Pressure in the center and side of 290-kg stirred-curd Cheddar cheese blocks was determined during 2 h of pressing at 12 kPa of cheese surface pressure. A strain-gauge pressure transducer and data logger were used to conduct the study. Statistical analyses and graphical depiction showed that pressure increased more rapidly and was higher in the center than at the side of cheese blocks during pressing. Possible reasons for these findings are proposed. (Key words: pressure, curd, whey, cheese)

INTRODUCTION

Pressing is employed to help separate curd from whey and to mold the curd into a desired shape (10). Whey affects curd fusion (1), cheese moisture content and distribution (6), and cheese ripening (3), which, in turn, affect cheese flavor, body, texture, appearance, and standard of identity. Achievement of desired cheese block shape and dimensions is of great economic importance to cutting and packaging operations.

This study was conducted to observe pressure in the center and side of 290-kg stirred-curd Cheddar cheese blocks during pressing. Greater understanding of pressure during pressing cheese blocks may help the cheese maker learn how to regulate cheese quality better and to reduce cutting and packaging costs.

MATERIALS AND METHODS

Cheese was manufactured at Cache Valley Dairy Association (Smithfield, UT). Curd was produced in Double "O" vats (Damrow Co., Fond du Lac, WI) from 22,727 kg of milk, drained, salted on enclosed finishing tables, and air-conveyed to stainless steel hoops (74.9 cm high x 71.1 cm long x 55.9 cm wide). The hoops were lined on all sides and the bottom with a perforated plastic cheesecloth liner bag. The hoops were placed on coasters equipped with drain plates. Before stainless steel hoops were filled, tennis string was drawn across the hoop interior and fastened to steel brackets extending across trier holes at the hoop sides. A screened plastic bulb connected to rigid plastic tubing was secured to the tennis string in the center or at the side of the hoop. The rigid plastic tubing was attached to a Super TJE absolute strain-gauge pressure transducer (.05% accuracy, range of 0 to 100 kPa of absolute pressure; Sensotec, Columbus, OH) located outside the hoop. The pressure transducer was connected to a Campbell Scientific 21X Datalogger (Campbell Scientific, Logan, UT). Figure 1 shows the experimental apparatus. Each hoop was filled with 327 kg of curd at 32°C. Cheesecloth liner and a press plate were placed on the top of the curd mass before pressing. Ambient room temperature was approximately 22°C. After filling, the screened bulb was either 2.5 cm from the side of the hoop or in the center of the hoop. Curd was pressed at 12 kPa of cheese surface pressure for 2 h. Each cheese block released approximately 25 kg of whey during pressing. Pressures at the side and in the center of three blocks were determined continuously during pressing. Atmospheric pressure also was determined with the pressure transducer.

Received February 7, 1994.
Accepted June 24, 1994.

This research was supported in part by the Utah Agricultural Experiment Station, Utah State University, Logan, Utah 84322-4810. Approved as Journal Paper Number 4579.

Missouri Department of Conservation, Columbia 65201.

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Statistical Analysis

Randomized block design ANOVA (9) for pressure were determined from data acquired during pressing (between 0 and 2.0 h), between 0 and 1 h of pressing, and after pressure was completed (between 2.0 and 2.3 h). A total of six blocks of curd were used for the study. Only one pressure transducer was available, so a statistical block consisted of two cheese blocks (one representing the center and one representing the side location) with repeated measures over time, and each statistical block was repeated three times.

Linear regression (2) of all of the data from the three trials was used to determine the slope for maximum pressure increase for the center (between 0 and .5 h) and the side (between .2 and 1.5 h) of cheese blocks. Significance of the difference between slopes was determined using a two-sample t test (2).

RESULTS

Figure 2 shows the pressures in the centers and sides of cheese blocks during 2.0 h of pressing and for .3 h after surface pressure was removed. Statistical analyses are in Table 1. Statistical analyses of the data between 0 and 1.0 h showed that pressure was significantly (P < .05) higher in the center than at the side of blocks during that part of pressing. The pressure difference between the center and side of cheese blocks between 0 and 2.0 h of pressing was significant (P = .065). No significant difference occurred between center and side pressure after pressing was completed (between 2.0 and 2.3 h).

The maximum pressure increases (linear regression of all data from the three trials) for the center (between 0 and .5 h) and the side (between .2 and 1.5 h) of blocks were 21.6 and 6.8 kPa/h, respectively. These increases were significantly (P < .001) different.

DISCUSSION

Pressure increased more rapidly in the center than at the side of cheese blocks during pressing. The pressure transducer may have responded to air and whey escaping from the
Figure 2. Center pressure (top) for trials 1 (●), 2 (▲), and 3 (○) and side pressure for trials 1 (△), 2 (△), and 3 (○) and means (bottom) from the three trials for center (●) and side (○) pressure during pressing of 290-kg stirred-curd Cheddar cheese blocks at 12 kPa of mechanical surface pressure application. Atmospheric pressure is the line with no symbol.
TABLE 1. Mean squares, degrees of freedom, and F ratios for the ANOVA for pressure from data between 0 and 1.0 h and between 0 and 2.0 h of pressing.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Between 0 and 1.0 h</th>
<th></th>
<th>Between 0 and 2.0 h</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
<td>F Ratio</td>
<td>MS</td>
<td>df</td>
</tr>
<tr>
<td>R</td>
<td>2</td>
<td>46.32</td>
<td>2</td>
<td>73.60</td>
</tr>
<tr>
<td>L</td>
<td>1</td>
<td>44.98***</td>
<td>1</td>
<td>44.98***</td>
</tr>
<tr>
<td>Error a</td>
<td>2</td>
<td>16.16</td>
<td>2</td>
<td>30.69</td>
</tr>
<tr>
<td>T</td>
<td>7</td>
<td>13.87***</td>
<td>11</td>
<td>74.73***</td>
</tr>
<tr>
<td>L x T</td>
<td>7</td>
<td>1.16</td>
<td>44</td>
<td>.83</td>
</tr>
</tbody>
</table>

1R = Replication of trials; L = location of pressure transducer in center or side of cheese block, and T = time pressure monitored.
2Error a was the interaction of R x L.
3Error b was a pooling of the interaction of R x T and R x L x T.
*P < .05.
**P < .001.
***P < .001.

Whether these factors affect pressure change during pressing must be elucidated by further study.

ACKNOWLEDGMENTS

We thank G. W. Reinbold for reviewing the manuscript and C. A. Ernstrom for his support. We also thank Paul Campbell, Campbell Scientific, for use of the Datalogger and pressure transducer and Steve Bush, Sensotec, for his explanation of pressure transducer function. We also thank Cache Valley Dairy Association for help and for facilities in conducting the study.

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