New Possibilities for Economy in First-Carbonation Filtration

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We all recognize the fact that during the past several years, the sugar industry has made some very rapid and very commendable progress in its manufacturing methods, which has resulted in a higher quality of refined sugar being placed on the market. This progress has to a small degree been connected with improvements in filtration, which in turn have been partly due to improvements in filtration equipment and also to improvements in filteraids. The improvement in filteraids, has involved changes of a rather surprising order. A few years ago, the only filteraid, or so-called filteraid, available to the sugar industry was the old kieselguhr, a natural and rather impure product with a very low flowrate. This crude material has since been supplanted by one improved material after another until at the present time, filteraids are available having flowrates 40 and 50 times that of the old material. Consequently, there are today many applications for filteraids that have been, and are now being brought into commercial use that would have been impossible a few years ago.

One such application that has become at least an economic possibility, is in the use of present-day high-efficiency filteraids to aid in the filtration of the first-carbonation juices. The word possibility is used here advisedly, for it is to be admitted at the outset that this application has only been investigated from the laboratory standpoint, using a laboratory type of filter. Even from the laboratory standpoint, thorough studies have not yet been made on juice characteristics, so that it is to be emphasized that no proved development is being discussed. All that can be said for the work to be discussed briefly here, is that it indicates, from the laboratory standpoint, that modern, high-efficiency filteraids have possibilities for economical application in first-carbonation filtration.

The proposition on which this work is based is dependent upon the idea that a large proportion of the lime used in first carbonation is there solely to make possible the filtration of the juice, and, that were it not for the necessity of filtering this juice, a decidedly lower percentage of lime could be used. In conventional practice in a non-Steffen house, of course, a relatively large percentage of lime, in the form of milk of lime, is added to the juice in the first-carbonation

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tanks, either raw juice or predefecated juice as the case may be. This lime is then carbonated out to produce insoluble and inert particles of calcium carbonate. When this mixture is passed through a filter, the calcium-carbonate particles form the rigid framework of the filter cake in which the insoluble impurities that are being filtered out are caught and retained. This calcium carbonate then acts as a filteraid. making the cake sufficiently porous that juice will pass through it at a satisfactory rate. Later on it may be sweetened off and washed free from sugar. It is the purpose of this paper to show that the calcium carbonate that functions in this way, namely, in aiding the filtration of the juice, may be replaced with a small percentage of high-efficiency filteraid with resultant increased economy and simplicity of operation.

A certain percentage of lime, of course, is needed for purification, and effective floeculation of the impurities contained in the raw juice. This percentage ordinarily appears to be around 0.2 percent to 0.4 percent of lime on beets, and corresponds to the amount ordinarily used in predefecation. In all the experiments on which this work is based, the problem was to filter this predefecated juice, without the addition of any more lime than was necessary to reach the point of optimum flocculation, but with a small amount of filteraid. This filtered, predefecated juice represents what would ordinarily be first-carbonation juice, but of course, no carbonation is used. This naturally raises the question whether or not an excess of lime is needed from the standpoint of juice characteristics. At least from a preliminary standpoint, and from these laboratory experiments, it appears that the purity of this defecated juice is just as high, and certainly its color is lighter, than the conventional first-carbonation juice.

This work was started in our laboratory in California with sugar liquors supplied through the courtesy of the Holly Sugar Company factory at Santa Ana. Later on more extensive tests were continued through the courtesy of the Amalgamated Sugar Company at the laboratory of their Rupert, Idaho, factory, and of the Utah-Idaho Sugar Company at the laboratory of their West Jordan factory.

The procedure in making these tests was first to determine the amount of lime necessary to reach the point of optimum floeculation, where the color of the juice was the lightest, its settling rate the fastest, and the clarity of the effluent the best. This point, expressed in terms of the pH of the juice, represents the iso-electric point of the colloids that are being flocculated, and is the point at which the electrical charge on the colloids reaches zero and allows these particles to coalesce and settle out.

This defecating procedure was carried out in two different ways, with surprisingly different results as far as the filtration was concerned. The first method tried was that of heating the raw juice to around 80° C, adding the proper amount of lime, allowing a few minutes for complete flocculation, and then filtering. The second method was to lime the raw juice in a relatively cold state, around 40° C. and heat it, with lime present, up to about 80° C, and filter. It was found that more lime was needed to produce good defecation in the hot method than in the cold, and in addition, the rate of filtration was tremendously greater with the cold method.

In one series of experiments in which hot defecation was used, satisfactory filtration of the defecated juice was not obtained, except by using amounts of filteraid in the region of 1.0 percent to 1.2 percent on beets. This would have been far beyond the bounds of economical operation. However, in another series of tests, more extensively conducted, in which cold defecation was used, satisfactory flowrates were obtained with 0.2 percent to 0.3 percent of filteraid on beets, which is quite within the economical limit. In this latter series, hot defecation was also used, and it was found that the flowrates were only ¼ to ½ of those when the cold method was used. Consequently, it does appear desirable to carry out the defecation in the cold state, at least as far as filtration is concerned. These tests are based on such a procedure.

Figure 1 shows the results of a series of tests in which diffusion juice was limed at about 40° C. with 0.3 percent CaO on beets, heated to 75° C. and filtered at this temperature with various amounts of filteraid. The flowrates, which represent the ordinates on the graph, are based on the flowrate of the average of a number of samples of regular carbonated juice taken from the carbonators, in which 100 percent represents this average. The percentage of CaO and percentage of filteraid are both plotted as abscissa. The heavy black line represents the increase in flowrate of the defecated juice with various percentages of filteraid.

Thus, with no filteraid the flowrate is 68 percent; with 0.25 percent filteraid, it is 104 percent; with 0.5 percent, it is 128 percent, and with 1 percent, it is 400 percent.

At the same time the dotted black line (x to x) represents the flowrate of the juice containing various amounts of lime. The point on the left is the flowrate of the juice containing 0.3 percent CaO but no filteraid, and is, of course, the same as the bottom point on the heavy black line curve, that is, 68 percent.

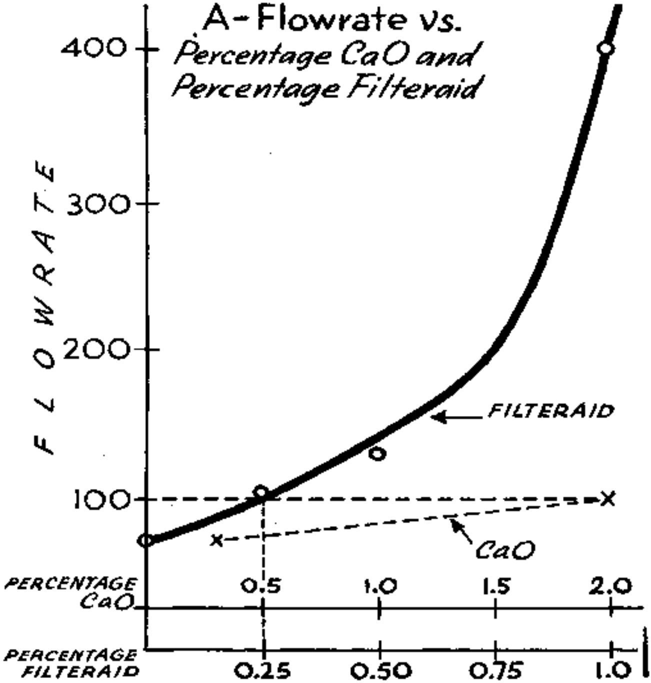

Figure 1.

The point on the right has a flowrate of 100 percent, by definition, and corresponds to about 2.0 percent CaO, which is approximately the amount used in first earbonation.

Actually we do not know if the curve (x to x) is a straight line or not, because only the end points have been determined, but for purposes of simplicity it has been assumed to be so, and because of this assumption, has been indicated as a dotted line. At any rate, the point in which we are interested is the amount of filteraid necessary to reach a flowrate of 100 percent, the same flowrate as is obtained with about 2.0 percent lime under present carbonation procedure.

This flowrate of 100 percent is indicated by a horizontal black dotted line, and the point of intersection between this line and the solid black line indicates how much filteraid must be added to obtain a flowrate of 100 percent.

In the series of tests indicated in figure 1, the amount of filteraid required amounts to about 0.25 percent. In figure 2 another series of tests, made on a different batch of diffusion juice, is plotted in the same way, and in this series the amount of filteraid necessary to give a flowrate of 100 was about 0.37 percent on weight of beets.

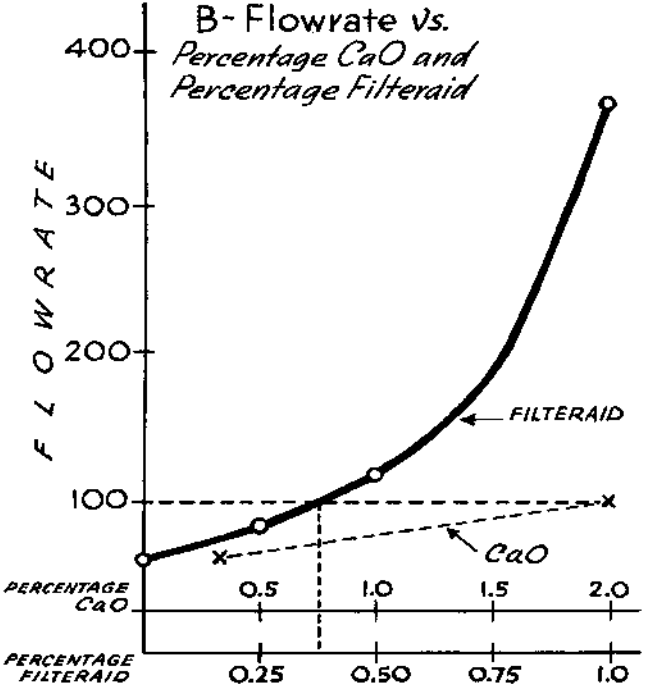

Figure 2.

In figure 3, another series of tests made on a third batch of diffusion juice was conducted and here the amount of filteraid required amounted to 0.15 percent on weight of beets.

The average of these 3 sets of tests, 0.25 percent, 0.37 percent, and 0.15 percent gives an amount of filteraid of 0.29 percent on beets. In other words, in order to match the flowrate of the carbonated juice containing 2 percent of CaO (in the form of carbonate) it is only necessary to add 0.29 percent of filteraid to juice which has been defecated with 0.3 percent CaO. In this way, 1.5 percent to 2.0 percent of lime would be saved, and in its place about 0.3 percent filteraid would be used This, in itself, would represent a very

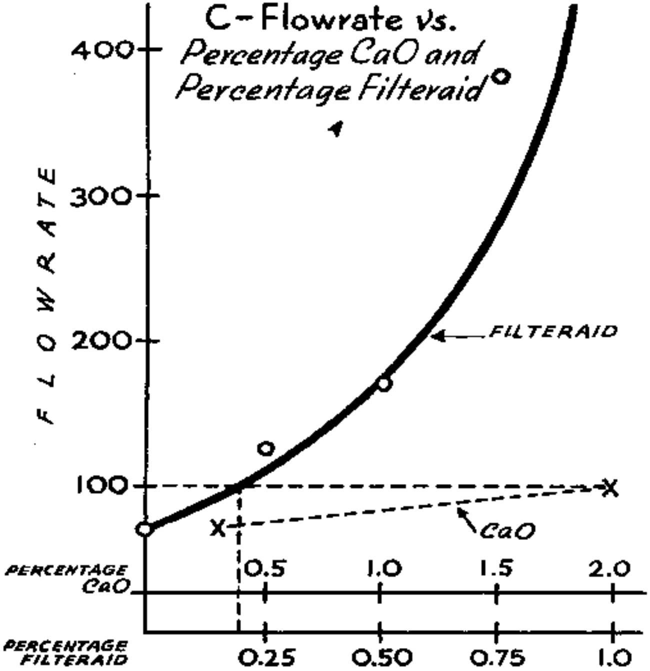

Figure 3.

considerable saving in cost, but in addition, the necessity of carbonating may be eliminated, with resultant simplification of equipment and increased speed of operation. Furthermore, the amount of first-carbonation cake would be cut down to 1/4 or 1/3 of the present amount, the washing would be simplified, and the sugar loss in the cake appreciably reduced.

This study neglects the important question of juice characteristics throughout the house, under the system described, but from a preliminary standpoint, it appears that the juice does not suffer and may indeed be considerably better, because by avoiding an excess of lime, we avoid exposing the juice to an undesirably high pH, which it ordinarily has during the period of carbonation.

It is definitely known that this high pH and high temperature has a harmful effect on the juice and causes it to darken. It is known that there is an optimum pH for any given raw juice at which the colloids flocculate and precipitate to the maximum degree. If this point is passed, a certain amount of these colloids return to their former state.

In other words, they re-disperse and are no longer filterable, which undoubtedly occurs when a very large excess of lime is used and the pH is raised to a high value. Of course, some of these re-dispersed colloids are re-coagulated when the pH is lowered again with $C0_2$, but only those colloids of the so-called reversible type will behave in this manner. Many will remain in their dispersed state, even though the pH is lowered again. Therefore, it would seem simply from general considerations that actually a better juice could be made with only a small amount of lime than could be made with an excess. Not only would a reduction in cost be effected, but an improvement in the juice may be expected. However, this point is undoubtedly open to some dispute, and whether the juice throughout the house, all the way from first carbonation to final molasses, would be better or not is a question that must wait for more extensive investigation.

But even if it develops that a juice treated with only a small amount of lime in first carbonation is unsatisfactory for any reason, there is still the possibility that use could be made of this filtration scheme purely as a means of filtering predefecated juice and removing the coagulated solids from solution.

In other words, this would be an operation carried out in addition to existing operations, rather than taking the place of any one. In such a procedure, raw diffusion juice would be treated with a small amount of lime, in accordance with accepted predefecation practice, and to this predefecated juice would be added a small amount of filteraid and the juice filtered, either with or without a settling step preceding the filtration, to be followed with a first and second carbonation in the usual manner.

The amount of lime used in a first carbonation could be considerably reduced, but the reduction in lime consumption in this case could not offset the cost of the filteraid. The increased cost of the over-all operation would have to be justified by an improvement in the juice, and by a higher extraction.

It would be logical to presume that removing the coagulated colloids at their iso-electric point, with the least possible amount of action tending to disturb and break up the floe, would result in a greatly improved juice whether filtration of the predefecated juice was carried out as a preliminary step to first carbonation, or whether carried out as a step to replace first carbonation. Both of these possible applications are being mentioned because neither one of them has been tested, during the study, from a factory standpoint, and all that can be claimed for the present work is that it represents laboratory filtration tests indicating that such applications as we are discussing are possible.

One important consideration in connection with the filtration of defecated juice is the matter of the relative ease of sweetening off the cake, as compared to a regular carbonation cake. A group of tests indicative of what may be expected is indicated in figure 4.

Two cakes were washed with ordinary tap water, one a regular carbonation cake made by filtering regular first-carbonation juice, and the other a defecation cake made by filtering diffusion juice defecated with 0.30 percent CaO on beets and 0.3 percent filteraid. The brix of the wash water is plotted against the number of centimeters of wash water. It is readily seen, from the 2 curves, that the defecation cake, containing filteraid, washes considerably more rapidly than the carbonation cake containing calcium carbonate. This would indicate that less wash water would be required, and that sugar losses in the cake would be lower.

Actually, in these tests, it would have been desirable to have determined the sugar left in the cake, as well as to determine the sugar in the wash water passing through the cake, but the laboratory procedure used in making these tests did not give enough cake to permit such tests to be satisfactorily conducted—consequently this was not attempted. But it is logical to suppose that the sugar in the wash water would be proportioned to the sugar in the cake, and if the brix of the wash water reduces to a minimum and shows no further decrease, then the cake has been washed practically free of sugar.

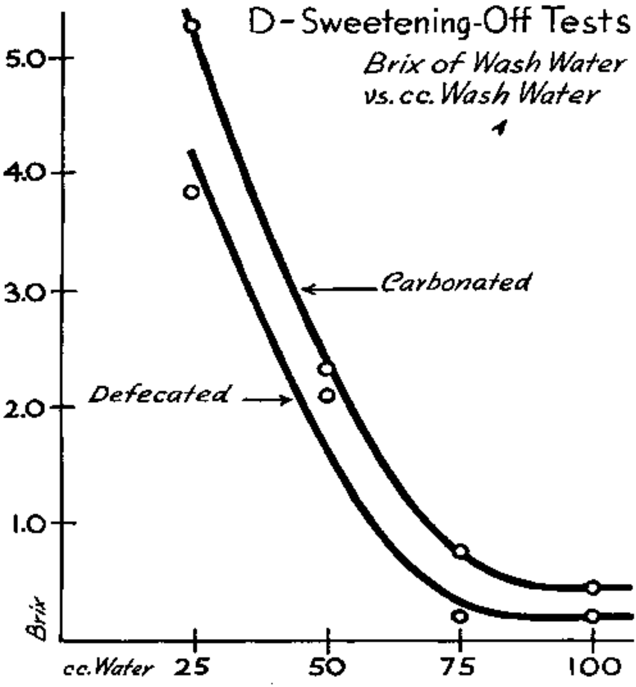

Figure 4.

Consequently, although we have not actually determined the sugar left in the cake itself, we may conclude that the defecation cake containing filteraid is much more easily washed and the sugar loss considerably less than in the regular carbonation cake.

Taking these tests as a whole, the filtration tests indicated in figures 1, 2, and 3, and the sweetening-off tests indicated in figure 4, it must be realized that these are only laboratory tests and do not in any sense conclusively prove the practicability or impracticability of this operation, but from the results that have been obtained, it appears that new possibilities for economy in first-carbonation filtration do exist through the use of modern high-efficiency filteraids.