CHAPTER- IX

TECHNOLOGY AND USES OF SUGAR

TECHNOLOGY AND USES OF SUGAR

Sources of Sugar : Sugar in some form is found in all green plants. Sucrose, is stored most abundantly by sugar cane and sugar beet, and these plants have become the world's principal sources of supply of sugar. In normal years, world production of sugar average is about 35,000,000 short tonnes, of which two thirds come from cane, and one third from beet. Cane flourishes in tropical and sub-tropical areas, and beet grows in the temperate zones. The rest of the world derives most of its sugar from cane. Countries whose production is consumed in the domestic market, often make products of varying qualities which are sometimes much inferior to the pure white sugar commonly used in the United States. The gurs of India, the palm sugars of the Malayas, as examples, are yellow to brown sticky materials which may contain as little as 60 to 70 per cent of sucrose. The major exporting countries generally furnish materials of much higher purity which are called raw sugars and usually contain about 97 per cent sucrose. Raw sugar are light yellow to brown in colour and relatively 'soft' in consistency. They require further processing before being accepted as a food.

Raw sugars have been in the past, and still, are shipped from the areas of production to the refining centres of the world. For economic reasons, these refineries are usually located at sea-ports.

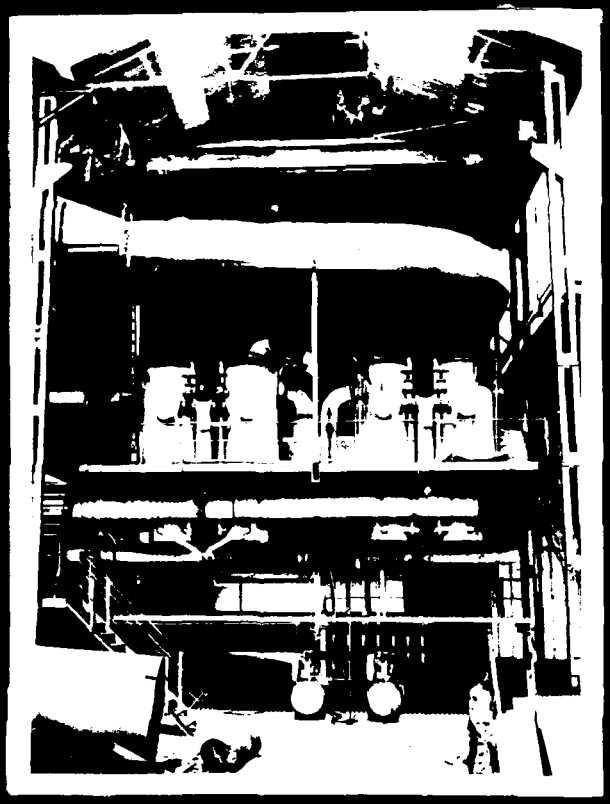
Botanical Aspects : The growing of cane, a tropical plant, is quite different from the farming of beets, a native of the temperate zones. The manufacture of sugar from the two principle. The refined products of the cane and beet are distinguishable and may be used for all purposes.

Sugar cane is a grass, genus Saccharum. The commonest species is Saccharum oppicinarum.

As the cane ripens, the manufacture of sugar by the green plant sets in, and the sugar content increases quite regularly in the final two months before harvest. The cane harvest begins at different times of the year in various parts of the world and may last from three to four months, as in Louisiana in U.S.A. to the entire three or four months or year, as in the Hawaiiam Island. The dense growth of nature cane, ten or more feet in height and shrouded in leaves, is generally cut by hand at the ground level. The upper most two or three modes are cut off and the leaves stripped and discarded at the same time.

The field-factory relationship throughout the sugar producing countries has evolved in several different patterns. The cane grower, large and small, may be entirely independent of factory, in which case the crop may be constructed to the factory even before planting.

Plate-13



Process of making juice.

Plate-14

Sugarcane kept outside

for the preparation of juice

Factory Processing : In the factories, much of the cane grown throughout the world is processed to final products.(Plate No.13 The factories use standard procedures. The cane is boiled in crude and primitive fashion for local consumption. This type of products are impure and their special characteristics are exclusively local matters. Particularly the more scientific methods are being introduced. The production of gurs are impure. Native sugars are soft, dark coloured, and impure and the purity (that is, the percentage of sucrose in total dry product) is often as low as 60 and 70 per cent. The white sugar of high purity is usually demanded in United States, but in Europe considerable tolerance is all owned in respect to colour.

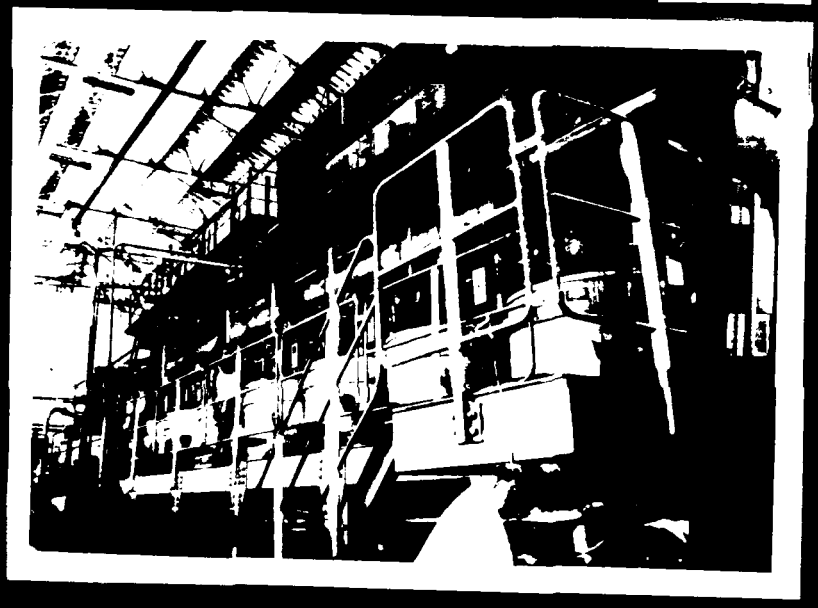
After cutting, sugar cane is taken to the factory as soon as possible, since deterioration is rapid. (Plate No.14). Throughout the season cutting and grinding are continued. Grinding of cane is the first step of raw sugar production. The subsequent refining of raw sugar is generally separate process.

Raw Sugar : The harvested cane is taken to the factory, where the first step consists of removing the sugar juices from the cells of the plant. This extremely variable juice within the

Plate-15

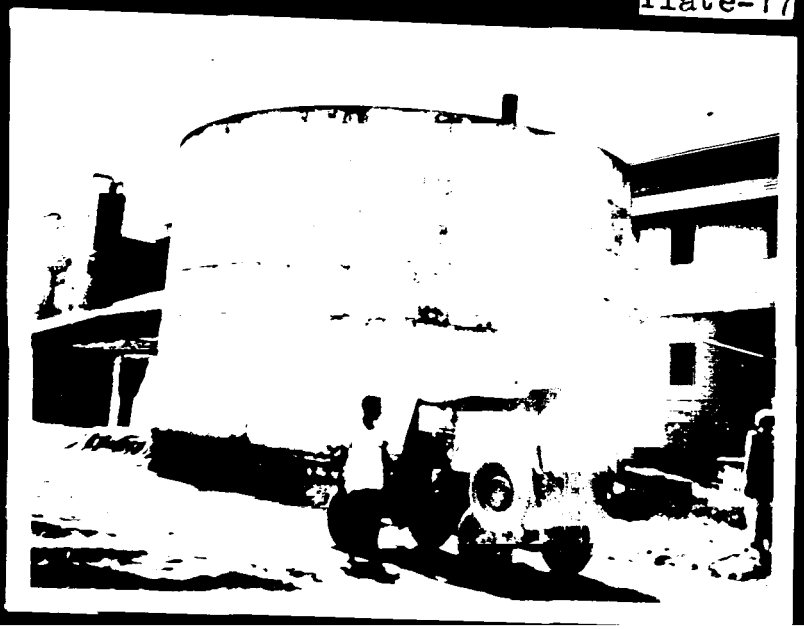
Sugarcane kept outside in South India.

Plate-16



Sugar processing in the factory

Plate-17



plant is extracted depending upon the intensity of the crushing process both in quality and quantity (Plate No. 15). The efficiency of standard milling process is about 95 per cent. With extracted juice the nonsoluable material is taken out ; and this impurity is troublesome in the subsequent processing (Plate No. 16). The residual material is bagasse (or megasse, as it is called in the British Colonies). Its fibre content comprises about 10 per cent of the original cane. Of this original cane 75 per cent is water, 14 per cent is sugar (mostly sucrose); and the balance consists of non-sugars. (Plate No. 17).

The crushing juice is expressed by the cane. Through various sets of rullers, the cane have been sliced or shredded. And this function is one of the most complicated due to their surface, shape, number of rollers employed, the size and speed of one roller with respect to another, the grinding rate.

The usual crushing unit consists of three rolls. Through the first few sets of rolls, the cane passes.

In recent years, the trend in grinding practice has been heavier rolls, higher bearing pressures, longer trains accessory shredding etc. In this improvements, power consumption is an

important factor, and the use of roller bearings has already done much to reduce operating costs. In any industry in a large sugar mills, the milling section constitutes one of the largest and heaviest installations of machinery.

The primitive grinding methods are followed in old sugar mills. Heavy rolls made by wood, are trolled about circular areas by animal or even by man. The cane is thrown on the floor of the collecting gutters.

Clarification : To remove dirt materials the juice is ready for "defecation", or "clarification" after coming from the grinding mills. To reduce the content of nonsucrose impurities, clarification is necessary.

The juice, now ready for clarification, contains 75 per cent or more water. During the clarification the water content may be increased to as much as 85 per cent because it is subsequently removed by evaporation and boiling. By heat and lime, the clarification is effected. To supplement their action, the other agents are added. In the unusual juices the phosphoric acid, in the form of its salts is found. Throughout the sugar processing chemical control is necessary. And in the defecation, in order to avoid later difficulties, extreme care and special attention is required.

Of the impurities of juice the combined action of heat and chemicals have been taken as precipitate part. In large clarified tanks and shelters the 'muds' 'scums', or 'slops' are separated from clarified juice. The continuous suction device which revolves slowly in a tank full of the slurry to be separated. The perforated cylinder is blanhted (covered) with a canvas, string, or other filter base and suction is applied from within. As the rotating assembly emerges from the liquid, the last traces of filtrate are sucked through. The residue is washed by water spray and by the free passage of air. The diatomaceous earth, kieselguar, or filter aid are the special clay usually employed for this purpose. Under some conditions, to serve satisfactorily, the reburned filter muds and even bagasse have been found.

With a canvas or other filtering cloth between them, a filter press consists of alternate plates and frames. The frames are hollow and for the filter muds collects as filtration proceeds.

To the mill workers, the washing from filtration is known as "sweet water", and throughout the processing the vario other diluted sugar solutions are obtained. The sweet waters

are collected and worked back into the process, thus partially replacing some of the fresh water otherwise required.

While juice is hot, the clarification occurs, and from the steam of power house, the heat having been supplied to the juice heaters. The juice may be heated further before going to the evaporators. At this point, it is known as "thin juice will contain perhaps 85 per cent water with purities higher than 90 per cent. For the manufacture of raw sugar the above process is essentially practised.

To remove the large quantities of water in thin juice and to extracted the desired sugar, a simple or direct matter is necessary. But the evaporation the excess water is removed. During the boiling step the substraction of water is continued in the vacuum pans. And throughout the second step, most of the crystallization or actual separation of sugar sets in.

Instead of one step process, this three step operation evolved as a matter of economical plant operation. In a very high capacity evaporators, the bulk of water removed. And the closest quality control is not necessary in this high capacity evaporators. Careful control and flexible manipulation become

critical and however, the solution becomes more concentrated and crystallization becomes immenent. So, to the single vacuum pans, where delicate and fine control is possible the thick juice is transferred. And due to an economical limit, which is reached, the another transfer to the crystallizers is made. Though each of these three process is complicated but is so much necessary in the sugar industry, and some further considerations are warranted.

Evaporation : In olden days raw juice was merely cooked to a very thick syrup. The crystallization did not necessarily occur under such conditions due to exceeded saturation point. By draining through a paper cone the crystals are separated from their mother liquor, and the cones of sugar is found. These are often of appreciable size and weight.

For modern commercial operation, the direct cooking is impractical, chiefly on two scores. First, evaporation by direct cooking leads to considerable deterioration and this results in products of low purity; and second, the cost of such single effect evaporation is prohibitive. By employing multiple effect evaporation, these two major defects very nicely overcome. The agitation accelerates the rate, at which heat can be transferred into the liquid and thus

Plate-18

Boiling House

quickens evaporation. By reducing pressure to boil, sugar solutions at temperature considerable below the standard, it is thus possible, and the disastrous decomposition which would occur at higher temperature is avoided. And in this way the deterioration and low purity, the first defect, is overcome, and the prohibitive cost is solved simultaneously.

In sugar houses, a horizontal film evaporator is an another type, is also very common.

Approximately, 20,000 pounds of water an hour is evaporated by a standard evaporator body. And for a quadruple effect, the ordinary efficiency will amount to perhaps 75,000 pounds an hour in all. This means that more than 100,000 pounds of thin juice, or in each hour about 50 tonnes are taken and to be finished to sugar and molasses and about 25,000 pounds of thick juice goes to vacuum pans.

Boiling : Vacuum pan which is so much essential and a single effect evaporator operated independently of the evaporators. In the entire process the work of pan is an important because it constitutes the boiling of sugar manufacture (Plate No.18). The sugar boiler is the true artisan of the sugar house and this

Plate-19

Steam boiler for Sugar godown.

step is reduced rapidly by the scientific operation or knowledge of the boiling operation. Its major function is the induction of crystal formation (Plate No. 19). Thus in the "strike" in the pan the entire process of sugar manufacture culminates. Bulk and the boiling is strategic and critical, and it is more sensitive to degradation and spoiling by improper handling.

For final processing, the corresponding high purity crystals go directly to this final processing, and in order to improve their initial low purity the subsequent lower purity strikes are worked back separately. The working system is rather complicated.

The process of crystallization may be likened to the evolution of life itself.

Crystallizing : The last system of sugar technology, crystallization which constitutes only the last minor fraction of the total separation, takes place in large, cooled troughs which are fitted with slow moving agitators. In the crystallizer, the exhustion of the molasses (that is, the extent to which all the crystallizable sucrose comes out) may be almost complete.

In centrifugal machines, the massecuite from the pan or from the crystallizer is separated into crystals and molasses (or "green" syrup) if it is not an end product.

The large perforated baskets which is about forty feet in diameter and two feet in deep and backed with fine brass or stainless coloured, turns to a lighter coloured when the syrup spins off. In each cycly of this process (crystallization) several hundreds pound of sugar are produced and it takes only a few minutes to complete.

For shipping, the raw sugar is bagged immediately, where as refined material it is dried before packaging. The standard raw sugar is 97 per cent pure, and most of these are shipped in jute bags; 325 pound bags are the rule in Cuba, and relatively small bags are found in Hawaiian regions, and holding about 100 pounds. For some time, in Hawaii, the raw sugar has been shipped in bulk to the mainland, and in Cuba, same type of shipping has recently been tried. In various areas the railway, shipping has also been tried.

Grades of Sugar Produced : After purging, the sugar is dried, or granulated, in large rotating drying drums through which steam-heated air passes counter currently to the sugar. The

water, which is the last in which the last residual amounts a found, is necessary for preventing the consolidation and inte growth of groups of crystals. For pan seeding, the inevitable dust which collects in the granulators is frequently used. By screening the additional fines, are removed, and in the same process the grading to size may be done. The usual practice is, rather, to attempt to boil to the desired size distribution.

For as solid products in the refinery, about 95 per cent of the initial raw material will be accounted, another 4 per cent or so will be the inevitable molasses ("refiner's black-strap" or "barrel syrup" as it is called at the refinery). For only industrial purposes this material is usually sold. The loss in manufacture will represent at a fraction of 1 per cent. From the refinery a wise variety of primary products is turned out. This is most important for standard granulated grade. By screening or by special boiling operations, larger or smaller crystals sizes are produced. For larger or smaller or for the finer grades, they are known as powdered, fruit, dissert, berry, bar, or superfine; and for the coarser grades, they are known as sanding, manufacturer's granulated, coarse brilliant, candy, etc.

Cube sugar is made by mixing white crystals. The press tablet is then dried and packaged. In recent years the paper containers for sugar are being more and more used widely, and then displace in cotton bag in similar way this fabric almost completely displaced the sugar barrel. In the modern refinery, the pakages of extremely wide variety is turned out.

A portion of the product going to market as high purity syrup (thick) for refineries, and it is not an unusual factor. This thick high purity syrup is usually designated "liquid sugar"? Distribution is usually made in glass lined trucks, mostly, to local consumers. By candy makers and bakers the inverted refined syrups are also produced for consumption and for edible purpose. And in this way dextrose syrups are widely used, and the dextrose syrups and the levulose, as the ultimate componants of sucrose are extremely important.

Dextrose, or Corn Sugar : Dextrose, which is produced from starchy materials, principally corn, and is available commercially under that name as well as under the names corn sugar or grap sugar. And this type of sugar is not sweet as sucrose, but it is so much important for the value of food. Sometimes

it is superior to sugar as a quick sucrose of energy. The levulose component has a sweetening power approximately 50 per cent greater than sucrose. In this type of sugars, there are many organic substances which are vastly sweeter. Saccharum for instance, is about 250 times sweeter than sugar. There are many organic compounds which are still sweeter than Sacchrum. Beryllartine is approximately 2,000 times as sweet as sucrose, and nitrobenzene derivatives have a sweetening power of about 4,000 times that of sugar. In this connection it is interesting to note that glycerine and the closely related ethylene glycol (antifreeze) are both approximately half as sweet as sugar. Ordinary choloroform is likewise very sweet about 40 times sweeter than sugar.

For most tastes, the sweetness of sucrose is "sweetness to the taste as beauty to the eyes". Eaxtrose which is produced entirely from corn, although any starch material can raadily be converted to dextrose and syrup products. By Indians of America, this sweet nature of Indian corn (maize or mealies) was expounded to Columbus. For many years to extract the sugar from corn had been made; but until quite recently a "starch" sugar in crystalline form were not successful. Grapes were an earlier and much more promising source of this material.

The grapes sugar has been recognised for almost as long as sucrose itself. Oliver de Serres, Francis Bacon, and Johann Glanber had likewise recognised grape sugar about one hundred years earlier. In 1806, grapes sugar was the hope of vitiating the Napoleonic blockade, but the French refineries were never successful in this purposes. Andreas Marggraf mentioned the possibility of making sugar from grapes.

Corn syrups have been manufactured in the United States since 1872, and even longer in Europe. In 1918 the first commercial production of crystalline dextrose was produced in United States.

By the saccharification the dextrose can also be obtain This is a simple chemical process and it is found in Europe where food is scarce.

"The manufacture of corn sugar necessitates the previou preparation of starch, and for this purpose the whole corn is separated into starch and germ the latter yielding the familiar corn oil. The starch, is a complex carbohydrate, is then converted to dextrose in solution by cooking with dilute acid". After filtration the liquors are concentrated to the point of crystallization.

Commercially, levulose has never been produced, and for this purpose, several projects have been proposed. It is one of the few sugars that are sweeter than sucrose. Levulose its found in the Jerusalem artichoke, chicory and other plants. But it seems to be the promising source of ordinary sugar or molasses.

Lactose, or milk sugar is consumed chiefly as an infant food, and it is a recent evidence that sucrose may serve equall well. From milk it is made and it is collected from cheese and cane. As an activated carbon refining of ordinary sugar, the production is essentially the same.[1]

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1. Sugar - Its Production, Technology and Uses, Andrew Van Hook (A Volume of the Humanizing Seience Series), Chapter- I.