A Research Note
Fate of Bacillus cereus in Whipped Potatoes During Pre-Service Holding as Could Occur in a Conventional Foodservice System

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ABSTRACT

Dehydrated potatoes were reconstituted (50 1/2-cup servings), mixed, transferred to a pan and the surface was inoculated with spores of Bacillus cereus to give \( \geq 40 \) colony forming units (CFU) per 20.3 cm\(^2\). Survival of the organism was determined following pre-service holding, (52°C; 32% relative humidity; 1 h) as could occur in a conventional foodservice system. No statistically significant differences were found in numbers of B. cereus before and after pre-service holding. Although the mean surface temperature (56°C) of whipped potatoes was below the maximum germination temperature of B. cereus (59°C), mean internal temperature (63°C) and surface temperature (56°C) of whipped potatoes were never low enough for growth of vegetative cells to occur.

Bacillus cereus was first implicated as a food poisoning agent in the United States in 1968 although it was recognized as a cause of foodborne illness in Europe since 1950 (12). Recently, B. cereus has been identified as the causative organism in two outbreaks of foodborne illness associated with improper holding of whipped potatoes in foodservice establishments (4, 15). Outbreaks were attributed to improper refrigeration of whipped potatoes in a school foodservice operation, and poor temperature control during hot-holding of whipped potatoes in a fast food restaurant.

The conventional foodservice system often uses two hot-holding stages--pre-service holding of food and holding food at the point of service. The former involves holding foods hot in electric cabinets, carts and/or pass-through warmers before the foods are transported to the service area, while the latter involves holding foods hot on hot food tables located in the service area. Foods are often subjected to fluctuating temperatures for various times during the two hot-holding stages of the conventional foodservice system.

The purpose of this study was to determine the fate of B. cereus in whipped potatoes subjected to pre-service holding by simulating foodservice practices and conditions that could occur during this processing step. Whipped potatoes were selected for this experiment because potatoes in this form are popular and appear daily on menus in schools, colleges and universities, and health care facilities (1, 2). Additionally, B. cereus grows rapidly in starchy food such as whipped potatoes (3, 5).

Figure 1. Seven locations for internal temperature, pH, and moisture in the pan of whipped potatoes. A, B, and C designate areas for surface temperature.

MATERIALS AND METHODS

Preparation and pre-service holding of whipped potatoes were observed in 2 college and 3 health care facilities where the conventional method of food production was used. Procedures observed in pre-service holding of whipped potatoes in these facilities were then simulated under controlled conditions in the Foodservice Administration Laboratory.

Whipped potatoes were prepared and held covered in a pre-service holding unit, set at 60°C for 1 h. Temperature of the holding unit was monitored by 10 type-T, copper constantan thermocouples located within the unit, while internal and surface temperatures of potatoes in the pan...
TABLE 1. Ingredients and procedures for preparing whipped potatoesa.

<table>
<thead>
<tr>
<th>Ingredients/amount</th>
<th>Procedures and equipment</th>
<th>Time/temperatureb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water, tap/2880 ml</td>
<td>1. Place water, milk and butter into an 18.9 L steam-jacketed kettle (Model TDC/2-20, Dover Corp./Groen Division, Elk Grove Village, IL). Stir while heating ingredients.</td>
<td>3 min/≥97°C</td>
</tr>
<tr>
<td>Milk, whole/1440 ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Butter, regular/113 g</td>
<td>2. Place the heated mixture into an 18.9 L mixer bowl. Beat with a flat beater on low speed (Model M1222, Universal Industries, Salem, NH). Add dehydrated potatoes and salt.</td>
<td>1 min/NAc</td>
</tr>
<tr>
<td>Potatoes, dehydrated granules/936 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salt/22 g</td>
<td>3. Beat with flat beater on medium speed.</td>
<td>4 min/68°C</td>
</tr>
<tr>
<td></td>
<td>4. Place whipped potatoes into a stainless steel pan (31.9 by 25.9 by 10 cm). Obtain pH and moisture samples. Inoculate with B. cereus.</td>
<td>11 min/52°C (surface)</td>
</tr>
<tr>
<td></td>
<td>5. Cover and place pan in pre-service holding unit (Model 1242-4, Hotpack Corp., Philadelphia, PA). Set dial at 60°C.</td>
<td>11 min/65°C (internal)</td>
</tr>
</tbody>
</table>

aYield = 50 1/2-cup servings.
bTemperature of product following each procedure.
cNot analyzed.

were measured by 7 and 3 thermocouples, respectively (Fig. 1). Materials and methods for preparation and pre-service holding of whipped potatoes for the 6 trials of the experiment are detailed elsewhere (14) and are summarized in Table 1.

Microbiological analyses

Before the actual experiment, preliminary studies were made to determine if spores of B. cereus were present in dehydrated potatoes or in the freshly prepared product. Food coloring was to be added to the inoculum to assure its even distribution when sprayed onto the product surface. Thus additional studies were conducted to determine if food coloring had an effect on B. cereus.

Food coloring. One drop of red food coloring (Durkee, SMC Corp., Cleveland, OH; water, propylene glycol, and 25% artificial color) was added to 18.8 ml of 0.1% peptone water. This tube, and a control were autoclaved and then allowed to cool to room temperature. A 24-h-old broth culture of B. cereus No. 6102A (obtained from the Food Research Institute, University of Wisconsin-Madison) was heat-shocked and diluted were made by sequential transfer of 1 ml to 9 ml of 0.1% peptone water. Two milliliters were taken from the 10-2 dilution and added to the tube containing the food coloring. This same procedure was followed for the control. Each tube was mixed for 1 min using a Vortex Mixer (Model 58223, Scientific Products, Evanston, IL). Additional dilutions were made by sequential transfer of 1 ml to 9 ml of 0.1% peptone water.

Dehydrated product. A sample was removed from a container holding approximately 25 kg of dehydrated potatoes. The jar and its contents were weighed (Model 1500D, Ohaus Scale Co., Flornbad Park, NJ). Sample in excess of 50 g was removed. The sample was then packed in crushed ice and transported to the Food Microbiology Laboratory in an insulated container. Samples were never held longer than 30 min before plating.

The 50 g sample was added to 450 ml of 0.1% peptone water and shaken. This mixture was transferred to a sterile Waring Blender cup and mixed on high speed for 2 min. Further dilutions were made by sequential transfer of 1 ml to 9 ml of 0.1% peptone water.

Experiment

Inoculation. The top surface of whipped potatoes was sprayed in 3 predetermined areas. Enough of the broth culture was used to provide ≥40 colony forming units (CFU) per 20.3 cm². The inoculum was sprayed onto the product with a glass atomizer. Spray was contained by a plastic hood.

Pre-service holding. Samples were collected before and after pre-service holding from predetermined areas (Fig. 1, 7 and 6) on the surface of whipped potatoes. A 2.6-cm square plastic template was placed over each sampling area. Each area was swabbed with a sterile swab (Culturette, Mediflex Division, Medical Supply Co., Rockford, IL), which was aseptically placed into a tube containing sterile 0.1% peptone water. Samples were placed on crushed ice and held in an insulated container until transported to the Food Microbiology Laboratory. Samples were never held longer than 3 h before they were plated.

Enumeration. The same procedure was used to enumerate B. cereus for the preliminary studies and the actual pre-service holding experiment. One-tenth milliliter of appropriate dilutions of the samples were surface-plated in duplicate on Kim-Goeppert (KG) agar, and plates were incubated at 33±1°C for 24 h. Following incubation, plates were examined for presence of typical B. cereus colonies. Colonies were counted, and spore and gram stains made on representative colonies. Several colonies were picked from the KG agar plates and identified as B. cereus using the following criteria: gram reaction, typical morphology of vegetative cells and spores, and location of the spore in the sporangium.

Objective measurements: Approximately 100-g samples from 7 different locations (Fig. 1, 1-7) in the pan were obtained for pH and moisture.
determinations both before and after pre-service holding. Method (7) of the Association of Official Analytical Chemists (A.O.A.C.) was used to determine moisture content (6); temperature was modified to 75°C.

Statistical analyses. Differences between the means for before and after pre-service holding for pH and moisture were analyzed using the paired t-test (13). This test was also used (a) to determine if differences existed between numbers of B. cereus present before and after the pre-service holding period in 6 trials of the actual experiment, and (b) to determine the effect of food color on B. cereus in the 3 trials of the preliminary study.

RESULTS AND DISCUSSION

Although variations in numbers occurred, no statistically significant differences for pH or moisture were found in whipped potatoes following the pre-service holding stage. Differences in pH and moisture before and after holding ranged from 0 to 0.5 unit for pH and 0.4 to 6.7% for moisture.

TABLE 2. Effect of food coloring on the survival of Bacillus cereus

<table>
<thead>
<tr>
<th>Trial</th>
<th>No color</th>
<th>Color</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(CFU/ml)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.3 x 10^3</td>
<td>8.0 x 10^3</td>
</tr>
<tr>
<td>2</td>
<td>1.1 x 10^3</td>
<td>5.5 x 10^3</td>
</tr>
<tr>
<td>3</td>
<td>6.0 x 10^3</td>
<td>1.5 x 10^3</td>
</tr>
</tbody>
</table>

Values represent the mean of duplicate plates.

Preliminary studies

Since food coloring was to be used to trace the inoculum on the surface of whipped potatoes, the effect of food coloring on survival of B. cereus was investigated. For 3 trials, food coloring decreased the number of Colony Forming Units (CFU) of B. cereus (Table 2). Hence, food coloring was not used to trace the location of the inoculum in the actual experiments.

Presence of B. cereus was detected in all 3 tests on uninoculated dehydrated potatoes. Plate counts on KG agar ranged from 5.0 x 10^4 to too numerous to count (TNTC) colony forming units per ml. However, when freshly prepared potatoes were made from uninoculated dehydrated potatoes no B. cereus was present. A wide range of heat resistance for B. cereus spores has been reported in the literature (7,11). Possibly the strain of B. cereus present in the raw product had a low resistance to heat and thus no spores survived when the dehydrated potatoes were added to water, milk and butter that had been heated to ≥97°C.

Actual experiment

Numbers of B. cereus in whipped potatoes before and after pre-service holding showed little change (Table 3); differences were not statistically significant. Mean surface temperature of whipped potatoes for the 6 trials of the experiment was 56°C. Temperature range was 6°C. Knaysi (9) reported 59°C as the maximum temperature for germination of B. cereus spores, while maximum temperature for growth of vegetative cells has been reported to be 49°C (8) and 50°C (10).

TABLE 3. Numbers of Bacillus cereus (CFU/20.3 cm^2 surface area) in whipped potatoes following holding in pre-service equipment.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Before holding</th>
<th>After holding</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.9 x 10^3</td>
<td>1.5 x 10^3</td>
</tr>
<tr>
<td>2</td>
<td>1.8 x 10^4</td>
<td>4.3 x 10^3</td>
</tr>
<tr>
<td>3</td>
<td>1.0 x 10^4</td>
<td>1.2 x 10^4</td>
</tr>
<tr>
<td>4</td>
<td>4.0 x 10^1</td>
<td>1.5 x 10^1</td>
</tr>
<tr>
<td>5</td>
<td>7.5 x 10^3</td>
<td>9.0 x 10^3</td>
</tr>
<tr>
<td>6</td>
<td>1.7 x 10^4</td>
<td>2.5 x 10^3</td>
</tr>
</tbody>
</table>

52°C; 32% RH; 60 min.

Although the mean surface temperature (56°C) of whipped potatoes was below the maximum germination temperature (59°C) reported by Knaysi (9), product temperature (surface temperature, X=56°C; internal temperature, X=63°C) was never low enough for vegetative cells to grow. The surface and internal temperature of the product could explain why no differences in numbers for B. cereus were found in this study.

Differences in germination rates among 6 strains of B. cereus spores were recently reported by Johnson et al (7). Based on their results, these authors speculated that rapidly germinating strains of B. cereus could germinate extensively at the initial temperature used in a heat process, with germinating spores being easily inactivated during subsequent heat processes. Conversely, slow germinators would remain dormant, but the potential for survival would be increased. In the present study, B. cereus spores were heat-shocked and then inoculated onto the surface of whipped potatoes; thus no differences in numbers of B. cereus would be expected during the short holding period (1 h) if the strain used was slow to germinate.

Holding conditions

For the 6 trials of this study, the overall mean temperature of the holding unit was 52°C even though the dial was set at 60°C at the time whipped potatoes were placed into the unit. Temperature of the product when placed into the holding unit was 52°C for the surface and 65°C for the internal mass. Following holding at 52°C for 1 h, the internal temperature dropped to 63°C, while the surface temperature rose to 56°C. This rise in surface temperature may be attributed to use of a lid covering the product, and heat transfer within the product during the 1-h holding period. Under these controlled conditions in the laboratory no growth of B. cereus occurred in whipped potatoes.

However, under actual operating conditions in foodservice establishments, temperatures of equipment and product can fluctuate. To ensure ideal conditions during pre-service holding it is recommended that (a) pans be covered and temperatures of menu items be >60°C when placed into holding units, and (b) holding equipment be maintained at temperatures greater than temperatures of menu items. Foodservice managers holding foods under these conditions can protect consumers from foodborne illness.
REFERENCES


Collins-Thompson et al., con't. from p. 407