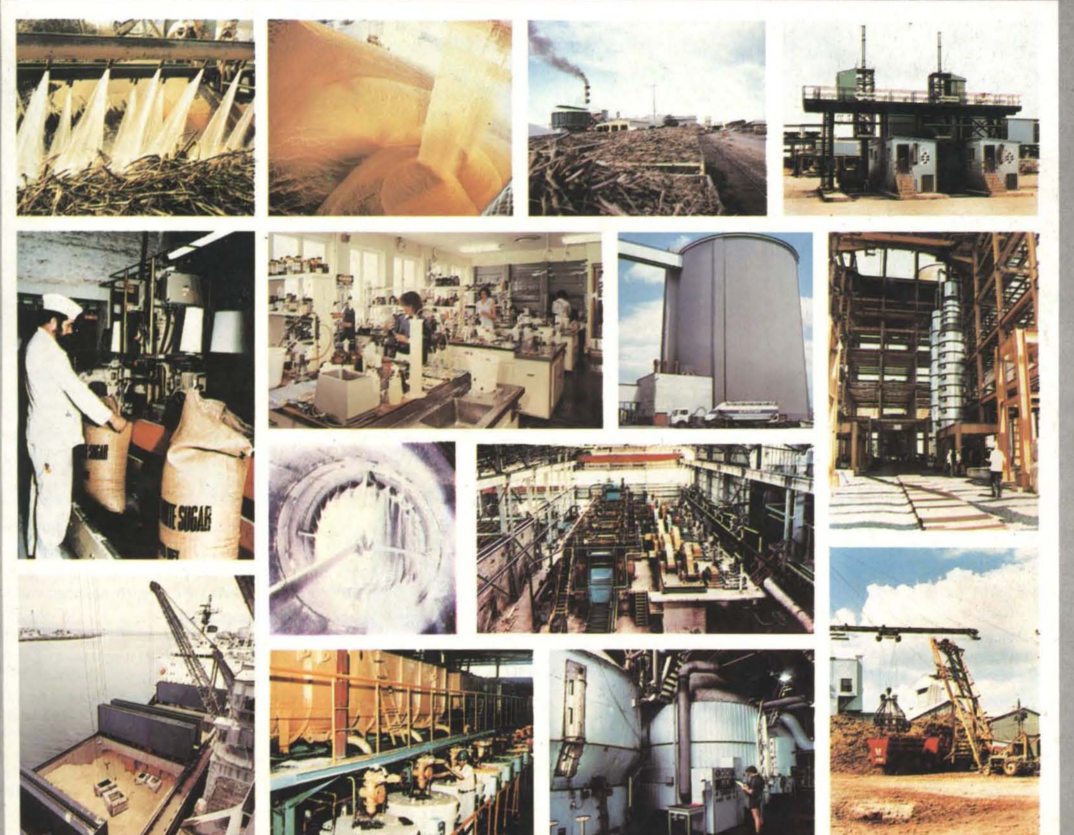
INTERNATIONAL SUGAR JOURNAL



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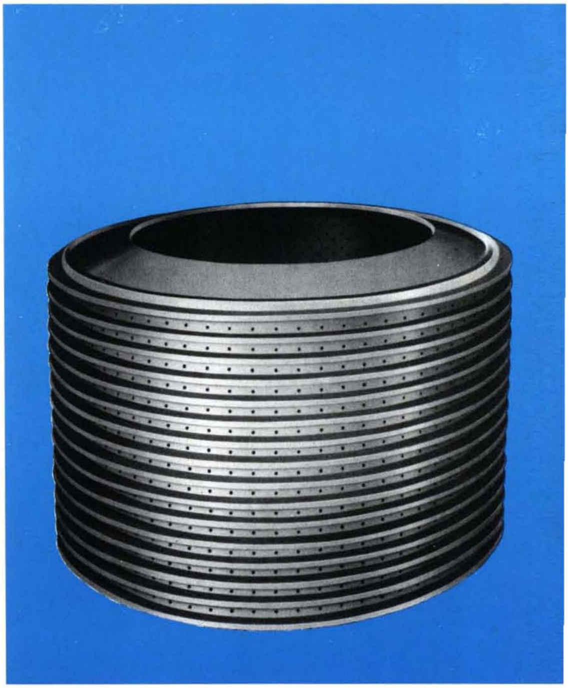
Ring-reinforced basket = proven protection.



Years of operation in the sugar industry have firmly established the inherent safety of the Western States basket design. The basket's stainless steel side sheet is reinforced by numerous, high tensile strength, weldless, steel rings . . . each machined from a forged billet. These rings contain the rotating mass should the side sheet ever fail. Or, should a ring fail, the basket still has a high degree of reinforcement because of the numerous remaining rings. We have refused to depart from this design principle . . . a primary reason why Western States Centrifugals offer proven protection against violent basket failures.

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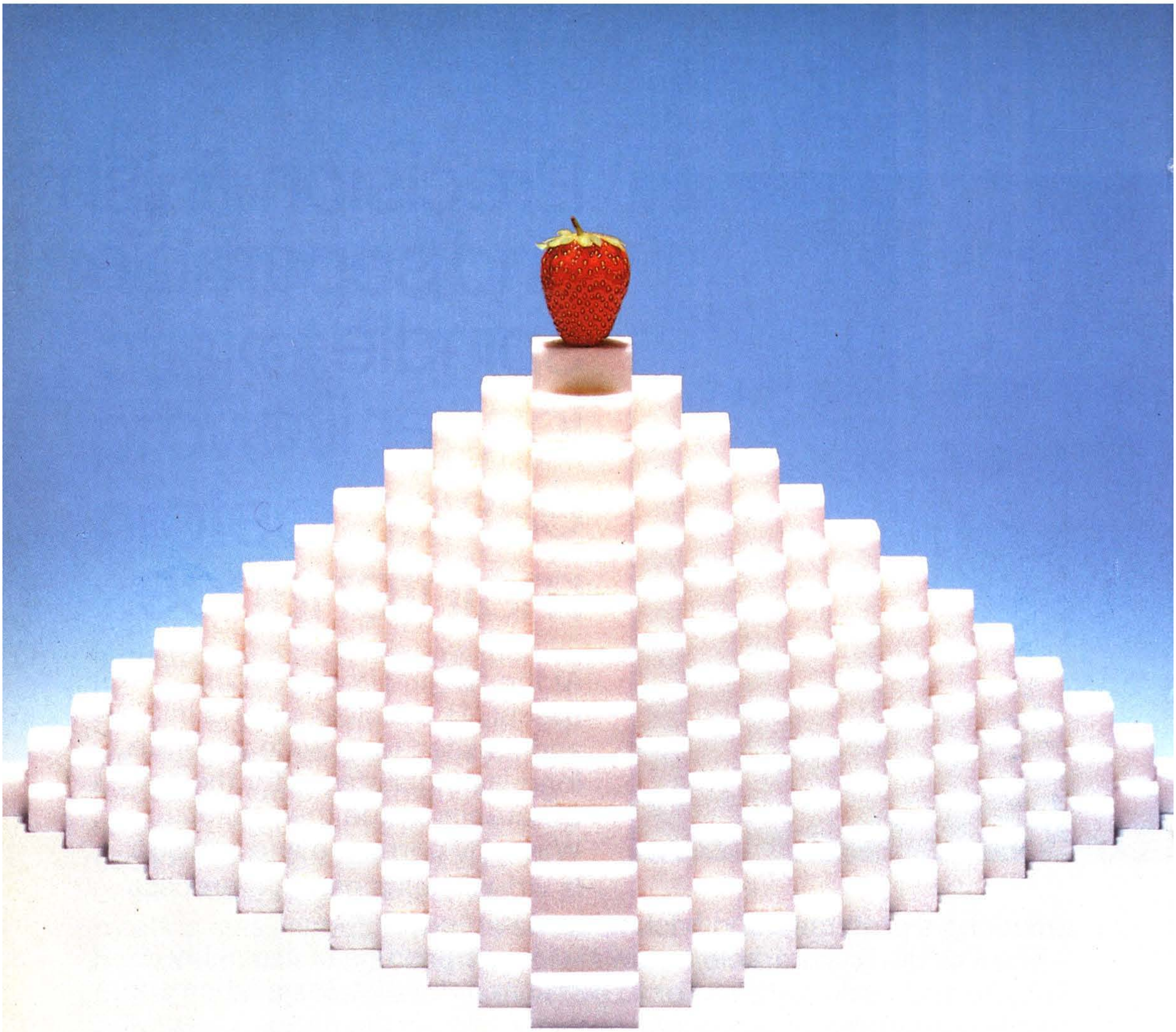


News and views

World sugar prices

At the start of March the London Daily Price for raw sugar continued its downward drift but press reports from Cuba on the delays and difficulties with the 1989/90 crop were taken as a sign of official concern about the harvest. Prices started to rise and the LDP which was $346.50 on March 1 and had eased to $345 the next day then increased, peaking at $386.40 on March 16. The rise was also stimulated by reports of crop damage by drought in Thailand, by F. O. Licht's report that European farmers had not responded to higher prices by increasing beet areas significantly, and by concern over the situation in Brazil where the new government's economic policies were creating uncertainty about the availability of Brazilian sugar to meet export commitments. However, the likely reduction in alcohol demand and higher actual exports than official figures were an influence to cool the market, while the continuing lack of purchases by China, India and the USSR also contributed. The market remained volatile, with the LDP fluctuating between $384 and $368 during the rest of the month, which it ended at $377 per tonne.

The London Daily Price for white sugar was less volatile but it too rose from $425.50 on March 1 to peak at $455.50 on March 20, thereafter declining gently to $443.50 on March 28 but ending the month at $451 per tonne.

Sugar consumption in Africa

A paper has been prepared on sugar consumption in Africa for discussion by the Market Evaluation, Consumption and Statistics Committee of the International Sugar Organization. The investigation was empirical and Africa was chosen because it is the second largest net importing continent after Asia. There are a large number of individual countries of widely differing consumptions; in 1988 only nine recorded consumptions of more than 200,000 tonnes, and only Egypt and South Africa consumed more than one million tonnes. The dependence of the region on outside supplies grew during the 1970's and up to 1983 but then declined owing to economic crises. Per caput consumption ranged between 1.8 and 37.8 kg in 1988 and also showed the same pattern of increase up to 1983 and subsequent stagnation.

The study concludes that Africa is a continent with the potential to become an important market for sugar, with low per caput consumption and fast growing population (averaging 3.0% between 1970 and 1985, against a world average of 1.8%). Only one example was found of decreasing income elasticity of sugar consumption; in many countries it was increasing. The economic problems of the continent have become an obstacle to an increasing role in the international sugar economy and it was also found that international sugar prices were not useful in explaining consumption in many African countries.

US sugar legislation discussions[1]

On March 5, the Senate Agriculture Sub-Committee on Agriculture Production and Stabilization held hearings on the 1990 Farm Bill. Testimony was heard from administration officials, producer representatives, processors and users, as well as international interests. The Administration proposed that no fundamental changes be made in the current program, stating that a tariff rate quota "makes the most sense" in replying to the Australian GATT challenge, and that marketing controls are a problem because percentage requirements related to domestic production *versus* imports could result in forfeitures. The Administration also committed itself to consult with Congress and the sweetener industry before replying to the GATT ruling on import quotas and to refuse to trade off sugar for concessions on other matters during the present round of trade talks.

The domestic cane and beet sugar producers want an increase in the loan rate to 20 cents/lb, with adjustments tied to production costs. Both agree that the loan period should be extended from 6 to 9 months and the no-cost provision in the current bill should be maintained. At the February Sweetener Users Colloquium beet processors had proposed a minimum import quota of 500,000 short tons and marketing controls if imports fell below that level. Florida cane growers and the cane refiners had suggested a minimum quota of 1.25 million tons and marketing controls (on corn sweeteners as well as sugar) if imports fell below. The sweetener users proposed a gradual reduction in the loan rate by 5% per year over 5 years and a gradual increase in the import quota to 2 million tons, while the corn processors favoured continuing the present program and loan rate and no marketing controls.

US Trade and Agriculture officials are examining ways of complying with the GATT ruling on Australia's complaint. They appear to be leaning toward a tariff rate quota system under which a country-by-country quota system could be continued with a tariff, set at the minimum allowed by law, imposed on a certain set quantity of imports. A secondary tariff would be levied on sugar in excess of the allotted amount at a rate sufficiently high to prevent too much sugar from entering the country.

EEC-ACP sugar payment disputes

The EEC proposals for reduction of guaranteed beet and sugar prices will also affect the payment made for the raw sugar imported under the Lomé agreement from the African, Caribbean and Pacific suppliers who were former colonies of the European member countries of the Community. This has, of course, met resistance from the ACP countries as well as European farmers, and they have demanded compensation from the EEC for the prospective loss of export earnings[2]. The ACP countries are also reported to intend to ask at the next Council of Ministers meeting for special measures including improvement of infrastructures and transport facilities, and upgraded technology to be put in

1 *Czarnikow Sugar Review*, 1990, (1794), 36.
2 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 181, 200.

place to enable their sugar industries to become more competitive. As far as the admission of Papua New Guinea and Zambia to the sugar protocol is concerned, the existing ACP countries have no objection provided that the overall supply quota is expanded whereby members' quotas are not reduced to provide allocations for the new members.

The European Community and the ACP countries are deadlocked over outstanding claims for compensation in past years for falling commodity prices. The Stabex system was intended to provide some protection to ACP countries when drastic falls in commodity prices reduced their income from exports. The ACP group claim that they are owed money from 1980, 1981, 1987 and 1988 when the available Stabex funds fell far short of the agreed claims. However, the Community has rejected this contention and is resisting a suggestion that the EEC member countries cancel the equivalent in bilateral debt owed to them by ACP members.

Indian policy for sugar production increase[3]

Just keeping pace with population requires an extra 300,000 tonnes of sugar per year in India and there is every indication that the authorities intend to make provision to cover this. The goal is to be able to meet such requirements from domestic production and the committee looking into the sugar industry provisions for the eighth five-year plan have already projected that installed capacity should rise to over 14.1 million tonnes, white value, by the mid-1990's.

The government is understood to have rejected proposals for a major increase in the area cultivated to cane; it is believed that new policy will focus on minimizing the diversion of cane to manufacturers of gur and khandsari. The difference in cane utilization patterns in Uttar Pradesh and Maharashtra illustrate the point. Last season the cane harvest in the U.P. totalled 89.3 million tonnes but sugar production in the state only amounted to 2,302,000 tonnes, white value. By comparison, the 25.5 million tonnes of cane harvested in Maharashtra yielded more than 2.6 million tonnes of sugar.

There are restrictions on the movement of cane within each state and the government feels that, by amending these, growers will not be so likely to divert cane deliveries away from sugar factories. To ensure that growers are encouraged not to deliver their cane to gur and khandsari units closer to the farm but to seek sugar factories even if these are some distance away, it is proposed to provide a transport subsidy for cane to reach the sugar factories.

World sugar balance and prices[4]

Their estimates of world production and consumption for the 12-months period to the end of September 1990 imply a statistically insignificant deficit of 332,000 tonnes, which is consistent with the ISO's view that there are insufficient stocks to make up a large deficit. The balance system permits checking of consumption estimates against availability in each country from domestic production, imports and stocks held domestically or in exporting countries. The increase in estimated world production from 1988/89 would enable consumption to grow this year by 1.3 million tonnes or 1%, well short of the average annual growth of 2 million tonnes which has persisted since the early 1950's. It would, however, be a considerable improvement on the previous year when consumption stagnated, after growing by around 5% in 1987/88.

Consumption is now constrained by production, which will allow modest growth this year. If funds were available to back potential demand (which everyone agrees is strong), the price would necessarily rise in the short term, since supplies are now virtually fixed for the current crop cycle. Although demand has been strong enough to prevent the price falling below 14 cents/lb in recent months, it has so far been insufficient to push prices significantly beyond 15 cents/lb. It should be emphasized again that, should demand rise, it will be the price that will change (and the destination of traded sugar, depending on who outbids whom for the available sugar), or the level at which the balance is struck will be lower if there is a late-cycle supply shortfall; there is little scope for the difference between production and consumption to vary from the currently estimated level.

USSR 1989 beet crop[5]

The Soviet sugar beet harvest in 1989 totalled 97.5 million tonnes, up 11% from the 87.9 million tonnes harvested in the previous season. Of the total, 91.9 million tonnes were purchased for processing, 13.9 million tonnes more than in 1988.

New Queensland sugar refinery possibility[6]

CSR Limited, the major refining company in Australia, has put a "jumbo refinery" in North Queensland on its agenda according to a December press report. The company's chief executive was reported to have said a Queensland refinery to supply all of the country's sugar needs was one alternative being considered. CSR is thought likely to sell the site of its Sydney refinery within the next five years to take advantage of inner-city real estate values.

Poland sugar production, 1989/90[8]

The 1989/90 beet campaign in Poland produced 1,850,000 tonnes of sugar, raw value, compared with 1,824,000 tonnes in the previous campaign.

Austria sugar production, 1989/90[8]

The three Austrian sugar factories sliced a total of 2,640,832 tonnes of beets in the 1989/90 campaign to produce 421,330 tonnes of white sugar.

3 *Czarnikow Sugar Review*, 1990, (1793), 15.
4 *ISO MECAS Review of the Market Situation*, March 19, 1990, p. 2.
5 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 99.
6 *Australian Canegrower*, 1989, **11**, (24), 2.
7 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 99.
8 *Zuckerind.*, 1990, **115**, 145.

Sugar Industry Technologists

49th Annual Meeting, 1990

The 1990 Annual Meeting of SIT will be held in the city of Vancouver, British Columbia, Canada, during May 6 - 9. This will be the second time in 16 years that the city has been the venue for the Meeting and it is appropriate for 1990 since this is the centenary year of the host company, BC Sugars. Members will gather at the Hyatt Regency hotel for the welcoming mixer and technical sessions will also take place in the hotel. On May 9 members will be able to tour the Vancouver refinery of BC Sugar, described elsewhere in these pages. A ladies program has been arranged for accompanying spouses.

The technical sessions will occupy Monday and Tuesday and a preliminary list of papers to be presented include the following: (1) Pipe kiln modifications to equalize the bone char flow, by Tom Pearson and Gene Snook of Imperial Holly Corporation; (2) Quality management systems in Tate & Lyle Sugars - the international standard, by Simon J. Gibbons and Richard B. Ratcliffe, of Tate & Lyle; (3) Five years experience with weak cation softening on thin juice, by Thomas H. Henscheid, Amalgamated Sugar Co.; (4) The use of infinite series for optimizing placement and operation of chromatographic separators, by Michael Kearney, Amalgamated Sugar Co.; (5) The performance of a new design of continuous centrifugal, by Philip G. Atherton and L. K. Kirby, of the Bureau of Sugar Experiment Stations, and C. R. Murry, of NQEA, Australia Pty. Ltd.; (6) Laser-cut screens for continuous centrifugals, by Philip G. Atherton, of BSES, M. Brandt of CSIRU and K. C. A. Krane of Action Laser Pty. Ltd.; (7) BC Sugar, the Vancouver refinery, by Kendon M. Foo, of BC Sugar; (8) Sugar conditioning, by J. Lemon and Don Ryan, of Lantic Sugar Ltd.; (9) Sugar technology - where are we going? Part I. Fundamentals of sugar processing, by Chung Chi Chou, of Amstar Sugar Corporation; (10) Analysis of raw sugar and process materials by ion chromatography, by W. S. Charles Tsang and Margaret A. Clarke, of Sugar Processing Research Inc.; (11) Fifty years of sugar research, by Margaret A. Clarke, of SPRI; (12) The reconfiguration of C&H Sugars, by R. W. Van Vleck, P. J. Langley and R. S. Ball, of C&H Sugars; and (13) The DDS computerized system for remelt boiling, by John Thompson, of Savannah Sugar Refinery. A symposium is to be held on methods of purification in cane sugar refining, with presentations by Michael C. Bennett on "Defecation and clarification", by Jean-Paul Merle on "Char house operations" and by C. A. Rousse on "Taloflote and Talofloc clarification".

BC Sugar: One hundred years

1990 sees the centenary of The British Columbia Sugar Refining Company Ltd., fore-runner of the present-day BC Sugar, and the company has published a brochure to commemorate the anniversary. It was the brainchild of — to quote the brochure — a brash young man, Benjamin Tingley Rogers, an American who had worked in the laboratory of the New Orleans sugar refinery managed by his father and who, at 24, had become a capable sugar technologist with Havemeyers & Elder, New York's largest sugar refinery.

He secured the backing of the Directors of the Canadian Pacific railroad and also persuaded the Aldermen of the City of Vancouver to provide the refinery site and build a wharf. The company was incorporated in March 1890 and melted its first sugar the following January. The company lost money in its first year and was only saved by insurance the next year when two consecutive cargoes of raw sugar were lost at sea. It survived a challenge from a merchant in Victoria, B.C., who imported cheap sugar from Hong Kong. but prospered with the increasing settlement of the Prairies. Refinery sales reached $1 million in the year to March 1899.

In 1905, the company sought to secure a reliable supply of raw sugar by purchasing a run-down cane plantation in Fiji. However, labour supply was inadequate and in 1914 the company was trying without success to sell the plantation. The advent of war caused sugar prices to soar and the plantation became profitable. However, the banning of recruitment of indentured labour by the Indian government cut off the supply of cane cutters, output fell and sugar prices collapsed in 1920. The plantation was closed in 1922 and its assets auctioned.

Sugar refining remained profitable, however, and the company was able to withstand the harmful effects of the Depression of the 1920's and 1930's. It expanded into the beet sugar business, buying in 1931 the Canadian Sugar Factories plant at Raymond, Alberta. A second beet sugar factory in the Province was opened in 1936 at Picture Butte and a third agreed for Taber; owing to World War II its construction was delayed until 1950, however. These factories were of benefit for Western Canada, because after December 1941, the war in the Pacific disrupted sugar supplies to the Vancouver refinery. Part of the refinery was given over to war construction, with the production of marine engines, deckhouses, etc.

In 1944, with the memory of sugar shortages after World War I, a new effort was made to secure reliable raw sugar supplies. BC Sugar bought Ozama Sugar Company in the Dominican Republic and invested heavily in a new railway system, introduction of modern equipment and methods, etc. However, the Trujillo regime introduced heavy taxation and also established competing sugar plantations which escaped taxes. When Trujillo decided to buy Ozama in 1956, offering BC Sugar enough to recover its investment, the company accepted the offer quickly.

In the same year the company bought part of Manitoba Sugar Company which owned the Fort Garry sugar factory; ultimately it acquired the rest of its shares. This plant was enlarged while in 1963 the Raymond factory was closed and that at Picture Butte in 1977. Beet sugar production in Western Canada is now centred in Fort Garry and Taber.

The company has always produced a range of sugars and syrups but in the 1960's started to diversify into other industries and now controls companies concerned with packaging, oil production and chemicals.

BC Sugar: A technical overview of the Vancouver refinery

By Alan D. Chapman* and Kenneth J. Curdie**

Introduction

The British Columbia Sugar Refining Company Limited was founded by B. T. Rogers in 1890. The transcontinental railroad had recently been completed by Canadian Pacific Railway with the western terminus in Vancouver, British Columbia. Mr. Rogers considered that locating a new sugar refinery in this city on the Pacific Coast should prove to be a sound business decision. Raw sugar was available from Pacific plantations and the new refinery would be ideally placed to supply the developing markets in the Western Canadian Provinces.

By early 1891, a cane sugar refinery had been constructed and commissioned on somewhat less than three acres of land on the southern shore of Burrard Inlet. Daily production in those early days was 100 barrels of refined sugar (at 300 pounds per barrel).

Today, the BC Sugar Vancouver refinery, while still occupying the original site, shows evidence of the development that has taken place over the past 100 years and now utilizes most of the additional land reclaimed by landfill during that period. The total land area now stands at close to 15 acres. None of the original buildings remain standing.

The current melt capacity of this refinery is 900 tonnes per day. A full range of sugars and syrups is produced. These include various grades of granulated sugar, cubes, yellow and brown soft sugars, demerara style blended sugar, icing, liquid sugars, cane and flavoured pancake syrups and Roger's Golden Syrup, a thick table syrup in production since 1913.

A. D. Chapman K. J. Curdie

Raw sugar receiving and storage

Currently, all of the raw sugar melted comes from Queensland, Australia, in bulk carriers. The wharf, which extends 145 metres into Vancouver harbour, has two Colby hinged-boom travelling cranes with a nominal capacity of 135 tonnes per hour each. It normally takes 80 hours to unload a 20,000-tonne cargo.

The raw sugar is conveyed to the Scale House at the south end of the wharf where a Toledo 5000-kg capacity scale automatically weighs, tares and prints the weights on a tape. Weighing is carried out under the supervision of Public Weighers. Samples are taken automatically with each dump and a composite is made of each 1000 tonnes unloaded. Duplicate samples are sent to the BC Sugar laboratory for full analysis and to the seller's laboratory for pol measurement.

The raw sugar is then stored in either No. 1 Bulk Storage, an 'A' frame building with a nominal capacity of 20,000 tonnes, or No. 2 Bulk Storage, a concrete building with a nominal capacity of 10,000 tonnes, which doubles as the melt feed bin.

Melt House

The present Melt House was started up in 1970 and was designed to handle 40 tonnes of raw sugar per hour with full automation for a one-man operation, although melts of over 1000 tonnes per day have been achieved. Raw sugar is reclaimed from No. 2 Bulk Storage through outlets in the floor which supply two variable-speed scroll feeders mounted on moveable carriages which are located in a tunnel below floor level. A bucket elevator delivers the raw sugar to the top of the Melt House and through a surge bin into an automatic 1000 kg-per-dump Parsons Scale, which determines the input into the refinery.

The raw sugar is dropped into a mingling scroll where it is dosed with hot, raw syrup to yield a 40 - 45°C magma for feed to the centrifugals. These are five Western States G-8, 48" × 36" × 7", 1200 rpm automatic batch centrifugals with three-minute cycles. The sequencing of these machines is controlled by the level of the washed raw liquor receiving tanks in the Pan House. Process control of the centrifugal wash times is based on the colour of the washed raw liquor and the non-sugar requirements in the raw syrup stream.

The washed raw sugar is dissolved in sweetwater and screened prior to

* Process Superintendent.
** Assistant to the Process Superintendent.

pumping to the remote tanks in the Pan House. There, refinery remelt sugar liquors are added before being pumped to the clarification station in the Filter House.

The raw syrup spun off the centrifugals is pumped through a steam heat exchanger to bring the temperature up to 80°C for pasteurization purposes. It then goes to a mingling syrup tank at the top of the Melt House. The excess raw syrup flows by gravity to a remote tank in the Pan House for coloured sugar production.

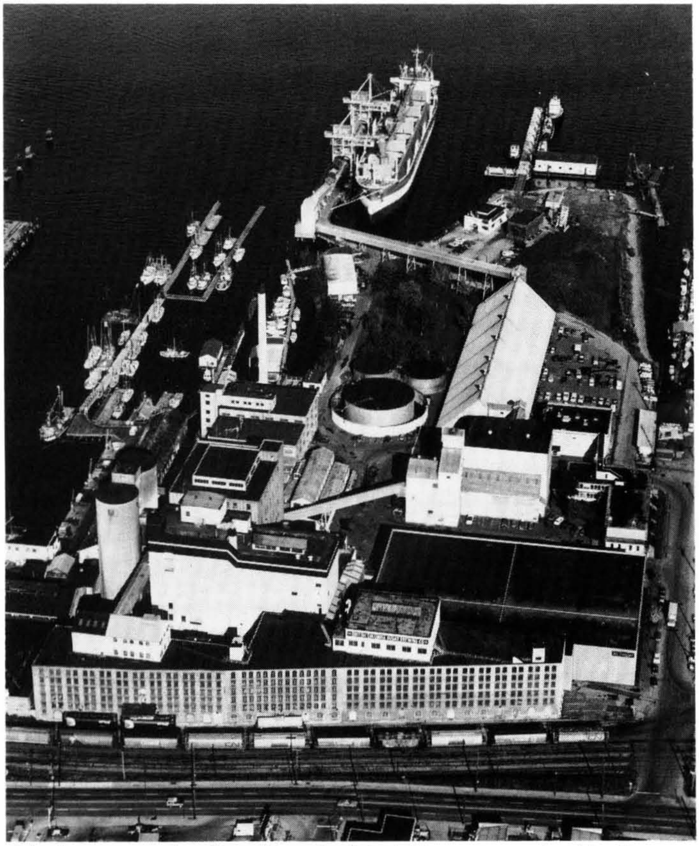
White sugar system

Clarification station

The washed raw liquor flotation clarification station was started up in 1985. It replaced filter aid/cloth filtration through four Sweetland presses. The liquor is first screened through three Microsieves (200 micron) to remove fine sand and fibre which inhibit flotation. The screened liquor is preheated from 75°C to 85°C through a plate heat exchanger which also cools the clarified liquor from 93°C to 80°C. It is then heated to 93°C through a steam heat exchanger, followed by in-line addition of phosphoric acid and pH adjustment to 7.5 with lime saccharate, before entering a reaction tank.

The reaction tank overflows into two streams, two-thirds going to a 30-tonnes/hour Tate & Lyle circular flotation clarifier and one-third going to a parallel, 15-tonnes/hour unit. Each stream is aerated and dosed with Taloflote flotation aid before entering the clarifiers. The clarified liquor is adjusted with lime saccharate to pH 8.0, cooled to 80°C and pumped to the adsorbent system feed tanks without filtration. This phosphatation clarification effects 30 - 35% colour removal from raw infeed liquor and the effluent liquor turbidity is between 15 - 20 JTU.

The scums are desugared through a three-stage countercurrent sweetening-off system. The resulting 15 - 20°Brix sweetwater is pumped to the Melt House for dissolving the washed raw sugar.



Adsorbent system – Decolorization and de-ashing

The adsorbent system consists of 16 cisterns of bone char (the 'A' side) and 30 cisterns of an admixture of 85% by weight of bone char and 15% by weight of Canesorb (the 'B' side). The 'A' and 'B' systems run in parallel. Both clarified washed raw liquor and low purity coloured liquors for light soft sugar production are decolorized sequentially in these cisterns. The requirement for light soft sugars establishes the level of adsorbent usage. As a result, a high-quality white liquor of 40 - 50 ICUMSA colour units is obtained which makes possible the white sugar in-boiling system used at this refinery.

A typical cycle for an adsorbent cistern would be 40 - 80 hours on clarified washed raw liquor at 3 m^3/hr, followed by 12 - 14 hours on coloured liquor at 1.5 m^3/hr to produce "C-run" for Golden Yellow sugar. The wash cycle typically consists of 12 - 14 hours on hot (90°C) water at 1.5 m^3/hr to sweeten off the adsorbent and then 9 - 13 hours on tempered (40°C) water to wash and de-ash the adsorbent. This is followed by three hours on hot water to reheat the adsorbent and facilitate dewatering. Finally, the cisterns are put on air to blow out the water and partially dry the adsorbent prior to revivification.

Spent adsorbents from the 'A' and 'B' cisterns are kept in separate systems for revivification through pipe kilns. Damp adsorbents from the cisterns are dropped into kiln hoppers and then substantially dried using kiln exhaust heat through louvred dryers. The adsorbent is then regenerated in stainless steel retort pipes. The hot adsorbent is cooled through louvred cooler pipes, discharged into hoppers, directed onto a collecting belt and screened to remove dust before being reused. A Kipp-Kelly specific gravity separator is used periodically to discard heavy fractions.

All kilns are equipped to burn natural gas. There are three 'A' kilns and five 'B' kilns. The 'A' kilns are operated at 525°C for the bone char and the 'B' kilns are operated at 565°C for the bone char/Canesorb admixture. Total 'A' char burn is 6.4% on melt and 'B' adsorbent burn is 11% on melt.

All "off-char" white liquors are filtered through polishing filters to remove fine particles. Entering the "in-boiling" system, this polished liquor is mixed with runoff syrups from No. 1 white strikes and controlled at 250 - 300 ICUMSA colour for feed to the white pans (No. 1 strikes). This produces a 25 - 30 ICUMSA colour white sugar. To control the colour of the feed liquor, No. 1 syrups are "bled-off" as required and boiled down into No. 2 and No. 3 strikes. Usually, the No. 2 strikes produce white sugar of acceptable colour while the No. 3 strikes are normally remelted, the sugar going back into the white pan feed tank or into the melt stream.

Sugar boiling

There are four calandria vacuum pans currently in use. Two are used for white sugar boiling, one for light soft sugar and the other for low-grade remelt boilings.

The white pans are identical, with a capacity of 45 m^3 each and are equipped with circulators. The boiling cycle is fully automated using a stepwise program. The key parameters used in the program are: pan level, refractometric Brix and circulator motor load. Seeding and initial grain development are carried out at constant temperature, using absolute pressure control. This system has been in service since 1981.

The white massecuites are dropped at 55°C into mixers which supply the centrifugal feed tubes. The white side consists of seven 48" × 30" × 7" Western States, 1200 rpm batch centrifugals. The two white sugar dryers in use are Link-Belt Rotolouvre granulators which dry the sugar in a "fluidized" bed using filtered air. Hot air is introduced into the first half of the granulator and cold (ambient) air into the second half. All air flow is co-current with the sugar flow. Humid exhaust air is discharged to wet Rotoclones for sugar dust recovery and then discharged to atmosphere. Fresh water is currently used in the Rotoclone sprays, the resultant sweetwater being returned to the Melt House.

Each dryer discharges sugar onto separate belts which lead to two automatic Servo Balans scales to determine the total white sugar output. The sugar is then directed into the top of the first of two silos. The silos, constructed in 1960, have a nominal capacity of 3500 tonnes each and are operated in series. In the first silo the warm sugar is conditioned by circulating it in countercurrent to dehumidified air blown into the bottom of the silo through a distribution ring. The exhaust air is drawn off to a Dracco dust collector. The conditioned sugar is then transferred to the second silo for storage. Retrieval of conditioned sugar from the silo is through up to fourteen perimeter outlets as required, to satisfy the packaging and liquid sugar production requirements.

White sugar screening and packaging

The sugar is first scalped over a 10-mesh screen and then passes through a battery of five Rotex screeners. The screeners can be equipped with two or three decks, depending on the fractions required. The grades produced are Sanding (20 - 35 Tyler mesh), Fine (28 - 100 mesh), Special Industrial Granulated (S.I.G., which is 35 - 100 mesh) and Superfine (through 65 mesh). A Medium grade of sugar is produced from a specially boiled strike. The sugar from this strike goes directly from the granulator over a Rotex screen (14 - 24 mesh) to the packing bin.

Fine sugar is packed in 1, 2, and 4-kg polyethylene bags and 1-kg cartons as well as 2, 4, 10 and 40-kg paper bags. Also, individual envelopes, both house brand and private label, are filled with Fine sugar for restaurants and institutions. Medium, Sanding, S.I.G. and Superfine sugars are packed in 40 kg paper bags for industrial use. Some industrial customers take Fine and S.I.G. sugars in bulk, either in tote bags or delivered in a BC Sugar self-discharging bulk trailer.

Icing sugar is also produced by passing coarse white sugar through a Micro Pulverizer mill, with 3% starch added to control caking of the sugar. The Icing sugar is packed in 1-kg pillow pack polyethylene bags and 40-kg polyethylene lined paper bags.

Liquid sugars

A continuous liquid sugar manufacturing facility was constructed in 1977 to produce liquid sucrose (67% solids) and 50% liquid invert (77% solids). It consists of a sugar feed bin; a gravimetric feeder; an agitated, multi-stage, vertical, cylindrical, continuous melter; a micro-filter unit; a spiral heat exchanger; a Pyrex glass inverter with pH control spigots; a flash cooler; and storage tanks. It was designed to be run by one operator who also monitors the process.

For liquid sucrose, white sugar is dissolved, heated to 110°C for pasteurization, adjusted with sodium hydroxide to pH 7.2 and cooled to 35 - 40°C for storage. For liquid invert, white sugar is dissolved, heated to 120°C and injected with hydrochloric acid to start inversion. After a one-minute pass through the inverter, sodium hydroxide is added to stop inversion at 50% invert sugars. The liquor is cooled through the flash cooler, adjusted to density and stored. The vacuum in the flash cooler is controlled by the flow of salt water through a multi-jet condenser.

Liquid sucrose and liquid invert are delivered in BC Sugar self-pumping tanker trailers. Some liquid invert is packed in 25-kg pails and 300-kg drums.

Cube sugar

Cube sugar is produced by wetting sugar from the storage silo with a spray of hot water metered into a blending scroll. The wet sugar is moulded into 1.5 cm cubes in a "Hershey"-type cube drum. The damp pressed cubes are discharged onto trays, bunched together and conveyed through a Grier dryer. Cube sugar is packed in 450-g cartons and 10 kg "loose pack" boxes.

Coloured sugar system

The coloured sugars produced are Golden Yellow, Best Brown and Demerara Style Brown. Golden Yellow is a light soft sugar boiled from affination syrups/thick sweetwater and remelt syrups which are defecated, filtered and decolorized over adsorbent. Best Brown and Demerara sugars are produced by blending screened white sugars with selected, low purity syrups which have been defecated and filtered, but not decolorized.

Defecation

This is accomplished at the "blow-up" station which consists of five 5.7-m^3 vessels equipped with air agitation and heating coils. All affination remelt syrup and affination/sweetwater remelt syrups to process are defecated using phosphoric acid and milk-of-lime. Acid addition rate is typically 0.20% P_2O_5 on solids for coloured liquors going to the adsorbent system and 0.03% P_2O_5 on solids for coloured liquors to be used in dark sugar production. Diatomaceous earth is also added at this stage to aid in filtration.

Press filtration

The defecated liquors are filtered through two sets of Sweetland pressure filters, referred to as the 'A' and 'C' Sweetlands. The 'A' presses consist of five Sweetlands for filtration of coloured liquors before decolorization. The 'C' presses consist of three Sweetlands for filtration of coloured liquors used in the production of blended dark sugars. Some coloured process liquors are also refiltered at this station.

All eight Sweetland presses are similar in construction. Each has a nominal surface area of 93 square metres provided by 72 circular, cloth-covered leaves on 2-inch centres. The spent filter aid from these presses is partially sweetened-off in place, manually hosed out (two presses have automatic sluicing) and transferred to the mud press station. Here, the mud is desugared with hot water in three small Sweetland presses. Wet, desugared mud is trucked away to waste disposal sites.

Golden Yellow sugar

After press filtration, the coloured liquors for yellow sugar production are run through the adsorbent systems for colour and ash removal. The decolorized liquors are then blended in the liquor gallery to standard colour and purity, polished through a Stellar filter and concentrated in a double-effect evaporator. The thickened liquor is boiled in a stirred calandria pan of 32 cubic metres capacity. (The stirrer and steam are shut off after the grain is established to cause deliberate conglomeration and give the sugar a "soft" texture.)

The massecuite is dropped into a mixer and is machined in the soft sugar centrifugals. These consist of three 40" × 30" × 6" Western States 1800 rpm batch centrifugals and one 48" × 30" × 7" Western States 1200 rpm batch centrifugal.

The soft sugar is packed in 1 and 2-kg pillow pack bags and 20 or 40-kg paper bags. The runoff syrup is diluted, press-filtered and used for purity and colour adjustment in the liquor gallery and the Pan Room.

A new, coloured liquor clarification system is currently being installed to replace the manual defecation and filtration of coloured liquors to the adsorbent system. This is a Tate & Lyle flotation clarifier with a separate three-stage scum sweetening-off system. The resulting sweetwater will be accommodated in the plant sweetwater system. The clarified coloured liquor will be filtered through a Tate & Lyle deep bed filter before going onto adsorbent.

Best Brown and Demerara Style sugars

These sugars are currently being blended. The blending syrup is heated and metered into a mixing/transfer scroll with the syrup rate automatically controlled in a fixed ratio to the flow of sugar. A 42-100 mesh Fine sugar is used to blend Best Brown and a 20-35 mesh Sanding Sugar is used in the Demerara blend. The scroll feeds directly to the packaging station where the sugars are packed in 1-kg pillow pack and 40-kg paper bags.

Roger's Golden Syrup and Pancake Syrups

Roger's Golden Syrup is made from a special blend of double char-filtered coloured liquors and inverted liquors which are filtered and concentrated. It is thickened to 81.0° hydrometric Brix and packed in 750-ml and 3.0-litre polyethylene bottles, 1.5-litre glass bottles, 25-kg polyethylene pails and 300-kg metal drums. Roger's Pancake Syrup is thickened to 72.0° hydrometric Brix and then packed in 375-ml and 750-ml polyethylene bottles.

Recently a line of flavoured syrups has been introduced including Roger's Maple and Butter Maple pancake syrups.

Power house

There are two Babcock-Wilcox boilers which are normally fired by natural gas with #5 fuel oil as standby. The boilers operate at 475 psig and have a combined continuous capacity of 50 tonnes of steam per hour.

Steam is supplied to any required combination of three turbogenerators. Two of these are rated at 1250 kW each and the third at 3000 kW. All turbines exhaust at 30 psig, this steam being used for process and building heat purposes.

Currently, two-thirds of electrical

continued on page 92

Mechanical blending system for dark soft sugars

By Goran Belic
(Project Engineer, BC Sugar, Vancouver, British Columbia, Canada)

Introduction

In order to facilitate production scheduling, it was decided at BC Sugar to produce dark soft sugars by a blending process rather than by a boiling process. An attempt was made to achieve the following main goals:
1. A blending system that will automatically meet the changing throughput required at the packing station, and still maintain the same sugar/syrup ratio to provide a consistent soft sugar quality.
2. Liquid load reduction on the coloured Sweetland presses and pans.
3. More flexible scheduling for the Process and Packaging Departments, based on crew availability rather than confinement to filter and pan availability.
4. Tighter tolerances in product quality control.
5. More crystallizer and centrifugal time for the recovery side.
6. Material (filter cloth, filter aid, water, sweetwater) and labour savings.
7. Significant reduction of clarifier sizing for coloured liquors.

Small scale experimental work in the laboratory, supported by the experiences of other sugar companies with the production of blended yellow sugar confirmed our intention to use a mechanical blending system for the production of dark soft sugars.

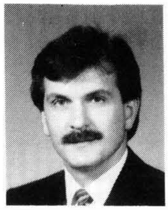
Objective

As a result of preliminary experimental work, it was found that the highest quality products could be achieved by blending sugar and syrup with the characteristics in Table I.

Final blended sugars have the characteristics shown in Table II.

Systems description

Our system for blending dark soft sugars is divided into four different sections, as follows:
(1) White granulated sugar section. (Figure 1)
(2) Blended syrup section. (Figure 2)
(3) Blending section. (Figure 3)
(4) Systems control and synchronization. (Figure 4)



G. Belic

Table I

Granulated Sugar	For demerara sugar	For brown sugar
Sugar grade	Sanding	Fine SIG
Rotex screens	Through 1340 on 540 Nitex cloth	Through 760 on 351 Nitex cloth
Typical size		
on Tyler	20 mesh - 5% maximum	42 mesh <1% maximum
through Tyler	35 mesh - 5% maximum	100 mesh - 5% maximum
MA/CV	600/20	235/25
Syrup		
Colour	120,000 ±10,000 ICUMSA	
pH	7.0 - 7.5	
Moisture	20.5% - 21.0%	
Temperature	82.5°C ± 2.5°C	
Invert	9.5%	
Ash	9%	

Table II

	Demerara sugar	Brown sugar
Colour	10,000 - 13,000 ICUMSA	13,000 - 16,000 ICUMSA
Moisture	1.75% - 2.25%	1.75% - 2.25%
Invert	1.4%	1.55%
Ash	1.3%	1.45%

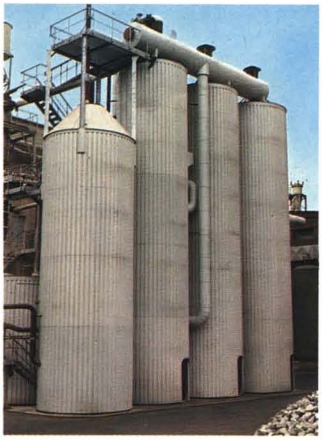
White granulated sugar section

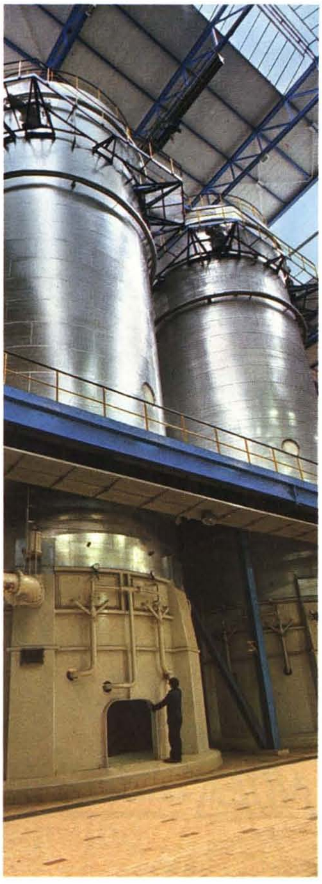
The white granulated sugar section is located in two different buildings. Sugar is screened on one of six Rotex screeners. The appropriate sugar fraction, extracted on the screener, is conveyed from the screen room into the stainless steel sugar bin in the Pan House. The sugar is conveyed using two screw conveyors, one bucket elevator and one belt conveyor. The sugar bin is a vertical cylindrical type and is equipped with two level probes. The higher level probe closes a pneumatically operated gate above the Rotex screener in the screen room. This stops the supply of sugar to the screener while the remaining sugar in the conveying system is emptied into the sugar bin. There is adequate bin capacity above this level probe to accept sugar in the conveying system. The lower level probe is installed just to provide a signal at the control panel on the packaging floor to advise the operator of low sugar level situation. The bottom of the sugar bin is fitted with a Vibra Screw bin activator. The "live" bottom of sugar bin eliminates the possibility of sugar bridging or segregating inside the sugar bin; otherwise, the latter would affect the quality and appearance of the blended sugar, i.e., at the beginning of the shift, the finer sugar crystals with more surface area for syrup distribution would create a drier, lighter coloured product and, at the end of the shift, the coarser sugar crystals, with less surface area resulting in a thicker syrup film on the crystal would create a wetter, darker product.

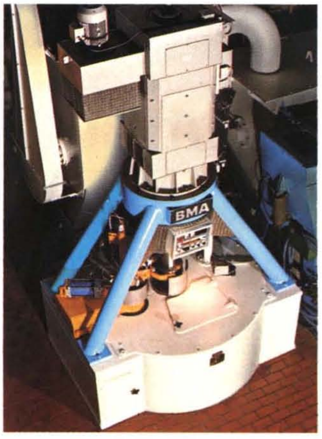
The conveyor system from the screen room to the sugar bin is manually operated and is monitored by the operator responsible for the screen room. An automatic protection system prevents overfill of the sugar bin, and conveyor components are electrically interlocked in reverse.

Every time the type of blended product is changed, i.e., from demerara to brown sugar, the complete white granulated sugar section must be emptied and cleaned in order to replace

Paper presented to Sugar Industry Technologists, 1989.







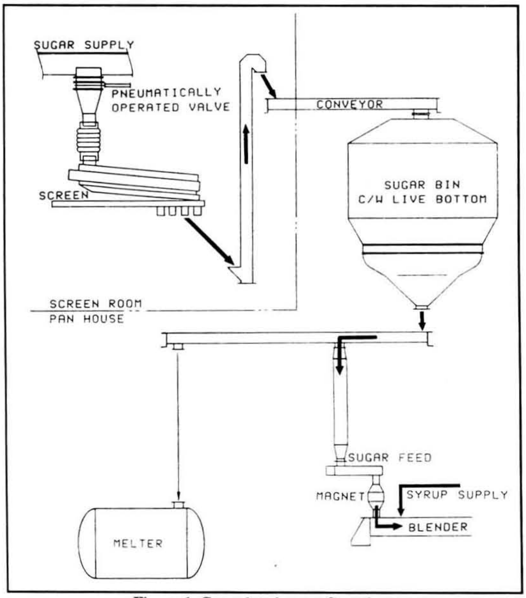


Figure 1. Granulated sugar flow sheet

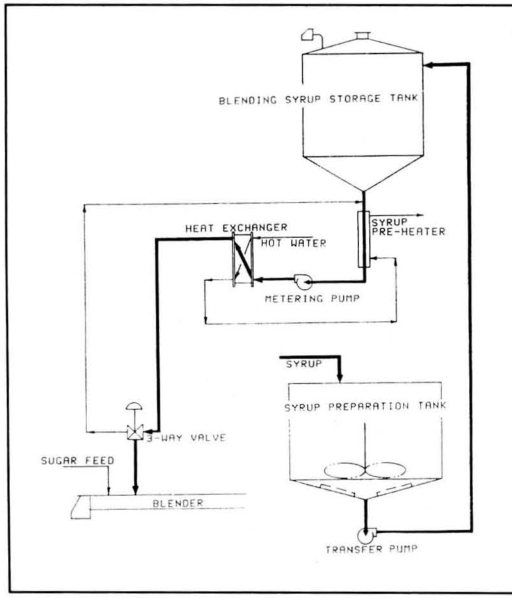


Figure 2. Blending syrup flow sheet

one type of white sugar with the other.

From the sugar bin, sugar is discharged into a screw conveyor via a flexible connection on the bin activator. From the screw conveyor, sugar is discharged into a pipe for a continuous supply of sugar to the feeder above the blender. This pipe has a total of three level probes which function as follows:

(a) high level probe – to stop the supply of sugar by stopping the screw conveyor from the sugar bin,

(b) low level probe – to start the supply of sugar by starting the screw conveyor from the sugar bin, and

(c) extra-low level probe – to stop the downstream blending process.

The sugar feeder has a variable speed motor and is capable of delivering up to 1900 kg of sugar per hour.

The white granulated sugar section ends at the beginning of the blender. White sugar passes a seven bar permanent magnet prior to being discharged into the blender.

Blended syrup section

Syrup is prepared in a blending syrup preparation tank located on the fourth floor of our Pan House. The preparation tank is a vertical cylindrical conical bottom tank made of stainless steel. Its holding capacity is 28.3 m^3 (1000 cu.ft.). This tank is also used for the preparation of other final syrups. It is equipped with a $7^1/_2$ h.p. turbine mixer, with a single impeller on a 10 foot long S.S. shaft. The bottom of the preparation tank holds plate heating coils, which are capable of raising the syrup temperature from 20°C to 40°C with 85°C hot water as the heating medium.

After the laboratory has confirmed that the prepared syrup complies with the specifications, it is transferred from the preparation tank to a storage tank located three floors higher. The transfer pump is made of stainless steel and has a capacity of 100 US g.p.m.

The stainless steel syrup storage tank has a capacity of 17 m^3 (or 600 cu.ft.) and it can store sufficient syrup for approximately 90 operating hours. The tank is equipped with a level transmitter. The amount of syrup inside the syrup storage tank is monitored and the information is displayed on the panel next to the blending syrup transfer pump.

The syrup storage tank is equipped with a permanent filter tank vent and with an overflow line back to the blending syrup preparation tank.

Once in the storage tank, the syrup is discharged as the packaging station demands by gravity from the bottom of the tank. A 4-inch diameter stainless steel pipeline runs from the seventh floor to the fourth floor providing a static head of 52 feet.

The gravity feedline is jacketed with a concentric 10-inch pipe, 40 inches long. This heating jacket uses hot water recirculated from the heat exchanger as the heating medium. After preheating, the syrup enters the variable-speed positive displacement pump made of 316 S.S. and with a capacity from 0 to 2 US g.p.m. Blending syrup is pumped into a plate and frame type heat exchanger. Heating is accomplished by a combination of refinery hot water and

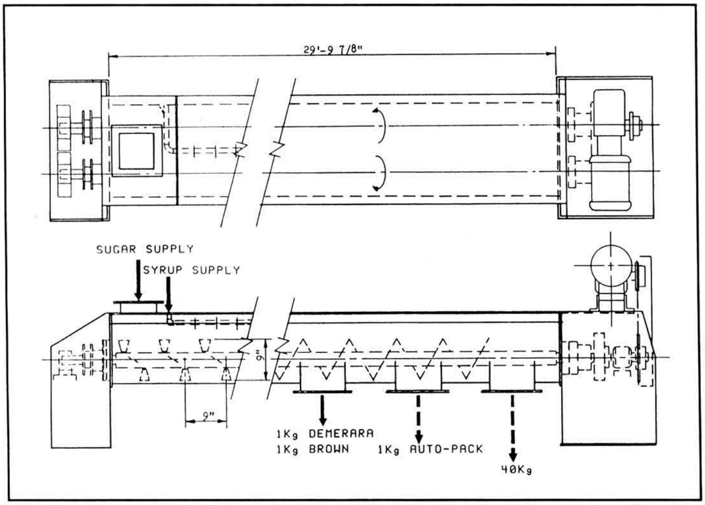


Figure 3. Blender

cold water. The correct proportion of hot and cold water is automatically mixed under temperature control prior to passing into the heat exchanger in order to achieve the right syrup temperature of 82.5°C ± 2.5°C. It is essential to ensure that the syrup is neither too cold nor too hot for the blending operation. If the blending syrup temperature is lower than 80°C, its higher viscosity would lower blending efficiency and if the temperature is above 85°C, its colour could increase, causing the blended sugar to be darker.

On leaving the heat exchanger, the syrup – which should be at the right temperature – is pumped into the blender via a 3-way diversion control valve. If the temperature of the syrup is outside the acceptable limits, the 3-way syrup temperature control valve will close to the blender and open for syrup recirculation back to the heat exchanger. The 3-way valve is an important element in the syrup section of the blending system because it confirms that the syrup is ready for blending. When the syrup passes the 3-way valve, it is pumped into a blender through three $^1/_4$-inch diameter discharge openings in a 1-inch diameter supply pipe.

Blending section

The blending section is the area where the white granulated sugar and the syrup are blended. The sugar is discharged into the blender first, and then it is mixed with the syrup under the correct conditions and proportions.

The blender is over 29 feet long and is made of stainless steel. It has two shafts rotating in opposite directions. Each shaft is made of solid stainless steel, and has a total of 109 adjustable paddles.

Every individual pitch on both shafts has all four paddles located at one of four angles, but in random sequencing. This is to minimize torque amplitudes when the paddles contact sugar during the rotation. The result is lower vibration, less power required and longer bearing life. Torque is transmitted to the shafts by the gear reducer, a chain drive and two spur gears. The shafts rotate at different speeds, giving variable output capacity, depending on demand from the packaging station. The blender has inspection and maintenance access covers along its total length.

The final 54-inch section of each shaft at the discharge end of the blender is fitted with $6^1/_2$-inch pitch ribbon flights, rather than paddles. This mechanism conveys blended sugar to one of three openings in the blender, as follows:

(1) 1-kg soft sugar packaging hopper.
(2) 1-kg auto-pack packaging hopper.
(3) 40-kg bag packaging station.

The first two openings are equipped with pneumatically operated slide gates which are opened or closed depending on the packaging station used. The 40 kg blender opening is always open and is used as a sugar "overflow" from the 1 kg packaging stations.

The blender's inspection cover next to the sugar and syrup inlet is always open approximately 2 to 3 inches and the full area is covered with $^1/_4$-inch S.S. mesh screen to prevent foreign objects from entering the blender. Also, as mentioned above, the opening for the 40 kg bag station is always open. This creates a natural air draft from one end of the blender to the other which eliminates the possibility of condensation forming on the inside of the blender; this would occur if the cover were left closed.

Packaging stations

Both the 1 kg Best Brown and the demerara sugars are packed at the soft sugar packaging station. The 1 kg Best Brown bags are manually collated and automatically bundled and the 1 kg demerara bags are manually baled. The Best Brown bundle comprises 24 × 1 kg bags and the demerara bale 20 × 1 kg bags.

The soft packaging station consists of Parsons electronic scales and a Bosch VFFS transwrap machine. The station is also equipped with an Icore checkscale and an Icore metal detector. 1 kg bags are produced at a speed of 19 bags per minute.

Both Best Brown and demerara sugars are packed in an open mouth multi-ply paper 40 kg bag. The bags are manually filled, weighed and sewn.

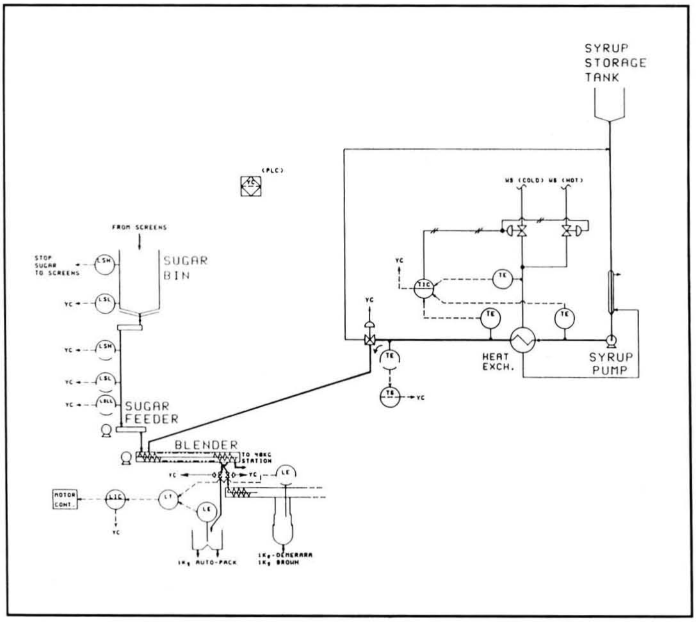


Figure 4. Simplified instrumentation control flow

LE	**Level element**
LIC	**Level indicating controller**
LSH	**Level switch high**
LSL	**Level switch low**
LSLL	**Level switch very low**
LT	**Level transmitter**
MOTOR CONT.	**Electric motor controller**
PLC	**Programmable logic controller**
TE	**Temperature element**
TIC	**Temperature indicating control**
TS	**Temperature switch**
YC	**PLC**

Systems control and synchronization

Blending systems control is performed by a Programmable Logic Control (PLC). In order to produce quality demerara or brown sugar by blending white granulated sugar and syrup, the following conditions must be met:

1. White granulated sugar must be of a specific grist.
2. Syrup must be of certain colour, moisture, pH, and temperature.
3. The ratio between white granulated sugar and syrup must be a constant at different output capacities.
4. Capacities for the sugar feed and syrup pump must be equivalent to the packaging stations demand.
5. If any of the previous conditions are not met, then the systems control will automatically discontinue the blending operation until those conditions are met.

The PLC will not start the blending operation until both sugar and syrup are available and until the syrup temperature is inside the acceptable range.

The level of the blended sugar inside the packaging station hopper is monitored by a radio frequency admittance type sensor. The major benefit of using this type of sensor is its immunity to sugar build-up. The sensor continuously monitors the sugar level inside the sugar supply hopper and feeds the information to the electronic controller. The output signal from the electronic controller is sent via a multiple speed ratio control module to the blender, sugar feed and syrup pump motors in order to alter their speed simultaneously while maintaining the preset constant ratio between them.

If for any reason, the level inside the supply hopper reaches a certain maximum level, the gate for blended sugar supply to the 1 kg packaging line will close. Blended sugar will then be conveyed to the blender's 40 kg opening and into an open mouth bag. This will not change until the packaging station resumes its operation and until the sugar level inside the supply hopper starts to go down. At this moment, the blender's 1 kg gate will reopen and the sugar supply to the 1 kg line will resume.

Syrup temperature is controlled by the water-syrup heat exchanger. The heat exchanger is capable of heating the syrup to the required temperature (82.5°C) in one pass. During lunch and coffee breaks, the white granulated sugar supply stops but the syrup is recirculated and kept at the operating temperature. Syrup temperature is kept below 85°C by introducing cold water to the heat exchanger.

The operator is provided with a switch in order to place the blending system in a stand-by mode if he wishes to do so for any reason.

The temperature of the hot water entering the heat exchanger and the syrup temperature leaving the heat exchanger are displayed at the packaging station control panel. The control panel at the packaging station gives the operator a visual and audible warning in case the preset parameters are not met. When it is operating in an automatic mode, the blending system for production of dark soft sugars does not require any supervision. This gives the operators time to concentrate their efforts on packaging rather than on production of the product.

Conclusion

To date, experience with the blending system for the production of dark soft sugar has been satisfactory. Blended sugars have less variation in colour and moisture and are easier to control on our flaker-type sugar feed to Parsons net weighers. Also, being able to produce and pack sugars at any time gave us considerable scheduling flexibility needed for our Process and Packaging Departments.

We experienced some problems with the formation of syrup balls. This problem was solved by the placement of a S.S. screen under the syrup outlets inside the blender and adjustment of the paddle angles. The adjustment of the paddle angles also eliminated the initial frequent overloading of the blender's drive. We found it was necessary to eliminate condensate formation on the inside of the blender. Condensate was rising up to the white granulated sugar feeder, moistening the dry sugar and creating a restriction in its flow. Restriction of white granulated sugar flow was gradual and over several shifts. Eventually, flow restriction of white granulated sugar was causing the blended product to increase in colour owing to a change in the sugar-syrup ratio. The majority of start-up problems have been eliminated and initially set goals of producing dark soft sugars in a mechanical blending systems have now been achieved.

Summary

The demerara and brown sugar blending system at B C Sugar is described. Background installation needs and reasons for the blending system are listed. Major mechanical blending system components and their control and synchronization are discussed. White granulated sugar and syrup specifications together with final product characteristics are presented.

Sistema de mezclado mecánico para azúcares oscuras suaves

Se describe el sistema de BC Sugar de mezclado de los azúcares morena y negra. Se menciona una lista de necesidades de la instalación básica y las razones del mezclado. Se discuten los componentes de los sistemas mecánicos de mezclado más importantes y su control y sincronización. Se presentan las especificaciones para el azúcar blanco granulado y para el jarabe, como también las características del producto final.

Système de mélange mécanique pour les cassonades brunes

On décrit le système utilisé au BC Sugar pour mélanger le sucre "Demerara" et le sucre brun. On établit une liste des besoins quant à l'installation et on cite les raisons de choix du système de mélange. On discute des composants majeurs du système de mélange mécanique, ainsi que de leur contrôle et de leur synchronisation. On présente des spécifications pour le sucre cristallisé blanc et pour le sirop. On donne aussi des caractéristiques du produit fini.

Mechanisches Vermischungssystem für dunkel Weichzucker

Beschrieben wird das System für Vermischung von Demerara- und Braunzucker bei BC Sugar. Eine Liste von Hintergrundserfordernissen hinsichtlich der Einrichtung und von Gründen für das System wird aufgestellt. Die wichtigste Bestandteile eines mechanischen Vermischungssystems und ihre Steuerung und Synchronisation werden diskutiert. Spezifikationen des granulierten Weisszuckers und des Sirops werden zusammen mit den Merkmalen des Endproduktes dargestellt.

BC Sugar: A technical overview of the Vancouver refinery

continued from page 87

power requirements are generated, with the remainder being purchased from the local power utility. The economics of steam/power requirements control this situation, which may vary from time to time.

Engineering and quality assurance

The Engineering Department provides technical support plus complete design for plant installations and alterations to existing systems. The Maintenance Department includes a full range of trades for plant repairs and modifications.

A 24-hour process control laboratory ensures in-plant quality control of process liquors and sugars. The Technical Control Laboratory, which includes a research facility, provides final quality assurance and ensures customer satisfaction.

Facts and figures

Paraguay sugar industry[1]

There are currently seven sugar factories in Paraguay with an installed capacity of 158,000 tonnes, against domestic consumption estimated at between 110,000 and 120,000 tonnes annually. There were 21,200 hectares of cane harvested in 1987 with an average yield of 49 tonnes/ha. During that year the crop was supplied by a total of 8200 growers, of whom 46% had a cane area of less than 1.5 hectares.

Dutch campaign results, 1989/90[2]

A total of 7.75 million tonnes of beets were processed during the recent campaign in Holland, and 1,141,000 tonnes of white sugar produced, 15% up from the previous campaign. The beet yield was 62 tonnes/hectare and the average sugar content 15.7%. The sugar yield of 9.9 tonnes/ha was a record.

1 *GEPLACEA Bull.*, 1990, **7**, (91), Sugar Inf. 2.
2 *Zuckerind.*, 1990, **115**, 72; F. O. Licht. *Int. Sugar Rpt.*, 1990, **122**, 85 - 86.

ISJ Abstracts

Cane sugar manufacture

The local area network at Darnall

P. M. Schorn. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 52 - 55.

A local area network (LAN) is a data network employing direct cable links between terminals in a local environment. The LAN installed at Darnall extends throughout the factory and administration building and has sub-systems such as a stores inventory and a planned maintenance scheme which are available to all users. Installation of a gateway to the Central Board of Cane Testing computer allowed access to laboratory data. A process control supervisory system is being linked to the network. The network and its components are described.

Washing with syrup in *A*-batch centrifugals

G. R. E. Lionnet. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 90 - 93.

See *I.S.J.*, 1990, **92**, 27A.

Double curing of *C*-sugar: why not?

L. M. S. A. Jullienne. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 100 - 103.

Double curing of *C*-sugar became unpopular in South Africa mainly because the introduction of the VHP sugar process allowed the sugar colour requirements to be met easily at most factories and because double curing tended to raise the minimum attainable low-grade massecuite purity. However, although the process became obsolescent as continuous centrifugals were being installed and was last used in 1985, the author suggests that current problems in maintaining the colour standards at some factories justify its reappraisal. Comparison with three processes introduced in recent years to improve sugar quality shows that the van Hengel modified boiling scheme[1] would (on the basis of trials at two factories) increase the volume and purity of *B*-massecuite to a greater extent than double curing, that a reduction in crystal size would be unlikely to give more than a 5% improvement in total raw sugar colour and that syrup clarification would be less effective than double curing as regards sugar colour and final molasses purity. Although double curing would give an average improvement in sugar colour of only about 10%, it could be operated together with crystal reduction and syrup clarification to give a combined effect of 20% colour reduction.

Self-discharging flat-bottomed centrifugal basket design

S. A. Gogate. *Bharatiya Sugar*, 1989, **15**, (1), 115, 117, 119, 121, 123.

Details are given of the design of a self-discharging centrifugal basket and of its method of operation.

Treatment of sugar factory effluent

-. Jamaluddin. *Bharatiya Sugar*, 1989, **15**, (1), 133, 135, 137, 139 - 140.

A proposed anaerobic/aerobic system for treatment of 400 m^3 of waste water per day at the author's factory is outlined.

Mill sanitation practices in sugar factories in Maharashtra state

S. S. Nimbalkar and S. J. Jadhav. *Bharatiya Sugar*, 1989, **15**, (1), 159, 161 - 162.

Results of a survey of mill sanitation practices in 54 sugar factories in Maharashtra during 1986/87 and 1987/88 are discussed. At 26 factories ammonium bifluoride was used alone or in combination with a Cl-based biocide (but its use has been banned in most countries because of its high stability and hence risk of residue in sugar, while Cl-based biocides are generally ineffective in a juice environment); quaternary ammonium compounds were used at another 7 factories, and a biocide containing dithiocarbamate was used at only one. Wide variation was found in the dosage rate and feedpoint. Advice is given on mill washing, criteria for assessment of the hygiene level and biocide application.

Core sampler installed

Anon. *Canefarm News* (Philippines), 1989, **14**, (1), 1 - 3.

A Cameco Industries cane sampling system installed at Victorias Milling Co. Inc. is described and illustrated; it includes a core sampler, cane breaker, hydraulic press and computer hard- and software.

Basic review of operability studies - possible application to the sugar industry

H. Farabi and W. A. Mellowes. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 25 - 33.

There are many potential hazards in sugar factory operations that can cause injuries and/or losses; some may be obvious while others may be the consequence of a combination of factors which individually are harmless. A hazard and operability study is described which includes a full description of the process including the intended design conditions, systematically examines every part of the process to find deviations from these conditions and decides whether these deviations could cause hazards. The operation of an evaporator station is used as example.

Cane payment and incentive systems at a truly egalitarian cooperative

N. Rozeff. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 41 - 55.

Details are given of the system of cane payment and financial incentives operated by Rio Grande Valley Sugar Growers Inc., a cooperative in south Texas owned and run by 100 farmers which includes a factory as well as cane harvesting and transport equipment, administrative and support services, etc.

1 van Hengel: *I.S.J.*, 1984, **86**, 149.

The problem of high-level manpower in the Trinidad and Tobago sugar industry

T. Lewis. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 56, 59 - 63.

The major problem discussed is the shortage of high-quality engineers in Trinidad and Tobago, so that the sugar industry depends on technologists from outside. Remedial measures are suggested, particularly involving the University of the West Indies.

The Supervisor

M. P. Arca. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 64 - 76.

The Supervisor is a program for use in an IBM microcomputer or compatible equipment that acts as an aid in the supervision of plant operation, maintenance and repair. Its application in the sugar factory is demonstrated.

Computer evaluation of processing options and decisions in cane sugar factory operations

S. J. Clarke. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 138 - 143.

The potential for computer application in the sugar factory is discussed. Possible uses include: (1) compilation of factory reports and accounts, (2) interfacing with instruments for process control, (3) calculation of the consequences of changes in cane quality, processes and equipment, and (4) process decision-making. Examples are presented.

Automation of weighing systems

S. A. Guzman H. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 159 - 165.

The performance of an electronic weighing system connected to a microcomputer for cane loads delivered at La Union sugar factory in Guatemala is analysed. During its first season of operation, the system recorded a weighing time (from arrival to departure of the vehicle from the platform) in the range 0.56 - 2.54 min and the probability of error was reduced from 4.24% to 0.14% (although the lower value was still considered too high in view of the fact that the information was used directly to pay the wages of cutters and equipment operators as well as to assess the performance of the loading, transport and unloading equipment). Occasional daily visits by a supervisor were needed but the requirement was gradually reduced throughout the season.

Automated cane receival data acquisition at Caroni (1975) Limited

R. L. A. Lake. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 166 - 191.

The modernization of the cane weighing systems at Brechin Castle and Ste. Madeleine sugar factories in Trinidad is described. The performances and benefits of the new systems, based on the use of load cells, a mini-computer and bar coding, are discussed.

Factory automation at Hawaiian Commercial & Sugar Co.

R. J. Kwok. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 192 - 204.

Computerized control of steam generation and cane processing at Paia and Puunene sugar factories is described. The objective was optimization of energy production and consumption and increase in the amount of electricity sold to the utility.

Steam economy and cogeneration in cane sugar factories

J. M. Ogden and M. Hylton. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 231 - 259.

Two cogeneration systems are described which include (1) a high-pressure condensing-extraction steam turbine as used in some factories in Hawaii and Réunion, and (2) a steam-injected gas turbine operating on gasified bagasse and able to produce about twice as much electricity for sale to the grid as system (1) although requiring some steam conservation measures. The beneficial effect of improved steam economy in increasing steam and power generation in such systems is discussed as well as integration of the systems with normal factory process requirements and the generation of surplus electricity as a function of process steam demand. Opportunities for steam economy in evaporation, juice heating and pan boiling are examined and some steam economy case studies analysed.

Automation at Hawaiian Commercial & Sugar Company

R. J. Kwok. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 205 - 219.

Aspects of computerized control at HC & S on the island of Maui in Hawaii are examined, including canefield operations and factory job control, compilation of laboratory reports, maintenance, etc.

Automation of boiler heat water

R. A. Echemendia. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 260 - 266.

While chemical treatment and draining will maintain the dissolved solids content in boiler water below the maximum permissible level, uncontrolled application of these measures will cause substantial monetary losses as well as leaving the equipment inadequately protected against incrustation and its adverse effect on heat transfer. An automatic surface blowdown system is described which, at a low solids concentration, could provide substantial savings in water and fuel by comparison with manual controls and ensure a clean heat transfer surface and prolonged boiler life.

Developing management software for the sugar industry

J. Alvarez. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 340, 343 - 347.

The concept of management software is explained and sources of such software suitable for the sugar industry are discussed.

Beet sugar manufacture

Juice purification with activated milk-of-lime

V. A. Loseva, I. S. Naumchenko, V. M. Perelygin, V. I. Gamayunov and T. P. Chernyshova. *Sakhar. Svekla*, 1989, (5), 49 - 50 *(Russian)*.

The reactivity of Ca hydroxide can be raised by increasing its solubility. Addition of ammonium chloride or HCl at respective rates of 0.0013 - 0.1924% and 0.0022 - 0.3709% on weight of lime to the water used for slaking has this effect and is the subject of a patent. The resultant increase in the positive charge of the carbonate particles formed in liming leads to greater non-sugars adsorption, while the high juice alkalinity permits increased degradation of reducing matter. In experiments at Livenskii sugar factory in 1985, addition of 0.003% ammonium chloride increased milk-of-lime activity by 10 - 17% and reduced the amount of unslaked lime by 2 - 4% as well as the juice lime salts, reducing matter and colour contents while increasing 2nd carbonatation and thick juice purity by 1.3 - 1.7% and sugar yield by an average of 0.15% on beet.

The plate evaporator - a new method in evaporation technology

H. Licha, P. Valentin, M. Wersel and G. Witte. *Zuckerind.*, 1989, **114**, 785 - 798.

Efforts to reduce steam consumption in factories of Süddeutsche Zucker-AG have necessitated increasing the heat surface area of evaporators, so that the typical system is a sextuple-effect evaporator consuming 25 kg of steam per 100 kg beets sliced as against a quadruple-effect evaporator consuming 40 kg/100 kg beets 10 years ago; the increase in specific heat surface area from 1.6 to 2.6 m² per tonne of beet has been met by installing falling-film evaporators for use primarily with juice of high Brix. Since the temperature difference between exhaust steam and the final effect vapour that is usable is constant regardless of the number of effects, the increase in pressure loss for each additional effect limits the extent to which an evaporator can be expanded in terms of heat economy, while increase in the heat surface area increases sugar degradation and juice coloration as a result of the greater residence time; the additional colour introduced with the thick juice into the pans leads to higher steam consumption. The design and method of operation of a plate evaporator are explained, and an experimental unit of 50 m² h.s. installed at Waghäusel as 1st effect (in which five different plate designs were tested) is described; subsequent design modifications were carried out and a plate evaporator of 1225 m² h.s., made up of a pressure vessel housing an Alfa-Laval unit and a plate evaporator from another manufacturer, was tested on an industrial scale during 1988/89 parallel to the existing Roberts evaporator. (Four Alfa-Laval plate evaporators were first operated parallel to Roberts evaporators used as 3rd and 4th effects in the Wissington factory of British Sugar plc in 1987/88.) Results of the trials showed that, under identical conditions, heat transfer in the plate evaporator was greater and the scale of inversion and colour formation smaller than in a Roberts unit. While the total operating time, with frequent starts and stops, was inadequate for conclusions to be drawn on scale formation, the plate evaporators at Wissington operated for 3000 hours without the need for cleaning.

Experiences in the use of adaptive control of a technological process

P. Svarc. *Listy Cukr.*, 1989, **105**, 224 - 230 *(Czech)*.

Adaptive control is a system that is self-adapting to unknown conditions unlike a conventional digital control system that will act regressively to compensate for any disturbances. An adaptive control algorithm was developed and its validity confirmed by computer simulation, after which it was introduced at a sugar factory for control of the remelt liquor temperature. Assessment of the performance of the controller showed that it reacted more rapidly to changes in temperature than did a standard PSD controller.

Mathematical modelling and simulation of the sugar extraction process

A. Korgul. Indian Sugar, 1989, 39, 273 - 280.

See I.S.J., 1988, 90, 128A.

The effect of topping height on beet yield and technological quality. I. Model laboratory tests and field operation experiments. II. Beet storage properties and technological parameters in separate factory processing

I. J. Zahradnicek, M. Duffek, L. Schmidt, V. Smatlak, B. Ticha and M. Bohackova. *Listy Cukr.*, 1989, **105**, 193 - 206. **II.** J. Zahradnicek, B. Ticha, M. Duffek, V. Smatlak and M. Bohuslavska. *ibid.*, 241 - 250 *(Czech)*.

I. The different morphological sections of the beet (crown hypocotyl and the true root) were analysed and their chemico-technological values determined. The results were used to establish the main technological properties of beet harvested by scalping and by removal of the leaves only. In subsequent 3-year field tests at two locations these two variants were compared with conventional topping and showed that they could increase beet yield by an average of 13% (scalping) and 16% (removal of leaves) as well as total sugar yield, but with a marked deterioration in processing quality as expressed by a lower pol content and a relatively high noxious non-sugars content.

II. The effects of (1) scalping, (2) normal topping and (3) removal of leaves alone on beet storage and processing at two separate factories were determined during 1986/88. Scalping gave the best storage properties in the first year and gave slightly better results than the other two variants in the second year, but in the third year normal topping gave the best results at one factory, with sugar losses two-thirds lower than occurred with (3), whereas at the other factory variant (2) gave worse storage properties than (3) as a result of greater impurities contents and contamination. However, beets harvested by variants (1) and (3) caused increased consumption of anti-foam agents, disinfectants and energy as well as labour requirements, gave a lower sugar yield and had poorer processing properties than normally topped beets.

RT diffusers

V. Hajek. *Listy Cukr.*, 1989, **105**, 259 - 261 *(Czech)*.

Descriptions are given of RT5 and RT5-E diffusers which are being built under licence in Czechoslovakia and installed in that country's sugar factories as part of a major modernization plan.

Filter-presses

J. Seiner. *Listy Cukr.*, 1989, **105**, 261 - 262 *(Czech)*.

Technical data are given on Czechoslovakian LF manual and LFP semi-automatic filter-presses provided with aluminium alloy or polypropylene plates. The largest are the LFA 1250 and LFA 1250-P having a filtration surface area of 312 m^2 (provided by 100 plates) which operate at a nominal feed pressure of 1.6 MPa and a maximum filter pressure difference of 31 MPa on carbonatation juice containing mud particles no larger than 0.2 mm. Maximum juice temperature is 85°C and its pH 7 ± 1.

The effect of operational factors on extraction rate and efficiency in inclined diffusers

A. I. Fel'dman, N. N. Pushanko, V. I. Asaulyuk, A. V. Emel'yanenko and E. V. Minenko. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 10 *(Abstract only)*.

The effect of throughput, scroll rotary speed and particle size of the solid phase on mass transfer rate and extraction efficiency was investigated with allowance being made for the real values of hydrodynamic parameters (mean integral residence time and coefficient of longitudinal mixing) of the cossettes-juice mixture in DDS twin-scroll diffusers. The localized values of the mass transfer coefficients were determined throughout the length of a DDS-30 diffuser under varying operational conditions and extraction efficiency values obtained using a mathematical model which took account of flow pattern. Optimum conditions for operation of the diffuser were established.

Investigation of anaerobic treatment of beet sugar factory process waste waters

A. G. Novak, V. A. Lagoda, G. M. Solovets, S. P. Tsygankov, R. N. Kramarenko, A. A. Ostrovskaya and T. A. Martynenko. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 49 *(Abstract only)*.

The possibility of a high degree of purification (85 - 90%) by batch anaerobic treatment of factory waste water was demonstrated. Kinetic and stoichiometric data obtained for the process may be used to establish theoretical fundamentals of both batch and continuous anaerobic processes.

Experience in biological treatment of beet sugar factory process waste waters

V. A. Lagoda, G. M. Solovets, V. S. Samoilenko, R. N. Kramarenko, S. P. Tsygankov and E. V. Grek. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 49 *(Abstract only)*.

Methods of biological treatment of waste waters at beet sugar factories in the USSR and other countries are assessed and the advantages of anaerobic over aerobic processing are indicated. A scheme is proposed which incorporates an anaerobic mesophilic stage with recirculation of the activated mud, aerobic treatment in an aeration basin or biofilter and recycling of the surplus aerobic activated mud to the methane tank; a 99.0 - 99.5% reduction in pollution load is possible.

Examination of the mechanism of formation of local accumulations of the solid phase in industrial twin-scroll inclined diffusers

V. I. Asaulyuk, A. I. Fel'dman, N. N. Pushanko, A. V. Emel'yanenko, E. V. Minenko and L. V. Zotkina. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 65 *(Abstract only)*.

The hydrodynamic conditions in industrial twin-scroll diffusers have been analysed in interconnexion with the structural and mechanical properties of the juice-cossettes mixture. The relationships between these juice-cossettes properties and the period and intensity of their heat treatment are presented and conditions established under which there is greatest probability of formation of local solids accumulation.

The effect of operational factors on the hydrodynamics of the streams of interacting phases in twin-scroll inclined diffusers

V. I. Asaulyuk, A. I. Fel'dman, E. V. Minenko and A. V. Emel'yanenko. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 65 *(Abstract only)*.

The effect of throughput, operational parameters of the transport elements and of the weight ratio between the interacting phases on the hydrodynamics of the flow streams in DDS twin-scroll inclined diffusers was investigated. It was found that during diffusion targeted or random disturbances may arise; as a rule they are introduced with the incoming streams or may be caused by a change in the operation of the transport elements and take the form of a change in residence time and in the degree of longitudinal mixing.

Experimental investigation of the hydrodynamic conditions of crystal growth in a sectioned continuous vacuum pan

A. K. Sushchenko, I. S. Gulyi, T. P. Grishagina and I. V. Biryukov. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 97

(Abstract only).

A qualitative analysis of a continuous vacuum pan was carried out and quantitative characters of the flow streams obtained. Experimental evaluation of the design of a sectioned vacuum pan was obtained by constructing response curves for each section. An investigation of the mother liquor-crystal phase streams was undertaken.

Examination of the kinetics of monosaccharide degradation under preliming and main liming conditions

L. I. Tanashchuk and N. A. Arkhipovich. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 99 *(Abstract only).*

It was found that Ca^{++} ions have a catalytic effect on invert sugar degradation in preliming and main liming. The reaction rates of invert sugar degradation were determined at pH 12.5 and at temperatures in the range 40 - 90°C.

A computer program for material calculation of products of beet sugar manufacture

V. V. Maiorov and V. M. Fursov. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 106 *(Abstract only).*

A program has been developed for an OCA 23. FOR computer and tested for material calculation of beet sugar factory products and of heat consumption in the diffuser, juice purification and crystallization stations of a factory. The program allows eight variants of processing schemes to be examined and up to 50 heat and process parameters to be calculated in each.

Experimental modelling of periodical temperature fluctuations in crystallizers

I. S. Gulyi, L. A. Kupchik and Yu. A. Dashkovskii. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 107 *(Abstract only).*

An investigation was conducted on the temperature level at the heat exchange surface, in the mother liquor and within crystals of sucrose and aluminium-ammonium sulphate obtained from aqueous solutions where temperature was subjected to periodical fluctuations in crystallizers. Analysis of the amplitude, frequency and phase shift occurring during the alternate heating and cooling of the system components may be used to calculate thermal and process parameters in a crystallizer to allow throughput to be determined and crystal granulometry to be predicted and may also be used for a study of redistribution of temperature and mass of the crystallizing substances resulting from recrystallization.

The role of pressing in raising the efficiency of extraction

Yu. A. Zayats, A. V. Lysikov and V. M. Lysyanskii. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 109 *(Abstract only).*

A survey is presented of juice extraction methods in the beet sugar industry. An analysis of factors determining the design and process parameters of the methods examined indicates the routes to follow to increase the extraction efficiency of diffusers. The promising role of a combination of pressing and diffusion technology used to create a high-capacity diffuser is noted.

Investigation of the kinetics of heating a juice-cossettes mixture with open steam

A. I. Fel'dman, A. V. Emel'yanenko, V. M. Lysyanskii and V. I. Asaulyuk. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 111 *(Abstract only).*

An experimental unit was used in an investigation of the kinetics of heating a juice-cossettes mixture with steam of varying potential fed into a heating chamber and with open steam fed directly to the mixture. The effects on the temperature of the juice-cossettes mixture of heating time with the different methods of heat supply, with varying specific charging of the unit with cossettes and with varying rotary speed of the mixer were established. It was found that the most effective method of heating the mixture was treatment with open steam.

Influence of some design features on the operation of a DDS diffuser

E. Carrocchi. *Ind. Sacc. Ital.*, 1989, **82**, 179 - 184, 186, 188, 190, 192, 194 *(Italian).*

Inadequacy and considerable fluctuations in the hourly throughput (<100 tonnes/hr) of the DDS diffuser (of 2400 tonnes/day nominal capacity) at Fermo sugar factory were found to be mainly caused by failure of the twin scrolls to provide sufficient forward movement of the cossettes to which was added the adverse effect of the counter flow of liquid; the problem stemmed from the excessive space between the intermeshing scrolls at a certain point in their rotary movement. Increasing the size of the flights reduced the space between them on the corresponding left- and right-hand scrolls and ultimately raised the throughput to 130 tonnes/hr at which level it tended to stay fairly constant; the sugar losses in pulp also fell.

Heat transfer in a vacuum pan at an extremely small temperature differential

K. E. Austmeyer, D. Schliephake, B. Ekelhof and G. Sittel. *Zuckerind.*, 1989, **114**, 875 - 878 *(German).*

The possibility is discussed of reducing energy consumption by using double-effect evaporation in continuous boiling whereby all the vapour from the first of two stages in an evapo-crystallization system is used to heat the second stage. However, it is essential to be able to operate with extremely small temperature differentials (<20°C); tests showed that this was possible where massecuite stirrers were used. In tests, heat transfer coefficients tended to be unaffected by the presence or absence of a massecuite stirrer where the temperature differential was sufficiently large but were markedly different with forced and natural circulation where the temperature drop was small, and sedimentation occurred at <20°C where there was no forced circulation. The heating steam consumption could be reduced by up to 54% depending on the boiling system used.

Facts and figures on the Eemshaven sugar terminal

J. H. Boersma. *Zuckerind.*, 1989, **114**, 879 - 884.

See *I.S.J.*, 1990, **92**, 33A.

Technical aspects of reducing production costs

N. R. Twaite and A. J. N. Warnes. *Zuckerind.*, 1989, **114**, 889 - 897.

Advances made in sugar manufacture at the factories of British Sugar plc over the last 20 years are reviewed, including measures to reduce energy and labour costs.

Investigations on the angle of friction of sugar in silos

M. Kaminski. *Zuckerind.*, 1989, **114**, 898 - 901 *(German)*.

Investigations are reported on the inner angle of friction and of the angle of friction of sugar at the wall of a silo. A special device was used to measure the normal and tangential components of stress in the thrust plane of sugar samples of varying bulk density, grain size and moisture content. The inner angle of friction ranged from 26°48' for loose, moist sugar of 0.06 - 2.0 mm grain size to 37°24' for air-dried, compacted sugar of the same size range, while an angle of 39° applied to a loose, air-dried sugar of 0.06 - 0.75 mm. Values of the angle at the silo wall as measured with steel and concrete membranes ranged from 19°24' to 26°06'.

Storage of injured and wilted beets

N. N. Gorbunov. *Sakhar. Svekla*, 1989, (6), 35 - 36 *(Russian)*.

A good proportion of the beets harvested in the Soviet Union is unsuitable for storage because of a high soil and leaf content, wilting, frosting or injury; there is noticeable increase in daily sugar losses with injury, and the highest losses occur where the crown has been removed. The question of topping height is discussed in relation to storage period; the height may be lower for beets due to be processed immediately after reception, but beets to be stored should be cut at a point just above the leaf bud. Forced ventilation helps to reduce the losses where many of the beets are damaged; spraying with sodium sulphite is beneficial with wilted beet while spraying with disinfectant is considered essential with all beet.

Operational supervision and calculation of the balance of the main production

A. L. Antonovich and V. K. Kuz'menko. *Sakhar. Svekla*, 1989, (6), 41 - 43 *(Russian)*.

A system of overall monitoring, material balance calculation and automatic control of the beet end and sugar house is described in which sugar production is made up of two "storehouses" characterized by a change in the amount of sugar with time. The appropriate mathematical equations for sugar balance, output and loss are defined and a control scheme for the beet end is presented.

Automatic control of limed juice alkalinity

Z. S. Voloshin, V. N. Shalatonov and A. R. Sapronov. *Sakhar. Svekla*, 1989, (6), 45 - 46 *(Russian)*.

Since measurement of the pH of defecation juice is not suitable for automatic liming control because of the considerable excess of lime in the mud, the validity of the pH of a mixture of limed and unlimed raw juice in the ratio range 1:4 - 1:10 as control parameter was investigated. Results demonstrated the dependence of the pH and its range of changes on limed juice alkalinity and raw juice pH as well as on the proportion of the two juices in the mixture, with a pH change of approximately 0.25 - 0.30 units corresponding to 0.1% CaO. (With dilution of the mixture, its pH considerably reflected that of the raw juice.) In factory tests, the two juices were fed under gravity to a mixer in a proportion controlled by valves receiving signals from a pH meter provided with an online sensor. Results indicated a pH variation of ± 0.2 units, permitting a reduction in lime consumption to 0.1% on beet. Greater accuracy could be achieved by measuring the pOH with simultaneous stabilization of raw juice pH, in which case the limed juice alkalinity value obtained could be applied directly to the milk-of-lime doser or used to correct the proportion of milk-of-lime to raw juice.

Cleaning the internal heat surfaces of boilers

V. G. Boiko. *Sakhar. Svekla*, 1989, (6), 50 - 51 *(Russian)*.

A 3 - 5 mm thick tarry deposit on boiler tube surfaces caused by caramelization of sugars and carbonization of carbohydrates in condensate used as feedwater was removed completely by 20 - 30 hours' treatment at 200°C with solutions of NaOH, soda ash and Na silicate.

Sugar solubility and molasses exhaustion. I. Simple calculations. The sugar solution separation function

L. Megyeri. *Cukoripar*, 1989, **42**, 143 - 149 *(Hungarian)*.

Mathematical expressions for sugar solubility are summarized and their application demonstrated by means of simple examples. A boiling house "separation function" (the interrelationship between the purities of massecuite and mother liquor) is introduced which permits comparison of different boiling schemes with particular attention to sugar solubility. The significance of solubility for a given scheme and for molasses exhaustion is discussed.

Starch based sweeteners

Sugar manufacture from plants other than sugar beet

K. Vukov. *Cukoripar*, 1989, **42**, 73 - 75,105 - 108 *(Hungarian)*.

A survey is presented of sugar and syrup manufacture from cane, sorghum, maple, palm dates, chicory, Jerusalem artichoke, maize and starch, as well as isomerization of glucose to fructose. The processes used are outlined.

High fructose corn syrup: examining worldwide trends

S. Vuilleumier. *Sugar y Azúcar*, 1989, **84**, (10), 14, 16, 18 - 19, 22 - 23, 26 - 27.

The current HFS situation in the USA and other countries and the world outlook are surveyed. Whereas North America accounted for 75% of the world HFS in 1982, by 1990 this was expected to have fallen to 70% with most of the increased production taking place in Asia; world production is expected to increase to about 8 million tonnes as against 4 million tonnes in 1982. World sugar consumption in 1990 was expected to be 110 million tonnes, with HFS representing about 20% of the increase in nutritive sweetener demand.

Cargill continues to expand corn milling operations

Anon. *Sugar y Azúcar*, 1989, **84**, (10), 28.

The corn wet milling activities of Cargill Inc. in the USA and other countries are outlined, with mention of plans to increase production of sweeteners and HFS.

Looking at today's US corn sweetener industry

R. C. Liebenow and K. D. Brenner. *Sugar y Azúcar*, 1989, **84**, (10), 33 - 34, 36.

The development of the HFS industry in the USA is outlined and future trends briefly discussed.

Enzymatic hydrolysis of non-starch biomass for the industrial production of sugars

J. L. Baret, M. Leclerc, Y. Gicquiaux, F. Brouard, B. Feng and R. de Baynast. *Ind. Alim. Agric.*, 1989, **106**, 621 - 627 *(French)*.

Liquozyme PCB is a mixture of products more or less rich in cellulases, hemicellulases and pectinases which can be used to liquefy roots such as beet, chicory and Jerusalem artichoke and to modulate the range of sugars present in the hydrolysate by compositions having greater or lesser β-glucosidase and invertase/inulinase activity. The manufacturer, Novo Nordisk A/S (formerly Novo Industri A/S), has developed a process in collaboration with ARD for liquefaction and saccharification of beets to yield (in a pilot plant trial) a hydrolysate containing 176 kg of total fermentable sugars (expressed as glucose) per tonne of beets and having a Brix of 9.6°. These results were considered sufficiently encouraging to justify construction of a small-scale plant having a daily processing capacity of 10 tonnes of beet of various types and able to process starch-containing raw materials such as wheat and corn meal and crushed wheat. Also proposed is a process of beet prehydrolysis followed by addition of yeasts and then simultaneous liquefaction and fermentation to alcohol at 30°C; a fermentation substrate could also be obtained by combined purification of hydrolysates from wheatmeal and beet. Mention is also made of inulin and fructose production from chicory and Jerusalem artichoke.

Carbohydrate composition and molecular structure of dextrins in enzymatic high-conversion starch syrups

E. Nebesny. *Starch/Stärke*, 1989, **41**, 431 - 435.

High-conversion syrups obtained by refining and concentration of starch hydrolysates of 60 - 70 DE and containing 35 - 45% glucose and 30 - 40% maltose on dry solids are used in a number of food industries. In an experiment, a 35% potato starch slurry liquefied with bacterial α-amylase to 13.6 DE was saccharified with a combination of fungal α-amylase and glucoamylase at varying enzyme ratios. During the 44 hours of saccharification, samples were taken at intervals for determination of the DE value, carbohydrate composition, molecular structure of the dextrins and viscosity at 35°C. Results demonstrated the changes with progress of hydrolysis and the effects of enzyme ratio, form and separate or combined use on changes in the properties studied.

Sugar substitute sweeteners: high fructose corn syrup

Anon. *GEPLACEA Bull.*, 1989, **6**, (12), 10 pp.

The characteristics of HFS, its production costs and world consumption are discussed, followed by a more detailed analysis of the HFS situation in the USA, Japan and the EEC and brief mention of other countries.

An improved scheme for crystallization of glucose hydrate

V. S. Shterman, M. S. Zhigalov and I. N. Nesterova. *Pishch. Prom.*, 1989, (10), 36 - 39; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (2), Abs. 2 R1460.

An improved two-stage scheme for glucose hydrate crystallization is proposed in which greater use is made of the advantages of acid-enzymatic hydrolysis of starch. For the process, which allows a 35 - 40% reduction in the crystallization time, the glucose massecuite must be cooled very rapidly in the 1st crystallization stage; however, the relatively small ratio of cooling surface area to massecuite volume makes it difficult to achieve high cooling rates in horizontal trough-type crystallizers, so that new forms of crystallizer need to be designed for the glucose industry.

Laboratory studies

Alternative methods of polarizing sugar

C. C. Chou. *Indian Sugar*, 1989, **39**, 211 - 223.

See *I.S.J.*, 1988, **90**, 8A.

Beet sugar colorant: recent studies

M. A. Clarke, M. A. Godshall, R. S. Blanco and G. T. Perret. *Paper presented to Int. Sugar Tech. Conf.* (Killarney, Ireland), 1989, 18 pp.

A brief review is presented of research on colorants in beet, factory intermediate products and beet sugar followed by details of more recent studies on high molecular weight colorants. Material having a molecular weight greater than 12,000 daltons [referred to as very high molecular weight (VHMW) colorant] was found in all molasses, raw sugar and process materials investigated as well as in many white sugar samples. White sugar samples showed a peak at 20,000 daltons, representing a clear, yellow colour which may be the material that is very difficult to remove in process and persists in even the highest quality sugar crystal. A pale buff colour having a peak at 800,000 daltons was not found in all white sugars but was present in samples in which colouring matter developed during storage; this peak may be associated with a soluble colorant-polysaccharide complex that preferentially enters the crystal during crystallization and, during storage (particularly at high temperatures), could undergo de-esterification to release colorant. De-esterification may also occur in process at high alkalinity, but the resultant colorant would no longer be associated with polysaccharide and so would be less likely to cocrystallize with sucrose; this type of colorant possibly contributes to the observed differences in crystallization behaviour of liquors from carbonatation (where the pH is high enough to hydrolyse the ferulic acid groups off the polysaccharide) and phosphatation (where the pH is lower). Alkaline decomposition of invert sugar also contributes to this phenomenon. Data showed 47% removal of polysaccharides by carbonatation and their concentration in molasses; both molasses and raw sugar colorant showed increasing quantities of VHMW colorant, and a peak at 300,000 in raw sugar may represent polymeric colorant that forms in process where it is broken down or eliminated. Residues of this material in molasses raise the MW of the peak at 20,000 daltons and create a typical VHMW colorant profile with a large shoulder on the high side. Darker coloured raw and white sugar samples were found to have a greater proportion of colour in the outer syrup coating and a smaller proportion in the crystal. Where darkening occurred during storage, well over 50% of the colour was found in the outer coating, demonstrating the importance of washing sugar that is to be stored. While more total and VHMW colorant was removed during carbonatation at pH 11 than at pH 10, the proportion of low MW colorant in thin juice increased with pH; while some of this increase could be attributed to monosaccharide degradation, it is also possible that some of it is due to breakdown of a HMW polysaccharide-colorant complex.

Polyphenolic colorants in sugar manufacture

I. F. Bugaenko and A. A. Yasin. *Sakhar. Svekla*, 1989, (5), 59 - 60 *(Russian)*.

Model solutions of polyphenols were obtained by sucrose caramelization at 140°C in a desiccator, by thermal degradation of monosaccharides under alkaline conditions and by melanoidin formation (for both of which reactions lime water at pH 12 was used instead of a buffer solution so as to approximate to factory conditions); during heating, samples were taken at intervals, their pH adjusted to 7, their optical density measured at 540 nm and the amount of colouring matter determined that could be eluted from anion exchange resin by acidified aqueous alcohol (found to be 10% of the total for the three groups). Their spectra were practically identical and were the same as those of colouring matter isolated from white sugar and molasses. The colour intensity of all three solutions changed reversibly with pH; its rise with increase in pH from 1.2 to 6.5 and subsequent fall was attributed to tautomeric isomerism and associated intramolecular regrouping of atoms. The colorants were considered to have properties close to those of colorants formed from a hexose reductone and were found to contain two molecules of a phenol which greatly determined their properties.

The use of a robot for juice analysis

P. G. Everitt, J. Smit and V. Mason. *Sugar J.*, 1989, **52**, (2), 8 - 12.

See *I.S.J.*, 1990, **92**, 9A.

Determination of sucrose in mixed juice and final molasses by the Jackson and Gillis method (Method IV)

A. Dunsmore and J. Thelemaque. *Proc. 63rd Ann. Congr. S. African Sugar Tech. Assoc.*, 1989, 73 - 75.

See *I.S.J.*, 1990, **92**, 23A.

Comparative study of sucrose, glucose and fructose determination by classical methods and HPLC

S. Zaam. *Sucr. Maghrebine*, 1989, (39), 4 - 7 *(French)*.

The principle of HPLC is explained and the various components described. Sucrose determination in beet brei and cane juice using Lichrosorb NH2 as stationary phase and 80:20 acetonitrile:water as mobile phase with a refractive index detector. After sample clarification with lead acetate, separation of sucrose, glucose and fructose took <20 min. Comparison with polarimetry showed differences in the results which were more marked in the case of the cane juice samples, averaging 1.16 units (a maximum of 3.03) with polarimetry giving higher values in all but two out of the twenty samples; for the 20 beet brei samples, the average difference was 0.60 (a maximum of 1.82) and polarimetry gave higher values in 15 cases. Comparison between the HPLC values for (glucose+fructose) and results given by the Berlin Institute method for reducing sugars in 11 beet brei samples showed that HPLC gave a higher result in only one case, and the maximum difference was 0.52 units.

Instruments for monitoring the colour of sugar and products of sugar manufacture

T. R. Topalo, T. F. Burlyai, A. A. Petrenko and L. N. Chernyavskaya. *Tez. Dokl. Nauch.-Tekh. Konf. Mol. Uchenykh i Spets. (Vopr. Povysh. Effektiv. Sakh. Proizv.)*, 1989, 64 - 65; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (21), Abs. 21 R1462.

A photocolorimeter KFK-3 developed and manufactured for the sugar industry has been checked by the USSR State Examining Commission. It is designed to measure the coefficient of transmission, optical density and concentration of solutions after calibration using standard solutions. It operates in the range 315 - 980 nm. A diffraction grating is used for dispersion, a KGM-12-10 halogen lamp as light source and a FD 2886 photodiode as light receiver. The permissible absolute error is ± 0.5 (abs.) and the complementary error does not exceed ± 0.8 (abs.). A set of cells 5, 10, 20, 30 and 50 mm long is provided. Voltage is 220 V. Measurements of the coefficient of transmission, optical density, rate of change in optical density and concentration and of wavelength appear in illuminated digital form on a screen. The instrument is suitable for determination of α-amino nitrogen in beet and process products.

Development of a non-toxic clarifying agent for analysis of beet sugar products and intermediate products

N. I. Khomutetskaya and A. A. Lipets. *Tez. Dokl. Nauch.-Tekh. Konf. Mol. Uchenykh i Spets. (Vopr. Povysh. Effektiv. Sakh. Proizv.)*, 1989, 65 - 66; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (21), Abs. 21 R1461.

Positive results were obtained in laboratory studies when a complex clarifying agent containing varying amounts of aluminium salts, CaO, chloramine and ammonium phosphate was used to treat raw juice. The proposed mixture has the advantages over lead salts of being non-toxic, cheap and containing components that are in good supply.

The rate of sugar dissolution in water

E. A. Knyazev and O. A. Ulitin. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 38 *(Abstract only)*.

The rotary disc method was used to show that the rate at which sugar dissolves in water is governed by the rate of diffusion of the sugar molecules and depends on the mixing speed. At a speed of 10 - 170 rps the rate of dissolution of melted sugar rose from 0.3×10^{-5} to 1.3×10^{-5} mol/cm²/°C.

Determination of reducing sugars with a 2,4-dinitrophenolate-selective membrane electrode

P. Gritzapis and M. Timotheou-Potamia. *Anal. Chim. Acta*, 1989, **218**, (1), 37 - 46; through *Anal. Abs.*, 1989, **51**, Abs. 12D74.

Internal reference solution (0.01M 2,4-dinitrophenolate - 0.1M NaCl) and the liquid ion exchanger solution (0.01M tetrapentylammonium dinitrophenolate in 2-nitrotoluene prepared by a method which is described) were injected into the appropriate ports of an Orion Series 92 electrode body. For the kinetic determination of fructose (**I**), glucose (**II**) or galactose (**III**), 20 ml of 2,4-dinitrophenolate - NaOH solution (A) was thermostatted at 30°C (**I**) or 60°C (**I, II** or **III**) in the reaction cell, 2 ml of sample solution was injected, the reaction rate was recorded and a calibration graph plotted of initial rate *vs.* sugar concentration. In the potentiometric method for **I** and **II** and for **II** in the presence of **I**, 20 ml of (A) was boiled for 5 min with 1 ml of sample solution or water for the blank, the mixture cooled and the potential measured with the electrode described. Typically, calibration graphs were rectilinear for 30μM - 0.01M 2,4-dinitrophenolate.

Control of sugar polarization and moisture using near infrared reflectance analysis

R. V. Ames, S. W. Norton and H. H. Nguyen. *Sugar J.*, 1989, **52**, (4), 7 - 10.

See *I.S.J.*, 1990, **92**, 9A.

Automation of analyses of sugar cane juice samples

B. L. Legendre and W. H. Thibaut. *Proc. Inter-Amer. Sugar Cane Seminar*, 1988, 220, 223 - 229.

One of the functions of the Sugarcane Research Unit of the US Dept. of Agriculture is the annual analysis of 5000 - 10,000 cane samples each consisting of 5 - 15 stalks harvested in trial fields. Each sample is weighed electronically, the juice extracted with a 3-roller mill or prebreaker + hydraulic press and analysed for Brix and pol. The refractometer and polarimeter are interfaced with a desk-top microcomputer for data storage and processing. Operation of the system is described.

Atomic spectroscopy and its possible application in the sugar industry

E. Megyeri-Kánya. *Cukoripar*, 1989, **42**, 150 - 155 *(Hungarian)*.

Aspects of atomic spectroscopy are discussed, including: various techniques such as atomic absorption, emission and fluorescence spectroscopy; atomization, particularly flame, electrothermal and plasma inductively-coupled atomization; light sources; atomic emission; and selection of suitable technique. Possible applications in the sugar industry are briefly considered, including sugar analysis for metals, determination of total cations in molasses and cossettes, corrosion monitoring and beet and soil analysis.

Evaluation of a high-speed disintegrator

Anon. *Ann. Rpt. Mauritius Sugar Ind. Res. Inst.*, 1988, 41 - 42.

Tests are reported on a disintegrator having a maximum rotor speed of 10,000 rpm for wet treatment of bagasse prior to polarimetry as an alternative to the current practice of hot digestion. Satisfactory disintegration comparable to that given by hot digestion was obtained at a water:bagasse ratio of 18:1 and application of the maximum speed for 10 min, at which the method was much faster than hot digestion. It is concluded that adoption of the method would eliminate the lack of standardization inherent in hot digestion (results of which depend on sample size, water: bagasse ratio and boiling intensity). However, at a water:bagasse ratio of 10:1, as recommended by the ISSCT, disintegration was frequently hampered by pads of bagasse that wrapped around the rotor; a more powerful model of the disintegrator was to be tested with a view to using the lower ratio.

Determination of ash elements using ion-selective electrodes

A. L. Shoikhet, L. I. Chernyavskaya, T. F. Burlyi and I. V. Zakharova. *Sakhar. Svekla*, 1989, (6), 38 - 40 *(Russian)*.

Two variants of a method for determination of K and Na are described in which the test solution, after suitable dilution, is added to a standard KCl and NaCl solution. In the addition method, the optimum dilution was obtained by preparing 8 - 10 working solutions of varying concentrations from a mother solution and measuring the K and Na concentration using both ion-selective electrodes and flame photometry; 5 - 10 g of thick juice of 60 - 65°Bx was best diluted with 1 litre of solution at which the difference in concentration between the two measurements was lowest. Where dilution is inadequate, the results are adversely affected by the higher viscosity (particularly caused by sucrose) and greater ionic strength (which affects electrolyte activity). For 2nd carbonatation juice, beet molasses of 80 - 85°Bx , refinery molasses of 70 - 75°Bx and liquid sugar of 72°Bx, the optimum quantities in 1 litre were 200, 1.5 - 2.0, 2.0 - 2.5 and 13 - 18 g, respectively. The differences in results between use of ion-selective electrodes and flame photometry were ± 9.8% for Na and ± 6.6% for K. In the potentiometric variant, a calibration curve is plotted from standard model solutions obtained by adding $CaSO_4$, $CaCO_3$ and $MgSO_4$ to the test solutions. Guidelines are given on volume and concentration of the standard solutions added in both variants.

Saponin determination in waste water

V. V. Sakhnenko, M. V. Issa and V. M. Zaitseva. *Sakhar. Svekla*, 1989, (6), 51 - 52 *(Russian)*.

Saponin in waste water causes abundant foaming, disrupts treatment processes and causes an obnoxious smell. For its determination down to 0.2 mg/litre at an error not exceeding ± 5%, a 200-ml sample in a 500-ml flask is acidified with HCl to pH 0.30 - 0.35 (possibly after dilution or evaporation to give a saponin content in the range 0.04 - 2.0 mg), boiled on a sand bath for 20 min, cooled to room temperature and filtered using a Schott No. 4 filter with a thin layer (about 3 mm) of kieselguhr. The solids are dried during 1 hour at 103 - 105°C and the saponin extracted with 15 ml hot glacial acetic acid while the filtrates are collected in a test tube and filtered *in vacuo*. The extract is mixed with 7.5 - 10.0 ml sulphuric acid in a 100-ml flask which is sealed and placed in a boiling water bath for 20 - 25 min followed by cooling to room temperature; the colour of the solution is measured at 400 nm and the saponin content found from a calibration curve for standards of up to 10 mg/litre.

Composition of the 1988 Louisiana final molasses

M. Saska. *Sugar J.*, 1989, **52**, (5), 13 - 15.

Samples of molasses from Louisiana sugar factories were analysed for refractometric Brix, total dissolved solids (calculated from the Brix), sucrose, glucose and fructose by GLC, conductimetric ash, K by flame photometry and Na, Ca, Mg, Fe, P and Cu by atomic absorption spectroscopy. Target purity was also calculated. The results, which are tabulated, varied significantly among the factories, particularly for sucrose and reducing sugars. A substantial average difference of 4.8% between the fructose and glucose contents possibly reflected a higher dextran content than in the previous year and corresponded to 2% of the total sugar production, which could indicate a serious economic loss; such a difference affects the polarimetry of low-purity sugar solutions and makes it unsuitable for control of low-purity work and for sucrose balances. An average difference of 4.1 between the true and target molasses purity represented a considerable economic loss representing approx. 1% of the total sugar production.

Sucrose crystal hardness (a review)

A. F. Zaborsin, L. K. Krsek, V. A. Shestakovskii and N. I. Ozloba. *Dep. AgroNIITEIpishcheprom.*, 1989, 24 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (2), Abs. 2 R1453.

A review is presented of current thinking on the question of sucrose crystal hardness. It is shown that chemical and physical properties of crystals are governed by their internal structure. Methods are described for measurement of hardness. The subject is of interest in relation to the production of icing sugar, pressing of wet refined sugar and charging and discharging of bulk sugar from silos.

By-products

Effect of volatile acids on the growth kinetics and technological properties of *Saccharomyces cerevisiae*

D. Pejin, R. Razmovski and S. Popov. *Zb. Rad. Tehnol. Fak.* (Novi Sad), 1988, **19**, 145 - 152; through *Ref. Zhurn. AN SSSR (Khim.)*, 1989, (21), Abs. 21 R1394.

The effect of three different concentrations of acetic acid (AA) on the fermentation time and specific growth rate of *S. cerevisiae* was studied. It was found that at all three concentrations (which corresponded to those typically found in molasses and cause a fall in alcohol yield per unit sugar in a substrate), AA caused a fall in the cell division rate and in yeast activity and increased the fermentation time. A study of the effect of butyric acid showed that it too had a negative effect on growth of the yeast but at much lower concentrations than AA, and also influenced alcohol yield.

The chemical composition and use of filter cake in the national economy

L. I. Tanashchuk, V. A. Lagoda, L. G. Belostotskii, V. E. Skriplev, V. F. Skripnik, T. V. Gutnichenko and T. A. Vdovina. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 96 *(Abstract only)*.

The major trends in the utilization of filter cake in the Soviet economy are analysed and its chemical composition examined with a view to determining the possibility of using it to regenerate lime and carbonatation gas. It was found that 85% of the weight of the mineral portion of filter cake consists of calcium carbonate and hence meets the requirements of a raw material for the production of lime to be used for raw juice purification in the beet sugar industry.

Examination of the hardening mechanism of a mixture of filter cake and lime with the aim of calcining it in vertical kilns

L. G. Belostotskii, L. I. Tanashchuk, V. A. Lagoda, T. V. Gutnichenko, N. P. Moklyak, N. V. Raskina, L. S. Zaets and V. F. Skripnik. *Izv. Vuzov, Pishch. Prom.*, 1989, (3), 96 *(Abstract only)*.

The possibilities were investigated of obtaining a stone-like material from filter cake, using unslaked lime as binder. It was found that the hardening process may be affected by the lime quality and granulometry, temperature of the mixture and the proportion of filter cake to lime. The strength of the artificial stone obtained was maximum when a finely dispersed rapid-slaking lime was used at 10% by weight of filter cake.

Diversification of the sugar cane agroindustry in Colombia

Anon. *GEPLACEA Bull.*, 1989, **6**, (11), 2 pp.

By-products utilization in Colombia is briefly surveyed. It includes the use of a 1:1 or 2:1 ash:filter cake mixture mainly as fertilizer for coffee plantlets and nursery flowers, ethanol produced at the rate of 10,000 litres/day at one factory and used chiefly in the perfume industry, bagasse board (produced at the rate of 50 tonnes/day) and the use of raw sugar, molasses, filter cake, cane, bagasse and pith as animal fodder. A number of projects are also being studied.

The chemical composition and utilization of filter cake in the national economy

L. I. Tanashchuk, V. A. Lagoda, L. G. Belostotskii, V. E. Skriplev, V. F. Skripnik, T. V. Gutnichenko and T. A. Vdovina. *Izv. Vuzov, Pishch. Tekh.*, 1989, (3), 96 *(Abstract only)*.

The basic trends in the utilization of filter cake in the national economy of the USSR are analysed. An examination of the chemical composition of filter cake to see if it is possible to use it to regenerate lime and carbonatation gas showed that 85% by weight of the mineral component consists of calcium carbonate, so that filter cake meets the requirements of a raw material from which to obtain lime for use in raw juice purification.

Use of heat-tolerant yeast strains for COD reduction and yeast protein production in vinasses from beet molasses and sugar cane press juice

K. I. Lee. *Thesis* (Berlin Tech. Univ.), 1988, 100 pp.; through *Zuckerind.*, 1989, **114**, 1022.

A special investigation was conducted on yeast culture for reduction of COD and production of protein as a means of utilizing vinasse from beet molasses and cane juice. Yeast strains from East Africa were screened for their heat tolerance. Of 40 strains, *Candida rugosa* and *Kl. marxianus* were selected for further study in which their metabolic performance, biomass and crude protein production and COD reduction in molasses vinasse were compared with those of *C. utilis* fodder yeast. *C. rugosa* proved to be acid- and heat-tolerant and gave high biomass yield on vinasse; for production of 7 - 19 g/litre biomass it gave 38 - 50% reduction of the initial vinasse COD under optimum conditions. In batch fermentation of molasses vinasse at 40°C it gave growth rates of up to μ_0 = 0.19/hr with correspondingly rapid COD reduction. It was found that flocculation of the yeast for separation of the spent beer was also best at 40°C rather than at lower temperatures. In studies on cane juice vinasses from Brazil to which 2.5 - 20.0% dry molasses was added, a biomass production of 21 g/hr and 41% COD reduction were achieved with 10% molasses addition. Continuous cultivation of *C. rugosa* on beet molasses vinasse at 40°C gave a productivity of up to 0.85 g/litre/hr, crude and pure protein contents of 45.1 and 36.5%, respectively (on a bovine serum albumin basis) and only 5.6% RNA. The protein from the yeast contained important essential amino-acids. For better utilization of vinasses it was recommended to combine the yeast cultivation with methane fermentation.

A SE-HPLC procedure to separate fructanase from sugar cane juices

By Maria Estrella Legaz*, Mercedes M. Pedrosa*, Isabel Medina**, Silvia V. Caffaro*, Maritza Martínez**, R. de Armas** and C. Vicente*

Introduction

Normal carbohydrate metabolism in sugar cane produces a heterogeneous pool of soluble polysaccharides. This pool includes arabino-galactans[1], starch-like polymers[2] which contain some 1,6-glucans[3], and β-1,4-glucans[4]. Recently, heteropolymers containing both fructose and galactitol have been described. These polysaccharides are $(Fructose_4{:}Galactitol_5)_n$, hereafter called SP, with a molecular weight higher than 10 kDa, and moderate sized carbohydrates $(Fructose_2{:}Galactitol_3)_n$, called MMWC, with a molecular weight varying from 0.7 to 10 kDa. Both polysaccharides are hydrolysed by a fructanase which has been purified from sugar cane juice, obtained from an 11 months-old Cuba 374-72 variety. The K_m value has been estimated to be 33.7 µg/ml and 20 µg/ml for SP and MMWC, respectively. Purified protein has a pI value of 6.35 and its activity appears to be Mn^{++}-dependent[5].

In this paper, we attempt to determine the molecular mass of this fructanase and to establish a chromatographic basis to identify this protein in other sugar cane varieties.

Material and methods

Plant material

Three field-grown varieties of sugar cane (*Saccharum officinarum* L.), viz. Cuba 374-72, Jaronú 60-5 and Barbados 63118 were used throughout this work.

Substrates preparation

Stalks from 9 months-old plants of each variety were mechanically crushed, immediately after cutting, and trichloroacetic acid added to the raw juices to give a concentration of 5% w/v. The juices were centrifuged at 20,000 *g* for 30 minutes at room temperature, the pellets discarded and the supernatants adjusted to pH 8.0 by adding a saturated solution of ammonium carbonate. The juices were re-centrifuged at 20,000 *g* for 15 minutes at room temperature and

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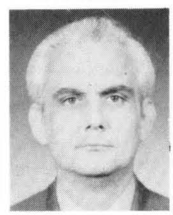

R. de Armas

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the supernatants filtered through Whatman No. 4 paper. Sodium azide was added to the filtrate to obtain a final concentration of 0.02% w/v.

The clarified juices were then filtered through columns of Sephadex G-10 (15 cm × 2.5 cm), pre-equilibrated with ammonium carbonate containing 0.02% sodium azide. Elution was carried out with the same solution. Fractions (1 ml) 1 to 20 were discarded. Fractions 20 to 32 ml were collected and filtered through Sephadex G-50 columns (30 cm × 2.5 cm), pre-equilibrated as above. Fractions 40 to 70 ml contained the soluble, high molecular weight polysaccharides (SP fraction) whereas mid-molecular weight carbohydrates (MMWC) eluted in fractions 70 to 120[6]. Total carbohydrates were measured by reaction with phenol-sulphuric acid[7]. HPLC analyses showed the absence of sucrose and monosaccharides in fractions 40 to 120 ml.

Enzyme extraction and purification

Crude extract from crushed Cuba 374-72 stalks (100 ml) was filtered through a column of Sephadex G-25 (30 cm × 3 cm) to remove low molecular weight metabolites. The filtrate in the void volume was then brought to 90% w/v with ammonium sulphate and stored for 4 hours at 2°C. The suspension produced was centrifuged at 27,000 *g* for 1 hour at 2°C and the pellet resuspended in 100 ml 1 mM sodium citrate buffer of pH 6.0. Supernatant and precipitate were dialysed against 5.0 litres of 1 mM sodium citrate, of pH 6.0, containing 0.02% sodium azide w/v for 60 hours at 4°C. The supernatant, which contained the highest hydrolase activity, was adsorbed on calcium phosphate gel (75 mg dry gel per mg protein) and the protein desorbed with increasing concentration of citrate buffer, of pH 6.0, from 1 mM to 70 mM (5 mM increments). The highest specific activity was obtained in the fraction desorbed with 15 mM citrate[5].

Enzyme assay

Hydrolase activity was measured in reaction mixtures containing 1.0 mg protein in crude extracts (5.0 µg protein as purified enzyme), 20 µmol sodium citrate, pH 6.0, 2.5 µmol Mn^{++} (as $MnCl_2$) and 2.0 µg MMWC or 8.0 µg SP in a final volume of 1.3 ml. Reactions

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1 Roberts *et al.*: *I.S.J.*, 1976, **78**, 10 - 12.
2 Covacevich & Richards: *ibid.*, 1977, **79**, 3 - 9.
3 Idem: *ibid.*, 1977, **79**, 33 - 37.
4 Roberts *et al.*: *ibid.*, 1985, **87**, 227 - 231.
5 Legaz *et al.*: *Plant Physiol.*, 1990, in press.
6 Rodríguez *et al.*: *Ciencias Agric.*, 1985, **24**, 55 - 61.
7 Dubois *et al.*: *Anal. Chem.*, 1956, **28**, 350 - 356.

were carried out for 30 minutes at 30°C and stopped by adding sufficient 2N NaOH to give a pH value of 8.0. Controls contained no substrates or protein. Fructose produced during the hydrolysis was determined by reaction with dinitrosalicylic reagent and the developed colour was measured[8] at 540 nm. Absorbance was transformed by using a straight-line calibration graph made with known concentrations of fructose. Protein was measured by the method of Lowry *et al.*[9] using bovine serum alumin as a standard. One unit of specific activity was defined as 1.0 µmol of fructose produced per mg protein per min.

Analysis of sucrose and monosaccharides by HPLC

SP and MMWC were lyophilized and the residues were extracted with 80% cold ethanol and stored at −13°C for 14 hours. The precipitates were then discarded and the supernatants heated at 60°C for 20 minutes. One ml of 80% (v/v) cold ethanol was added to 1.0 ml of clear supernatant and this heated three times as above. After heating, the suspensions were centrifuged at 3000 *g* for 15 minutes. The precipitates were discarded and the supernatants dried in an air flow[10]. The residues were dissolved in 0.5 ml acetonitrile: water (80:20 v/v) and injected onto the column. HPLC analysis was performed in a Varian 5060 liquid chromatograph equipped with a Vista CDS 401 computer[11]. Chromatographic conditions were as follows: column, MicroPak-NH_2 10 P/N (30 cm × 3 mm i.d.); loading, 10 µl; mobile phase, acetonitrile:water (80:20 v/v); flow rate, 1.3 ml/min; temperature, 20°C; pressure, 90 atm; detector, UV set at 195 nm; absorbance range, 0.05; attenuation, 64; internal standard, 2.0 mg/ml ribose; external standards, 2.0 mg/ml sucrose, glucose and fructose.

Determination of molecular mass of fructanase

Variable amounts of partially purified fructanase (from 5 to 60 µg) were chromatographed on a 30 cm × 7.8 mm PWSX GO209 HPLC column packed with G5000 PWXL, equilibrated with 75 mM sodium citrate buffer of pH 6.0, using a Spectra Physics SP8800 liquid chromatograph equipped with a SP 4290 computer. Chromatographic conditions were: loading, 10 µl; temperature, 30°C; mobile phase, 75 mM sodium citrate, pH 6.0; flow gradient, from t = 0 to t = 16 min, 0.3 ml/min; t = 17 min, 0.25 ml/min, decreasing to 0.2 ml/min until t = 20 min; from t = 20 min to t = 40 min, 0.2 ml/min; detector, UV set at 280 nm. Blue dextran 2000 was used to measure void volume. Apoferritin (448 kDa), β-amylase (200 kDa), alcohol dehydrogenase (150 kDa), carbonic anhydrase (28 kDa) and cytochrome C (12.4 kDa), from Sigma Chemical Co., were used as molecular weight standards. Molecular mass of the fructanase was determined by plotting log molecular mass *versus* log (V_e/V_o) where V_o is the void volume of the column and V_e is the elution volume of a protein.

Results

To test fructanase activity, crude extracts filtered through Sephadex G-25 were used as a source of enzyme. As is shown in Table I, both Cuba 374-72 and Jaronú 60-5 varieties produce low fructanase activity which is able to hydrolyse both SP and MMWC. This activity was not detected in extracts from Barbados 63118 plants.

The enzyme from Cuba 374-72 plants has been purified 167-fold against MMWC and 88-fold against SP with an overall yield of 5.7% and 3%,

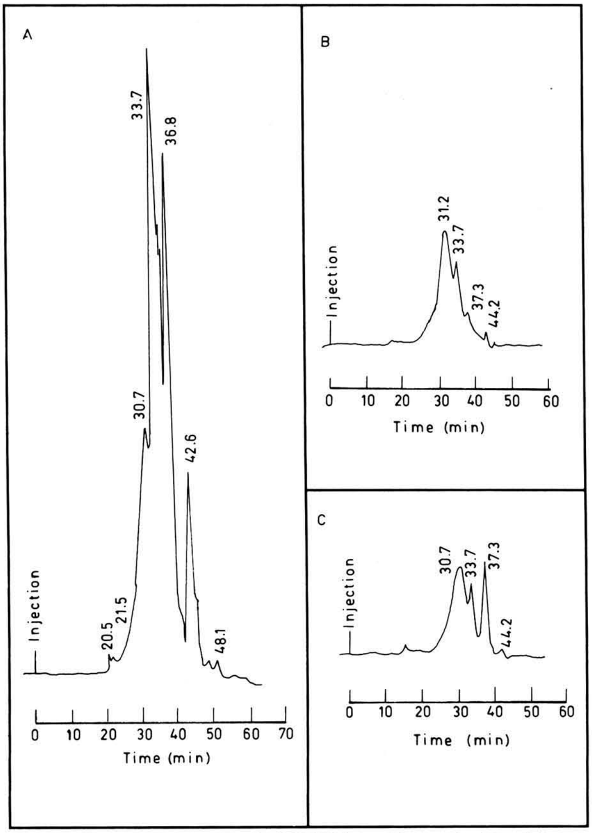


Fig. 1. Chromatographic traces in SE-HPLC of protein contained in cell-free extract (A), supernatant (B) and pellet (C) from 90% ammonium sulphate precipitation of the juice obtained from Cuba 374-72 stalks

8 Sumner: *J. Biol. Chem.*, 1921, 47, 5 - 9.
9 *ibid.*, 1951, 193, 265 - 275.
10 Legaz *et al.*: *Photosynthetica*, 1985, 19, 230 - 236.
11 Idem: *Lichen Physiol. Biochem.*, 1986, 1, 35 - 46.

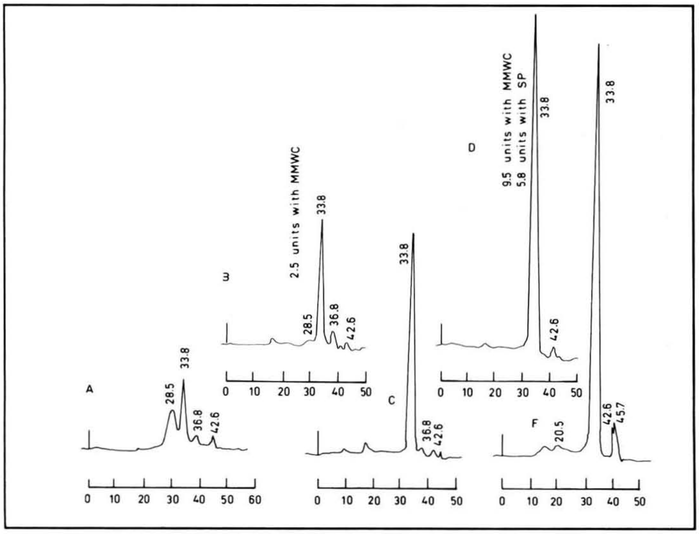


Fig. 2. Chromatographic traces in SE-HPLC of fractions obtained from calcium phosphate gel when protein is desorbed sequentially with 1mM (A), 5 mM (B), 10 mM (C), 15 mM (D) and 20 mM (E) citrate buffer of pH 6.0

Table I. Fructanase activity* from Cuba 374-72 and Jaronú 60-5 sugar cane varieties

Origin of the enzyme and substrate	Substrate SP	MMWC
Cuba 374 - 72	66.0 ± 4.7	57.2 ± 4.3
Jaronú 60-5	98.6 ± 7.5	100.3 ± 9.8

* Specific activity expressed as milliunits

respectively (Table II). Each step of the purification procedure was tested by SE-HPLC. As was expected, cell-free extract was resolved as a multiprotein system, showing 9 peaks that eluted from 20.5 min to 50.3 min (Fig. 1A). Precipitation with ammonium sulphate diminished the amount of protein and the number of chromatographic peaks to 6 in the supernatant and to 4 in the precipitate (Figs. 1B and 1C).

Analysis by SE-HPLC of desorbed fractions from calcium phosphate gel showed a constant component which appears as a peak with a retention time value of 33.8 min. However, only that desorbed with 15 mM sodium citrate was active in hydrolysing both MMWC and SP (Fig. 2D and Table II). This fraction represented a fructanase practically purified at homogeneity, since 93.5% of the total protein was active hydrolase. Peaks with identical retention time values (Figs. 2B, 2C, 2D and 2E), eluted with different molarities of the buffer from calcium phosphate gel, could not be this fructanase since they are not active and, in addition, their absorbance at 280 nm was from 3 to 50 times lower than that eluted with 15 mM citrate (Fig. 3). However, a residual activity against MMWC has been observed in the eluate with 5 mM.

Purified fructanase migrated then as a monomer in the G5000 PWXL column with a V_e/V_o value of 1.754. The apparent molecular mass of the enzyme

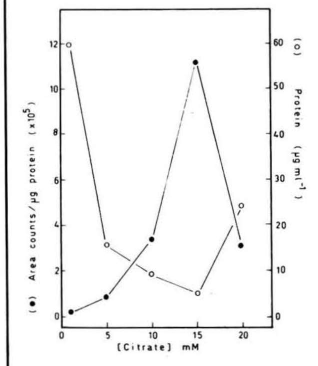


Fig. 3. Relationship, between area counts at 280 nm per µg protein (•) and protein concentration (o) of different fractions adsorbed from calcium phosphate gel with citrate buffer

Table II. Purification of fructanase activity from 9 months-old sugar cane variety Cuba 374-72, using MMWC* or SP as substrate**

Step	Volume, ml	Protein, mg/ml	Total protein, mg	Specific activity, units	Total activity, units	Yield, %	Purification -fold
Juice filtered through Sephadex G-25 column	300	0.735	220.5	0.057* 0.066**	12.57* 14.55**	100	-
Supernatant from 90% saturation with ammonium sulphate	70	0.068	4.76	2.34* 1.05**	11.14* 4.98**	88.62* 34.23**	41.05* 15.84**
Fraction desorbed with 15 ml citrate from calcium phosphate gel	15	0.005	0.075	9.55* 5.82*	0.72* 0.44**	5.73* 3.02**	167.5* 88.2**

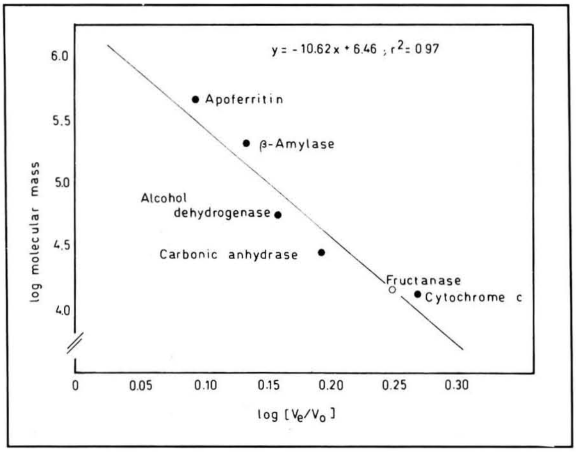


Fig. 4. Determination of molecular weight of purified fructanase in SE-HPLC

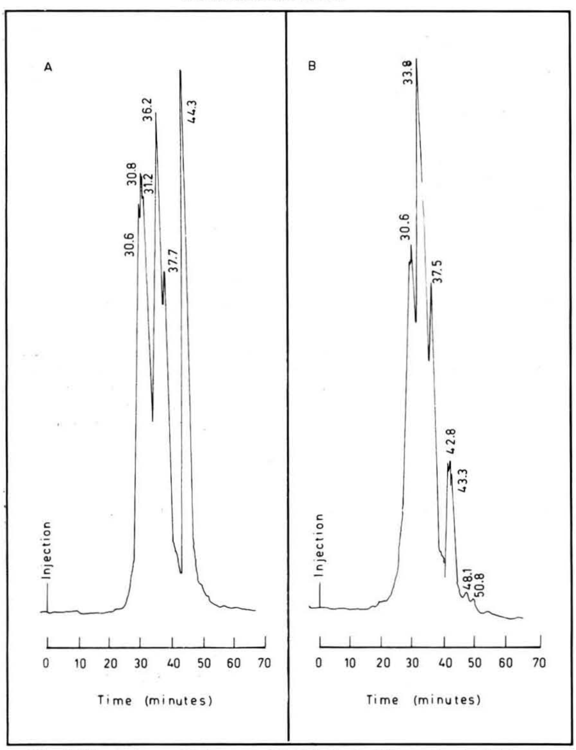


Fig. 5. Chromatographic traces in SE-HPLC of cell-free extracts obtained from Barbados 63118 (A) and Jaronú 60-5 (B) stalks

was calculated as about 15,166 ± 522 kDa (Fig. 4).

The peak corresponding to purified fructanase also appeared when crude extract from Jaronú 60-5 plants was chromatographed under the same cond-itions (Fig. 5A). This is not surprising since this extract contained active fructanase (Table I). By contrast, this peak was not revealed by SE-HPLC analysis of cell-free extract from Barbados 63118 plants, which did not contain detectable hydrolase activity (Fig. 5B).

Discussion

An identification procedure using SE-HPLC has been developed for a purified fructanase obtained from sugar cane juice. According to the general law that the smaller the slope of the calibration curve the better is the separation between proteins of different molecular weights, it can be deduced that resolution for the standards used here is good (Fig. 4), since R_s values, calculated according to the general equation

$$R_s = 2(V_{e2} - V_{e1})/(V_{p2} + V_{p1}) \times (\log M_1/M_2)$$

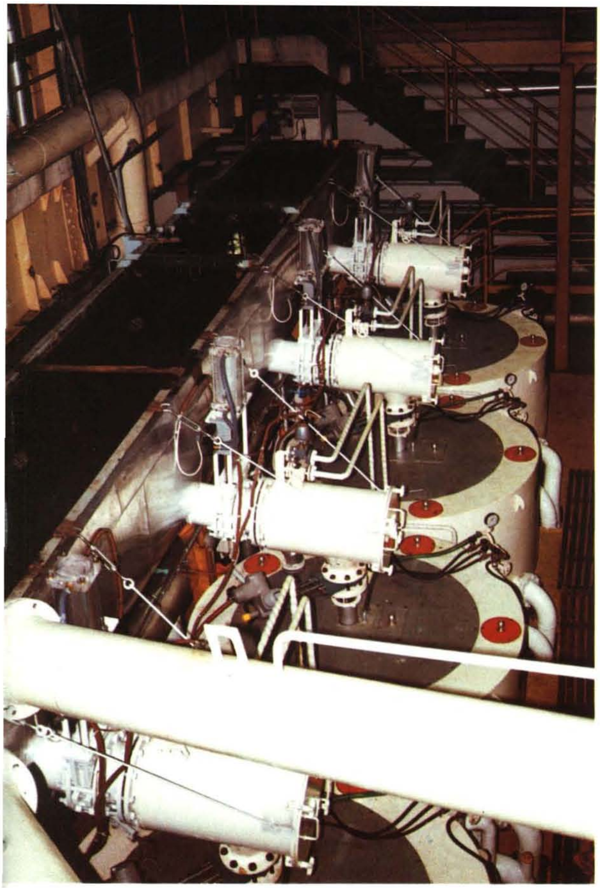
where V_e, V_p and M are the elution volumes, peak volumes and the molecular weights, respectively[12], varies from 2.08 for β-amylase and apoferritin to 2.93 for cytochrome C and carbonic anhydrase. In addition, determination of fructanase molecular mass has been achieved with a standard error lower than 4%.

Although phosphate, with several modifiers, is the most successful buffer used in SE-HPLC separation of proteins[13,14], citrate buffers are also used[15] without harm to the column integrity. No problems have been detected when the described procedure using SE-HPLC is applied to a tentative pre-identification of fructanase in clarified juices from different sugar cane varieties. The peak with a retention time of 33.8 minutes corresponds to active fractions from Cuba 374-72 and Jaronú 60-5 juices. However, this peak does not appear in the chromatographic traces from Barbados 63118 juice in which fructanase also has not been detected (Fig. 5).

This does not necessarily imply that Barbados 63118 variety was unable to produce fructanase. The occurrence of both MMWC and SP in Barbados juices has been detected in plants 15 months old or older[16]. This implies that hydrolytic activity can be produced as a function of the age of plants and, thus, its synthesis by Cuba 374-72 and Jaronú 60-5 can be explained as a pre-ripeness physiological status opposite to that supposed for Barbados 63118. The screening SE-HPLC of fruct-

continued on page 102

12 Welling & Welling-Wester: in "HPLC of macromolecules", Ed. Oliver (IRL Press) 1989, pp. 77 - 89.
13 Winkler *et al.*: *J. Chromatog.*, 1984, **297**, 63 - 75.
14 Idem: *ibid.*, 1985, **326**, 113 - 127.
15 Josic *et al.*: *Anal. Biochem.*, 1984, **142**, 473 - 481.
16 de Armas: in "La caña de azúcar en Cuba"(Cientifico-Tecnica, Havana), 1987, pp. 385 - 408.



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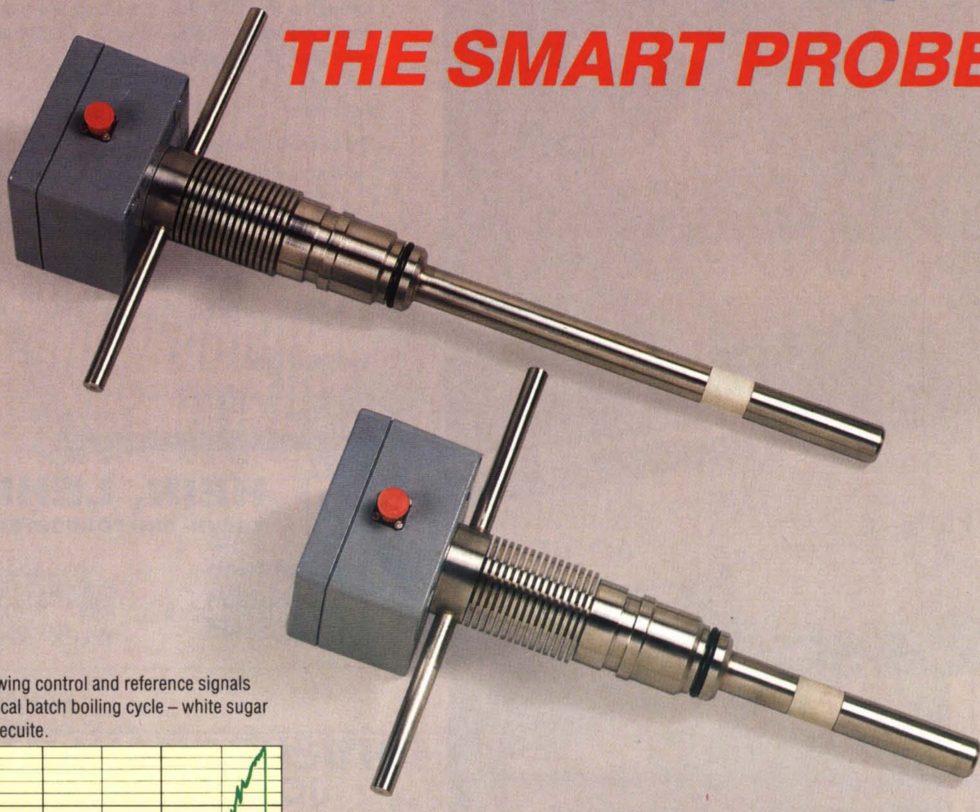
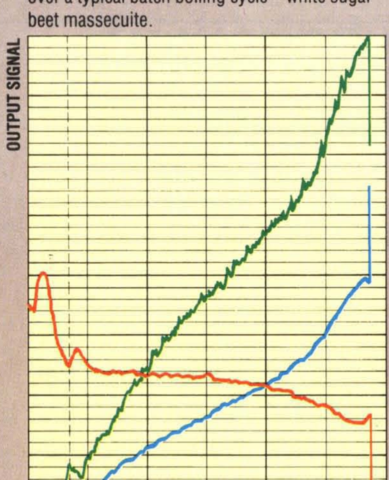


Chart showing control and reference signals over a typical batch boiling cycle – white sugar beet massecuite.



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Flotation-clarification in sugar refining. Part II.

By Fok Hon-Jun
(P.O. Box 801, Guangzhou, China)

Flotation and aeration

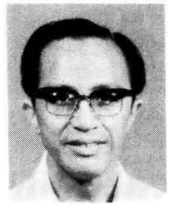
Principal mechanism

The modern flotation process is a highly efficient technology for separating the solid particles in a liquid to remove or recover them by adding suitable air bubbles and flocculant. By comparison with the traditional method of sedimentation which is still in common use in the sugar industry and many other areas, the flotation process has a much higher separation velocity so that the flotation equipment can be of smaller volume. Most solid particles in sugar juices settle under gravity at such a low velocity that many factories have to install sedimentation tanks (clarifiers) with a very large volume. An additional advantage for the sugar industry of increasing the separation velocity is shortening of the retention time and, hence, reduced sugar loss.

The flotation process works on the principle of forming low-density aggregates of particles and bubbles, and the lower the density, the more quickly they float. It is obvious therefore that the most important factor for this process is to have all solid particles attached firmly to sufficient air bubbles, which in turn is determined by many physical-chemical factors and hydrodynamic parameters.

Physicochemically, the properties of the solid particle surface can be divided into two classes: hydrophobicity and hydrophilicity. Particles with hydrophobic surfaces themselves repel the water from their surfaces and tend to adhere to air bubbles by their own nature, so they can become firmly attached to the bubbles and rise together spontaneously. On the other hand, hydrophilic particles have surfaces with affinity for water, so they do not adhere readily to bubbles and are difficult to float.

As pointed out by Gochin[1]: "Almost all naturally occurring solid particles and most inorganic chemical precipitates have surfaces with a strong affinity for water (hydrophilicity) and they are invariably unflotable". This is also true of the situation in sugar syrup



Fok Hon-Jun

or liquor: most insoluble matters are coagulates of hydrophilic organic colloids and various calcium salts and are typical substances having hydrophilic surfaces. Experience shows that it is not easy to make them float.

In order to further examine this problem and the relative mechanism of the flotation process, a series of researches have been carried out by the author and some important phenomena have been studied. The first problem is to find out the properties of calcium phosphate – a major chemical constituent in the phosflotation process. A test was made as follows: sodium phosphate and calcium chloride solutions were added to distilled water, equivalent to the mixture containing 300 ppm P_2O_5 and 400 ppm CaO. Calcium phosphate was precipitated in the form of many tiny solid particles. These gradually combined into floccules of a slightly larger size and settled slowly. Subsequently this liquid was aerated by the addition of some aerated water, which is made by pressurization of the mixture of water and injecting compressed air under 6 kg/cm^2 pressure with a retention time of 3 minutes to make the air dissolve in the water. This aerated water, called "dissolved air" water, liberates a great many minute air bubbles when it comes out from the pressurized vessel, because the solubility of air in water decreases at low pressure. When this water was mixed with the liquid containing the phosphate particles in the abovementioned test, although lots of minute air bubbles were released, they did not adhere to the solid particles and rose by themselves. None of the solid particles were floated, and all of them continued settling gradually. This demonstrated that the phosphate precipitate has hydrophilic surfaces. Further tests showed that, if some surface-active agents are added to the liquid before the aeration, the air bubbles will attach to the solid particles and cause them to float together. This is because of the orientation of the adsorbed surfactant molecules on the surface of the particles, whereby the hydrocarbon chains of the surfactant make the surface of particles hydrophobic. However, it is impossible to use this method in the production of sugar.

Calcium phosphate has a characteristic in that it can flocculate spontaneously into forms having a loose structure, with plenty of cavities inside. In the course of forming floccules, some other solid particles such as the impurities in sugar liquor can be trapped inside and these settle together. This is why phosphate is very effective in removing suspended matter (including chemically inert particles). Similarly, in the course of flocculation, calcium phosphate particles can also trap minute air bubbles forming floccules having a lower density than the liquid. This can be proved by a test which is like that described above but in a different sequence as follows:

Water containing dissolved air is continuously added at the same time as sodium phosphate solution to a liquid which contains calcium chloride. Calcium phosphate is precipitated, and gradually forms floccules which have air bubbles inside or on the surface that can be seen clearly. They float upwards at different velocities depending on the size of the floccules and the amount of air occluded. This type of flotation is based on the flocculation of the solid particles, and it has different characters from that of hydrophobic particles.

When the air bubbles float up singly, the larger bubbles rise more quickly and the smaller ones slowly. In the case of flocculation-flotation, only minute bubbles can be trapped and are effective, whereas the bigger bubbles are wasted and may even be harmful. In the system, the major factors which have

1 in "Solid-liquid separation" Ed. Svarovsky, 1981, Chapter 19, pp. 503 - 535.

been found to be most important in determining the success and efficiency of flotation-separation are the parameters of the bubbles and the creation of flocculation.

Air bubble parameters

Air bubbles provide the lifting force for flotation of the solid floccules; their size and number have great influence on the stability and velocity of flotation. A basic physical-mathematical analysis has been made, from which some fundamental rules can be shown.

The force F_1 causing a body to float in a liquid is:

$$F_1 = v(d_2 - d_1) \qquad (1)$$

where v is the volume of the body, d_2 the density of the liquid, d_1 the density of the body.

The resistance F_2 to a body in motion is given by

$$F_2 = Cd_2AV^2/2g \qquad (2)$$

where C is the coefficient of motion resistance, A the sectional area of the body, V the moving velocity of the body, and g the acceleration due to gravity.

The resistance coefficient varies with some other factors. Under the conditions to be examined, it can be expressed as:

$$C = 24/Re \qquad (3)$$

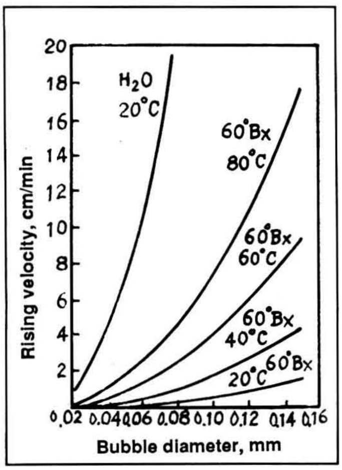


Fig. 1

where Re is the Reynolds Number of the system examined.

The rising velocity of an air bubble in a liquid is determined by its size and the properties of the liquid, which can be calculated according to the above formulae and the relative parameters. Some figures of these velocities for air bubbles of various diameters in water and in a 60°Brix sugar solution at various temperature are shown in Figure 1. They coincide with the results of observation.

It can be seen from the figure that the rising velocity of air bubbles increases rapidly with their size, and is approximately proportional to the square of the diameter, other conditions being equal. From this relationship, the size of bubbles can be estimated roughly by observing their rising velocity. For sugar processing, minute air bubbles smaller than 50 micrometres in diameter are advisable; these float in a 60°Brix sugar solution and at 60°C to 80 °C with a velocity less than 2 centimetres per minute. If an aerated sugar liquor is held for about two minutes but plenty of bubbles remain it can be said that the aeration effect is satisfactory.

In a high Brix sugar solution, the rising velocity of small air bubbles is quite low. But in a good flotation process, the floccules can rise at higher speed. It may be seen in this process that, after most of the floccules have risen, there are still some minute bubbles left in the clarified liquor which makes the liquor look somewhat turbid. The floccules have a much higher density than that of the air bubbles but, because they are much larger than the bubbles, when their density is lower than the liquid by occlusion of many air bubbles, the floccules will rise faster than individual bubbles.

This can also be shown by calculating the rising velocity of floccules of different size and different density by the above formulae. The results of such calculations are shown in Figure 2, which gives the rising velocity of spherical bodies having densities of 0.9, 1.0 and 1.1, respectively, and having

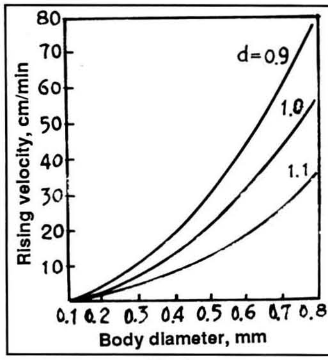


Fig. 2

diameters of 0.1 to 0.8 mm, floating in a 60°Brix sugar solution at 60°C (with density of 1.264 and viscosity of 9.69 centipoises). It can be seen that the rising velocity of these bodies increases rapidly with their sizes; this is the same as in the sedimentation process (only replacing rising by settling). Particles larger than 0.5 mm and with densities lower than 1.1 can rise at more than 10 cm/min which is much faster than that of small air bubbles.

The above figures are calculated for spherical bodies, whereas, in practice, floccules have different, complicated shapes. This affects the coefficient of motion resistance and the rising velocity to some extent, but the above correlation between the relative parameters is still applicable on the whole.

The size and density of the floccules are two major factors in determining their rising velocity in a certain liquid. It can be seen from Figure 2 that, if the density decreases by 0.1, the rising velocity increases by 40 to 70%. Since the densities of the solid and the liquid show little variation, the density of the floccules is mainly determined by the amount of air bubbles occluded. This discussion explains the important role of modern flocculation technique in considerably improving the flotation-separation velocity through forming floccules with large size and low density by occluding bubbles. Through a series of researches, the following factors have been found to be essential in achieving good results.

(1) Air bubbles must be of microscopic size. As pointed out by Saranin[2]: "The bubbles need to be of sufficiently small size as to be easily enmeshed into the floccules of the precipitate". Generally, sizes smaller than 30 microns are preferable, and smaller than 50 microns are acceptable. Larger bubbles are wasted and may even be harmful, because they can bring about detrimental turbulence in the clarifier and interfere with the flotation of floccules.

(2) The quantity of bubbles should be sufficient but not too much; as the floccules can only enmesh a certain quantity of bubbles, excessive bubbles are useless and harmful. In a good system using a high-efficiency flocculant where air bubbles can be utilized effectively, the quantity of bubbles required for lifting these floccules is not large. In the simple phosflotation and sulphitation-phosflotation process, a volume ratio of bubbles to liquor between 0.5 and 1% is sufficient. Taking into account the amount of insoluble solids in the liquor, including the precipitate formed by chemical treatment, is only 1 to 3 grams per litre, the bubbles of the above-mentioned volume of air amount to 3 to 5 ml per gram of solid. If the bubbles and solids can mix together by themselves, the mixture will have a density as low as 0.2 to 0.3. It is obvious that, in this case, the key factor is to utilize the bubbles effectively, but not to supply too many. On the other hand, too many bubbles increase the volume of floating scum and, hence, decrease the effect of a certain amount of flocculant in the floccules and the scum.

(3) Good flocculation is of great help in the occlusion of bubbles by the floccules. During the flocculation of calcium phosphate, named "primary flocculation", they can enmesh some bubbles. Based on this function, the phosflotation process has been applied in many sugar refineries for some fifty years. However, this effect is limited, the process is therefore not too stable, and the practical results are not very good. The application of polyacrylamide greatly improves flocculation in what is known as "secondary flocculation", when floccules are formed of much larger size, often reaching several millimetres, while they have many more bubbles occluded inside. These make the flotation process more stable and of much higher efficiency. In this aspect, aeration at the right time to coordinate both flocculations to achieve the best effect is also important.

Method of aeration

Many aeration methods have been used in the flotation process in the sugar processing and other industries. In the early years, the aeration of liquor was done by injecting compressed air into it, or pumping either the whole or a part of the liquor through an injector to suck air in, but these methods formed many large bubbles. In the 1950's, the so-called "dissolved air" method was introduced in some sugar refineries. This method can make minute and uniform air bubbles and has been used extensively in other industries. Its application in the sugar industry was examined in detail by Saranin[2]. However this aeration system is somewhat complicated. Another method is the use of an aerating pump, usually a modification of a centrifugal pump, with some changes in the construction to increase the breaking effect on the bubbles. In general, these machines provide bubbles that are not so good as those produced by the "dissolved air" method.

According to the above-mentioned mechanism, a new aeration system has been designed by the author. The aerator is of multi-knife style, consisted of a rotor having 20 knife blades running at high speed (about 2900 rpm) inside a cylindrical shell. The knives are machined to make their edges very sharp, and both ends are made tortuous in a special shape to increase the cutting effect on the bubbles; the shell is machined to form hundreds of small troughs with sharp edges on the inner surface. The annular clearance between the rotor and the shell is very small. The treated liquor or syrup with air flows through the passage formed by this clearance, and is cut by knives and ground by the shell, producing numerous minute bubbles. All larger bubbles are broken down and eliminated. Microscopic observation shows that the bubbles formed are in the size range 10 to 30 microns, as good as those liberated in the "dissolved air" method, and much more suitable than those produced by other methods. The aerator is equipped with a 7 kW electric motor and can provide sufficient aeration for a refinery with a capacity of 1000 tons raw sugar per day.

The aerated liquor or syrup from this aerator is a yellowish emulsion, containing 10 to 30% by volume of minute bubbles, depending on the composition of the liquor. Generally speaking, washed raw sugar liquors contain less surface-active substances and bubble-forming action is not too strong. On the other hand, during the crushing season, cane syrups contain much more surface-active substances, such as nitrogenous compounds; they often form many bubbles which are very stable and can stand for a long time. Some syrup samples have been found to be able to form an aerated emulsion containing as much as 40% by volume of stable minute bubbles.

Since the aerated liquors contain a great many bubbles, it is not necessary to put all the liquor through the aerator. If a part of the liquor is treated by the aerator and then mixed with the rest, by adjusting the proportion of this first part the amount of bubbles in the whole liquor can easily be controlled at a suitable level. Usually, this proportion is 15 - 25% for cane syrup and 25 - 40% for washed raw sugar liquor. Since some air bubbles will disappear (merge and break) in the course of the process before they pass into the clarifier, the proportion of aerated liquor should be controlled according to the flotation in the clarifier.

2 *Sugar Technol. Rev.*, 1972, **2**, 1 - 72.

Flocculation and the use of flocculant

The efficiency of modern flotation process has been raised greatly by using polyacrylamide, of which the chemical constitution and the relative parameters, as well as the preparation and application method, have great influence on the effect of flotation.

Most flocculants used in the sugar industry are co-polymers of acrylamide and acrylic acid, the latter component usually comprising about 20 - 30%. Some other flocculants have other components containing other chemically active groups. A chemical plant in Guangzhou has made many species of flocculant samples according to our requirements and, through a series of tests and comparisons, some highly effective flocculants have been selected for sugar industry application. In general, polyacrylamides of higher molecular weight have higher efficiency in flocculation. The flocculants we use now have a molecular weight of over ten million and also contain some other special active groups. They should be carefully dissolved in warm soft water using a low-shear stirrer to give a 0.1% solution.

The dosage of flocculant has great influence on the flotation velocity of floccules. Some results of laboratory tests shown in Figure 3 present the effect of flocculant dosage on the rising velocity of floccules in cane syrup treated by phosflotation. It can be seen that the rising velocity obviously increases with the dosage of flocculant, since bigger floccules containing more bubbles are formed.

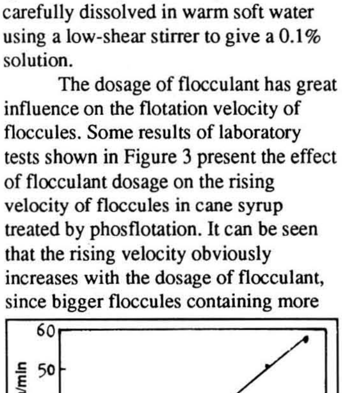


Fig. 3

The flocculant dosage required for the process is not only dependent on the variety of flocculant used and its properties, but also on the arrangement of the process. For example, in the cane syrup phosflotation process, aeration should be arranged before phosphate flocculation, so that the primary flocculation of phosphate can play a useful role in enmeshing air bubbles. This action decreases the density of floccules, thus diminishing the load of flocculant and the dosage required. By this means, combined with good treatment, 3 ppm flocculant on solids in the laboratory and 5 ppm in production are sufficient to obtain good and fast flotation. On the other hand, when treating raw sugar liquors, even if aerated earlier, some of the bubbles will disappear in the course of treatment. So, the principal aeration mainly depends on the action of the secondary flocculation through adding the flocculant, and more flocculant is therefore needed. As a rule, 8 - 10 ppm on solids for simple phosflotation, 10 - 15 ppm for sulphitation-phosflotation, and 20 ppm for carbonatation-flotation are required.

The thorough mixing of flocculant and liquor is another aspect which must be emphasized but may often be neglected in practice. Since the flocculant solution is very viscous, it is not easy to disperse it uniformly in the liquor which is also viscous. Incomplete mixing often leads to uneven distribution and distinctly decreases the effect of the flocculant. In some systems, flocculant solution is added into the liquor pipe prior to the entry of the clarifier, as the pipe is quite short and without a stirrer, the flocculant hardly ever disperses to the whole liquor. In some other systems, flocculant is added to the overflow-exit of a high-level container prior to the clarifier; since the pipe is longer and the greater level-difference leads to a stronger turbulence, the mixing effect is better. But this method often brings about another problem: sucking in air from the opening of the overflow, which produces many large bubbles that seriously disturb the flotation process in the clarifier.

In the new system designed by the author, a special mixer is equipped beside the clarifier. It first mixes the aerated liquor with the rest, then mixes the whole liquor with the flocculant. Each step is achieved completely. The liquor stays in it for about one minute to get better mixing and to bring-about pre-flocculation to trap the air bubbles. The mixture flows out from the bottom of the mixer, which ensures the liquor only carries away minute bubbles. The larger bubbles, having a higher upward velocity, will rise to the surface of the mixer and separate from the liquor. This measure eliminates the detrimental effect on the flotation process of large bubbles, which are often formed in liquid or syrup.

The clarifier

The clarifier is the main equipment in the flotation process and many designs have been used in the sugar industry. The major ones are: Williamson's, Jacobs', Bulkley-Dunton's, Saranin's and the Talo clarifier. Some designs are round, and some are rectangular; most are of single layer, and one is multicell. Although they have different structures, their basic principles are similar.

The aim of the flotation process is to achieve high-quality clarified liquor with high separation rate and short retention time, in conjunction with a small volume of concentrated scum. The attainment of these goals mainly depends on the previous treatment before the clarifier, but also depends on the working of the clarifier, the construction of which is also significant.

A new style of clarifier having many new improvement designed by the author has obtained satisfactory results in recent years. It has two layers, shallow but broad in cross-section, which serve for two steps of flotation. The shallowness shortens the distance the floccules are required to float through the liquor, and thus shortens the retention time, while the broad area

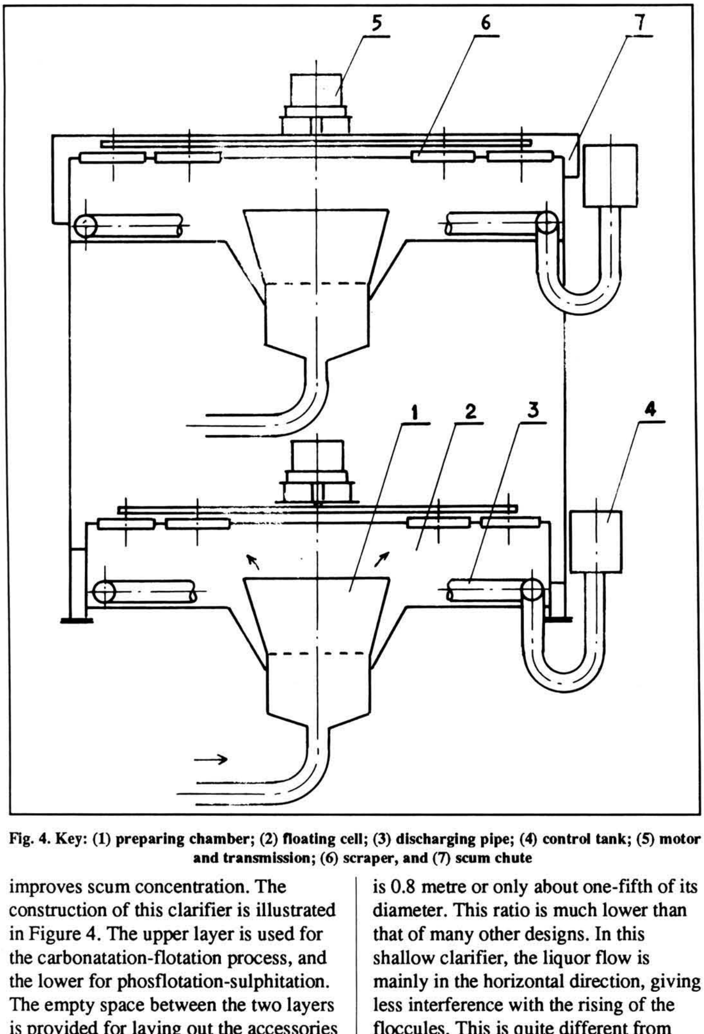


Fig. 4. Key: (1) preparing chamber; (2) floating cell; (3) discharging pipe; (4) control tank; (5) motor and transmission; (6) scraper, and (7) scum chute

improves scum concentration. The construction of this clarifier is illustrated in Figure 4. The upper layer is used for the carbonatation-flotation process, and the lower for phosflotation-sulphitation. The empty space between the two layers is provided for laying out the accessories and piping. The design of both layers is similar but, for ease of construction, the upper layer is slightly larger than the lower one. Some main dimensions are as follows:

	Upper	Lower
Diameter, m	4.7	4.4
Flotation area, m^2	17.3	15.2
Available volume, m^3	15.1	13.4

The available depth of each layer is 0.8 metre or only about one-fifth of its diameter. This ratio is much lower than that of many other designs. In this shallow clarifier, the liquor flow is mainly in the horizontal direction, giving less interference with the rising of the floccules. This is quite different from that in some clarifiers with a deep flotation cell, in which the liquor flows mainly in a vertical direction, which exerts a direct influence on the floccules' floating. If the descending velocity of the liquor is higher than the rising velocity of the floccules some of the smaller particles will be carried out by the liquor, making it turbid.

Of course, the adoption of the shallow clarifier must be based on good flotation with the system having good aeration and good flocculation, and the floccules rising quickly. Moreover, the entry of liquor must be smooth without surging, and in the clarifier the liquor must be evenly distributed over the whole area and flow in a laminar state without turbulence. For this purpose, the entrance of the clarifier and the method of discharge must be carefully designed with reference to hydrodynamic principles, and adjusted through practical test running for new designs.

In our clarifier, the liquor enters the bottom at the centre, through a preparing chamber which plays the role of ensuring good flocculation and bubbles entrapment and eliminating turbulence in the feed liquor, which is then distributed over the whole area of the clarifier. The flocculum floats to the surface and then gradually concentrates into scum, which is scraped off by a low-speed rotating scraper into a annular chute and discharged. The clarifier liquor flows towards the outer circumference of the clarifier and passes through a annular pipe with many small holes, to discharge in a control tank. This controls the level of liquor in the clarifier which is slightly lower than the overflow surface, so that the scum has a suitable time for concentration to reduce its volume.

In the process having two steps of flotation, the upper layer of the clarifier discharges more scum containing a large amount of $CaCO_3$. It flows down to the scum chute of the lower layer, mixes with the scum discharged there, and then is sent to the filtration station. This method can improve and simplify the treatment of scums.

Experience has shown that this clarifier has a capacity of treating 800 to 1000 tons of raw sugar per day, depending on the quality of the raws and the working conditions of the process. The retention time of the liquor in each layer is 14 to 18 minutes.

This double-layer clarifier also has the advantages of reducing the area required for the equipment, centralizing operation and control, and reducing the heat loss.

Acknowledgements

The author express his thanks to Professor Chen Shi-Zhi of Guangzhou Cane Sugar Institute for his generous guidance, and to Mr. Li Chi-Sin, San Shi-You, and Zhi You-Zhong, etc., engineers of Zhongsan and Meisan sugar factories, for their cooperation in this work.

Summary

It has always been a goal for sugar technologists to find a way to yield high quality white sugar by a simple method at low cost. Many achievements have been made, especially since the 1970's. Our work has shown an economical benefit and an encouraging future. Through combining the traditional sulphitation or carbonatation with a newly-developed flotation technique, high clarification efficiency as well as low investment and running cost has been achieved. The key factors for this system are to ensure a suitable process and its working conditions, and to adopt good methods in aeration and flocculation in conjunction with new machinery. Many new improvements for this system with their mechanism and application have been discussed in detail.

Flotacón y clarificación en la refinación del azúcar. Parte II

Siempre ha sido una meta para los tecnólogos del azúcar encontrar una manera de obtener azúcar blanco de alta calidad por un método sencillo a bajo costo. Muchos avances se han realizado, especialmente desde 1970. Nuestro trabajo ha mostrado un beneficio económico y un futuro muy optimista. Al combinar la técnica tradicional de sulfitación o carbonatación con una técnica recién desarrollada de flotación, se puede lograr una alta eficiencia en la clarificación como también costos bajos en la inversión y en el funcionamiento. Los factores claves para este sistema son asegurar un proceso apropiado y sus condiciones de trabajo, y adoptar buenos métodos en aireación y floculación en conjunto con maquinaria nueva. Se discuten en detalle muchas maneras nuevas de mejorar este sistema con su mecanismo y aplicación.

Clarification par flottaison dans la raffinerie de sucre. Partie II

Les technologues sucriers ont toujours voulu trouver une voie pour obtenir un sucre blanc de haute qualité, tout en utilisant une méthode à faible coût. En particulier depuis 1970, on a fait beaucoup de travail à ce sujet. Nos études ont montré un bénéfice économique et un avenir encourageant. En combinant la sulfitation ou la carbonatation traditionelle à une technique de flottaison nouvellement développé, on a pu réaliser une bonne efficience de clarification tout en gradant un niveau bas d'investissement et un faible coût d'opération. Les facteurs de base pour ce système correspondent à un processus convenable qui opère dans de bonnes conditions. On doit également adopter de bonnes méthodes pour l'aération et la floculation pour laquelle on utilise de nouvelles machines. On discute en détail de plusieurs nouvelles améliorations pour ce système et on décrit le mécanisme et leur application.

Flotation-Klärung in Zuckerraffination. 2.Teil

Zuckertechniker immer suchen eine einfache, billige Methode zur Herstellung von Weisszucker hoher Qualität. Manche Leistungen sind vollgebracht worden, vor allem seit den 1970en Jahren. Unsere Arbeit hat einen Wirtschaftsvorteil und vielversprechende Zukunftsaussichten gezeigt. Ein hoher Klärungswirkungsgrad auch niedrige Investitions- und Betriebs-kosten wurden durch die Verbindung der herkömmlichen Sulfitation oder Carbonatation mit einer neuentwickelten Flotationstechnik erzielt. Die Schlüsselfaktoren für dieses System bestehen darin, ein geeignetes Verfahren und seine Betriebsbedingungen zu gewährleisten und gute Belüftungs- und Flockungsmethoden in Verbindung mit neuen Maschinen einzusetzen. Viele neue Verbesserungen von diesem System werden zusammen mit ihren Mechanismen und Anwendungen detailliert besprochen.

A SE-HPLC procedure to separate fructanase from sugar cane juices

continued from page 96

anase purification steps is a very easy and accurate method, as deduced from Figs. 1, 2 and 3. The fact that different proteins can exist with similar retention time values cannot be excluded. However, the residual hydrolase activity against MMWC, observed in the eluate from calcium phosphate gel with 5 mM citrate possibly indicates the existence of several isoforms of this enzyme. These can be partially active or inactive forms, but these last could be reactivated *in vivo* following metabolic conditions as yet unknown.

In any case, crystallization of sucrose is an inverse function of the impurity content of juices[17]. According to the rationale that the occurrence of MMWC must be accompanied by fructanase activity[5] and related to the loss of efficiency in sucrose crystallization rate[6], a fast and easy procedure to detect fructanase in sugar cane juices can be important in order to optimize sugar production.

Switzerland sugar production, 1989/90[18]

The two sugar factories in Switzerland processed a total of 889,019 tonnes of beets during the 1989/90 campaign and produced 140,022 tonnes of white sugar and 33,953 tonnes of molasses.

17 Sarka & Oubranim: *I.S.J.*, 1989, **91**, 109 - 116.
18 *Zuckerind.*, 1990, **115**, 72.

Facts and figures

UK sugar imports and exports[1]

	1989	1988
	tonnes, raw value	
Imports		
Barbados	41,705	52,461
Belgium	958	1,173
Belize	44,048	42,992
Denmark	51,883	52,020
Fiji	187,952	188,460
France	25,810	20,013
Germany, West	1,368	497
Guyana	151,673	116,870
Ireland	36,258	43,703
Jamaica	135,835	138,416
Malawi	10,807	15,931
Mauritius	483,091	447,509
Réunion	12,100	3,440
St. Kitts	15,112	13,759
Swaziland	76,996	62,742
Tanzania	10,810	10,860
Trinidad	49,450	47,048
Zimbabwe	33,000	31,300
Other countries	1,413	61,253
	1,380,903	1,360,993
Exports		
Antigua	1,835	1,764
Bangladesh	11,402	1
Barbados	1,754	245
Belgium	1,471	1,046
Cyprus	5,686	196
Denmark	508	5,423
Egypt	3	2,538
France	2,744	2,944
Germany, West	2,856	2,985
Greece	45,001	30,718
Grenada	1,960	1,801
Holland	4,178	955
Iran	55,999	28,021
Ireland	2,079	2,650
Israel	76,389	77,311
Italy	19,663	16,836
Jordan	14,000	0
Lebanon	3,899	0
Libya	220	12,113
Malta	14,869	18,158
Norway	39,796	46,327
St. Lucia	1,119	559
Saudi Arabia	14,624	10,500
Togo	5,709	2,678
Tunisia	6,224	0
USSR	16,000	20,099
Other countries	5,976	5,141
	386,183	315,540

West German beet sugar factory closure[2]

The Brühl sugar factory of the Pfeifer & Langen group closed at the end of the 1989/90 campaign. It was built in 1883 and from an initial slice of 220 tonnes/day had been expanded to 5500 tonnes/day in its last campaign.

Pakistan sugar import requirements[3]

Owing to the smuggling of sugar to neighbouring countries, there is an impending sugar shortage in Pakistan and sugar traders expect import requirements to exceed 300,000 tonnes. The government estimates consumption in 1989/90 at 2,200,000 tonnes, white value, up nearly 13% on 1988/89, while production is estimated by the Pakistan Sugar Mills Association at about 1,950,000 tonnes. As the government wants to build up sugar stocks, imports will have to exceed the production shortfall.

Denmark sugar production, 1989/90[4]

The six Danish sugar factories sliced 3,709,800 tonnes of beet in the 1989/90 campaign to produce 487,800 tonnes of white sugar and 151,900 tonnes of molasses.

Japan sugar imports[5]

	1898	1988
	tonnes, tel quel	
Australia	687,315	676,411
Cuba	275,267	331,889
Fiji	56,206	31,397
Korea, South	2,119	2,328
Samoa	1,074	0
South Africa	339,287	355,274
Taiwan	3,476	4,072
Thailand	520,152	482,597
USA	13	1,353
Other countries	12,099	648
Total	1,897,008	1,885,969
Total, raw value	1,897,201	1,886,400

Chinese sugar factory for Nepal

China has completed construction of the Lunbini sugar factory in Nepal, according to a Xinhua news agency report of February 6. It has a crushing capacity of 1000 t.c.d. and will also produce 12,000 litres of alcohol. A 3000 kW power plant is incorporated.

New Indian sugar project[6]

Sakthi Sugars Ltd. has signed a Memorandum of Understanding with the government of Orissa state for erection of a new sugar factory of 2500 tcd capacity in the Dhenkanal district of the state. It is also proposed to diversify into drugs and pharmaceuticals.

Brazil sugar exports, 1989[7]

	1989	1988
	tonnes, tel quel	
Algeria	23,904	0
Angola	47,461	20,846
Bangladesh	12,251	0
Bulgaria	0	63,146
Chile	2,099	3,443
China	0	357,667
Egypt	150,781	132,918
Ghana	11,355	0
Haiti	0	15,737
Indonesia	19,920	25,498
Iran	83,665	145,541
Iraq	0	93,002
Jamaica	0	21,912
Jordan	101,031	38,346
Malaysia	0	15,590
Mexico	18,392	0
Morocco	71,500	97,000
Nigeria	48,254	20,719
Peru	11,355	35,857
Portugal	25,000	0
Sri Lanka	0	37,574
Sweden	20,350	24,000
Syria	10,757	11,952
Tunisia	13,546	0
USA	15,750	126,648
USSR	219,323	193,397
Venezuela	0	75,496
Yugoslavia	0	12,600
Other countries	11,952	0
Total	918,645	1,620,388
Total, raw value	964,743	1,685,634

Food quality control symposium

A European symposium on "Quality and the food industries" is to be held in Paris during October 18-19, 1990. The first morning will deal with general questions of quality, EEC policy , etc., while the afternoon will be concerned with quality

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S110 - S112.
2 *Zuckerind.*, 1990, **115**, 71.
3 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 90.
4 *Zuckerind.*, 1990, **115**, 72.
5 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S114.
6 *Indian Sugar*, 1989, **39**, 582.
7 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S130

and sensorial analysis, and quality and nutritional value. The program for the second day includes presentations on quality and food hygiene, and on "Quality and the European outlook". The symposium is being organized by the Regional Council of the Ile de France and participation costs 2000 French francs. Registration forms and further information may be obtained from CRITT IAA Ile de France, ENVA, 7 Avenue du Général de Gaulle, 94704 Maisons-Alfort Cedex, France.

Australian purchase of machinery producer[8]

Bundaberg Foundry Engineering Services Co. has been bought from the Sydney-based ANI Corporation Ltd. by Bundaberg Sugar Co. Ltd. The foundry constructs and supplies sugar factory equipment as well as material for other industries.

Beet molasses sugar recovery[10]

Amalgamated Sugar Company has developed and is marketing its "chromographic separator technology" which is able to recover up to 80% of the sugar currently lost to molasses. This increases factory extraction rates from 82 to 92%. A pilot plant is reported to exist in Japan.

EEC non-quota sugar carryover[11]

Sugar producers of the European Economic Community will carry forward 601,000 tonnes of C- or non-quota sugar to the next marketing year, just over half the 1,102,000 tonnes carried forward from 1988/89. This is the sugar produced in excess of the basic (A) and "insurance" (B) quotas which must be either sold at world market prices or held over until the subsequent market year when it counts against the A and/or B quotas of the producing country. Total C-sugar was recently estimated by the French Sugar Market Intervention Agency at 2,918,000 tonnes, white value, so it it would appear that more than 2.3 million tonnes will be exported to the world market during 1989/90.

French sugar exports, 1989[9]

	1989	1988
	tonnes, raw value	
Algeria	137,059	127,457
Bahrein	0	1,600
Belgium/Luxembourg	254,482	232,770
Benin	4,210	6,891
Burkino Faso	9,756	2,105
Cameroun	333,554	58
Cape Verde	0	1,500
Central African Republic	0	3,803
Chad	4,565	1
Chile	1,087	600
China	0	1,250
Congo	2,113	0
Czechoslovakia	1,087	0
Djibouti	420	3,063
Egypt	102,010	172,510
French Polynesia	5,485	3,655
Gambia	13,289	15,260
Germany, East	43,587	533
Germany, West	173,129	135,183
Ghana	1,779	13,132
Greece	26,594	15,668
Guadeloupe	1,537	1,073
Guinea Republic	19,334	18,547
Guyana	1,502	1,287
Holland	1,116,109	739,977
India	1,223	21,872
Iran	8,814	0
Iraq	25,790	21,051
Ireland	3,590	3,983
Israel	25,218	0
Italy	73,172	44,653
Ivory Coast	3,760	6,650
Jordan	53,750	61,678
Kenya	21,739	5,000
Kuwait	16,527	14,300
Lebanon	7,580	14,447
Liberia	2,024	2,778
Libya	25,252	21,099
Madagascar	1,349	0
Mali	22,880	5,687
Martinique	5,432	5,366
Mauritania	34,370	16,360
Mexico	10,299	0
Mozambique	0	2,265
New Caledonia	1,413	794
Niger	11,326	10,450
Nigeria	59,402	135,188
Pakistan	3,179	53
Peru	11,806	70,602
Poland	20,677	5
Portugal	21,826	44,465
Saudi Arabia	64,704	65,802
Senegal	137	1,018
Sierra Leone	1,348	5,704
Spain	134,491	89,911
Sri Lanka	11,250	383
Sudan	2,212	2,820
Switzerland	20,682	29,062
Syria	7,300	64,042
Tanzania	5,435	1
Togo	13,642	20,518
Tunisia	24,566	1,250
U. Arab Emirates	9,303	7,950
UK	28,341	19,940
USSR	33,555	24,040
Yemen, North	42,883	32,556
Yemen, South	0	2,593
Yugoslavia	16,424	7,000
Zaire	0	1,750
Other countries	38,399	23,673
	2,850,104	2,611,994

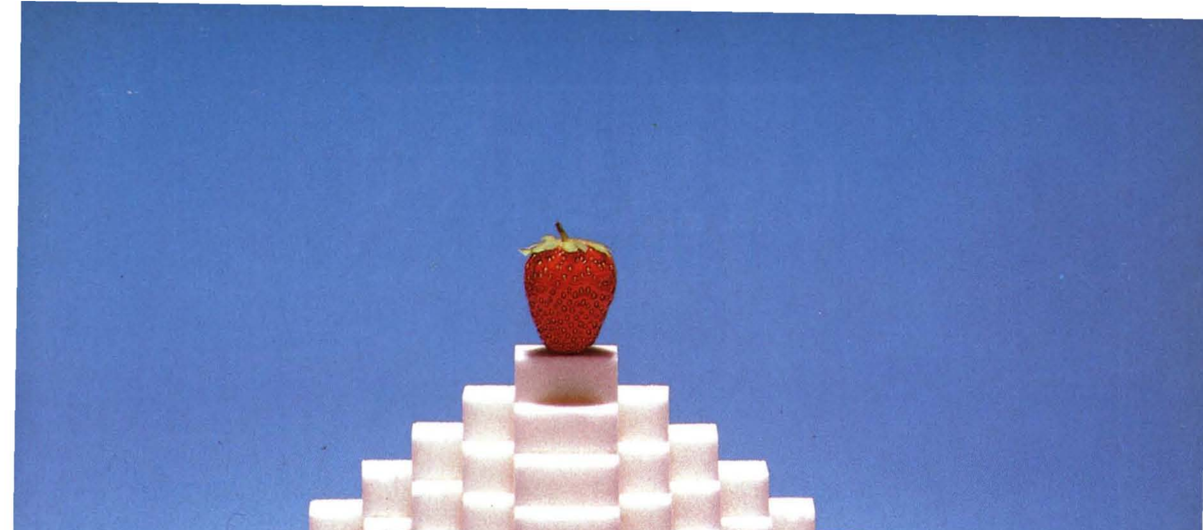
Bundaberg Sugar Co. Ltd. bid for Babinda accepted[12]

In November last, 78% of the shareholders in the Babinda Cooperative Sugar Milling Co. voted to accept an offer by the Bundaberg Sugar Co. Ltd. to purchase their sugar factory. The decision marked the end of a struggle with a consortium of three milling cooperatives – Mulgrave, Mossman and South Johnstone – which had been running for much of 1989. The Mourilyan and Babinda factories, now owned by the same company, may rationalize transport and other arrangements.

Mexican crop damage by frost[13]

A reduction of cane and sugar production in the states of Vera Cruz, San Luís Potosí and Tamaulipas occurred as a consequence of heavy frost in late December 1989. Estimated sugar production from the 1989/90 season, at 3,150,000 tonnes, raw value, is significantly lower than had been expected and Mexico will require a million tonnes of sugar imports in 1989/90. Contracts signed in 1988/89 will provide 200,000 tonnes and the state agency Azúcar S.A. has signed new contracts for a further 400,000 tonnes of refined sugar. Private sugar factories are expected to import 200,000 tonnes.

8 *Australian Canegrower*, 1989, **11**, (23), 3.
9 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, S110 - S111.
10 *Sugar y Azúcar*, 1990, **85**, (2), 14.
11 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 97.
12 *Australian Canegrower*, 1989, **11**, (23), 5.
13 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 101.



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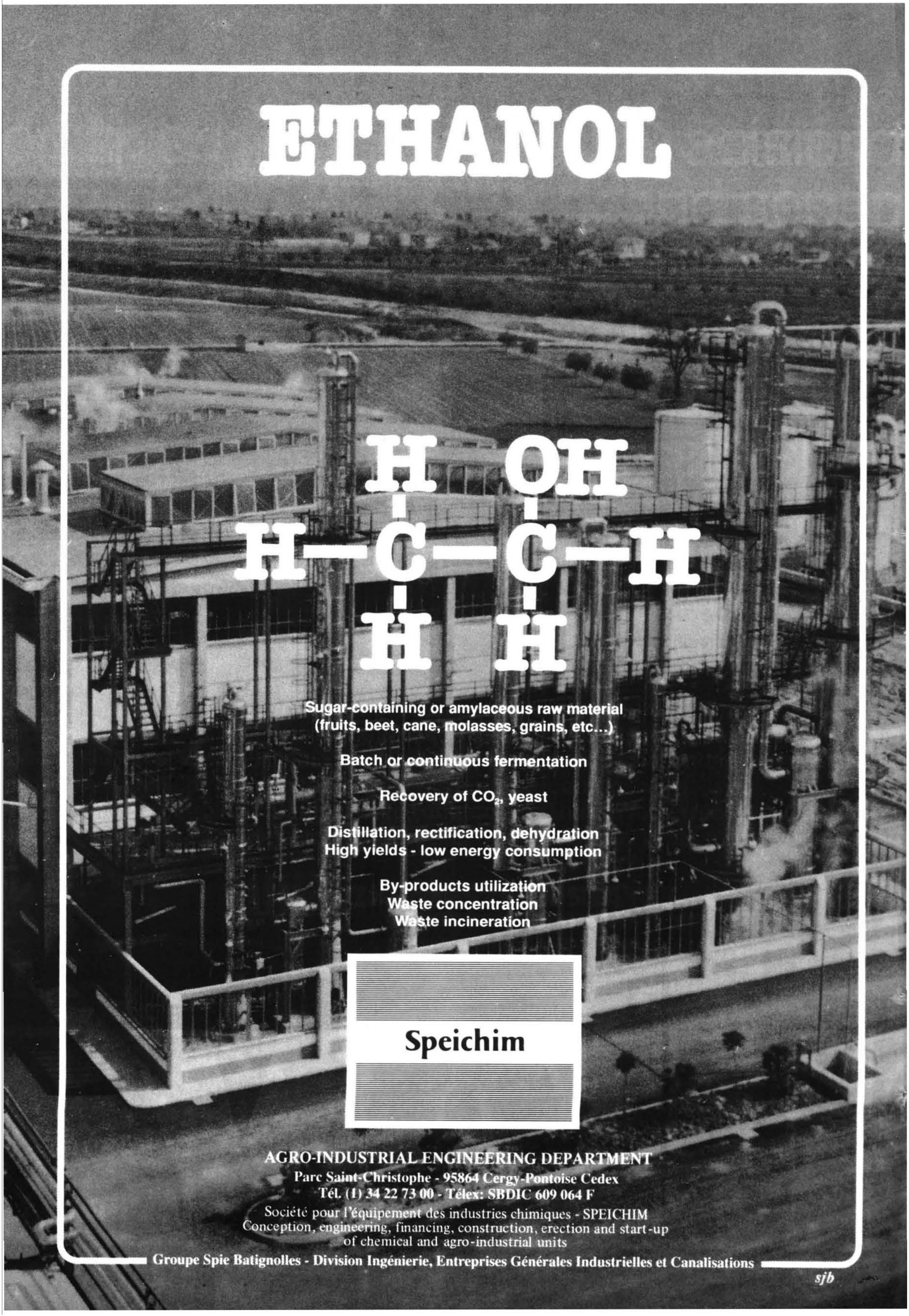
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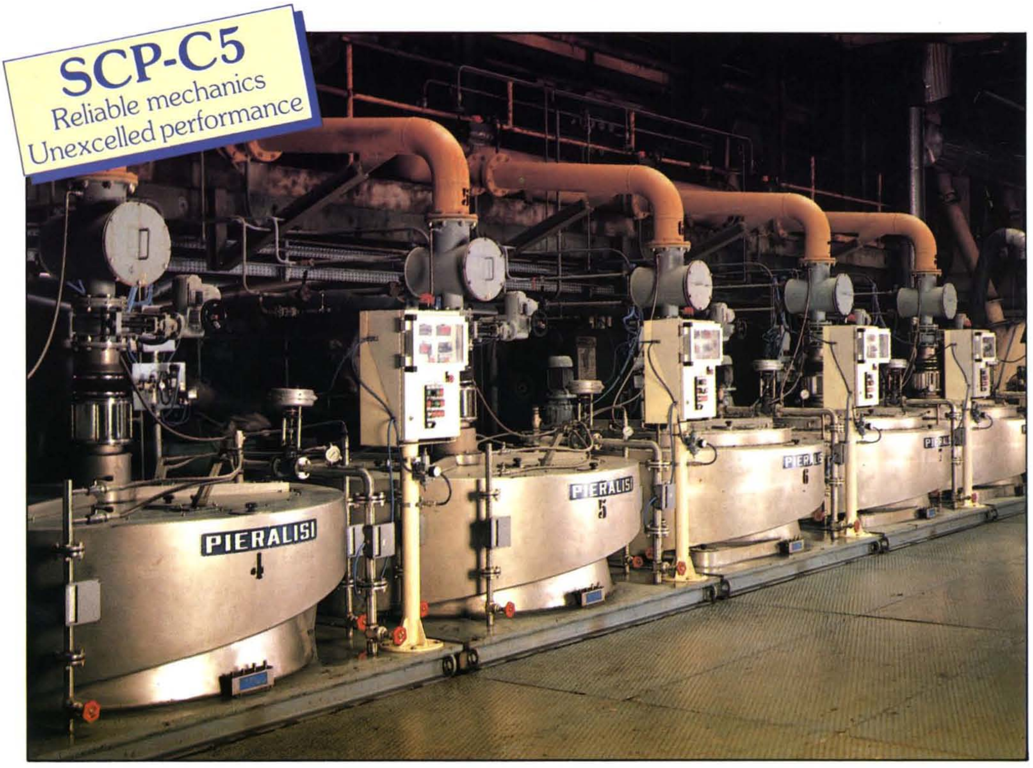

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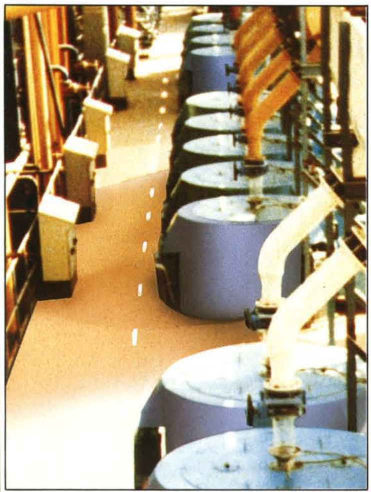

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