Time to *B. Cereus* about Hot Chocolate

Pamela K. Nelms, MPH RS
Oren Larson, RS
Debora Barnes-Josiah, PhD

At the time of the study, all authors were with the Minneapolis Department of Health and Family Support (MDHFS). Ms. Nelms was an Environmental Health Specialist with the Division of Environmental Health, Mr. Larson was a Section Supervisor with the same Division, and Dr. Barnes-Josiah was an Epidemiologist. Currently, Ms. Nelms is a Health Program Analyst with MDHFS, Mr. Larson is the Acting Director of Environmental Health in the Minneapolis Department of Regulatory Services, and Dr. Barnes-Josiah is a Research Scientist in the Division of Family Health, Minnesota Department of Health.

Address correspondence to Ms. Nelms, Minneapolis Department of Health and Family Support, 250 South Fourth Street, Rm. 510, Minneapolis MN 55415; tel. 612-673-3817; fax 612-673-3866.

SYNOPSIS

Objective. To determine the cause of illnesses experienced by employees of a Minneapolis manufacturing plant after drinking hot chocolate bought from a vending machine and to explore the prevalence of similar vending machine-related illnesses.

Methods. The authors inspected the vending machines at the manufacturing plant where employees reported illnesses and at other locations in the city where hot chocolate beverages were sold in machines. Tests were performed on dry mix, water, and beverage samples and on machine parts.

Results. Laboratory analyses confirmed the presence of *B. cereus* in dispensed beverages at a concentration capable of causing illness (170,000 count/gm). In citywide testing of vending machines dispensing hot chocolate, 7 of the 39 licensed machines were found to be contaminated, with two contaminated machines having *B. cereus* levels capable of causing illness.

Conclusions. Hot chocolate sold in vending machines may contain organisms capable of producing toxins that, under favorable conditions, can induce illness. Such illnesses are likely to be underreported. Even low concentrations of *B. cereus* may be dangerous for vulnerable populations such as the aged or immunosuppressed. Periodic testing of vending machines is thus warranted. The relationship between cleaning practices and *B. cereus* contamination is an issue for further study.

B. cereus, an aerobic spore-former, is a ubiquitous organism found in soil and commonly detected at low levels in raw and dried foods, including dry milk[1] and grains. Although *B. cereus* is reported relatively rarely in the United States, it is a common source of foodborne illness worldwide. Illness may occur when the *B. cereus* spores are exposed to warm, moist conditions, causing the bacteria to grow. Toxins are produced by the bacteria, and the subsequent ingestion of the toxins can make people ill. This type of illness is most often a result of eating foods that have been held at room temperature after cooking and then only briefly reheated or not reheated at all.[2,3] Although reheating may kill the *B. cereus* organisms in the food, the toxins already present remains unaffected by the reheating. In the case of cooked rice, time spans as short as two hours at

room temperature may be sufficient for the production of large numbers of organisms and a high concentration of toxin.[4] Other grain products in addition to rice can be sources of *B. cereus* foodborne illness.

It is generally held that a concentration of at least 100,000 *B. cereus* organisms per gram (c/gm) of food is required to induce this type of illness. Although rarely fatal, the illness may last up to 24 hours[2] and may complicate other health conditions when symptoms contribute to dehydration.

In August 1994, three employees of a Minneapolis manufacturing plant reported nausea and vomiting shortly after drinking a hot chocolate beverage from a vending machine located in the employee cafeteria. The vending company that owned the machine replaced the plastic hoses and the powdered chocolate mix in the machine and "flushed the system" to clean it. The following day, when another employee reported feeling ill after drinking hot chocolate from the same machine, the plant manager decided to call the city health department.

We report the findings of the initial investigation and a subsequent study of the prevalence of *B. cereus* contamination in hot chocolate dispensed by vending machines in Minneapolis.

Of 39 machines in the city dispensing hot chocolate, we found seven that were positive for *B. cereus*, with the beverage from two contaminated at a level likely to cause illness.

Methods and Results

Initial investigation. The initial investigation focused on the cases of illness reported at the manufacturing plant. One of the authors questioned representatives of the manufacturer, the vice-president of the vending machine company, and three of the four employees who reported illness. Employees who had consumed products other than hot chocolate from the same machine were questioned by the manager about recent illnesses.

The plant manager reported that each of the employees reporting symptoms was unaware that other similar illnesses were being reported. No other employees questioned by the manager recalled any recent or past experiences of illness after consuming hot chocolate or any other products from the same vending machine.

When interviewed, the employees who had reported illness confirmed that they had experienced nausea and vomiting approximately one hour after drinking the hot chocolate and that they had consumed no other foods in common in the previous 72 hours.

The machine, manufactured in 1972, was of a make and model used throughout the city. It had one holding tank, where water was heated and held hot until needed. In addition to hot chocolate, this machine dispensed coffee, chicken soup broth, and tea. All products were stored as powders; each had its own "mixing cup" inside the machine where the product was mixed with hot water from the holding tank before being dispensed to the customer. This separate mixing and dispensing system prevented each product from contacting equipment used to dispense the other products. All components of the machine were made of either stainless steel or food-grade plastic and appeared on examination to be in good condition, without visible defects or worn areas.

The vice-president of the vending machine company reported that the machine was serviced weekly; this included manual "flushing of the hoses" using the hot water in the holding tank, replacement of depleted powdered mix in the hoppers, and emptying of the waste bucket.

The City Health Department collected and analyzed samples of powdered hot chocolate mix from the hopper, water from the holding tank, and a "customer-ready" hot chocolate beverage.

Tests at the health department laboratory showed a high level of *B. cereus* contamination (170,000 c/gm) in the sample hot drink. No detectable levels of *B. cereus* were present in either the powdered hot chocolate mix or an additional beverage sample made in the laboratory using water from the implicated

Table 1. *B. cereus* concentrations in hot chocolate samples dispensed from three vending machines, Minneapolis, 1994

Machine	Sample		B. cereus count/gm
A	#1	Initial sample	2,500,000
	#2	30 seconds after initial sample	115,000
	#3	1 minute after initial sample	900,000
	#4	1.5 minutes after initial sample	1,100,000
B	#1	Initial sample	30,000
	#2	30 seconds after initial sample	22,000
C	#1	Initial sample	<100
	#2	30 seconds after initial sample	<100

NOTE: Concentrations ≥ 100,000/gm can induce illness.

Table 2. *B. cereus* concentrations in two cleaned and sanitized vending machines, Minneapolis, 1994

Source	B. cereus count
Machine A (beverage sample)	200,000/gm
Machine B (beverage sample)	500,000/gm
Machine A (dry mix)	< 100/gm
Machine B (dry mix)	< 100/gm

NOTE: Concentrations ≥ 100,000/gm can induce illness.

machine's holding tank and part of the dry mix sample. We therefore were unable to conclude the source of contamination but suspected that concentration of the bacteria sufficient to cause illness occurred in the mixing cup during the mixing process. The positive sample was sent to the Centers for Disease Control and Prevention for evaluation and was confirmed positive for toxin production.

Secondary investigation. The initial positive finding of *B. cereus* contamination led to further questions: (*a*) Would the concentration of *B. cereus* diminish with repeated dispensing of the beverage? (*b*) How common is *B. cereus* contamination in local vending machines?

To answer these questions, we collected several more samples. First, we collected a series of four servings of hot chocolate from the implicated machine (Machine A) with no lag time between samples. Then we collected two consecutive samples, with no intervening lag time, from each of two machines not previously tested, one at the same plant (Machine B) and one at the vending machine company (Machine C). All samples were analyzed at the health department laboratory.

The laboratory results are shown in Table 1. Samples from Machine B also proved positive for *B. cereus*, although at a level not expected to cause illness. These results suggest that once machine parts are contaminated, serving of two or more beverages in succession does not appreciably reduce the concentration of *B. cereus* in the dispensed product. One week later, Machines A and B were tested again following thorough cleaning by the operator. During the cleaning, removable parts, including the mixing cups, were soaked in a chlorine solution. Testing showed that efforts to clean and sanitize the machines were not effective in eliminating the bacterial contamination and may have actually *increased* the concentration of bacteria dispensed by Machine B (see Table 2).

The parts of Machine A associated with making hot chocolate were analyzed to determine the areas likely to be causing the problems. Although all appeared to be intact and had no visible flaws, we found healthy cultures of *B. cereus* in two areas: (*a*) on the silicone gasket that sealed the shaft of the mixing blade where it entered the mixing cup, and (*b*) in the mixing cup itself, around small, raised lines or flutings that ran from the top of the mixing cup to near its funnel-like base. Because only a small amount of material was available, it was not possible to quantify the *B. cereus* concentration in the residue in either location.

Autoclaving all components used in the contaminated machines was effective in eliminating *B. cereus* bacterial contamination. However, because these machines were subsequently removed by their operators from the Minneapolis city limits and therefore from the city health department's jurisdiction, the long-term effectiveness of this strategy is not known.

These initial results led to concerns that *B. cereus* contamination was widespread in city vending machines and that vending machines may be a significant source of unreported illnesses. From brief interviews with several local health officials, it appeared that there had not previously been any hot chocolate-related outbreaks reported locally. We then

Table 3. *B. cereus* concentrations (count/gm) in hot chocolate samples from five vending machines, Minneapolis, 1994–1996

	Time of collection						
	12/27/94 to	1/3/95		2/1/95		7/10/95	4/29/96
Machine	12/29/94	11:15 a.m.	11:25 a.m.	9:30 a.m.	9:45 a.m.		
E.	780,000	5000 after cleaning	2100 after rinse cycle connected	18,000–23,000 After 28 days using rinse cycle[a]	<100 after new parts installed	1600	11,000
F.	1300	...	...	...	...	<100	<100
G	300	...	...	...	...	<100	<100
H	2900	...	...	...	...	3000	...
I	1000	...	...	...	...	30,000	...

[a]*B. cereus* detected on plastic parts from Machine E.

NOTE: Concentrations ≥ 100,000/gm can induce illness.

used city licensing lists to identify all registered machines known to dispense hot chocolate beverages. These machines were owned and maintained by several different companies and used three different brands of powdered hot chocolate.

Of the 36 additional licensed machines in the city, we found five that were positive for *B. cereus*, with the beverage from one (Machine E) contaminated at a level likely to cause illness (780,000 c/gm; Table 3). (All five machines did not use the same brand of hot chocolate mix.)

The owner of Machine E was permitted to clean the machine thoroughly before a second sample was taken. (The other machines were left in operation because of their low levels of contamination.) During the cleaning, we observed that Machine E was equipped with an internal automatic rinse cycle that flushed hot water from the holding tank through the hoses to the internal waste bucket every four hours and that this mechanism had been disabled. Vending machine company service technicians later told us that disabling the rinse cycle was a common practice because waste buckets otherwise tend to overflow between service visits.

The automatic rinse cycle was reconnected and two hot water flushes were run through the machine before a third beverage sample was taken. The product label was pulled from the customer display window to discourage purchases, and the machine was left in operation so we could observe the effect of the automatic rinse mechanism on the concentration of *B. cereus*. Because *B. cereus* contamination had been reduced to below dangerous levels, the machine was not taken out of service altogether and was allowed to continue vending other products. One month later, a fourth sample was collected from this machine. The hot chocolate dispensing parts were replaced with new ones, and a fifth sample was immediately collected.

The thorough cleaning of Machine E, performed immediately before the second sample was taken, did reduce the concentration of *B. cereus* to levels low enough that they would not likely cause illness, and the reattachment of the rinse cycle further reduced observed concentrations in the third sample. However, when the fourth sample was collected, one month after the automatic rinse mechanism was engaged, the *B. cereus* concentration had again increased in the dispensed product (Table 3). The fifth sample, taken after replacement parts were installed, was negative for *B. cereus*.

Vending machines can support the growth of *B. cereus* organisms capable of producing toxins, and under favorable conditions, these toxins can be produced in sufficient quantities to induce illness.

We noted that of all the machines tested, the ones that were positive for *B. cereus* (at a concentration higher than 100 c/gm) had several things in common:

- All were manufactured prior to 1980.
- None was cleaned by the operator more than once a week. (Cleaning typically meant "flushing the hoses" with hot water from the holding tank.)
- Affected machines either had no systems for automatic "flushing" with water from the holding tank at regular intervals or the existing mechanisms had been disconnected.

However, each of the above features was also present in one or more of the *unaffected* machines.

The active investigation was halted because (*a*) there was no evidence of widespread illness associated with the drinking of contaminated beverages, (*b*) all machines at that point had low levels of bacteria, and (*c*) the resources available to the investigative team were limited. We informed vending machine owners of our findings and our suspicion that inadequate cleaning was a factor in the prolific growth of *B. cereus* in some vending machines. Follow-up tests of all available machines previously testing positive for *B. cereus* were conducted in 1995 and 1996. (Machines A and B had been moved outside the city; two additional machines were lost to follow-up when the companies where they were placed went out of business or stopped using them.) Although several of these tests showed contamination, none were at concentrations likely to cause illness.

Discussion

Hot chocolate beverages from three Minneapolis vending machines contained *B. cereus* at significant levels. Illness consistent with *B. cereus* food poisoning was reported in four people who had consumed hot chocolate from one of the three machines. Typically, *B. cereus* contamination is found in cooked foods that are left for extended periods of time at room temperatures and then served. Heating stimulates the germination of spores commonly present in the food, causing the illness-inducing toxin to develop. In the present case, spores may have been present in the dry chocolate mix at acceptably low levels but germinated and multiplied

rapidly when exposed to warm water for extended periods of time in places where the beverage "pooled" or where it remained on various machine components. No other likely source of contamination was identified.

The investigation focused on identifying the feature(s) of the vending machine that promoted excessive bacterial growth. Since each of the common characteristics of the affected machines was present in one or more of the unaffected machines, we are unable to specifically conclude that the rinse mechanism, the cleaning protocol, or the age of the machine are important factors in promoting bacterial growth. We note, however, that none of the nine machines reportedly cleaned daily by their operators had detectable levels of *B. cereus*.

Although Machine E carried significant levels of bacteria, no cases of illness were identified at the company where it was installed. In fact, the CEO of the company reported drinking the product daily, without adverse effect. It seems possible, therefore, that although vending machines are capable of promoting *B. cereus* growth, they may not always be conducive to the production of toxin.

B. cereus food poisoning is most commonly linked to ingestion of reheated grains.[2] We were unable to find other reports linking *B. cereus*-associated illness to beverage consumption. Sutherland has reported that a high sugar content apparently inhibits the production of toxin in dairy products with substantial *B. cereus* contamination.[1] While cocoa is reported to contain substances capable of suppressing bacterial growth, it appears that under certain conditions, or perhaps with different ratios of cocoa to milk products or sugar, bacterial growth may be sustained. *B. cereus* is a frequent contaminant of dairy products, including dried milk products.[1,6] However, although the chocolate beverage mix in the study machines contained dry milk products, *B. cereus* was not detected in samples of the powdered mix. In this situation, undetectable levels of spores may have been present in the mix and the small quantities that remained in the mixing cup and funnel may have multiplied during extended exposure to warm water.

Vending machines are designed for intermittent use; there will normally be periods of time during which an automatic rinse cycle does not engage. Even under heavy use, small amounts of product may pool in areas that rinsing and routine cleaning do not affect. Determining the specific design features that encourage pooling would be a useful issue for study.

We were unable to identify the initial source of the bacteria, although the powdered chocolate mix was the most likely source. Nor was it clear what specific feature(s) of the vending machines promoted excessive bacterial growth. It is clear, however, that vending machines can support the growth of *B. cereus* organisms capable of producing toxins and that under favorable environmental conditions these toxins can be produced in sufficient quantities to induce illness. Such illnesses are likely to be underreported, as they are generally of short duration, and hot chocolate may not be recognized as a likely candidate for suspicion.

Periodic testing of vending machines is thus warranted, particularly when they are used by vulnerable populations such as the aged or immunosuppressed, for whom illness may have severe consequences. City sanitarians should be aware that vending machines may be a potential reservoir of *B. cereus* contamination. The relationship between the presence of *B. cereus* and the frequency and thoroughness of machine cleaning is an important issue for further study; laboratory investigations into conditions in vending machines conducive to toxin production are needed.

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