NOTES

ON THE

MANUFACTURE OF SUGAR

IN THE

ISLAND OF CUBA,

BY

CHARLES A. GOESSMANN,

PH. DR. UNIVERSITY OF GOTTINGEN; SOCIUS PHY. MED. SOCIETY OF ERLANGEN, GERMANY, &C.

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In the following pages I propose to give some descriptive remarks on the soil and sugar cane of the Island of Cuba, together with details of the process employed in the manufacture of sugar there, as witnessed by myself. I shall also offer a few suggestions of my own, which, I venture to hope, will not detract from whatever interest the main subject may elicit.

The general appearance of the numerous plantations along the railroads in the interior of the Island cannot but present to the tourist very pleasing impressions; while the careful observer soon notices here and there a striking change in the colour of the soil, as well as the various shades of green in the sugar cane fields. These seem obviously to suggest the following questions. Is there any relation between the colour of the soil and its particular fitness for the successful cultivation of the cane? Are the various shades of green due to a different degree of fertility of the soil, or are they the result of any peculiarity in the varieties of the cane? In pursuing these inquiries, I shall avail myself of the personal experience which I acquired during a period of three months close observation, aided by the free interchange of opinion with some intelligent and practiced managers of large plantations.*

*The extent and importance of the manufacture of sugar on the Island of Cuba, may be inferred from the statements of T. Hunt's Merchants' Magazine in November, 1858, page 548; also, C. Rebello Estados relations a la Prod. Azuc. de la Isla de Cuba, Habana, 1860.

The most characteristic soils of the Island are the red and black. A mere enumeration of the quantitative analytical results obtained from the different soils would give us but little insight to their relative value for cane cultivation, particularly when the results merely differ in regard to the relative proportions of the same component parts. It is of far more consequence to consider the general physical condition of the soil and subsoil, and the particular meteorological features of the country in question. Red calcareous soil, underlaid with limestone, will, as I was informed, in moist years, yield a sound crop; while in a dry season its crop will be likely to suffer,—the cane turning a yellowish colour, and the juice becoming subjected to serious changes as the growth advances. When the cane has become diseased through drought, the juice usually presents an increased amount of free acid, less sugar, and extra quantities of soluble vegetable matter as the results of its abnormal condition. A limestone, which I found quite extensively underlying the canefields of one plantation where the sugar cane (*cana crystalina*) had been raised successfully without any perceptible diminution of yield for more than twelve years, gave me the following analytical results:—

Carbonate of Lime,.....	83.34
" " Magnesia,.....	1.98
" " Protoxide of Iron,.....	1.37
Silica and Alumina,.....	13.38

This stratified limestone forms layers of considerable thickness, and seems to extend over a large district. The various strata, of a more or less white colour, were compact, almost amorphous, and dissolved readily in a fine pulverized state to 86.62 per cent. in diluted hydrochloric acid. Wherever this limestone had been exposed for some time to atmospheric or rainy influence, it has crumbled to a yellowish red mass. The more the clayish admixture in the subsoil increases, the better the red soil generally is. The dark colored soil upon the more elevated localities of the Island, is, as a general rule, considered a superior soil, on account of its admixture of clay, for the raising of the sugar cane; the sandy soil, and particularly the low lands along the sea shore are less valuable, for the former frequently suffers from drought, and the latter are oftentimes moist, saliferous and cold, and liable to the ac-

cess of sea water in the form of spray during gales.* This access of soluble alkalies, especially chlorides, as in the case of sea water, is most deservedly dreaded by planters and refiners, for they interfere seriously with a successful crystallization, being only slightly absorbable by Boneblack, a fact which has been repeatedly confirmed. (Peligot, Hoehstetter, Walkhoff, &c.) The nature of the subsoil must be of the utmost importance in tropical regions, where the main precipitation of moisture—rain—predominates usually in one season, leaving the remainder of the year more or less deficient in that important resource for normal vegetation. It is generally conceded that the cane crop upon a light calcareous or sandy soil, of which large areas are under cultivation in Cuba, would suffer more seriously if the favorable proximity of the Island to the Gulf of Mexico did not secure the benefit of a copious supply of nocturnal moisture and even of occasional rain-showers throughout the so called dry season.

No striking improvements in the mode of cultivating the soil arrested my observation. Unwrought lands still abound in the interior. Transportation, &c., is quite expensive, and the roads, in general, at the close of the sugar campaign—what with the lightness of the soil and heavy showers then prevailing—are almost in an impassable condition.

Three varieties of sugar cane are at present mainly cultivated on the Island, viz:—

1. *Cana crystalina*, sometimes called smoky cane, on account of its bluish green colour. It is hard and furnishes nearly 50 ℔ of bagasse; its juice is supposed to produce the best sugar; it seems to prosper on less fertile soil and resist the effects of drought better than any other cane; and the superiority of its bagasse renders it of eminent value to planters, who depend solely on that kind of fuel.

2. *Cana blanca* or *Otaheite cane*, is of a light green colour, and on account of its large per centage of juice, very highly valued; yet it requires a rich soil, and is not as hardy as the *Cana crystalina*. The inferiority of its bagasse for the purposes of fuel has sometimes proved quite a serious disadvantage in its cultivation

*D. I. Garcia de Arboleya in his "Manual de la Isla de Cuba, mentions that in 1845, Oct. 10, a hurricane carried the spray of sea water from 15 to 20 miles inland, blackening the vegetation as though fire had passed over it.

in localities where other kinds of fuel are scarce. *Cana crystalina* may prosper where *cana blanca* cannot be raised.

3. *Cana de Cinta*, called ribbon cane from the alternate bluish-red and green stripes running along the cane from knot to knot. It stands in regard to its general qualities between the two preceding varieties.

The harvesting of the cane for manufacturing purposes begins, usually, towards the end of November and continues until the end of April, when the beginning of the rainy season interferes with further successful field-work. A large number of planters throughout the West Indies have endeavoured for many years past to introduce the improved apparatus and modes of operation of those countries where the manufacture of sugar from beet root has engaged a suitable application of scientific principles. I found Rillieux's apparatus (of American workmanship), Derosne's system of apparatus (of French manufacture), superior English *vacuum* pans (Pontifex' apparatus), &c., in extensive use on the Island; supported in many cases with centrifugal apparatus of latest improved patterns.

To convey some idea of the ordinary outfit of a plantation carried on under an improved system, I shall enumerate the most important parts of the working material, &c., of those plantations visited by myself, and then enter upon the details of the manufacture.

Plantation No. 1.—1,400 to 1,600 acres of sugar cane in cultivation, daily produce 60 to 70 boxes (450–500 lbs. per box); annual produce 7,000–8,000 boxes.* The machinery consists of a double set of steam boilers, alternately in use, one steam engine 60 horse power, two iron sugar mills consisting each of three iron cylinders 5 feet long and 2 feet in diameter, 12 copper pans for defecation, each 500 gallons, three serpentines, eighteen boneblack filters 7x5 feet, two large Rillieux's boiling apparatus and one strick-pan (French) equal to 160–170 loaves at 90 lb. each, one vacuum pump, five to six centrifugal apparatus, besides extensive arrangements for condensing the steam, a number of iron

*More reliable detailed statements concerning the annual yield of cane sugar, I was not enabled to obtain; the annual produce of the same plantation differs often much in succeeding years, which seems to be mainly due to the amount of cane worked. During the years 1861 and 1862, there were produced in France upon two acres as a mean result—40,000 kilogrammes of beet roots; they yielded 2,300 killogrammes of raw sugar, 1,177 killogrammes of molasses, 128 killogrammes of crude potash. (M. Lefebvre—Compt. Rend. 1863.)

boxes for the crystallization of the Moscovade sugar, several bone-black furnaces, gas works for the illumination of the establishments, &c., &c. Bagasse is the only fuel used. From 250 to 300 cart-loads of sugar cane are, as I am informed, every day sent through the mills when in full operation.

Plantation No. 2.—1,000 to 1,100 acres of sugar cane in cultivation Daily produce 50 boxes (including the moscovade as above—three boxes equal to one hogshead). Annual produce 5,000 boxes of sugar. The main machinery consists of a double set of steamboilers, one steam engine 42 horse power, one iron grinding mill, each cylinder 5 by 2½ feet in diameter, six to eight pans for defecation (each 500 gallons), two serpentines, three Rillieux's boiling apparatus with one vacuum pan and two extensive Derosne's systems of copper pipes for concentrating the defecated cane juice (*guarapa*) by means of the steam escaping from the various boiling apparatus, fifteen boneblack filters (7 by 5 feet), four centrifugal apparatus, several boneblack furnaces, a large number of iron tanks for the crystallization of the moscovade, &c., and a distillery for the working of the molasse coming from the centrifugal apparatus. Bagasse was the only fuel used.

Plantation No. 3.—Two English (Pontifex') strick pans with vacuum pump, two Derosne's condensers, twelve boneblack filters, 14 by 5 feet, five centrifugal apparatus, eight defecation pans (450 to 500 gallons), several wash apparatus for boneblack, besides the usual outfit with mill, engine, &c. Bagasse and coal are used as fuel. There is a distillery connected with the establishment.

The scarcity of fuel and water is sometimes productive of great inconvenience, for the method of working and the selection of apparatus must frequently be guided, in spite of a better judgment, by the degree of supply of these main requisites.

The usual course pursued in the conduct of the whole establishment is as follows:—

The mills are kept in motion day and night, with little or no intermission, from ten to fifteen days, after which they are allowed four or five days' inaction. These intervals are beneficial to the health of the laborers, and desirable for an advantageous working up of the juice and syrups on hand. An often repeated, and thorough cleansing of the whole set of apparatus employed in the manufacture of sugar is of the utmost importance. The best cane

juice may be seen running, in a short time, in string like streams if the necessary precaution of cleanliness has been neglected. The cutting of the cane begins several days in advance of the starting of the mills. A certain amount of cane is therefore, usually, somewhat old before being subjected to grinding, and a flavor of alcohol is thus always perceptible in the pile of stored cane. The cane of plants a few years old is preferred to that of younger or much older growth. It is cut from the same plant, often, for twelve or fifteen years, or even more. Canes not quite ripe, or too ripe—cut too late in the season—or after long drought, are equally disliked by the planters; for they contain sugar, as I have already intimated, under a disadvantageous condition.

The introduction of the powerful iron cylinder mills would seem to prove somewhat deleterious to the quality of the juice. particularly where they are used without any discrimination in the variety of cane subjected to their superior crushing force. The cane of strongest fibre will, of course, offer the best resistance while passing through the rollers, and be least liable to have its interior spongy parts together with the chlorophyl, &c., washed off with the juice. It may be for this reason that the hard *cana crystilina* enjoys the reputation of yielding a better sugar than the two other kinds before mentioned. An injudicious use of powerful mills has also the bad effect of cutting up the bagasse to such an extent as to render it much less valuable for fuel; and I am altogether of opinion that the disadvantage resulting from an undue application of their power must depreciate samewhat the expected benefits from an increased yield of juice. A careful setting of the iron rollers before grinding, as well as their properly regulated feeding, and additional fitting, would no doubt greatly enhance the advantages of the grinding apparatus.

The cane juice is not only subjected to changes in composition, but in concentration also. Its density during the months of November and December, is usually from 8° to 9° Baum (20° Cels); during the latter part of the season from 10° to 11° Baum. After the juice has passed the process of defecation it varies from 7° 9° to Baum (Pese-syrup).

The juice coming from the mills is simply passed through a metal sieve and then pumped into the defecation pans which are usually of the same construction as those used in the manufacture of sugar from beet root. These defecators

rarely exceed a capacity of 500 gallons, which favors a rapid process of clarification; they are of copper with funnel shaped bottom terminating in an arrangement for discharge; they are heated by steam playing upon about two-thirds of the pan's height by means of a steam cloak, the juice being here brought to the boiling point merely. This temperature best favors the separation of the albuminous and other foreign matters into a copious solid scum; thus leaving the juice clear, for its convenient discharge at the bottom of the pans.

The process of defecation is usually carried on in the following manner: the defecators are filled up to nearly six inches below their upper surface, then rapidly heated by steam, as above mentioned, to bring the juice to the desired temperature; caustic lime is then added, and the whole mass immediately and thoroughly stirred. As soon as the boiling point is reached by a gradual increase of heat, the further access of steam is cut off. The defecated juice is subsequently discharged into a system of iron tanks as soon as a sample drawn from the bottom of the defecators proves limpid. So soon as the flow is found to become turbid it is diverted from the tanks and conducted to the sewers by suitable connections in the faucets. No provisions have yet been made for turning a turbid guarapa to profitable account. A successful defecation resulting in a clear, slightly yellowish, limpid guarapa of alkaline reaction is of the utmost importance, for on that mainly depends the quality and quantity of sugar to be produced. Should the defecation have been imperfect, or the separation of parts of the scum and suspended particles of the cane not thoroughly accomplished, more or less of the sugar will be changed, by either influence, throughout the further progress of the operation; the boneblack filter will soon become overcharged with impurities, and exhausted; a small but requisite excess of caustic lime in the liquid will rapidly increase its colour, foreign soluble matter (more or less indifferent) thus accumulate, and the slightly alkaline reaction soon be changed into an acid one. A direct destruction of the cane sugar would then not only be favored, but the remaining unaltered sugar brought under more disadvantageous circumstances in regard to a free crystallization; a state of things which even such costly means as boneblack, and large quantities of fuel could only, and then but partially, retrieve. A due appreciation of these facts has, apparently, caused a difference of opinion among sugar masters

touching the safest means for managing the defecation most successfully. They differ,

Firstly, In regard to the *quantity* of caustic lime needed to accomplish a good defecation.

Secondly, As to the *mode* in which the caustic lime should be applied, and

Thirdly, As to the *temperature* at which the application should be made.*

Some used 1 lb. of powdered slaked lime to every 690 gallons of cane juice, others the same quantity of lime to every 450 gallons; again others half a gallon of milk of caustic lime (which weighed directly after being stirred up 15 ° Baum at 20 Cels.) to every 450 gallons. The quantity of lime is somewhat increased every where during the progress of the season. One planter stated that in some instances, particularly towards the close of the sugar campaign, and after a dry season and where the cane has been raised on sandy soil, 100 gallons of cane juice had required 2 oz. of caustic lime to neutralize the free acid present; and that he had also used to apply 1 lb. of caustic lime to every 150 to 175 gallons of cane juice even under ordinary circumstances. Some add the caustic lime at 40 ° to 50 ° Cels., others at 60 ° to 65 ° Cels.

The numerical statements here reported admit of very little comment. They fail in that preciseness which every well entitled controversy requires; yet, I am sorry to say, they are all I was able to gather. They were, in most cases, no doubt, the result of an ill advised routine. My total ignorance of the quality of limestone originally used for the manufacture of the caustic (quick) lime employed, its causticity when slaked, and the proportions of water used for slaking, &c., renders a satisfactory comparison impossible, even though we should assume that the cane juice had been of equally good quality and the method of working executed with equal care. This uncertainty in regard to the quality and quantities of caustic lime usually applied has, most undoubtedly, furnished the main impediment to more reliable conclusions upon a successful management of the process of defecation during the various stages of the season, &c. It appears to me that caustic

*The manufacturer of sugar from beet root adds the caustic lime usually after coagulation of the albuminous mass has taken place—at 85 ° C (185 ° F) for the large per centage of alkalies in the juice of the beet root interferes with a successful coagulation if set free by lime before that purpose is accomplished.

lime dissolved in a solution of inferior sugar (always present) might answer satisfactorily. A solution of cane sugar mainly dissolves the caustic from the slaked lime and in large proportions, at common temperature. Such a solution may easily be brought to a uniform strength, and thus the first requisite—reliability—may be secured.* The action of this solution would begin immediately on its application, and with the full amount of lime available, thus shortening the process and greatly assisting the judgment of the operator engaged in that department of the manufacture. The sugar used for the solution of caustic lime is by no means sacrificed, for it will soon be returned in an improved state and most frequently without any additional expense. Although I had, while in Cuba, but crude means at my disposal to test this idea, I have convinced myself that, at least, an apparently good defecation may be obtained by carrying it into practice. It is undeniable that the influence of the soil and season, the difference in the juice, the usual delay in working the cane after it is cut, and, finally, the greater or less deficiency in the general arrangement for keeping the fresh cane juice unaltered, must render the question of defecation one of great vexation and embarrassment to the sugar master, particularly if he be without the necessary means and opportunities to study, with time and care, all the circumstances by which he may be surrounded during an ensuing season. I noticed very good results in one case where the slaked lime had been added in a finely divided (sifted) state at a temperature of 55 ° to 60 ° Cels., and the mixture subsequently brought to the boiling point. A defecated juice (guarapa) of a somewhat darker color, yet alkaline reaction, the result of a certain excess of caustic lime, though requiring more boneblack, it is true, thus causing increased delay and expense, may still furnish a good sugar in the end, if treated with proper care.

A defecation accomplished with too small a quantity of caustic lime, although producing a light colored (greenish yellow) guarapa, will always result in an inferior quality of syrup and sugar. It is a deplorable fact that no efficient provisions have been adopted in the present system of making sugar, by which the evils arising from

*Peligot's statements concerning the compositions between cane sugar and lime (Compt. Rendus XXXII-333; Liebig's and Kopp's Jahresbericht 1851-549) and Berthelot's observations on the solubility of caustic lime in a solution of cane sugar (Annal de chimie et de phys. XLVI—1 zs; Liebig's and Kopp's Jahresbericht 1856-635, &c.) may render the question an easy task.

a deficient defecation might be advantageously checked, or, at least, lessened. The guarapa coming from the defecators is usually filled into a system of iron tanks, to be from thence discharged (still hot) into the boneblack filters of which nearly two-thirds of the number at disposal were, as I noticed, used for the decolorization of the guarapa, while the remainder were retained for that of the syrups (meladura.) The accumulation of the guarapa is often so rapid that it can not be advantageously filtered through the boneblack, and this arises from the want of arrangements for keeping the liquid at a certain temperature which is so very desirable in the interest of a full and unimpaired effect of the boneblack. A coarser kind of boneblack is generally used for the decolorization of the guarapa than for that of the syrup; the filters are usually covered with a straw matting. The guarapa being cleared by settling merely, always contains more or less small particles of suspended cane, and in most cases also new separations of compounds of lime. A boneblack of a fine grain would, under such circumstances, easily be filled up, the passages through the granulated mass stopped and the filter prematurely rendered useless. The boneblack used for the filtration of the guarapa, for these very obvious reasons, requires a most thorough cleansing before being subjected to a reburning.* Fermentation and washing with water, or the application of the hydrochloric acid and subsequent washing with water before reburning are the usual methods of renewing the boneblack. A fermentation of the boneblack before applying the hydrochloric acid, &c., is undoubtedly the most efficient way. The quantity of guarapa which the boneblack retains after being removed from the filter will almost always support a strong fermentation, which, under the influence of the climate, may be rapidly generated. I saw piles of boneblack colored cherry-red inside from the high degree of oxydation in progress.

Various modes are pursued to concentrate the defecated juice, after coming from the coarse boneblack, into a syrup of 26 ° to 28 ° Baum. The scarcity of water or fuel, or both, at certain periods during the sugar making season has, as before alluded to, oftentimes to serve as an excuse for the misappropriation of other-

*A good boneblack contains 10 per cent. of carbonaceous mass; its relative value depends mainly on the per centage of carbon. M. Monier found in a fresh boneblack 10.5 per cent. of carbonaceous mass and 5.1 per cent. of carbonate of lime, while a sample of exhausted boneblack contained 4 per cent. of carbonaceous mass and 16 per cent. of carbonate of lime.

wise well devised apparatus, or more or less disadvantageous methods of disposing of a large amount of cane juice in the shortest time. The condensation of the guarapa in pans—Rillieux's apparatus for instance—under exclusion of air by means of a well regulated heat, aided by a successful condensation of the vapors produced, must favor a good final result, particularly when the guarapa has always retained a slight alkaline reaction. The condensing of the steam arising from the concentration of the guarapa is, in many cases where a scarcity of water periodically happens, quite an important consideration; while, on the other hand, a supply of the boilers by warm water, which may be easily obtained from the various steam condensing apparatus, will materially affect the quantity of fuel required to produce the necessary steam power for the establishment. The question of an advantageous condensation of steam has thus for several reasons shown itself worthy of serious reflection, and various schemes for its solution have been proposed. Derosne's system of copper pipes for condensing the steam coming from the various boiling apparatus by running a colder liquid over them, seems to be frequently introduced. The guarapa coming from the boneblack filter, before entering the boiling apparatus, is also often employed for that purpose, and apparently for two reasons, viz: to aid in condensing the waste steam of the whole establishment, and to be concentrated by the heat to which it is thus subjected. In pursuing this course the condensation of the waste steam and consequent partial evaporation of the guarapa are effected, even under the most favorable circumstances, at the expense of the final yield of sugar both in quality and quantity, and the degree of advantage must depend mainly on the general management of the sugar master. I will not dispute that there may be cases on the Island where such a proceeding, by proper management, has sometimes secured advantages to the planter; but notwithstanding such facts there remains but little doubt that, before the adoption of such extreme remedies can be pronounced judicious, a well devised system of economical application of the steam usually at disposal ought first to prove inefficient, and an additional supply of fresh water entirely out of the question.

A most rigid economy in the application of steam for boiling the various solutions of sugar, will ever prove very advantageous in regard to the preservation of the sugar for a copious crystalliza-

tion. Steam of a very high pressure (as required to run the frequently overburdened mills, &c.), applied without any additional controlling check, or any discrimination in the operations of manufacture, must be considered one of the most damaging influences, particularly on relatively impure solutions of sugar, and causes, to say the least, an unnecessary waste of fuel.

By whatever means the concentration of the guarapa to a syrup of 26 ° to 28 ° may have been effected, a new separation of compounds of lime resulting from changes continually going on in the liquid will be the consequence. To remove these impurities the syrup is subjected to a skimming process. This operation is carried on usually in iron tanks heated with steam coil, commonly called serpentines. The suspended impurities are, during a brisk boiling process, here raised in scum to the surface and removed by a skimmer; the remaining syrup is thence directly discharged into the boneblack filter. The general condition of the syrup before entering the boneblack, and the quantity of the latter employed for decolorization, have both a very decided influence on the sugar and molasses thence resulting. The last of the syrup is usually expelled from the filter by means of guarapa.

It is at this state of the manufacture that I have proposed in a late publication to introduce as beneficial a new additional refining process. I recommended the removal from the syrup of the excess of lime by means of superphosphate of lime, and the restoration of the alkaline reaction, &c., by means of caustic magnesia. My proposition in this respect is based upon actual observation of the superior effects of both compounds under circumstances similar to those here under consideration; and my experience, acquired during an engagement of several years as superintendent of a large sugar refinery, has sustained the expectation which I placed in the effect of a joint application of an acid phosphate of lime and caustic magnesia, when contemplating (in 1857) their introduction into the refining of raw sugar. In my former publication I have omitted numerical statements; and I shall prefer to do so here, for the proportions are entirely governed by circumstances, as quality of the syrup, &c. To ascertain these proportions correctly is the task of the sugar master, to whose individual qualification the proper execution of the proposed process must be entrusted.

The syrups after being skimmed and once again filtered (this

time through a finer boneblack) are, in the system of manufacture usually adopted, ready for the separation of the sugar. The final evaporation for that purpose is accomplished in a manner similar to that practised in sugar refineries. A sufficient number of suitable pans, of various patterns, as before stated, with vacuum pumps attached, are used to carry into effect that most important process. The efficacy of the best devised pan depends largely on the capacity of the vacuum pump attached, and the efficiency of additional apparatus for aiding the rapid condensation of steam produced in the boiling of the syrups. The same kind of pan may therefore give very different results according to the more or less advantageous circumstances under which it is placed. Arrangements by which the sugar master might be enabled to secure to himself an independent control of the quality and quantity of steam required at the different stages of the boiling process, and in peculiar states of the syrup, seem not yet, as a general rule, to have been provided. To enumerate here the various rules, represented as having been confirmed by experience, for boiling the syrups to the best advantage, or for counteracting unfavorable influences arising from an inferior quality of cane or other causes, would prove of little interest, since they all differ; depending as they must on the more or less correct view taken by the sugar master in regard to the general qualities of the syrup, sugar, &c., as well as on his own personal experience. It may suffice to state that the majority of the sugar masters boil the syrups with the object of forming a good and copious crystallization of sugar within the pan; while others prevent the crystallization in the pan by a higher temperature and a well regulated supply of new syrup to the boiling mass, thus forming the grain (crystals) mainly afterwards by stirring it in a cooler. The contents of the pans are discharged in both cases into a heated cooler as soon as they have attained the desired density. These coolers are generally of an elongated semicircular shape, are surrounded by a steam cloak, and are large enough to permit a thorough stirring up of the whole mass of one boiling process. Weak and impure syrups are always boiled at a lower temperature and to lower density than better qualities. As soon as the sugar has been brought to a uniform state, by stirring in the heated cooler, it is filled into funnel shaped moulds of various size, but mostly of the capacity of from 60 to 90 lb. each. The usual size of the boiling (or strick) pan

permits the production of from 60 to 120 moulds full of sugar at each boiling operation. The lower openings of these moulds, when filled with warm sugar mass are stopped sometimes with wooden blocks and sometimes with pieces of sugar cane.* These obstructions are removed as soon as the mass has receded to a temperature of from 80 to 90 Cels., whereupon the moulds are carried into the purging house where the purging is effected in due time by the claying process. The clay is applied either directly after the smeary sugar mass has been removed from the moulds, or after it has been spread upon cloth. Syrup of any kind is rarely used for purging. The purged sugar is now cut up and assorted.

The various qualities of sugar thus resulting from the same loaf are, after being broken up, sufficiently dried and packed in boxes, ready for market.† The first precautions in the interest of a successful and advantageous purging operation are a gradual cooling of the sugar mass liberated from the coolers, and a uniform temperature which should never be permitted to fall below 75 Cels. within the purging house for any length of time. It is well known to the manufacturers of raw (box) sugar as well as to sugar refiners that the best sugar mass may be considerably reduced in value by disregarding these rules. Where planters have not heeded these lessons of experience (and there are many such cases) the neglect is counteracted by a thinner clay mass or an increased (renewed) claying, according to circumstances, resulting in either case in a great sacrifice of crystallized sugar from the first process of crystallization.‡

The syrup from the first product of the manufacture is discharged—I am not able to speak generally—into large wooden tanks in common with the solution of sugar produced by the claying of the first sugar mass. This ill-advised mixture of solutions of so different value and density is, quite naturally, always in a

*Fresh stalks of cane immerged into the melasse can only aid in creating a rapid fermentation.

†The sugar left after purging in the moulds is usually assorted in three qualities; the upper part is white, the middle part yellowish white and the end of the cone (cucurucho) is mostly of a brown red color; the relative quality and proportion of these three kinds of sugar often vary.

‡The coldest months on the Island of Cuba are December and January; their mean temperature is 17° Cels. (62.6° F.) in the interior of the Island, and 21° C, (69.8° F.) at Havana; the temperature during the winter season seldom falls from 10° to 12° C. (50° to 53° F.) Compare T. L. Thrashere's translations, &c,, of A. V. Humbold's "Island of Cuba," pag. 151-153.

state of fermentation. A rapid working up is the only mode of preventing, in this state, further serious changes and consequent waste of sugar. The clayed *melasse*, as it is usually called, is either boiled to the consistency of molade and exported as "clayed molade;" or the boiling is still further continued and the mass left to a slow process of crystallization in iron tanks from 12 to 18 inches in depth. When the crystallization has here proceeded to its fullest extent, the sugar and *melasse* are thoroughly mixed, and the sugar is subsequently separated by means of centrifugal apparatus in a manner well known to manufacturers. The sugar thus obtained is known as *centrifugal moscovade.* In its softer state it is filled into hogsheads; but after having been, by means of steam comparatively freed from the *melasse* and artificially dried, it is packed into boxes. The separation of the second product of crystallization having been accomplished by the aid of steam, it may well be concluded that the *melasse* running from the centrifugal apparatus is so thin as to be unfit for transportation; it is therefore usually converted into alcohol. A distillery is generally to be found on large plantations, the supply for which is always more or less increased by purchase from the smaller plantations in its vicinity.

From the foregoing remarks, I think the conclusion will be apparent, viz: *that the unsettled state of opinions* in regard to the best methods of carrying out the more important processes connected with the manufacture of sugar is an evil of far greater magnitude than *any deficiency* which has been shown to exist in the *machinery* and *apparatus* usually employed. Although local and climatic disadvantages may sometimes present formidable impediments to a strict and full appreciation and adoption of well established principles, there can be no doubt, on the whole, not only that there is still room for steady, progressive, practical and scientific investigations, but that a rigid obedience to the experience thus derived, must result in a highly remunerative compensation to those engaged in the manufacture.

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