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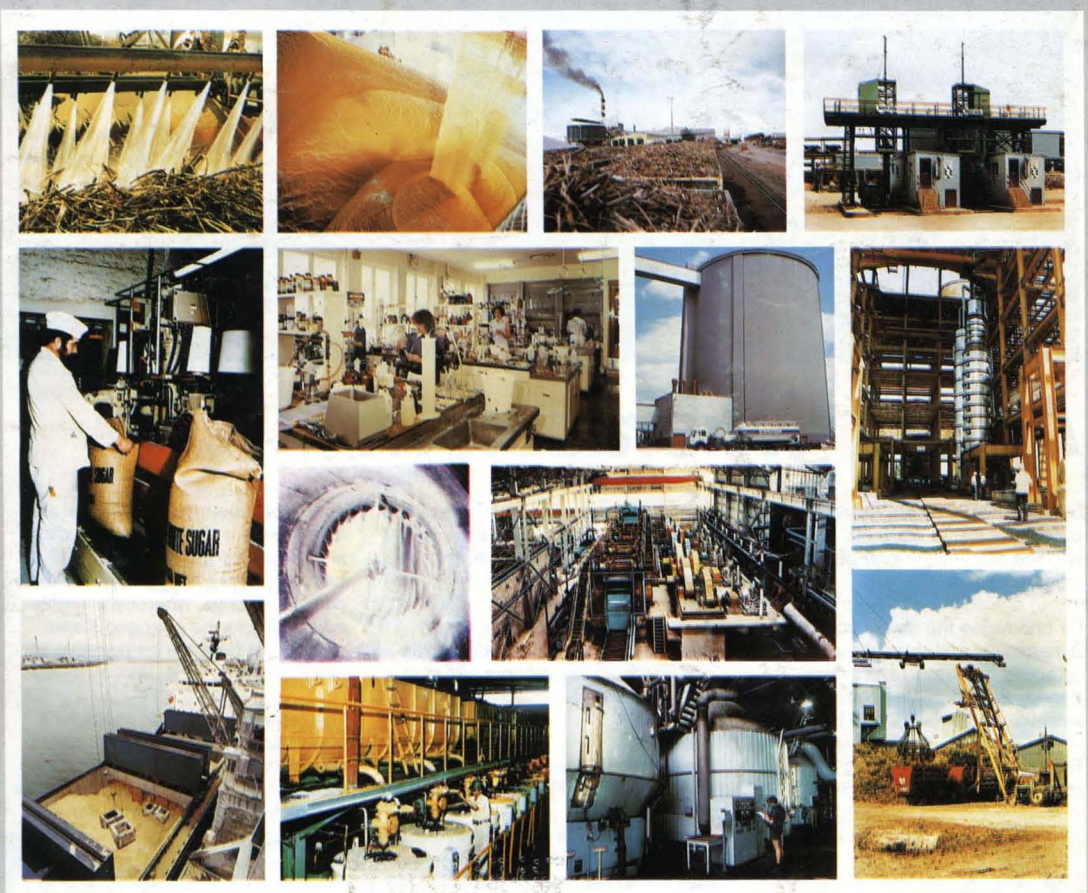

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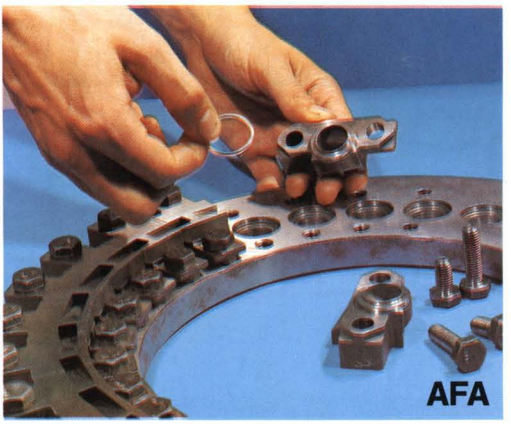

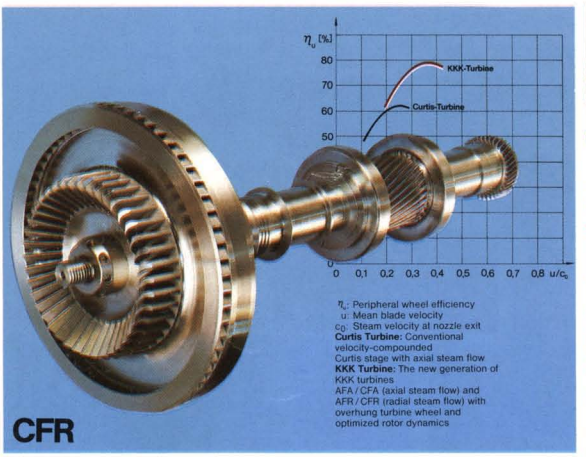

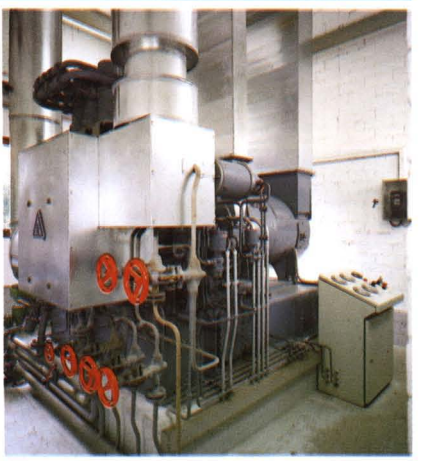

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News and views

A record year for *International Sugar Journal*

The number of subscribers to *ISJ* rose by 11% in 1987 and now exceeds any other independent magazine serving the international sugar industry. The geographical spread of editorial and readers is unequalled.

Doubtless this reflects the unique service which *International Sugar Journal* provides as the only international publication devoted exclusively to sugar process technology. Readers will recall that this came about in 1983 when articles on cane agriculture were transferred to our new sister publication *Sugar Cane*. This too is experiencing rising subscription numbers.

Our survey of readers in 1987 confirmed our position; readers rated *ISJ* more highly than any other magazine in the sugar industry.

World sugar prices

Sugar prices followed a downward trend through February, following five months of steadily rising prices. The decline began with a flurry of sales by commission houses, speculators and funds which, in turn, triggered stop-loss sales. The sharp drop in the precious metals markets, to their lowest levels of the past six months, gave rise to liquidations on the sugar market so that dealers could cover their margins on the metals exchanges.

Several firms issued higher estimates of sugar production from the 1987/88 campaign in the USSR which indicated reduced requirements from the world market and this had a weakening effect; both Czarnikow and Licht reduced their forecast of the likely draw-down of stocks during the current crop period to August 1988.

The falls were curbed by a number of positive factors, however; China made several purchases from traders, taking advantage of the lower price levels; Cuba is reported to have reached agreement with the USSR on financing of approximately 500,000 tonnes of raws, part of which will be going to the Soviet Union; and the announcement by he Philippines that it would need to import 100,000 - 150,000 tonnes (market estimates are 200,000 tonnes) of raws to meet its domestic consumption and export commitments, owing to inadequate production caused by drought. Although, unlike Pakistan, India has not bought more sugar since its purchases in January, reports of the progress of the current crop and the apparent determination of the government to prevent price rises, have led the market to expect its return as a buyer, and this has been a factor in maintaining confidence. Nonetheless, the London Daily Price for raw sugar showed a substantial fall over the month, from $250 on February 1 to $205 on February 29, with the corresponding price for white sugar falling from $251 to $225 per tonne during the same period.

Indian sugar prospects to 1990

Cane and sugar production in India were recently discussed by F. O. Licht GmbH who noted[1] that, with a record level of 8.5 million tonnes, white value, in the October 1986/September 1987 season, India has regained first place among sugar producing countries after a lapse of five years. In raw sugar terms output is nearly 9% of the world's output. This takes no account of the open-pan sugars produced – gur and khandsari – the proportions of which, relative to vacuum pan sugar produced in factories, vary from state to state. Factories crush up to 90% of the cane grown in Maharashtra, but in Uttar Pradesh, which produces more cane than Cuba, the khandsari units predominate and only 20 - 30% of cane goes to the sugar factories. If 50% of the cane grown in UP were sent to factories, sugar production would rise by no less than 1,850,000 tonnes!

The 7th Five-Year Plan, which ends in 1990, sets a target of 217 million tonnes of cane from 3.3 million hectares. Since in 1986/87 185 million tonnes were grown on less than 3 million ha, this seems realistic, especially since, whereas in the southern states of Tamil Nadu and Karnataka average yields exceed 80 tonnes/ha, those in Bihar and U.P., which account for 45% of cane production, average less than 50 tonnes/ha, indicating a vast potential for development.

In spite of the drought which affected the northern states, where cane production is expected to fall by 10 - 15% and recovery of sugar by 1.5 - 2.0%, sugar output during the first two months of the 1987/88 season is ahead of the corresponding period of 1986 and the 1986/87 sugar production may be expected to be maintained or even marginally bettered. Meanwhile, consumption has been growing faster than other foods, partly owing to a rise in the standard of living and partly to a movement in eating habits toward more sophisticated foods.

To meet this demand, India has been a net importer of sugar since 1984/85, the imports reaching 950,000 tonnes in 1986/87. This required costs of $200 million and the govermnment has been under pressure to limit the spending of foreign exchange on sugar imports. The domestic industry has suggested a number of means of encouraging sugar production expansion, including raising of the statutory minimum cane price, reducing the proportion of levy to free sale sugar, decontrol of molasses prices, application of excise tax to khandsari; rigorous enforcement of the reservation of cane fields for particular sugar factories and encouragement of sugar cane development. No major changes in sugar policy are expected in the current plan period, however, and it is concluded that India will continue to be a net importer, subject to the future policies of the government, in order to meet the gap between consumption and production and, if possible, to build up buffer stocks.

Mexico sugar industry privatization plans[2]

After a long period of frozen prices which led to stagnating investment, the government of Mexico launched a major rationalization program at the beginning

1 *Int. Sugar Rpt.*, 1988, **120**, 21 - 25.
2 *Czarnikow Sugar Review*, 1988, (1769), 3.

of this decade. In addition to structural changes, the authorities took over many sugar factories that were in financial difficulties, leading to an escalation in the level of government owned or controlled factories. Although slow to gain momentum, this policy gradually succeeded to the extent of raising sugar production from 2.5 million tonnes in 1980/81 to around 4.1 million tonnes expected this season. In the first half of the 1980's consumption was in the range 3.1 - 3.5 million tonnes and exceeded production so that Mexico imported on average more than 600,000 tonnes each year. In the last few years, Mexico has reverted to the role of exporter and now carries high stocks.

The government intends to cut back its direct participation in the sugar industry, from 76 to 50%, according to GEPLACEA, as part of a national policy of government divestment of state-owned firms, and plans have been announced for the sale of 16 factories having a total production in 1986/87 of 832,000 tonnes, raw value[3]. This will leave 34 factories still state-owned, while there are 14 private factories and 2 cooperatives. At the end of the current season, the state organization, Azúcar S.A., is to close its small mill Ingenio Oacalco in the state of Morelos.

Mr. Eduardo MacGregor, Director of Azúcar S.A., mentioned that closure of two factories in Jalisco was also under study, and his comment that workers might be relocated in other industries within the province implies that other jobs will not be found in sugar and that some contraction of the industry may result from the disinvestment program by the government.

Chinese sugar supplies[4]

The Chinese authorities have announced that sugar sales in 1987 totalled no less than 7.12 million tonnes, white value, to show a growth of 13% over the year before. Net imports for the first eleven months reached almost 1.2 million tonnes; for the calendar year this probably grew to some 1.3 million tonnes which, when added to production from the 1986/87 crop of 5.26 million tonnes, white value, implies that stock levels were run down last year, possibly by as much as 0.5 million tonnes.

It is not surprising, therefore, that some concern is now being shown about availability for 1988. There have been recent reports of lower production in some areas, and official plans have been implemented to reverse the decline in area. Subsidies to factories and growers have been increased and there is now a major national effort to stimulate production growth. Despite these measures, results may not be apparent until the 1988/89 crop and C. Czarnikow Ltd. expect a modest retrenchment in output to 5.2 million tonnes, white value, for the current season.

Imported sugar is likely to cost more than in recent years and it remains to be seen whether the authorities will endeavour to damp down demand or limit availability in view of the drain on foreign exchange made by imports. Without changes in pricing policy it would seem that a rising trend in consumption will continue. Growth of 5% would result in demand approaching 7.5 million tonnes and, since this would exceed the estimate of domestic supply by 2.3 million tonnes, it appears that further buying will be needed for the current year, as well as to cover any re-exports, which last year rose quite sharply.

EEC sugar policy[5]

At their session on February 22, the Foreign Ministers of the European Community agreed on production control measures for seven non-arable farm products, unblocking a radical reform of EEC budget and farm policy. On the sugar sector, the Commission's proposal for this stabilizer emerged from the Council unscathed. The main objective is to ensure that the sector is self-financing on an annual basis, which means that there will be a supplementary levy, applied retrospectively, to ensure a coverage of the deficit each year if the proceeds from the two protection levies are insufficient.

Quotas will be maintained at their present level for 1988/89 to 1990/91. Together with the acceptance of the "summit package" by the Foreign Ministers, the application of a special elimination levy for the current sugar economic year to June 1988 was agreed upon. The Council of Ministers also accepted the Commission's proposal to leave for the period 1988/89 to 1990/91 the A- and B-production quota unchanged as well as the maximum amounts of production levies (2% basic levy and up to 37.5% additional B-levy).

3 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 71.
4 *Czarnikow Sugar Review*, 1988, (1769), 3 - 4.
5 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 115.

Facts and figures

UK beet campaign results, 1987/88[6]

Harvesting and processing of sugar beets in the 1987/88 campaign was completed by January 28, when the last two sugar factories finished processing. The beet harvest reached some 8 million tonnes and a white sugar outturn of 1,230,000 tonnes was expected against 1,340,000 tonnes in 1986/87. The campaign had been average but harvesting had been hindered by wet weather; as a consequence 19,000 tonnes of beets were still in the ground and may be lost. The average sugar content of the beet reached 16.78% by January 24, substantially below the previous campaign's 18.18%.

Italian sugar factory closure[7]

The Eridania group is to close the Comacchio sugar factory in Ferrara on technico-economic grounds. It had been foreseen in the 1984 national sugar plan that either the Comacchio factory or that at Mezzano would be closed.

Dutch sugar exports, 1987[8]

Holland exported 1,876 tonnes of raw sugar and 598,402 tonnes of white sugar in 1987, giving a total of 652,313 tonnes, raw value. Of the white sugar exports the largest amounts went to Nigeria (116,825 tonnes), Iran (97,645 tonnes), Algeria (63,250 tonnes) Saudi Arabia (55,928 tonnes), India (42,799 tonnes), Syria (41,601 tonnes), Egypt (41,003 tonnes), South Yemen (34,103 tonnes), North Yemen (14,004 tonnes), Jordan (12,862 tonnes) and Turkey (12,000 tonnes).

6 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 69.
7 *Ind. Sacc. Ital.*, 1987, **80**, 188.
8 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, S94.

ANALYSIS

Microbiological quality evaluation of Indian plantation white sugars

By R. Katiyar and K. A. Prabhu
(Sugar Chemistry Division, National Sugar Institute, Kanpur, India 208017)

Introduction

In the techniques of refining for producing quality sugars, Cameron[1] and Pivnick[2] reported the role of thermophilic spore-forming micro-organisms in sugar manufacture. Owen[3] and Brooks *et al.*[4] have stressed the need of sanitation for microbial control during plant operations. The American Bottlers and National Canners Associations have established bacteriological limits for sugar employed in beverages and canned foods. The problem faced is not due to the losses of sugar by the action of micro-organisms but the fact that their presence makes it unsuitable for canning purposes[5]. Several physical[6,7] and chemical[8,9] techniques for the elimination and control of micro-organisms have been reported.

The present paper deals with the analysis of Indian plantation white sugars for thermophilic bacteria contents as a criterion for quality evaluation and methods of elimination and control during the processing of sugars.

Materials and methods

The sugars were collected and stored in sterilized sealed glass bottles. The procedure followed was essentially the same as prescribed by the US National Canners' Association, the Indian Standards Institution and ICUMSA[10-12].

The flat sour thermophilic counts were carried out by the Koch pour plate technique using dextrose-peptone-BCP agar medium[11] and by the MPN method[13] using sucrose tryptone BCP (modified) liquid medium. 20 g quant-ities of sugars, syrups or massecuites were weighed aseptically into sterile flasks and made up to 100 ml with sterile water. These 20% solutions were boiled for 5 minutes, cooled and used as inoculum. Samples containing bacteria above 1600/100 ml were determined by suitable dilutions (1:50) in sterile water. Colonies showing yellow zones with opaque centres appearing on a medium containing glucose 0.5, peptone 1.0, BCP 0.04 and agar 2.0 (g/100 ml), at pH 7.0 after 48 hr incubation at 50° - 55°C (±0.5°C) were taken as flat sour thermophilic bacteria. The colonies

R. Katiyar

which did not show change of colour (purple) were not taken up.

The MPN (Most Probable Number) method for counting the bacteria in sugar samples was standardized. A liquid medium containing sucrose 0.5, tryptone 1.0 and BCP 0.04 (g/100 ml) at pH 7.0 was found to be suitable[14] for growth. 10, 1 and 0.1 ml inoculum sets (five tubes in each) were taken up in these studies. Incubation time and temperature was as in the pour plate technique. The tubes were examined for changes to yellow from the original purple colour; these were taken as positive while no change in colour was negative. The data calculations were done by referring to standard MPN tables.

For testing the effect of different chemical agents, the required concentration of chemicals were added to the boiled and cooled sugar solutions obtained as described above and reacted for 30 minutes at room temperature. After this they were inoculated in the sucrose-tryptone-BCP medium with necessary controls for measuring the counts. In the study of physical agents:

(a) 20 ml of 45°Bx sugar solution at 50°C was treated separately with 5 g each of

(i) Bentonite
(ii) Hyflo supercel
(iii) Amberlite cation exchanger
(iv) Activated charcoal.

and filtered in sterile containers and analysed for bacterial counts.

(b) 40°Bx sugar syrup was treated for 20 minutes ultrasonically at 20 kHz (Vibronics Model P2)

(c) Sugar was spread in sterile petri dishes (7 cm dia) in thin films (monolayer crystal) and exposed to U.V. light at 4 - 5 inches distance for 20 minutes. Data were expressed in counts per 10 g solids.

Results

The samples of sugars analysed (Table I) did not meet ISI and Canners' standard requirement with regard to thermophilic bacteria count. The bacteria counts by the pour plate and MPN methods were comparable.

Table I. Thermophilic bacteria counts per 10g sugar*

Sample	Plating method	MPN method
Sulphitation		
S_1	100	90
S_2	135	140
S_3	65	60
S_4	60	55
S_5	65	70
Carbonatation		
C_1	80	85
C_2	65	60
C_3	80	75
C_4	90	85
C_5	125	120

* According to the Canners/ISI standard, the maximum thermophilic count per 10g is 75 and the average is 50

Antibiotics such as penicillin, streptomycin, tetracyline and chloramphenicol at 10 mg/l concentration removed 90 - 100% of the thermophilic bacteria. CPB, SLS, Triton, 2-chloropropionic acid, Boroquat, Busan and Odocide at 50 mg/l successfully eliminated 80 - 90% of these bacteria from sugars. Among the solid materials tried activated charcoal was the best in the removal of bacteria. Exposure of sugars to U.V. light and ultrasonic treatments of syrups were found to be effective for eliminating the thermophiles (Table II).

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2 Pivnick: In "Microbial Ecology of Foods, Vol. II. Food Commodities" Eds. Silliker & Elliott: (Academic Press, N.Y.), 1980, p. 778.
3 Owen & Mobley: *Ind. Eng. Chem.*, 1932, **24**, 1042.
4 Brooks *et al.: Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 8.
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7 Lodos *et al.: CubaAzucar*, 1982, (Oct./Dec.), 29 - 34.
8 Pugh: *Proc. Philippine Sugar Tech.*, 1981, **28**, 211.
9 Nystrand: *Zuckerindustrie*, 1985, **110**, 693.
10 *Research Inf.* (National Canners' Association), 1970, (159).
11 Indian Standard No. IS:1679 (1960).
12 *Proc. 14th Session Int. Commission Uniform Methods Sugar Analysis*, 1966, 124.
13 "Standard methods for the examination of water and waste water" (American Public Health Assoc. Inc, New York), 1960, p. 502.
14 Katiyar & Prabhu: *J. Basic Microbiol.* (East Germany), 1987 *(Communicated).*

Table II. Effect of different physical and chemical agents on flat sour bacteria contents of sugar

	Count per 10 g	% Inhibition over control
Control	100	-
Physical agents		
Ultrasonic treatment 20 minutes	12	88
U.V. rays 20 minutes	12	88
Adsorbents		
Bentonite	60	40
Hyflosupercel	70	30
Amberlite IR-120	85	15
Activated charcoal	20	80
Chemical agents (50 mg/l)		
Ammonium bifluoride	25	75
Sodium hypochlorite	15	85
2-Chloropropionic acid	0	100
Sodium lauryl sulphate (SLS)	10	90
Triton X-100	13	87
Busan-881	22	78
Chloramine T	40	60
Octyl alcohol	95	5
Odocide	0	100
Sulphamoxole	55	45
Sulphanilamide	38	62
Cetyl pyridinium bromide (CPB)	15	85
Boraquat	20	80
Noigen X-100	25	75
Antibiotics (10 mg/l)		
Penicillin	0	100
Streptomycin	0	100
Tetracycline	10	90
Chloramphenicol	0	100

The thermophilic bacteria counts in cane juice and its products at various stages e.g. filtration, concentration, crystallization, and bagging indicated that contamination by microflora is highly variable. It decreases during filtration and concentration and then increases during crystallization in massecuites where temperatures are favourable. Most of the micro-organisms remain in the mother liquor i.e. molasses, and thus the count in bagged sugar is smaller. The contents were very high in all the products in this experimental plant possibly owing to lack of sanitation control. The bacteria content was less in closed vessels, i.e. the Dorr clarifier, the evaporator and pans, as compared with mills, open tanks, crystallizers, etc. (Table III).

Discussion

Abundant microflora in filtered clear juice showed that colour removal and purity rise in clarification cannot be considered as criteria for assessement of removal of bacteria. The filtered juice must be properly disinfected and not further exposed. The high content of thermophilic microflora in primary juice and its further increase in mixed juice indicated that infection is soil- and water-borne. Filtration and evaporation reduced appreciably the bacterial count but during the residence of massecuites in crystallizers it further increased, infection coming primarily from microorganisms in the air.

Other authors[14] have earlier described the characteristics of thermophilic bacteria found in sugars. The study and removal of these heat-resistant micro-organisms can be of help in quality evaluation and refining of sugar, and the MPN method can be used as a convenient and simple means of microbiological quality control.

Table III. Thermophilic bacteria counts of various intermediate products during sugar manufacture (by the sulphitation process)

	Counts/10 g
Primary juice	10750
Mixed juice	13500
Filtered juice (Dorr)	2650
Evaporator juice	2350
Syrup	3500
Pan (before crystallization)	4250
Pan (after crystallization)	2200
Massecuite	3400
Sugar (ESF)	600
Final molasses	32000

Filtration using adsorbents and addition of disinfectants can control the bacteria. Antibiotics, though good for control of bacteria, cannot be recommended for ethical reasons. Surface active agents, SLS, chloropropionic acid, Odocide, Boroquat and Busan can be considered for industrial application. Synthetic sugar esters[15] are being tried in some sugar factories in Germany and Cuba.

The increase of thermophilic microflora in the crystallization and bagging steps can be countered by providing germicidal U.V. lamps in their vicinity and taking steps to achieve asepsis in the bagging of sugar.

Summary

Sugars have been analysed for thermophilic flat sour bacteria by following pour plate and MPN techniques. The MPN method has been standardized for application in the sugar industry to evaluate easily the quality of sugars. Thermophilic micro-organism contents at various stages during the manufacture of sugar in an Experimental Sugar Factory are given. Some of the methods to eliminate these bacteria by chemical and physical methods have been suggested.

Acknowledgement

The authors are grateful to Prof. Ram Kumar, Director, National Sugar Institute, Kanpur for providing facilities and taking a keen interest in these studies.

15 Nakayama *et al.: J. Food Hygiene Soc. Japan*, 1982, **23**, 25.

Observations on the dissolution of sucrose crystals

By Andrew VanHook
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Introduction

The dissolution of sucrose crystals has been amply studied[1] but not so much as the reverse process of growth, even though it is the ultimate fate of most raw and white sugars.

While dissolution is the reverse of growth they are not necessarily equivalent kinetically unless diffusion forces prevail in both cases. This appears to be so for sugar at higher temperature (>50°) but not at low[2,3]. Here dislocations guide the growth[4] but have little influence on dissolution even though both originate from the same point sources. This is clearly evidenced by etch patterns[5]. The rate of dissolution of sucrose crystals, as well as many others[6] but not all, is invariably greater than that of growth, at least at finite concentration gradients. This difference is understandable when we realize that the activation entropy demands in the last act of fitting a molecule into its crystal lattice is quite different from the reverse as the first step in its removal. An alternate atomistic interpretation would be that the growing crystal is bounded by low index faces whereas curved and rough surfaces develop upon dissolution. Many other explanations can be justified[7].

While there is no doubt that $R_D > R_G$ for finite concentration gradients, the relationship of their values as both approach zero net value is very significant theoretically[8,9]. However, interpretation becomes difficult experimentally because the crystal area increases inordinately owing to etching as dissolution proceeds and the shape factor changes on account of rounding of corners and edges[10].

Previous results and methods

The greater speed of dissolution of sucrose at finite undersaturations is well established but, to the writer's knowledge, only a few isolated cases at very low levels have been reported. These are his own measurements[11] at 0° and 35°C when excursions into the undersaturated range were taken primarily to establish saturation during growth measurements. In that case a dissolution rate of 0.07 μm/hr at σ_m – 0.002* and 0°C, followed

A. VanHook

a steady growth rate of 0.10 μm/hr at σ_m = +0.005. Assuming a linear change between these very low levels and saturation indicates that the dissolution rate is at least 1.7 times the growth rate. At 40°C the ratio is about 3:1 at σ_m = 0.001 but again only one or two measurements at temperatures only slightly above saturation were involved. This is qualitatively the same pattern Millicent Taylor observed in her very exact measurements of the solubility of sucrose at elevated temperatures as well as common observations with the saturoscope[13] – erosion with rising temperature is more apparent than sharpening in the opposite direction.

To assure the point at vanishing concentration differences, the same microscopic and weighing procedures as before were followed, using changing temperatures and water injection to alter the over- and under-saturation, respectively. At 0°C, as well as at 30°C, a change of 1°C corresponds approximately to a change in σ of 1%. Stirring was not employed, in order to give every advantage to the dissolution rate which is very sensitive to circulation.

Present results with discussion

Figure 1 is a point-to-point representation of the growth and dissolution of a 500 mg crystal at 30°C and successively lower concentrations. Clearly, the

* The degree of supersaturation σ is defined as $\sigma = (C - C_{Sat})/C_{Sat}$ where the concentration is expressed in weight (molal) or volume (molar) scales. The latter is probably more significant theoretically, especially when pure diffusion controls. It is about one-third that on the molal basis[12].

1 Freund: *Zeitsch. Zuckerind.* 1962, **87,** 554 - 556.
2 Nicol & Parker: *I.S.J.*, 1971, **73,** 355.
3 VanHook: *ibid.*, 1972, **74,** 131.
4 Idem: *Zuckerind.*, 1984, **109,** 638.
5 Mantovani: *Proc. 13th Gen. Assembly CITS*, 1967, 279.
6 Buckley: "Crystal growth" (Wiley, New York) 1957.
7 Hermann: "Auflösung von Kristalle" (Springer Verlag, Wien), 1975.
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10 Nielson: "Mineralization and demineralization", Ed. Nancollus (Springer Verlag, Berlin), 1982, p 37.
11 VanHook: *Proc. 10th Congr. ISSCT*, 1959, 305.; *J. Cryst. Gr.*, 1969, **5,** 305.
12 Idem: *Proc. 17th Gen. Assembly CITS*, 1983, 615 - 631.
13 Wright: *Proc. 17th Congr. ISSCT*, 1980, 2264 - 2278.

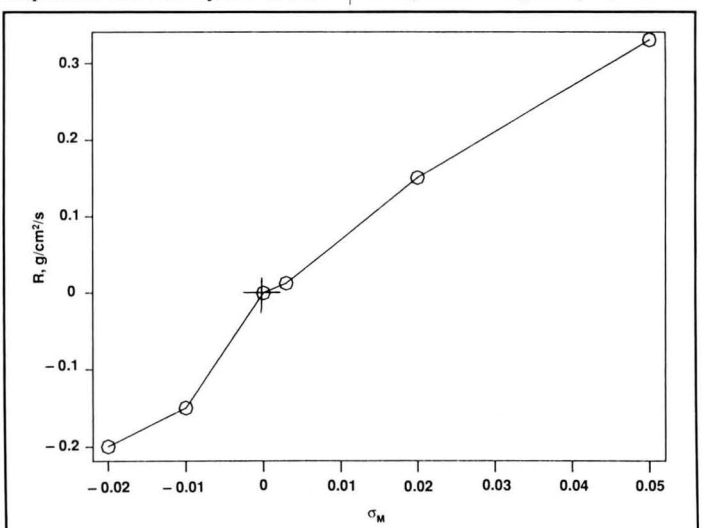

Fig. 1. Dissolution following growth, weighing method, σ_m diminished by injection of water

rate of dissolution exceeds that of growth in the neighbourhood of saturation by a factor of at least 1.5. Repetition often yielded even higher values well within $\Delta\sigma = \pm 0.01$. The ratio is higher at 0°C but the two seem to merge at 60 - 70°C[2,3]. At still higher temperatures rapid inversion interferes but the rates appear to be approximately equal.

Figure 2 is a typical run with the microscope in which the length (b) of a crystal was measured as the temperature of its mother liquor was progressively increased. Again, $R_D > R_G$ by a factor of at least 1.6. When the temperature of the partially dissolved crystal is reduced for regrowth, values higher than before are realized and the more so the more extensive the etching. This is no doubt the result of eroded surfaces, as noted many years ago by Kukharenko and Grut.

The pattern of $R_D > R_G$ close to saturation was further endorsed by adding some alcohol washed crystals to a 3% oversaturated syrup at 30°C. The refractive index change from $\sigma = 0.030$ to 0.025 indicated a first order rate constant of 0.14/hr which then settled to 0.04/hr at $\sigma = 0.02$ and below. The temperature was then raised to 32°C, which would be equivalent to 1% undersaturation, when the rate of dissolution was 0.45/hr. Upon returning to 30°C, σ now 0.01, the early regrowth was 0.10/hr which quickly settled to 0.05/hr. Evidently $R_D/R_G > 3$ within $\sigma \pm 0.01$.

The influence of impurities is most revealing. Certain additives, particularly raffinose, have a pronounced impeding effect on growth rate[14] by comparison with others such as invert, ash constituents, etc. Yet, all have relatively little influence on the dissolution rate, at least at finite potentials[5] ($\sigma = 0.10$). Whether or not the difference persists at low potentials ($\sigma = 0.01$) bears directly upon the possibility of the impurity acting on the centres of dissolution just as effectively as poisoners during growth. This is not an impossibility, as evidenced by the case of NaCl[15] and other salts although the general pattern is for

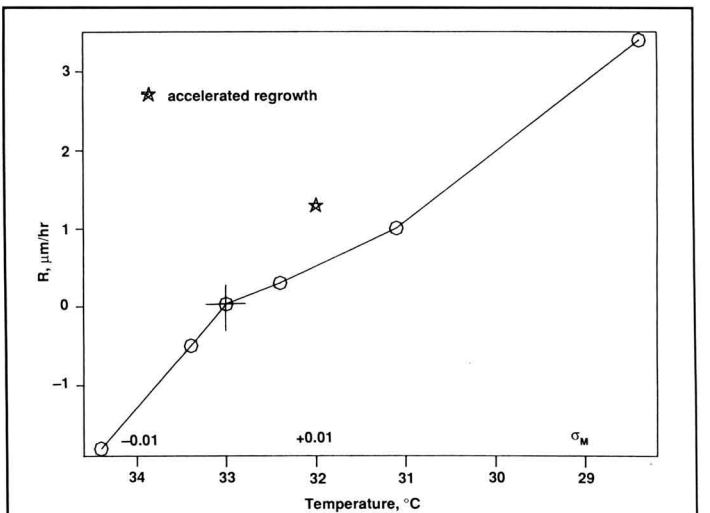

Fig. 2. Dissolution following growth, microscopic length B

R_D to exceed R_G.

To examine the case for sucrose, both normal and doped† crystals were grown further and then dissolved in slightly over- and under-saturated syrups, respectively. Most of the experiments were at 30°C and $\sigma = \pm 0.01$ to 0.05. In all cases R_D remained greater than R_G – just as before – but some interesting behaviours emerged in the study.

1. As is well known from Bates' work[16], the normal sucrose crystal extends faster in the right hand direction (p', 010, untruncated) than left-wise and similarly for dissolution[17]. However, in the presence of sufficient raffinose, progress toward the right is virtually stopped, as dramatically demonstrated by Mantovani[14], but no change is observed in the dissolution behaviour except that doped crystals appear to dissolve even faster than normal ones. This probably follows from different types and degrees of roughening although no pronounced difference in etch patterns was discerned on casual microscopic examination.

A $^1/_2$-gram normal-shaped crystal growing at a rate of 0.25×10^{-6} in pure syrup at 30°C was transferred to some of the same syrup to which 4 g raffinose/100 water had been added. The growth rate fell to 0.062×10^{-6}. Upon returning to the original syrup, growth resumed to 0.29×10^{-6} and fell again on replacement into the spiked solution to 0.065×10^{-6}. Using the same large crystal throughout excludes any question of shape factor. This prompt response of the overgrowth to the medium has been demonstrated microscopically by Dunning[18] for the cases of raffinose, invert components, etc. as the additives.

Repeating with a larger (1.5 gram) doped crystal yielded the same result. Introducing dissolution into cycling demonstrated again $R_D > R_G$ as well as R_D of the doped crystal being about double that of the norm. This was further confirmed microscopically when it was observed that whereas extension of the b-dimension toward the right was impeded by the presence of raffinose in the syrup, no difference was noted in

† These are crystals grown from syrups containing raffinose, usually 4 g/100 water, or crystals with a considerable layer of overgrowth.

14 Vaccari *et al.: Sugar Tech Rev.*, 1986, **13**, 133; Mantovani *et al.: Paper presented to the Amer. Soc. Sugar Beet Tech.*, 1987.
15 *Colloq. Int. C.N.R.S.* (Nancy), 1965, **132**, 419, 433.
16 *Nat. Bureau Standards Circ.*, 1940, (C 440).
17 Kelly: *Zuckerind.*, 1981, **106**, 900; Kelly & Mak: "The sucrose crystal" (Singapore Univ. Press), 1975.
18 *Acta Cryst.*, 1960, **13**, (6), 495.

reciprocal dissolution, the right end receding even faster than the left, thus emphasizing the hemimorphic[17] nature of the sugar crystal‡.

2. Common surfactants have little influence upon the rate of growth of single crystals of sucrose[19] even at low temperature where surface integration is the rate-determining step. Neither do they influence the rate of dissolution.

3. Standard tablets were soaked in alcohol and also in dilute alcohol solutions of cetyl alcohol and Span 40 surfactant. After air-drying they were submerged in water on a 10-mesh screen, when the control showed first signs of disintegration after 2-3 minute, the crystal alcohol about 4 and the Span 40, 6 minutes. Disintegration was complete after 3, 6 - 7 and 8 minutes, respectively. This delayed dissolution speed may have some particular applications.

‡ Tapering, especially of granulated doped crystals, was occasionally noted but this is considered to be an artifact due to poor circulation.

19 VanHook: *Paper presented to the Amer. Soc. Sugar Beet Tech.*, 1987.

CHEMISTRY

Hydrolytic enzymes of sugar cane

Properties of acid phosphatases

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Introduction

It is a well known fact that sugar cane should be processed immediately after harvesting; if a delay occurs, the cane becomes less suitable for processing. Post-harvest deterioration of sugar cane, and sugar losses therein, have been attributed to the action of hydrolytic enzymes[1-3].

The presence of different hydrolytic enzymes such as amylase, invertase, cellulase, phosphatase, etc. in cane juice has been reported. These enzyme systems can be of great use for sugar technologists in clarification of juices.

The present study describes some of the properties of acid phosphatases of sugar cane and their application in the clarification of cane juices is suggested.

Materials and methods

p-Nitrophenyl phosphate (p-NPP), fructose 1,6-diphosphoric acid sodium salt, β-glycerophosphate sodium salt, RNA (yeast), carboxymethyl cellulose, salicin etc., were BDH and E. Merck chemicals of analytical reagent grade.

In these studies 8 - 10 months old CoS 767 plant cane was cut, collected

G. Das

from the fields and stored at ambient temperature. At regular intervals, an adequate quantity of cane was crushed and the juice filtered through muslin cloth, centrifuged in the cold at 3000 rpm for 20 minutes and taken for the different analyses. Reducing sugars content was estimated by the DNS method[4]. Inorganic and total phosphorus were estimated by the Fiske & Subbarow method[5] in samples before and after digestion with perchloric and sulphuric acids. The difference in phosphorus content was taken as organic phosphorus. Total polysaccharides were determined by the anthrone method[6]. Starch was estimated by the formamide method[7] and protein by the method of Lowry *et al.*[8]. Cane juice was clarified by the sulphitation process.

Enzyme preparation

Cane juice samples from cut cane, stored up to 120 hr after collection, were treated to precipitate the enzyme by adding cold ethanol/acetone to 60% concentration, i.e. $1^1/_2$ volumes. The precipitated purified enzyme was removed by centrifuging in the cold, dissolved in acetate buffer, dialysed and used for the enzymatic studies. Amylase[9], invertase[10], CMC-ase[11], FDP activity[11], salicinase[11] and phosphatase[12] enzymes were tested by standing procedures.

1 Browne & Bloum: *Louisiana Agric. Expt. Sta. Bull.*, 1907, (91).
2 El-Kareem *et al.*: *Proc 15th Congr. ISSCT*, 1974, 1266.
3 Kapur & Kanwar: *Proc. 46th Conf. Sugar Tech. Assoc. India*, 1982, Agl - Ag5.
4 Miller: *Anal Chem.*, 1959, **31**, 426.
5 *J. Biol. Chem.*, 1925, **66**, 375.
6 Madhu *et al.*: *I.S.J.*, 1984, **86**, 136.
7 Bose *et al.*: *Indian Sugar*, 1968, **17**, 739.
8 *J. Biol. Chem.*, 1951, **193**, 265.
9 Venkataramu *et al.*: *Indian J. Biochem. Biophys.*, 1975, **12**, 107.
10 Rosario & Santasopasri: *Phytochemistry*, 1977, **16**, 443.
11 Mandels & Weber: *Adv. Chem. Ser.*, 1969, **95**, 391 - 413.
12 Colowick & Kaplan: "Methods in Enzymology" Vol. II. (Acadamic Press, New York) 1955, p. 523.

Table I. Hydrolytic enzyme activities in cut cane after harvest (specific activity per mg protein)

Hours after harvest	*Enzyme activity, mg of reducing sugar released per hour*					
	Amylase	Invertase	*Acid phosphatase	CMC-ase	FDP	Salicinase
0	35.59	3.16	0.18	5.00	1.64	0.01
24	36.10	3.24	0.37	5.52	2.57	N.D.
48	32.50	3.88	0.70	4.26	4.02	N.D.
72	20.94	4.97	0.72	3.20	6.97	N.D.
96	8.68	5.20	1.04	1.08	4.01	N.D.
120	8.04	3.80	0.98	0.30	0.60	0.03

* mg of inorganic phosphorus released per hour (with p-NPP)
N.D. – Not determined

Table II. Amylase of cut and stored cane for different constituents

Hours after harvest	pH	Total polysaccharide	Starch	Organic phosphorus	Inorganic phosphorus	Reducing sugar, (w/v)
				mg per 100 ml juice		
0	5.4	207	29.06	11.00	9.23	0.89
24	5.0	210	24.37	9.43	10.80	0.98
48	4.9	222	19.13	8.83	11.40	2.19
72	4.8	250	14.06	8.14	12.09	4.32
96	4.8	432	10.31	6.40	13.83	5.23
120	4.4	550	6.47	4.43	15.80	6.08

Enzyme assay[12]

Activity of acid phosphatase was assayed by incubating a reaction mixture of 3 ml containing 2 ml of 0.2 M acetate buffer of pH 5.2, 0.5 ml enzyme (containing 320 µg of protein) and 0.5 ml of substrate (p-NPP / β-glycerophosphate, etc.) at 40°C for 60 minutes. The reaction was then stopped by adding molybdate reagent and inorganic phosphorus released was estimated. Phosphatase activity was expressed as mg of P_i (inorganic phosphorus) released per hour and per mg protein.

Determination of K_m and V_{max}

The kinetic parameters K_m and V_{max} were calculated from the Lineweaver-Burk plot by plotting 1/V *vs.* 1/S. The value of K_m and V_{max} were determined from the initial rates of reaction.

Thermal stability

The reaction mixtures were incubated in the presence and absence of sucrose (20%) for different periods and at temperatures from 50°C to 70°C; they were then tested for activity.

Results

In the cut and stored cane the hydrolytic enzymes were active for about 5-6 days (Table I). Amylase and CMC-ase activities increased up to 24 hr and FDP activity up to 72 hr. Salicinase activity was not appreciable. CMC-ase and FDP activities were found to be higher than invertase and phosphatase activities. Invertase and acid phosphatase activities increased up to 96 hr after harvest.

Analysis of cane juice from cut and stored cane showed that with increasing time of storage, the starch content decreased, polysaccharides, reducing sugars and inorganic phosphorus increased and pH dropped (Table II).

Effect of various parameters on acid phosphatase

pH: The pH profiles of acid phosphatases with p-NPP and β-glycerophosphatase as substrates showed pH optima of 5.2 to 5.4 (Fig. 1).

Different substrates: Acid phosphatase could decompose all types of organic phosphates (Table III) such as p-nitrophenyl phosphate, β-glycerophosphate, RNA-nucleotides and nucleosides, pyro and meta-phosphates and sugar phosphates, etc. Only acid phosphatase activity was present in the samples.

Effect of substrate concentration: The apparent Michaelis constant K_m for acid phosphatase activity with β-glycerophosphate as substrate showed a value of 7.14 mM and V_{max} of 2.38 µg Pi/min as calculated from a Lineweaver-Burk plot (Fig. 2).

Effect of temperature: The temperature optima for p-nitrophenyl phosphatase was 52°C and for glycerophosphatase 62°C (Fig. 3).

Table III. Acid phosphatase activity with different substrates

Sample	Substrate	Specific activity, mg inorganic phosphorus released/hr/mg protein
1	p-Nitrophenyl phosphate (p-NPP)	0.180 *
2	β-Glycerophosphate sodium salt	0.160
3	Fructose 1,6-diphosphoric acid sodium salt	0.078
4	Ribose nucleic acid (RNA)	0.022
5	RNA nucleosides	0.017
6	Hexametaphosphate	0.130
7	Sodium pyrophosphate	0.290 *
8	Clarified cane juice	0.021
9	Clarified cane juice + p-NPP	0.189

* No activity at pH 9.2

ISJ Abstracts

Cane sugar manufacture

Running a small-scale open pan sugar plant in Kenya

B. V. Patel. *Paper presented at Conf. on The Future of Small-Scale Sugar Processing*, 1987, 3 pp.

Details are given of the 200 tcd open pan plant operated by the West Kenya Sugar Co. Ltd. since 1981 and of the equipment used, which includes shell furnaces for wet bagasse burning and an experimental cane expeller.

The economic viability of small-scale sugar production in Kenya

E. Mallorie. *Paper presented at Conf. on The Future of Small-Scale Sugar Processing*, 1987, 26 pp.

The economic performances of five different systems of sugar production are evaluated: vacuum pan processing of 3600 tcd, vacuum pan processing of 450 tcd using diffusion, open pan sulphitation of 100 tcd to produce white sugar and liquid molasses, open pan sulphitation of 100 tcd to produce white sugar and solid molasses, and open pan processing of 45 tcd to produce jaggery.

The policy and performance of the sugar industry in Kenya

D. P. Nyongesa and J. I. Mbuthia. *Paper presented at Conf. on The Future of Small-Scale Sugar Processing*, 1987, 9 pp.

The sugar production, consumption, imports and exports in Kenya over the period 1964/86 are tabulated and the strategy adopted by the government to achieve self-sufficiency in sugar is outlined.

The sugar industry in developing countries: import substitution, government policy and scale of production

H. Lone. *Paper presented at Conf. on The Future of Small-Scale Sugar Processing*, 1987, 44 pp.

The author briefly examines the changing structure of the world sugar market, the main organizational forms of cane sugar production and the requirements of an import-substituting sugar industry, including the chief methods employed in different countries for fixing cane and sugar price levels, with particular emphasis on the cane pricing policy. The various sweeteners produced from cane are discussed and the costs of sugar production using open pan sulphitation and vacuum pan technology compared. Sugar manufacture in India and Kenya is examined and reasons are given for the flourishing open pan technology in India but not in Kenya. The situations in Indonesia, Colombia, Thailand and Papua New Guinea are described.

Factory research in Australia

Anon. *Ann. Rev. Sugar Research Inst.*, 1986/87, 6 - 18.

Swirl burner development: Extensive combustion trials have confirmed the validity of the modelling techniques applied to the swirl burner for bagasse furnaces[1]. The prototype burner was able to burn bagasse with a maximum mean moisture content of 31% under all burner loads, while the burner turn-down range was better than 3:1, which is important for operational flexibility and fast boiler load changes. Flame temperature and gas composition measurements under a variety of burner and furnace operating conditions confirmed the characteristics of the burner flame measured previously. The larger bagasse particles did not burn within the region of the main burner flame, although the ends of the particles were ignited during passage through the flame and complete combustion occurred downstream of the burner in the general furnace space. The burner can form a stable attached flame with a bagasse moisture content which is considerably higher than that possible when firing pre-dried bagasse; this results from the differential bagasse particle drying that occurs in the associated high-temperature dryer. The finer particles are dried to a lower moisture content which stabilizes the burner flame. Detailed high-temperature dryer measurements covering a range of drying gas and bagasse conditions were used to develop a mathematical model of the unit; the model is being used to examine operating conditions and design configurations that may be applied in full-scale swirl burner firing systems. Drying of bagasse to low moisture levels (<10%) for use in boilers modified for increased steam production is of particular interest. A study has been started which is aimed at quantifying the ability of swirl burner firing to enhance steam production from an existing boiler and to establish the relative costs of an installation.
Maintenance studies: Official Australian approval has been conditionally granted for the construction of sugar factory condensers from 3CR12 corrosion- and erosion-resistant metal which has been used successfully for barometric condensers outside Australia; it has already shown promise when used in non-pressure areas of condensers built in Australia but had not been approved for the construction of pressure vessels. Investigations of the performance of corrosion-resistant alloys downstream of wet flue gas scrubbers have shown clear evidence of attack on all types of material, although in some cases the attack was slight; some materials suffered cracking. Trials of various corrosion inhibitors in vacuum pans showed that all those tested offered effective protection when applied to lightly corroded surfaces, but variation was found between them in performance on more severely corroded surfaces.
Cane bin number identification: The automatic bar code reading system mentioned earlier[2] performed well in extensive tests, each scanner giving a reading success rate of >99%. The commercial system using active transponder tags that could be re-programmed in the field failed to provide an adequate reading success rate in tests, although the manufacturer has since announced a modified version that is better.
Direct-contact secondary heating: Some Australian factories have found success in the use of 3rd and 4th effect vapour

1 *I.S.J.*, 1987, **89**, 69A.
2 *ibid.*

for primary juice heating by direct contact, and it has been suggested that the same method could be used for secondary juice heating and thereby eliminate excessive cleaning and maintenance. The ultimate capacity of a 305-mm diameter pilot contactor, designed to handle 20 tonnes of juice per hour using up to 2 tonnes of 1st effect vapour per hour, varied with changes in the internal arrangements; modifications to the original multiple rain tray system to create a more open flow system and reduce flooding permitted an increase in the maximum throughput to 25 tonnes/hr. Control of the heating operations was excellent at juice rates up to these limits, and the heated juice appeared to be sufficiently degassed to be processed without further flashing. Further modifications to the internal arrangements are planned with the addition of an integral juice degassing facility. The heater seems particularly suitable for those factories experiencing severe fouling and maintenance problems with conventional tubular heaters. A schematic layout is presented of the pilot heater installed at Farleigh factory.

Milling studies: Results of experiments conducted during the 1960's at the University of Queensland involving a 60-tonne hydraulic press and a test cell with grooved platens to simulate the surface effects of rollers during milling have been re-analysed and used to confirm the validity of a theoretical model of juice flow and resulting pressure distribution; the experiments had placed emphasis on quantifying the effects of speed of compression, degree of fineness of preparation and compression ratio on platen load. The new model includes a speed-dependent component provided by the pressure gradients required to force the juice through the mat of fibrous material as well as a static component that is independent of speed. The model will be used to study the more complex boundary conditions that occur in the nip region between a pair of rollers, but changes in cane varieties and in cane preparation practices will necessitate obtaining experimental data from new uniaxial compression tests.

Mill roller bearing monitor: While spherical roller bearings can be used instead of brasses as mill bearings, they often give no indication of failure until considerable damage has occurred to shafts and bearing housings. Traditional methods employed to determine the state of a bearing, including the use of accelerometers and shock pulse sensors, are susceptible to other noises and vibrations from the mill, and the use of sensitive displacement probes to monitor the bearings is under investigation. The technique involves drilling a hole through the bearing housing and inserting a probe to measure the minute deflections in the outer race of the bearing as the rollers pass; for a bearing in good condition, the probe output should be a smooth, almost sinusoidal signal, and any damage to the rollers or inner or outer races will cause a departure from this smooth wave. A filter circuit, designed to monitor the signal from the probe and provide alarms in the event of any departures, gave too many false alarms when there were sudden changes in mill speed or load; the circuitry has been modified and was to be tested during 1987.

Computer-based process control systems: Computer-based control systems, especially for clarification, juice heating and evaporation, are being installed in factories; they lead to increased efficiency since more control functions can be supervised by an operator, while sequencing of various pieces of equipment is so easy that fully automatic start-up and shut-down procedures can be adopted. Because computer-based systems offer data storage facilities, they can be used as data loggers to generate daily progress reports, to investigate the causes and effects of disturbances in the system and to evaluate performance before and after process changes; such facilities are of value when tests are to be undertaken, since the installation and operation of a data logger to record more than just a few signals is time-consuming. Computer-based systems are also of advantage for mathematical calculations.

Filtration: Control of the ratio between fibre and mud solids in juice is a convenient method of conditioning filter feed without a separate bagacillo collection and transport system, and preliminary studies on an ultrasonic suspended solids meter and nephelometer for sensing fibre and mud solids, respectively, in screened juice have shown promise, and it is proposed to use them in a ratio control loop around a rotary juice screen provided with coarse and fine meshes, control being achieved by varying the proportion of unscreened feed to each section. Two forms of final actuation are being evaluated. One system installed on a new rotary screen uses a remotely actuated movable feed pipe and trough-traversing screens of varying aperture size; in another system, a refurbished trommel was equipped with removal coarse and fine screens and control achieved by varying the proportion of feed via separate fixed piping to each section. A wide range of external filtrate piping systems is used in filter stations, and considerable losses of vacuum have been measured between the valve heads and filtrate receivers; increases in head vacuum of up to 20 kPa have been obtained either by enlarging piping in this section or by installing a simple air-liquid separator near the valve head to reduce two-phase flow and associated higher vacuum losses in the subsequent filtrate piping.

Extraction of sugar from cane: A combination of hard and soft canes requires extra versatility in cane mills and diffusers. In milling tests, the first mill included a drive for the pressure feeder rollers independent of the main mill drive; the ability to vary the feeder speed independently of the mill speed worked very well as a control agent, although the installation was costly. A load cell in the top roller cap to sense milling conditions was also highly successful. LiCl was used as tracer to determine the time distribution of recirculation water from various distribution troughs as canes of differing percolation characteristics passed through the diffuser at Fairymead factory.

Ultrafiltration: While ultrafiltration of clarified juice to remove polysaccharides

was found to be technically feasible, there was severe membrane fouling by juice components and the fluxes achieved were well below the expected values, and it was concluded that the process would be economically viable only if the flux could be substantially improved. However, despite minor modifications to the pilot plant to allow insoluble abrasive solids such as sand, bagacillo and kieselguhr to be recirculated through the membrane modules in an attempt to reduce fouling, the improvement in flux was not enough to affect the process economics significantly. Particle sizes were limited to <0.5 mm because of pumping restrictions, and larger particles could possibly give better results.

Vacuum pan overstirrers: Use of a pan overstirrer installed just above the top tube plate in a floating calandria vacuum pan improved the heat transfer coefficient by about 20% in tests at a factory, and four pans fitted with the stirrers were to be in operation during the 1987 season. The improved heat transfer and circulation reduced boiling times by approx. 7%, despite which massecuite Brix, crystal content and viscosity were also improved, yielding more crystal sugar and reducing molasses purity. No differences in crystal mean size, coefficient of variation or fine grain percentage were found as a result of stirrer operation.

Developments in continuous pans: Several Australian sugar factories have examined various options for continuous boiling of high-grade massecuite, particularly *B*-massecuite, and computer simulations were undertaken to examine the range of options and designs based on an in-line cell arrangement with internal calandria configuration similar to that of a continuous pan installed at Tully for low-grade massecuite boiling; this design offers good flexibility in operation, simplicity in construction and excellent exhaustion, so that it remains the preferred layout.

Seed crystal initiation pan: The number of crystals established in graining in low-grade pans is often variable and the quality of seed material directly affects the overall sugar recovery from molasses as well as the quality of shipment sugar; variation in graining quality is attributed to variation in the survival rate of fine slurry particles caused by difficulties in achieving good control and uniform conditions in the large volume of molasses blend in a typical graining pan. To overcome these problems, a specially designed seed initiation pan of 100 litres capacity was constructed for initial establishment of seed crystals and to grow them to 25 μm before transfer to a factory pan; a programmable sequence controller was developed so as to minimize operator supervision and allow the graining procedure to be consistent. Factory trials with the pan showed that the footing of small crystals produced was suitable for transfer to the factory graining pan. However, while the prime purpose was to reduce the variation in the number of crystals established in graining and to make the entire procedure more reproducible, the trials yielded results similar to slurry seeding in the factory pan, although the variation was considered better than average. Nevertheless, valuable information was obtained on the variability in numbers of crystals established in slurry seeding, and it is proposed to continue the investigations.

Waste water treatment: Studies on the suitability of Upflow Anaerobic Sludge Blanket (UASB) digestion of waste water for the Australian sugar industry have been conducted over the last four years; the process, used in the beet sugar industry, has yet to be applied commercially at cane raw sugar factories. Laboratory-scale treatment showed that UASB gave significant improvements over activated sludge treatment; while more than one crushing season was needed to develop appropriate micro-organisms from sewage sludge inoculum, surplus micro-organisms from a UASB digester were able to establish a suitable sludge blanket within an acceptable time. Under optimum conditions, UASB digesters removed >90% COD within two hours at loadings of up to 25 kg COD per m^3-day, while shock loadings up to 14 times the normal rate of 6 kg COD per m^3-day over a 3-day period caused negligible harm to the micro-organisms provided enough alkali was added to neutralize the extra acid produced; detection of methane and hydrogen in the biogas allowed automatic control of alkali addition. After 9 months' storage at 25°C, the laboratory digesters returned to normal operations within 3 weeks. The experiments suggest that a typical 300 m^3 full-scale UASB digester would require 13 tonnes of molasses to restart, which is much less than with the activated sludge process.

Corrosion of evaporator tubes: Following some cases of serious pitting of evaporator tubes, laboratory tests are being undertaken to compare the corrosion characteristics of 304, 316 and 430 titanium stainless steels. A Richert P130 Potentiostat coupled with a Scan-Log 66 V scanner is being used to examine the metals by an electrochemical technique known as potentiodynamic anodic polarization, in which carefully prepared specimens are held in a controlled environment and their electrical potential varied relative to a constant reference electrode potential. By observing the variation of current with applied potential, changes in the corrosion rate of the metal surface, regions of passivity and the breakdown potential at which pitting starts can be followed. Preliminary results showed the expected superiority of 316 over 304 stainless steel in syrups and salt solutions.

Chloride levels in process streams: A survey conducted to determine typical chloride concentrations in process streams and evaporator cleaning solutions showed that they were generally well above levels known to promote corrosion and indicated the need for particular care to ensure that other factors that can accelerate corrosion rates, such as low pH and stagnant conditions, do not occur.

Distributed control systems lower production costs

R. P. Lawler. *Food Processing* (USA), 1986, **47**, (11), 80 - 82; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (16), Abs. 16 R427.

An account is given of experience in the introduction of automatic process control systems in Hawaiian sugar factories, covering the entire range of processes from juice extraction to crystallization. The systems permit an increase in labour productivity, production of a higher quality product and a reduction in energy consumption.

Estimation of sugar losses from cane delay

M. T. Hernández N., G. Moya C. and H. Cuéllar F. *ATAC*, 1985, **44,** (3), 12 - 17 *(Spanish).*

The spontaneous fermentation test[3] and apparent purity measurement were applied to juice extracted in a sterilized laboratory mill from samples of cane representing different varieties, harvested by different methods, and kept for different periods of delay between cutting and milling. Losses were greatest with burnt cane harvested as billets, and it is calculated that, over a crop of 8 million tonnes of sugar in Cuba, delays of 48 or 72 hours could result in losses between 79,000 tonnes and 235,000 tonnes, depending on the varieties and harvesting method. Traditional means of estimating losses, based on measurement of juice, Brix, pol and apparent purity show erratic behaviour which invalidates the results obtained, and the spontaneous fermentation test is therefore preferred.

Laboratory study on obtaining direct white sugar by carbonatation

M. Delgado and N. Alvarez. *ATAC*, 1985, **44,** (3), 18 - 21 *(Spanish).*

Trials have been made comparing the results of double carbonatation followed by single sulphitation with the same followed by syrup sulphitation, and with single carbonatation followed by juice and syrup sulphitation. Flow diagrams show the systems and conditions employed, and the results obtained are tabulated. The second process was superior to the others, giving clear juice and syrup of high quality from which white sugar could be obtained directly.

Use of spiral heaters in the cane sugar industry

A. Valdés and O. Gómez. *ATAC*, 1985, **44,** (3), 35 - 40 *(Spanish).*

Installation, operation and evaluation of two Alfa-Laval spiral juice heaters are described for tests of the heating of mixed juice at a Cuban sugar factory. The overall heat transfer coefficient fell only slightly with time, indicating that scale formation was slow, the constant action of the juice on the walls producing its partial removal. The fluid friction against the walls and spacer pins, continual changes in direction of flow and centrifugal force generated by the circular motion of the juice all contributed to a fall in hydraulic pressure as well as to low scale deposition. Use of spiral heat exchangers in sugar factories would permit an extension of the cycle times between cleaning.

Usina Boa Vista S.A.

Anon. *STAB*, 1985, **4,** (1), 4 - 9 *(Portuguese).*

General, agricultural and industrial information is provided on the title company's two factories, together with results obtained during the 1984/85 season, when each crushed a total of about half a million tonnes of cane, the first to produce sugar and the second to produce alcohol directly by fermentation of cane juice.

Linear programming applied to the improvement of white sugar boiling

L. E. Aralde and G. J. Cárdenas. *Rev. Ind. Agric. Tucumán*, 1984, **61,** (2), 127 - 152 *(Spanish).*

The material balance and steam consumption for a 2- and 3-massecuite system used in a cane sugar factory in Tucumán producing white sugar was solved by use of linear programming techniques. Optimization with minimum recirculation of the massecuite was sought. Balances were made on the basis of 100 parts of total soluble solids, the values being obtained by experimental determinations. Steam consumption was determined by calculation from the material balance streams and the corresponding temperatures for each. Three different conditions of operation for the case of three massecuite systems were considered and comparison made with actual operation. In one case studied, a reduction of 10.4% was achieved, with a steam consumption lower by 16.9%. Two variants of 2-massecuite boiling were examined and compared with actual operation; one variant involved a reduction of 16.02% in massecuite soluble solids and 15.31% lower steam consumption.

Technical panorama. Yield and its variations

E. David. *ATAC*, 1985, **44,** (4), 2 - 5 *(Spanish).*

Weather conditions of drought and low to moderate temperatures are favourable for giving high yields of sugar with respect to cane weight. The most reliable indicator of cane quality, on which to judge yield, is the juice Brix without dilution, the first expressed juice being suitable for this. When the juice Brix is high an increase in final molasses production has to be expected and thus greater sugar loss. Prolonged drought results in loss of cane weight and also physiological phenomena capable of inducing important increases in viscosity of the materials handled in the crystallization process, limiting the exhaustion of final molasses.

Revalidation of models of the cane milling tandem

F. González, C. Rubalcaba and E. Sevilla. *ATAC*, 1985, **44,** (4), 28 - 33 *(Spanish).*

During 1975 - 1980 a series of equations were developed relating the percentage of mixed juice pol and pol in bagasse to factors concerned in milling, and the whole has served for mathematical modelling of the cane milling process. Data from the 1982 crop were used to verify the accuracy of forecasting by

3 Hernández *et al.*: *Proc. 18th Congr. ISSCT*, 1983, 1138 - 1156.

computer, based on the model, and a table shows the numbers of proved and acceptable models. They number 47 and 9, respectively, for mixed juice pol and 99 and 27, respectively, for bagasse pol.

Anaerobic digesters and their application to the treatment of sugar residues

S. Orúe V. and H. González Ll. *ATAC*, 1985, **44**, (4), 39 - 43 *(Spanish)*.

A review is presented of designs for anaerobic digestion of effluents and a design developed by the Cuban Sugar Research Institute called the sequential stage digester which also serves as a sedimentation vessel, thereby providing a long retention time for solids and short time of hydraulic retention. Its efficiency is based on these two factors and on providing intimate contact between the micro-organisms and the substrate by means of system of mixing by jets.

Usina da Barra S.A. Açúcar e Alcool

Anon. *STAB*, 1985, **4**, (2), 4 - 6, 7 - 10, 12, 14 *(Portuguese)*.

The title company crushes 39,000 t.c.d. to produce 4300 tonnes of sugar and 2000 cu.m. of alcohol. A very detailed account is given of its operations in the agricultural and industrial sectors, as well as by-product utilization and its refinery. Data from the 1985/86 crop are tabulated.

Development of juice extraction

S. Brunelli. *STAB*, 1985, **4**, (2), 41 - 42, 44, 48 - 49 *(Portuguese)*.

A discussion is provided of developments which permit higher extraction of cane juice, such as the use of shredders for improved cane preparation, pressure feeders, mill roller surface roughening, compound imbibition, higher pressures and more suitable mill openings. Results achieved in Brazil, South Africa, Australia and Florida are tabulated and other aspects of extraction reviewed, including choice of mill size, and a comparison of milling with diffusion.

Increase of time of operation of limed juice heaters by utilizing low-temperature bled vapour

O. Gómez and A. Valdés. *CubaAzúcar*, 1985, (Jan. - March), 40 - 45 *(Spanish)*.

Scaling in juice heaters is attributed to the deposition of non-sugars the solubility of which falls with rise in temperature. Trials were carried out in which the juice was heated with vapour bled from first and second evaporator effects, measuring the heat transfer coefficient, hydraulic pressure drop and calculating the relation between heat transfer and duration of operation. It is concluded that with first effect vapour cleaning could be cut to alternate days and with 2nd effect vapour to every 3 - 5 days. Pressure drop remained constant during the trials, indicating low levels of scaling.

Rapid trayless clarifier; project and performance data

D. T. Oliveira, C. P. Coelho and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1985, (32/85), 52 - 54 *(Portuguese)*.

On the basis of experience with the Sugar Research Institute clarifier of Australia, similar units were designed of 50, 150, and 300 m^3/hr capacity, a drawing of the design and of its system of operation being presented, together with photographs of an installation at a Brazilian sugar factory. Operating results are tabulated for the two smaller units. A comparison with a Dorr clarifier showed the SRI design to give juice of higher purity and lower turbidity but more dilute muds.

Mill sanitation - another look

U. C. Upadhiaya. *Sugar J.*, 1987, **50**, (2), 8 - 11.

Causes of post-harvest deterioration of cane are discussed, particularly the effect of invertase and of dextransucrase on sucrose hydrolysis and, in the case of the latter enzyme, on dextrose polymerization to dextran. Means of reducing losses in cane milling are examined, including the use of biocides such as Busan 881, disinfecting with chlorine and adopting appropriate mill hygiene measures, including regular steaming and washing with high-pressure hot water at intervals of 3 - 8 hours to remove slime caused particularly by *Leuconostoc mesenteroides*. The effects of juice dilution, temperature and pH on microbial activity are briefly examined, with an indication of the favourable influence of hot imbibition on microbe multiplication and of alkaline conditions on dextran production at room temperature (although heating raw juice before liming minimizes infection by *L. mesenteroides*, which becomes inactive at 43°C). Methods for direct and indirect determination of sugar losses in milling are described and assessed.

Development of the Latin American and Caribbean sugar industry: predictions for the year 2000

E. Latorre. *Sugar y Azúcar*, 1987, **82**, (9), 23 - 24, 26, 30.

See *I.S.J.*, 1987, **89**, 181.

Reverse osmosis concentration of hot mixed juice

D. Hsu. *Ann. Rpt. Hawaiian Sugar Planters' Assoc.*, 1986, 48.

Tests were conducted over 21-hour cycles on single-pass concentration of limed and heated mixed juice using reverse osmosis at a feed temperature of 70°C. Results for a total of six runs showed a dramatic fall in permeate flux with time, indicating that process economics projected in the previous year (which assumed a constant permeate flux throughout the crushing season with 3-hour cleaning cycles after every 21-hr operation) were excessively optimistic. The initial fluxes suggested that the membrane was permanently fouled; cleaning failed to restore it to full performance, and the supplier of the equipment regarded lime in the juice as the prime suspect. Trial runs with unlimed mixed juice were therefore planned.

Beet sugar manufacture

Removal of filter cake

V. N. Koshevaya and A. F. Zaborsin. *Sakhar. Prom.*, 1987, (8), 32 - 36 *(Russian).*

Experience in different countries in the pneumatic conveying of undiluted filter cake to points up to 700 m from the nearest factory buildings is summarized, and recommendations are made concerning various aspects of pipeline systems, including their design and construction and rational use of compressed air.

A rotary frame-type trash catcher

A. D. Baglyuk. *Sakhar. Prom.*, 1987, (8), 38 - 40 *(Russian).*

Inclined frames from which are suspended two pivoted sets of tines, one shorter than the other, are carried through the water in a beet flume as the main hexagonal frame supporting them rotates; the lower ends of the two sides of the inclined frames travel along guide rails in the flume at 0.6 m/sec in the same direction as the beets. As the frames leave the water and are carried to the top of the rotating frame, the sets of tines fold back against them and the frames themselves flatten towards the main frame; the trash is removed when the end of each frame bounces down a step arrangement. As the frames approach the flume, their mid-points strike the top of a vertical plate which scrapes off any residue before they enter the water. A prototype of the patented trash catcher has been operating for two campaigns at a sugar factory.

Saving fuel-energy resources

M. P. Spivak and V. F. Bereznii. *Sakhar. Prom.*, 1987, (8), 41 - 44 *(Russian).*

At Teofipol' sugar factory, where nominal fuel consumption has been gradually reduced to 5.76% in 1986, some of the thick juice from the 3rd effect of the quadruple-effect evaporator is mingled with remelt liquor to give a Brix of 58 - 62° before sulphitation and filtration and transfer to the holding tanks in the pan station; the rest of the thick juice is concentrated to 75 - 78°Bx in the 4th effect and used for *A*-massecuite boiling. The higher Brix has permitted a 30-minute reduction in the boiling time and a 0.1 unit fall in sugar colour. Increase from 20% to 90% in the use of condensate for juice and water heating has also contributed to energy economy, as has a 32% reduction in lime consumption as a result of mud recycling to preliming.

Design requirements of heaters in beet sugar manufacture

V. N. Gorokh, A. A. Knyazev, B. F. Us and K. O. Shtangeev. *Sakhar. Prom.*, 1987, (8), 44 - 46 *(Russian).*

The effects of heat surface area, overall tube length, number of passes, juice flow velocity and length of tube runs on the heating efficiency of juice heaters are discussed and some advice is given on heater design and selection.

Disinfection of the surface of washed beet with a solution of calcium hypochlorite

L. G. Belostotskii, V. Z. Nakhodkina, A. Z. Usmentseva, S. S. Guseva and A. Ya. Kashpur. *Sakhar. Prom.*, 1987, (8), 47 - 49 *(Russian).*

Treatment of washed beet with 1% calcium hypochlorite solution at 0.015 g dry ingredient per kg reduced the counts of all groups of micro-organisms in cossettes and diffusion juice by between 40% and 94% as well as reducing matter and unknown sugar losses.

Description and comparison of three different systems of seed magma production

H. Schiweck, M. Munir and G. Witte. *Zuckerind.*, 1987, **112**, 681 - 693 *(German, English).*

See *I.S.J.*, 1988, **90**, 5A.

Studies on sugar beet storage methods. I. Quality of sugar beet stored under various conditions. II. Long-term storage experiment. III. Experimental results of storage using a recirculating ventilation and humidification system

I. N. Tomiyama, T. Tsutsumi and H. Usui. *Proc. Sugar Beet Res. Assoc.*, 1983, (25), 211 - 215; through *Food Sci. Tech. Abs.*, 1987, **19**, Abs. 5 L 7. **II.** J. Dohkoshi *et al. ibid.*, 216 - 220; through *Food Sci. Tech. Abs.*, 1987, **19**, Abs. 5 L 8. **III.** J. Dohkoshi *et al. ibid.*, 1984, (26), 175 - 179; through *Food. Sci. Tech. Abs.*, 1987, **19**, Abs. 5 L 10.

I. Numerous observations and experiments on beet storage in Hokkaido revealed that sugar loss from sprouting beet was less than that from frozen or rotting beet. It was evident that buffering air layers above the top surface of a pile had favourable effects on beet storage, and this system has been adopted as a common storage method. Experiments with forced-air ventilation were not always successful. Preliminary experiments have indicated that a recirculating ventilation system is most promising.

II. A newly developed beet storage system with a wide ceiling space and a recirculating ventilation system (via above-ground ducting) was compared with the conventional pile system and a modification of it. The temperature inside the ventilated pile dropped quickly and was fairly stable throughout storage. Temperature distribution inside the ventilated pile was also more uniform than in the other two piles. The proportion of frozen and sprouting beets in the outer part of the ventilated pile was less than that in the others. The conventional system gave large numbers of frozen beets, while the modified system produced numerous sprouting beets. Differences in weight loss between the three systems were not significant. Loss of sugar was lowest in the ventilated pile and greatest in the conventional system. The recirculating ventilation system is expected to be effective in long-term storage of beet.

III. Investigations were made to compare the quality of beets stored under two piling conditions: in a system with recirculating ventilation and humidification, and in a conventional system keeping a large space over the top surface (control). The temperature in the ventilated pile was fairly constant throughout storage and was more uniform than in the control pile. In the ventilated pile there was less development of mould, and weight and sugar losses were smaller than in the control pile. Humidification was effective in keeping moisture at an adequate level, which otherwise tended to decline at night in the early stage of storage. Results indicated that a recirculating ventilation and humidification system would be effective in preventing deterioration of beets during long storage.

Studies on storage rot in sugar beet. I. Fungi isolated from stored sugar beets and their pathogenicity. II. Development of fungi during the storage season

I. H. Uchino and K. Kanzawa. *Proc. Sugar Beet Res. Ass.*, 1984, (26), 180 - 189; through *Food. Sci. Tech. Abs.*, 1987, **19**, Abs. 5 L 11. **II.** Idem: *ibid.*, 190 - 193; through *Food. Sci. Tech. Abs.*, 1987, **19**, Abs. 5 L 12.

I. 26 species of fungi (17 genera) were isolated from beets stored during the winter, of which four were storage pathogens: *Botrytis cinerea, Penicillium expansum, Phoma betae* and *Fusarium roseum. B. cinerea* accounted for 71.7% of the pathogens isolated from rotted beets, *P. expansum* for 7.5%, *P. betae* for 9.4% and *F. roseum* for 6.6%. The rot area developed in two weeks following injection of each pathogen, and (expressed as a % of *B. cinerea*) was 39 for *P. expansum*, 32 for *P. betae* and 65 for *F. roseum.*

II. In Hokkaido sugar beet is piled during late October to early November. An ordinary storage pile is 4.5 m high, 22 m wide and about 80 - 150 m long. Some of the storage piles are kept >150 days. Three groups of fungi developed on the surface and/or inside the pile at different times. Mycelia of *Botrytis* spp. were first detected two weeks after piling, and extended gradually. They were found in all parts of the pile. Mycelia of *Cladosporium* spp. occurred on the dry surface of roots early in storage, and also occurred later, rather frequently on the side surface of the pile. Mycelia of both *Penicillium* and *Geotrichum* were found within the pile in the later part of storage. They also occurred frequently on the moist top surface of the pile.

Effect of (beet pulp) pressing additives on the ionic balance of a sugar factory

P. Devillers, J. P. Lescure, G. Deruy, P. Lageat and J. P. Lamy. *Sucr. Franç.*, 1987, **117**, 287 - 302 *(French).*

See *I.S.J.*, 1987, **89**, 107.

Automation of evaporation

J. C. Giorgi. *Sucr. Franç.*, 1987, **117**, 305 - 309 *(French).*

See *I.S.J.*, 1987, **89**, 107.

Design and construction of beet yards

R. Lippe. *Zuckerind.*, 1987, **112**, 781 - 783 *(German).*

The types of beet transport used in West European countries and the means used to unload them are outlined, with particular mention of Oppermann + Deichmann side-tippers. Beet piling and reclamation systems are also described, and the importance of adequate air ducting for ventilation is stressed.

Beet yard equipment

F. Kugel. *Zuckerind.*, 1987, **112**, 783 - 786 *(German).*

After briefly explaining the disadvantages of storing wet beet (risk of infection and leaching as well as higher sugar losses), the author describes beet unloading and stationary and mobile piling equipment. An account is also given of a Gebr. Bütfering unit for dry removal of soil and beet pieces and separation of these two forms of extraneous matter. The ventilation properties of a beet pile are highly dependent on the size of the beets and on the proportion of soil and beet pieces and tails; an intermediate station that has already been installed at a number of factories separates small beets, beet pieces and tails from the main stream of beet going to storage and conveys them direct to processing, thus allowing more efficient natural ventilation of the piled beet (with greater spaces between the beets) and, in the case of forced ventilation, reduced energy consumption.

Beet unloading and storage

H. Hartmann. *Zuckerind.*, 1987, **112**, 786 - 788 *(German).*

Details are given of three polar silos supplied for storage capacities of 15,000, 15,000 and 21,000 tonnes of beet, with a pile height of 9 m for the two smaller silos and one of 6 m for the larger; the piling, reclamation and forced ventilation arrangements are briefly described. While a water jet system is the usual method used to reclaim the beets, dry reclamation can also be incorporated (as in schemes already designed by BMA). Factors of importance in the design and construction of polar silos are examined, and advice is given on efficient operation of wet unloading of beets. Plant for removal of sand and stones and for flume-wash water separation is also mentioned.

Innovations in the beet yard

K. Gerlach. *Zuckerind.*, 1987, **112**, 788 - 790 *(German).*

After a brief description of beet reclamation from storage piles by centrally controlled jet sprays which reduce the risk to personnel who do not have to enter the storage area, a Bammann & Schreiber elevator is described which raises the beet and water flowing along the flume at normal ground level to an overhead factory feed flume; the elevator has an hourly capacity of 2500 m^3 depending on lifting

height and has the advantages of reduced beet damage and of lower energy consumption than a beet pump of identical capacity. Energy consumption is also reduced by decreasing the beet:water ratio, which should however be no lower than 1:3. A prototype of 500 m^3/hr capacity operated without any breakdowns throughout the 1986 campaign at a West German factory.

The effects of cell and microbial invertases on juice extraction from sugar beet

K. Buchholz and D. Rabet. *Zuckerind.*, 1987, **112**, 792 - 795 *(German).*

Beet invertases comprise an acid form bound to the cell wall which has an optimum activity at pH 4.5 and a neutral form existing freely in the cytoplasm which has an optimum activity at pH 7.5. In experiments to determine the influences of the two enzymes on sucrose inversion as a function of pH, temperature and reaction time, neutral invertase caused more rapid hydrolysis than the acid form, although in the pH regions around 5.5, 6.0 and 6.5 the hydrolytic action of both enzymes was at the about the same level. Since greater knowledge of invertase activity as a function of temperature and time is important for evaluation of losses in diffusion, incubation of invertase preparations was carried out for 30, 60 and 90 minutes at 30°, 50° and 70°C. As expected, both enzymes became denatured by heating and so suffered a loss of hydrolytic activity, this occurring more rapidly the higher was the temperature; inactivation of neutral invertase was complete after 30 min at 70°C, whereas acid invertase did not become completely inactive even after 90 min at 70°C, probably a consequence of its being bound to the cell wall and thus immobilized and hence stabilized. Calculations using the classical kinetic approach showed that beet invertases caused only 0.01 - 0.02% losses on beet at pH 6.0 - 6.5 and 70°C, or approx. 10% of unknown losses at 0.2% pol on beet, with acid invertase making the greater contribution. Further studies showed that invertases of a microbial origin in raw juice had a greater activity than beet invertases from which they differed markedly in their greater temperature stability; they were mostly cell-bound invertases formed from thermophiles and ultrathermophiles.

Solving dextran problems in beet sugar factories

Anon. *Bio Times* (Novo Industri A/S), 1987, **2**, (3), 4 - 5.

The problems caused in diffusion and filtration by dextran formed by *Leuconostoc mesenteroides* are indicated and trials with Dextranase DN 50 L reported. Results showed that even a small amount (20 - 25 ppm) of the enzyme added in the diffuser was enough to allow a factory to operate at 85 - 90% of its full capacity, whereas without it the plant would have had to cease operations. DN 50 L has optimum effect at pH 5 - 6 and 50 - 60°C; the diffusion temperature had to be reduced from 67 - 70° to approx. 65°C to allow for its introduction.

Quality assurance - vehicle turnround at factories

F. Turner. *British Sugar Beet Rev.*, 1987, **55**, (3), 40 - 41.

Investigations of vehicle turnround times at UK sugar factories confirmed the benefits of flat concrete storage pads in reducing waiting periods and the length of vehicle queues at the weighbridges.

Kinetics of carbon dioxide absorption by raw sugar remelt in an atomized system

V. V. Ponomarenko, V. B. Vyskrebtsov, L. P. Reva and I. S. Gulyi. *Izv. Vuzov, Pishch. Tekh.*, 1987, (3), 74 - 76 *(Russian).*

In experiments in which CO_2 of 20 - 25% concentration was introduced as an atomized spray at a pressure of 0.23 - 0.43 $\times 10^5$ Pa and a feed rate of 35 - 220 m^3/hr into remelt flowing through a bubble column at 5 - 10 m^3/hr, the alkalinity fell by 0.45 - 0.1% CaO. From statistical analysis of the results, an equation was derived for calculation of the mass transfer coefficient per unit volume as a function of gas flow rate and wetting density.

Reflections on the preparation of cossettes

J. M. Niel. *Ind. Alim. Agric.*, 1987, **104**, 623 - 632 *(French).*

The aim of optimum beet slicing and its fundamentals are explained with the aid of diagrams. Comparison is made between the results obtained with a sharp knife and with a blunt one, particularly the increase in the specific length of cossettes as the cutting edge becomes gradually lower with use; while this effect is not easily observed, since any samples taken will be a mixture from a number of slicers showing different degrees of knife wear, it takes place much more rapidly in the case of inadequately washed beet and causes a large amount of mush. The difficulty of determining the specific length, its variability and the effect of this on calculation of diffusion throughput are examined. While it is impossible to measure the weighted mean length of cossette samples as an indicator of slicer performance, a patented system used in a number of sugar factories automatically calculates rate coefficients as a function of slicer speeds and throughputs from which is obtained both the specific length and the mean weighted length, the latter parameter being important as an indicator of the material actually entering the diffuser. While the system shows when knives need to be changed, it does not show which particular slicer is involved, for which the cossettes from individual machines must be examined. Mush may be produced by the slicer knives themselves as a consequence of misalignment or may emanate from small beets or pieces; it is defined by GTS as any slice shorter than 2 cm or, if longer than 2 cm, lacking rigidity. The percentage of cossettes having a perfect ridge form is generally low, reaching no more than 40% under best conditions; reasons for this are briefly discussed. An

example is cited of a daily analysis conducted on cossettes to establish the specific length and % mush. The choice of cossette geometry (only found by a trial-and-error approach) is discussed and the adjustments needed to the slicer and its operation to give the required cossette dimensions are described. Maintenance of knives and knife frames and cleaning of knives during slicer operation are considered, as well as nominal slicer throughput, the effects of beet quality and comparison between drum and disc types of slicer.

The dry solids content in press water as indicator of the degree of sugar extraction from beet cossettes

M. Ludwicki and S. Wawro. *Ind. Alim. Agric.*, 1987, **104**, 635 - 637 *(French).*

In a system installed in a sugar factory to measure press water density continuously as an indication of dry solids content and diffusion losses, the water is screened as it passes continuously from the main pipeline to a settler (where it is degassed and small impurities removed) and thence to a density meter; the transmitter attached to the meter gives a measurement of the dry solids content from 0 to 3%, and a signal from the meter is transmitted to a recorder. Comparison of readings with refractometric Brix values for 47 samples taken at different times showed a mean square difference of ± 0.09% dry solids at 0.05 probability of ± 0.18% measuring error. Good correlation was found between the water dry solids content and sugar content on the one hand and the sugar content in exhausted cossettes on the other (r = 0.8607 and r = 0.8503, respectively).

Influence of pressing additives on the process of pre-exhaustion of cossettes by presses

C. A. Accorsi, G. Cerolini and F. Zama. *Ind. Alim. Agric.*, 1987, **104**, 639 - 644 *(French).*

See *I.S.J.*, 1987, **89**, 108.

Biological aspects of fixed-culture nitrification of methanized sugar factory waste water

B. Delannoy, J. P. Lescure and H. C. Dubourguier. *Ind. Alim. Agric.*, 1987, **104**, 657 - 663 *(French).*

While anaerobic treatment of waste water is a suitable means of reducing the COD it has very little effect on nitrogenous matter, so that the effluent cannot be discharged during the campaign. Investigations indicated the possibility of using autotrophic nitrifying bacteria: one group (including *Nitrosomonas* sp.) oxidizes NH_4^+ in two stages to nitrite, while another group (including *Nitrobacter* sp.) oxidizes the nitrite in a single stage to nitrate, after which the effluent could be diluted and discharged into lower reaches of small rivers (although denitrification would be needed where there was risk to drinking water). Constraints on the use of nitrifying bacteria are briefly discussed, including their susceptibility to small concentrations of dissolved oxygen and the difficulty of maintaining the bacterial population and activity in a pure culture (although this problem is somewhat alleviated with a mixed culture in a fixed bed). Four means of conserving activity were tested: (i) rapid freezing at –18°C in 10% (v/v) glycerol solution based on nitrified effluent, (ii) drainage and rapid drying followed by storage in the open air, (iii) rinsing and immersion in nitrified effluent, and (iv) as in (iii) but with constant oxygenation of the medium. Method (i) maintained a satisfactory level of activity but is limited to the laboratory. Tests on (ii) indicated the importance of maintaining the medium in a moist condition, while immersion without aeration as in (iii) led to a marked fall in activity. Application of (iv) on a pilot scale showed interposing 15-day rest periods between cycles of nitrification over a total period of 128 days on schist as culture support and 68 days on pumice stone increased the rate of survival of the bacteria and gained more than 10 days of activity.

The wheel scoop

M. Barre and M. Prodhomme. *Ind. Alim. Agric.*, 1987, **104**, 681 - 685 *(French).*

Since its introduction to the sugar industry 10 years ago, the wheel scoop has been installed at 21 beet sugar factories for beet piling and for reclamation from piles at a rate of 2000 - 24,000 tonnes/day. The wheel, 8 - 12 m in diameter, is mounted at right angles to a gantry in the form of a box-sectioned, open-bottomed housing carrying a fixed upper horizontal conveyor and a lower reversible conveyor. The wheel is carried on a trolley that travels the length of the gantry, which also moves in the same direction as the rotation of the wheel. During piling operations, the wheel remains immobile at one end of the gantry, and beets are fed from an inclined conveyor to the upper one in the housing, from the end of which they fall onto the lower conveyor; this distributes the beets below the gantry. Piled beets are reclaimed by being scooped up in buckets around the wheel circumference and are transferred via a chute to the upper conveyor; this feeds them to the main conveyor by which they enter the factory. Advantages include lower losses than with a conventional system incorporating flumes, lower energy consumption and operation at an adjustable constant beet rate.

Sugar factory process control by computer

A. Chielens and H. Lavogiez. *Ind. Alim. Agric.*, 1987, **104**, 691 - 696 *(French).*

Details are given of a Fives-Cail Babcock microcomputer-based process control system in which the database is made up various types of block, with a scan period per input block (the time taken to carry out set calculations and thus determine the value of the output block at the end of the control chain) ranging from 1 to 255 sec. The software allows the microcomputer to handle about 40 control loops per sec. Application of the system to automatic control of continuous boiling is described with the aid of diagrams.

Sugar refining

Remelt recovery system at Savannah sugar refinery

J. E. Hamilton. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 6 pp.

A basic 3-boiling system is used at Savannah in the low-grade (remelt recovery) station, but diminishing profit margins have necessitated improvement in the operations. Information is given on modifications that have been made over the past 18 years and which have raised the capacity of the station in line with an increasing melt rate. The average colour of No.1 remelt sugar during the first quarter of 1987 was 3300 units compared with a standard for the sugar of 3500 and a target of 3000 units at 420 nm and pH 8.5. The formation of needle-shaped grain is a problem that has not been significantly reduced at Savannah; the grain results in a reduction of crystal content and difficulty in drying, while the apparent purity of molasses from the massecuite averaged 45 during the period of study.

Resin beds for fine liquor polishing

B. F. R. Hickey and M. J. Elliott. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 25 pp.

With an ever increasing demand on the decolorization process (carbonatation, filtration and bone char treatment) at Redpath refinery in Canada, it was decided to install a resin system for supplementary decolorization. Two columns connected in parallel contain Talonex A1000 macroporous polystyrene strongly basic anion exchange resin in Cl^- form; the fine liquor, having an average colour of 104 units, from the four oldest bone char cisterns is treated with the resin, while the liquor from the four newest cisterns and having an average colour of 42 units is sent direct to the evaporator. Trials with two other resins are reported, indicating a decolorizing efficiency of at least 64%, and details are given of the controls and of the sequence of 10 stages in the operating cycle.

Studies on the decolorization of sugar by the use of ion exchangers in sugar cane refineries in Egypt

A. Abd Elkader and A. A. Yassin. *Taiwan Sugar*, 1987, **34**, (2), 23 - 27.

Investigations were conducted at Hawamdiah refinery (the only one in Egypt) concerning the possible application of decolorizing resins; in the refining process as currently used, clear syrup is decolorized by treatment with bone char. Results showed that use of anion exchangers would not be advisable after carbonatation in view of the high colour load when the syrup:resin volume ratio exceeds 16:1; the colour content of the treated syrup would not provide a high-grade refined sugar. However, the use of resin for polish decolorization of the syrup off char was found to be very effective, with up to 240 bed volumes of syrup giving a high-grade sugar.

Advances in the processing of cane raw sugar

E. Gutknecht. *Lebensmittelind.*, 1987, **34**, 69 - 72 *(German)*.

The current trend towards higher quality raw sugar (such as VHP sugar) is discussed in relation to the costs involved and the benefits to both producers and refiners, particularly the elimination of the need for affination. The question of whether or not to affine raw sugar is discussed, and the importance of the amount of wash water used is stressed. The optimum conditions to follow in liquor phosphatation or carbonatation, filtration, decolorization, evaporation and boiling are set out, and mention made of liquid sugar and other speciality products.

Neutralization of effluent from AV-17-2P anion exchange treatment in a sugar refinery

G. M. Solovets *et al. Sakhar. Prom.*, 1987, (6), 41 - 43 *(Russian)*.

Eluate from anion exchange treatment cannot be handled as normal waste water because of its high NaCl content; however, the evaporation process described earlier[1] recovers the NaCl for use in resin regeneration, while the liquid residue is of value in recovering chromium salts used in tanning and/or as an additive to concrete mixes in the building industry, thereby eliminating the need for further treatment and storage at the refinery.

Carbonatation of Brazilian raw sugars: Influencing factors and verification of the efficiency by the filtrability index

I. V. Aoki and F. A. Tavares. *STAB*, 1985, **4**, (1), 46, 48, 50, 52 *(Portuguese)*.

A study was made of the parameters affecting the raw sugar melt carbonatation process, using the filtrability of the carbonated liquor, determined with a laboratory pressure filter, as the criterion. Results show that suitable conditions are: pH 8.0 - 8.5, a temperature of 80°C, reaction time of 80 minutes and use of 0.9% CaO on solids.

Analytical characterization of the process of sugar production with ozone on the pilot scale

M. Hernández, R. Ramos, S. Báez and A. Mesa. *CubaAzúcar*, 1985, (Jan. - March), 1985, 36 - 39 *(Spanish)*.

Raw sugar liquor was treated with ozone to decolorize it, filtered with the aid of diatomaceous earth and then heated at 70 - 80°C for 6 hours to simulate the effect of pan boiling. The colour was measured at 420 nm, iron measured by atomic absorption and ozone measured at the start and end of the period, while polysaccharides were determined by gel chromatography using Sephadex G-50. It was found that there was no substantial increase in colour on heating. Polysaccharides were unaffected by the ozone treatment but it reduced the iron concentration in the clarified liquor. Ozone measurements showed a high level of absorption by the colorants.

1 Solovets *et al.*: *I.S.J.*, 1985, **87**, 40A.

Laboratory studies

Polyol bonded to silica gel as stationary phase for high-performance liquid chromatography

M. Verzele and F. van Damme. *J. Chromatography*, 1986, **362**, (1), 23 - 31; through *S.I.A.*, 1987, **49**, Abs. 87-1005.

The chromatographic properties of Polyol-RSiL, a new silica gel phase to which a polymer is bonded, are presented. Efficient separations of polar compounds (including mixtures of sugars) were achieved. The selectivity for sugars of the polyol phase is comparable to that of a cross-linked aminopropyl phase; separations between groups (mono-, di- and tri-saccharides) as well as within groups are possible.

A critical review of some liquid chromatography systems for the separation of sugars

M. Verzele, G. Simoens and F. van Damme. *Chromatographia*, 1987, **23**, (4), 292 - 300; through *S.I.A.*, 1987, **49**, Abs. 87-1006.

Several systems which are currently used are evaluated: reversed-phase octadecylated silica gel, amino-modified silica gel, cation exchangers based on polystyrene and on silica gel, polyol-derivatized silica gel and anion-exchange systems. The elution pattern, analysis time, column efficiency and expected column life are considered to be the most important parameters on which to base the comparison. The use of silica gel-based cation exchanger and of polyol-derivatized silica gel (see preceding abstract) is new in this field. The choice of system depends on the problem under investigation. For simple mixtures an octadecyl-derivatized silica gel phase may be best. For more complex separations, none of the systems has yet been shown to be best.

Gel permeation chromatography of sugar cane products

M. Saska and Y. Oubrahim. *Sugar J.*, 1987, **50**, (1), 22 - 25.

Details are given of gel permeation chromatography and of its application to analysis of raw sugar, including determination of dextran T2000 with which the sample was spiked, to analysis of massecuites, molasses and the corresponding sugar, and to analysis of juice from core samples. Determination of dextran distribution between molasses and sugar showed that the dextran of high-molecular weight (1,000,000) was readily incorporated in the sugar crystal at a partition coefficient K of about 0.6, whereas the dextran of lower M.W. (100,000) was totally absent from the sugar. No column degradation was observed during 6 months of almost continuous use.

Effect of temperature on solubility in the system water-glucose-fructose

V. M. Perelygin and D. V. Kryl'skii. *Izv. Vuzov, Pishch. Tekh.*, 1987, (2), 125 - 126 *(Russian)*.

The mutual solubility of glucose and fructose in water was studied in the temperature range 20 - 60°C. It was found that in the composition region corresponding to glucose saturation, the solution could be in equilibrium with crystals of glucose monohydrate or anhydride, depending on temperature and fructose concentration. The temperature at which the monohydrate became dehydrated in the solid phase fell with increase in the fructose content. Equations developed from the experimental data define the intersections in the solubility diagram.

Ion exchangers as stationary phase in liquid chromatography - their application and limitations in plant research

N. Kubadinow. *Zuckerind.*, 1987, **112**, 700 - 704 *(German)*.

It is shown how sulphonated polystyrene copolymers in H^+ form can be used to separate sugars by partition chromatography, to separate low-strength organic acids and amino-acids by ion exclusion chromatography and to separate aliphatic alcohols by reversed-phase liquid chromatography. Sulphuric acid can be used as mobile phase, and partial hydrolysis of sugars such as sucrose is avoided by limiting the working temperature to 25°C. The question of type of detector is discussed; while a refractive index detector was unable to detect certain organic acids present at very low concentrations (0.03 - 0.2 ng) in a mixture, a U.V. detector was of sufficiently greater sensitivity to detect them. However, if the concentration of a substance such as *cis*-aconitic acid is increased so as to make it detectable by a R.I. detector, one peak is presented that is common to the acid and sucrose; separation is possible if a U.V. detector is used simultaneously.

Near-infrared spectroscopy utilization for sugar products analytical control

G. Vaccari, G. Mantovani, G. Sgualdino and P. Goberti. *Zuckerind.*, 1987, **112**, 800 - 807.

Sucrose analysis and dry solids determination by means of NIR using a Technicon Italiana Infralyzer 450 was applied to beet brei, raw juice, thick juice and 1:1 diluted molasses samples from three different factories and the results compared with polarimetric readings and refractometric Brix values. Results, given in graph form, are discussed. For beet brei analysis, there was no significant difference at 99% probability between the polarimetric and NIR values, and the standard deviation was ± 0.277°S; for the juice and molasses samples, good agreement was obtained between the two sets of values at a given factory provided the Infralyzer was calibrated at that factory. NIR is therefore recommended for use as a routine technique.

Lime solubility in water and aqueous sugar solution

V. A. Loseva, I. S. Naumchenko and V. M. Perelygin. *Izv. Vuzov, Pishch. Tekh.*, 1987, (3), 76 - 78 *(Russian)*.

The solubility of calcium hydroxide in

water and a 10.95% sugar solution was determined at 25°C and at temperatures in the range 40 - 90°C at 10°C intervals, and in sugar solutions in the concentration range 10.95 - 55.65% by weight at a constant 60°C. The results are tabulated, and an equation presented for calculation of the solubility in water and 10.95% sugar solution as a function of temperature; for solubility as a function of sugar concentration, an isothermal curve is plotted with a maximum corresponding to a concentration of 32.19% by weight.

Improved method for the determination of sugars using capillary gas chromatography with flame-ionization and nitrogen-selective detection

K. J. M. Burke, M. C. Berry and M. Cooke. *Analyst*, 1987, **112**, 1427 - 1431.

For determination of reducing sugars, derivatization with hydroxylamine hydrochloride and dimethylaminopyridine in pyridine-methanol (4 + 1, v/v) followed by acetylation yields two derivatives: aldonitrile acetates in the case of reducing sugars, and polyacetates in the case of non-reducing sugars. Both types of derivative respond to flame-ionization detection but only the N-containing derivatives of reducing sugars respond to N-selective detection. The derivatives are easy to prepare in only approx. 40 minutes, have shorter retention times than trimethylsilyl ethers or alditol acetates, good stability and retain structural integrity. The prepared samples are suitable for direct injection into a gas chromatograph without further processing. Separation is carried out by capillary gas chromatography on a non-polar column, and primary identification is by mass spectrometry with routine identification on the basis of relative retention time. The chromatography may be conducted separately or as a combined dual-detection system to yield either a complete sugar profile or only a reducing sugars profile. The chromatographic standards chosen were pyrene for monosaccharides, tetracosane for disaccharides and hexatriacontane for trisaccharides, with *n*-undecyl cyanide and tri-*n*-octylamine as reference standards for N-selective detection. Resolution was generally much better than with other derivatization methods and chromatograms had fewer extraneous peaks in an experimental study.

Liquid chromatography of sugars on diol columns. Detection with cuprammonium reagent

M. Abbou and A. M. Siouffi. *J. Liqu. Chromatogr.*, 1987, **10**, (1), 95 - 106; through *Anal. Abs.*, 1987, **49**, Abs. 10D147.

A mixture of ribose, xylose, arabinose, fructose, glucose, galactose, sucrose and lactose was separated on a column (25 cm × 4 mm) of LiChrosorb NH_2 (5 μm) by using 4:1 acetonitrile:water as mobile phase (1 ml/min). The eluted sugars were caused to react with a cuprammonium reagent (preparation of which is described) in a 20-cm coil, and the resulting complexes were detected at 315 nm. Separation of several sugars on a column (25 cm × 4 mm) of Lichrosorb Diol (5 μm) was less efficient.

Determination of sugar and ethanol content in aqueous products of molasses distilleries by near-infra-red spectrophotometry

E. D. Dumoulin, B. P. Azais and J. T. Guerain. *J. Food Sci.*, 1987, **52**, 626 - 630; through *Anal. Abs.*, 1987, **49**, Abs. 10F20.

The total sugar content of aqueous beet molasses and the ethanol content of fermented molasses were predicted by near-IR spectrophotometry. The measurements were carried out at 19 wavelengths from 1445 to 2348 nm and the results obtained were subjected to linear least-squares regression analysis. The errors for 99 - 167 g/litre of sugar and 5.9 -9.5% of ethanol were <3.5 g/litre and <0.12%, respectively. Results were similar to those obtained by polarimetry (sugar) and density measurement (ethanol).

Preliming evaluation of the determination of starch in raw sugar

L. Curiel L. and J. L. Pérez A. *ATAC*, 1985, **44**, (4), 25 - 27 *(Spanish)*.

Starch determination by the standard method in Cuba is a troublesome analysis and is not carried out regularly in the refineries although it is an important aspect of raw sugar refining quality. A new, simple technique involves making a 10°Bx solution, adjusting to pH + 0.2, filtering through paper, discarding the first 25 ml and reading the transmittancy which is then related to the starch content by means of a previously prepared graph. Tests have shown that the relationship between the measured transmittancy and starch content is almost linear and the method gives results which are close enough to those given by the standard method for practical purposes. Statistical analysis of results is needed to determine the reproducibility and repeatability of the method.

Acid-base characterization of products from the cane sugar manufacturing process

R. Cuervo F., H. Manso J. and A. Rodríguez A. *ATAC*, 1985, **44**, (3), 34 - 38 *(Spanish)*.

Averages of 15 measurements are tabulated for the buffer capacity, pH/ΔT gradient between 30 and 90°C and $\Delta pH_{1/2}$, the pH variation on dilution by half. All three are tabulated for mixed juice, clear juice, syrup and final molasses and, additionally, the buffer capacity for primary juice and A-massecuite. A general tendency is observed for a reduction of pH as the temperature rises, but this variation is less marked as the purity is lower. pH increases with dilution, except in the case of clear juice, and the value of $\Delta pH_{1/2}$ is greatest with final molasses. Variation of pH with temperature and with dilution is linear but in opposed directions. Evaporation produces chemical changes which increase considerably buffer capacity of the syrup; it also is higher the lower is the purity.

By-products

Use of alcohol vapour recovery towers in the tubes for venting to the atmosphere in the head condensers

J. D. Paz A. *STAB*, 1985, **4,** (1), 42, 44 - 45 *(Spanish).*

Incondensables from the distillation column are vented to atmosphere but contain a certain amount of alcohol which is thereby lost. A separating tower has been designed and is illustrated; the discharged incondensables pass up against a counter-flow of water which falls from a distributor through a packed chamber to a sump from which it is recirculated by pump. The unit, fitted at a distillery attached to a Bolivian sugar factory, increased alcohol recovery by 0.5 - 0.7%.

Study of some cations and anions in vinasses by alcohol fermentation of intermediate products and by-products of the manufacture of cane sugar

G. J. Gárdenas, R. M. Ruíz and A. A. Delfini. *Rev. Ind. Agríc. Tucumán*, 1984, **61,** (2), 1 - 25 *(Spanish).*

During one season, fermentations were carried out of clear juice, acidified juice, syrup and molasses in various combinations, and the vinasse obtained was analysed for aconitate, sulphite, phosphate and silicate as well as calcium, magnesium, potassium and sodium. Average values are tabulated and their influence on the value of the vinasse as fertilizer and on its incineration are discussed.

Effect of vinasse on soil acidity

M. E. Mattiazzo and N. A da Glória. *STAB*, 1985, **4,** (2), 35, 38 - 40 *(Portuguese).*

The effects of microbiological activity on soil acidity components in soils previously treated with vinasse were examined by measurement of pH, exchangeable Al, titratable acidity and total acidity. The results showed that there was no rise in soil pH in the absence of microbiological acitivity after the use of methyl bromide. It was concluded that organic matter oxidation is responsible for increased soil pH and that microbiological activity is what brings about the oxidation.

Options for juice treatment for manufacture of sugar and alcohol

D. T. de Oliveira and C. E. V. Rossel. *STAB*, 1985, **4,** (2), 50 - 52, 54 *(Portuguese).*

Recent developments in processing for sugar and alcohol are briefly discussed, including multi-jet sulpho-defection and the use of in-line liming mixers, use of calcium saccharate for liming and correct preparation and dosing of poly-electrolytes, syrup clarification, new equipment and processes for use when alcohol is being made, such as removal of juice solids, pasteurization, juice clarification, etc.

Preliminary study of the purification of sucroglyceride synthesized at laboratory level

L. R. de La Nuez F., P. L. Gutiérrez M. and M. López L. *CubaAzúcar*, 1985, (Jan. - March), 9 - 12 *(Spanish).*

When sucrose is reacted with one or more triglycerides it yields a mixture of sucrose esters, glycerides, soaps and unreacted material which nevertheless finds application as a surfactant because it is biodegradeable and non-toxic. A laboratory procedure has been developed for purifying the sucroglyceride, in which the crude mixture (100 g) is stirred with 6.4% w/v solution of $CaCl_2$ (250 ml) for 15 minutes at 65°C; the liquid phase contains unreacted sucrose and the solid phase the soaps converted to insoluble Ca forms. The solids are washed with 125 ml of a 6% NaCl solution at 65°C and then dried at 105 - 110°C for 3 hours, after which the product is extracted with 1300 ml of 95% alcohol at 45°C for 30 minutes. On evaporation the extract yields a yellow, waxy product containing the sucrose esters and glycerides. Details of the original and purified product, and corresponding data for a laboratory-synthesized sucroglyceride mixture are tabulated.

Biogas from the treatment of sugar wastes in a horizontal reactor

A. G. Núñez and M. S. Leal. *CubaAzúcar*, 1985, (Jan. - March), 13 - 16 *(Spanish).*

The performance of a horizontal plug-flow digester during loading and its subsequent operation using liquid waste and filter-cake are described. The objectives were stabilization of organic matter and reduction of environmental pollution, production of bio-fertilizer, and production of biogas as an energy source. High rates of COD removal, of the order of 93%, were achieved as well as a sludge with a content of 50% inorganic matter and gas yields higher than 280 litres/kg volatile solids.

Preliminary economic evaluation of the obtaining and use of a national temporary coating

J. Rosa P. *CubaAzúcar*, 1985, (Jan. - March), 33 - 36 *(Spanish).*

An anti-corrosion coating has been made by heating to 90°C cane wax oil, agitating it with 0.5N $Ca(OH)_2$, separating the water by decanting, raising to 99°C and adding further oil. The economics of the process have been studied and it is calculated that the product affords considerable savings by comparison with imported materials for the same purpose.

Possibilities of ethanol production

G. Blanco and E. Rodríguez. *Revista ICIDCA*, 1984, **18,** (2/3), 10 - 15 *(Spanish).*

A discussion of the use of cane and molasses for alcohol manufacture, its applications and the economics of manufacture recommend its adoption in sugar cane countries.

Production and industrial utilization of dextran in Cuba

C. Santiesteban. *Revista ICIDCA*, 1984, **18,** (2/3), 16 - 21 *(Spanish).*

A survey is presented of the characteristics and use of dextran in Cuba, the process of manufacture, and prospects for some potential applications.

Brightening of bagasse chemimechanical pulp

N. Fernández, J. Sabatier and O. Sardiñas. *Revista ICIDCA*, 1984, **18,** (2/3), 27 - 31 *(Spanish).*

The brightening of bagasse pulps by single and double-stage streatment with peroxide, dithionite, hypochlorite, chlorine dioxide and sodium sulphite under acid and alkaline conditions has been studied. The dependance of the final brightness on its initial value was established but it was found possible to obtain from unbleached material a pulp of sufficient brightness for newsprint manufacture with peroxide and/or dithionate in one or two stages.

Study of calcium carbonate and Cuban zeolites in the production of newsprint

A. Abril, A. Hernández, T. Rodríguez, O. Alvarez and M. Rodríguez. *Revista ICIDCA*, 1984, **18,** (2/3), 32 - 36 *(Spanish).*

Use of three locally produced fillers with bagasse chemimechanical pulp in the manufacture of newsprint was studied using high quality imported clay as the standard. Best results were obtained with a green zeolite which gave a high increase in opacity and porosity, improved brightness and lower density.

Influence of the density on the mechanical properties of bagasse cement particle boards

J. L. Valdés, J. Puig, J. Leal, M. E. Rodríguez and P. Sosa. *Revista ICIDCA*, 1984, **18,** (2/3), 62 - 67 *(Spanish).*

Trials showed that densities between 1150 and 1300 kg/m^3 gave excellent values of bending strength and modulus of elasticity in bagasse particle boards bound with cement, for use in the construction industry.

Study of the anaerobic treatment of wastes from the alcohol industry

E. Valdés, M. C. Obaya, A. García, A. Reyes and M. Chivás. *Revista ICIDCA*, 1984, **19,** (1), 7 - 10 *(Spanish).*

Laboratory tests were carried out on treatment of vinasse from a Cuban distillery which did not recover yeast, so that the organic matter content was high. An inoculum was used to treat the waste and, after it had become acclimatized to its composition, the conditions were varied in order to determine those suitable for larger scale trials. It was found that at low organic load, removal of COD depended on load and not on the time of treatment, pH affected COD removal and should be brought within the range 6.7 - 7.2, while N and P were needed to give a maximum ratio of 100:5:1 BOD:N:P for high degradability and microbial activity.

Comparison of double and single stage systems for the production of *Rhodotorula glutinis* from cane final molasses

M. Klibansky, L. González and M. A. Otero. *Revista ICIDCA*, 1984, **19,** (1), 16 - 21 *(Spanish).*

In the double-stage system, exhausted fermentation medium is treated with molasses for additional yeast production without the need for further mineral supplements. This and the single-stage system were studied to determine suitable conditions and it was concluded that the single-stage process is feasible and that the yield and composition of the product of this and the double-stage system are very similar but protein and fat productivity is higher for the single-stage system.

Economic evaluation of the production of bagasse cement panel

M. Martínez. *Revista ICIDCA*, 1984, **19,** (1), 22 - 26 *(Spanish).*

An economic study shows that manufacture of bagasse cement panels for construction is advantageous because it uses material produced locally in Cuba or within the Socialist bloc. It also provides savings in the cost of walls over other forms of construction as well as savings in materials and human resources.

Problems and prospects for the manufacture and the market for furfural

I. Ramos and R. López. *Revista ICIDCA*, 1984, **19,** (1), 27 - 33 *(Spanish).*

The production of furfural from agricultural wastes is reviewed, with a table of plants installed up to 1980 for manufacture from bagasse. Trade in furfural is discussed and is expected to increase.

Drying of filter-cake with solar energy and its use in animal feeding

I. Namer. *Revista ICIDCA*, 1984, **19,** (1), 34 - 38 *(Spanish).*

At a plant in Cuba, filter-cake is discharged onto half of a 1-hectare asphalted surface using a fertilizer spreader. It is left in the sun for two days, dried cake being removed continuously and piled on the other half of the surface. Daily capacity is 50 tonnes of filter-cake of 75% moisture content; during two days this is converted to 14 tonnes of 12% moisture content, employing four workers. The dried material is suitable for incorporation in animal fodder as a source of protein, crude fibre and mineral elements and in its dry state it can be readily stored. Other methods of drying are briefly discussed.

CP and CPD bleaching of bagasse dissolving pulp: screening of variables

J. Sabatier and J. C. Román. *Revista ICIDCA*, 1984, **19**, (1), 39 - 45 *(Spanish)*.

Results of experiments on variation of conditions in bleaching of raw pulp with chlorine (C), peroxide (P) and dioxide (D) treatments have been submitted to analysis. It is concluded that it is possible to obtain α-cellulose values higher than 90% under all conditions but to obtain suitable degrees of polymerization of 800 ± 50 it is necessary to have a total chlorine coefficient of around 0.325 or slightly higher, and 0.5% H_2O_2 or slightly more. The temperature and time of peroxide treatment both influence the α-cellulose; a time of 2 - 3 hr is required for a temperature of 75°C and a soda:peroxide ratio of 2.5 - 3.5; to shorten the process the other values have to be raised. With these conditions an Elrepho brightness of 80 is achieved by CP bleaching and a brightness of 88 with CPD bleaching. The temperature of the dioxide treatment did not influence the results.

Potential of bagasse chemimechanical pulp for printing and writing papers

C. Agüero, J. Ponce and E. Cabo V. *Revista ICIDCA*, 1984, **19**, (1), 46 - 50 *(Spanish)*.

The properties of bagasse pulp are compared with those of wood pulps, and the effects of its addition on the quality of the paper produced are analysed. It is concluded that the bagasse pulp-containing paper compares favourably with that from wood pulp and that the main problems of low brightness and poor brightness stability are the same as encountered with wood pulp and can be solved in the same way, i.e. by surface sizing, incorporation of bright pigments, suitable refining and calendaring.

Modifications to the CEH bleaching sequence: chlorination at high temperature

N. Fernández, M. E. Naranjo and J. Alvarez. *Revista ICIDCA*, 1984, **19**, (1), 51 - 54 *(Spanish)*.

Variations have been made to the title bleaching process which uses chlorination (C), alkaline extraction (E) and hypochlorite (H) in order to improve its efficiency. Replacement of less than 10% of the chlorine in the first stage with ClO_2 improved the brightness, while 3 - 10% improved the viscosity and resistance properties. Chlorination at high temperature (70°C) was possible without appreciable loss of optical and resistance properties; it gave pulp quality comparable with conventional chlorination (at 30°C) and with good colour stability; this modification allowed reduction of the chlorination time from 60 to 2 - 4 minutes, eliminating the chlorination tower and its investment, maintenance and operation costs. Use of an intermediate temperature (45°C) is not recommended. Chlorine dioxide in the first stage at 70°C has an effect comparable with that of chlorine in respect of brightness.

Obtaining animal fodder by acid treatment of bagasse and sugar cane pith

J. Villar, O. Torres and E. Manganelly. *Revista ICIDCA*, 1984, **19**, (1), 55 - 58 *(Spanish)*.

Acid pre-hydrolysis of bagasse and pith during 30 minutes with 1% H_2SO_4 at 130° or 140°C gave a product containing simple sugars, digestable polysaccharides and nitrogen as ammonium sulphate. Enzymatic degradability of the raw material was increased 4 - 5 times.

Influence of the degree of depithing on the properties of bagasse particle boards

O. Carvajal, J. Puig, J. A. Leal and P. Sosa. *Revista ICIDCA*, 1984, **19**, (1), 68 - 74 *(Spanish)*.

It is considered that the wet depithing method using a vertical rotor is the most suitable for Cuba. The greater the degree of pith separation the better are the mechanical properties of the boards produced.

The use of fibrous sugar cane by-products by ruminants. Part 8. Composition of the residues from sugar cane collection centres and effect of NaOH treatment on *in vitro* digestibility

R. Hanke and P. C. Martin. *Cuban J. Agric. Sci.*, 1985, **19**, 161 - 167.

The physical and chemical composition of 40 samples of residues from cane transloading stations (tops, leaves, sheaths, stalks and impurities) and the effect of treatment at ambient temperature with NaOH (0 - 10 g/100g of residues) in volumes of 60 - 100 ml/100g dry matter. The *in vitro* digestibility and total volatile fatty acids production increased with NaOH use but the effect was not affected by the volume. With 4 - 6% NaOH and 60 ml/100g volume digestibility reached 46 - 56% which is sufficient for its use as animal fodder.

Requirements of dried beet pulp - raw material for production of pectin

N. S. Karpovich, E. V. Yarovaya, S. M. Pochko and V. V. Nelina. *Sakhar. Prom.*, 1987, (8), 37 - 38 *(Russian)*.

The requisite properties of dried pulp for extraction of pectin are described and a pectin recovery process is outlined.

The dried beet pulp market - analysis and recent developments

M. Roche and M. Taccard. *Ind. Alim. Agric.*, 1987, **104**, 673 - 678 *(French)*.

Various aspects of dried pulp are discussed, including fluctuation in both quantity and quality, its distribution, costs of treatment, quality standards, demand (which has fallen on French beet farms but has increased nationally, principally with animal breeders in non-beet growing areas). Other products that compete with beet pulp and the competition from US beet pulp imported into France are also discussed, and future prospects are examined.

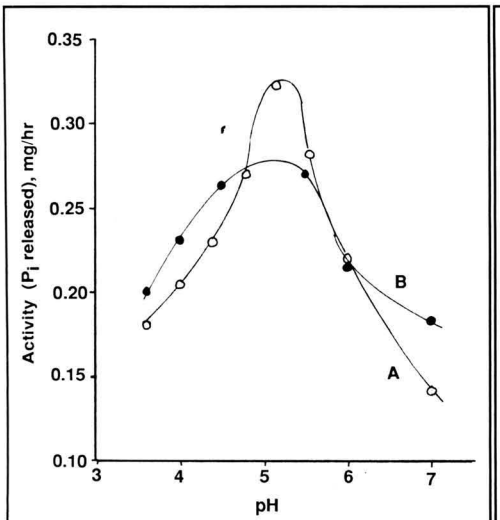

Fig. 1. Effect of pH on acid phosphatase activity; A, with p-NPP; B, with β-glycerophosphate

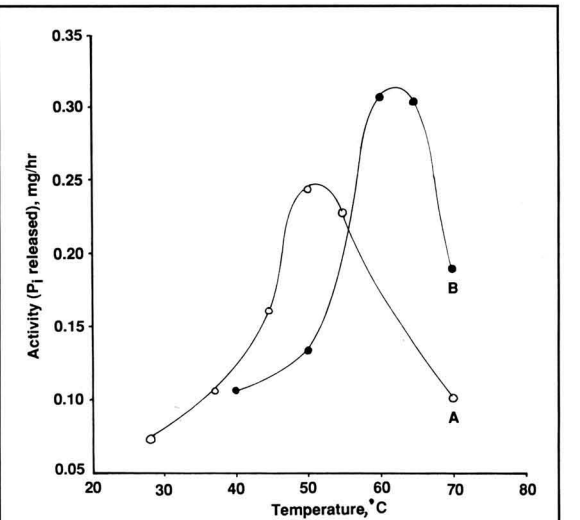

Fig. 3. Effect of temperature on acid phosphatase activity: A, with p-NPP; B, with β-glycerophosphate

Thermal stability

The p-NPP and glycerophosphatase activities were stable at 50°C for about one hour without any loss in activity. At 60°C, the glycerophosphatase lost about 16% of its activity during one hour whereas p-NPP showed a 36% loss, and activity loss was maximum at 70°C for both the enzymes. Compared with p-NPP, glycerophosphatase was thermally stable and, in the presence of sucrose, its stability was further increased (Fig. 4).

Effect of metallic salts

Ca^{++} ions did not inhibit phosphatase activity, although Zn^{++} and molybdenum ions inhibited all phosphatases except fructose 1,6-diphosphatase. The reducing agent cysteine , showed activation of fructose 1,6-diphosphatase; other enzymes were inhibited, except for pyrophosphatase which was comparatively normal. Mg^{++} did not show inhibition of p-nitrophenyl-phosphatase though it inhibited other phosphatases. Cu^{++} and tungsten ions were inhibitory for all the phosphatases. EDTA was found to have no action on these phosphatases (Table IV).

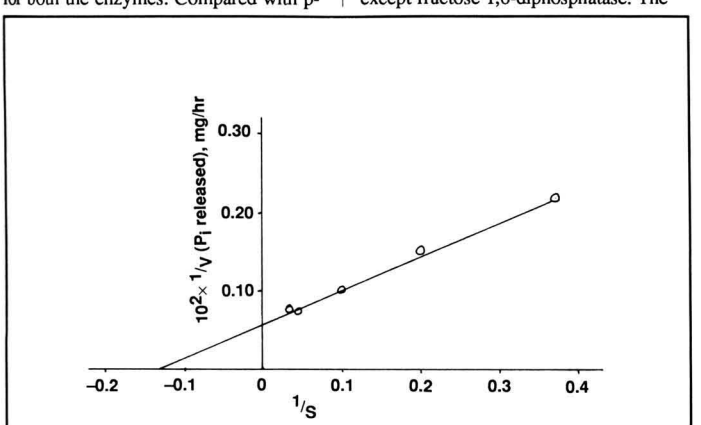

Fig. 2. Lineweaver-Burk plot, acid glycero phosphatase K_m = 7.14 mM; V_{max} = 0.1428 mg.P_i/hr (2.38 μg/min)

Discussion

The activities of all the hydrolytic enzymes increased after harvest. Amylase and CMC-ase were active up to 24 hr and then decreased, whereas acid phosphatase, invertase and FDP activities increased up to 72-96 hr, possibly owing to release of enzymes from the bound state to a free state. Cellulolytic activities (C_1 and C_x) found were significantly high indicating a close association of alternate pathways in the accumulation of sucrose in the cane plant[13].

The acid phosphatase activities in cane juice were appreciably high at a juice pH of 5.2 - 5.5 and, during storage, cane juices showed major conversion of

13 Soloman & Kumar. *Proc. 47th Conf. Sugar Tech. Assoc. India*, 1983, Ag 117.

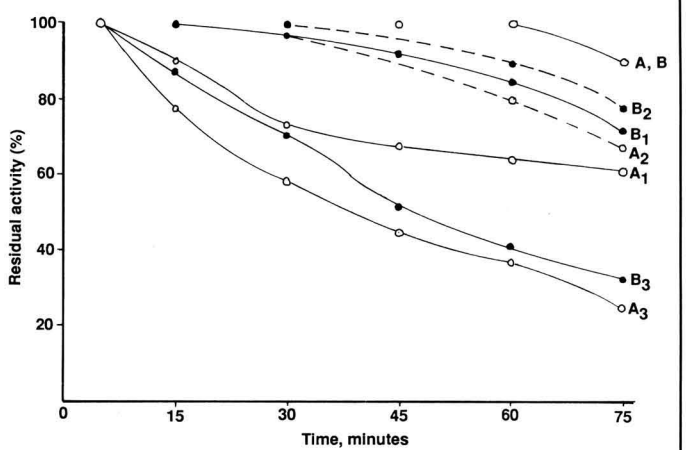

Fig. 4. Thermal stability of acid phosphatases at different temperatures: A, with p-NPP at 50°C; A_1, with p-NPP at 60°C; A_2, with p-NPP at 60°C with sucrose; A_3, with p-NPP at 70°C; B, with β-glycerophosphate at 50°C; B_1, with β-glycerophosphate at 60°C; B_2, with β-glycerophosphate with sucrose at 60°C; and B_3, with β-glycerophosphate at 70°C

organic phosphorus to inorganic. In freshly cut cane most of the phosphorus occurs in organic form. High sucrose-yielding varieties have high organic phosphorus contents[14]. It has been shown that the activity of sucrose synthesizing enzyme[15] in freshly cut cane is high as long as the organic phosphorus content of cane juice is maximum and reducing sugar content is minimum. According to Honig[16] the inorganic phosphorus content of cane juice is an important factor in the clarification of juice. It influences the formation of mud volume and the removal of colour and non-sugar impurities in clarification. A major portion of the organic phosphorus present in cane juice is as glycero-, phosphatidyl- and acid-stable phosphorus[15] and may go to waste if not utilized. In phosphate-deficient juices, addition of phosphoric acid has been recommended to improve juice clarification[17]. Sharma *et al.*[17] have shown that cane juices rich in natural phosphate levels have superiority in purity rise, colour removal, juice clarity and final mud volume by comparison with juices made by extra addition of phosphate (phosphoric acid) from outside. They have also shown that phosphate levels of raw juices can be increased by application of N-K fertilizers at peak maturity period. Increased organic phosphate contents in cane juices may give trouble during clarification owing to their colloidal[17] properties and have to be hydrolysed by phosphatase activity.

No work seems to have been done on these lines so far. The present study of the properties of acid phosphatase can enable technologists to clarify the juices properly and economize the process.

The different types of acid phosphatases present in cane juices are able to operate efficiently at prevailing pH values of juices (5.2 - 5.5). The fact that the activity of phosphatases is stable in the presence of sucrose for more than an hour at 50 - 60°C is of great significance in clarification. The phosphatase activity is not inhibited by sulphitation and thus can also be used to release P_i from sulphited and clarified juices (Table III). The enzyme parameters reported by the authors differ from earlier reports. K_m for glycerophosphatase was 7.14 mM as compared with 0.77 mM for p-nitrophenyl phosphatase reported by Nakasone[18]. Ca^{++} and EDTA did not inhibit the phosphatases. Literature data on pH and temperature optima for p-nitrophenyl phosphatase activity agreed fairly well with the work of the present authors.

Acid phosphatases all differed with respect to metal ion inhibition, showing that the cane plants have a mixture of substrate specific phosphatase enzymes having their role in synthesis and degradation of intermediate phosphate compounds as and when needed.

Summary

Some of the hydrolytic enzymes in cut and stored cane have been studied.

14 Alexander: "Sugarcane physiology", (Elsevier, Amsterdam), 1973, p. 222.
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Table IV. Effect of some metallic salts (10 mM) on different acid phosphatases

Relative activities, %

Substrates	p-Nitrophenyl-phosphate	β-Glycero-phosphate	Pyrophosphate	Hexa-meta-phosphate	Fructose 1,6 di-phosphoric acid
Control	100	100	100	100	100
Zinc sulphate	53.8	50	78.6	40.8	100
Calcium chloride	100	100	100	100	100
Copper sulphate	51.9	50	44.2	36.7	55.8
Magnesium sulphate	100	66.6	85.5	76.5	38.1
Sodium molybdate	49.1	51	21.3	21.4	100
Sodium tungstate	57.7	51	25.2	30.6	68.2
Cysteine	57.7	78	100	83.6	123
EDTA	97	100	94	97	100

Acid phosphatase enzyme, isolated by precipitation from cane juice, has been purified and studied for different parameters. pH and temperature optima for p-NPP phosphatase and glycerophosphatase were 5.2 and 52°C and 5.4 and 62°C, respectively. The enzymes were thermo-stable at 50 - 60°C for about an hour and the presence of 20% sucrose increased this period to about 75 minutes. The K_m for glycerophosphatase was 7.14 mM, and Ca^{++} and EDTA did not inhibit phosphatases. Application of acid phosphatase activity of sugar cane juices in the liberation of inorganic phosphorus and its role in juice clarification has been suggested.

Acknowledgement

The authors are grateful to Prof. Ram Kumar, Director, National Sugar Institute, Kanpur, for providing the facilities and taking a keen interest in these studies. One of the authors (G. Das) wish to thank the Ministry of Food and Civil Supplies for the award of a Junior Research Fellowship.

ANALYSIS

Raw sugar analysis by chromatographic methods

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Introduction

High performance liquid chromatography (HPLC) has been widely used for the determination of carbohydrates in natural products[1-7]. In our research laboratory, this technique is well established for analysis of sugar and sugar related compounds[8-10].

Carbohydrates can be separated on several types of HPLC columns. Most commonly used types are amino-bonded silica[11,12], alkyl reverse phase[12-15], strong cation exchange[8,9,12] and anion exchange[16] columns. Until recently the direct determination of invert (glucose and fructose) in raw sugars and high purity syrup has been hampered by several factors: the lack of a suitable column, the inability to detect invert at low level and the disparity in concentration between sucrose and invert sugar (200:1) in raw sugar.

Recently developed methods employing post-column derivatization reagents such as tetrazolium blue[17-20], 2-cyanoacetamide[21-23], copper (II) ammonia complexes[24,25] and p-aminobenzoic acid hydrazide[26] have greatly improved sensitivity and selectivity for reducing sugars. These methods, however, require more elaborate equipment and chemical reagents than the direct HPLC determination.

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It has been found that reverse phase C18 columns with small diameter packing material (4 μm) can give rapid separation of sucrose from invert. This analysis is appropriate for routine use in raw sugar factories where analysis of individual sugars (glucose and fructose) is not routine. To improve resolution, without sacrificing significant time, we have used two such columns (Waters Nova-Pak) in series for analysis of sucrose and invert. The use of two columns improves resolution sufficiently that raw sugar can be analysed on this system. Two runs at different sensitivities or sample sizes are necessary, however, to achieve desirable accuracy both for sucrose (one run) and invert (second run).

Paper presented to Sugar Industry Technologists, 1987.

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This paper presents some results obtained from studies in the direct determination of invert level in raw sugars by HPLC and ion chromatography (IC). Data are compared with results from traditional GLC methods. Results of the HPLC sucrose are compared with polarimetric measurements on high and low quality raw sugars.

Materials and methods

HPLC

Analyses were carried out with a Sugar Analyser I equipped with an M-45 pump and a 410 differential refractometer. The samples were injected by a WISP 710A sample autoprocessor (all from Waters Associates). Columns were two Waters Nova Pak C18 reverse phase columns (3.9 mm × 15 cm) in series operated at 35°C with a flow rate of 0.4 ml/min. Data were recorded and analysed by a Data Module 730 (Waters Associates) which displayed the chromatograms, calibrated the area of peaks against a set of standards and printed out the results. The chart speed was 1 cm/min. The RI detector was set at a sensitivity of 32 and scale factor of 20. Each sample was assayed in triplicate and the injection volume was generally 5 µl. The eluant used was water, purified on a Millipore MilliQ water purification system, filtered with a 0.45 µm membrane filter and degassed in an ultrasonic bath.

Ion chromatography

All chromatography was performed on a Dionex 2000i IC system equipped with pulsed amperometric detector I (operated at 100,000 nanoAmperes full scale) and Dionex 4290 computing integrator. Samples were introduced via a Rheodyne injector with a 50 µl loop. An HPIC-AS6 anion exchange column was used at 35°C. The mobile phase was 0.15N NaOH at 1 ml/min flow rate.

Gas chromatography

Gas chromatography was performed using a Hewlett Packard Model 5880 instrument with a 30 m DB-5 fused silica capillary column and a flame ionization detector. The temperature program was: 225°C for 4 minutes; increase 4°C/min; at 11 minutes increase to 290°C to elute sucrose.

Polarimetry

Pol values were measured with a Perkin-Elmer Model 241 MC polarimeter.

Sample preparation

Standards containing sucrose and invert sugar (glucose and fructose) were prepared by dissolving pure compounds in purified water. For accurate results, the component concentration in the standard should match closely those in the raw sugar sample. The samples were filtered through a 0.45 µm Millipore filter held in a Swinney adaptor, and then placed in the WISP.

GLC of invert sugar

Raw sugars were prepared for GLC analysis by dissolving 20-30 mg portions in 0.5 ml pyridine containing a quantity of methyl β-glucoside, the internal standard, approximately equal to the invert sugar content. The sugar was allowed to equilibrate overnight. The reducing sugars were converted to the oxime using the method of Schäffler & Morel du Boil[27] and the mixture silylated with hexamethyldisilazane and trimethylchlorosilane, in a 2:1 ratio.

Results and discussion

Direct determination of invert in raw sugars

With the recent improvement in the sensitivity of detectors and advancement in column technology, direct and rapid analysis of invert in raw sugars becomes possible. Refractometric detection is the most popular method used for carbohydrates, but it is only moderately sensitive. The introduction of high sensitivity RI detectors such as the Waters 410 differential refractometer used in this study, however, allows detection down to the sub-microgram level.

The use of Waters Nova Pak C18 columns with highly efficient 4 µm packing materials leads to an increase in overall resolution. Since the invert peak comes out first, it will not be overwhelmed by the large sucrose peak which emerges after the invert (Figure 1).

27 *J. Chromatog.*, 1981, **207**, 221 - 229.

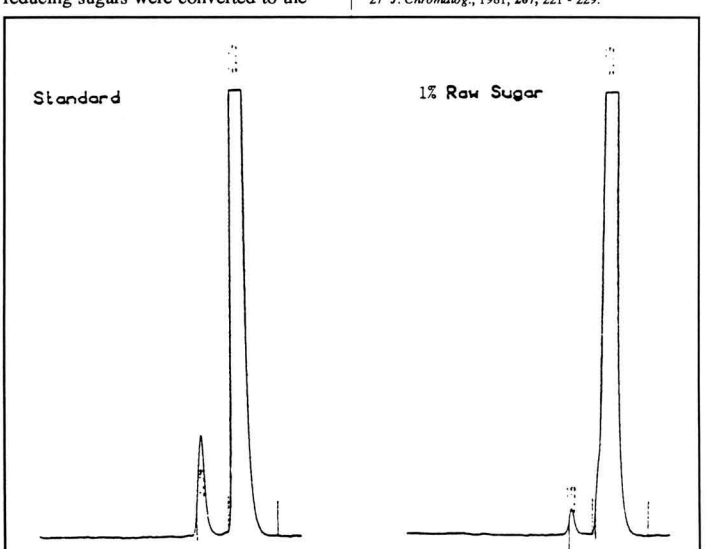

Fig. 1. Determination of invert in raw sugar by C18 Nova-Pak column with a high sensitivity Waters 410 differential refractometer. The standard consisted of 1% sucrose and 0.01% invert

Table I. Precision of sugar analysis using a Nova-Pak column

Sugar	n	C.V.
Sucrose	9	0.5%
Invert	9	0.9%

Column: 2 Nova-Pak C18 steel columns (3.9 mm × 15 cm)
Temperature: 35°C
Detector: Waters 410 differential refractometer.
Solvents: Water.
Flow rate: 0.4 ml/min.
Run time: 8 minutes.

The precision of the analyses is shown in Table I. The C.V. of 0.9% for invert and 0.5% for sucrose are low, compared with the normal C.V. for chromatographic procedures, which is 5%. The levels of invert for a series of raw and washed raw sugars were determined by this method and are tabulated in Table II.

Table II. HPLC analysis of raw and washed sugars

Raw sugar samples	*% invert by HPLC***	*% Invert removed in affination*
A	0.838	
B	0.477	
C	0.283	
C washed	0.056	80
D	0.263	
D washed	0.056	79
E	0.297	
E washed*	0.037	88
F	0.245	
F washed*	0.107	56
G	0.266	
G washed*	0.128	52
H	0.252	
H washed*	0.075	70
I	0.360	
I washed	0.129	64
J	0.188	
J washed	0.354	
J washed*	0.018	90

* Rewash with methanol
** Average of three determinations

It is interesting to observe that HPLC results show that 52 - 90% of the invert present in raw sugar is removed by the affination step. In this study, several washed raw sugars had deteriorated through fermentation when they were received, and had to be rewashed with methanol to avoid further fermentation. The invert peak of the sugar "J" washed raw (Figure 2b) is larger than that of its raw as a result of fermentation, even though the ash level is essentially eliminated. After washing with methanol, the invert peak practically disappears (Figure 2c). Some sucrose has been lost in these cases, but analytical results, on a weight basis, should be similar.

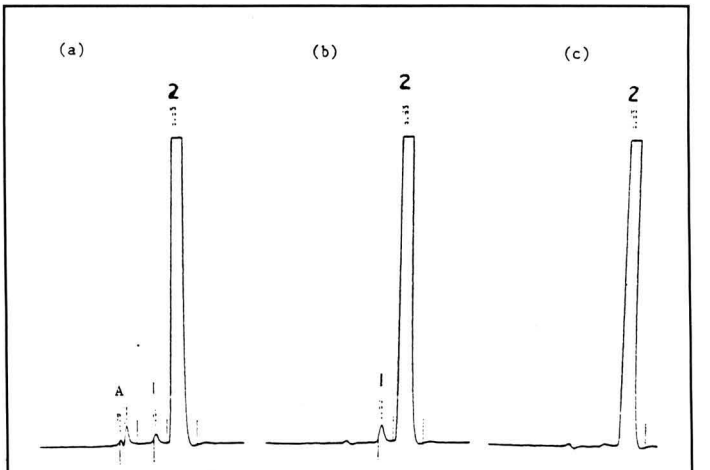

Fig. 2. Determination of invert in (a) raw sugar, (b) washed raw sugar (fermented), (c) washed raw sugar – rewashed with methanol. Peak identities: 1, invert; 2, sucrose; A, ash

In an earlier study using GLC techniques for a series of raw and washed raw sugars, the amount of invert removed by the affination step was found to be in the range of 64 - 91% (Table III) which is in good agreement with the HPLC results.

The HPLC method described here provides a rapid and quantitative analysis of total invert in raw sugar. It does not, however, permit the determination of the glucose:fructose ratio since the reducing sugars elute under the same peak. The accuracy of the HPLC results can be evaluated by comparison with those obtained by ion chromatography and gas chromatography, as below.

Ion chromatography

Recently, direct separation of carbohydrates by anion exchange with highly alkaline eluents has been reported[16]. This method provides a powerful new tool in the analysis of carbohydrates. The combination of this chromatographic method with pulsed amperometric detection provides a highly sensitive and selective method for complex and difficult samples. The invert and sucrose in raw sugar can be separated and detected using this system (Figure 3), at high precision and

Table III. GLC Analysis of raw and washed sugars

	Raw		Washed		% Invert
Sugar	*% Fructose*	*% Glucose*	*% Fructose*	*% Glucose*	removed
I	0.405	0.424	0.055	0.058	86
II	0.221	0.244	0.033	0.032	86
III	0.303	0.182	0.026	0.018	91
IV	0.318	0.361	0.044	0.044	87
V	0.124	0.094	0.026	0.030	74
VI	0.067	0.316	0.109	0.136	64
VII	0.355	0.451	0.037	0.034	91
VIII	0.289	0.321	0.055	0.062	81
IX	0.334	0.383	0.054	0.058	84
X	0.322	0.305	0.044	0.039	87

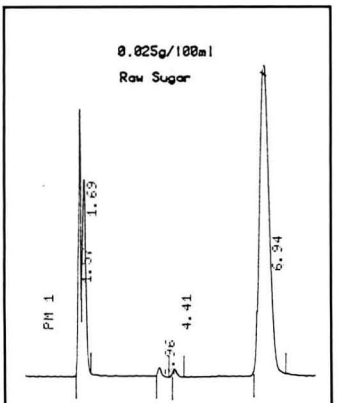

Fig. 3. Determination of invert sugars and sucrose by anion-exchange chromatography with electrochemical detection

accuracy. Results are compared with GLC results in Table IV.

Table V. Comparison of HPLC, IC, and GLC techniques

	HPLC (C18)	*HPLC (Ion exchange)*	*IC*	*GLC*
Sensitivity	High with high sensitivity R.I. detection	Moderate	High	High
Selectivity	Moderate	High	High	High
G/F ratio	No	Yes	Yes	Yes
Sample derivatization	No	No	No	Yes
Run time, min.	7	12	10	15
Sample preparation time	Short (dilution)	Short (dilution)	Short (dilution)	Long (hours)

Table IV. Comparison of invert contents in raw sugars by HPLC, GLC, and IC

	Rapid HPLC	GLC			IC		
Raw sugars	*% Invert*	*% Glucose*	*% Fructose*	*% Invert*	*% Glucose*	*% Fructose*	*% Invert*
A	0.71	0.451	0.355	0.806	0.480	0.590	1.07
B	0.83	0.424	0.405	0.829	0.444	0.408	0.852
C	0.70	0.383	0.334	0.717	0.316	0.396	0.712

Gas liquid chromatographic analysis

Gas liquid chromatography requires prior sample derivatization. In this study, invert sugar was measured by GLC as the trimethylsilyl ethers of the sugar-oximes. The analyses of invert in three raw sugars obtained by HPLC, GC and IC are compared in Table IV. Results indicate that both HPLC and IC analyses compare well with the more established GLC analyses.

The characteristic features of these chromatographic methods used in the separation and detection of invert in raw sugars are outlined in Table V.

Reproducibility of sucrose analysis by HPLC

In order to determine the reproducibility of the analysis, three subsamples of raw sugar were prepared and analysed for sucrose content on three different days. The results of these determinations are presented in Table VI. Although the precision of this HPLC method does not approach that (0.1%) of the polarimetric method[10], the RSD value of 0.24% is satisfactory and highly promising.

Comparison of HPLC analysis with polarimetry

Raw sugar samples were analysed for sucrose by the HPLC C18 reverse phase method (Figure 4). Results of typical samples show that the differences between the HPLC method and polarimetry are not significant (Table VII). The correlation coefficient between the two methods for data shown in Table VII on sugars of pol >98 is 0.82, with a standard deviation of 0.17. When data for sugars of low pol, <98, are considered, the correlation coefficient falls to 0.77, with a standard deviation of 0.32. Data on low pol sugars emphasize that pol does not show true sucrose, and deviates further from true sucrose as the purity decreases. These results agree with earlier observations by other workers[19,28] that with high purity material the methods showed good agreement.

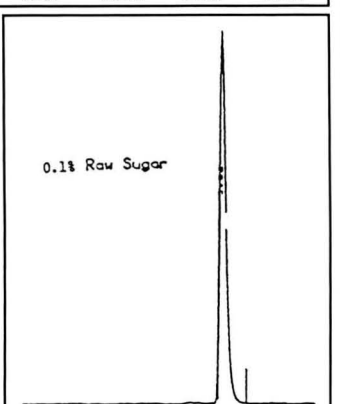

Fig. 4. Determination of sucrose in raw sugars using a C18 Nova-Pak column

Table VI. Precision of raw sugar analysis

% Sucrose by HPLC		
Day 1	*Day 2*	*Day 3*
98.16	98.35	98.55
98.68	98.62	98.99
98.48	98.87	98.72

Average = 98.60
RSD = 0.24%
Pol = 98.54

Table VII. Comparison of sucrose in raw sugar by HPLC and polarimetry

Sample	*HPLC sucrose**	*Pol*
1	98.00	97.76
2	97.15	97.36
3	97.03	97.04
4	96.91	97.40
5	97.28	97.59
6	98.88	98.88
7	98.38	98.63
8	98.44	98.54
9	98.73	98.93
10	98.72	98.42
11	98.71	98.73
12	98.46	98.44
13	98.00	98.15

* Average of three determinations

Figure 5 compares pol with HPLC sucrose on raws with a wider range of pol values. Over this extended range, from 97.4 to 99.1, the overall correlation is 0.97, with a standard deviation of 0.18.

28 Abeydeera: *I.S.J.*, 1983, **85**, 300 - 306.

Facts and figures

New Pakistan sugar factories

A new sugar factory at Asifabad in the Sind province of Pakistan is to go into trial operation in the coming season. The 2000 t.c.d. plant belongs to Al-Asif Sugar Mills Ltd. and was supplied by Ittefaq Foundries Ltd. of Lahore, in collaboration with Fletcher and Stewart Ltd., of Derby, England. The plant cost 350 million rupees and in a normal season will make about 30,000 tonnes of direct consumption white sugar. Dewan Sugar Mills Ltd. at Jilaniabad, also in Sind province, will go into trial production this season; it was supplied on a turnkey basis by Heavy Mechanical Complex Ltd., of Taxila, and is of 3000 t.c.d. capacity. During the normal 200-day season it will produce about 40,000 tonnes of white sugar. Among the equipment are Takuma boilers, TSK batch centrifugals and pressure leaf filters, and a "Unigrator" from Fabcon Inc. Sanghar Sugar Mills Ltd., at Sanghar, also in Sind province, is another factory going into trial production in the 1987/88 season. Designed and erected by Karachi Shipyard & Engineering Works, it began operation on January 18 and is of 2000 t.c.d. capacity. Some of the equipment, including the boilers, centrifugals, continuous vacuum pans and crystallizers are FCB design, made under licence. The three new factories bring the total in Pakistan to 44 with a combined installed capacity of 108,700 t.c.d. and the capacity to make 1,417,000 tonnes of sugar per season.

Indian sugar factory expansions[1]

The Bagaha sugar factory in Bihar, recently bought by the H. M. Prasad Group of Calcutta, owners of Sirguppa Sugar & Chemicals Ltd. with a 1500 t.c.d. factory in Karnataka, is to be expanded from its present 1000 t.c.d. capacity to 2500 t.c.d. Similarly, the Jagatjit sugar factory at Phagwara in the Punjab has been taken over and is to have its capacity more than trebled to 4000 t.c.d., while it is intended to use the molasses produced to make 60,000 litres/day of industrial alcohol.

International Sugar Agreement

It is reported[2] that neither Egypt, Iraq nor New Zealand will be joining the new ISA. The countries which had signed the agreement by February 10 were expected at a meeting on that date to agree to bring the new ISA into force among themselves and to set terms for others to join.

Kenya sugar industry rehabilitation[3]

In addition to the reported modernization of Muhuroni sugar factory, the US Company Arkel is reported to be undertaking a $23 million rehabilitation of the Nzoia sugar factory. The government intends to set aside 68 million shillings ($4.1 million) for the development of sugar cane in the adjacent Miwani area, while consideration is being given to construction of two new factories at Busia and Siaya.

Yugoslavia beet sugar campaign, 1987[4]

The Yugoslavian sugar factories processed about 6.6 million tonnes of beets in the 1987 campaign, including some 300,000 tonnes imported from Hungary. A total of 850,000 tonnes of sugar, white value (924,000 tonnes raw value), was produced which, with stocks, will be sufficient for the country's needs until the start of the 1988 campaign. The long drought in 1987 substantially reduced the planned production of the crop which had been sown on 154,000 hectares compared with 136,000 ha in 1986.

Zimbabwe sugar production, 1987[5]

After an excellent record crop of 484,712 tonnes, tel quel, in 1986, the 1987 crop in Zimbabwe was understandably lower, at 428,402 tonnes. Until recently the 1988 crop prospects were depressing but the serious drought conditions have been broken and rain received should ensure a reasonable crop this year.

Guyana study on power generation from bagasse[6]

Funding of $490,000 by the Inter-American Development Bank and $60,000 from local sources will permit a study on the most efficient way of burning bagasse to generate electricity in Guyana, with the object of making the sugar factories self-sufficient in power and allowing them to supply to the country's grid. At present the factories derive only about 60% of their power requirements from bagasse. The studies will focus on increasing steam and power production from a given weight of bagasse, reducing the amount of steam needed in processing, increasing the fuel value of bagasse by drying and possibly densification, and finding a supplementary fuel for use in the off-season for the co-generation plant so that it provides electricity throughout the year. Success would reduce imports of petroleum for power generation, currently 40% of Guyana's total merchandise imports.

Australian bagasse paper pulp project[7]

Rothwells Ltd., a merchant bank, have bought the rights to a process for converting bagasse to paper pulp and are to build a $Aus 61.3 million plant at Innisfail, construction of which was due to start at the beginning of this year. Three factories have contracted to supply the plant with 50,000 tonnes of bagasse annually, and the pulp quality produced will range from that for tissue paper to newsprint and coated papers. The plant will also be able to use other raw materials including straw and wood fibre. Payback on the initial investment is expected to take 4.7 years.

Ghana sugar factories rehabilitation[8]

Ghana and Czechoslovakia are reported to have signed an agreement under which the latter will provide assistance for the rehabilitation of the Komenda and Asutsuare sugar factories, which have not operated in recent years.

Cuban sugar harvest unaffected by rains[9]

The 1987/88 sugar season began satisfactorily with 94 of the island's 154 sugar factories in operation at the end of December. Despite excessive, unseasonable rains in November and early December, the harvest was reported by the sugar industry minister to be processing favourably.

Madagascar sugar industry rehabilitation[10]

The French Caisse Centrale de Coopération

continued from previous page

HPLC analysis of sucrose and reducing sugars provides more accurate information than pol values for raw sugars, particularly those of low quality. While the technique is very useful for process control, it still does not have a reproducibility equivalent to that of polarimetry for the purposes of trading raw sugar.

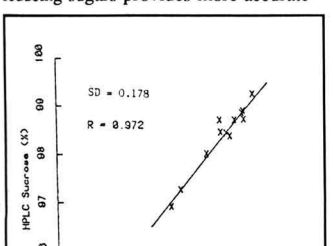

Fig. 5. Plot of pol *versus* HPLC sucrose for raw sugars

Summary

Direct determination of invert in raw sugar using HPLC reverse-phase and IC methods are described. Invert measurements compared favorably with those obtained by the GLC method. These methods can be applied to the quantitative analysis of reducing sugars in other high purity sugar products. A direct HPLC analysis of sucrose and invert in high purity products is now available.

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Economique in December approved a further 92 million francs ($17.2 million) loan for the rehabilitation of the Madagascar sugar industry. This is in addition to 100 million francs ($18.7 million) allocated in 1987. Production at four of the island's five factories is to be raised to 115,000 tonnes a year from the current 80,000 tonnes; a fifth, Chinese-built factory near Morondava started up recently and has a capacity estimated at about 22,000 tonnes a year.

Uganda sugar factories return to operation[11]

The sugar factory at Lugazi, owned by the Uganda Sugar Corporation, a company jointly formed between the original owners – the Mehta family who were dispossessed by the Amin regime in 1972 – and the Uganda government, was to be reopened on January 25. It is expected to produce about 42,000 tonnes of sugar in the current season. The plant had been closed since the mid-1970's but has been rehabilitated with equipment from a number of countries. Rehabilitation is also under way for the Kakira Sugar Works factory and plantations at Jinja and it is hoped that the former will be processing 1200 t.c.d. by mid-1988, or one-third of total eventual capacity.

Thailand sugar expansion[12]

Firming sugar prices are expected to encourage Thailand to produce 2.64 million tonnes of sugar from 25.6 million of cane in the 1988/89 season, up from an estimated 2.23 million tonnes of sugar and 21.7 million tonnes of cane in the drought-affected 1987/88 season. The projected improved cane crop is conditional on a normal May/October monsoon season later this year; the current harvest has been reduced by the severe drought in mid-1987. The Thai government has raised the provisional basic cane price that farmers receive to 405 baht per tonne from 310 baht a year ago. Under a government-supervised system, sugar factories are obliged to pay growers the basic price early in the milling season and to share with them any additional export revenue later in the crop year if world sugar prices rise above original estimates.

China sugar production[13]

Calendar year sugar production in 1987 in China amounted to 5,108,000 tonnes, white value, down 2.5% from the year before. Production in December was 878,000 tonnes bringing cumulative output from the first four months of the 1987/88 crop year to 1,287,000 tonnes, substantially down from 1,527,000 tonnes produced in the same period the year before. This points to a fall in total 1987/88 sugar production, attributed to a reduction in the areas devoted both to beet and to cane.

Denmark sugar production, 1987/88[14]

The six Danish sugar factories sliced a total of 2,537,951 tonnes of beet in the 1987/88 campaign to produce 338,843 tonnes of white sugar.

China sugar imports, 1987[15]

Chinese sugar imports in calendar year 1987 totalled 1,880,000 tonnes, raw value, up nearly 53% from the 1,182,000 tonnes of the year before.

UK sugar imports and exports, 1987[16]

	1987	1986
	tonnes tel quel	
Imports		
Barbados	71,142	31,742
Belgium	3,718	765
Belize	49,815	42,217
Denmark	34,368	40,743
Fiji	147,906	186,534
France	6,084	17,287
Germany, West	535	758
Guyana	164,481	156,382
Holland	2,588	2,430
Ireland	42,894	33,718
Jamaica	111,272	125,513
Malawi	20,179	16,750
Mauritius	406,751	396,451
Réunion	1,580	36,453
St. Kitts	15,615	14,189
Swaziland	80,627	132,914
Trinidad	46,301	46,448
Zimbabwe	47,882	27,929
Other countries	140,499	774
	1,394,238	1,309,997
Exports		
Algeria	0	36,000
Antigua	1,643	1,889
Belgium	629	741
Bermuda	775	519
Cyprus	113	380
Denmark	216	455
Dominica	321	319
Egypt	10	12,648
Ethiopia	19	1,025
France	633	487
Germany, West	3,623	2,959
Gibraltar	650	524
Grenada	1,897	766
Holland	1,961	2,260
Iceland	359	999
India	12,215	1
Iran	84,089	14,071
Ireland	10,415	4,313
Israel	82,346	44,108
Italy	22,507	25,689
Malta	16,442	11,532
Nigeria	867	3,513
Norway	46,532	35,128
St. Kitts	300	84
St. Lucia	1,409	880
St. Vincent	429	424
Saudi Arabia	18,341	540
Spain	578	185
Sri Lanka	1,812	0
Sudan	626	693
Switzerland	673	190
Togo	919	2,649
Tunisia	5,101	41,000
United Arab Emirates	216	357
Yemen, North	5,246	1,833
Yemen, South	3,259	3
Other countries	1,605	1,706
Total	328,776	250,892
Total, raw value	332,627	265,311

Australian sugar production, 1987[17]

Australian raw sugar output rose to 3.54 million tonnes, raw value, in the 1987 crushing season from 3.48 million tonnes in 1986. Total raw and refined sugar exports rose to 2.83 million tonnes, raw value, from 2.71 million tonnes in 1986. Raw sugar exports amounted to 2.81 million tonnes and refined exports to 13,000 tonnes, compared with 2.7 million and 12,000 tonnes respectively, in 1986. Japan was the largest market for Australian raw sugar last year, taking 693,000 tonnes, the highest level since 1980 and up from 514,000 tonnes in 1986. Exports to China, the second largest market, rose to a record 484,000 tonnes from 443,000 tonnes in 1986.

US sugar refinery closure[18]

The rumoured closure of the Boston refinery reported earlier[19] has been confirmed by the owners, Amstar Corporation. The closure took effect on March 18 and was stated to be due not to inherent inefficiency but to the reduced demand for refining capacity consequent on legislation which has resulted in a fall in raw cane sugar supplies of almost half since 1981.

Hungary sugar production, 1987/88[20]

During the 1987/88 campaign, Hungary's twelve sugar factories processed 3,960,000 tonnes of beets, nearly 500,000 tonnes more than in the year before, and produced 483,000 tonnes, white value, of sugar. It was the first campaign for several years when the factories worked almost at full capacity, largely owing to measures increasing the financial interest of the producer in the speediest harvesting and delivery of beets. Technical reconstruction carried out in recent years has also promoted better use of production equipment. The area sown to beet was 17% up from 1986 and the yield 3% higher than the plan value. The area is expected to decline in 1988.

Belgium sugar exports, 1987[21]

Belgium exported 709,694 tonnes, raw value, of sugar during 1987, of which 2,485 tonnes was raw sugar and the balance as white sugar (650,632 tonnes, white value). The principal destination was Holland which took 183,713 tonnes of white sugar while Saudi Arabia took 72,174 tonnes, the UK 56,666 tonnes, Iran 28,475 tonnes, Lebanon 27,579 tonnes, West Germany 24,393 tonnes, Peru 24,227 tonnes, Algeria 23,293 tonnes, India 22,939 tonnes, Nigeria 22,778 tonnes, the United Arab Emirates 21,839 tonnes, Turkey 20,550 tonnes, Egypt 16,899 tonnes, Sudan 15,350 tonnes, Syria 14,542 tonnes and North Yemen 12,129 tonnes, all as white sugar.

11 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 72 - 73.
12 *Reuter Sugar Newsletter*, January 13, 1988.
13 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 73.
14 *Zuckerindustrie*, 1988, **113**, 166.
15 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 87.
16 *ibid.*, 1987, **119**, S160 - S161; 1988, **120**, S81 - S82.
17 *Financial Times*, February 18, 1988.
18 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 118.
19 *I.S.J.*, 1988, **90**, 20.
20 F. O. Licht, *Int. Sugar Rpt.*, 1988, **120**, 85 - 86.
21 *ibid.*, S92 - S93.

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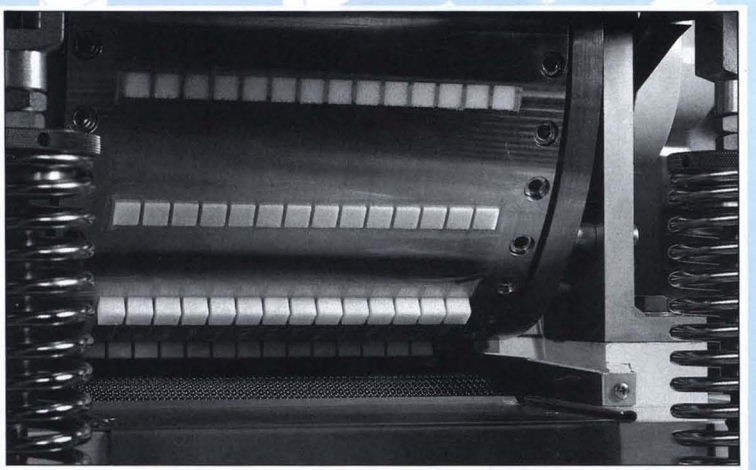

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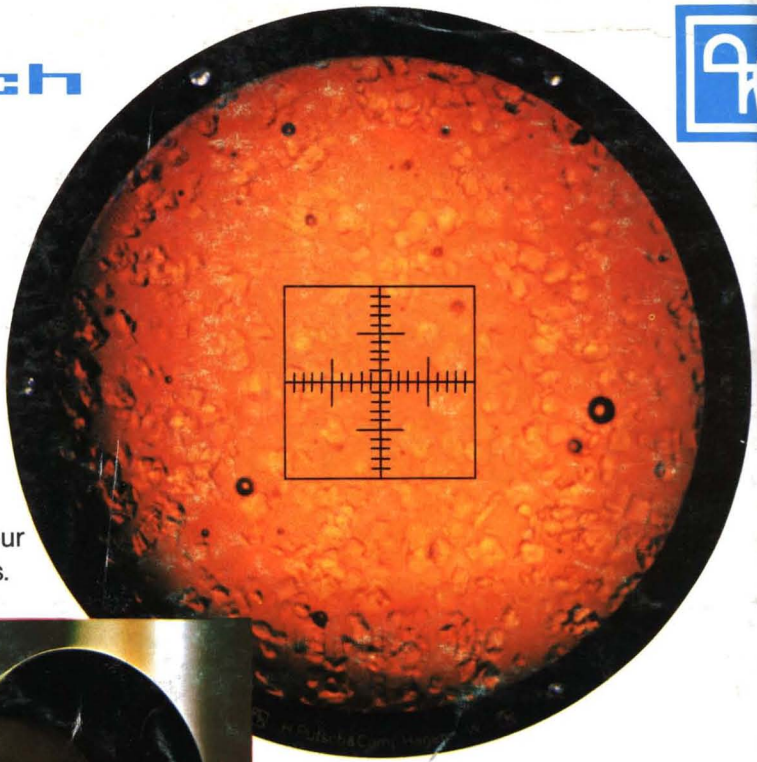

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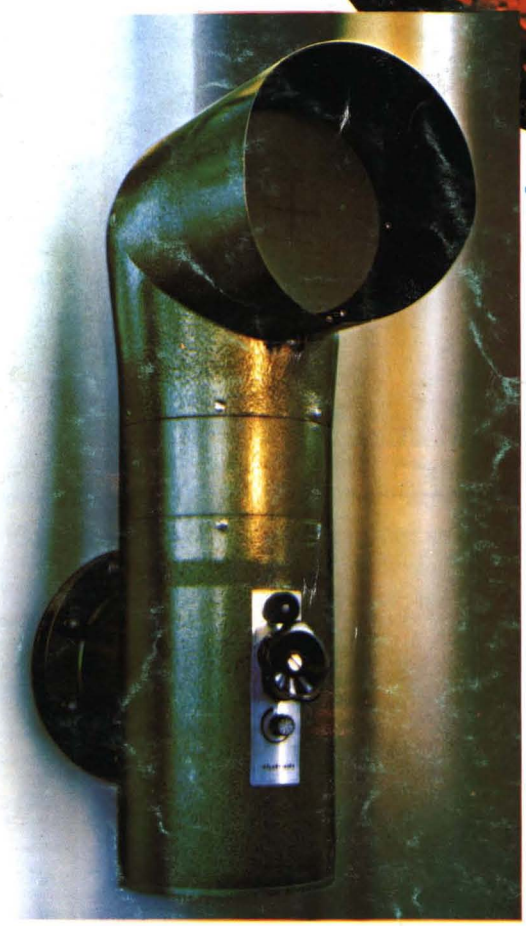

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