

THE USE OF ADDITIVES FOR PROCESSING FROST-DAMAGED BEETS

Tom Henscheid, Larry Velasquez,
Vadim Kochergin, Mike Stroebel

The Amalgamated Sugar Company
Twin Falls, Idaho



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A period of wet weather the last week of October during the 1990-91 beet harvest campaign brought the beet digging operations to a stand still. This was followed by a few days of extremely cold weather. Temperatures dropped into the single digits at night for three days and daytime temperatures never reached 32°F (Figure 1). Needless to say the beets were frozen solid in the ground to a depth of 3-4 inches and the tops lay limp on the surface. Temperatures then immediately warmed to normal reaching into the 50°F range during the daytime and mid 30's at night. This allowed the ground and beets to thaw.

A substantial number of growers were surprised by this change in weather conditions and a significant quantity of beets were effected. It was impossible to process the effected beets fast enough to save all of them and there were too many to set up a controlled harvest. If left in the ground or if dug and stored they would rapidly deteriorate.

Some growers would have lost the entire crop and been seriously effected financially if the beets were not processed. An agreement was therefore made with the growers that the Company would receive the beets and attempt to process as many as possible. However the growers would have to share in the costs of losses and extra processing costs. These beets were stored separate from the non-frozen beets wherever possible and would be processed first as long as it was economical to do so.

It became evident very early on that these beets would not store well. Topping was a problem because the leaves were all frozen down. These special piles not only contained beets with the top six inches of the root frozen (Figure 2) but also beets with more tops and trash present. When these beets were dug they were soft and susceptible to cuts and bruises which caused them to weep juice. This along with the additional dirt and trash present made the piles an ideal setting for bacterial growth.

Not all the beets in these special piles were frozen. Some of them were of sound composition and were sorted out by hand over equipment normally used for sorting potatoes. Figure 3 shows a composite sample of the sorted beets. All beets in the sample were of good quality.

This experience is not new to the industry but was foreign to our operating people as far back as we could remember. It was also not isolated to the growing areas of Amalgamated Sugar but covered all beet growing areas of the intermountain North American continent. Similar occurrences have been experienced in Western Europe^{1,2,3,4} and Canada⁵ in past years. It was the results of their experience which helped us get through the processing season as well as we did.

When the beet root freezes and thaws the cell walls are disrupted making them susceptible to mechanical damage and bacterial attack. Soil bacteria rapidly go to work on the sugar in the beet to produce high concentrations of invert and polysaccharides such as dextrans and levans^{1,3,5,6}. When these substances enter the process in sufficient quantity it is

immediately noticed on the second carbonation filters. These filters immediately blind off making it impossible to filter the juice. Dextran levels above 100 ppm are noticeable by change in the operation of the filters. Above 200 ppm dextran filtration becomes a real problem. Figure 4 shows the effect of these frozen beets on the number of filter changes in the Twin Falls factory.

The first week or so these frozen beets were being processed all went quite well. After about two weeks of storage the impact really hit. The factories could not handle a beet supply made up of 100% frozen beets. Blending beet sources improved the situation somewhat but still made processing difficult because it was impossible to predict how the flow of beets actually entered the process.

In order to survive this processing dilemma it was necessary to act immediately to solve the problem. After a search of the literature, communication with British Sugar Company, Danish Sugar Company, and Alberta Sugar, and some help from our local Mazer representatives, a number of processing aids appeared promising. British Sugar Company had found that "Aragonite", a specific crystalline form of calcium carbonate, had helped them filter the second carbonation juice when processing frozen and deteriorated beets^{2,3}. It has been shown that calcium carbonate crystals formed in the presence of dextrans are much smaller than the crystals formed when dextrans are not present³. This small crystal size is what causes the filter cloth to blind when filtering the second carbonation juice prepared from deteriorated beets. The addition of the aragonite does not change the size of the crystals of

calcium carbonate formed but seems to cause them to agglomerate into larger particles. With the help of Mazer Chemical, a source of this material was located and brought into the factory. Figures 5 and 6 show electron micrographs of aragonite crystals at different magnifications. Figure 7 shows a photo-micrograph of calcium carbonate crystals produced while processing good beets. The crystals are large and filter well. Figure 8 shows the fine crystals formed in carbonation when dextrans are present. The crystals are very fine. When aragonite is added to carbonation these crystals tend to agglomerate together giving larger particles and improved filtration (Figure 9).

Since the filtration was caused by fine particles it was felt that filter aid should help filtration. Figure 10 shows the particles formed in the presence of filter aid. Particles are larger and filtration improved. A mixture of filter aid and aragonite produced large agglomerated particles shown in Figure 11. Filtration of the juice was better than either material used alone.

Two questions needed to be answered immediately for the processing people: (1) How can the dextran content of the juice be determined quickly and reliably so the additive can be started when needed? (2) Can the effects of the additive be measured to make certain that the results are derived from the additive and not some other processing change?

Several laboratory tests were used to help processing make their decisions. The standard haze test was used in the factory to determine the polysaccharides content in diffusion juice. The method seemed to be erratic and somewhat inconsistent from test to test but did alert the operators of pending problems.

A second test was used in the process to measure the filterability of the second carbonation juice. This consisted of measuring the time required to filter a given volume of second carbonation juice through filter paper in a Buchner funnel. The results however did not correlate well with the polysaccharide content of the juice or factory operation. The best method was to watch the second carbonation filters. When the pressure started to raise rapidly it was time to start the additives.

The determination of the filtration coefficient using the Brieghel-Müller apparatus gave results that correlated well with dextran content in the juice and was used to evaluate the effects of various additives.

Particle size analysis of the calcium carbonate was also tried but was not sensitive enough to distinguish between samples.

Figure 12 shows that the determination of the filtration coefficient is the only method that tracked the actual dextran content of the juice. At first, tests were conducted to see if aragonite actually affected filtration rate. When a positive effect was found the next thing was to determine the application rate necessary to produce reasonable results and still be economical. It can be seen in Figure 13 that the filtration coefficient is dramatically improved by the presence of aragonite. Addition rates of 1000-2000 ppm gave the best results. Above that level the filtration rate actually showed a slight decline. The test results were reproducible as is shown in Figure 14.

These tests were carried out in the laboratory by carbonating clarifier overflow juice to second carbonation optimum alkalinity in the presence of aragonite. The filtration coefficient was determined on the resulting juice at 80°C.

The point of addition of the aragonite also made a difference. The best results were achieved when it was added directly to the second carbonation tank. If added to the clarifier overflow ahead of second carbonation or to the filter (Kelly) supply tank after carbonation the results were not as good (Figure 15).

A comparison was then made between aragonite and two sizes of Eagle-Pitcher brand filter aid. The FW-12 filter aid gave better filtration than the aragonite while the coarser grades were not as good (Figures 16 and 17). A combination of aragonite and filter aid produced better results than either used singly (Figure 18).

It was then learned that other sugar companies effected by this same weather pattern were using flocculating agents to improve filtration. Samples of these agents were obtained from Mazer Chemical Company and tested for their effectiveness. Figure 18 shows that two of the four flocculents tested gave a slight improvement in filtration characteristics while the other two made filtration significantly worse. The Mayfloc 2009 is one of the polymers that was being used by another company with good success. In our case it did not work. Possibly the method of addition, the point of addition, style of equipment, or composition of the juice made it effective for them but not for us. None of the polymers were as effective in our process as just plain filter aid.

Filter aid was used most of the time to maintain filtration unless the dextran levels were high. Then a blend of filter aid and aragonite was required to improve filtration so slice could be maintained.

REFERENCES

1. Harold Skogman, C.I.T.S. Proceedings, p. 307-319, (1971).
2. J.F.T. Oldfield, J.V. Dutton, H.J. Teague, E.L. Williams, C.I.T.S. Proceedings, p. 229-249 (1975).
3. J.F.T. Oldfield, J.V. Dutton, H. J. Teague, International Sugar Journal, 73, pp. 3-8, 35-40, 66-68 (1971).
4. R.S. Palmer, S.C.H. McCarey, Zuckerindustrie 106, pp. 517-520 (1981)
5. M.K. Faviel, J.R. Logic, B.L. Karren, Zuckerindustrie 116 (2), pp. 103-109.
6. M.A. Clarke, J. Maarten de Bruijn, E.J. Roberts, M.A. Godshall, paper presented at 1992 British Sugar Conference.

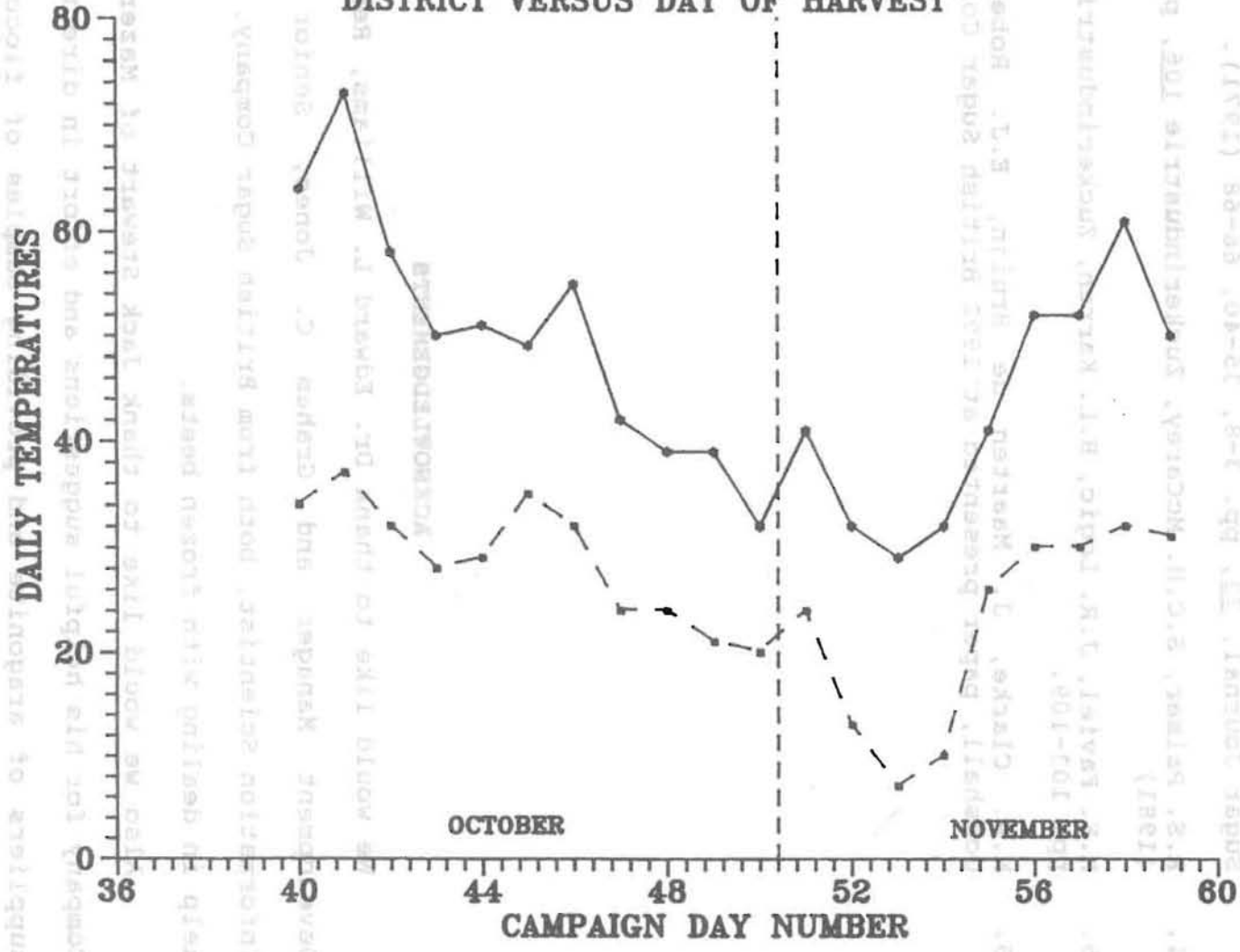
ACKNOWLEDGEMENTS

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Also we would like to thank Jack Stewart of Mazer Chemical Company for his helpful suggestions and effort in directing us to suppliers of aragonite and providing samples of flocculent for testing.

FIGURE 1

HIGH AND LOW TEMPERATURES IN THE TWIN FALLS DISTRICT VERSUS DAY OF HARVEST



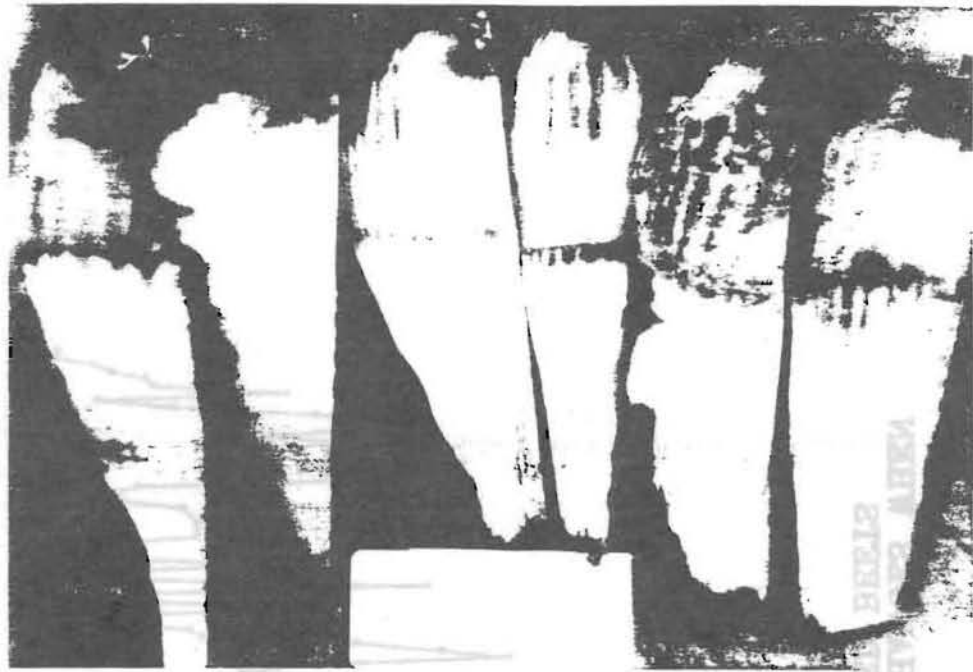


FIGURE 2.

Internal appearance of frozen beets after two weeks of storage.

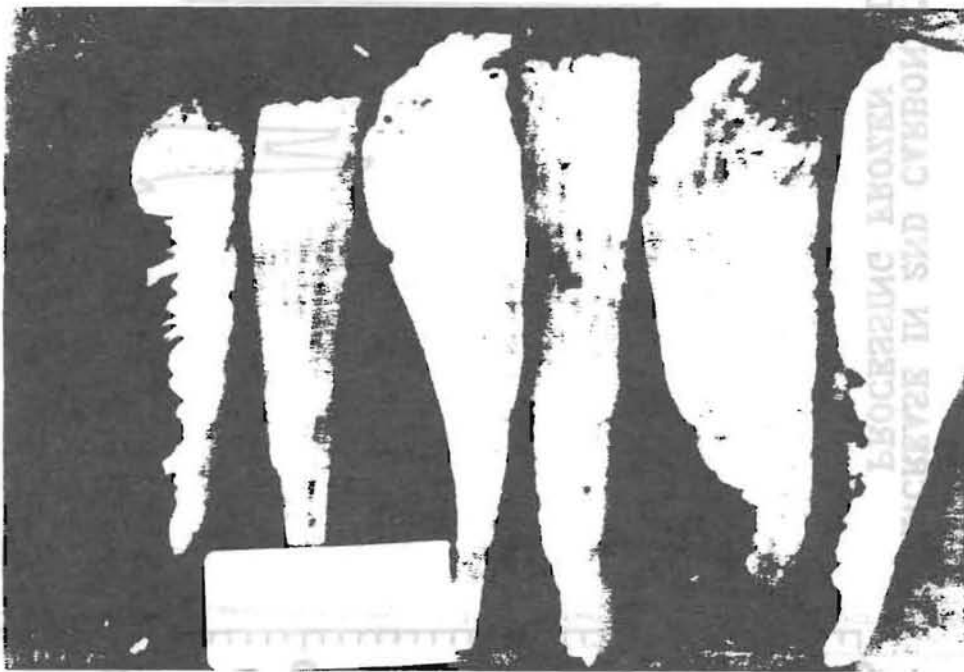
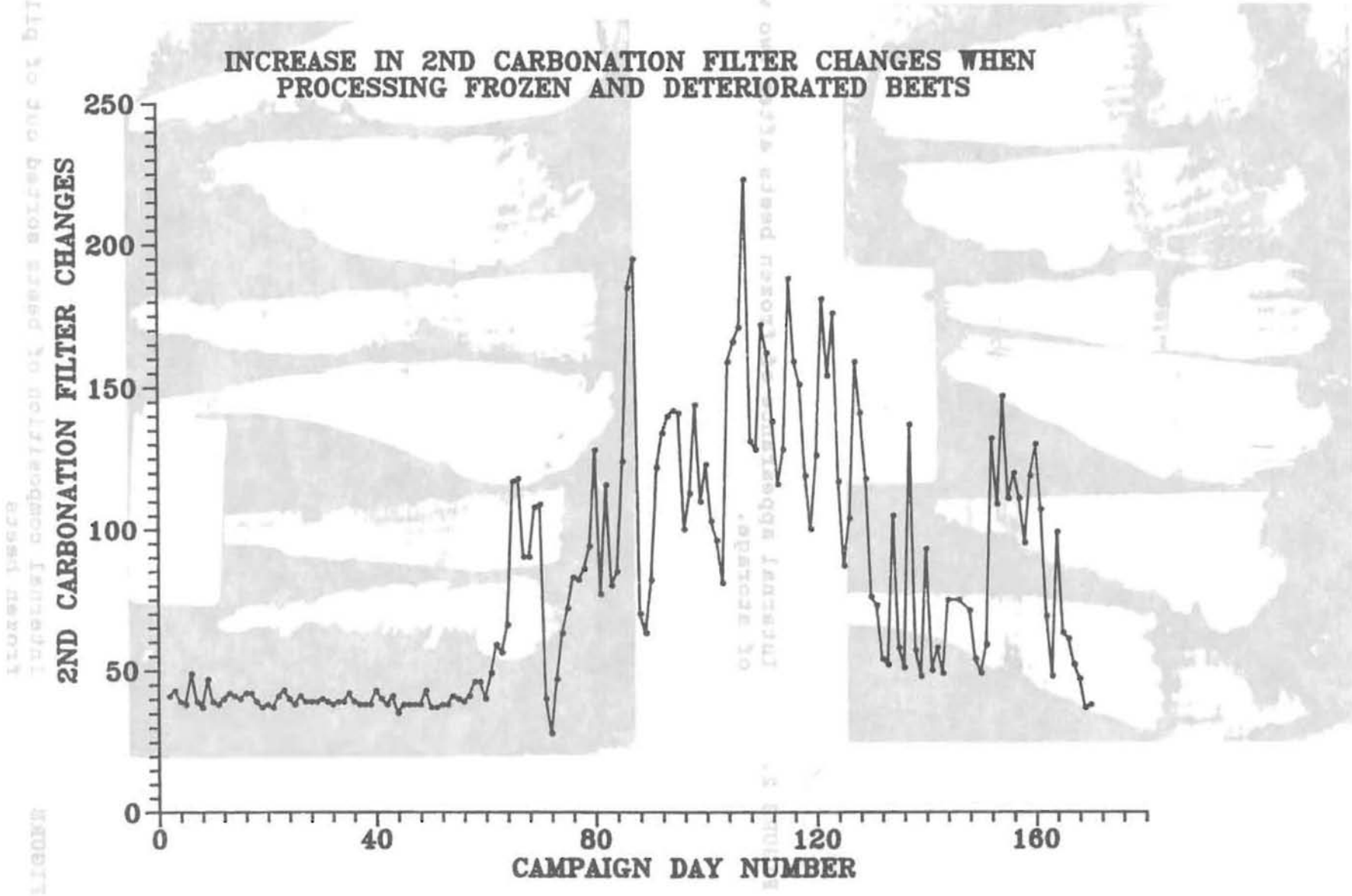


FIGURE 3.

Internal composition of beets sorted out of pile of frozen beets

FIGURE 4



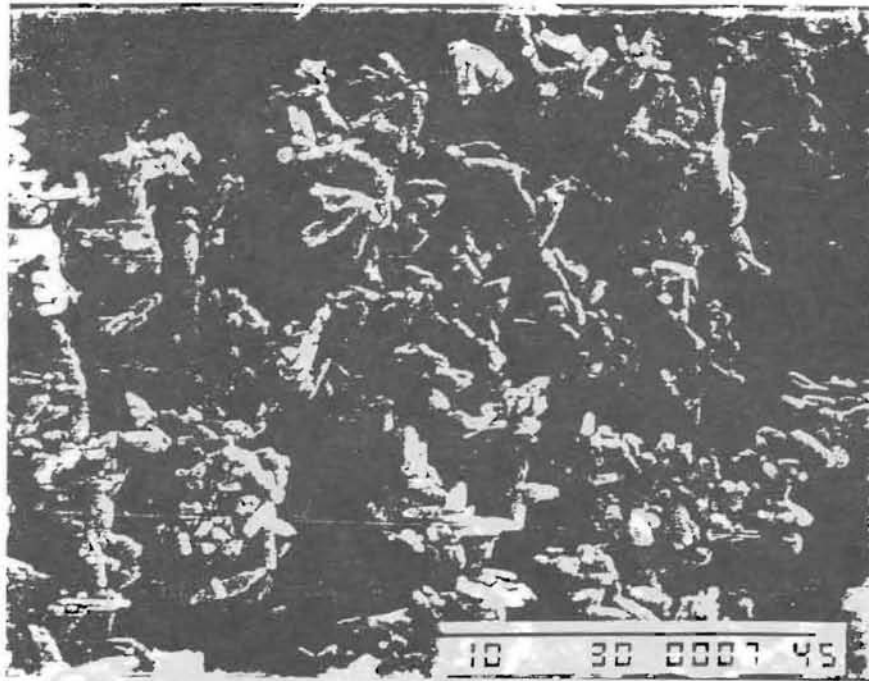


FIGURE 5. Aragonite crystals at 5000X. Line is 10 micron.

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FIGURE 6. Aragonite at 20,000X. Line is 1 micron.

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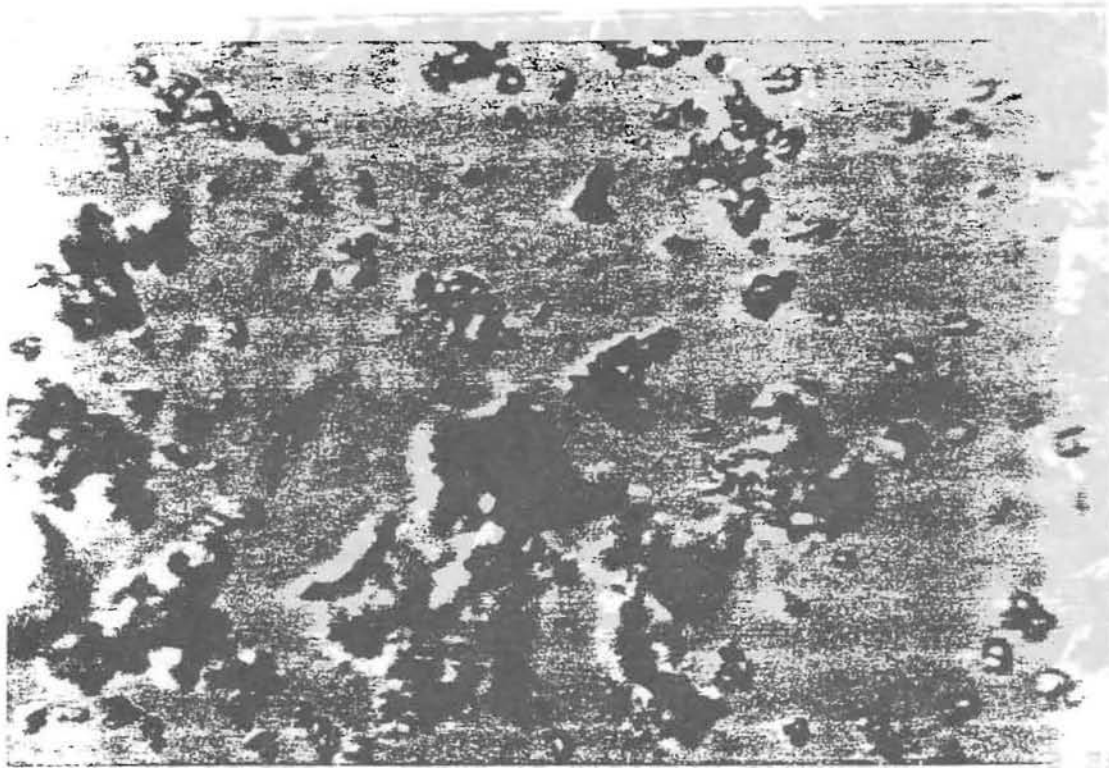


FIGURE 7. Calcium carbonate formed while processing good beets

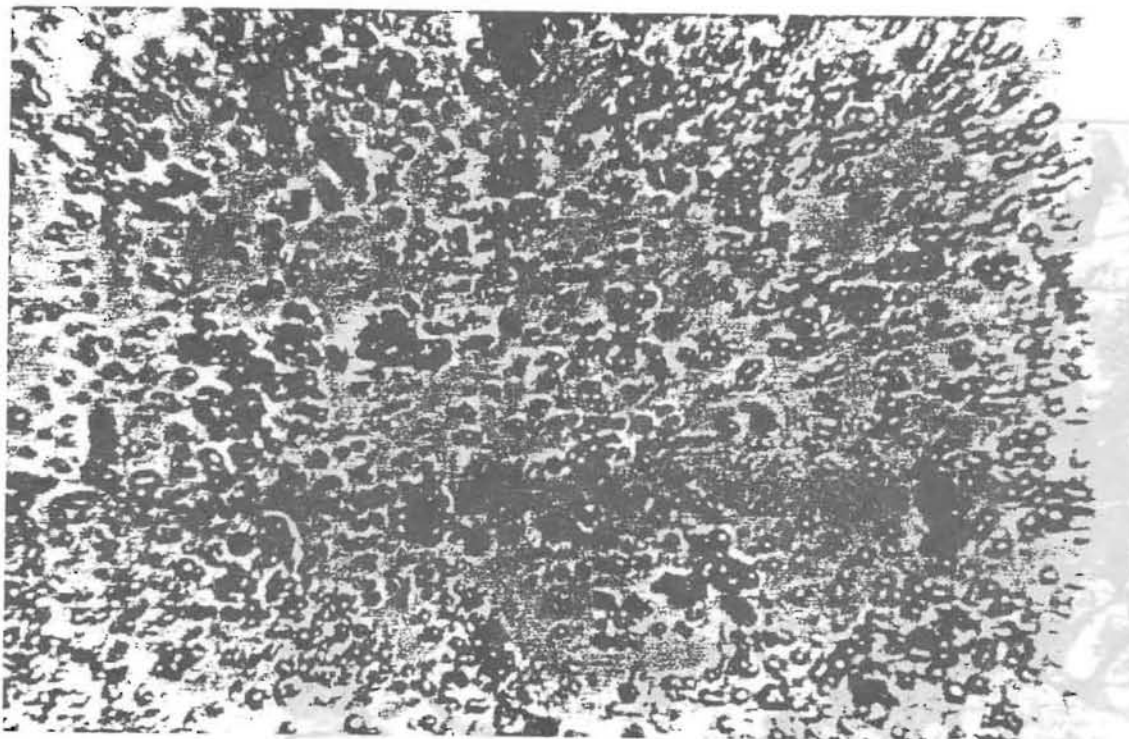


FIGURE 8. Calcium carbonate formed when high quantities of dextran are present

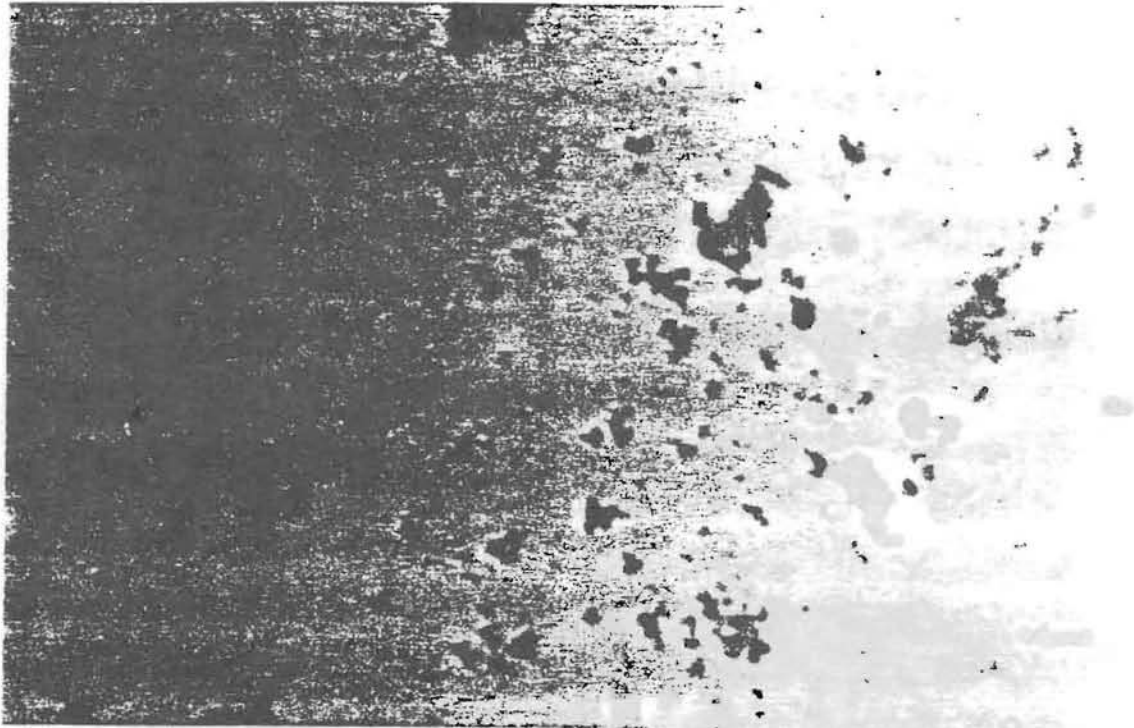


FIGURE 9. Calcium carbonate crystals formed when aragonite has been added to second carbonation

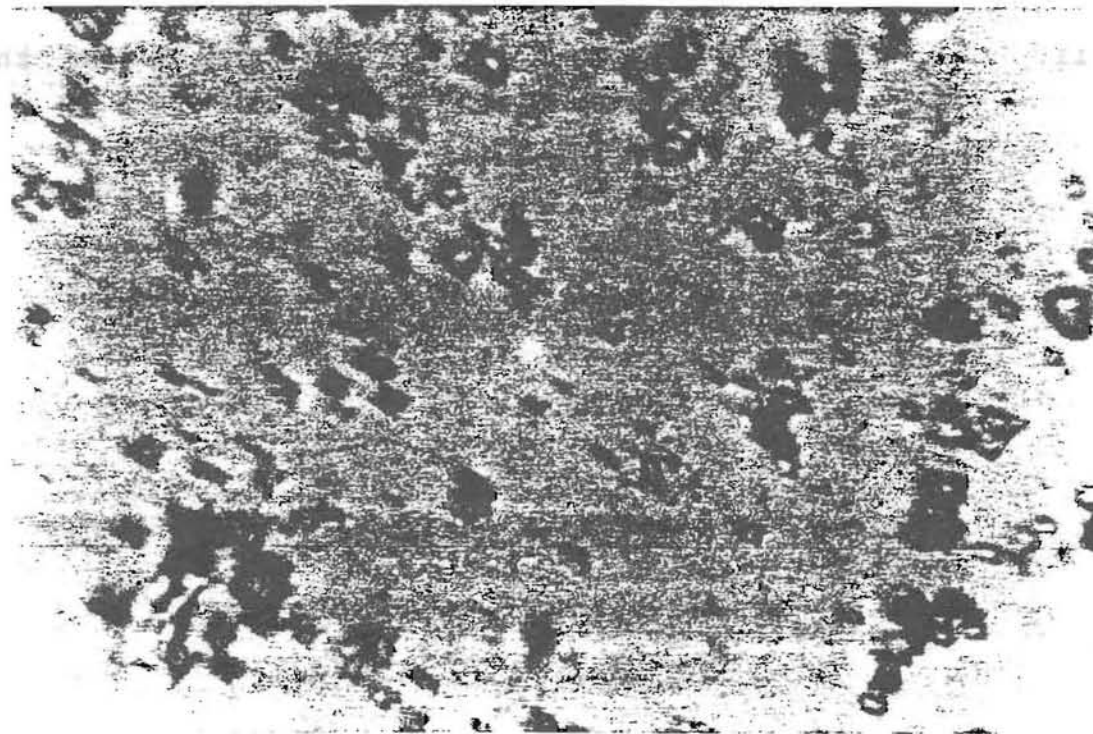


FIGURE 10. Calcium carbonate crystals formed when filter aid (Celatom FW-12) is added to second carbonation

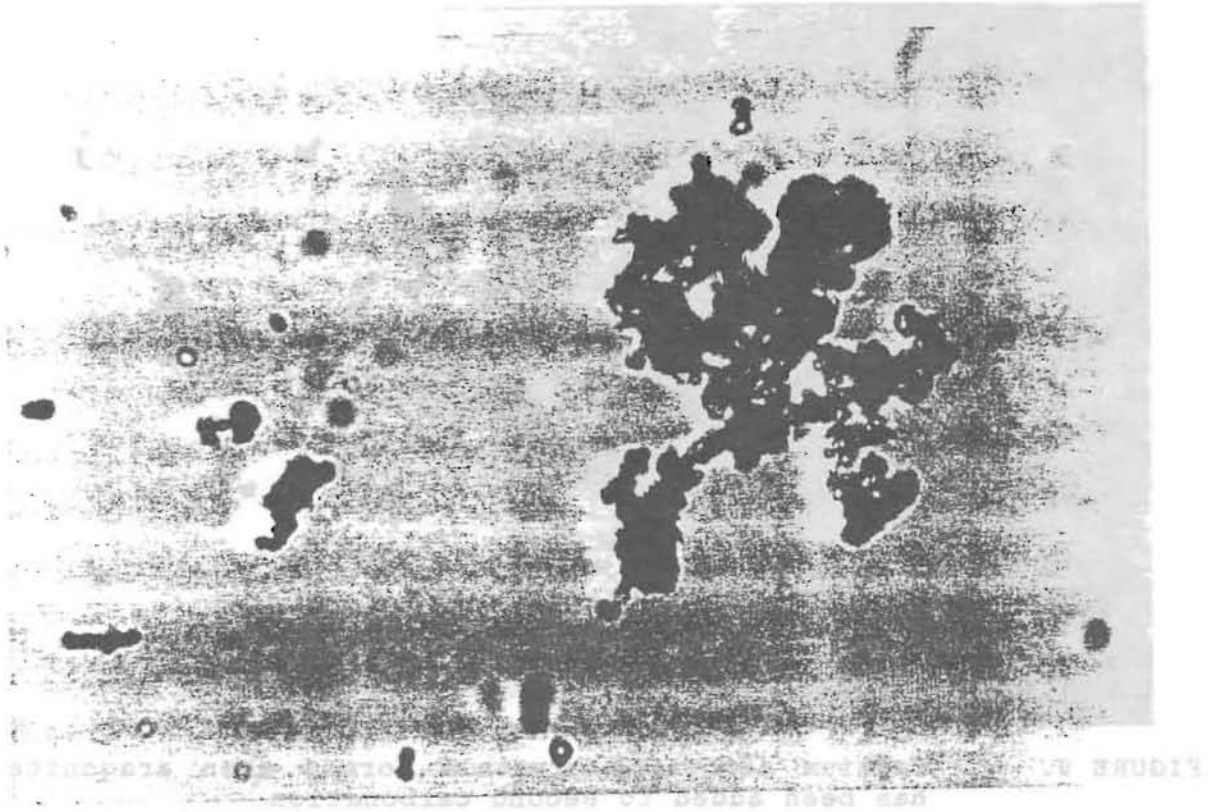


FIGURE 11. Calcium carbonate crystals formed in the presence of aragonite and filter aid

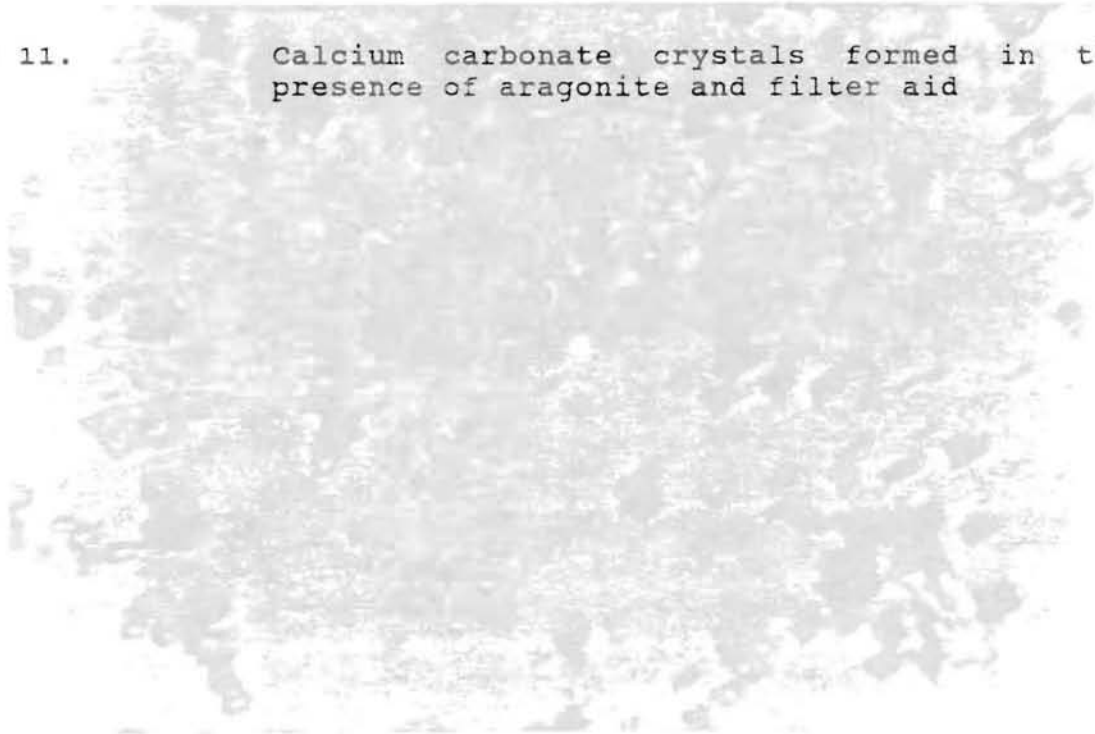


FIGURE 10. Calcium carbonate crystals formed when filter aid (Calson W-17) is added to calcium carbonate suspension

FIGURE 12

COMPARISON OF METHODS

METHOD VERSUS DEXTRAN LEVEL

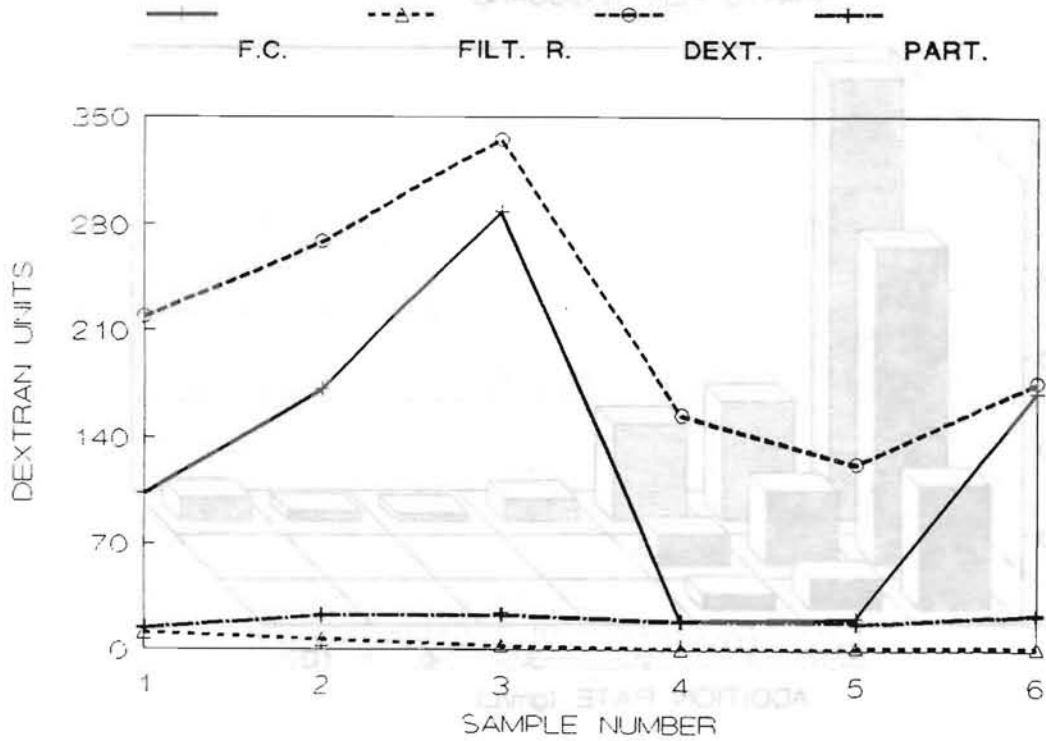


FIGURE 13

ARAGONITE ADDITION TO 2ND CARB

PARTS PER THOUSAND

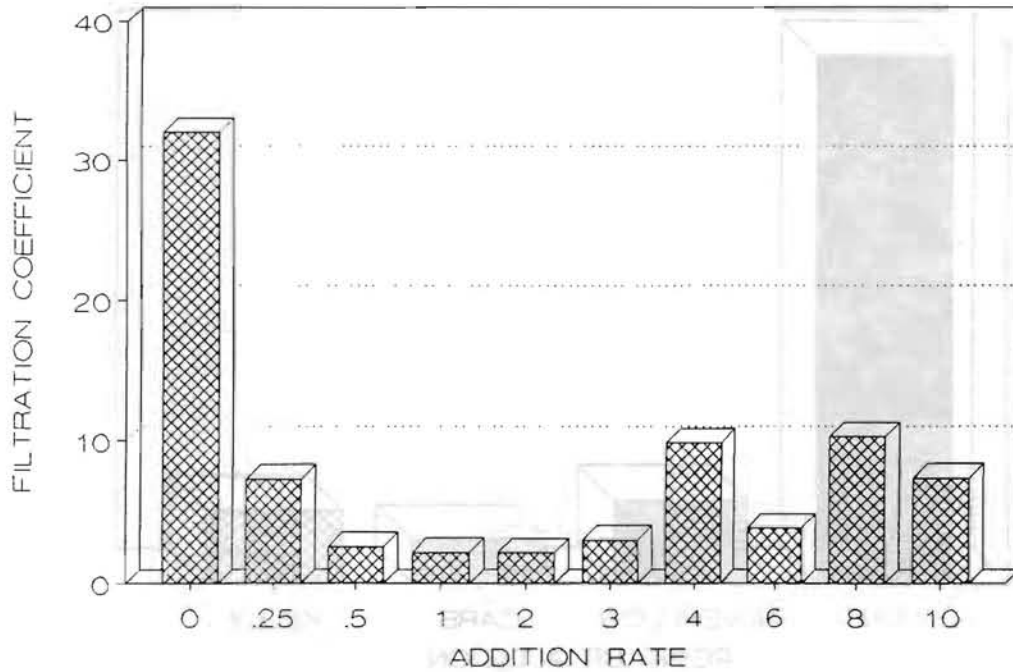


FIGURE 14

ARAGONITE ADDITION TO 2ND CARB

PARTS PER THOUSAND

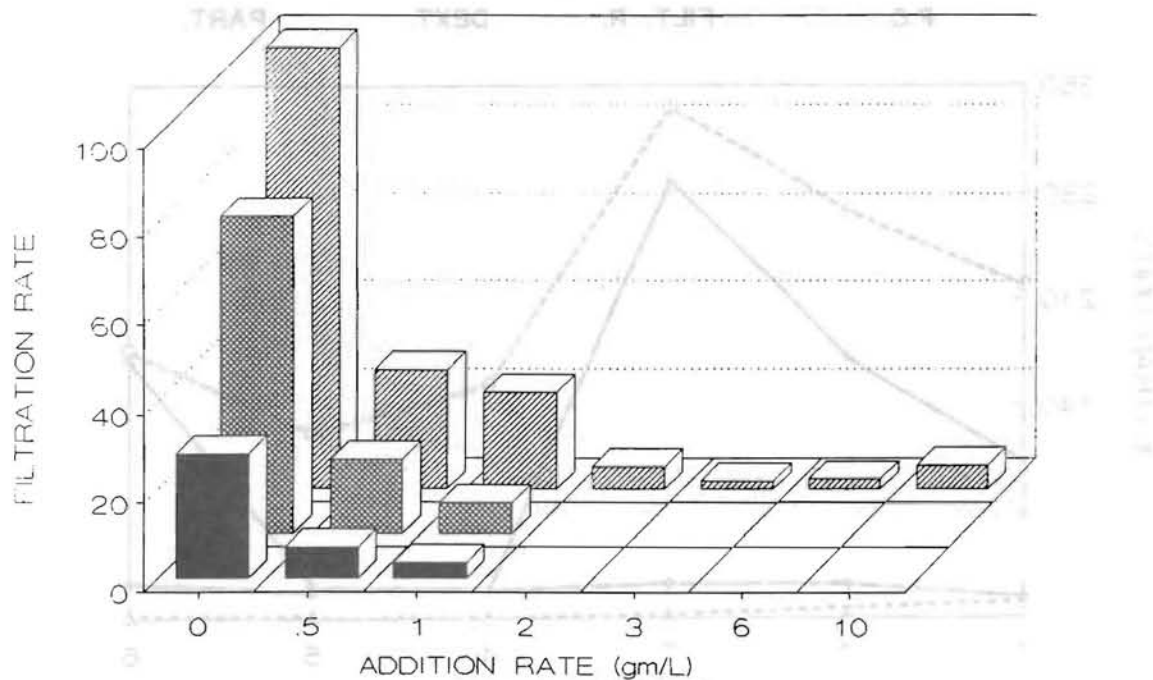


FIGURE 15

ARAGONITE ADDITION

1000 ppm LEVEL

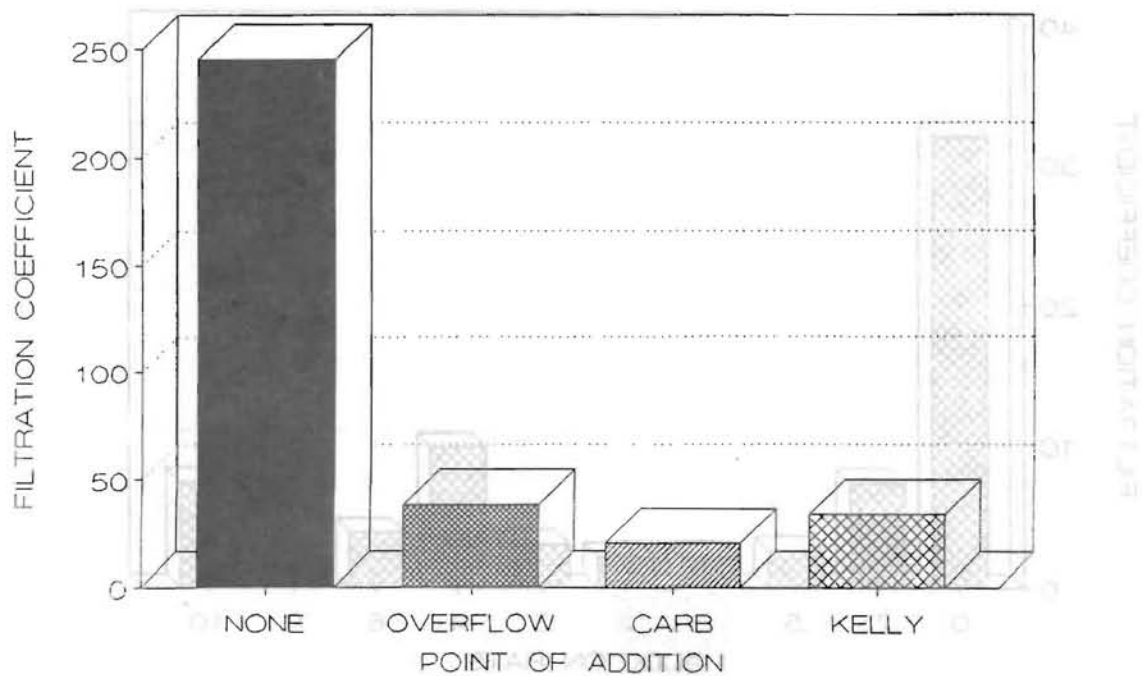


FIGURE 16

ADDITIVES TO 2ND CARB EFFECT ON FILTRATION

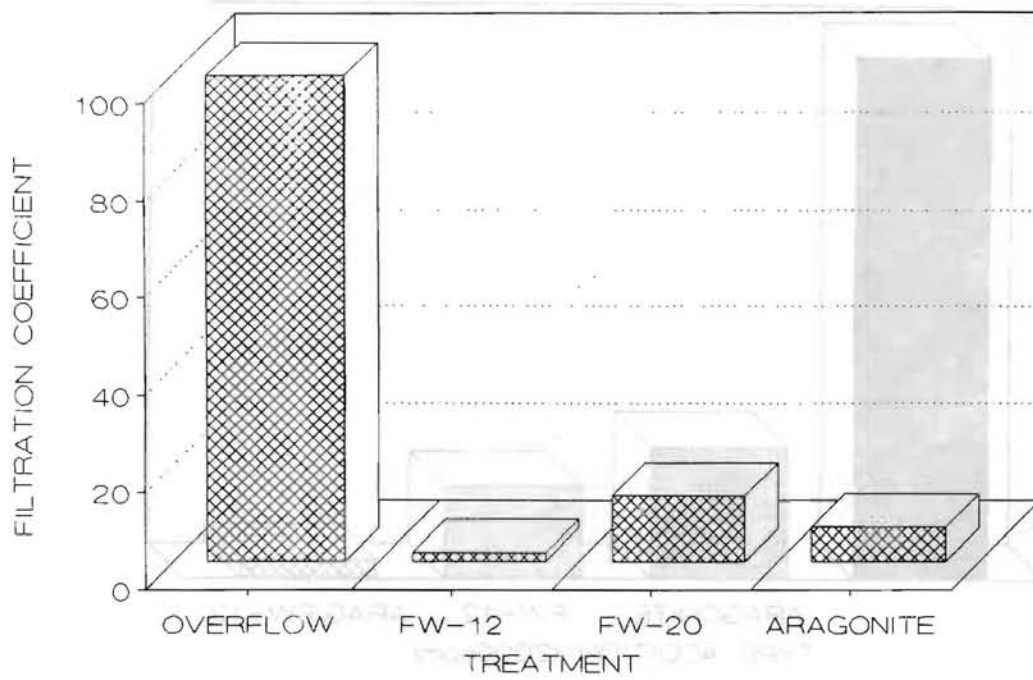


FIGURE 17

ADDITIVES TO 2ND CARB EFFECT ON FILTRATION

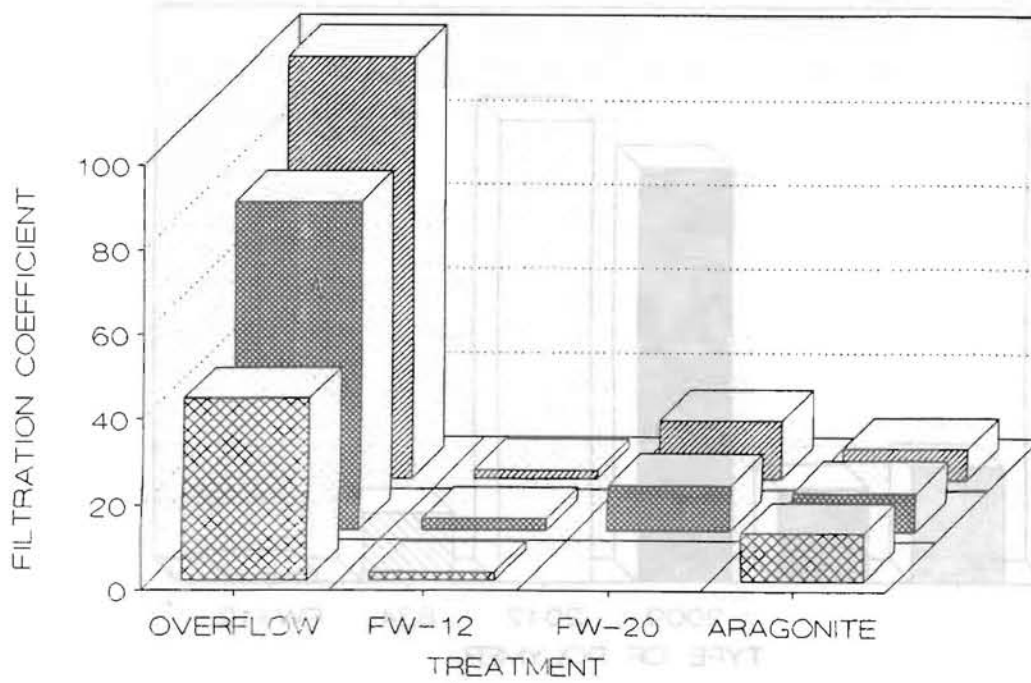


FIGURE 18

ADDITION TO 2ND CARBONATION

450 ppm DEXTRAN

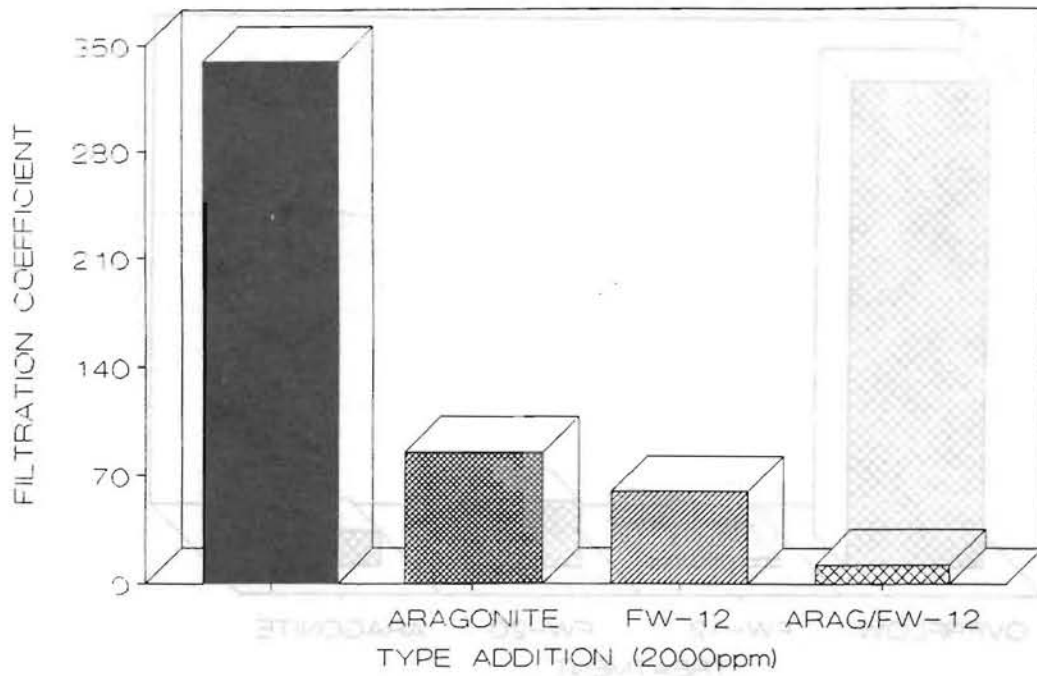


FIGURE 19

EFFECT OF POLYMER ON FILTRATION

MAFLOC POLYMERS

