A Bacteriological Investigation of a Silver Scroll Type Diffuser

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Acid formation has been a major problem in the use of continuous diffusers, since it causes inversion of sucrose and corrosion of the equipment. There has been very little research reported on this subject but it is generally recognized to be due to bacterial action, and most operators have used formaldehyde as a disinfectant to inhibit the growth of these organisms and thus maintain a satisfactory pH level.

This report presents the results of studies made on the Silver Scroll-type diffuser, which was installed at the Taber Factory in 1950. The work was designed to obtain information on the bacteriological conditions and their relation to the pH of the juice under varying treatments with heat and disinfectants. The preliminary survey was made in 1951, followed by a much more detailed study in 1952, and some specific check tests in 1953, all of which involved counting the bacterial population in samples taken from individual cells of the diffuser.

Culturing and Sampling

To accurately reproduce in the laboratory the particular conditions in each cell of the diffuser was obviously impossible, so arbitrary standard conditions were set up under which the bacteria could be cultured and thus have a common basis for comparison when counts were made.

A trial with Bacto Dextrose Tryptone Agar as a medium indicated that it supported the growth of a great number and variety of organisms found in the diffuser and this was used during this investigation, although a synthetic beet juice medium had been developed in case B.D.T. was unsatisfactory.

Because of the temperatures in the diffuser, it was assumed that the organisms would all be thermophilic and it was found most practical to use a humidified incubator maintained at 55° C. Samples were obtained from each cell or from the supply water tank as required and were immediately plated. Suitable dilutions were estimated for each sample so that after 24 hours incubation the colonies on duplicate plates could be readily counted.

Investiation into Methods of Bacterial Control

1. The initial investigation consisted of introducing various amounts of p-formaldehyde into the diffusei with the simultaneous application of steam until cell No. 13 reaches 80° C. Sampling was done one hour after the treatment.

In Figure 1, the comparative effectiveness of four types of treatment is shown.

A. 15 pounds p-formaldehyde in cells Nos. 11 and 17.
B. 10 pounds p-formaldehyde in cells Nos. 7, 13 and 20.
C. 10 pounds p-formaldehyde in cells Nos. 5, 10, 15, 19 and 23.
D. 5 pounds p-formaldehyde in cells Nos. 5, 10, 15, 19 and 23.

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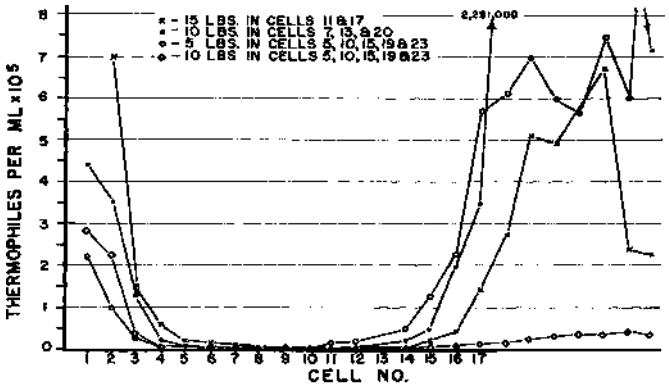

Figure 1.—Thermophilic counts one hour after treatment with various amounts of p-formaldehyde.

It will be noted that *in* all cases there was a definite reduction in bacteria from the first to tenth cells, with a steady increase to more than 600,000 *in* cell 22, except in case "C" where the bacterial numbers *in* the lower part of the diffuser were below 50,000 per ml.

2. To establish the amount of microbial activity under naturally occurring conditions, the diffuser was left untreated for a 12-hour period.

The counts obtained from samples taken after that time are shown in Figure 2. The heat in the upper deck appeared to have inhibited growth to some extent, but the juice in the cells of the lower deck contained about 300,000 organisms per ml. and these were mostly acid formers, which resulted in the pH of the juice being depressed far below average as will be seen *in* Figure 3.

3. To obtain information under conditions completely opposite to those of the last experiment, a complete disinfection of the whole diffuser was attempted by adding ten pounds of p-formaldehyde to each cell with a simultaneous application of steam. The effects of this treatment were evaluated by sampling I, 4 and 8 hours after the addition and the counts are compared in Figure 2, along with those obtained in the preceding experiment.

It will be seen that after 1 hour the only high counts were in the last four cells and this condition was generally maintained after 4 hours, in spite of the constant introduction of bacteria by the incoming cossettes. The population increased very appreciably during the next 4 hours, particularly in cells 10 to 19, and the growth curve for the 8-hour samples approaches the one when no treatment was applied for 12 hours. It should be noted that the pH of the juice in cell 13 remained above 6.0 for 14 hours after the p-formaldehyde was applied.

4. The results of all these tests consistently indicated that the focal point of re-infection was in the lower deck, where the more moderate temperatures would encourage the growth of thermophiles. This suggested that the addition of p-formaldehyde toward the water end of the diffuser might be more effective, and when this was tried, by injecting the disinfectant into cell 21, the control was indeed superior. It was also observed that raising the temperature of the diffuser prior to addiing the p-formaldehyde increased the lethal effect and the pH of the juice was kept at a higher level for a longer period.

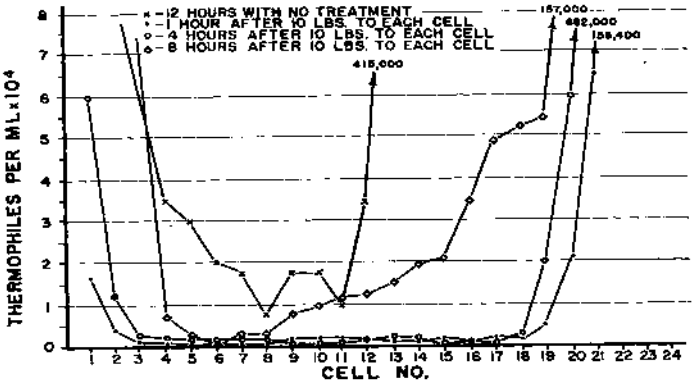

Figure 2.—Thermophilic counts after 12 hours without treatment and one hour, four hours and eight hours after adding 10 pounds p-formaldehyde to each cell.

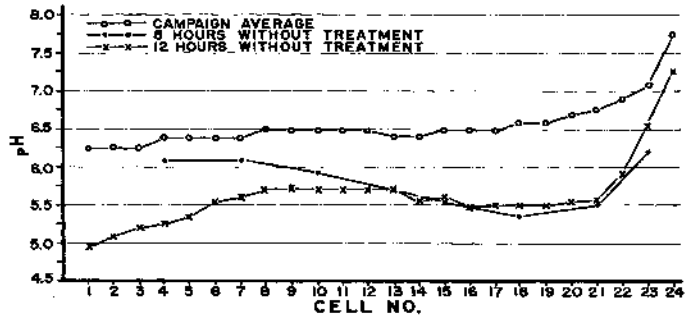

Figure 3.—pH values of the juice in each cell.

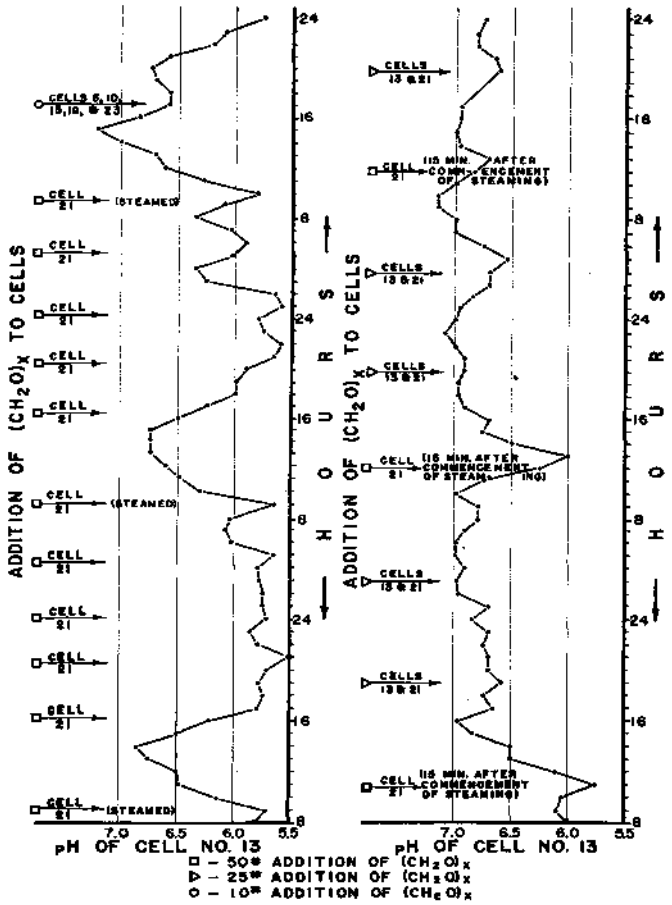

Figure 4.—Relation of pH of juice in cell 13 to p-formaldehyde and heat treatment.

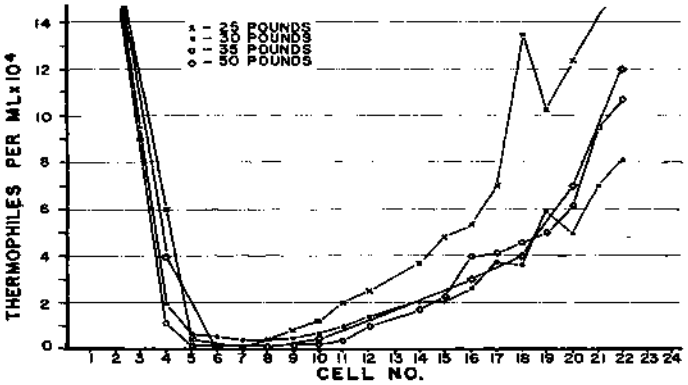

Figure 5.—Thermophilic counts one hour after adding various quantities of p-formaldehyde to cell 21.

In Figure 4, a plot of the pH of the juice from cell 13 illustrates these observations. It will be seen that, without steaming, the p-formaldehyde had little effect, but what was more important, the raising of the temperature before adding this material greatly enhanced its usefulness.

5. To establish the minimum amount of p-formaldehyde necessary to obtain effective control, a series of tests was undertaken in which quantities of 25 to 50 pounds were added to cell 21. These results are shown in Figure 5.

It is apparent that the application of 30 pounds or more was about equally effective, but the 25-pound quantity was less satisfactory. It was, therefore, concluded that a minimum of 30 pounds added to cell 21 would give the most economical results and this was further substantiated in 1953, when a re-check of the work was carried out.

6. The use of other disinfectants was also investigated from the point of view of economy and as an alternative in case of the development of a formaldehyde-resistant strain of bacteria.

The chlorination of the battery supply was tried in 1952 and the few tests for which time was available indicated a favorable response. However, in 1953, a more extensive trial, with residual chlorine as high as 10 p.p.m., failed to show any appreciable control of bacterial growth, and it was concluded that chlorination was not of economic importance.

Experiments with "Dowicide 31," a chlorinated phenol compound, showed it to be effective only when the temperature of the diffuser was raised. Because this compound appears to be mainly carried on the pulp,

it was found to give its best effect when introduced about cell 18, so that it would have a longer retention time in the last 6 cells. On a cost basis, the material could not compete with p-formaldehyde and its main value would seem to be as an alternative bactericide used in conjunction with p-formaldehyde, particularly if formaldehyde-resistant bacteria should develop.

Application in 1953

In 1953, the principles which were established from this research were re-checked. Counts made before and after disinfection followed the same pattern as in 1952, and it was found that adequate pH control could be obtained for periods of slightly more than 9 hours, if a regular routine of steaming and bactericide addition were carried out.

The following program for bacterial control was thus established:

Every 9 hours, the temperature of the diffuser is raised. Fifteen minutes after the steaming is started, 30 pounds of p-formaldehyde dissolved in water are introduced to cell 21 and the heating continued until the temperature in the center of the diffuser reaches 80° C. The diffuser is then allowed to return to normal temperatures.

This routine requires about one hour to complete, and results in the pH at cell 13 remaining near 6.8 for several hours, followed by a drop to about pH 6.2 before the next treatment is due.

Conclusions

From this work, we have concluded that the major growth of bacteria in the Silver Diffuser takes place in cells 19 to 24. The constant inoculation of the system by the incoming cossettes is of minor importance, as the bacteria from this source are largely destroyed by the temperature prevailing *in* the first six cells.

Effective control of bacterial growth, and hence the pH of the juice in the diffuser, is obtained by adding 30 pounds p-formaldehype, dissolved in water, to cell 21, about 15 minutes after a general increase in temperature is started, which is continued until the temperature in cell 13 reaches 80° C.

ACKNOWLEDGMENT

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