COOLING MENU ITEMS BY AGITATION UNDER REFRIGERATION

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SUMMARY

The present investigation was concerned with cooling menu items by agitation, under refrigeration. The aim was to investigate the effects on cooling times of foods of the following variables: the design of the agitator, the width of the scraper blade of the agitator, and the rate of agitation. Observations were made of changes in certain quality characteristics of the items cooled by agitation.

The cooling times of the agitated menu items were reduced to fractions of the time lengths required when comparable batches were cooled without agitation.

The design of the agitator and the rate of agitation had little effect on cooling time but had a strong effect on the physical quality of the entrees, especially stews. A simple frame agitator equipped with wide plastic scraper blades rotating at 8 rpm gave satisfactory results in that it effected fast cooling without rendering the item unacceptable in appearance.

Agitation under refrigeration may be looked upon as an efficient and feasible method of precleaning menu items.

Large batches of foods cool slowly even under refrigeration creating temperature conditions favorable for bacterial growth (2, 5, 7). Research data are available which point toward agitation as a tool for speeding up cooling of food. Several methods of cooling large batches of food by agitation have been studied: manual agitation of the food (6); mechanical agitation using a food mixer at room temperature (3) and a U-shaped tube with cold water flowing through the tube (4, 8).

The present investigation was concerned with cooling menu items by agitation, under refrigeration. The aims were to investigate the effects on cooling times of foods of the following variables: the design of the agitator, the width of the scraper blade of the agitator, and the rate of agitation. Observations were made of changes in certain quality characteristics of the items cooled by agitation.

Preliminary to this investigation, agitators of various designs were tested to determine whether they were worthy of being included in this study. The determining criterion was that entrees containing cooked cubed vegetables should not be broken up and thus be rendered unacceptable for service.

EXPERIMENTAL PROCEDURE

There were four parts to this investigation. In Parts I, II and III, soft custards and puddings were used; in Part IV, soups and entrees. In Part I, the effect of the design of the agitator was studied; three designs were compared. In Part II, the effect of the width of the scraper blade of the agitator was studied; in Part III, the effect of rate of agitation. In Part IV, soups and entrees were agitated to test the feasibility of cooling by agitation some less homogeneous menu items, namely soups and entrees.

Control batches were allowed to cool under refrigeration without being agitated.

MATERIALS

The custards were made with 3 oz cornstarch/gal milk and the puddings with 6 oz/gal milk. In both custards and puddings, 2 levels of egg and 2 levels of sugar were used: the levels of egg were 13 and 16.5 oz/gal milk; the levels of sugar were 0 and 16 oz/gal milk. The items were prepared in 4-gal batches using the 2-step method as described in an earlier publication (8). In Part IV, 2-gal batches of soups and entrees were prepared following the formulas given in Wood and Harris (10).

EQUIPMENT

The custards and puddings were cooled in heavy-duty 25-qt aluminum stock pots, 13 in. high and 12 in. in diameter. The soups and entrees were cooled in 15-qt stock pots 11 in. high and 10 in. in diameter. The 55 cu ft refrigerator used has been described in an earlier publication (7). A variable-speed agitator was installed above, with the rotating agitator shaft entering through the ceiling of the upper left hand compartment. The stock pot was clamped to the floor of this compartment. The temperature of the

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1 Commercial brand.
2 Dried whole egg, reconstituted in the proportion of 1 part egg to 3 parts water by weight.
3 Spray low heat non-fat milk solids reconstituted in the proportion of 1 lb milk to 1 gal water.
4 Wearever, No. 4252
5 Wearever, No. 650
6 Jewett, General Electric Model CS-450
refrigerator ranged from 32 F to 42 F. The experimental unit is pictured in Figure 1.

Agitators of four different designs, C, D, E and F (Fig 2) were used in this investigation. Models A and B were eliminated after preliminary tests. All agitators were made from sheet aluminum, 1/8 in. thick. Model B was designed from model A by cutting the 1/8-in. width of the cross connections down to 3/4 in. A third agitator, model C, was designed with the aim of achieving good mixing throughout the mass and also at the surface. Model D was arrived at by cutting the 3/4-in. width of the cross connections of model C down to 1/4 in. and rounding the surfaces. Model E was fashioned after model D, but equipped with 1/4-in. wide non-bevelled plastic* scraper (1/16 in. thick), attached to both sides of the agitator, to provide for more efficient scraping from the periphery of the stock pot. In model F, the inside cross connections were cut away and a wider plastic blade (3 in. wide, 1/16 in. thick) was attached to the sides and bottom of the agitator.

Two inches of this blade were curved forward to plow the food materials away from the periphery during agitation.

**TEMPERATURE MEASUREMENTS**

Throughout the cooling period temperatures were recorded in the batch at 10-min intervals using three thermocouples attached to a glass stirring rod. To measure the temperature in the agitated batches, agitation was stopped and the glass rod holding the thermocouples was inserted down the center of the batch. In the 4-gal batches of custards and puddings these thermocouples were located 1/ in., 4/-in., and 7 in. from the surface of the mixture. In the 2-gal batches of menu items the thermocouples were located 1/ in. from the surface of the mixture and in the middle of the mass. Data representing total cooling times are based on the readings recorded in the warmest spot which was the middle of the mass. Temperature readings were also made in the refrigerator air in the upper left and right rear corners of the cooling compartment, and in the room approximately 4 ft in front of the refrigerator.

In Part I, the mixtures were cooled from an initial temperature of 140 F to a final temperature of 80 F. The final temperature of 80 F was chosen because in an earlier study involving the same refrigerator (7), it was found that when large amounts of food were precooled to 80 F before they were introduced into this same refrigerator, the refrigerator air temperature did not rise. In Parts II, III, and IV, the foods were cooled to 50 F. By choosing this lower final temperature, the period of agitation was considerably lengthened and an opportunity was afforded to determine possible consistency changes under more rigid conditions. Cooling to this low temperature should be rapid in order that the food will remain in the bacteriologically dangerous temperature zone (9) for a minimum length of time.

**RELATIVE VISCOSITY**

The relative viscosity of the custards and puddings was determined by measuring the radius of spread using a modification of the linespread method as described by Billings (1). The measurements were taken on two samples of the mixtures: one sample at a temperature of 140 F removed from the cooked mixture before agitation, and a second sample removed from the mixture that had been cooled to the desired endpoint and reheated to 140 F.

**SUBJECTIVE OBSERVATIONS**

In Parts I, II, and III, subjective observations were made by a panel of six judges from the staff of the Department of Institution Management. The judges
were presented with two samples of the mixtures, one sample of the mixture was taken before treatment, the other after. The judges were asked to determine whether the consistency of each sample was acceptable for service.

In Part IV, subjective observations were made by ten judges on the agitated menu items. The judges were asked to determine, by appearance only, whether the menu items were acceptable for service. When a certain proportion of the discrete pieces of meat and vegetables were broken up, the items were considered unacceptable.
RESULTS

Effect of Agitator Design (Part I)
Approximate cooling times in batches agitated by the models C, D, and E were similar, 90 min. The values for increase in radius of spread were the same, 4.5 mm. Level of egg and level of sugar had no effect on total cooling times and change in relative viscosity.

Effect of Rate of Agitation (Part III)
The data showing the effect of rate of agitation using model F on total cooling time and on increase of radius of spread of the custards and puddings are presented in Table 2. The mixtures were cooled from 140 F to 50 F.

In custards and puddings refrigerated without agitation, cooling times were approximately 10% to 11 hrs. In the custards and puddings which were agitated under refrigeration, the cooling times were reduced to approximately 4 hrs. There was no consistent trend which showed a relationship of rate of agitation to cooling time when rates of 8, 12, 16 and 38 rpm were employed. The percent increase in radius of spread which indicates thinning, was highest in the custards and puddings agitated at 38 rpm. No effect on cooling time and change in radius of spread could be ascribed to level of egg and level of sugar.

Subjective Observations on Custards and Puddings
In some of the agitated mixtures thinning was noted by the judges. However, all the custards and puddings used in the experiments described under Parts I, II and III were considered acceptable for service. In general, the judges remarked on the smoothness and glossiness of the agitated mixtures.

Agitation of Soups and Entrées (Part IV)
In preliminary tests, agitator models A, B, and C were compared regarding destruction of cubed potatoes, celery, carrots, and meat. On the basis of these tests, models A and B were ruled out. These models did not effect fast cooling and they caused some destruction of cubed vegetables and considerable destruction of cubed meat.

The effect of agitation on the total cooling times and on the acceptability of soups and entrées is presented in Table 3.

Soups. The total cooling times of the soups agitated by model E at 38 rpm were 1/2 to 1/5 of the cooling times of comparable batches which were refrigerated without agitation. The longest cooling time observed was 40 min for the agitated items and 200 min for the non-agitated items. All of the soups were considered by the judges to be acceptable for service.

Entrées. When model E was used at 38 rpm, maximum total cooling time was 40 min. The entrées containing cubed meat (stews) were not considered acceptable for service.

Beef stew which was among the menu items which were rendered unacceptable by agitation with model E at 38 rpm, was again agitated using model F at

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Effect of Size of Scraper Blade (Part II)
The data showing effect of size of scraper blade (Figure 2, E and F) on total cooling time and increase in radius of spread of the custards and puddings are presented in Table 1. The comparison was made on items cooled from 140 F to 50 F.

Average total cooling times achieved when model F was used were slightly shorter than the cooling times achieved when model E was used. The total cooling times of the batches agitated with model F were less than 4 hrs. Increases in radius of spread were similar.

Table 1. Effect of width of scraper blade: average cooling time and average increase in radius of spread of four 4-gal batches of custards and puddings agitated at 38 rpm using agitation blades of two widths

<table>
<thead>
<tr>
<th>Menu Item</th>
<th>Agitator model E (narrow blade)</th>
<th>Agitator model F (wide blade)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total cooling timea (min)</td>
<td>Increase in radius of spreadb (mm)</td>
</tr>
<tr>
<td>Custard</td>
<td>240</td>
<td>8.8</td>
</tr>
<tr>
<td>Pudding</td>
<td>265</td>
<td>11.5</td>
</tr>
</tbody>
</table>

*aCustards contained 3 oz cornstarch per gal milk; puddings, 6 oz.
*bFrom 140 F to 50 F.

In the custards and puddings which were agitated under refrigeration, the cooling times were reduced to approximately 4 hrs. There was no consistent trend which showed a relationship of rate of agitation to cooling time when rates of 8, 12, 16 and 38 rpm were employed. The percent increase in radius of spread which indicates thinning, was highest in the custards and puddings agitated at 38 rpm. No effect on cooling time and change in radius of spread could be ascribed to level of egg and level of sugar.

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Beef stew which was among the menu items which were rendered unacceptable by agitation with model E at 38 rpm, was again agitated using model F at
two rates of agitation, 38 rpm and 8 rpm. At an agitation rate of 38 rpm the stew was again unacceptably altered. However, when model F was used at a slow rate (8 rpm) excellent results were obtained in that the pieces of meat and vegetable retained their shapes well. The cooling time was similar to the cooling time achieved with model E.

CONCLUSIONS

Agitation under refrigeration may well be regarded as an efficient and feasible method of precooling menu items. Cooling times could be reduced to a fraction of the times required for cooling these items without agitation in the same refrigerator. Objectionable consistency changes could be avoided in custards, puddings, soups and entrées provided that an appropriate type of agitator and an appropriate rate of agitation were used. The design of the agitator models compared in this study had little effect on cooling times, but had a considerable effect on objectionable consistency changes of some entrées. Since it was found that a simple frame equipped with wide plastic scraper blades effected fast cooling and kept cubed vegetables and meats intact, provided the rate of agitation was kept low, this latter type of agitator seems to have practical significance. In addition, the simple construction of this agitator has the advantage of easy cleaning and sanitizing.

Slow rates of agitation (16 rpm and 8 rpm) resulted in cooling times almost as brief as those achieved by applying the considerably higher agitation rate of 38 rpm; at the slow rates the danger of objectionable changes in consistency was much reduced. These facts have practical significance when cooling entrées which contain large but highly destructible pieces like cubed meat, vegetables, macaroni, spaghetti, etc.

A word of caution is in order. Some menu items may well have to be regarded as being not suitable for agitation because of the high proportion of solids they contain or because of degree of doneness. These items may be cooled in a manner commonly employed in the cooling of solid foods: spread out in shallow pans, precooled on ice, and refrigerated promptly.

The question of whether under practical conditions menu items should be cooled to a final temperature of 80°F or to lower temperatures, cannot be answered by the results of this study, because the answer depends on the specific conditions. Before all, the nature of the menu items being subjected to agitation must be considered, since in some items the changes brought about by prolonged agitation would be more objectionable than in others. In general, the food should be cooled to a temperature of 45°F (9) as rapidly as possible; but, as the temperature decreases, the rate of cooling slows down considerably even when agitation is employed. Therefore, prolonged agitation may not always prove the best decision.

Managerial aspects would play a role in setting up a unit for precooling menu items—in particular, the refrigerator space available and the number of items to be precooled. In many food service establishments, refrigerator space is gradually being released because of the general trend toward the use of frozen food items.

It seems then, that it would be rather easy to set up a precooling unit in a food service establishment: to designate a refrigerator, or a refrigerator area, to the purpose of precooling; to install one or more

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**Table 3. Agitating soups and entrees: cooling times and acceptability judgments (items were cooled in 2-gal batches)**

<table>
<thead>
<tr>
<th>Menu item</th>
<th>Agitator model</th>
<th>Rate of agitation (rpm)</th>
<th>Total cooling time (min)</th>
<th>Acceptability judgments</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Soups)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chicken gumbo</td>
<td>E</td>
<td>38</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>Clam chowder</td>
<td>E</td>
<td>38</td>
<td>150</td>
<td>10</td>
</tr>
<tr>
<td>(New England)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn chowder</td>
<td>E</td>
<td>38</td>
<td>145</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>55</td>
<td>10</td>
</tr>
<tr>
<td>Cream of asparagus</td>
<td>E</td>
<td>38</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Cream of chicken</td>
<td>E</td>
<td>38</td>
<td>200</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Creole</td>
<td>E</td>
<td>38</td>
<td>95</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td>Navy bean</td>
<td>E</td>
<td>38</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>Stockless vegetable</td>
<td>E</td>
<td>38</td>
<td>185</td>
<td>10</td>
</tr>
<tr>
<td>(Entrées)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chili con carne</td>
<td>E</td>
<td>38</td>
<td>60</td>
<td>10</td>
</tr>
<tr>
<td>Chop suey</td>
<td>E</td>
<td>38</td>
<td>140</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>45</td>
<td>10</td>
</tr>
<tr>
<td>Lamb stew</td>
<td>E</td>
<td>38</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Raviola, Austrian</td>
<td>E</td>
<td>38</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Meat and</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable Stew I</td>
<td>E</td>
<td>38</td>
<td>160</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>40</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>38</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>38</td>
<td>40</td>
<td>10</td>
</tr>
</tbody>
</table>

*From 140 to 50°F.
*Maximum of 10 judgments.
agitter devices; and to set up a schedule for the precooling of those menu items which are known to belong to the group classified as being "potentially dangerous" from a public health standpoint.

References


