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EXPERIENCES IN THE MANUFACTURE OF CANE SUGAR IN PORTO RICO

BY

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EXPERIENCES IN THE MANUFACTURE OF CANE SUGAR IN PORTO RICO.[1]

By R. Menéndez Ramos, M. S.

INTRODUCTION.

The object of this paper is to collect in a permanent form some of the data the author was able to obtain during seven years of continuous work as Chemist and Superintendent in a small, but modern, cane-sugar factory in Porto Rico. It is not the intention of the writer to teach anything fundamentally new to his fellow workers in the industry; but merely to recall hereby the problems which he had to deal with and to discuss some of the facts he found of importance in the routine of his daily work. The fact that seven consecutive years were spent in the same sugar house gave us ample opportunity to compare our observations, to correct the inevitable errors and to check the results obtained during different crops under similar conditions. This is especially true of the four consecutive seasons for 1917–18, 1918–19, 1919–20, and 1920–21. During the first two years, 1915–16, 1916–17, the factory equipment was incomplete and no attempt was made to exhaust the final molasses below 30 purity. The last season, 1921–22, was also abnormal in that the grinding was not continuous; the factory running only 12 to 18 hours a day, on account of lack of cane, and of course no comparative results can be expected from a work of this nature.

There is no claim for anything of supreme importance in this work. The discussion of our past troubles might help somebody else to get by the same or similar difficulties in the future; then our aim would be fulfilled. When we read a travel book telling of the experiences of some other party while going over places which to us are familiar, the acquaintance with the subject-matter makes the reading of interest; it is in a similar way that the attention

[1] Paper presented at the third biennial meeting of the "Association of Sugar Technologists of Porto Rico," June 17, 1923.

of our fellow sugar technologists might be held by this work. Possibly there may be in it something more than the mere sugar-house chronicle; but that, of course, remains to be seen.

The discussion will take place in two parts; one, the first, dealing with the exhaustion of final molasses; and the other, with the method of centrifuging low grade massecuites called by the writer "differential curing of final sugars."

I.

KEEPING DOWN THE PURITY OF FINAL MOLASSES.

THE TASK OF THE SUGAR CHEMIST.

The more perfect exhaustion of the final molasses resulting from the process of manufacturing is, to be sure, the task to be accomplished by every superintendent of fabrication in a sugar house. Naturally, the keeping down of the purity of the final molasses has its limitations. Sometimes the managers and owners of sugar mills give too much importance to the fact that their final molasses are well exhausted, say to a purity of 28, for example; but at times it is true that they have not taken the trouble to inquire if it would have been a better bargain for them to obtain only a final purity of 30 or more. We know perfectly well that it all depends on several factors, to wit: the price of sugar, the capacity of the boiling house in relation to the milling plant, the equipment of crystallizers, centrifugals, etc. But there is no desire to go into details. We only want to state the fact, so that no one need think that we attach supreme importance to the mere circumstance that the final goods be well exhausted, without considering if to get such low purities the economic side of the manufacture was ignored.

We are fully convinced that the best superintendent of fabrication is the one who adapts and combines his technic to the environment and the business in such a way, that he gets, out of a given amount of cane ground, the greatest possible amount of sugar at the lowest possible cost. This made clear, it would be well to add, also, that in order for him to attain high proficiency in his art the sugar chemist must give eternal vigilance to all the multiple details of the process of manufacture.

This is especially true in regard to his work with the final goods. Am I keeping down the purity of the final molasses without any extraordinary expense? Are the molasses for the present week being exhausted as well as those of the previous run? Is there proper uniformity in the work at the crystallizers? Are the final massecuites curing well? Is there any minor detail of the process that could be improved? Would the improvement be worth while?

These and similar questions were always in my mind while at my daily work as Superintendent of Fabrication in a modern sugar factory in Porto Rico.

BOILING HOUSE CAPACITY AND ITS RELATION TO FINAL MOLASSES.

Every experienced sugar chemist is familiar with the fact that the larger the excess capacity of the grinding plant over the capacity of the boiling house, the higher the purity of the final molasses. This seems to indicate that in order to obtain the optimum exhaustion of the final molasses the work should be performed without rush. If the mill produces more juice each 24 hours than the amount the factory can dispose of with ease, it is inevitable that the work is rushed, and the hastening of the elaboration process, caused by the unavoidable "full houses," is bound to result in final products of high purity. If the cane that is ground is of low purity, it is natural to expect that the sugar chemist will have a more difficult task to accomplish.

We have had the opportunity to work, during the last seven years, in a sugar factory whose milling capacity was superior to its centrifugal capacity; and where, moreover, the cane ground was of low purity, because of various reasons outside of the control of the management. The work was to be accomplished, therefore, under difficulties in respect to the final molasses. The centrifugal capacity was scarcely enough to carry on through and in many occasions there was before us the eternal dilemma of either permitting higher purities in the final molasses (over 30 purity) or cutting down the grinding of the mill. Both solutions of the problem are always disliked by every superintendent of fabrication who strives to keep up the quality of his work. It was, hence, our aim to look for some way to facilitate the curing of the final massecuites, in such a manner that the elimination of the impurities be made without sacrificing either the grinding capacity or the house recovery.

To this effect the author's attention was concentrated on the crystallizer department and on the outfit of centrifugals for final sugars.

One of the difficulties that called our attention was the fact that some low-grade strikes were taking too much time for curing; so much so that sometimes we found ourselves working under great difficulties in the factory and in fact at our wits end, in order to make way for other final massecuites which had of necessity to be dumped into one of the crystallizers.

PROCESS OF MANUFACTURE.

In order that the situation be better understood it may be convenient to outline here part of the process of fabrication such as it was carried on at the Central. The three-strike method was used. First strikes were always boiled from syrup, without any addition of first molasses or "topping off." Naturally the purity of such massecuites varied according to the purity of the syrup, both having always about the same coefficient of purity. Such first strikes were usually about 82 purity and gave first molasses of about 60 purity. This molasses was reboiled on seed from syrup, to make second massecuite of about 70 purity, whose resulting second molasses had purities fluctuating around 46. With these molasses, reboiled over a seed of syrup, the final massecuites were concentrated to a Brix of 96°+, and the purities were worked down to about 56. Good care was also taken to see that the temperature was kept around 150°F. with a vacuum of 27 inches.

The first and second massecuites were always cured hot; the final strikes were dumped into air-cooled crystallizers, where they were cooled in motion for four or five days previous to curing.

It is important to state that final goods were worked into magma; that is, the final strikes were only partially dried—the charge was dropped wet from the baskets—and the resulting sugar was mixed in a special small mixer placed at one end, just below the sugar conveyor,[1] with undiluted second molasses of 87°–88° Brix. The magma thus prepared was pumped to a small crystallizer situated just over the mixer corresponding to the centrifugals for first and second sugars. From here the magma was intermittently discharged, as the occassion warranted, into the centrifugal mixer and was usually dried together with the hot second massecuites or alone. Magma was never cured together with first sugars.

The molasses yielded by the magma, with a purity around 40, was considered and handled as second molasses. The polarization of the sugar from magma was always below 96, varying usually from 92 to 95; but as the commercial sugars are always mixed with one another and the first and second strike comprise the greater bulk of the total production, the final result was 96°+ test sugar uniformly.

[1] Screw conveyor.

ACCUMULATION OF IMPURITIES IN THE SUGAR HOUSE.

It is evident that molasses from magma sugar contain a large part of the impurities which would be eliminated with the final molasses if the low grade sugars were dried to the bag or until dry enough to be mixed with first and second sugars. These impurities circulate, naturally, from the pans to the crystallizers and back with the magma molasses, in such a fashion that they tend to increase enough to hinder the process of manufacture. The freeing of the house from such impurities is then unavoidable, and it is necessary to dry all the crystallizers to the bag and hence to stop temporarily the making of magma. Such drying to the bag of a set of crystallizers meant, in our case, a weekly run with final molasses at 34 or 35 purity, a condition which was very unwillingly run into by us.

The antiquated method by which final sugars are dried enough to be directly mixed with the higher polarizing sugars, never appealed to us all because in that way it is difficult to get the final molasses to low purities. The making of magma and double curing of final sugar,[1] even though it is more troublesome and even though it makes the process of manufacture somewhat more complicated, is undoubtedly the one way to keep down the coefficient of purity of the final molasses below 30.

The question to be solved is, then, to maintain a permanent equilibrium between the impurities coming into the house with the juices on the one hand, and the impurities to be eliminated from the factory in the form of final molasses on the other, keeping these always at the lowest possible coefficient of purity.

FACTORS AFFECTING THE VISCOSITY OF THE FINAL MASSECUITES.

Now then; the viscosity of the final massecuites, or better said, the viscosity of the molasses contained therein, is known to depend on various factors, to wit:

(*a*) Concentration of the massecuite.

(*b*) The amount and nature of the impurities.

(*c*) The presence of insoluble material in the form of very minute grains.

(*d*) Temperature.

The concentration and temperature can be easily controlled.

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[1] Magma may, of course, be made with syrup instead of second molasses and be then used for seed grain for first and second strikes.

Every superintendent of fabrication knows well that a third massecuite which has been rightly boiled, with a concentration of 96° Brix, and coefficient of purity from 56 to 57, should cure well after cooling, without any difficulty arising from excess viscosity. Dr. Prinsen Geerligs states[1] that cooling beyond 45° C. is detrimental, because at this temperature crystallization has come to an end; he further explains that at lower temperatures the viscosity of the final goods increases to such an extent that it only causes difficulties without offering any advange in compensation.

During our experience we have been unable to ascertain that a massecuite cooled in the crystallizer to a temperature of 30°C. is considerably more difficult to cure than one cooled to 40° C., provided the strikes were otherwise identical; but it was found that final sugars which stayed in the crystallizers more than the usual time allowed for cooling. and which were cooled in motion to the temperature of the air around them (28°–30° C), have cured with practically equal ease as the others, which were not at quite such low temperature. This was the case during the first weeks of grinding and after the usual stops of New Year and Easter Week festivities. It should be noticed that exceptionally low coefficients of purity were then obtained in our final molasses, a fact which should surely compensate some extra labor involved in the centrifuging of those sugars.

Here again, the price of sugar is a factor to be taken into consideration; as it always will be a determining factor in narrowing or broadening, so far as final molasses is concerned, the margin of diminishing returns.

The following tables of crystallizers sugar and their corresponding final molasses may be of interest:

Milling Season 1917–1918.

Massecuite			Date of boiling	Date of curing	Time of cooling. Days	Purity of final molasses
Brix.	Suc.	Pur.				
95.6. ...	53.4	55.85	Dec. 22	Jan. 10	18	25.33
96.6. ...	51.0	52.79	Dec. 23	Jan. 12	19	26.36
95.4.....	52.4	54.93	Mar. 27	April 5	9	27.05
96.0.....	52.4	54.58	Mar. 28	April 6	9	26.81
96.4.....	52.8	54.80	June 13	June 22	9	27.30
96.4.....	52.4	54.36	June 14	June 25	11	28.10
96.8.....	55.6	57.44	June 14	June 27	13	28.10

[1] "Cane Sugar and its Manufacture," by H. C. Prinsen Geerligs.

Average time in the crystallizers for the crop --------- 6 days.
Massecuites:
Average Brix ---------------------------------- 96.30
Average purity ---------------------------------- 57.00
Final molasses:
Average purity ---------------------------------- 30.00
Gallons per ton of cane ---------------------------------- 5.5

The slow and complete cooling undoubtedly contributed to the thorough exhaustion of the final molasses, the history of which has been set out in the table above.

Milling Season 1918–1919.

Massecuite			Date of boiling	Date of curing	Time of cooling. Days	Purity of final molasses
Brix.	Suc.	Pur.				
97.8.....	56.0	57.26	Feb. 1	Feb. 9	8	26.26
96.8. ...	55.2	57.02	Feb. 1	Feb. 10	9	27.45
95.4.....	54.0	56.70	Feb. 2	Feb. 12	10	27.94
96.2.....	54.0	56.13	April 13	April 22	9	29.70
96.6.....	50.8	52.59	April 13	April 23	10	29.43
96.8.....	54.8	56.61	April 14	April 23	9	28.70
95.4.....	54.4	57.02	April 15	April 24	9	28.77
96.4.....	54.8	56.85	April 15	April 28	13	25.11

Average time in the crystallizers for the crop --------- 6 days.
Massecuites:
Average Brix ---------------------------------- 96.47
Average purity ---------------------------------- 55.53
Final molasses:
Average purity ---------------------------------- 29.64
Gallons per ton of cane ---------------------------------- 5.4

The slow cooling of the massecuites to the temperature of the air around the crystallizers was again a factor in producing final molasses of lower purities than the average for the crop.

Milling Season 1919–1920.

Massecuite			Date of boiling	Date of curing	Time of cooling. Days	Purity of final molasses
Brix.	Suc.	Pur.				
96.4.....	54.4	56.43	Dec. 30	Jan. 10	11	26.67
96.8.....	54.6	56.40	Dec. 31	Jan. 13	12	26.61
96.8.....	54.8	56.61	Jan. 1	Jan. 14	13	26.09
96.4.....	55.2	57.26	Mar. 30	April 11	12	28.97
96.6.....	55.2	57.14	Mar. 30	April 12	13	28.10
96.4.....	53.2	55.19	Mar. 31	April 13	12	28.84
94.8.....	54.6	57.59	Mar. 31	April 13	12	28.44

Average time in the crystallizers for the crop ---- 5.6 days.
Massecuites:
- Average Brix ---- 95.57
- Average purity ---- 56.20

Final molasses:
- Average purity ---- 28.67
- Gallons per ton of cane ---- 5

The final molasses corresponding to the 10th, 13th, and 14th days of January are noteworthy because of their low purities, after the long period of cooling during the stop of New Year and "Reyes" celebration. Those corresponding to April 11th, 12th, and 13th do not appear of so low purities; but it should be remembered that the ten immediately preceding crystallizers, cured after cooling periods varying from 4 to 6 days to temperatures from 45° to 35°C, gave higher final purities. The same was true in the case of the next ten crystallizers worked from April 14 to April 22.

It may be timely to copy here part of a page from our crystallizer record, where the analytical data of the third massecuites and the molasses yielded by each was recorded daily. It should be noticed that the massecuite corresponding to strike No. 304, which went into crystallizer No. 3, serial No. 73. on the 29th of March, was abnormal in that the concentration was not enough (94.8) and the purity too high (60.13). For this reason it was not included in the previous table in spite of its 12 days period of cooling in the crystallizer.

Crystallizer Record.

No.	Crystallizer No	Strike No.	Date filled	Massecuite			Date cured	Final Molasses		
				Brix	Suc.	Pur.		Brix	Suc.	Pur.
65....	1	270	Mar. 23	96.6	54.4	56.31	Mar. 27	91.2	27.9	30.59
66....	3	274	Mar. 24	95.0	53.4	56.21	Mar. 28	87.2	26.4	30.28
67....	4	279	Mar. 24	94.6	51.2	54.12	Mar. 28	79.8	23.2	29.07
68....	5	284	Mar. 25	96.2	53.6	55.72	Mar. 29	81.0	25.2	28.64
69....	6	287	Mar. 26	95.4	54.4	57.02	Mar. 30	82.0	25.6	31.22
70....	7	292	Mar. 26	98.6	56.4	57.20	Mar. 31	89.4	26.4	29.35
71....	8	296	Mar. 27	96.0	55.0	57.29	Mar. 31	89.4	26.4	29.53
72....	1	300	Mar. 28	96.4	53.0	54.98	Mar. 31	88.6	26.8	30.24
73....	3	304	Mar. 29	94.8	57.0	60.13	Apr. 10	88.0	26.8	30.45
74..	4	308	Mar. 30	96.4	55.2	57 26	Apr. 11	85.6	24.8	28.97
75....	5	311	Mar. 30	96.6	55.2	57.14	Apr. 12	85.4	24.0	28.10
76....	6	317	Mar. 31	96.4	53.2	55.19	Apr. 13	86.0	24.8	28.84
77....	7	320	Mar. 31	94.8	54.6	57.59	Apr. 13	87.2	24.8	28.44
78....	1	322	Apr. 10	96.2	52.4	54.46	Apr. 14	84.2	24.6	29.22
79....	2	326	Apr. 11	98.4	50.8	51.63	Apr. 15	88.0	28.8	32.73
80....	3	331	Apr. 12	96.6	52.4	54.24	Apr. 16	89.0	24.8	27.87
81....	4	334	Apr. 12	95.4	53.2	55.77	Apr. 17	89.4	25.2	28.19

Attention should be called to the massecuite corresponding to strike No. 326, which was given too much molasses, a mistake which resulted in an exceptional low purity of 51.63. Also it was brixed up too high; to 98.4° Brix. The said massecuite became too hard on cooling and it was necessary to bring down the concentration to about 95° Brix by addition of water. The added liquid was not run into the sugar with due care and some crystals were dissolved, thus yielding a final molasses with a high (32.73) coefficient of purity.

Notice, then, how different variations from the established routine may lower the efficiency of the process in regard to the exhaustion of the final molasses.

During the next milling season, 1920–1921, the same results were noticed in regard to the effect of abnormally long cooling periods of several third massecuites in the crystallizers.

Milling Season 1920–1921.

Massecuite			Date of boiling	Date of curing	Time of cooling. Days	Purity of final molasses
Brix.	Suc.	Pur.				
96.0.....	52.8	55.00	Mar. 18	Mar. 31	13	27.39
95.0.....	54.0	56.85	Mar. 19	Mar. 31	12	29.17
95.6.....	56.0	58.58	Mar. 20	April 1	12	29.05
96.0.....	54.8	57.08	Mar. 30	April 11	11	28.04
94.8.....	56.4	59.49	April 2	April 14	12	27.49
95.8. ...	54.8	57.20	April 11	April 23	12	28.05
95.8.....	54.6	56.99	April 12	April 24	12	28.85
96.0.....	52.8	55.00	May 28	June 9	12	28.14
96.0.....	54 6	56.88	May 28	June 10	13	27.27
95.2.....	54.0	56.72	June 2	June 13	11	27.97

Average time in the crystallizers for the crop------ 5. 8 days.
Messecuites:
Average Brix ------------------------------------ 95. 76
Average purity ---------------------------------- 57. 50
Final molasses:
Average purity ---------------------------------- 28. 73
Gallons per ton of cane ------------------------- 5

The data given above is not, of course, conclusive. We do not believe, however, that it is always profitable to carry the cooling of the low grade massecuites below 45°C.; but our experience seems to indicate that temperatures as low as 30°C. do not increase so considerable the viscosity of the mass, and that certainly the long periods of cooling after which such temperatures are obtained, invariably resulted in final molasses of lower purity. Even though crystallization due to cooling is complete at 45°C., the retardation of the process in the air-cooled crystallizers seemed to be in our case profitable in spite of the lower temperatures obtained after prolonged cooling periods.

It should be understood that our experiments were carried on in closed-type crystallizers, with no water circulation; and that naturally no massecuite could be cooled to temperatures less than that of the surrounding air; which was usually around 30°C. Low-grade strikes which were carefully boiled and the viscosity of which was not above normal, always dried well at that temperature. Those massecuites which, because of careless boiling (false grain) or excessive viscosity were hard to cure after cooling, were always little improved by warming up or by the addition of water.

DILUTION OF OVER CONCENTRATED FINAL MASSECUITES.

The bringing down of the degree Brix or "doping" of the final goods in the crystallizers was practised in the Central whenever the concentration was found to be too high. Usually massecuites over 97° Brix were diluted to about 95° Brix before curing.

It may be well to remember that whenever a low-grade massecuite is overconcentrated, a condition which in our experience was found to be reached when Brixes of over 97° were obtained for 55–56 purities, the corresponding molasses have lost some of their normal moisture. The molasses of such massecuites, are, of course, supersaturated. It is, therefore, theoretically possible to add afterwards some water without disolving any of the crystallized sucrose; because the water is incorporated with the non-sucrose medium which, being hygroscopic, requires a certain amount of the liquid to reduce its concentration to normality. There should be, then, no solution of the sucrose crystals until an excess of water be present over the amount needed for the establishment of the hygroscopic equilibrium of the final molasses.

In our daily work it has been found that the addition of water, diluted molasses or any other liquid to the low grade massecuites always results in considerable melting of the previously crystallized sucrose with the corresponding increase in the purity of the final molasses. It is also true that the more carefully and gradually the liquid is added to the crystallizer, the less opportunities there will be to dissolve the sucrose crystals; but under the usual conditions of the sugar factory, with the known rushes and difficulties, it is wellnigh impossible for the Chemist to perfectly control the operation.

Some authors recommend the addition of dilute molasses. Prinsen Geerligs[1] cautions us that this should be done "in a judicious manner, until the compounds of sucrose with salts[2] have absorved their full proportion of hydration water." Personally we have not found any advantage in the use of dilute molasses over the use of pure water; furthermore we have always found it advisable to prefer the water alone, because of the fact that it produces the same effect without the necessity of preparing a molasses solution and also because it never was thought advantageous to add any more impurities over those already present in the massecuite.

Somebody has pointed out that dilute molasses has less dissolving action than water. We agree to the fact; but when the question—How much less?—is asked, the argument gets complicated. Our experience with both is convincing enough to warrant the statement that there is no advantage whatsoever in the use of the dilute molasses over the use of water alone.

The old-fashioned sugar makers or "maestros de azúcar" may consider this statement nearly sacrilegious. We remember well the expression of admiration and perplexity which was shown by an old centrifugal foreman in the Central when we ordered the piping for taking final molasses over the crystallizers to be taken down. Up to then final molasses could be discharged into a small tank over the set of crystallizers and there mixed with water, in such a way that the solution could be emptied through convenient pipes into any one of the crystallizers. Hence his surprise. He asked: "And . . . how are you going to cure the final massecuites . . . ? Don't you think it will be necessary to put up again the molasses pipe?"

We wanted to try out the effect of the water alone, without the possibility of having the man in charge of the crystallizers letting go "just a little molasses"—accidentally, you know—when desirable to lower the concentration of some strike. In this way we decided to burn our ships, and the molasses pipe was taken down. It was never missed during the following seasons.

It was found that the best method to add the water to the massecuite in the crystallizers was by letting it drip slowly, in such a way as to insure a uniform admixture of the liquid and the massecuite; so that at no time there be any "free" water around the

[1] "Cane Sugar and its Manufacture," by H. C. Prinsen Geerligs.

[2] The presence of such compounds has been disproved by more recent investigations.

sucrose crystals long enough to dissolve some of the sugar. The liquid was preferably added during the day previous to centrifuging.

In the case of some very viscous final massecuites due to an abnormal high content of gums, massecuites which generally underwent frothy fermentation in the crystallizers, it was found that a solution of caustic soda at about 15° Brix could be used to advantage instead of water in order to reduce the concentration of the massecuite, diminish the viscosity and thus facilitate the curing.

It is probable that this solution has, in addition to the work of hydration previously mentioned, some chemical effect on the vegetable gummy material and other impurities in the molasses, and that this effect tends to check somehow the viscosity. The sodium may also replace the calcium in some organic salts, forming less viscous organic compounds. In the case of massecuites undergoing frothy fermentation the action of the hydrate of soda was worthy of attention. We suppose that the alkali added neutralizes the organic acids produced by the so called 'fermentation', thus helping to check the characteristic frothing.

FACTORS INDUCING FROTHY FERMENTATION.

Frothing of the low-grade massecuites in the crystallizer has been often attributed to the fact that the strikes are boiled at too high a temperature.[1] Our observations seem to indicate that this is not the one only determining factor inducing frothy fermentation; probably it is not the most important one, either. Our experience has been otherwise. We believe that certain impurities, which in our case were believed to originate in the poor quality of cane ground, have *as much* and perhaps *greater influence* on frothy fermentation. Slow boiling at temperatures of 145°F. helped somewhat, but in most cases this was not a sure way to prevent the fermentation. Our pan capacity was scarce and usually final boilings had to be ready to strike in five or six hours.

These impurities, mostly consisting of viscous vegetable gums, were very often present in our low-grade massecuites in such a high proportion as to cause violent frothy fermentation in the crystallizers in spite of all precautions taken to maintain reasonably low temperatures while boiling. These impurities, which were collectively grouped under the name of "gums," hindered very much the

[1] Frothy "fermentation" is here discussed as a chemical reaction. Our experiences warrant the belief that it is not a result of the action of either yeast or bacteria.

drying of final sugars, causing sometimes troublesome difficulties at the centrifugals.

WORKING JUICES OF LOW PURITY.

We have good reasons to believe that an important factor in bringing about an abnormal content of gummy impurities in the final goods was the poor quality of the cane ground during the discussed milling seasons. This question requires some kind of "historical" explanation.

In the year 1918, the price of sugar being already on that upward flight which culminated in the undreamed of prices of 1920, there was of course great demand for *colonos'* cane[1] without any regard almost as to its price and quality. The growers sold their cane at so much per cent sugar on the *weight of the cane,* and therefore they did their best to send to the mills as much *tonnage* as they possibly could.

It was only to be expected, then, that the cane coming to the Central had incorporated with it a large percentage of top seed and even plain green tops, at times including some parts of the leaves. The cane also contained a large amount of dirt and trash. Oftentimes it was entirely unripe. The price of sugar, nevertheless, gave ample margin for it all. Sugar chemists, generally, protested at such a state of things and called attention to the fact that such canes were detrimental to the best general recovery; but it was certain that, in spite of all this, good profits were being made and the managers and owners of the mills were satisfied. It was good business to grind and grind to full capacity.

The result, naturally, was a season of exceptionally low purities; so much so that the following year some Centrals which were buying *colonos'* cane began to take measures to stop the evil.

Guánica Centrale, the largest mill on the Island, made during the crop of 1918–19 a very interesting study of a few wagon loads of *colonos' cane.* These wagons, six in number, were unloaded separately in the plaza of the Central after each was carefully weighed. All trash, earth, seed and suckers were separated and weighed. The juice from each wagon of cane was analyzed and also the juice of the seed cane corresponding to each load.

[1] Cane bought from growers on percentage bases.

The following table gives in quite a convincing way the result of the experiment:

Comparative Analytical Data of Six Wagon Loads of Colonos' Cane, unloaded in the plaza of Guánica Centrale with separate weight of trash, seed, etc. (Milling Season of 1918–19.)

	Pounds					Percentage					Analysis			
											Mill juice from cane		Mill juice from seeds	
Car No.	Total weight	Trash	Seeds	Earth	Suckers	Trash	Seeds	Earth	Suckers	Total	Suc.	Pur.	Suc.	Pur.
K-517.	28.510	824	1.080	......	......	2.89	3.78	.....	......	6.67	15.0	82.8	4.5	38.1
CF-325.	33.910	703	2.471	18	......	2.093	7.286	.053	. ...	9.432	11.3	86.2	4.8	33.1
324.	31.299	572	1.488	39	......	1.83	4.75	.012	.....	6.592	13.0	78.6	1.6	19.1
489.	29.714	660	1.514	......	......	2.22	5.09	......	......	7.31	16.0	86.3	7.6	58.5
339.	32.309	598	1.681	......	370	1.851	5.20	......	1.14	8.191	10.0	65.1	1.4	16.1
777.	28.555	527	708	.....	......	1.8	2.4	......	.....	4.2	13.2	70.8	2.9	24.8
6 cars.	184.297	3.884	8.942	57	370	......	......	......	......	......	......	......	......	......
Avgs..	30.716	647	1.490	10	62	2.11	4.75	.011	.19	7.07	13.1	78.3	3.8	31.6

No comment need be passed over the said table. Central Boca Chica, on our recommendation, reprinted the data obtained at Guánica and sent copies to each one of her *colonos,* accompanied by a circular letter of explanation. It might be of interest to copy here the said letter:

CENTRAL BOCA CHICA,
PONCE, P. R., *November 1919.*

MY DEAR SIR:

We must inform you that during the last milling season, 1918–1919, the cane sent by some *colonos* to this Central arrived here in very poor condition, with large amounts of seed, suckers, trash and dirt. Guánica Centrale, which met with the same difficulty, unloaded six wagons of cane in the *plaza,* separated the cane from the seed, trash, etc., and made a separate analysis of each portion in their chemical laboratory.

Please notice that there is an average total of 7.07 per cent trash, seed, suckers and dirt; also that the juice extracted from the "seed" is of exceedingly low purity and sucrose, namely 3.8 per cent sucrose and 31.6 per cent purity; It is ruinous to pay for such material as if it were a good sugar-producing cane; but the matter is worse yet if we consider the fact that such impure juice usually contains high percentages of non-crystallizable sugars, vegetable gums, mineral salts, etc., which, when mixed with juices of normal composition, hinder the process of fabrication, causing, therefore, larger losses to the Central.

Moreover, we beg to call your attention to wagon C. F. 335. With a net weight of 33,910 pounds of cane there was in it an amount of 3,198 pounds of seed, suckers, trash and dirt which the Central paid for as good sugar-yielding cane. The truth is that such material did not produce any sugar; but, on the contrary, made it impossible to recover a certain amount of the sucrose present in the good canes, as both these juices were mixed at the mill.

We are fully acquainted with the good faith which accompanies all your business transactions, and do not doubt that you will understand and accept our reasons in requesting that the *colonos* who grind their cane with us during the coming season, 1919–1920, see to it that the cane be sent perfectly free from seed, trash, suckers and dirt. This request is fully in accordance with our grinding contract. We believe we are justified in stating that the said contract has been fully kept by us in all its parts, and therefore we are entitled to expect that you observe it as well.

Your very truly,

(Signed) M. León Parra,
Manager.

Attention is given to such details because they show that we were getting poor quality of cane and that the factory had, therefore, to work with juices of low purity, which means a proportional abundance of final molasses.

Our centrifugal capacity was not sufficient.[1] We found ourselves during the crop of 1917–1918, in great difficulties to get rid of the impurities that came in the juices and which it was impossible to remove in the process of defecation.

By this time we had already installed the necessary machinery to go into the making of magma as a routine in the process. It was expected, of course, that the final molasses were going to be of lower purity than before. This was accomplished; but under great difficulties, up to the first days of May.

Up to this time we had noticed an excessive viscosity in the final massecuites, a viscosity which was more troublesome at times. Some final massecuites with normal brixes and purities, which did not have any false grain, nevertheless took much time to dry in the centrifugals. As we were working magma, the sugars were dumped only partially dried or "wet," so that only the well-exhausted molasses be removed from the massecuite.

We have already explained how we tried to facilitate the curing of such low-grade massecuites by diluting in the crsytallizers with water and with weak solutions of hydrate of soda. The time that the massecuite stays in the crystallizer and the limitations of its effect on the centrifuging have also been discussed.

It is important that we state now that great care was taken to control properly the liming, heating, and defecation of the juices. This was done in order to be sure that the high viscosity of the final molasses was not due to defficient clarification. The juice was limed until the reaction was slightly alkaline, using phenolpthalein

[1] Our centrifugal outfit for final goods consisted of six 30-inch Mackintosh centrifugals. Cane ground was around 520 tone each 24 hours.

as indicator; then it was pumped through heaters so that the temperature was raised to 215°F., a degree of heat which has been found elsewhere[1] to be fully sufficient to obtain good clarification. Defecation of the juices, was, therefore good, and it was not here that the difficulties could be remedied.

The problem was, then, to be solved at the centrifugals, if it was desired, on the one hand, to keep the purity of the final molasses under 30°; and, on the other hand, to keep the factory grinding at full capacity.

The question before us was, hence, the following: How to separate from the low-grade massecuites the viscous substances which hinder the process of curing.

[1] I. S. J. 1922, pp. 638 to 639.

II.

DIFFERENTIAL CURING OF FINAL SUGARS.

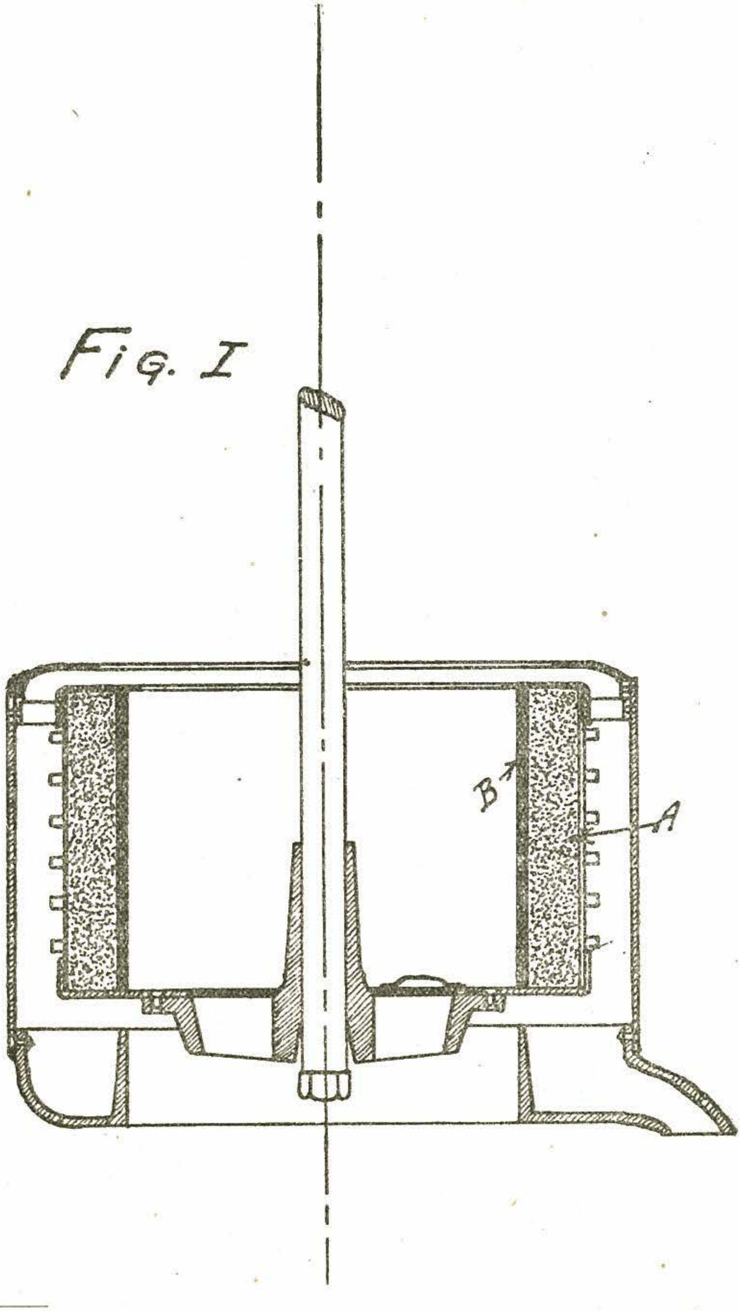
The idea occured to us, then, that it would be worth while to look for some new way to facilitate the curing of those sugars, which took too much time to dry by the ordinary centrifugal method. We had found out that some final massecuites which contained too much gummy material would be free from the more fluid, less viscous molasses during the first ten or fifteen minutes of the centrifugal process; but, also, that these gummy sugars would afterwards rotate in the centrifugals for thirty, forty or fifty additional minutes without getting rid of the gummy molasses or "gums."

It was clear that two distinct layers were formed in the massecuite as it adapted itself to the centrifugal basket; layers evidently arranged according to their corresponding specific gravities. The sugar crystals and the heavier molasses formed a layer (A). about three inches thick, immediately against the sides of the screen. On the outer side—the nearest to the centrifugal shaft—there remainded a second layer (B), consisting of gummy, very viscous material, spongy in texture and of very low purity. These impurities could be turned around in the centrifugal machine almost indefinitely without passing through the layer of sugar, in spite of the fact that the massecuites in layer (A) was practically free from molasses, and also in spite of the fact that—and this is very important, we are sure—the massecuite did not have false grain.

If the centrifugal machine was stopped after running ten minutes or so, it was observed that while the sugar forming layer (A), already free from molasses and ready to be discharged, stayed strongly adhered to the sides of the basket, the gummy impurities of layer (B) flowed down to the bottom of the centrifugal and, if the discharge valve was opened, the gummy molasses fell into the sugar conveyor.

The idea of doing away with these impurities by letting them flow down by gravity and collecting them in special wide canals, was the immediate and logical result. The first gummy molasses extracted by this method from a 30-inch Mackintosh centrifugal gave a volume of 1½ gallons with a weight of nine pounds.[1]

Fig. I



[1] The small weight of this material is due to its spongy texture, the mass often containing a large amount of very minute bubbles (mostly CO2 gas) incorporated in it. Its low specific gravity is, hence, only apparent.

The polarimetric analysis of the material thus obtained was as follows:

Brix	91.6
Sucrose	22.4
Purity	24.45

The final molasses obtained by centrifugal force gave the following analysis:

Brix	89.3
Sucrose	25.6
Purity	28.67

The separation of 90 per cent of the gummy material constituting layer B, a material which would not pass through the centrifugal in 30 or 40 minutes sometimes, was disposed off by the gravity method in less than ten minutes. The centrifugal basket was then set in motion for a few minutes, five or six, and finally the sugar was free from molasses and "gums" and ready to be discharged.

One of the trays used to collect the "gums".

This fact called strongly upon our attention. Immediatedly an attachment was devised for our centrifugal machines. With the help of this attachment we succeeded in separating the gummy molasses with comparative ease making use of the force of gravity in addition to the centrifugal force.

The method finally adopted for the work was as follows:

Each centrifugal was charged and put in motion for ten minutes more or less; then the machine was stopped, when the layer of sugar (layer A) was sufficiently free from molasses. After a little practice, the men at the centrifugals could easely tell, by "cutting" the sugar in motion with a wooden paddle, if the sugar in layer A was free enough from molasses to be stopped for the removal of the "gums."

Once the basket was not in motion, the gummy molasses began to flow down; the workingmen helping to accelerate the flow by pushing gently with the palm of the hand or the familiar wooden paddle used for hand discharging of the sugars.

The "gums" came out through the discharge valve of the centrifugal basket and were received in special receptacles sustained under the basket for the purpose, in a manner which will be explained later. The machine was set in motion for five or six minutes and then the final sugar was dried enough and ready to be discharged in the usual manner.

It was found that there was always a notable difference between the gummy material and the usual molasses extracted by centrifugal force. Of course, we were not washing at all while curing the final sugars. The difference in purity between the normal molasses and the "gums" was generally about three points.

There may be some interest in the following comparative table including analyses of twenty molasses and the corresponding "gums" taken from the same centrifugals. With the object of getting uniform and representative samples, the portions of molasses to be analyzed were taken five minutes after the particular centrifugal was in motion and at full speed. From the same centrifugal was then taken the sample of "gums" as separated by gravity in the manner already explained.

Comparative Table of Some Final Molasses and their Corresponding "Gums."

Analysis of the molasses			Analysis of the "Gums"			Difference in purity
Brix	Sucrose	Purity	Brix	Sucrose	Purity	
90.2..	26.2	29.05	91.0	23.4	25.71	3.34
89.0..	24.6	27.64	91.8	23.2	25.27	2.37
89.2.	25.6	28.70	90.6	23.0	25.38	3.32
89.3..	25.4	28.56	91.2	24.0	26.31	2.25
88.6..	24.4	27.54	91.7	22.8	24.86	2.68
89.8..	25.0	27.84	93.6	22.8	24.35	3.49
90.5..	26.2	28.95	92.0	23.6	25.65	3.30
89.2..	24.2	27.13	90.8	21.2	23.34	3.79
89.6..	24.4	27.23	91.6	22.4	24.45	2.78
90.7..	26.0	28.67	92.8	22.8	24.57	4.10
90.2..	25.8	28.60	92.7	23.6	25.45	3.15
91.3..	26.4	28.92	92.9	23.8	25.61	3.31
89.8..	24.6	27.40	91.2	22.4	24.56	2.94
90.3..	26.2	29.01	92.0	24.6	26.74	2.27
92.1..	26.8	29.10	93.4	24.0	25.69	3.41
90.7..	25.6	28.22	92.3	22.0	23.83	4.39
88.9..	24.2	27.22	90.4	21.0	23.23	3.99
91.4..	26.8	29.32	92.6	24.2	26.13	3.19
90.6..	25.2	27.81	93.2	22.8	24.46	3.35
90.2..	24.8	27.49	91.9	22.2	24.15	3.34

These gummy molasses may sometimes be of higher purities, a fact which seems to indicate that once the troublesome impurities are accumulated in the factory it would not be of much help to raise the purity of the final boilings. This was found to be true in our case. Final massecuites of 58 and 60 purities have oftentimes yielded very viscid molasses, which were separated by gravity and had coefficients of purity of 32 in the gummy portion.

A more or less low sucrose content does not appear to be the determining factor in regard to the viscosity of the molasses. We found that a high content of mineral salts and vegetable gums is generally associated with viscid and gummy molasses. This may be inferred from the following analysis of representative samples made by the author and other analysts.[1]

Analysis.

Sample No.	1	2	3
Brix	92.8	93.3	93.6
Polarization	22.8	28.1	30.2
Purity	24.56	30.11	32.26
Reducing sugars	15.96	14.58	14.58
Ash	16.22	12.04	12.12
Vegetable gums	3.45	2.82	3.07

This viscid material is, to be sure, the last one to separate from the crystals in the ordinary process of centrifugation. Regularly it remains adhered to the grain of sugar and goes into the magma mixture, thus returning again to the pans. It does not make any difference whether the magma sugars be dried to the bag or taken into the pans as seed for first and second boilings; anyway the impurities are bound to circulate in the factory and will accumulate if not properly expelled from the house in the final molasses. The importance of maintaining this equilibrium between the income of impurities in the cane juice and the outgo of impurities in the final waste products is generally recognized.

The low purities of the juices with which we had to work, together with an insufficient centrifugal capacity, were united to aggravate *our problem*. To solve this we were helped by the attachment for the centrifugal outfit which we devised and used at the Central.

[1] The author wishes to thank the following cooperators for some determinations in these analysis: Mr. J. O. Carrero, of the Federal Experiment Station, at Mayagüez, and Messrs. F. Colón Moret and H. J. Ramírez, of the Insular Experiment Station.

Sample No. 1 was taken and analyzed by the author in February 1921; samples Nos. 2 and 3 were secured during the last milling season (February 1923), when the author was not in control of the factory.

The accompanying drawings will serve to give a clearer idea of our centrifugal attachment. It consisted of:

(1) Three wide trays (one for each two centrifugals) shaped somewhat like a trapezoid; movable from under one centrifugal basket to another.

(2) A long, narrow canal, situated alongside and in front of the canal of the screw conveyor.

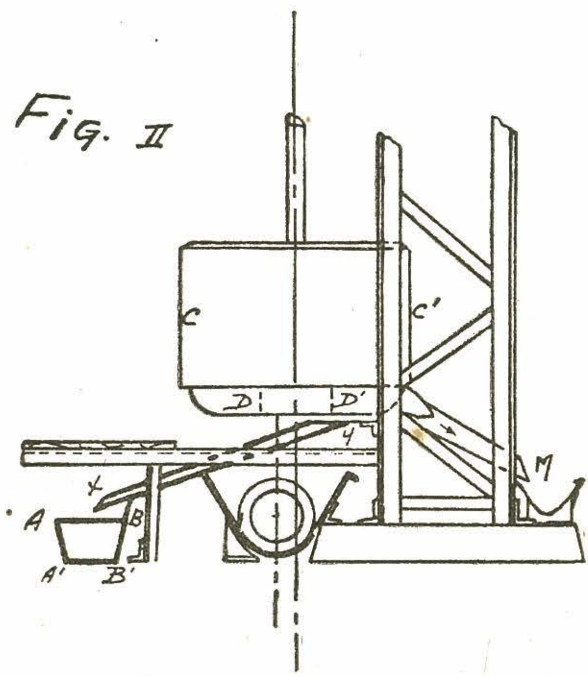
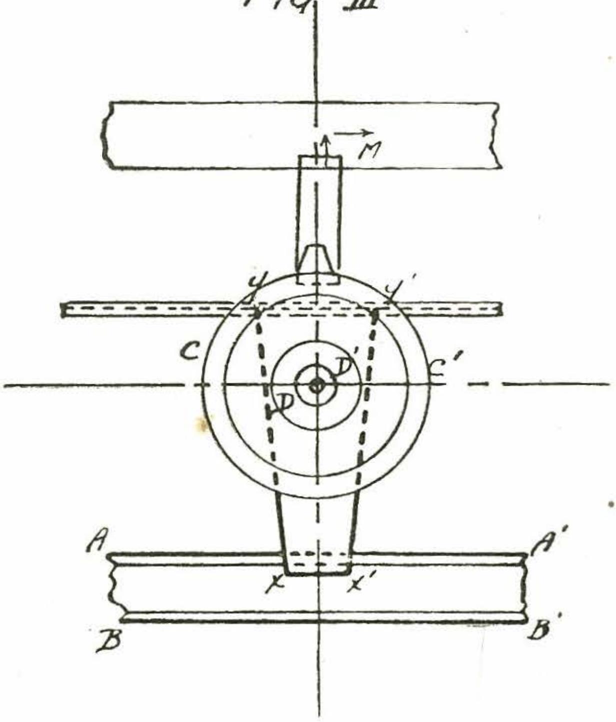


Fig. II

The wide trays (Fig. II and III, lettered XYX'Y') had the form of a trapezoid, 24 and 28 inches at the bases and 30 inches in height. They had on each side, right and left, walls about three inches high to prevent the gummy molasses discharged into them from running out at the sides. A lip at the smaller base, which was the one (Fig. III, XX') discharging into the long canal recipient of the molasses, was fixed so as to facilitate the discharge. The trays were made of zinc plate at the shop of the Central. They were, therefore, light enough to be easily managed, even by a boy.

The molasses canal (Fig. II and III, ABA′B′) was made of wood. It was approximately 10 inches wide, 8 inches deep, and ran parallel to the screw conveyor canal, along the front of the centrifugals, and under the platform where the centrifugal workers stand (see Fig. II). Into this canal were discharged the gummy molasses and through it they flowed slowly towards the final molasses tank. In this tank the "gums" were mixed with the less viscous and richer final molasses extracted by centrifugal force, molasses

FIG. III



which went there by the usual canal situated back of the centrifugal baskets.

In this tank the mixed molasses were heated with exhaust steam in order to reduce their viscosity and to facilitate the pumping up to the molasses scales and out of the factory. Because of this heating, when considerable condensation water from the exhaust steam was incorporated into the molasses, the commercial molasses always appeared with a concentration (85° to 88° Brix) lower than the samples taken directly at the centrifugals.

During the milling seasons of 1917–18, 1918–19, and 1919–20, this method of curing very gummy final massecuites was used by the author, always with excellent results. The effect was oftentimes surprising; not only because the final sugars thus obtained were practically free from any gummy, viscid impurities, but also because magma mixture made with such final sugars and second molasses (about 46 purity) resulted every time in a much looser, freer mass; a mass which did not foam at the mixer, which purged freely without any previous heating, and yielded commercial sugar of 94°–95° polarization without excessive washings. The resulting molasses (magma molasses) was of very low "gum" content—very contrary to the case when the gummy molasses were not removed from the sugars previous to the making of the magma mixture. These molasses were apparently like second molasses; their purity generally being about 40.

Magma molasses, as we have already explained were mixed with the second molasses and were reboiled over syrup grain to make third massecuites, of about 56 purity, which were to go into the crystallizers to cool. The final massecuites thus boiled in general did not undergo frothy fermentation; about one crystallizer out of ten did show the characteristic fermentation, while formerly it was taking place in about nine out of ten strikes.

In the presence of final massecuites of great viscosity which cannot be otherwise prevented or disposed of, this method of differential curing of final sugars has undeniable advantages. Our experience has been such as to repeatedly test its advantages which may be summed up as follows:

1. Saving of time in the process of curing.

2. Separation of a very large part of the gummy impurities which resulted in—

(*a*) A looser magma mixture which is less viscous and of higher purity. This, of course, implies easier drying of magma sugars, and a better magma molasses.

(*b*) Better final massecuites which dried freely and which generally did not undergo frothy fermentation in the crystallizers.

3. A smaller quantitiy of molasses per ton of cane.

As may be seen, a factory can be cleaned from impurities in this manner without falling back on the old, wasteful method of drying to the bag the whole set of crystallizers. The chief difficulty with the magma process is the continuous circulation of impurities in the boiling house. Such difficulty and that of the trouble in curing gummy magma mixtures is entirely obviated by the removal of the excessive "gums" at the centrifugal.

We feel justified in stating that, by the method here discussed, any sugar house can be free from gummy impurities in a few days by curing the entire set of crystallizers in that manner. Little by little, we found out, the impurities began to accumulate and to give trouble in the factory; hence, after two months or so, it was necessary to resort again to the "apparatus for the gums" (*el aparato de la goma*), as the attachment was called by the workers.

Our attachment is, evidently, rudimentary. Certainly some better mechanical arrangement can be devised to collect the gummy molasses as they flow out of the centrifugal baskets, in such a manner that all the outfit can be handled by laborers at the centrifugals, easely and efficiently. Even with the crude outfit we had, there was little difficulty in its working. The laborers at the centrifugals soon learned to operate the attachment, and very often they themselves notified us of the need of it—"because there was much 'gums' in the sugars."

o-O-o