Bacteria Investigations in a Silver Diffusor

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During the 1950 and 1951 campaigns Holly has been investigating bacterial activities in the Silver chain type batteries at the Carlton, California, and Sidney, Montana, plants.

The bacterial problems encountered in a continuous type battery are much more serious than those found in the conventional Roberts cell type battery, primarily because in the Roberts type the cells are dumped and thoroughly washed every hour while in the continuous type no such cleaning procedure is practical. The bacterial population must be controlled either by temperature or by addition of a bactericide.

Bacterial activity manifests itself by a lowering of pH of the battery juices, loss of sugar in the juices due to acid inversion, and an alteration of nonsugars so that the resulting juice is difficult to process. pH's of juices from the individual cells of a continuous battery may be as low as 5.5 and if a minimum pH of 6.0 is to be maintained some treatment such as formaldehyde or else high temperatures must be employed. An investigation of pH's of juice from individual cells in a Roberts battery operated in the usual manner showed a minimum pH of 6.3.

The first investigation performed was that of determining the thermal death points of the bacteria involved. An infusion of equal weights of cossettes and cold sterile water was mixed for thirty minutes and six plates in duplicate were inoculated. After mixing, the plates were exposed to temperatures ranging from 55 to 85° C. for thirty minutes. The plates were then incubated and counted in the usual manner.

Figure 1 shows the results of this study. It should be noted that the ordinates of this figure and all following figures are on a log scale. A log plot is necessary to cover the range from 1,000,000 organisms per ml. down to zero. Such a plot is confusing since a drop in population from 100,000 to 10,000 represents a 90 percent kill and yet only a 20 percent decrease on the vertical scale.

Referring to the data presented in Figure 1, a number of different species of each type of bacteria are present in the cossettes and each specie has a slightly different death point. If only one specie were present the count would remain constant to the death point and then drop to zero. This is shown in the curve on molds in which about 50 percent are killed between 60 and 65° C. At 80° C. yeast, mold, and acid producer counts drop to insignificant levels while the total count drops from 400,000 to 17,000

It appears then that temperature above 80° must be employed if temperature sterilization is to be effective. Nineteen hundred fifty-one campaign averages for maximum battery temperatures are Carlton 78° C, Sidney 70° C, average for Roberts type battery 84° C, minimum for Roberts type 79° C. It appears that freedom from bacteria trouble in the Roberts type battery is at least due in part to higher temperatures.

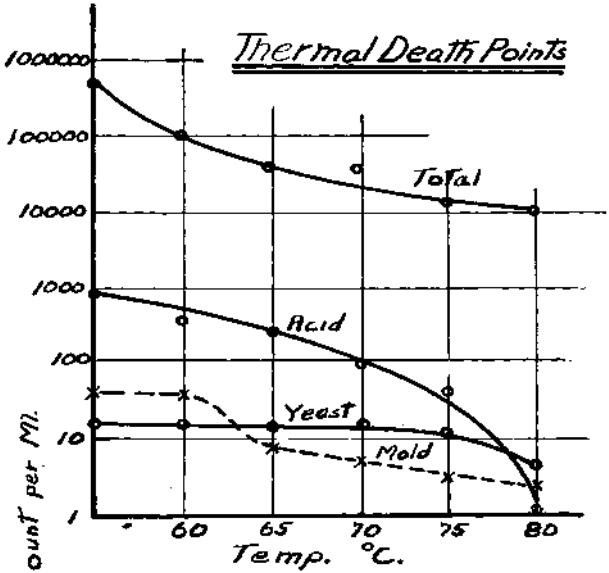

FIG. 1

Another factor equally as important is the latent period of the bacteria involved. It is well known, and we have verified on raw juice, that bacteria require a certain period of time after being transplanted to new surroundings before normal reproduction commences. In raw juice this latent period is about two hours during which time practically no increase in bacteria counts is noted. This latent period is of sufficient duration to allow the cossettes to pass thru the battery without an increase in count. The fact that we have a counter-current flow allows some increases in population. Dead spots and surfaces not continuously wiped by moving juices or pulp also allow increases in counts.

Figures 2, 3 and 4 are graphs of bacteria counts in raw juice, the juice from odd number diffusor cells, and battery supply water. Juice pH and temperature are also shown. The general shape of these curves is typical. Raw juice is highly contaminated due to contact with the cossettes. The counts decrease in the first several cells of the battery but in many cases show an increase at cell number thirteen due to aeration as the pulp is

lifted from the bottom to the top tier of cells. Quite often a decrease in pH was recorded at this point.

An important point which appears in these graphs, especially in Figure 3, is that of bacterial contamination of battery supply water. In Figure 3 this is most apparent. In several of the other graphs bacterial contamination of battery supply water infects the entire top tier of cells. Since at most mills battery supply temperatures of about 65° C. are common and it has been shown that this temperature is not high enough to effectively sterilize the water, we believe chlorination, bromination, or other treatment of battery supply water would be advantageous. A limited test at Carlton using 1.5 to 2.0 ppm residual chlorine seemed to assist in maintaining higher battery pH's. No bacteria counts were made.

Control of bacterial activity within the battery has been accomplished by either use of bactericides or higher temperatures. The use of bactericides such as formaldehyde or para-formaldehyde will maintain normal battery pH's if enough of the material is employed. It is unfortunate, however, that such materials as the aldehydes, chlorine, bromine, and halogenated phenols

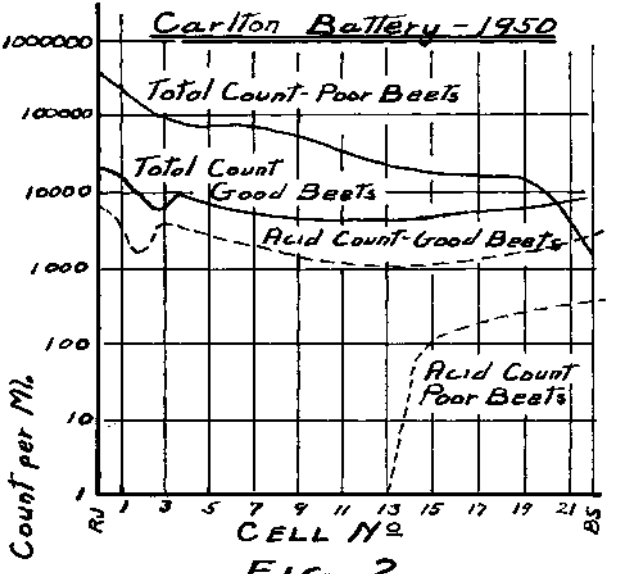

FIG. 2

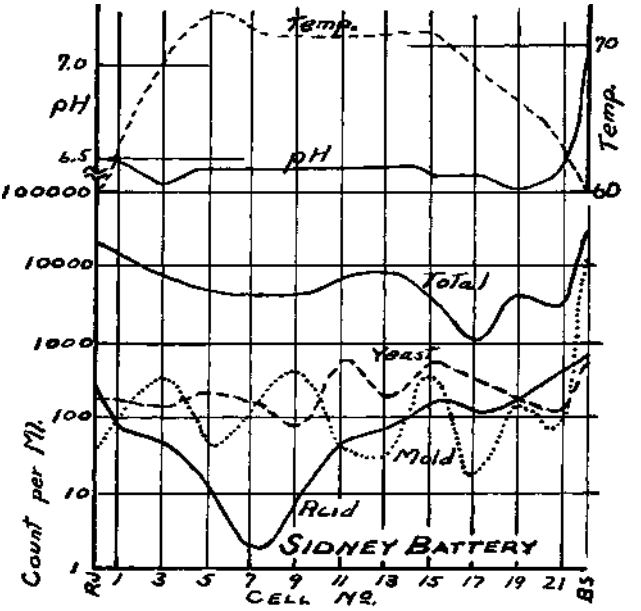

FIG. 3

quickly react with the organic matter in the pulp either chemically or by adsorption and become quite ineffective.

Increase of temperature through the battery is another means of controlling bacterial population. If the pulp is dried, temperatures on the tail end of the battery must not be too high or the pressability of the pulp is adversely affected. During the campaign just completed at Sidney, an

Table 1.

	No Dome Steam	Dome Steam
Average Dome Temperature	67	72
Maximum	67	77
Average Juice Temperature	62	66
Total Bacteria Count per ml.	464,000	63,750
Total Percent Kill		86.2%
Acid Bacteria Count per ml.	86,400	13,481
Acid Percent Kill		84.4%

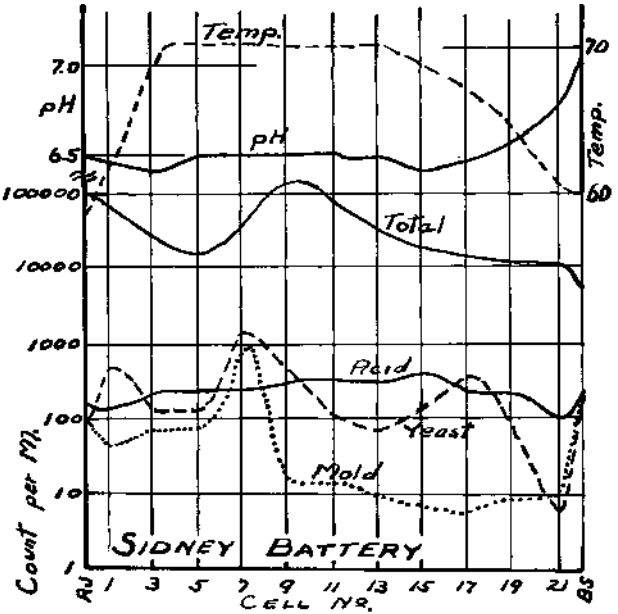

FIG. 4

attempt was made to increase dome temperatures to the thermal death point of 80° C. This was carried out by steaming individual domes in rotation against the flow of beets making a round of the battery on a four-hour cycle. Pan boiling steam was employed. Results are shown in Table 1.

Unfortunately it was not possible to introduce sufficient steam into the domes to reach the thermal death point; however, a maximum of 77° C. effected an 85 percent kill.

The last experiment on which we wish to report is the effect of a bactericide spray on the whole beets before slicing. Most of the bacteria entering the battery are contained on the surface of the beet rather than in the interior of it. It was reasoned that if the beets could be sprayed before slicing the bacteria could be killed and there would be less inactivation of bactericide due to reaction with the organic matter. Ten-day treatment periods were established, alternated with ten-day nontreatment intervals. Testing took place a day before the treatment was changed. Four sprays

were installed at the beet elevator discharge into the beet hopper, positioned so that the beets were sprayed while rolling and turning. This was an attempt to get as complete spraying as possible of the beet surface.

Roccal was employed as the bactericide. One hundred seventy-five gallons per day of 1,200 ppm (100% basis) solution were used. Results are shown in Table 2.

Table 2.

% Kill Total Bacteria	68%
% Kill Acid Bacteria	55%
% Kill Yeast	72%
% Kill Molds	80%
Daily cost at $8.00 gal	$3.36
Average pH during treatments	6.35
Average pH between treatments	6.15

The curves of batceria population throughout the battery are not included, but are typical of those previously given.

Conclusions

Due to the continuous nature of operations without hourly cleaning, bacteria problems *in* the continuous diffusor are much greater than those encountered in the conventional Roberts battery. Treatment of some type must be practiced to control bacteria populations or excessive corrosion and destruction of sugar will result.

pH of the juice is a good criterion of bacterial activity. Due to the latent period of the bacteria present, the most serious contamination arises from dead spots within the battery. The battery is, however, being continually reinfected from the beets at the head end and from battery supply water at the water end. Temperatures necessary to produce satisfactory kills are about 80° C. and periodic dome steaming on a regular cycle seems to be an entirely practical mode of control. In addition, dome steaming does not heat the juice excessively and so should not cause pulp pressing difficulties in the drier as does high juice temperature.

Roccal spraying of whole beets indicated significant kills, and additional work will be done evaluating the use of additional sprays. Possibly with the use of additional Roccal on beets, high intermittent dome temperatures, and treatment of battery supply water bacteria in the continuous diffusor can be effectively controlled.