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NATIONAL CANE SUGAR INDUSTRY RESEARCH CENTRE

DP/CPR/82/005

THE PEOPLE'S REPUBLIC OF CHINA

(R) China.

Technical report: Application of high performance liquid chromatography and sampling programmes in cane sugar industry * .

Prepared for the Government of the People's Republic of China by the United Nations Industrial Development Organization, acting as Executing Agency for the United Nations Development Programme

Based on the work of Margaret A. Clarke

Expert in cane sugar technology

United Nations Industrial Development Organization
Vienna

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GOALS OF VISIT

There were two major goals of this visit to the National Cane Sugar Industry Research Center in Guangzhou. The first was to work with scientists at the Sugar Institute on High Performance Liquid Chromatography (HPLC) technology; to initiate research projects using this technology, and to initiate and develop sampling programs for the Institute to use at sugar factories. This area of the program included lectures on HPLC analysis in sugar processing, and other current research areas of interest.

The second goal was to present a seminar on clarification technology to Institute personnel and to engineers from the Guangdong Sugar and Paper Company, and to discuss and evaluate current and prospective clarification processes for sugar factories in China. With the growing demand for refined quality white sugar in China, processes for its production were of particular interest.

Nature of report

In this report, general descriptions of the sugar industry in China and the Sugar Research Institute will not be included. These were outlined in the author's first report to UNIDO, on her visit in November-December, 1983 (UNIDO Project CPR/82/005). Major changes observed in the sugar industry since the 1983 visit (a period of 13 months) included the relaxation of the quotas for standards of sugar produced at the factories, and concomitant emphasis on the production of high grade white (refined type) sugars, suitable for food processing and beverage manufacturing.

At the Sugar Research Institute, a pilot plant for factories has been built.

Schedule of Activities

Guangzhou, January 30 - February 22, 1985

January 30, Wednesday. Arrived Guangzhou from Beijing.
January 31. Sugar Institute. Welcome, outline of plans and first discussions. Inspection of HPLC instruments and facilities. Dinner to welcome visitors.
February 1. Sugar Institute. Lectures: High Performance Liquid Chromatograpy (HPLC) of Carbohydrates. Sampling methods and systems. Analytical systems for sugars and special products.
February 2. Sugar Institute. Preliminary experiments, standard tests on HPLC Instrument and Sugar Analyzer. Observation of instrumental problems--new injector and column installed. Electrical problems appeared--whether caused by instrument or electrical system is not clear.
February 3. Sugar Institute. Visit to Foshan.
February 4. Monday. Visit to Guangzhou Factory, also to factories for brown slice sugar and rock crystal sugar. Visit to molasses distillery. Visit to bagasse board plant.
February 5. Sugar Institute. Lectures, liquid (HPLC) chromotography of carbohydrates; cane deterioration; growth regulators and cane ripeners; use of LC to follow these experiments.
February 6. Sugar Institute. Lectures. HPLC of organic acids. Importance of organic acids to sugar manufacture. Systems of analysis. Polysaccharides of sugarcane, natural and induced. Colorant and color in sugarcane and sugar products.

N.B. During lectures on Feb. 5 and 6, engineers continued to operate the HPLC systems (Sugar Analyzer and research model) to determine source of problems in analysis. Problem was determined to be of electronic origin in the Sugar Analyzer (irregular signal, in no regular pattern, like an open circuit) so M.A. Clarke telexed Waters Associcates (manufactures) Service office in Beijing to request that a service engineer be sent to repair the electrical system problems. Engineer was sent on evening of Feb. 9—earliest flight--and remained on Feb. 10 and 11 to repair problems.
February 7. Sugar Analyzer HPLC not operating well, but other HPLC instrument (research model; Sugar Analyzer is for process control) was used for analysis of factory samples. Sampling and analysis schemes discussed. Sample preparation demonstration.

Visit to bagasse board pilot plant; sugarcane factory pilot plant, in process of construction, and discussion on some research projects with Mme. Bao Guoyu, Director.
February 8. Sugar Institute. Analysis of factory samples on HPLC. Discussions of analytical methods for atomic absorption analysis of metal and inorganics in sugars. Discussion of procedure used at S.P.R.I. Trials of this procedure at Institute; safety procedures required were incorporated.
February 9. Sugar Institute. Sample analysis on HPLC research instrument. Demonstration on desk-top computer of regression analysis. Discussion of calculation and presentation of analytical results: how to compare different materials on

equivalent basis.

Translation of paper on new syrup clarification process from Spanish to English, for use by Institute and Guangdong Sugar and Paper Company.

February 10. Sugar Institute. HPLC repair engineer arrived from Waters' Associates, Beijing office. Visit to Mei San Sugar Factory, model factory for industry (5000 t) for new equipment and processes. Trial with pocket-size pH meter on liming of juice.

February 11. Sugar Institute. Work with repair engineer on Sugar Analyzer. Analysis continued on research instrument. Lunch and discussions with Sheldon Kent, Hodag Corporation (sugar process additive manufacturer), also visiting Institute. Problem parts on HPLC identified late p.m. Engineer worked until late (midnight) to replace and test.

February 12. Sugar Institute. Lectures. Color and colorant tests. HPLC of Amino Acids. Importance of amino acids in sugar process and color development. Sucrose and Food Technology—why properties of sugar important in food processing.

[illegible] instrument in operation on factory samples.

February 13. Science Hall. Symposium on Clarification Technology, to engineers from factories in Guangdong province. Phosphatation clarification, equipment and techniques. Refinery technology. The new phosphatation-color precipitation processes, equipment and techniques. Press filtration and effect on non-sugars. Decolorization: ion-exchange resins; activated carbon systems; systems for processes in use and proposed; advantages and disadvantages. Classical refinery systems and new production systems. Dextrans—prevention and control in sugar production. Dinner with Mr. Ho, Mei San Factory, and engineers.

February 14. Science Hall. Symposium on Clarification Technology continued. Direct production of white sugar from cane juice—new processes, including syrup clarification, Talodura and JSP, Blanco Directo and Deep Bed Filtration. Raw sugar clean-up processes (small scale refining processes), current and possible for future. Question and answer sessions.

February 15. Visit to Import and Export Commodity Inspection Bureau of Guangdong (C.C.I.B.), who inspect all imports/exports, including raw sugar imports, their center in Guangzhou, and lab. at Whampoa (port) where sugar is analyzed.

February 16. Sugar Institute. Continued analysis on Sugar Analyzer and amino acid analysis. Molasses analysis. Attempt to demonstrate programs for word processing on desk-top computer. Discussions with Mr. Chen Shi Zhi.

February 17. Sugar Institute. Continuation of analyses. Plans for amino acid analysis program with future samples from SPRI, for comparison with local juice which appears to have very unusual amino acid composition. Discussions with Agricultural Department. Agronomy, Plant Protection, Cane Breeding.

February 18. Sugar Institute -- Winding up.

February 19. Day available for preparation of report, questions and answers.

February 20. Chinese New Year. Visit to Botanical Institute of Guangzhou.

February 21. Discussions with Mr. Liang Chi, Director of Guangdong Sugar and Paper Company.

February 22. Departure for Hong Kong.

Symposium on Clarification Technology, Guangzhou, February 13, 14, 1985.
Outline

1. Refinery Technology
   a. Clarification -- Carbonatation; phosphatation; phosphatation-precipitation.
   b. Press Filtration
   c. Decolorization -- Ion-exchange resins and carbon decolorizers.
   d. Classical refinery systems and new production systems.
2. Dextrans -- Prevention and Control in Sugar Production.
3. Direct Production of White Sugar from Cane Juice
   New Processes
   a. Syrup clarification -- Talodura and JSP
   b. Blanco Directo
   c. Deep Bed Filtration
4. Raw Sugar Clean-Up Processes
   Systems for small scale white sugar production, under 10 tons/hour.

OBSERVATIONS

CANE SUGAR INDUSTRY RESEARCH INSTITUTE

Lectures were held at the Institute for four days (February 1, 5, 6 and 12). Topics are listed in the outline of activities (p. 3).

A Symposium on Clarification Technology was held at the Science Hall on February 13 and 14. An outline is shown on p. 5. Topics are also detailed in the outline of activities.
The author (only speaker) held question and answer periods; written questions were submitted to Mr. Chen Shi Zhi, the organizer, and a general discussion was held at the end of the symposium.

Both lectures and the symposium were transcribed and will be translated into Chinese and circulated.

Research Projects

HPLC (High performance liquid chromatography) projects.

The Institute is well equipped with a standard research model HPLC analysis system, complete with Radial Compression system, and amino acid analytical system using post-column derivatization. There is a second system a SugarAnalyzer. All equipment is by Waters Associates.

The SugarAnalyzer projects were hindered by some instrument problems that required replacement of an electronic component by a service engineer, who had to come in from Beijing. It was possible to use the research model instrument for some of the analyses in the interim period.

The two instruments are in different divisions of the Institute, although in adjoining rooms: the research model belongs to the Analytical Department and the SugarAnalyzer to the Processing Department. It would seem advisable to coordinate work on both instruments as much as possible.

The goals of analysis of sugars in juices and factory samples were as follows:

1. To establish ranges for sucrose, glucose and fructose in normal samples of good cane coming into Guangdong factories.

2. To identify old, stale cane with glucose and fructose levels above the normal.

3. To observe sucrose loss across clarification, carbonatation and sulfitation, with possible invert formation and subsequent loss.

4. To observe sucrose loss across evaporators, with regard to process effciency.

5. To observe sucrose loss and invert formation in crystallizers, with regard to process efficiency.

It is understood that while HPLC analysis of sugars can give an estimate of polysaccharides, it cannot give an accurate analysis of dextran. The Institute has approached the dextran analysis problem in a most thorough fashion, and, in the summer of 1984, held classes for some eighty sugar technologists in performance of the dextran analysis by the Roberts Copper Method (developed at S.P.R.I.).

Institute scientists had worked on methods for cane juice and syrup analysis since the author's 1983 visit and were familiar with sample preparation techniques. A sampling system was worked out with Mr. Chen Shi Zhi for samples from the Hua Qiao factory. This program is attached as Appendix 1.

The ideal system is to take the instrument to the factory but because of electrical and transportation problems this was not realistic. Samples, therefore, were brought to the Institute from the factory. It is important that these samples, especially juice and low Brix samples, be kept on ice as much as possible to prevent deterioration. Formalin should not be added to juice samples designed for LC analysis because formalin is bad for the resin-type LC column, and alters concentration of samples.

Because of instrument problems, not all planned sampling was possible (work had to wait until the Sugar Analyzer was operating properly). There were lectures etc. scheduled for these days, so no time was lost, but the author had hoped that Institute personnel would continue to carry on analyses while she was lecturing. However, when the Sugar Analyzer was repaired, samples were taken according to plan, and good results were obtained, as shown in Appendix 2. Results show that cane was quite fresh and in good condition. Analytical conditons are also indicated on this table, which is a reproduction of the printout from the Centre computer.

In sample preparation, juice samples were diluted 10:1, v:v, and syrups and molasses from 10:1 to 20:1, w:v, so that the dilute solution was under 5 Brix (the author now recommends under 2 Brix, or 50:1 dilution).

A study on standards showed a good coefficient of variation, well below 1% for sucrose analysis.

Shortly after the author's visit, samples from Mei San Factory were brought in for analysis. Typical results are shown in Appendix 2A. In addition to information on juice, the results show some invert loss over the first evaporator stage, and further invert loss (with concomitant inversion of sucrose and therefore sucrose loss) from juice to syrup. This is a general problem with sulfitated juice, where too low a pH going into the evaporators, along with a high inorganic load, causes these losses.

Analysis of molasses was begun. It will be necessary to build up a bank of data of compare LC values for sucrose and invert with traditional analyses for purity, some of which are still run on single pol values at factories.

The author has been informed that HPLC analysis on samples from factories is continuing and growing, and has become a National Project, this year, in the National Cane Sugar Research Center.

Amino acid analysis

The Waters post-column derivatization system for amino acid analysis had been set up at the Institute, and scientists were familiar with the analytical procedures.

Sample preparation techniques similar to those for sugars analysis were used, and samples of juices and molasses were run.

Juices showed the expected high levels of aspartic and glutamic acids, which are concentrated in final molasses. These are the amino acids most generally found at high levels in sugarcane juice.

However, these juice samples showed extremely high levels of threonine and probably of serine, and unusually high levels of tyrosine, tryptophan and lysine. The difference is probably caused by the high levels of organic fertilizer used in China. The threonine, particularly, is concentrated in final molasses; this could be an economically important observation. In this protein-short world, amino acids of least abundance are lysine and methionine, and next in that order is threonine. The amino acid analyses of some typical samples are shown in Appendix 2B.

Juice samples (freeze dried) are to be sent from the author's lab. for comparison of amino acids profiles from canes grown on other soils.

Pilot plants

A pilot plant for particle board for bagasse is in operation at the Institute. This plant, described in the author's 1984 report, was the basis for the newest board factory, described herein under "Byproducts." This area shows excellent use of pilot plant work for development of industrial process, and scaling up to economic size. Experiments on simultaneous drying and size separation of bagasse are underway.

A pilot plant size cane factory has been constructed at the Institute, complete with a two cubic foot pan, crystallizers and a syrup clarifier. This plant was not yet in use during the author's visit, but should prove extremely useful in factory projects.

Agricultural Research Department, Cane Sugar Research Institute

This Department is the major center of agricultural research for the sugarcane industry in China. Discussions were held on Agronomy with Mr. Qu Zhengquian; Plant Protection with Mr. Chai Lianming and on Cane Breeding with Mr. Su Derzhi. Agricultural Research is housed in the same building as the Sugar Research Institute. There are some experimental plots on size, but the major cane breeding area is on Hainan Island.

Cane Breeding

About 25 varieties are currently planted in China. Breeding work is conducted at the Hainan Island crossing station. The variety NCo310 is planted in the northern areas only; Black Cheron is planted in Szechuan. Some use is made of wild canes and F-1 hybrids. New varieties developing in Guangdong now occupy 80,000 hectares. A widely planted variety is GD 63-237 (GD stands for Guangdong) to which 25,000 hectares are planted, out of a total of 230,000 hectares to cane in Guangdong province (This figure seems low, based on sugar sugar produced). The CP varieties are major contributors to parentage of the GD varieties, especially CP57-614 and CP 72-357.

A second new major variety is GD 57-423 (also apparently known as GD7. About 10% of varieties planted are early maturing, and the majority are middle-to-late maturing.

The main breeding factors are high yield (tonnage) and early maturity. Other factors include wind resistance, drought and disease assistance. Disease resistance is a recently introduced and increasingly important area. Fiber content is, ideally, kept below 10-11%. Best varieties found for early ripening and high yield are CP57-614, CP63-588 and CP72-1210.

To release a new variety, representatives from the Ministry of Agriculture (Agricultural Production Department) and the Ministry of Light Industry (Cane Sugar Institute) make a joint decision. Approval is given to the Provincial Department for planting, in trial plots which exist throughout Guangdong. Farmers can then buy seed cane from the experiment stations of the Institute and the province, and from experiment stations at some factories.

Variety tolerance for the high nitrogen soils is another factor to be considered in the breeding program.

Only two batches of seed cane have been received from the United States, both from Dr. James Irvine, former Director of the U.S. Sugarcane Field Station at Houma, Louisiana. The author recommended that the Institute scientists contact Dr. Ben Legendre of this Station, for further information on cane breeding.

Cane Disease

Cane disease resistance is a fairly recent problem in this area, and has caused the introduction of quarantine for all cane going in and out of China. Major diseases, for which resistance factors are considered in the breeding program, are Smut, Eye Spot and Brown Spot, Yellow Spot and White Streak (these may not be the standard names). Mosaic disease used to be a serious problem only in the northern areas but for the last two years has also been seen in Guangdong. Pineapple disease is present, but under control. There is a program to develop smut-resistance varieties, as no effective chemical control is available. The scientists felt that diseases caused greater problems than pests. A list of pests found in China is attached as Appendix 4. Borer is the principle pest; and both biological and chemical control are used. Control with Diatrea (from Cuba) was begun in 1963, then stopped, and begun again in 1980, with species from Trinidad. Trichogramma are used locally for control.

The main chemical for pest control is Furantan.

In addition to the list of pests (Appendix 4) the author received a gift of a beautiful set of colored engravings showing various pests and stricken cane plants. These prints are distributed to the farmers to aid them in recognition of various pest forms.

Agronomy

The main task is to increase the sucrose yield from available land. One approach, developed at the Institute, is to plant baby cane plants in peat pots which are then handplanted in the field and covered with plastic for protection. This system, now used on about 60,000 hectares, is spreading as a replacement for seed cane, to get a cane with higher sucrose content early in the season.

Multiple ratooning is not the customary practice in China, hence the emphasis on importance of planting practices. A one-year ratoon crop is taken on dry land, but not on wet lands. Planting takes place between December and March.

A major problem is the desired reduction in high nitrogen fertilizer application, now at a general level of 330 kg/hectare. A reduction would reduce the cost of planting and improve cane quality.

Phosphate was not of concern for many years, because it used to be in adequate supply, but is now observed to be decreasing in the soil and application is becoming required.

The author inquired about potassium levels in soils and was told that they were low and had not yet appeared to be of significance.

Coordination

There appears to be little coordination between the Agricultural Research and Factory research departments. Useful projects to increase efficiency of sugar production could be developed using the Institute's analytical facilities to study new varieties, disease resistance and the cane amino acid profile, to name a few.

SUGAR FACTORIES

The two factories visited, Mei San and Hua Qiao, both make direct white sugars. As the processes are quite different, the factories will be described separately.

Mei San Factory

Mei San Factory is a new factory below Guangzhou, part of a new complex of sugar factory, alcohol distillery and yeast plant (to open in 1986). A power plant, steel factory and hydroponic vegatable production system are planned additions to the complex. Longer range plans include a plant for aluminum blocks and other building materials, and for RNA and ATP production in conjunction with the yeast plant. Production of sugarcane juice drinks and candies may also be included. Mei San is a model factory for efficiency and high production for future factories in China.

The factory crushed 4200 t.c.d. in the '84-'85 season, mostly from boat deliveries, with planned expansion to 6000 t.c.d. for the following year. The mill was designed in Guangdong, with four sets of self-setting three-roller mills using constant ratio, after two sets of knives. The juice recycling also lowers the maceration water requirement to 14-18%. An unusual system of juice recycling over the second and third mills gives a high degree of extraction of 96% to 97%. A lotus-type roll was under test, but seemed to have very few holes. Juice sucrose (double pol) was about 13% to 14%. This factory weighs the juice, after preliming, then sulfites, using the vacuum injector system (0.07% S on cane), and limes to pH 7.2-7.4. Sulfited juice is heated to about 100^{o} C and introduced into a 450 m^3 Rapidorr type (4 x 4) settling clarifier, where TaloDura is added as a flocculant to a level of 2 to 6 ppm. The clarifier is currently over capacity, in preparation for increased factory throughput. Filtrates from rotary mud filters are sent forward and mixed with clarified juice. Clarified juice pH going to evaporators is 6.9 - 7.0.

The emphasis on efficiency at Mei San is clear at the evaporator station. There are five effects, designed for a future capacity of 10,000 t.c.d., so at present the first evaporator is on water only, for boiler feed. Vapor bleeding from the second effect is used for juice heating and boiling A-massecuite. These procedures, and some care at the pan station, have reduced steam consumption to 46% on cane, from an average of 60%, and reduced fuel consumption to an average of 5.5% coal equivalent on cane, well below the national average of 7%. Mei San factory is unusual in China in that it burns bagasse almost exclusively, using little coal, whereas most factories burn 40-60% coal, reserving their bagasse for other uses. There is apparently some cogeneration of electricity here. Manual cleaning of evaporators was observed, as is the usual practice in China.

There are eight vacuum pans of 40 m^3, of low head calandria design, using a three boiling system to produce the top two grades of white sugar only, with over 90% the first grade (see 1983 report for standards). Powdered sugar in alcohol is used to grain; B's are used as a footing for A's, and C's are remelted. A neat blackboard representing the system of strikes, times and steam lines, was observed. Final molasses purities (gravity purities) were reported as 29 to 30, with a target of 27.

Another innovation is that magma is moved by air pressure, to avoid crystal breakage and steam in the pumps, with pressure generated by a hydraulic system.

The factory is eager for further innovation, particularly for automatic controls such as pH controls. The pH is currently measured by bromthymol blue. A check was made, using the author's portable pH-pen, and showed the pH into the clarifier to be a little low by bromthymol blue (indicating overliming) and pH on clarified juice to be about the same by both measurements. The color test is labor intensive, but this is not a problem, whereas inaccuracy and time delay are problems.

Sugar is classified and dried through a series of screens, which appeared more efficient than the usual, although they were not covered from the air, and then is packed in 50 kilo bags. Centrifuges have the usual lack of automation observed in China, with a hose used for washing, but the author was told that trials are in progress at this factory to decrease losses at the centrifuge station. The wash is not always separated from the molasses, in current practice at Chinese factories, and experiments to show the benefits of this separation, and to control the wash times are in progress. The author thought this very good news, as losses at the centrifugal stations are very high, and should be some of the easiest to remedy.

No cane sampling was observed at Mei San, although some sampling is planned. Factory hygiene appeared to be much better than the normal.

Hua Quio Factory

Hua Qiao factory (also referred to as Guangzhou factory) is a smaller, older mill, running 2500 t.c.d., with 5 sets of three-roller mills after two sets of knives. About 80% of cane is delivered by boat.

The general condition of the cane at this time (February, 1985) was much better than at the time of the author's previous visit (December, 1983), sucrose in cane was higher, and sucrose yields were improved.

Better weather conditions in 84-85, without the storms that appeared in late '83, were a major factor, but improved systems of delivery appear to be making their mark. The author was informed that in certain districts, instead of individual deliveries by each farmer (which cause slow deliveries of very old cane), trusted men were now designated to deliver cane to the factories and to organize harvesting to a schedule set by the factories. These men were rewarded on the basis of a percentage of cane delivered. This system certainly appears to offer greater efficiency in this area where there are so many individual farmers and such small plots of cane.

Hygiene in factories also appeared much improved. Better weather conditions helped. The bonus incentive program (described later) also appeared to help the hygiene problem. Increased use of cleaning procedures was observed, and of steam cleaning over the mill, particularly at Mei San factory.

Hua Qiao factory does not practice any cane sampling, but pays for cane deliveries on weight only. Cane was running 12.6 to 12.8% sucrose (single pol) and about 11% fiber. Trash, as usual in China with hand cut and cleaned cane, was very low—well under 1%. There was no cane washing: the knives and mills gave a very finely prepared cane, and achieved extraction of up to 97%, with 16 to 18% maceration water on cane (cool condenser water was used).

Juice sampling was on mixed juice only, with a drip sample taken every two hours. Bagasse was sampled via a series of holes in the belt, which dropped the sample into a funnel and then to a bucket: sample was collected every two hours. Bagasse showed, on average, 1.6 - 1.8% sucrose (bag extraction) and 54-55% moisture by drying. Both samples were preserved with formalin.

This factory has an unusual clarification system, combining two stage carbonatation with settling clarification. Preliming takes juice to pH 6.2 - 6.4; it is then weighed, heated to 60° C, limed with about 1.7% on cane (total lime use is 2.5 to 4% on cane) and sent to first carbonatation. The CO_2 gas comes from the generation of lime from carbonate rather than from boiler flue gas. There are two saturation tanks on first carbonatation. After a residence time of 40 to 60 minutes, juice, at pH 10.5, 55° C is sent to a single tray clarifier, where Talodura (more generally used as a syrup flotation agent) is added, at a level of 2 to 3 ppm. There is a residence time of some 20 minutes here. Mud is taken off from the bottom and sent to rotary vacuum filters and juice out, at pH of 8.5, goes to second carbonatation (single stage) and from thence to sulfitation.

The sulfitation system here burns sulfur and the SO_2 gas is introduced by the vacuum system developed by Mr. Chen Shi Zhi (of the National Cane Sugar Research Center) which won a National Award in China in 1964 and has been installed in all sugar factories since that time. Sulfited juice, at pH 7, is filtered and sent to evaporators. Syrup is ideally brought up to 60 Bx before being sent to pans, but often does not reach this concentration. The report of J.G. Ziegler, whose visit on the UNIDO project coincided with the author's, discusses this problem and other problems in pan boiling practice, in detail. Pan boiling practice will therefore not be discussed in this report. Massecuite from pans went to centrifuges where is was overwashed by manual hosing (see 1984 report of this author). The sugar was not steamed in the centrifugal, and there wee no plows, so that very lumpy product emerged. A series of screens provided the sole drying system, while dividing the sugar into three fractions. Many lumps from the centrifugal were recycled, or sent to lower grade sugar—this loss could be avoided by better centrifugal work, or by a series of fingers across the screens to break up the lumps.

Production efficiency among personnel is being strongly encouraged. A large blackboard compares performance of workers from each shift on the various factory stations, and lists points for production efficiency. Total points for each shift affect the bonus payment. This has already been found to be an effective way to increase production efficiency in Guangdong, although only started this year. It is also a means to acquaint workers with English terms.

Other Products

The Hua Qiao factory complex also contains a distillery, and several small plants for products unique to China: slice or slab sugar, (Ping bian tong) ice sugar, or rock crystals (ping tung); and beehive coal. This last is a compressed coal dust product that can contain some filter mud, providing another use for mud as well as that of soil additive. The cone shaped product has many holes in it, giving rise to its name. There was formerly also a fermentation plant to produce butanol-acetone from molasses (by Clostridium spp. process) but this has been closed down because of high costs.

The alcohol distillery runs on molasses from the factory, and runs intermittently because the supply is not constant. The distillery is scheduled to produce 15 tons of 95% alcohol, 2nd grade, during crushing season. A list of the grades of alcohol in China may be found in Appendix 3.

Lumps of sugar and lower grade sugar from the factory are collected and made up to an 80 Brix syrup for the production of rock crystal sugar (ping tung), a popular product in China which the author has seen packaged in food stores (in P.R.C. and U.S.A.). The heavy syrup is allowed to sit in buckets for 10 to 14 days, after which time the buckets are dumped out and crystals separated from mother liquor. The lumps of light colored crystals are the ping tung. The author did not see the washing and packaging process, which last may be done on another site.

The mother liquor is collected, and further evaporated. It is heated up to 128° C (at which temperature the heat of crystallization will drive off remaining water) and poured onto straw mats. The mass cools to hardness in about 20 minutes, and is cut into approximately 5 x 15 cm. pieces. As it cools, sugar color migrates to the outside of the crystallizing mass giving the effect of an inner layer of whiter sugar between two layers of brown, as shown in Figures 1 and 2. This is a widely sold and very tasty product, ping bian tung. It appeared to the author that more of this product was prepared than could be supplied by the rock crystal run-off syrup, so other input material may be used, or perhaps slice sugar is not made every day but only when sufficient run-off is collected.

There is now a system for continuous automated production of slice sugar, developed in part by Engineer Zheng Changgeng of the Guangzhou Cane Sugar Industry Research Institute. This process, in operation at a factory in the Southern part of Guangdong, is pictured in Figure 3. The belts are some 25 meters long and move at 1.5 m/minute.

The non-centrifugal sugar products known variously as panela, gur, khandsari, and piloncillo, among other names, for which cane juice is boiled into a thick syrup which is allowed to crystallize spontaneously in molds does not appear to be made in China. The slice sugar, made here from byproducts of the sugar factory, appears to have taken that place in the diet. The Chinese diet, of course, contains a much lower percentage of sugar (an average of 4 kg per person per year) than does that of most sugar producing countries.

The author was informed that the rock crystal and slice sugar operations are run by the families of men who work in the Hua Qiao factory.

Current developments in white sugar production

There is change, as well as expansion, in the sugar producing industry. The need for refined quality sugar (as by U.S. or European standards) is increasing, as the market for soft drinks and processed foods (some for export) increases. There has been a desire to export white sugar to Hong Kong, but quality has not been sufficiently high. The top grade of sugar, superior grade, still has off-color problems, and a finer grade is required by industrial users. Superior grade has color of < 1 Stammer (about 80 ICU) and pol > 99.75.

With the relaxation of quotas for standard white sugar production, and the release of fixed prices for foods (other than rice), there is incentive for factories to direct more of their production to refined quality sugar to be sold at a higher price (40 Yuan per ton is the premium for superior grade in Guangdong). There exists the potential problem that too many factories will take this direction, overloading the superior grade sugar, and eventually the refined quality sugar, markets at the expense of an increase in overall sugar production. The author is not aware of any "Sugar Board" per se, such as exists in many sugar-producing countries to oversee the production system. The Ministry of Light Industry has always fulfilled these functions, and will doubtless continue to direct the industry, taking into consideration these new goals and their inherent difficulties of balance between quantity and quality of production.

Several factories have already put in equipment to improve product quality, i.e. establish "white-end refineries." There is, as yet to the author's knowledge, no autonomous refinery in China (which treats raw sugar only, not cane) although one such is said to be under construction in Fukien province. Several large factories process imported raw sugar (from Australia, Thailand, Philippines, Cuba) after cane-grinding season, as do some beet sugar factories.

Ion exchange treatment

The large Chun De sugar factory uses ion exchange decolorization (with IRA-900 resin, polystyrene macroreticular) to treat white sugar liquor, presumably from offshore raw sugars since sulfitation-produced sugars are very bad for resins and cut back resin life. There have been some difficulties with these resins; perhaps sulfited liquors have been used on them, causing irreversible fouling.

This factory is the only one currently to produce specialty sugars, including cubes (from a linear process, perhaps Elba), fruit sugar, Q sugar and icing sugar.

In Yunnan province, there have been pilot plant experiments on cleanup of juice with ion exchange resins, but these have not been very successful. Again, the author does not know if sulfited juices were used, as these could damage the resin badly.

There is still interest in the project outlined in the author's 1984 report for ion exchange treatment of B molasses, to increase quality and quantity of first strike sugars at some factories.

There was great interest expressed in the use of XAD resins (from Rohm and Haas), which have a very high capacity for removal of organics and color, in powdered form on a throw away basis. The author telexed to Rohm and Haas (Philadelphia) during her visit to obtain prices on XAD-2 and XAD-4, which proved rather high for use as a throwaway one-time-only decolorizing agent.

Plans to improve quality

In the short term, the production of superior grade white sugar will undoubtedly increase. Production of refined grade sugar will begin by remelting second grade (B, pol >99.2) sugar and treatment with powdered carbon in press filtration. This seems a good procedure to fill immediate and short term needs for improved quality. Improvements in cane quality and use of a larger grain size together with improved centrifugal operation will give sugar of better storage quality.

The expense of remelting white sugar, however, will require installation of clean-up processes to produce a higher grade white sugar directly. Processes such as the Blanco Directo system (Talodura syrup clarification combined with Talofiltrate), as discussed in the 1984 report, are discussed in detail at the Symposium on Clarification Technology. This system is highly recommended for future white sugar production in China.

Guangdong is anticipating a considerable increase in sugarcane planting for the 1985-86 harvest season, possible double production for 1983-84, and so plans are in operation for increased production of white sugar that year, by means of press filters (already available) and powdered carbon.

Longer term plans involve the development of a granular carbon manufacturing plant, and the use of ion exchange resins with improved regeneration capacity.

On the smaller scale, there will continue to be many very small factories and for these there is still considerable interest in use of the Tilby separator process, with bagasse fiber thus prepared going to a central plant for medium density fiber board production. Fiber from the center of the stalk, containing high sugar levels, would be treated by the Honiron cane disintegration technique.

BYPRODUCTS

1. Board manufacture from bagasse

China has a relatively short supply of wood, and so all types of fiberboard are important for construction and furniture. Sugar factories generally use up to 2/3 coal as fuel in order to save bagasse for board and paper manufacture.

Processes for manufacture of particle board using bagasse fiber have been developed for Guangdong province at the Guangzhou Institute. There are now seven plants in China producing board, which is a good interior grade, used for manufacturing of room dividers, furniture (tables, desks, chests of drawers, cupboards) and for sound boxes for amplifiers, and speakers, for which it is especially suited.

The largest factory produces 7 million cubic meters per year. Four factories are in Guangdong, one in Szechuan, one in Yunnan and two in Southwest China, producing a total of 35 to 50 million cu. m. board per year.

A new plant near Guangzhou was visited. This plant demonstrates the new economic programs in China: it is owned by cane farmers, who, through the bank, supplied some of the $2.4 M. Yuan capital required for plant construction. It is the only board plant run as a cooperative.

The plant has a capacity of 5 million cubic meters per year, but in '84-'85 will produce only 3 million, because bagasse supplies are the limiting factor. Bagasse from local sugar factories had already been assigned to other uses before this plant opened. For the next year, full production and an adequate supply of bagasse are planned.

Bagasse, most of it obtained from the Hua Qiao sugar factory, is stored in bales near the plant, with some loose pile storage. Some 40 tons per day is used to produce 20t board. Bagasse moisture, as received from the factory, is 45% to 52% which must be reduced to < 30% (partly in storage) for board production.

Bales are broken up and dumped into an air separator, to isolate the usable mid-range fraction. Rotoclones collect the small particles and dust. Very long and very short fibres are sent to the 4-ton boiler that supplies power to the plant. After passing through a hot-air dryer, the dried bagasses is then separated into two fractions (fined coarse) in the S-model separator developed by Mr. Chen, head of Bagasse Fibre Research at the Guangzhou Institute. The fractions go to two separate mixers where they are combined with urea-formaldehyde resin. The resin, prepared in autoclaves, where urea is added in four stages over a 3-hour period, is added to the level of 8%.

Board is then made in a continuous process, using machinery either designed or modified at the Guangzhou Institute. The resin-bagasse mixture is sprayed on to a rubber belt. The fine mixture is sprayed first, then the coarse fraction gradually increased, and then the fine again, to form a layered board with good appearance. The material, spead smooth by a spiked upper rotating belt, passes through primary rollers, of heavy stone, and the rough board is deposited onto iron plates, cut in 1.2 by 2.6 m. sheets, and moved into a hydraulic press, 15 sheets at a time, and held there for one hour under high pressure. Board is removed from press, treated with an optional wax finish, and stored in stacks.

There are three shifts in the plant, with competition between the shifts for both quantity and quality of board produced. Competition points are awarded with monetary rewards included in the shift workers' bonus.

There is a great need in China for bagasse or other particle board of exterior quality. The interior-quality board now manufactured has reached world standards on product quality and "swelling" criteria. There is a need for more quality control and test procedures. The Institute is anxious to find an expert in these areas, and to have more information on recent developments in the manufacture of exterior-quality board of exterior quality. The interior-quality board now manufactured has reached world standards on product quality and "swelling" criteria. There is a need for more quality control and test procedures. The Institute is anxious to find an expert in these areas, and to have more information on recent developments in the manufacture of exterior-quality board (see Recommendations).

2. Slice sugar (ping bian tung) and rock crystal sugar (ping tong).
   See section on Hua Qiao factory.

3. Beehive Coal.
   See section on Hua Qiao factory.

4. Alcohol manufacture--industrial and beverage.
   See under FACTORIES section. The author was informed that in addition to the mao tai, brandy, and other beverage distilleries, there is now one Guangdong distillery making rum.

5. Animal feed from bagasse and cane tope.
   A project on feeding dairy cattle a bagasse-based mixture is in progress at Guang Ming (Kuomin) Farm, near the Shen Zhen Industrial zone. The dairy, cattle, currently 3000, expected to increase to 5,000 next year, are Holsteins or Freesians, obtained from Denmark. Bagasse is treated with sodium hydroxide at pH 12, to help release the hemicellulose and increase digestibility, and is then mixed with molasses and urea. The mixture, after 1 months storage, shows good fermentation with no observable bacterial decomposition, and analyzes at 65% solids, 44% crude protein and pH 4.2. The mixture is stored in brick lined tanks in the ground, covered by plastic. Feed value equivalent is reckoned at 100 yuan per ton. The cattle's diet also includes a little corn and some wheat straw.

   Another project involves ensilage of cane tops, collected by farmers. These are piled and covered with plastic so that some anaerobic fermentation occurs. They are used after about two weeks but can be kept up to 1 year.

6. Soft drink from cane juice.
   A type of cane juice drink, pasteurized and packaged in waxed paper cartons, has been on sale in China for some time. The Institute has developed a new drink, with more "adult" appeal in U.S. terms. Juice is slightly fermented, but contains less than 1% alcohol, and then treated with ultrafiltration (filtration is easier after the fermentation) and pasteurized. The clear drink has better keeping qualities than the whole juice.

<u>Other Visits</u>

<u>China Commodities Inspection Bureau (CCIB).</u>

This agency functions in China in a Food and Drug Administration capacity, with some duties and services of a Customs Bureau. All goods both imported into and exported from China are inspected by CCIB, including raw sugar.

The author had met a scientist from this Bureau in Washington, D.C., through the Association of Official Analytical Chemists, and contacted him upon her return to China. The chemist, Mr. Liu Yong Rong at CCIB in Beijing, kindly arranged a visit to the Bureau in Guangzhou.

The first stop was the CCIB Central Laboratory in Guangzhou, for a tour of the food inspection laboratories. All commodities are inspected, but the author visited only food crops, including citrus fruit, and semitropical crops (visual inspection); nuts, tea (loose and compressed), canned goods, milk products, oils, rice and grains. A wide range of equipment, including Hewlett-Packard gas chromatographs, a Perkin-Elmer HPLC and two Perkin-Elmer atomic absorption units, was available. One laboratory was devoted to Kjehldahl analyses, another to aflatoxin analysis. The aflatoxin analyst expressed dissatisfaction with the accuracy of the thin-layer chromatography method of analysis, but could not use the HPLC method because the required sample size was too large.

The CCIB has quality control centers such as this one in each province. Guangzhou Bureau is especially large because of the diversity of products and because the city is a major port. Raw sugar imports to Guangzhou enter the port of Whampoa and are tested at a CCIB laboratory there. Coal, wheat, rice and sugar are the main commodities through Whampoa. Over half-a-million tonnes of raw sugar (mostly from Queensland; some from Cuba, the Philippines and Thailand) comes in each year, from March through July. It is unloaded at Whampoa onto barges or lighters, and barged to those sugar factories which operate as refineries on the imported raw after the cane grinding season is finished. Sugar is bought by the Guangdong Sugar, Tobacco, Wine and Liquor Company which redistributes it to the factories. Sugar delivery weights are estimated by draft readings before and after unloading. The sugar is not weighed in until barges are offloaded at the factories.

Sugar is routinely tested for pol and loss on drying only (occasionally other tests may be run). Pols are run on a Perkin Elmer 241 MC automatic polarimeter, water-cooled cell, in an air-conditioned room, standardized with quartz plates from the Braunschweig Institute.

Chemists working on sugar at CCIB had not heretofore had any communication with the Cane Sugar Research Institute. A recommendation will be that such be established, as could be done through a local sugar technology organization or committee to ICUMSA.

RECOMMENDATIONS

CANE SUGAR INDUSTRY RESEARCH CENTER

1. It is recommended that this Center continue to grow in its role as a center for sugar research in China and as a national coordinating center for research of the sugar industry, beet and corn in addition to cane (see "General Recommendations"). The Institute has grown in these respects since the author's 1983 visit. Recommendations in the 1984 Report for implementation of this growth are repeated.

2. It is recommended that processing research be coordinated with agricultural research at the Institute, for the goal of improved efficiency of sugar production. Specific projects are, for example, in the area of cane breeding and sugars content of new varieties. An initial project of considerable importance is investigation of the amino acids profiles of cane juice and the relationship of levels of amino acids of economic importance to cane variety, agronomic practice (especially irrigation and fertilizer use), soil type and cane disease.

3. Specific research projects recommended for the Institute in the area of improved efficiency of sugar production are:

a) Analysis for juice quality and cane deterioration, using HPLC, and dextran analysis: A study of the major cane varieties in Guangdong and their sugar content, after a defined time period after harvest, under known conditions of temperature. Results can be helpful in planning harvest schedules, as well as in documenting sugar loss caused by poor harvest practice. In juice studies, it is important that a record be kept of the sample pH.

b) Project on juice quality and milling efficiency. The cane preparation at Chinese sugar factories appears to be extremely thorough, with very fine cane fibers produced. The aim, of course, is maximum extraction. A project is recommended to study juice quality from various degrees of cane preparation, to see if the degree of milling now popular is necessary. The pilot plant mill at the Institute could be used for this study. Level of maceration must also be considered. It may be that the intense cane preparation increases extraction of non-sugars more than of sucrose, and that the energy requirement for milling can be lowered.

c) Project on invert formation and sucrose loss over factory clarification (several systems in use) to determine the best conditions for clarification. This project should be organized in cooperation with factories using clarification systems of interest. Sample schedules must be carefully arranged.

d) Project in cooperation with factories to examine sucrose loss and invert buildup over evaporation systems. There appears to be extensive use of low-pressure steam on evaporation stations. Brix of syrup leaving the final stage often appears to be less than 60 Bx. This combination of factors indicates the possibility of improved efficiency in evaporator stations. Before HPLC analysis, it was not possible to determine the composition of input and output materials, to record the efficiency, but a project to do so is now possible and is recommended.

This could be combined with observations on juice quality clarification, and pH of material entering the first evaporator. It is essential, especially in factories using sulfitation, that this pH not be too low (under 6.4), to keep invert formation and loss in the evaporators to a minimum.

e) A study by HPLC on sugars in molasses, to establish correlations on true sucrose (HPLC) in molasses with traditional values, obtained from polarization measurements.

f) In the area of personnel and training, it is recommended that the senior scientists at the Institute in charge of HPLC instrumentation train technicians and junior scientists (or engineers) to operate the instruments and prepare samples.

It is recognized that the instruments represent a considerable financial investment. They should, therefore, be in constant operation to make best use of facilities. The time of the senior scientists must be divided among many projects; they cannot be expected to operate one instrument exclusively. Therefore, junior personnel must be trained for this purpose.

4. Specific research projects recommended for the Institute in the area of amino acid analysis are:

a) To develop profiles of amino acids in cane juices and relate composition to field factors (cane variety, age, soil type, irrigation and disease), as mentioned in Recommendation 2.

b) To identify which amino acids remain in process after clarification, to have an effect on color formation in sugar.

c) If threonine is present in the levels observed during the author's visit, a project on isolation of this amino acid from juice should be instituted.

5. A study of processes for production of improved quality white sugar should be carried on, in cooperation with engineers from the Guangdong Sugar and Paper Company. This study has already begun. Equipment at the Institute pilot plant can be used for parts of this work e.g. to examine various additives for use in syrup clarification (see recommendation in 1984 report). New processes were discussed in detail at the Clarification Symposium.

6. It is recommended that coordination with the Institute for Fermentation Research, that is also housed in the same building as the Sugar Research, be considered. The Fermentation group use gas liquid chromatography for much of their analytical work. Exchange of analytical methodology on sugars by HPLC and alcohol and organics by GLC would provide a useful initial basis for coordination.

7. The Sugar Institute should begin to publish papers on results of their research in international journals. The publication of Wen Musheng's paper on dextran analysis in Sugar y Azucar (August, 1984) is a good beginning. Establishment of the Institute as a serious center for sugar research will be fortified by such publications. This will encourage communication from research centers in other countries, and cooperation in research projects, which increases the yield of results from Institute scientists' contributions. Publication and recognition also provide important support for sending Institute scientists for training in other countries, and for hosting visiting scientists at the Institute.

8. Recommendations for experts who might be useful to the Institute, and for places where the Institute may send scientists for further study are listed under "General Recommendations."

FACTORIES

Note: Many of the recommendations from the author's 1984 Report are still in effect, particular those for long term, because only a year passed between visits.

1. Cane sampling procedures should be instituted as widely and as quickly as

possible (see 1984 Report). A team to study systems of cane quality payment should be organized in cooperation with the Institute.

2. Recommendations made in the author's 1984 Report with regard to factory hygiene, and system of sugar boiling, centrifuging and washing are repeated. Progress has certainly been made in the area of hygiene at the factories visited. The grain size still appears unnecessarily large, and centrifugal practice still encompasses overwashing. This subject is discussed in detail in the 1984 report. An expert on centrifugals is recommended (see below).

3. Projects on new processes of white sugar production, as outlined at the Clarification Technology Symposium and in the author's 1983 Report, should continue under study, to determine those most practical for the Chinese industry. It should be remembered that only a certain amount, perhaps 10%, of production needs to be of refined-quality, high grade white sugar. In the interest of maximizing sugar yield on cane, no more of this grade than necessary should be produced. Over production of refined-quality white sugar will lover overall yield of product on cane, and will also lower the premium (on price) for this grade, extending the payback time for equipment necessary for its production.

It is anticipated, as described under "Observations," that in the short term the requirement for this grade of sugar can be filled by remelting white sugar and filtering through filteraid and powdered carbon. The study referred to is for longer term implementation of new processes, such as the Blanco Directo process for improved white sugar (which can be combined with carbon press filtration before initial crystallization) and ion exchange resin decolorization (for use on unsulfitated material).

4. A project on improvement of white sugar drying and screening is recommended. Yield of first strike sugar could be increased through increased attention to the sugar screening systems. Lumps of white sugar are often soft, and could easily be broken up by a simple set of steel fingers across the screen, or manually by a factory worker, to increase the yield of first strike sugar and decrease the amount of sugar remelted.

5. Recommendations for instrumentation, e.g. pH control, automatic polimeters, and refractometers to replace hydrometers for Brix measurement, are repeated, as in the 1984 Report.

GENERAL RECOMMENDATIONS

1. The Guangzhou Institute has continued to develop its position as the major Sugar Research Institute in China, supported by its position in the major sugar-producing province. As the cane industry continues to grow, it is expected that the Institute will also, particularly in the area of by-products and new products. The author has been pleased to observe the presence of research and factory personnel from other cane-producing provinces and from sugarbeet growing areas at the Institute.

China, with developing and increasing production in sugarcane, sugarbeet and now corn, is in a unique position to coordinate these crops. It is recommended that research on cane, beet and corn be coordinated: the wide range of expertise in sugar production can be utilized in application to corn sweetener production, from corn crops grown in the temperate zones, as well as to sugarbeet crops grown in the North. There is the opportunity to replace the competition and replication of effort existing in other countries with efficient coordination and division of effort in the production of sugar and syrups.

It is recommended that the National Cane Sugar Research Institute and the Guangzhou Institute scientists play a major role in coordinated research on sugarcane, sugarbeet and corn sweetener production and products.

2. The increased emphasis on production of high quality white sugar has been discussed. It is recommended that there be distribution of production of this project and of other specialty products that bring higher profits (e.g. cubes, icing sugar) among various factories to prevent overproduction and loss of price premium while maintaining distribution of increased profits.

3. Membership for sugar industry personnel in international industry organizations is highly recommended. Some scientists have attended U.S. meetings as individuals: this practice has established a good beginning in communications. It is important that the Institute or Guangdong Sugar and Paper Company should join these organizations e.g. Sugar Industry Technologists, as a unit, to obtain voting representation. The list of appropriate organizations, from the author's 1983 Report, as appended in Appendix 5.

It is particularly recommended that:

a) the Chinese Society of Sugar Cane Technologists become a member of the International Society of Sugar Cane Technologists (next meeting: Jakarta, August 1986).

b) The Institute organize a Chinese National Committee to ICUMSA, in cooperation with other groups interested in sugar analysis, such as the C.C.I.B. who analyze sugar imports, and food processor groups who use sugar.

4. It is recommended that a representative part of the Chinese sugar industry, perhaps the Guangdong Sugar and Paper Company, become a sponsoring member of Sugar Processing Research, Inc.

5. Considerable progress in training and the setting up of short courses has been made in the course of the past year. It is recommended that communications be established with the following groups, in addition to those recommended in the author's 1983 Report.

a. CENICANA

This is the agricultural and processing Sugar Research Institute of Colombia. There are studies in many areas of mutual interest in Guangdong and the Cauca Valley area. This Institute, the research arm of the Sugar Board of Colombia, provides good coordination between agricultural and processing research. Most scientists speak good English here. Cooperative study in the area of other tropical crops has already been established between China and the CIAT .(International Centre for Tropical Crops). The Director of CENICANA is also on the Board of Directors of CIAT and so provides a logical contact. Recommendations for contact are: Dr. Armando Samper, Director General; Dr. Sammy Sung Jen Yang; Dr. Jesus Larrahondo, Chief Chemist--all at CENICANA, Aptdo. Aereo 9138, Cali, Valle, Colombia.

b. SUGAR ASSOCIATION IN INDIA.

At the request of Mr. Liang Chi, General Manager of the Guangdong Sugar and Paper Company, the author contacted the following scientists in India, to establish communication between the sugar industry in India and the Chinese industry: Dr. P.J. Manohar Rao, Managing Director, National Federation of Cooperative Sugar Factories, Ltd., "Vaikunth" (III Floor) 82-83, Nehru Place, New Delhi 110019, India, and Mr. Asim Kumar Bose, Director (Technical and Projects), Directorate of Sugar, Ministry of Food and Civil Supplies, Government of India, Krishi Bhawan, New Delhi 110001, India.

c. It is recommended that an expert in centrifugal operations be invited to consult with the Guangzhou sugar factories. Particularly recommended is: Mr. George Conrad, Western States Machine Co., P. O. Box 327, Hamilton, Ohio 45012. Mr. Conrad is an effective teacher and communicator, as well as the foremost expert on centrifugal operations of all types in the sugar industry.

d. It is recommended that the following general experts for operations, and coordination of agriculture and production, be considered for consultation in the Chinese Sugar Industry.

i. Beet sugar.

Mr. Stanley Bichsel, Vice President - Research
American Crystal Sugar
101 North Third St.
Moorhead, MN 56560

ii. Cane sugar.

Mr. William Patout III and team
M. A. Patout and Son
Jeanerette, Louisiana USA 70544

e. It is also recommended that the following scientist in China, who has worked with Australian and U.S. scientists on sugar colorants, be contacted: Dr. Yong-Long Liu, Institute of Materia Medica, Chinese Academy of Medical Sciences, Beijing.

f. It is recommended that the following expert in production of exterior quality bagasse board be contacted: Mr. K.C. Shen, K.C. Shen Technology Int'l., Ltd. 2118 Radford Court, Ottawa, Ontario, Canada KLJ 8K1.

NON TECHNICAL COMMENTS

Translation

Translation facilities in Beijing were again excellent: Mr. Chen Ruquan, of the Foreign Office of the Ministry of Light Industry is a first class interpreter.

Translation facilities at the Guangzhou Institute were very good. Professor Huang Wei Gan, who had recently returned from two years at Louisiana State University, did a fine job interpreting the author's lectures. Mr. Chen Shi Zhi was, as always, extremely helpful at times when translation was too colloquial. Ms. Li Jinding, Project Officer for the National Cane Sugar Research Center, was of the greatest assistance at all times for her colloquial English and general advice on daily life.

Cooperation

Cooperation from all parties involved was extremely good. Scientists at the Institute were well prepared for laboratory studies and for lecture work. Engineers at the Clarification Technology Symposium were well prepared, and has submitted questions of interest before the Symposium, which were of help to the author in orienting the talks to areas of special interest. Mr. Chen Shi Zhi, Director of the National Cane Sugar Research Center, deserves special commendation for this fine organization.

Mr. Chen Shi Zhi, and Mme. Bao Guo Yu, Director of the Institute, were extremely helpful. The author wishes to offer them special thanks for their care and planning for her visit. The author also wishes to thank Mr. Liang Chi, General Manager of the Guangdong Sugar and Paper Company, for his help and cooperation on factory visits and arrangements for the Symposium.

Ms. Li Jinding, Project Officer, again acted as the author's companion and was invaluable in ensuring the smooth and efficient progress of her visit.

Ministry of Light Industry Foreign Office officers were most helpful, especially Mr. Liu Shao-Hsi, at the Dong Fang Hotel office, who handled any possible difficulty successfully, and made very efficient arrangements.

APPENDIX 1

Sampling Schedule

1. Mixed Juice

   Composite sample of 8-12 a.m. sterilized by crusher juice and maceration: 1 trial.

   Amount of sample 100 ml each.

   Take records of Bx. Suc. pol, rs of factory lab.

   Samples delivered to institute on Feb. 3, 4, 5 and 6.

2. Clarified juice

   Same as mixed juice, but time for collecting 1 to 2 hours.

   Lagged behind the time for mixed juice.

3. Sulfitated syrup

   Composite sample of 8-12 a.m.

   Amount of sample 100 ml each

   Samples delivered to institute on Feb. 3, 4, 5, and 6.

4. Boiler feed water

   Take sample when sugar content in water exceeds safety limit. Feed water has to be rejected.

   Amount of sample 100 ml.

   Take records of sugar content of factory lab. Both with α-Naphthol and amm. moblybdate.

5. Low grade (c) massecuite in crystallizer

   Take sample during dropping of massecuite to crystallizer

   Take another sample of the same strike at middle interval of centrifuging.

   Feb. 3rd. Sample No. 1 to crystallizer.

   Feb. 4th. Sample No. 1 centrifuging, Sample No. 2 to crystalllizer.

   Feb. 5th. Sample No. 2 centrifuging, Sample No. 3 to crystallizer

   Feb. 6th. Sample No. 3 centrifuging.

APPENDIX 2

HPLC Analysis Record

Feb.10,1985

Column: HPX-87C
Solvent: Water with 20 ppm Ca propionate
Flow rate: .5 ml/min.
Detector: R.I.
Samples: Sampling from Hua-qiao Sugar Mill

Analysis Date		Feb.6				Feb.7			
Samples	No.	Bx. (%)	Sucrose (%)	Glucose (%)	Fructose (%)	Bx. (%)	Sucrose (%)	Glucose (%)	Fruct (%)
Mixed Juice	1	15.7	12.25	.1567	.2866	16.2	13.49	.19	.17
	2	15.7	12.60						
	3								
	Av.	15.7	12.43	.1567	.2866	16.2	13.49	.19	.17
Clarified Juice	1	13.2	10.38	.1500	.2480	13.6	9.70	.2100	.08
	2	13.2	10.36	.207	.286	13.6	10.59	.34	.04
	3	13.2		.165	.27				
	Av.	13.2	10.37	.174	.268	13.6	10.15	.28	.06
Syrup	1	57.4	48.93	.9000	.4400	57.9	48.48	.40	.54
	2	57.4	50.31			57.9	47.32	.79	.39
	3					57.9		.6	.49
	Av.	57.4	49.62	.9	.44	57.9	47.90	.6	.47
C Massecuite	1	93.0	51.67	1.49	4.05	93.0	56.84	1.49	3.8
	2	93.0	51.89	1.57	3.52	93.0	53.35	2.35	4.51
	3					93.0		3.08	4.28
	Av.	93.0	51.78	1.53	3.79	93.0	55.10	2.31	4.2

APPENDIX 23

HPLC Analysis Record

Feb.28,1985

Column: Sugar Pak I
Solvent: Milli-Q Water with 20 ppm Ca Propionate
Flow Rate: 0.5 ml/min.
Detector: R.I.
Samples: From Mei-shan Sugar Mill

Sample	Ref.Bx.	Sucrose%	Glucose%	Fructose%
Mixed Juice	15.01	11.00	0.58	0.59
Clarified Juice	14.81	12.36	0.12	0.12
Thin Juice that enter evaporator	14.51	11.99	0.11	0.12
Juice in bottom of #1 evaporator	23.09	19.96	0.40	0.26
Juice comes out from #1 evaporator	24.40	21.18	0.30	0.23
Syrup	55.34	47.33	1.02	0.47

Remarks:
1. The sucrose, glucose and fructose are determined by HPLC
2. The contents of sucrose, glucose and fructose are weight % sample.
3. The sucrose% in mixed juice is too low and the glucose% and fructose% are too high indicate that the sample had been decomposed.

APPENDIX 13

Amino Acids HPLC Analysis Record

Feb. 18, 1985

Column: Waters Amino Acid Column (IX in Na form)
Solvent: A.0.2N Na, pH 3.10, B.0.2N Na pH 9.6, 0-100%B Curve 6 for 48min.
Flow Rate: 0.4ml/min.
Detector: Fluorescene

Concentration (Millmole/Litre)

Samples	Mixed Juice	Clarified Juice	Syrup	Final Molasses
Aspartic acid	0.46	0.15	1.22	7.26
Threonine		*	12.63	*
Serine				
Glutamic acid	**	0.28	**	**
Glycine	0.30	0.36	1.30	7.59
Alanine				
Valine	0.21	0.28	***	5.66
Isoleucine	0.23	0.12	1.14	5.22
Leucine	0.11			
Tyrosine	0.29	0.26	2.45	6.04
Phenylalanine	0.16	0.22	***	4.59
Histidine	0.09	0.12	***	
Tryptophan	0.26	0.18	***	11.38
Lysine	0.13	0.25	1.26	7.61

Remarks:
- * Peaks are too high to estimate
- ** Data Module does not integrate the peaks
- *** Sample too dilute so the peaks are too small

APPENDIX 3

Grades of Molasses in China

1. Molasses Grade

Molasses Grade	Sugar Content	Purity	Cells/Gr. Mol.
1	above 58%	67%	10,000-90,000
2	50-58%	60-67%	150,000-500,000
3	under 50%	under 60%	above 500,000

2. National Standard of Alcohol Specifications

	Standard Grade (pharmaceutical)	First Grade (beverage)	Second Grade	Third Grade	Fourth Grade
appearance		transparent			
color, number		10			
odor		no odor other than ethyl alcohol			
alcohol % by volume					
sulfuric acid test, number					
oxidation test, minutes					
aldehydes (as acetaldehyde) %					
fusel oil % (as isobutyl alc. and isopentyl alc)					
methyl alcohol, %					
acids (as acetic acid), %					
esters (as acetyl acetic acid), %					
non volatile matter, %					

NOTE: % --- gm/100 ml. (except alcohol content)

APPENDIX IV

1. International Society of Sugar Cane Technologists. The Chinese Society should be a member of this, the largest and most diverse sugar organization. Each member Society has representation on the Board. I.S.S.C.T. meets every 3 years, and each congress is organized by the host country, which alternates from Eastern to Western Hemisphere, and is chosen by vote of the Board. The Congress, about 5 days long, has sections on the various agricultural areas, processing, by-products and energy. Proceedings are published.

The next Congress will be in Indonesia, April 25 to May 3, 1986. Information can be obtained from: R. Moeljono Hadipoero, Jalan Tanjung Karang 5, P. O. Box 3185, Jakarta, Indonesia.

2. Sugar Industry Technologists. This organization of sugar refiners, producers and suppliers to the industry is based in North America, but has international membership. It meets annually (next in Houston, May 6-8, 1984) for 2-3 days to hear papers on sugar technology and engineering. Its annual Proceedings is a very useful publication. Membership is available to companies (U.S. $350 per year) or to individuals as allied members (U.S. $50 per year). It is recommended that an official from the Ministry of Light Industry and the Head of Sugar Technology should belong to this group. When meeting attendance is possible, S.I.T. will be a most useful source of contacts with technologists and management, internationally.

The author has observed, in the S.I.T. Membership Roster, that there is a member in the P.R.C.; Dr. Yun-Men Huang, Executive Vice-President, Science and Technology Association, Neijiang, Sichuan.

3. International Commission for Uniform Methods of Sugar Analysis (ICUMSA). Technologists in China, especially at the Institute, are aware of **ICUMSA and follow its progress and regulations closely. As an importing**

country and, more importantly, as a country interested in exporting, China should participate in ICUMSA meetings, where test procedures and standards are set. Individuals cannot belong to ICUMSA: each country that has a National Committee on Sugar Analysis is a member, and sends delegates to the Conference, held every 4 years (next in France in 1986). Formation of a Chinese National Committee on Sugar Analysis is recommended. Such a group would be instrumental in promoting industry unity and development of procedures especially suited for use in China, in accord with international standards. Organization of a Chinese National Committee, with members from the industry and the universities, would permit membership in ICUMSA. Further information can be obtained from General Secretary Dr. Albert Emmerich, Institut fur landwirtschaftliche, Technologie und Zuckerindustrie, Postfach 5224, Langer Kamp 5, 3300 Braunschweig, West Germany.