common goal. This is a concept of total quality management. The USD 383 management team members exhibited their commitment to employees, school board, and community by recognizing the need to improve the foodservice operation so as to meet the demands of a growing student population. This commitment was enhanced further by recognition of the importance and need to implement HACCP, even though it is only recommended, not required, by state regulations for any foodservice operation. To date, the United States Department of Agriculture (USDA) has established regulations for meat processing operations to reduce or eliminate the presence of foodborne pathogens in meat *(10)*. HACCP is not mandated for foodservice operations by federal regulations. However, many commercial foodservice operations have instituted HACCP, and increasingly, noncommercial establishments such as schools are implementing HACCP on their own.

To accomplish microbial reduction or elimination, the cook-chill

system standards of cooking food to pasteurization temperatures and chilling as rapidly as possible were proven effective in this project, except for the survival of *Salmonella* spp. As with any new system, areas exist where trial and error will be necessary to find the best process or method. Areas where improvements can be made for USD 383 include the following:

1. Standardizing recipes to maintain consistency in quality.
2. Standardizing cleaning and sanitizing procedures for the cook-chill system to minimize microbial growth.
3. Purchasing a tumble chiller to achieve maximum chill in the least amount of time; thus extending shelf life.
4. Scheduling production based on the maximum capacity of specific equipment, in this case, the blast chiller, although this may not be feasible because of the amount of product.
5. Reducing the amount of raw ground beef cooked at one time in the tilting fry pans; which will help cook the meat properly and completely.
6. Turning on the recording thermometer chart of the cook-chill kettle at the beginning of the day and turning it off at the end of the day; using one chart per day and properly labeling the temperature peaks.
7. Purchasing appropriate equipment for satellite schools to improve reheating of product.
8. Sanitizing serving utensils prior to use to reduce the chance of microbial contamination.
9. Emphasizing the importance of using plastic gloves for handling ready-to-eat foods.
10. Calibrating thermometers regularly, such as once a week.
11. At the suggestion of the County Health Inspector, replacing bimetallic thermometers with digital thermometers.
12. Purchasing a thermocouple to test accuracy of digital thermometers and to use in verification of the HACCP program.
13. Continuing to redistribute responsibilities of employees in the central kitchen to separate cooking functions from distribution functions, because requiring employees to perform both functions increases the chance of cross-contamination.
14. Obtaining samples once or twice a year from the central kitchen and schools for microbial analysis as a verification step in the HACCP program.
15. Continuing to request suggestions from all employees and consumers to improve products and functions, and working together to achieve high quality.
16. Establishing procedures to obtain temperatures of products upon delivery at satellite schools.
17. Working with suppliers to reduce the number of dented canned products, and rejecting unacceptable product.
18. Maintaining the level of product in the pan at 2 inches or less when cooling leftovers after serving.
19. Removing or venting the lid to allow heat and steam to escape from leftover products cooling in pans.
20. Maintaining good communication at all levels to establish uniform and consistent practices.
21. Limiting refrigerated storage of product to 5 to 10 days, based on microbiological data. The use of focus groups, evaluations of the production processes, and measurements of temperatures, microbial contamination, and sanitation provided data to identify needed improvements and to develop a model HACCP plan.

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ABOUT THE AUTHORS

'Shade Pasta, Inc. and Department of Animal Sciences & Industry, Kansas State University, Manhattan, KS 66506, USA; Phone: 785.532.1672; Fax: 785.532.5681.

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