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Validation of a Procedure Using CO_2 for Rapid Cooling of Cheese Sauce

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SUMMARY

Cheese sauces are commonly produced in commercial kitchens. These sauces must be handled as potentially hazardous foods, unless challenge tests with *Clostridium botulinum* and *Bacillus cereus* are performed to demonstrate their microbial stability. Although there are inhibitors in many cheese sauces (e.g., salt and exudates from lactic acid bacteria fermentations), the FDA 2001 Food Code requires that all potentially hazardous food be cooled from 140 to 70°F in 2 hours and from 70 to 41°F in 4 hours. Actually, this is a straight-line exponential cooling curve from 140 to 41°F in 6 hours. Because cooling a large quantity of cheese sauce in 2-inch pans requires overnight refrigerated storage, during which time the sauce may be handled multiple times, the cooling process increases the risk of bacterial growth while placing a burden on the cooling capacity of refrigeration units. This study examined two cooling methods: cooling of cheese sauce in an ice bath followed by further cooling in refrigerated storage, and addition of CO_2 (dry ice) to cheese sauce to cool it rapidly.

The latter method of cooling was found to be more rapid, less labor intensive, and more cost effective. CO_2 (dry ice) can also be used for cooling other potentially hazardous liquid or semi-liquid food products.

INTRODUCTION

Cheese sauces are commonly produced in commercial kitchens. These sauces must be handled as potentially hazardous foods, unless challenge tests with *Clostridium botulinum* and *Bacillus cereus* are performed to demonstrate their microbial stability. Although there are inhibitors in many cheese sauces (e.g., salt and exudates from lactic acid bacteria fermentations), the FDA 2001 Food Code requires that all potentially hazardous food be cooled from 140 to 70°F in 2 hours and from 70 to 41°F in 4 hours. Actually, this is a straight-line exponential cooling curve from 140 to 41°F in 6 hours.

Cooling food in an ice bath has been used as a rapid cooling method. An even more rapid method is to use dry ice pellets, which consist of compressed, food-grade quality CO_2 and are available from local vendors. The pellets can be added directly to liquid or semi-liquid foods such as sauces. CO_2 has been shown to both inactivate microorganisms responsible

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FIGURE 1. Sauce made in 10-gallon electric steam kettle

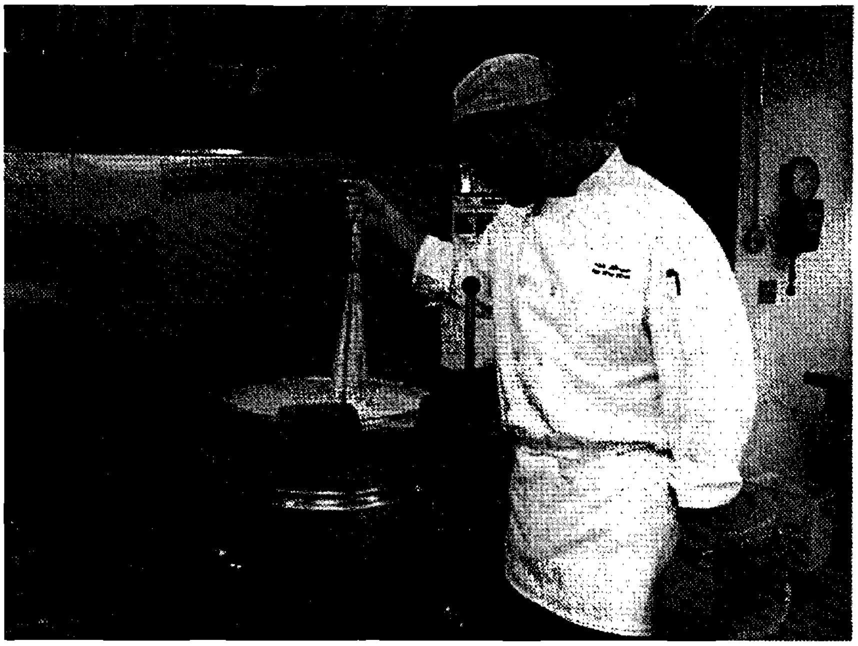
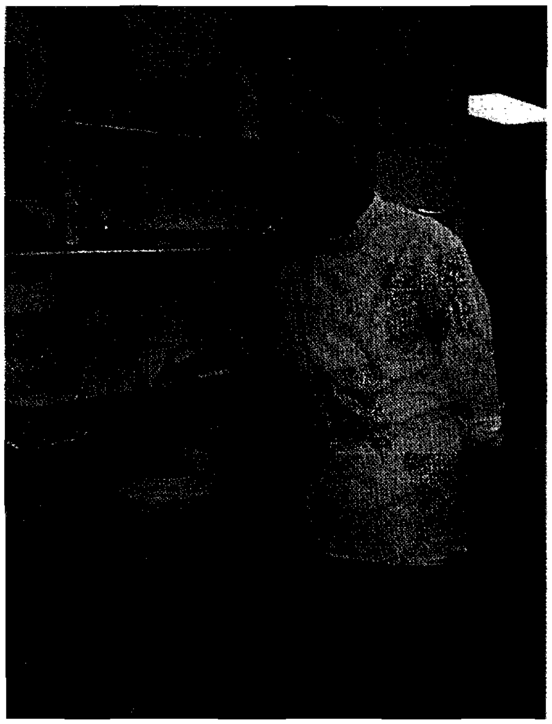


FIGURE 2. Five gallons cheese sauce in fruit and vegetable sink for ice bath cooling



for foodborne illness and inhibit bacterial growth *(1, 3)*. When dry ice is used to cool food, some of the CO_2 combines with the H_2O in the food to form H_2CO_3 (carbonic acid), thus, extending the shelf life of the product. This particular aspect was not studied in this test, but based on other studies, an extension of the refrigerated shelf life of the sauce would be expected. The flavor of foods cooled in this manner is not adversely affected and, in some cases, may be enhanced.

METHODS

The recipe for the sauce used in this study is as follows:

Ingredients:

2 cups chicken base
5 gal water
1/2 cup chopped garlic (sauteéd in olive oil)
1/2 cup prepared mustard
8 lb processed American cheese
1.2 qt heated heavy cream
16 oz cornstarch slurry
5.5 lb flour roux
Salt and pepper to taste

Method:

1. Sauté garlic in olive oil.
2. Add chicken base and water.
3. Bring to a boil.
4. Add American cheese.
5. Thicken with flour roux.
6. Reinforce with cornstarch.
7. Add heavy cream.
8. Strain and cool to 41°F.

Figure 1 shows the sauce being made in a 10-gallon electric steam kettle.

Five gallons of cheese sauce were cooled in a 5-gallon container in an ice bath. Figure 2 shows the container of cheese sauce surrounded by ice and water in a fruit-and-vegetable washing sink. The sauce was stirred about every 15 to 20 minutes to mix the warmer sauce in the middle of the container with the cool sauce along the edge of the container, thus assuring a uniform temperature throughout the product.

FIGURE 3. Five gallons cheese sauce to be cooled with dry ice pellets

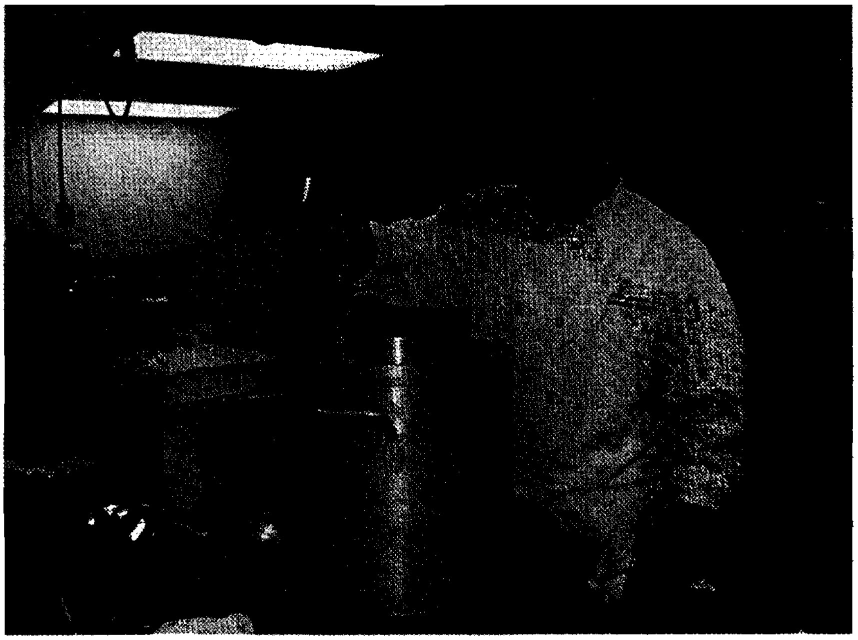


FIGURE 4. Cheese sauce at 50°F

Figure 3 shows the other 5 gallons of sauce, to which CO_2 pellets were added in a 10-gallon pot. The dry ice pellets are shown on the scale to the left of the pot. The CO_2 pellets were added to the sauce in 5-pound increments, because, as gaseous CO_2 is evolved through sublimation, there is vigorous bubbling and spattering of the hot sauce, which may initially be at a temperature above 200°F.

Figure 4 shows the sauce in the pot at a temperature of about 50°F. The sauce became very viscous as it cooled and was difficult to stir toward the end of the cooling.

RESULTS

Figure 5 and Table 1 show the cooling curve and time-temperature results for the 5 gallons of sauce cooled in the ice bath in the sink followed by continued cooling during refrigerated storage.

The cooling time was much shorter for CO_2-pellet-cooled sauce. Table 2 shows the temperature of the sauce as the dry ice pellets were added.

Although all of the CO_2 pellets could have been added at the same time, this was not a practical solution with this very thick sauce. An alternative that would have allowed this, shown in Fig. 6, is use of a Hobart 40-quart/10-gallon mixer.

It would have been possible to put 5 gallons of sauce in the mixer and, using a dough hook, slowly stir the sauce while adding the CO_2 pellets. This would have avoided the problems of the increased viscosity of the sauce as it cooled and the difficulty in stirring it, and would have permitted rapid incorporation of the pellets.

It can be seen from Table 2 that 18 lb of pellets were sufficient to cool the 5 gallons (42 lb) sauce to about 40°F. It took approximately 1 h, but, as stated previously, this was due mostly to the difficulty in manipulating the thick sauce at the end of the cooling period.

Note that in the first 15 minutes, the cheese sauce was left in the kettle. However, it was recognized almost immediately that cooling the kettle jacket, with its hot water and hot stainless steel, would require a great deal of cooling energy. For this reason, the sauce was removed from the kettle and placed in a 10-gallon pot for cooling.

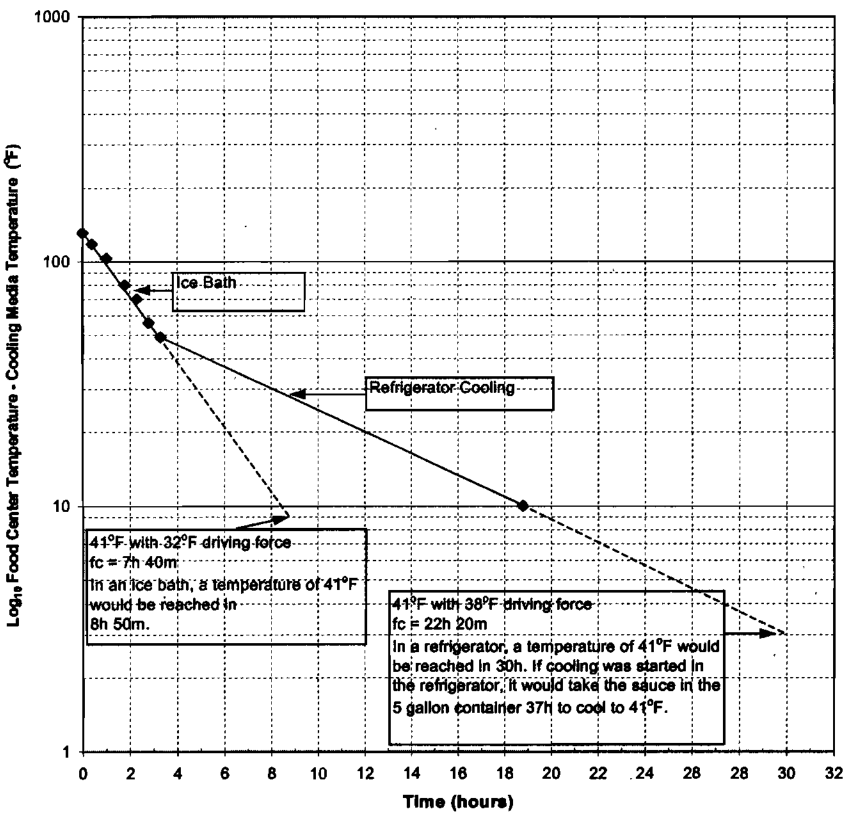
DISCUSSION

The results of this experiment show that cooling and stirring cheese

TABLE 1. Cooling of 5 gallons sauce in ice bath

Clock Time (24 hours)	Δt h:m	ΔT Ctr-Air	Food Ctr Temp.	Cooling Media Temp.
1:13 p		131	163	32
1:37 p	24 m	118	150	32
2:14 p	1 h 1 m	103	135	32
3:00 p	1 h 47 m	80	112	32
3:30 p	2 h 17 m	70	102	32
4:00 p	2 h 47 m	56	88	32
4:30 p	3 h 17 m	49	81	32
8:00 a	18 h 47 m	10	48	38

FIGURE 5. Cheese sauce cooled in 5-gallon plastic container in an ice bath and refrigerator



sauce in a 5-gallon container in an ice bath with further cooling overnight in a refrigerator is a very labor-intensive and time-consuming cooling process. It requires that food be made the day before and cooled so that it can be combined with chilled meals to be sent out to subsidiary kitchens for client feeding.

In contrast, adding CO_2 pellets to the hot, freshly prepared sauce is a simple method of cooling the sauce rapidly so that the sauce can be combined much sooner with other ingredients, and the final product can be finished and packaged without a storage delay of many hours.

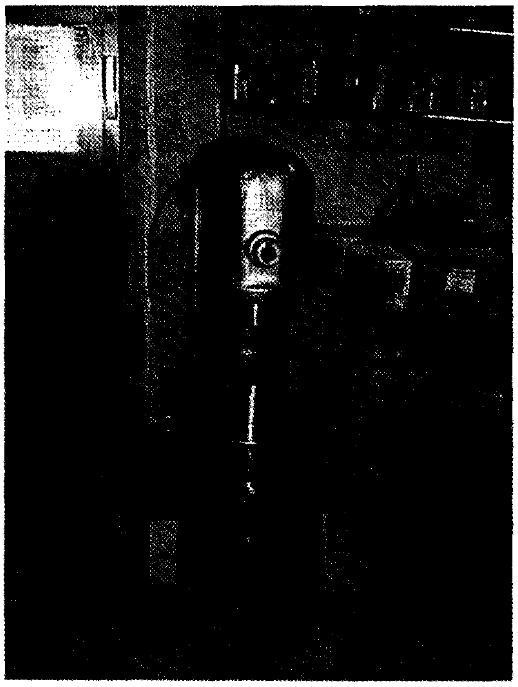
To cool the cheese sauce in this study from 163 to 38°F took approximately 1 lb of dry ice pellets per 2 lb of cheese sauce. When the dry ice sublimes as CO_2, it provides about 246 Btus cooling per 1 lb of pellets. Food such as cheese sauce is expected to have a specific heat (amount of energy to cool 1 lb of food 1°F) of about 0.84 Btu. In this case, the equation that predicts this cooling from 163°F to approximately 38°F (a change in temperature of 125°F) is as follows:

$$\frac{246 \text{ Btus / lb } CO_2 \text{ pellets} \times 18 \text{ lb pellets}}{42 \text{ lb sauce} \times 0.84 \text{ Btu to cool 1 lb. of sauce } 1°F} = 125°F$$

TABLE 2. Cooling time for sauce cooled with dry ice pellets

Time	Pounds of pellets added	Resulting temperature (°F)
1:13 p	—	163
Added	5	126
1:26 p	5	100
1:35 p	5	62
1:45 p	3	38

FIGURE 6. Hobart 40-quart/10-gallon mixer



One pound of pellets costs approximately $0.30. Hence, the cost of the CO_2 pellets used for cooling the 5 gallons of cheese sauce in this study was about $5.40. The labor time required for the CO_2 cooling is simply the time needed to add the pellets and stir the sauce, which is approximately 15 minutes; at $10.00 labor cost per hour, this is equivalent to $2.50. Thus, the total cost of cooling the food by use of this method was $7.90.

The sauce cooled in the ice bath in the sink was stirred at timed intervals throughout the afternoon, then moved into a walk-in refrigerated storage unit and cooled to a lower temperature. Labor time associated with the ice-bath-cooled sauce was approximately 1 h at a cost of $10.00. The savings in labor cost alone more than covers the cost of the dry ice pellets used to cool the cheese sauce rapidly.

CONCLUSION

This study examined two methods of cooling cheese sauce: in an ice bath followed by further cooling in refrigerated storage, and addition of CO_2 (dry ice) to cool cheese sauce rapidly. The latter method of cooling was found to be more rapid, less labor intensive, and more cost effective. Cooling food with CO_2 (dry ice) can also be applied to cooling other potentially hazardous liquid or semi-liquid food products.

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