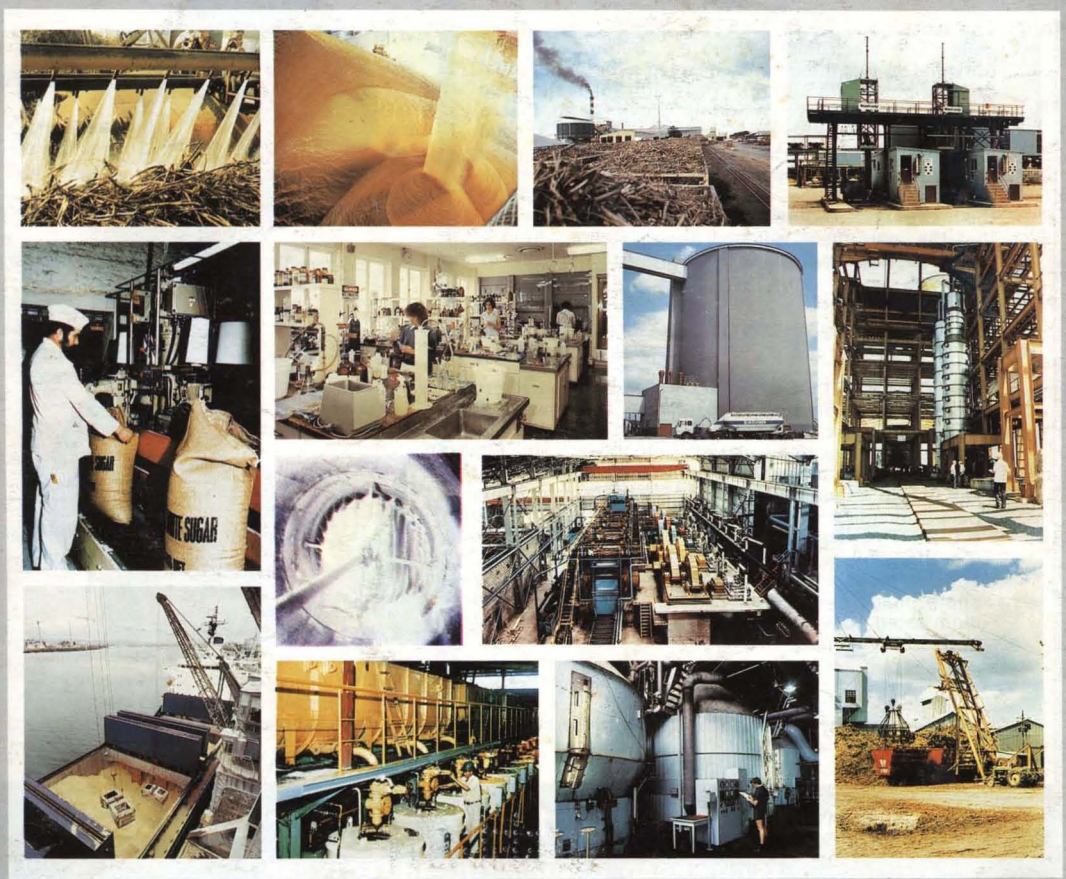
INTERNATIONAL SUGAR JOURNAL



VOLUME LXXXX/ISSUE No. 1070

FEBRUARY 1988

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News and views

Automated white sugar trading

For the past few months, an Automated Trading System (ATS) has been in use at the London Futures & Options Exchange (London FOX) for trading in white sugar. The broker – one of nine using the system – enters buy and sell orders which are processed in sequence of entry. The system matches an order at a price equal to or better than the opposite order. As soon as the order has been matched the system will provide an automatic print-out of the trade that has taken place. Orders are of several types; they may be entered to be matched immediately or otherwise cancelled; they may be held until matched, cancelled by the broker or until the end of the trading day; or they may be entered to remain in the system until matched by the broker. All contracts are cleared and guaranteed by the independent International Commodities Clearing House, providing total security to the market floor. Further, by trading screen-to-screen, brokers do not need to get together on a market floor to trade.

Brazil's fuel alcohol program under fire[1]

The alcohol-for-fuel program in Brazil comes under regular re-examination in which how much government subsidy should be provided is a perennial topic. Currently, the government is under increasing pressure to reduce a growing public sector deficit and mounting losses by Petrobras, the state petroleum monopoly, responsible for distribution of gasoline and alcohol. The National Energy Commission has been studying two proposals: to reduce the pricing differential and to adopt a new system for alcohol whereby producers could deliver directly to distributors without Petrobras acting as an intermediary.

Growers argue that cutting the differential would create doubts in consumers' minds as to the government's commitment to the program and could persuade them to switch to gasoline cars, leaving an excess of alcohol capacity. Such a switch would be welcomed by Petrobras, however, since it produces an excess of gasoline, which has to be exported, in order to meet diesel oil demand. Were the distribution system to be changed, it would become necessary to reduce government taxes to increase the amount available to cover distribution costs.

According to demand projections, there is not expected to be an exportable surplus of alcohol from the 1987/88 harvest unless demand is pinched by higher prices. The government decreed in September that the differential would be maintained but, since Brazil now produces 60% of its own crude oil requirements it may be concluded that the alcohol program is not as strategically necessary as it was.

Sugar supplies for the Philippines

A severe drought has affected sugar production in the Philippines and the current season's sugar output has been slower than usual[2]. At the same time, domestic consumption has risen substantially and refined sugar stocks had fallen to less than a month's supply in November. To meet this temporary situation – factories are expected to be in full swing by January – a loan of between 30,000 and 100,000 tonnes of sugar was to be obtained from Thailand, the closest available supplier. The quantity was to be repaid in the form of sugar within the next 6 - 12 months, and traders handling the deal were to receive a fee of 10% of the transaction. The deal fell through, however, because sugar traders refused to participate, but an agreement was reached in December for the purchase of 36,500 tonnes of refined sugar from South Korea, to be delivered that month, and a further 63,500 tonnes to be delivered in January[3]. No origin of the second delivery was quoted.

Choice for Latin America

F. O. Licht GmbH recently published an analysis of the Soviet sugar economy[4] in which they showed that since the middle 1950's the USSR has been a substantial buyer of Cuban sugar but it was only after Cuba's rift with the United States that annual tonnage rose to around 2 million tonnes and sometimes more than 3 million. Import needs are growing and, although imports of Cuban sugar are rising, they no longer meet practically all Soviet needs as they once did.

Although beet sugar production in the current five-year plan period to 1990 is projected to exceed recent levels by 8 - 12%, the beet production goal has been reduced by nearly 10 million tonnes from the levels established by the 1982 food program. The constant reduction in area sown to beets reflects the low priority for this crop. A shift to other crops than sugar beet will probably increase import requirements, which could be used as a political weapon against the United States.

The support system for US sweetener producers has led to a constant fall in US import requirements which has taken a toll on relations with sugar producing Latin American nations. The costs of lost sugar markets is believed to have wiped out gains achieved through the President's Caribbean Basin Initiative. Senator Bradley recently said that it is ludicrous to benefit 10,000 growers at the expense of US strategic interests, hundreds of thousands of American workers and millions of American consumers.

The Senator is one of the group of 34 members of Congress who are backing legislation to reduce US sugar supports and increase sugar imports. Their proposal would reduce the domestic loan rate for sugar from the current level of 18 cents/lb to 12 cents/lb in 1991 while increasing the import quota by 500,000 tonnes a year over the next four years. A similar proposal was put forward by the administration some time ago but was defeated in the Congress. Since then, however, members have become more aware of the effect the support program is having in the Western Hemisphere and

1 *Financial Times*, November 5, 1987.
2 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 569.
3 *Public Ledger*, December 12, 1987.
4 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 553 - 558.

the Philippines. Nevertheless the proposal is not considered to have much chance of passage[5].

An alternative proposal is being supported by some sugar suppliers; it would involve raw sugar being shipped to the US at its domestic price and outside of quota for refining in the US and exporting with the aid of government subsidy. Government sources said the plan would operate like the Export Enhancement Program used for grain exports. Adminstration officials sharply criticise the scheme, however, since it would be a serious breach of their aim to dismantle farm export subsidies. Australia would also challenge the scheme at the GATT if it were to be approved, and would also resist another idea, for the quotas of richer countries to be transferred to poorer ones of the Caribbean and Latin America. Consequently, it seems likely that the import quota will remain in existence but that its size will continue to be reduced until, in the not too distant future, the US will be self-sufficient. Choice for Latin America will then be gone.

As Licht says "Whatever the logic behind the US sugar policy may be, it has opened vast political opportunities for the Soviet Union in Latin America and elsewhere, and the Dominican Republic's announcement of a sugar supply agreement with the USSR is clear writing on the wall".

US production and consumption trends[6]

US production of sugar will reach a record 7.3 - 7.4 million short tons, raw value, during the 1988 financial year, reducing the portion of the US market left for imports to only 800,000 - 900,000 tons, according to the President of Commodity Information Inc. in a speech prepared for the US Department of Agriculture's annual sugar outlook conference. He attributed the rise to extraordinary beet and cane yields, and expanded acreage stimulated by the high US domestic price support of 18 cents per pound.

US consumption, which increased by 3% in 1987 – the first rise in ten years – is also expected to continue to rise but at a slower rate of 1% annually during 1988 to 1990. As a result, the gap between product and consumption will probably return to 1.0 - 1.1 million tons in 1989 and 1990.

The overall trends towards sharply rising domestic production and modest consumption rises mask underlying shifts, the most important being that beet sugar is making inroads in regional markets previously supplied with cane sugar. The 1988 forecast suggests that beet sugar usage in the US will almost achieve parity with cane sugar, at 48% of total usage against one-third of the market in the early 1980's.

Growth of total sweetener demand in the US (caloric and non-caloric), which reached 3.3% annually in the first half of the 1980's, is expected to slow to 1.5% in the second half.

Europe beet sugar production, 1987/88

F. O. Licht GmbH have recently published their second estimate of beet sugar production in Europe in the campaign just ended[7]. Expectations improved as conditions for harvesting in many countries were favourable. Overall production is now expected to reach 30.3 million tonnes, raw value, which compares with 29.9 million tonnes forecast in the first estimate, and the revised figure for 1986/87 of 31.7 million tonnes. Actual production will, however, depend on Soviet sugar output which cannot be estimated with a high degree of accuracy at this stage.

In the EEC, weather conditions towards the end of the vegetation period were less favourable than the previous year so that extraction rates remained more or less in line with expectations and the total forecast has risen only to 13.8 million tonnes against 13.5 in the first estimate, published at the end of August last. Elsewhere in Western Europe estimates are only slightly changed, except for Yugoslavia where output is now set at 923,000 tonnes against 1,010,000 tonnes earlier.

Severe winter conditions in the USSR delayed sowings and consequently shortened the growing period. This, along with reports of delayed lifting of the beet, led many observers to believe that sugar production would fall well below the 1986/87 output of 8.7 million tonnes. Reports of illegal use for making vodka and of limitation in Cuban supplies indicated a need for imports, but the absence of Soviet purchases suggests that the domestic output may not after all, have been reduced as much had been expected, and Licht's estimate is raised by 100,000 tonnes. Increases have also been made in the estimates for East Germany, Hungary and Poland. The latest figures appear below, together with revised figures for the 1986/87 campaign.

	1987/88	1986/87
	tonnes, raw value	
Belgium	860,000	1,017,000
Denmark	380,000	543,000
France	3,915,000	3,734,000
Germany, West	2,906,000	3,469,000
Greece	201,000	312,000
Holland	1,060,000	1,325,000
Ireland	239,000	202,000
Italy	1,870,000	1,868,000
Portugal	5,000	5,000
Spain	1,055,000	1,092,000
UK	1,305,000	1,438,000
Total EEC	*13,796,000*	*15,005,000*
Austria	380,000	307,000
Finland	73,000	132,000
Sweden	277,000	386,000
Switzerland	120,000	129,000
Turkey	1,790,000	1,414,000
Yugoslavia	923,000	855,000
West Europe	*17,359,000*	*18,228,000*
Albania	40,000	38,000
Bulgaria	110,000	179,000
Czechoslovakia	770,000	860,000
Germany, East	690,000	730,000
Hungary	522,000	473,000
Poland	1,793,000	1,892,000
Rumania	560,000	610,000
USSR	8,450,000	8,700,000
East Europe	*12,935,000*	*13,482,000*
Total Europe	30,294,000	31,710,000

5 *Czarnikow Sugar Review*, 1987, (1767), 173.
6 *Reuter Sugar Newsletter*, December 1, 1987.
7 *Int. Sugar Rpt.*, 1987, **119**, 571 - 574.

World sugar prices

Usually sugar prices tend to decline during December but 1987 showed a different pattern. The London Daily Price for raw sugar began the month at $201.80 and hovered between this and $208 during the first half of the month, sustained by expectations of purchases by China, India and the USSR. Even the announcement of a cut in the US sugar import quota on December 15 did not cause a fall; indeed, the LDP then started to rise, notwithstanding the lack of actual buying by the USSR – which is being taken as indication of better results from the 1987/88 beet sugar campaign than had been expected. Purchases by China and efforts by Cuba to postpone shipment of sugar had a strengthening effect and the greatly improved statistical position supported sugar prices. The LDP continued to rise during the second half of the month and closed at $238 per tonne, white sugar values following closely. The premium, which had been small at the beginning of the month at $6.70 per tonne, had halved at the end of the month, so that the LDP(W), which had started at $208.50, ended at $241.50 per tonne.

Brazil Sugar Institute problems

In December it was announced that the Brazilian government had dismissed first the President and then the Export Director of the Instituto do Açúcar e do Alcool amid allegations of serious irregularities in the management of sugar policy. The new President, Mr. Nilson Miranda Motta of the Banco do Brasil, was appointed to investigate and correct these irregularities. First, he announced, after a meeting of the Export Committee on December 11, that negotiations were almost complete for bringing forward to January/February shipment exports previously scheduled for May and August, but then this arrangement was cancelled. After heavy shipments during the last quarter of 1987 there was nothing scheduled for the first two months of this year, and storage difficulties could arise.

The Institute has for a long time been the sole authority for the export of sugar from Brazil, but the government has decided to privatize exports from next June[8]. The decision was taken as part of broader fiscal measures aimed at cutting government expenditure this year. Subsidies to producers and the costs of carrying sugar stocks are estimated at 10,000 million cruzados ($149,000 million) for 1987. It is a victory for the producers of São Paulo, led by Copersucar, who have been lobbying for an end to the Institute's monopoly, and a defeat for the producers of the north-northeast region who have favoured government control of exports. Regulations are being worked out by the Ministry of Commerce and Industry, but it is thought that trading companies or cooperatives will be formed to handle the exports.

The government is concerned because such bodies will be inexperienced in handling exports; however, it hopes to cut export subsidies – currently $34 per tonne – by half for the first harvest after privatization and remove them entirely for the next.

International Sugar Agreement

The new ISA, negotiated last September, was due to come into force on January 1, 1988, but by that date, it had not been ratified by countries having a total of 50% of all the exporters' and importers' votes. As a consequence, the old Agreement was extended until March 1. The International Sugar Organization is pressing those countries which have not yet ratified to do so before March 1 and is confident that there will be sufficient signatures for the 1987 Agreement to come into force before that date.

In the opinion of Dr. Albert Viton, former head of the Sugar Division of the F.A.O.[9], it can by no means be assumed that the new Agreement would survive three years of inactivity. The head of the Philippines delegation stated, at the end of the 1987 negotiations, that his government will review during the last part of 1988 its membership of the Council in the light of progress made on negotiating an agreement with economic provisions. Even now, there may be a substantial number of members who will forfeit their votes for non-payment of membership dues.

The improvement in the production/consumption balance that has taken place since the 1983/84 UNCTAD conference would make it relatively easy to raise the world price by 2 - 3 cents by means of an ISA with economic provisions. Export limitations would not make necessary crippling production cuts, and a price improvement would not only help producers immediately, but would also militate against a major price rise down the road, followed by a depression which would last longer than those following other price rises and may well prove irreparable, especially in Asia and other low income areas.

Dr. Viton analyses prospects for new negotiations in the light of his assessment of the attitudes of important member countries, and the means whereby they might be brought about. He urges adoption of the triumvirate technique which proved successful in negotiating the 1968 Agreement. A group of three eminent political figures or civil servants would stimulate more attention than any individual, and should be chosen with an eye to their access to the top authorities of major parties to the ISA. He suggests that the Executive Director of the Council should be the chief adviser or, as in 1968, a member of the team. But, "whatever the technique for launching negotiations, the time for action is now"!

International workshop on molasses utilization[10]

A workshop on the use of cane and its by-products as animal fodder was held in Cuba recently. Sponsored by the International Foundation for Science, of Sweden, and the University of Camagüey, the workshop was attended by scientific advisers from the Foundation, lecturers from various Latin American countries and a representative of the FAO. It was concluded that there is experience in the region in the use of cane and its by-products as animal fodder, but there is a need for greater exchange of information and integration among producers of sugar and animal feeds.

8 *Financial Times*, December 23, 1987.
9 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 585 - 590.
10 *Australian Canegrower*, 1987, **9**, (10), 5.

Product news

Contra-Shear extends waste water screen range

Contra-Shear took three years developing what is called the Suboscreen. This company first became known for the work they had pioneered with internally fed screens. The Suboscreen is completely different in its screening technology. There is no infeed tank and the screen sits in a liquid, normally in a semi-submerged state. The wires run circumferentially around the drum so that the liquid goes through a 90° change of direction. The solids are progressively picked up by carrying staves which lift them into a top tray. The solids are then moved out of the screen by fluming with water from the showers situated at the twelve o'clock position or the drainer screw, a special development by Contra-Shear, is used to screw the solids out of the drum to an elevated position at the same time expressing liquid out of the screenings. The Suboscreen unit on its first commercial installation, handling raw sewage, exceeded design performance.

In the application engineering various factors were taken into consideration including loss of screen face. Earlier designs on the market failed to handle cotton lints, stringy materials, wool and fabrics which have all caused stapling and closing off of the apertures that make up the screen face. These conditions have been successfully overcome by the technology used on Suboscreen.

The screen is capable of handling very substantial volumes up to 51,000 gallons per minute (193,000 litres per minute or 73 mgd). The smallest Suboscreen is of 900 mm or 36 inches diameter, the largest one being two metres (6.56 feet) in a range of slot sizes from 1 mm to 12.8 mm.

Traditionally, in-line screens, particularly bar screens and climber screens, have allowed long stringy material to pass through the screen because of being "lined up" with the flow. Because the Suboscreen includes a change of direction, this traditional problem has been overcome and the Suboscreen rejects products larger than the screen slot. Much design thought has been given to the mechanical make-up of the Suboscreen. At the downstream end the screen is closed off completely and is supported by a sealed thrust-race. On the upstream end the rotating assembly is supported by rollers at the ten o'clock and two o'clock position. Under usual operating conditions the parts (with the exception of the seal) will be above the water-line with single position greasing of the bearings. The seal itself is a proven Contra-Shear design requiring little attention.

Further details:

Contra-Shear Engineering Ltd.,
C.P.O. Box 1611,
Auckland,
New Zealand.

New management contracts for TLTS

Tate & Lyle Technical Services have won contracts in Indonesia and the Sudan. In the latter country, a team of nine specialists is to provide management assistance and training over a 2-year period to Sennar Sugar Co. Ltd., which grows sugar cane on approximately 24,000 acres of irrigated land. Training of local staff will be undertaken by the TLTS team in Indonesia; the trainees will then in turn train project and sugar factory personnel employed in a number of Indonesian sugar factories as part of an overall development to make the country self-sufficient in sugar.

EEC - Andean Pact agro-industrial cooperation

In September 1986 an Agro-Industrial Conference was held in Caracas under the auspices of the European Community and the Junta de Acuerdo Cartagena (the economic treaty of 5 Andean countries: Bolivia, Colombia, Ecuador, Peru and Venezuela). Representatives of more than 100 companies from each group of countries participated, and joint venture and other commercial agreements have been negotiated as a direct outcome of the contacts established. Encouraged by this success, the EEC is taking further steps to promote industrial cooperation with Andean group, and has appointed Metra – the consulting group responsible for organizing the 1986 Caracas Conference – to establish an information and business promotion service for EEC companies interested in cooperation with Andean firms in the agro-industrial sector. Metra will create a data bank with details of all agro-industrial projects in which Andean companies would welcome European participation, and EEC companies may ask Metra to seek Andean partners for developing new markets for their products, processes, equipment and know-how. Andean countries are now facilitating such partnership by easing restrictions on foreign investment. Interested EEC firms are invited to provide Metra with information about the products and technologies they wish to promote, preferred countries, and the types of cooperation desired.

Further details:

Metra Consulting Group Ltd.,
1 Queen Anne's Gate,
London SW1H 9BT.

Controlled cooling towers save money

It is often simple control devices which are the most cost-effective. The auto-control panel from Carter is one of these: it simply controls the operation of the tower fan and the immersion heater in the tank. This enables the tower fan to be operated automatically on/off according to the demands of heat load or level of outside ambient wet bulb temperature. It also controls the on/off operation of the immersion heater to prevent water freezing in the tower tank when it is not in operation.

The product has proved extremely popular as it saves considerable time and money for a company installing a cooling tower. The control panels are completely suitable for use with cooling towers other than those from Carter. A leaflet describing the range is available from Carter Cooling Towers, Carter Industrial Products Limited, Bedford Road, Birmingham B11 1AY, England.

Solubility of sucrose in water in the presence of raffinose

By B. Liang*, R. W. Hartel** and K. A. Berglund***

Introduction

It is known that the presence of raffinose has a rather considerable influence on the crystallization of sucrose from aqueous solution. Since raffinose exists in commercial beet sugar solutions, it is important to investigate the kinetics of crystallization in the presence of this impurity. However, the solubility of sucrose in raffinose solutions must be known before these kinetics can be obtained.

Several investigators have attempted to measure the solubility of sucrose in raffinose solutions. Mariani & Ciferri[1] investigated the phase equilibrium of the sucrose-raffinose-water system and obtained the isotherms at temperatures of 293 and 337°K. Their results showed a decrease in sucrose solubility with increasing raffinose concentration. Symthe[2], using a refractive index technique, measured the solubility of sucrose at 314°K at several raffinose concentrations. His results showed that raffinose affects sucrose solubility in much the same way as does invert sugar. Binder & Murphy[3] measured the solubility of sucrose in the presence of raffinose to determine the effect of raffinose on the kinetics of sucrose crystallization, but were unable to obtain consistently reproducible results.

As pointed out by Binder & Murphy[3], there are no reliable data on the solubility of sucrose in the presence of raffinose in the range of temperatures suitable for crystallization kinetics research. This work employs a refractive index measurement technique as suggested by Smythe[2] to determine sucrose solubility with raffinose content from 0 to 6% and over a temperature range from 313 to 333°K.

Experimental

The concentration of a pure sucrose solution can be accurately determined by measuring its refractive index[4]. For this work, it was found that a sucrose-raffinose-water solution showed a monotropic relation between sugar concentration and refractive index. Once such a relationship is generated, the concentration of sucrose in a saturated solution is easily found from the refractive index.

A Bausch & Lomb refractometer with constant temperature water circulation was used to measure the refractive index of the solution. Standard curves for determining the refractive index of sucrose in raffinose solution

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1 *Ann. Chim.*, 1954, **44**, 797.
2 *Aust. J. Chem.*, 1967, **20**, 1097.
3 "The effect of raffinose on the kinetics of sucrose crystallization"; *Paper presented at the AIChE Ann. Meeting*, 1982.
4 "Polarimetry, saccharimetry and the sugars" (Circular C440, National Bureau of Standards, Washington) 1942, pp. 254 - 261; 652 - 665.

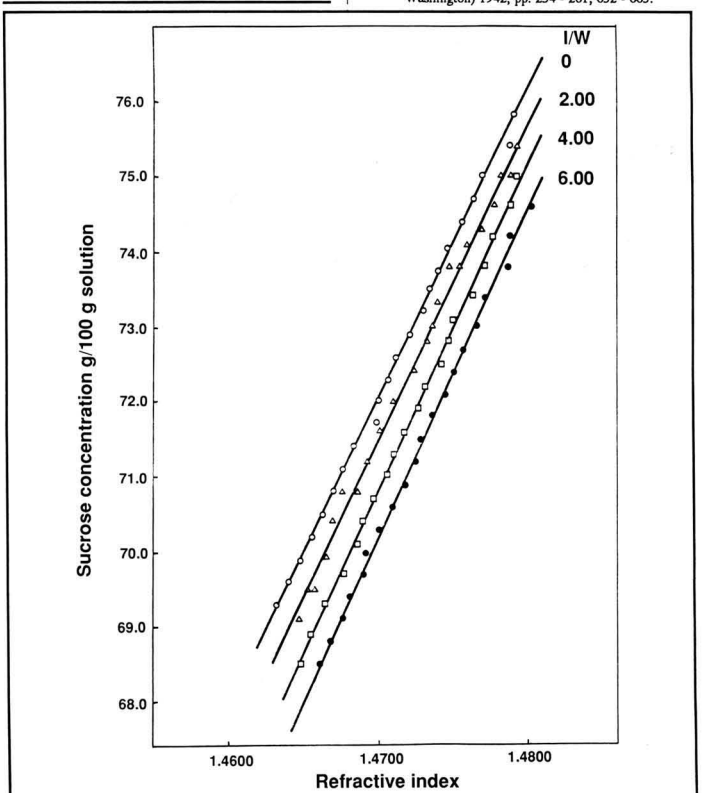


Fig. 1. Relationship between sucrose concentration and refractive index of solution at various ratios of raffinose to water

were determined in the following way. A specified weight of sucrose was added to a raffinose solution of known concentration. The sucrose was dissolved by heating and stirring the mixture in a sealed flask so that a solution of known composition was prepared. The measurement of refractive index of solution was performed at 293°K using the refractometer.

Equilibrium solubilities of sucrose in raffinose solution were found in the following way. An excess of sucrose over saturation was added to a raffinose solution with a known raffinose concentration. The mixture, sealed in a flask, was immersed in a constant temperature water bath and agitated with a magnetic stirrer in order to attain phase equilibrium. By taking successive refractometer readings, it was found that 7 days of stirring was adequate to reach equilibrium. A sample solution was taken from the equilibrium system by pipetting and then filtered through a 0.45 μm filter. The clear, saturated sample solution was analysed at 293°K with the refractometer. For each sample, the average value of ten readings was taken as the refractive index. For each temperature and raffinose concentration condition, four observations were performed.

Results

The relationship between sucrose concentration and refractive index for raffinose concentrations between 0 and 6% is shown in Figure 1. A near-linear dependency is found for all levels of raffinose with the refractive index of the solution increasing with increasing raffinose level. From these data, equilibrium saturation concentrations of sucrose in raffinose solution could be determined.

Equilibrium conditions at various temperatures and raffinose levels are shown in Table I. The mean of four different determinations of refractive index is given at each condition. These values of equilibrium refractive index can be identified with a sucrose concentration as shown in Figure 1 to give solubility values for sucrose under the conditions investigated.

Table I. Refractive index of equilibrium sucrose solutions at various temperatures and raffinose levels

T,°K	I/W,%	n[1]	σ[2]
313	0	1.4655	9.10E-5
	2	1.4661	2.06E-4
	4	1.4662	6.35E-4
	6	1.4661	2.39E-4
323	0	1.4705	4.80E-5
	2	1.4709	5.88E-4
	4	1.4714	1.35E-4
	6	1.4713	4.16E-4
333	0	1.4755	1.20E-4
	2	1.4765	2.12E-4
	4	1.4767	2.97E-4
	6	1.4768	1.83E-4

[1] Mean of four observations
$n = [\sum_{i=1}^{4} n_i]/4$
[2] Standard deviation of four observations,
$\sigma = [\sum_{i=1}^{4} (n_i - n)^2]/3$

Analysis and discussion

After fitting the data in Figure 1 with various models and comparing the results, a linear model was chosen as the most suitable relationship between the concentration of sucrose and the refractive index of solution. The general form of this model is given by the equation

$$C = a + bn \qquad (1)$$

The results of this modelling are listed in Table II. The correlation coefficient, r, indicates that the linear model has a high significance. As shown in previous work[4], a linear relationship fitted quite well for the pure sucrose-water system in the concentration range of 68 to 77 g sucrose/100g solution. This work shows that there is also a linear fit between sugar concentration and refractive index for the sucrose-raffinose-water system in the same range.

Table II. Regression result of sucrose concentrations as a function of refractive index of saturated solution, as fit to C= a + bn

I/W,%	a	b	r*
0	–527.0	407.5	0.9986
2	–540.4	416.2	0.9964
4	–565.0	432.5	0.9988
6	–567.2	433.6	0.9988

* Correlation coefficient in linear regression for C = a + bn

The calculations can be made for solubility measurements under different conditions (see Table I) based on the above models, the results of which are given in Table III. For the pure sucrose system (I/W = 0), the results are consistent with the second order polynomial model summarized by Kelly[5]. This is:

$$C_T = 62.77 + 0.17060(T - 273) + 0.000344(T - 273)^2 \qquad (2)$$

Table III. Solubility of sucrose based on the observations of refractive index of saturated solution at various temperatures and raffinose levels

T,°K	I/W,%	C[1]	σ[2]
313	0	70.13	0.0372
	2	69.80	0.0858
	4	69.10	0.2746
	6	68.44	0.1034
323	0	72.19	0.0194
	2	71.83	0.2449
	4	71.36	0.0584
	6	70.71	0.1804
333	0	74.25	0.0490
	2	74.14	0.0881
	4	73.65	0.1283
	6	73.11	0.0792

[1] Mean of four observations
$C = [\sum_{i=1}^{4} C_i]/4$
[2] Standard deviation of four observations,
$\sigma = \{[\sum_{i=1}^{4} (C_i - C)^2]^{1/2}\}/3$

The comparison of the present results with those of Equation (2) is shown in Table IV. This excellent agreement indicates that this method is

5 "Principles of sugar technology", Vol. II, Ed. Honig (Elsevier, Amsterdam) 1959, Chapter 2.

Table IV. Solubility of pure sucrose as determined from solubility equation of Kelly[5] as compared with that determined from this work

T,°K	C_{T1}	C_{T2}	Relative error, %
313	70.144	70.127	–0.0248
323	72.160	72.188	0.0388
333	74.244	74.249	0.0063

[1] Solubility as determined by Equation (2):
$C_T = 62.77 + 0.1706\ (T - 273) + 0.000344(T - 273)^2$
[2] Solubility as determined in this work; from Table III

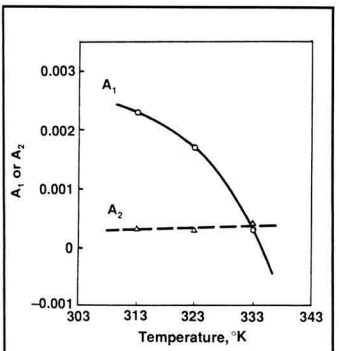


Fig. 2. Relationship between temperature and the coefficients A_1 and A_2 in Equation (4)

an acceptable means of measuring sucrose solubility and that it may be used for impure systems.

It was hoped that the effect of raffinose content on the solubility of sucrose could be distinguished from the temperature effect using the following formulation.

$$C = C_T f(I/W) \quad (3)$$

Several functions for f(I/W) were investigated, with the best fit being given by a second-order polynomial in raffinose content. This model is shown as

$$C = C_T [1 - A_1(I/W) - A_2(I/W)^2] \quad (4)$$

It was found, however, that A_1 was a function of temperature, as shown in Figure 2 and Table V. The relationship between the coefficient A_1 and the temperature was fitted to a second order polynomial and is given as

$$A_1 = -3.4(10^{-3}) + 3.1(10^{-4})(T - 273) - 4.1(10^{-6})(T - 273)^2 \quad (5)$$

Table V. Coefficients A_1 and A_2 from Equation (4) at each temperature

T,°K	A_1	A_2	Residual*
313	0.002303	0.0002978	0.31284
323	0.001698	0.0002743	0.28865
333	0.000277	0.0003850	0.11403

*$\sum_{i=1}^{N} \{C_i - C_T[1 - A_1(I/W)_i^2]\}^2$

It can be seen from the table that the coefficient A_1 is the key factor influencing the solubility, whereas the coefficient A_2 is less important and is nearly constant with temperature. It can also be seen that the raffinose content has a slightly larger effect on the solubility of sucrose at lower temperature than at higher temperature. A comparison between the experimental values and the solubilities predicted by Equation (4) is shown in Figure 3.

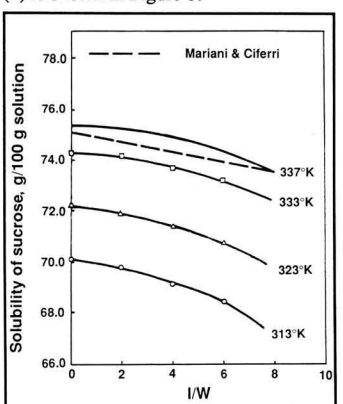


Fig. 3. The effect of temperature on the solubility of sucrose in the presence of raffinose. The solid line at 337°K represents the extrapolation of the current data to be compared with the experimental results of Mariani & Ciferri[1] (dotted line)

If the synergistic effect of raffinose content and temperature is taken into account, the following could be assumed to fit the data,

$$C = C_T + k_1(I/W) + k_2(I/W)^2 + k_3(I/W)(T - 273) \quad (6)$$

The coefficients k_1, k_2, and k_3 have been obtained as –0.355, –0.0231 and 0.00508, respectively, by the flexible simple optimization method.

The predicted values of solubility from Equations (4) and (6) are quite close, as shown in Table VI. Thus, both Equations (4) and (6) can be used to estimate the solubility of sucrose in the presence of raffinose in the range of temperature and raffinose concentration studied.

It is clear that the solubility of sucrose decreased with the increase of raffinose content and the decrease of temperature. It is also shown from Figure 3 that there is a quantitative difference between the results of Mariani & Ceferri[1] and this study, as their results predict a linear decrease in sucrose solubility with raffinose level.

Conclusion

The relationship between sucrose concentration and refractive index for sucrose-raffinose-water solutions was found to be linear in the range of raffinose content between 0 and 6%.

From this relationship, the solubility of sucrose in water in the presence of raffinose was obtained at the temperatures of 313, 323 and 333°K. The effect of both raffinose content and temperature on the solubility of sucrose has been expressed by polynomial equations in each variable. Two distinct equations have been developed for prediction of sucrose solubility at various temperatures and raffinose levels.

The results of this work are consistent with those of the others in the respect that the sucrose solubility decreases as the raffinose concentration increases and the temperature decreases. However, some quantitative disagreement exists regarding the rate of the solubility decrease with the increasing raffinose level.

Acknowledgement

This work was supported by the

(continued in next column)

Table VI. Comparison of predicted values of sucrose solubility from Equations (4) and (6) at various temperatures and raffinose levels

	T,°K	I/W, %			
		0	2	4	6
Equation 4	313	70.14	69.74	69.16	68.42
	323	72.16	71.84	71.35	70.71
	333	74.24	74.09	73.70	73.09
Equation 6	313	70.14	69.75	69.17	68.40
	323	75.16	71.86	71.38	70.72
	333	74.24	74.05	73.67	73.11

HPLC determination of organic acids in sugar cane and its industrial by-products

By Danielle A. Celestine-Myrtil and Aubert Parfait
(Station de Technologie des Produits Végétaux, I.N.R.A., Petit-Bourg Research Centre, Guadeloupe, French West Indies)

Introduction

Rum, the major alcoholic beverage produced in the French West Indies, is obtained by mixed fermentation of cane juice or cane molasses, followed by a single distillation[1]. Yeast and bacterial fermentation, and therefore the aromatic profiles of the rum, are influenced by cane juice or molasses composition[2-4]. After demonstration of the important part played by organic acids in rum fermentation[3], a detailed study of these compounds in sugar cane raw material, and in its industrial by-products (molasses, effluent from vinasse anaerobic digestion), was judged necessary. According to the literature, aconitic, malic, oxalic, citric, succinic, fumaric, glycolic, mesaconic and syringic acids have been identified in sugar cane[5-7]. Partition chromatography[6,7] and ion exchange HPLC[8-10], have been used to separate some organic acids from sugars in sugar factory and refinery samples. Weak or strong anion exchange[11-17] and reverse phase[11,14,15,18,19] HPLC columns have been used to identify organic acids in a number of food products (fruits, dairy products, silages). Determination by HPLC of organic acids in the raw material for rum or ethanol distilleries and in their wastes has not been previously reported, however.

D. A. Celestine-Myrtil A. Parfait

In this study, individual organic acids were quantified and the presence of two isomers of aconitic acid *(cis* and *trans)* was demonstrated in the samples of sugar cane juice, molasses, vinasse, and effluents from vinasse anaerobic digestion using C18 reverse-phase HPLC and U.V. detection at 214 nm.

Materials and methods

Samples

Cane juice was obtained from a rum distillery in Guadeloupe.

Two *molasses* samples were studied one of which was a mean sample from the 1986 crop, sampled at a sugar factory in Guadeloupe and the other a sample of commercial Louisiana blackstrap molasses, low in invert sugar, from the 1985 crop.

Vinasse from ethanol fermentation of cane molasses and from fermentation of cane juice were sampled at rum distilleries in Guadeloupe.

Effluents from molasses vinasse after anaerobic digestion were sampled from a 1800 m³ digester at a rum distillery in Guadeloupe.

Digested cane juice vinasse was obtained from a 4-litre laboratory pilot digester at I.N.R.A. in Guadeloupe.

Samples preparation

Vinasse and digester effluents were centrifuged at 4000 rpm during ten minutes. Cane juice, molasses and vinasse were diluted with water. Samples, diluted or not, were purified by passing through Waters Sep Pak C18 cartridges. All the samples were then treated with Dowex 50 cation exchange resin in H^+ form (Sigma) to remove interfering compounds (5 ml of sample, 1 g of H^+ resin, stirring 1 hour). Before HPLC analysis, the samples were filtered through 0.22 µm Millipore filters.

Department of Chemical Engineering of Michigan State University as well as by the National Science Foundation through grant number CPE-8412101.

Notation

a	Constant in Equation 1 (g/100g solution)
A_1, A_2	Coefficients in Equation 4 (dimensionless)
b	Regression coefficient in Equation 1 (g/100 g solution)
C	Concentration of sucrose (g/100 g solution)
C_T	Solubility of sucrose at a specific temperature T (g/100 g solution)
I/W	Mass ratio of raffinose to water in solution (%)
k_1, k_2	Coefficients in Equation 6 (g/10 0g solution)K_3
	Coefficients in Equation 6 (g/100 g solution – K)
n	Refractive index (dimensionless)
r	Correlation coefficient in linear regression
T	Temperature (°K)
σ	Standard deviation for refractive index (dimensionless) or sucrose concentration (g/100g solution)

1 Parfait: *Kemia Kemi*, 1983, **10,** 982 - 983.
2 Fahrasmane *et al.*: *Ind. Alim. Agric.*, 1983, **100,** 297 - 301.
3 Idem: *J. Food Sci.*, 1985, **50,** 1427 - 1430.
4 Lencrerot *et al.*: *Ind. Alim. Agric.*, 1984, **101,** 763 - 766.
5 Martin: in "Principles of sugar technology", Ed. P. Honig, (Elsevier, Amsterdam) 1953, pp. 128 - 156.
6 Roberts & Martin: *Anal. Chem.*, 1954, **26,** 815 - 818.
7 Idem: *Proc. 6th Tech. Session Bone Char*, 1959, 67 - 99.
8 Charles: *I.S.J.*, 1981, **83,** 169 - 172, 195 - 199.
9 Tsang & Clarke: *Proc. Sugar Processing Research Conf.*, 1984, 316 - 331.
10 Clarke & Tsang: *I.S.J.*, 1984, **86,** 215 - 220.
11 Buslig *et al.*: *J. Agric. Food Chem.*, 1982, **30,** 342 - 345.
12 Wilson *et al.*: *ibid.*, 1106 - 1108.
13 Shaw & Wilson: *J. Sci. Food Agric.*, 1983, **34,** 1285 - 1288.
14 McFeeters *et al.*: *J.A.O.A.C.*, 1984, **67,** 710 - 714.
15 Goiffon *et al.*: *Analusis*, 1985, **13,** (5), 218 - 225.
16 Picha: *J. Agric. Food Chem.*, 1985, **33,** 743 - 745.
17 Gancedo & Luh: *J. Food Sci.*, 1986, **51,** 571 - 573.
18 Shaw & Wilson: *J. Sci. Food Agric.*, 1981, **32,** 1242 - 1246.
19 Wilson *et al.*: *ibid.*, 1982, **33,** 777 - 780.

Table I. Detection and measurement limits

Organic acids	Retention time, min	Response factor	Detection limit, mg/l	Measurement limit, mg/l
Oxalic	4.1	0.470×10^{-5}	0.5	1.6
Glycolic	4.5	0.208×10^{-5}	30	45
Malic	5.27	0.143×10^{-5}	10	20
Shikimic	5.85	0.233×10^{-5}	0.5	1.5
Lactic	6.05	0.152×10^{-3}	30	40
Citric	8.1	0.129×10^{-3}	20	65
Cis-Aconitic	9.5	0.209×10^{-5}	0.5	1
Fumaric	9.9	0.112×10^{-5}	0.4	0.6
Trans-Aconitic	13.5	0.184×10^{-5}	0.8	1.2

HPLC analysis

A Waters M510 pump, a Waters M440 UV detector set at 214 nm and 0.2 AUFS, a Rheodyne manual injector U6 K fitted with a 20 µl loop and a Waters Data Module recorder integrator were used. The organic acids were separated on a 25 cm, 5 µm Sup Rs C18 (Prolabo). Eluent was a 2% ammonium dihydrogen phosphate ($NH_4H_2PO_4$) buffer of pH 2.18. Eluent temperature was 32°C and flow rate was 0.7 ml/min.

Analyses were made in external standard mode. Individual acids were identified by comparison with reference compounds. Standard curves relating integrator response to concentration were used to quantify the results. Analysis were carried out in duplicate for each sample.

Results and discussion

The different organic acids sufficiently separated in less than 15 minutes (Figure 1). Detection and measurement limits are given in Table I. The detector response to different concentrations of each acid was linear throughout the range of the concentrations found in the injected samples (Table II). In order to determine the precision of the method, including sample treatment and HPLC analysis, nine dilutions of organic acids standard solution were purified, and then injected. The results are given in Table III. Except for oxalic acid, data obtained for organic acids repeatability can be considered as reasonable. In order to examine the effect of sample clean-up, the results of standard solution injections with and without treatment were compared (Table IV). With 99% confidence limits the difference between treated (Sep-pak C18 and cation exchange) and non-treated samples was not significant.

The time for a complete analysis was around 90 minutes, including stirring during one hour with cation exchange resin as clean-up procedure. Sample treatment time can be greatly decreased by using a cation exchange column (10 cm × 1 cm). Under these conditions, only 40 minutes were necessary for complete sample analysis including clean-up and HPLC analysis.

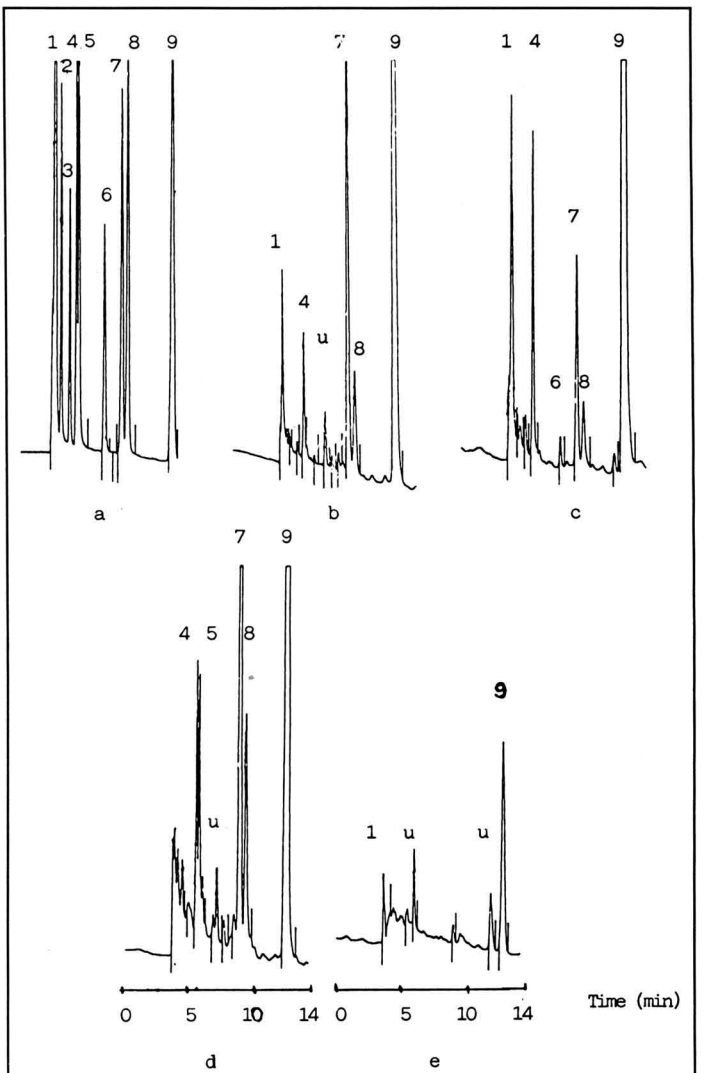


Figure 1. Organic acids chromatograms of: (a) standard solution, (b) cane molasses (c) cane juice, (d) vinasse, (e) anaerobically-digested vinasse. Peaks: 1 = oxalic, 2 = glycolic, 3 = malic, 4 = shikimic, 5 = lactic, 6 = citric, 7 = *cis*-aconitic, 8 = fumaric, 9 = *trans*-aconitic acid, u = unknown

Generally speaking, the HPLC method developed here was considered satisfactory for comparison of organic acids composition of sugar cane and its industrial by-products.

Nine organic acids were quantified in the samples (Table V) and unknown components were observed (Figure 1). No mesaconic, syringic, nor succinic acid were detected, contrary to the results previously reported in the literature[5-7,20].

Confirming the findings of Martin[5]

Table II. Response detector linearity

Organic acids	Range of concentration, mg/l	Equation	Correlation coefficient	Data number, n
Oxalic	1.60 to 306.00	Y = 1.5X + 9.00	0.997	8
Glycolic	45.9 to 10187	Y = 50.8X + 44.7	0.999	8
Malic	20.8 to 5541.2	Y = 27.7X + 15.2	0.999	8
Shikimic	0.40 to 21.80	Y = 0.8X + 0.09	0.998	7
Lactic	38.7 to 1844.7	Y = 72.7X - 22.5	0.999	7
Citric	32.6 to 6934.6	Y = 34.7X + 4.90	0.999	8
Cis-Aconitic	1.00 to 177.70	Y = 0.9X + 1.50	0.999	8
Fumaric	0.60 to 112.60	Y = 5618.5 X + 0.70	0.999	8
Trans-Aconitic	1.20 to 255.50	Y = 1274.5X + 1.70	0.999	8

and McCallip & Seibert[21], *trans*-aconitic acid was shown to be the major organic acid in cane juice and molasses (Table V). Analytical methods used to quantify organic acids[6-10] did not separate *cis*- and *trans*-isomers of aconitic acid and, hence aconitic acid has been listed in the literature as a single quantity. There have been few references relative to *trans*-

20 Carles: in "Encyclopedia of plant physiology", Ed. Ruhland (Springer Verlag, Berlin), 1960, **12**, (2), 663 - 700.

21 *Ind. Eng. Chem.*, 1941, **33**, 637 - 640.

Table III. Method repeatibility — all measurements in mg/litre

Acid		Oxalic	Glycolic	Malic	Shikimic	Lactic	Citric	*Cis*-Aconitic	Fumaric	*Trans*-Aconitic
Sample	X1	61.80	1201.20	601.00	14.70	1501.20	980.00	19.70	9.20	24.50
	X2	51.20	1033.60	507.50	12.40	1265.10	847.40	17.80	7.90	21.70
	X3	46.70	997.50	500.30	12.00	1209.60	809.80	17.00	7.80	20.41
	X4	35.20	964.50	502.90	12.10	1208.50	836.20	17.00	7.60	20.70
	X5	37.30	1123.80	546.90	13.70	1359.00	900.00	18.30	9.00	22.90
	X6	38.30	1142.40	542.50	13.70	1372.10	893.70	18.30	9.00	23.00
	X7	47.80	1110.81	527.80	13.60	1354.10	908.10	18.10	8.60	23.33
	X8	49.50	1033.40	534.00	12.80	1308.80	882.50	17.90	8.10	22.98
	X9	60.00	1117.90	559.70	13.40	1375.20	908.40	18.40	8.70	23.90
Mean	X	47.53	1080.57	535.84	13.16	1328.18	885.12	18.06	8.43	22.60
Standard deviation σ_{n-1}		9.48	76.94	32.02	0.89	92.49	49.83	0.81	0.59	1.39
Precision R.S.D. $(\sigma_{n-1} \times t)/(x \times \sqrt{n})$		15%	5%	5%	5%	5%	4%	3%	5%	5%

n = 9; t = 2.306 with 95% confidence limits

Table IV. Sample clean-up effect — all measurements in g/litre

Acid	Oxalic	Glycolic	Malic	Shikimic	Lactic	Citric	*Cis*-Aconitic	Fumaric	*Trans*-Aconitic
Without sample clean-up									
x1	0.0535	1.2281	0.5946	0.0148	1.5131	0.9753	0.0194	0.0099	0.0267
x2	0.0411	1.2050	0.6082	0.0149	1.5374	0.9968	0.0196	0.0099	0.0265
x3	0.0428	1.1674	0.5634	0.0144	1.4332	0.9196	0.0189	0.0094	0.0240
Mean	0.0458	1.2002	0.5887	0.0147	1.4946	0.9639	0.0193	0.0097	0.0257
σ_{n-1} $n_1 = 3$	0.0067	0.0306	0.0230	0.0003	0.0545	0.0398	0.0004	0.0003	0.0015
With sample clean-up									
y1	0.0478	1.1108	0.5278	0.0136	1.3541	0.9081	0.0187	0.0086	0.0233
y2	0.0495	1.0335	0.5340	0.0128	1.3088	0.8825	0.0179	0.0081	0.0229
y3	0.0600	1.1180	0.5597	0.0134	1.3752	0.9084	0.0184	0.0087	0.0239
Mean	0.0524	1.0874	0.5405	0.0133	1.3460	0.8997	0.0183	0.0085	0.0234
σ_{n-1} $n_2 = 3$	0.0066	0.0468	0.0169	0.0004	0.0339	0.0149	0.0004	0.0003	0.0005
d1 = x1 – y1	0.0057	0.1173	0.0668	0.0012	0.1590	0.0672	0.0007	0.0013	0.0034
d2 = x2 –y2	-0.0084	0.1715	0.0742	0.0021	0.2286	0.1143	0.0017	0.0018	0.0036
d3 = x3 – y3	-0.0172	0.0494	0.0037	0.0010	0.0580	0.0112	0.0005	0.0007	0.0001
$\|d\| = \|x - y\|$	0.0066	0.1127	0.0482	0.0014	0.1485	0.0642	0.0010	0.0013	0.0024
σ_{n-1} (d)	0.0116	0.0612	0.0387	0.0006	0.0858	0.0516	0.0006	0.0006	0.0020
$t = \|d\|/\sigma_{n-1}$ (d).$\sqrt{(1/n_1 + 1/n_2)}$	0.7032	2.2568	1.5247	2.9959	2.1216	1.5242	1.8415	2.8167	1.4697

$n = n_1 + n_2 - 2 = 4$; t = 4.604 with 99% confidence limits

ISJ Abstracts

Cane sugar manufacture

Dust control and particulate conveying systems in the sugar industry

R. B. Patel. *Bharatiya Sugar*, 1987, **12**, (3), 23 - 24, 27, 29 - 30.

Dust arrestors installed on the top of boiler chimneys at one Indian sugar factory had an efficiency no greater than 60% dust separation by weight and had a number of other disadvantages which are listed. The question of permissible emission levels as officially set out is discussed, and a system proposed based on use of a baffle-type wet scrubber. Problems concerning bagasse conveying to boilers are also discussed, and details given of a pneumatic system installed by the author's company.

Microprocessor controls for bagasse-fired furnaces

W. Keenliside and K. McGrew. *Sugar J.*, 1987, **49**, (9), 14 - 17.

See *I.S.J.*, 1987, **89**, 101A.

Non-sugars adsorption during carbonatation at low pH

M. I. Daishev, R. S. Reshetova and M. S. Kulibali. *Sakhar. Prom.*, 1987, (4), 15 - 17 *(Russian)*.

While liming at pH 9.8 is intended to prevent excessive reducing sugar degradation and resultant darkening of the juice, the purity rise in clarification is usually inadequate because of the weak positive charge of the calcium carbonate formed and hence its low adsorptive properties; however, as indicated by laboratory studies, oversaturation to pH 7.0 - 8.2 gives a much greater adsorption. Cane juice brought to pH 11 while cold and then slowly adjusted to pH 7.0 - 7.5 was heated and the mud separated, after which the clear juice was limed to pH 8.7 - 8.9 (at which the lime salts content was minimal) and divided into two portions, one of which was further limed; treatment with a supplementary 1.5% CaO on juice gave an extra purity rise of up to 4% by comparison with only 2 - 3% without the extra liming. Similar beneficial effects of liming to a low pH (7.0 - 7.5) were found in experiments with beet juice, but prior removal of the mud had little positive effect on purity rise.

Different massecuite boiling schemes and exhaustibility of molasses

D. S. Lande. *Indian Sugar*, 1987, **36**, 605 - 612.

See *I.S.J.*, 1987, **89**, 90A.

A new process for syrup treatment and filtration

N. K. Varma and R. K. Saksena. *Bharatiya Sugar*, 1987, **12**, (5), 9 - 14.

A process is described in which continuous sulphitation of syrup takes place with recirculation in a precipitator in which lime salt particles grow so as to increase their removal by subsequent filtration in a pressure leaf filter to which the syrup is fed under gravity. Some of the syrup from the filter is returned to the precipitator, while the cake is is either mixed with raw juice, mixed with vacuum filter cake or is transferred to filter-presses; the remainder of the filtrate from the leaf filter is sent to the pan station. The syrup was found in trials to contain less lime salts than conventional sulphitation syrup, was clearer and contained no sediment. The expected monetary effect of the increased sugar recovery and lower molasses losses is calculated.

Technical control in sugar manufacture. Role of the laboratory

D. P. Kulkarni. *Bharatiya Sugar*, 1987, **12**, (4), 9, 11 - 13; (5), 17, 19 - 20.

Chemical control of cane milling, clarification, evaporation and boiling house processes and analysis of e.g. waste water, boiler feed water, condensate and oil and molasses are discussed as well as maintenance of records.

The sugar house scheme at Felixton II sugar factory

C. Voss. *Zuckerind.*, 1987, **112**, 377 - 380 *(German)*.

An account is given of the processes used at Felixton II, which operates Tongaat-Hulett continuous vacuum pans and was the first sugar factory in the world to use continuous boiling for all products. *A*-sugar is boiled on a 90°Bx footing made up of *B*-sugar melted in *A*-sugar wash syrup, the use of which provides a material that is practically free of fine crystals despite the use of continuous centrifugals to produce the footing. All massecuite cooling is carried out in vertical crystallizers. *A*-sugar raw washings are used as footing for *B*-sugar and low-grade boiling. The greater ease with which continuous boiling is conducted than in beet sugar factories is attributed to the lower supersaturation and risk of scale formation resulting from the low purities, and to the self-sufficiency in energy, which permits the use of lower Brix syrup drinks and the application of steam to promote circulation and dissolve fine crystals in water where necessary.

Disposal of filter cake by combustion

F. le Grand. *Sugar y Azúcar*, 1987, 82, (6), 39 - 41.

While land disposal of filter cake poses a number of problems, incineration would produce a free-flowing dry ash containing some P and Ca which could easily be spread over a field. Incineration together with bagasse in normal sugar factory furnaces is difficult because of the high moisture content of filter cake and temporary temperature changes in the furnace caused by irregular feeding. Details are given of the Vortex solid fuel burner which, when operated in conjunction with a Stokermaster automatic control device for maintenance of an optimum balance between preheated combustion and biomass fuel, is considered highly suitable for filter cake incineration. Since automatic maintenance of ignition would be difficult if the filter cake contained >60% moisture, predrying by passage between steam-fed rollers is advocated. Diagrams are given of both pre-dryer and of the Vortex unit.

Experiences with the BMA G 1500 centrifugal on *A*-massecuite

A. F. Currie. *S. African Sugar J.*, 1987, **71**, 127 - 129.

See *I.S.J.*, 1987, **89**, 78A.

Hydrazine monitor

Anon. *S. African Sugar J.*, 1987, **71**, 131 - 132.

A description is given of the Kent Instruments EIL 7835 dissolved hydrazine monitor, which is a microprocessor-based instrument that uses an electrochemical cell to measure the amount of hydrazine in boiler water. Addition of hydrazine to the water prevents corrosion by (i) reacting with oxygen to form nitrogen and water, (ii) breaking down into ammonia and thus raising the pH and (iii) reacting with any soft haematic layers on boiler tubes to change them to a much harder layer of magnetite; however, unless there is an excess of hydrazine over and above the amount needed to scavenge the oxygen, the magnetite layer will revert to haematite, so that it is desirable to have a continuous record of the hydrazine level.

Quaternary ammonium compounds. Chemical control of bacteria in sugar cane juice by using quaternary ammonium compounds

Boonsong Saeng-on and Wiwut Daengsubha. *Kasetsart J.*, 1985, **19**, (3), 213 - 220; through *S.I.A.*, 1987, **49**, Abs. 87-718.

Tests were carried out on three quaternary ammonium compounds, Maquat-1416, CMA and Hexemine X-100. In factories in Thailand these are commonly used at 5 ppm concentration to control microbial growth in cane juice. Concentrations tested ranged from 0.5 to 50 ppm. All three compounds were inhibitory at 10 - 20 ppm to the following bacteria: *Leuconostoc mesenteroides*, *Streptococcus* sp., *Lactobacillus cellobiosus*, *Bacillus subtilis* and *Lactobacillus fermentum*. Four other bacteria (*Erwinia herbicola*, *Proteus* sp., *Pseudomonas* sp. and *Klebsiella* sp.) were more resisistant to these chemicals. Further tests using 10 ppm of each compound showed that CMA could inhibit the bacteria but not kill them, Maquat-1416 could kill many bacterial species, and Hexemine X-100 could inhibit most of the test bacteria and kill a few species. To prevent or decrease sucrose degradation, it is recommended that 10 ppm of one of these compounds should be used.

Cane sugar factory in Burma

J. Rohlena and J. Valach. *Czechoslovak Heavy Ind.*, 1987, (7), 29 - 32.

Information is given on the 2000 tcd sugar factory constructed by Czechoslovakia for the Burmese Foodstuff Industries Corporation at Zeyawaddy in the Sitang river valley. The main equipment comprises a 4-mill tandem, a 5-tray clarifier, quadruple-effect evaporator, vacuum pans supplemented with a special vacuum crystallizer and a seed massecuite crystallizer, and fully-automatic ARO 850 centrifugals. After commissioning trials in 1986, the factory operated at a capacity which was 5 - 8% (sometimes 20%) higher than the guaranteed level.

An overview of the Indian sugar industry

P. J. M. Rao. *Sugar y Azúcar*, 1987, **82**, (3), 26 - 27, 29 - 31.

A review is presented of the Indian sugar industry, including both cane growing and processing, with information on factory performance and by-products utilization.

SAI (steam-aided imbibition), a new process for reducing pol and moisture in bagasse

K. S. G. Doss. *Indian Sugar*, 1987, **36**, 559 - 560.

See *I.S.J.*, 1987, **89**, 98 - 99.

Sugar drying with a modified fluidized bed

H. C. Tso, C. H. Chen, T. P. Hsieh and Z. S. Wu. *Rpt. Taiwan Sugar Research Inst.*, 1987, (115), 35 - 42 *(Chinese)*.

An investigation of fluidized bed drying of sugar is reported. Test bench experiments were conducted to establish the relationship between air flow velocity, pressure drop and bed height, and the optimum open area of the perforated plate was determined. A pilot-scale unit having a cross-sectional area of 0.27 m^2 was used to dry instant sugar and fine granulated white sugar at Talin sugar factory. Results showed that too high a moisture content of the sugar particles caused lumps to form and stick together; using a stirrer rotating at 30 - 90 rpm in the feed section and blowing air up through the sugar at an adequate velocity solved the problem. Insertion of two vertical baffle plates above the perforated plate resulted in a particle residence time distribution that approached plug flow. The flow rate of the warm air was controlled from the temperature of the bed; this ensured that the temperature of the discharged sugar was in equilibrium with that of the drying air so that a very low residual moisture resulted. At an air-to-particle heat transfer coefficient of 3000 - 5000 kcal/m^3/hr/°C and a residence time of 10 minutes the sugar moisture content was reduced from 1.5 - 3.0% to 0.1%.

Studies on the adsorption of sugar colorants

S. C. Sharma and P. C. Johary. *Indian Sugar*, 1987, **37**, 19 - 31.

Studies conducted by various authors on the adsorption of artificially prepared colorants (caramel, melanoidin and glucose alkaline degradation products) by calcium sulphite, phosphate and carbonate and by defecation, sulphitation and carbonatation muds are summarized. Results showed that freshly prepared precipitates of the calcium salts had better adsorptive properties than the pure salts, and 1st carbonatation mud was superior to the other two muds. The degree of colorant adsorption fell with rise in temperature, while the effect of pH varied with the nature of the adsorbent.

Beet sugar manufacture

Further experiences with continuous crystallization at Wabern sugar factory

G. Witte. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 16 pp.

An account is given of experiences with the BMA evapo-crystallization towers at Wabern[1] since initial trials in 1983. For 1987 it was planned to add a further raw sugar crystallization stage to produce a coarser high-raw sugar of 0.50 crystal size and increase the white sugar yield.

Some recent developments and installations in Irish sugar factories. I. Double purging of *B*-product sugar. II. The coupling of a tower prescalder with an RT diffuser at Carlow. III. Computer control in sugar manufacturing at Carlow. IV. Pulp pressing at Carlow. V. New sugar silo at Thurles. VI. Experiences with filtration of standard liquor at Carlow.

I. M. E. Buckley. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 16 pp. **II.** J. Dodd. *ibid.*, 9 pp. **III.** V. G. Duignan. *ibid.*, 15 pp. **IV.** T. F. Cronin. *ibid.*, 12 pp. **V.** T. F. Cronin. *ibid.*, 15 pp. **VI.** P. Rochford. *ibid.*, 26 pp.

I. A description is given of the *B*-sugar double affination system used at Carlow which has raised the quality of the sugar and reduced *B*- and *C*-massecuite purities as well as that of molasses while also improving the performance of the standard liquor filter station.
II. Operation of a BMA counter-current mixer in conjunction with the RT diffuser at Carlow helped to increase diffuser throughput by an average of 400 tonnes of beet per day. The average rise in raw juice Brix across the prescalder during first year trials was 2.67°, and cold raw juice temperatures are consistently maintained at 28 - 33°C or about 15°C above the temperature of incoming beet; the raw juice is subsequently heated to 65 - 70°C using low-grade steam and condensate. The levels of thermophiles and mesophiles in the prescalder are such that they can be controlled using shock doses of formalin and spraying beet with a quaternary ammonium salt biocide as they enter the factory.
III. Details and diagrams are given of the computerized controls based on use of the Rosemount Diogenes system for white sugar boiling in four batch pans, diffusion and juice reheating, juice purification and *B*- and *C*- massecuite boiling. Automatic control is also applied to vapour compression. The systems have generally performed very well and proved reliable.
IV. The performance of the 11 pulp presses at Carlow is reported, including the performances of a Babbini P.18 press and of a pulp recycling screw installed in 1985 as well as two variable-speed drives fitted to two presses, and the results of modifying the system used to add calcium sulphate to beet at the rate of 1.17 kg/tonne.
V. Details are given of the 40,000 tonne capacity Abay silo installed at Thurles for bulk storage of sugar conveyed to it from the cooler; moisture control is very good and very little dust forms inside the silo.
VI. While Schenk filters have performed well in the treatment of standard liquor at Carlow, they have proved sensitive to process conditions that have given rise to problems such as leakage of filter aid and consequent danger of product contamination, while the consumption of filter aid has been high. The various remedial measures adopted are described; they include the replacement of kieselguhr with perlite of greater bulk density which gave the same filter-cake thickness at a reduced precoat rate. Check filters were also installed.

Performances of the Fives Cail Babcock continuous vacuum pan and new prospects

J. de Crémoux, P. Credoz and M. Pattacq. *Sucr. Franç.*, 1987, **128**, 213 - 222 *(French)*.

The advantages of the FCB horizontal continuous vacuum pan in terms of massecuite circulation, heat exchange and crystallization kinetics are discussed and the effects of massecuite purity and Brix, vacuum and water evaporation rate on thermal efficiency indicated. Details are given of the automatic controls used in the pan, and their contribution to the ability to boil on a graining volume as low as 10% (compared with 25 - 30% in conventional continuous boiling) without impairing the crystal size of the final sugar is described. At Saint Germainmont factory, where two strikes of Category 2 white sugar are made, the 1st strike is boiled on a mixture of footing and massecuite (the latter from the continuous pan) followed by cooling, the purity being reduced by recycling some of the run-off to both the pan and crystallizer; the sugar is affined and melted. At the same factory, a pilot plant has been installed for crystal footing production from some of the massecuite boiled in the continuous pan; the massecuite is diluted so as to desaturate the mother liquor and milled to provide the desired number of crystal nuclei of required size.

The ZUP-Nysa WL horizontal twin-spindle pulp press

K. Buck. *Gaz. Cukr.*, 1987, **95**, 1 - 4 *(Polish)*.

Information is given on the WL twin-spindle pulp press which is a modification of the PDW-1 but is smaller and, in the case of the 5 variable-speed versions, has a wider range of speed control. It is available in 7 constant-speed versions ranging from 360 to 3350 tonnes/day, while the variable-speed models cover approximately the same range but have maximum dewatering capacities which are about the same at 24 - 26% compared with a stepped range for the other models.

An automatic system for lime kiln charging

J. Wajs and J. Najmola. *Gaz. Cukr.*, 1987, **95**, 4 - 7 *(Polish)*.

An automatic system for proportioning coke and limestone and feeding the

1 Witte: *I.S.J.*, 1987, **89**, 136A.

charge into a kiln as at Garbów sugar factory is described.

Comment on the use of formalin

M. Piotrowski. *Gaz. Cukr.*, 1987, **95**, 7 - 8 *(Polish).*

Views expressed on the causes of screen blockage in DDS diffusers and on the effects of formalin on diffusion losses are discussed. In answer to the suggestion that formalin can disrupt the diffusion process where the water is not pretreated with SO_2, mention is made of the performances of the two diffusers at Lublin factory, where 0.021% formalin on beet was added throughout the campaign and average losses were 0.24% on beet at an average combined throughput of 3742 tonnes/day compared with a nominal 3400 tonnes/day; acidification of the water was interrupted because of pump breakdown without any adverse effect on diffusion.

Tests on the application of radiation technology to sterilization and degradation of effluent in the sugar industry

J. Perkowski, M. Jezierski and F. Nowak. *Gaz. Cukr.*, 1986, **94**, 153 - 155; 1987, **95**, 10 - 11 *(Polish).*

Experiments on application of ^{60}Co irradiation to raw juice and pulp press water sterilization and to waste water treatment are reported. The raw juice bacterial count fell progressively with increased radiation dosage up to 10 kGy, at which the total count was 100/cm³ compared with an initial count of 5000/cm³, 90% of which were bacilli and more resistant to treatment. A dosage of 0.5 kGy reduced the bacterial count in press water by 99.99%. A 40 - 50% reduction in COD and BOD_5 of effluent was achieved with a dosage of 20 kGy, but higher dosage rates gave only slight improvement on this; a high rate of aeration gave an additional improvement to 60%. The use of oxidizing agents hydrogen peroxide, chlorine water and sodium hypochlorite in conjunction with irradiation failed to have any further positive effect on effluent degradation compared with use of the chemicals alone. On the other hand, 20 kGy irradiation plus treatment with ozone-containing air at a rate of 10 dm³/hr and an ozone concentration of 31.7 mg/dm³ reduced the COD by about 60% and the BOD_5 by about 70%. Reference is also made to the literature on irradiation of sugar solutions, and the effect on optical rotation of irradiation of a 10% solution at doses of 5 - 100 kGy is indicated in graph form.

The use of compressed air for accurate cleaning of sugar from baskets of *A*-massecuite centrifugals

K. Lewandowski, P. Slugocki and A. Wisniewski. *Gaz. Cukr.*, 1987, **95**, 20 *(Polish).*

The plough in LWA centrifugals does not come close enough to the wall of the basket to scrape off the adhering 0.8 - 1.5 cm layer of sugar, while spraying with hot water to dissolve the sugar which is then recycled to process has a negative effect on technology and energy consumption. Application of 0.9 m³ compressed air at 0.55 - 0.65 MPa every cycle has been found to have a number of advantages. At Chelmza it reduced by 14.7% the number of *A*-massecuite cycles as well as electrical and thermal energy consumption and unknown losses. The compressed air may be applied through a duct bored in the shaft of the plough or via additional piping attached to the plough.

The effect of an electric field on the pH of a juice-cossettes mixture

I. M. Katrokha, V. A. Zaets and M. P. Kupchik. *Elektron. Obrab. Mater.*, 1986, (5), 70 - 71; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (11), Abs. 11 R497.

An experimental investigation is reported on the effect of an electric field on the pH of a juice-cossettes mixture in a laboratory-scale horizontal electric diffuser divided into eight working and two electrode chambers by close-weave canvas. Data were obtained on the change in pH of reducing and colloidal matter as well as on the raw juice purity in each working chamber as a function of voltage, temperature and the distance between the electrodes.

Vapour compression in the sugar factory

A. Laudanski. *Gaz. Cukr.*, 1987, **95**, 25 - 29 *(Polish).*

Circumstances are considered under which compression of 1st effect and pan vapours is of advantage in regard to reduction in energy consumption, and the advantages of mechanical over thermal compression are indicated. Data are given for seven types of compressor; while the screw-type compressor has a number of merits, it also has some disadvantages, while the flow-through type is of benefit at low and medium pressures and for large outputs. The effect on evaporation and juice parameters of compressing up to 50% 1st effect vapour (on beet) is demonstrated.

The mechanical properties of sugar beets - comparative tests on general beet slicing operations

M. Bzowska-Bakalarz. *Gaz. Cukr.*, 1987, **95**, 29 - 31 *(Polish).*

A prototype test stand is described which incorporated a cutter and tensometric sensors linked to an oscillograph. The system was used to investigate the slicing properties of four beet varieties; results are tabulated and discussed.

Treatment of sugar factory flume water with organic flocculants of Polish manufacture - laboratory tests

B. Polec and T. Wolski. *Gaz. Cukr.*, 1987, **95**, 43 - 46 *(Polish).*

Results of tests on Polish flocculants used to treat flume water showed that non-ionic Rokrysol WF-1 and cationic Instar K-4 caused considerable accel-

eration in the settling rate by comparison with unaided settling and increased the amount of settled suspension and of COD removed, but gave generally lower settling rates than Allied Colloids products at the same dosage.

Current problems concerning treatment of beet samples at reception

L. Rigo. *Le Betteravier*, 1987, **21**, (220), 11 *(French)*.

After beet samples have been washed and stones and dirt removed at reception centres in Belgium, they are subjected to supplementary topping where (i) this operation has not been carried out or (ii) where it has been done so but inadequately; in (i) the cut is made at the base of the crown where leaf buds form, whereas in (ii) the cut skirts the crown to give a truncated conical sample. However, the tendency has been to regard all beets that have not been satisfactorily topped as belonging to category (i); the processors argue that there is insufficient time to apply the other method and in any case look on beet crowns as a hindrance to factory operations. The author discusses various aspects of the topic, including an attempt to answer the questions as to what is the crown and what is its processing quality, and complains that the grower loses where supplementary topping is carried out (giving a lower quantity of beets for which payment is made and a corresponding reduction in the amount of pulp) or where the beets are passed to processing as is (in which case the measured pol content in the whole beet sample including crown will be lower and the price paid per tonne reduced). A call is made for proper implementation of the official rules governing beet sample treatment.

A viscosity equation for 1st and 2nd massecuites

K. Wagnerowski. *Gaz. Cukr.*, 1987, **95**, 49 - 53 *(Polish)*.

While earlier work by Silina defined low-grade massecuite viscosity in terms of crystal content, and Wagnerowski demonstrated a relationship between it and both Brix and temperature, on the basis of which equations have been derived, there has been need for comparable formulation relating to 1st and 2nd massecuites. An empirical equation is developed which is based on the fact that, at identical Brix, temperature and crystal contents, the ratio between the viscosities of a 1st or 2nd massecuite and a low-grade massecuite is defined by the viscosity ratio between the corresponding mother liquors; the method is valid for purities up to 95 and a temperature in the range 70 - 80°C. Similarly, an equation is developed for Brix calculation, and for calculation of massecuite viscosity as a function of mother liquor viscosity and crystal content at purities >80 and crystal contents >20%. Worked examples are presented.

The optimum temperature and duration of 2nd carbonatation

K. P. Zakharov *et al. Gaz. Cukr.*, 1987, **95**, 53 - 56 *(Polish)*.

See *I.S.J.*, 1987, **89**, 19A.

A combined sugar dryer-cooler. Operational tests on an industrial prototype

R. Glaser, Z. Gawrzynski, J. Blacha-Jurkiewicz, M. Styczynska and J. Stanislawski. *Gaz. Cukr.*, 1987, **95**, 56 - 62 *(Polish)*.

Moist sugar from the centrifugals at Strzelin sugar factory was conveyed to the top of a tower housing a series of turntables rotating at 40 rpm, one above the other; the sugar fell from the end of a belt conveyor and passed down the tower, being thrown by the turntables and finally arriving at an inclined screen surface through which up-currents of warm air were blown to create a fluidized bed. After passage through the screen onto a lower horizontal screen, the sugar (still in a fluidized state) spilled over into a lateral inclined chute and thence into a fluidized bed cooler from which it was discharged via a chute to a bucket conveyor transporting it to storage. At an average throughput of 19.3 (11 - 28.5) tonnes/hr, the moisture content was reduced from 0.283% (0.074 - 0.570%) to 0.030% (0.012 - 0.066%) in the drying stage and then cooled from an average 62.7°C (53.9 - 75°C) to 38°C (33.9 - 49°C) in the cooling stage (although the average moisture content rose in this stage to 0.0398% (0.021 - 0.064%). Technical data for the system are compared with those of two other Polish fluidized bed systems.

Ion exchange properties of the cell wall substance of sugar beet

R. Tarrach. *Thesis Dr. der Naturwissenschaften* (Braunschweig Tech. Univ.), 1985, 97 pp.; through *S.I.A.*, 1987, **49**, Abs. 87-603.

The effects of salts as pressing aids for beet pulp have been tested by other workers, but little has been known up to now about the mechanism of the effect, which depends on cation exchange. Studies on the ion exchange properties of beet tissue are reported. This tissue was isolated in the form of marc and was analysed for inorganic anions (phosphate, sulphate and chloride) and cations (K^+, Na^{++}, Mg^{++}, Ca^{++}, Al^{+++} and Fe^{+++}), pectin, degree of esterification of the pectin, and crude protein. Measurements of the ion exchange capacity for Ca^{++}, Al^{+++} and Fe^{+++}) showed this to be about 1 meq/g both for beet marc and for pulp, confirming that only the cell wall material is responsible for ion exchange. Pulp had a higher affinity for Ca^{++} ions than did beet marc; complete loading occurred at a salt concentration of 0.01 eq/litre, as in practice when Ca^{++} salts are used as pressing aids. The degree of exchange attainable was influenced by pH in the strongly acid and strongly alkaline ranges; uptake of Ca^{++} was lower under acid than under alkaline conditions. Tests at different contact times showed that ion exchange was rapid. Pulp was completely loaded after 0.5 hr contact even at low Ca^{++} concentrations. Contact time affected the degree of exchange attainable only with beet marc at low solution concentrations and

very long contact times. Temperature had an influence only if high temperatures and long contact times led to degradation of the material and hence lower capacity. Condensate used as diffusion water may contain NH_4^+ ions; the beet tissue had less affinity for NH_4^+ than for Ca^{++} ions. Ca^{++} uptake was affected only if NH_4^+ was present in excess or was added afterwards. The anions in the Ca^{++} salts had no effect on the degree of exchange. Addition of acid did not lead to better pressability of pulp than did "'neutral loading", in contrast to results found by Shore *et al.*[1]. The dry solids content of pressed pulp could be increased even more by adding salts of trivalent cations (Al^{+++} or Fe^{+++}) than by Ca^{++} salts. If deteriorated beet tissue was treated with Ca^{++} salts, the pressability of the pulp was improved if the deterioration was due to frost damage or microbial infection during diffusion, but was adversely affected if there had been excessive scalding or acidification.

Sugar losses during storage of badly damaged sugar beet

N. Lambrev. *Khranitelnoprom. Nauka*, 1986, **2**, (6), 100 - 104; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (12), Abs. 12 R428.

Experiments conducted with and without forced ventilation showed that the mean daily losses of sugar rose markedly when 6% of the beets in the pile were badly damaged, particularly where no forced ventilation was used. A correlation was found between daily losses and the percentage of badly damaged beets.

Efficient use of energy in the sugar industry

I. Friedemann. *Lebensmittelind.*, 1987, **34**, 76 - 79 *(German)*.

The current level of energy consumption in the East German sugar industry and possible means of reducing it while increasing the daily slice are discussed. Besides measures involving more rational use of existing equipment and smoother operation of plant, newer ideas that are gaining acceptance are also discussed, including the use of heat pumps, vapour compression and utilization of boiler flue gases, particularly in pulp drying. Desulphurization of boiler flue gases is also briefly examined.

Possibilities of raising the quality of starting products in 1st massecuite boiling

A. I. Gromkovskii, V. A. Golybin and Yu. I. Zelepukin. *Rpt. Voronezh. Tekhnol. Inst.*, 1987, 6 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (13), Abs. 13 R457.

With the aim of obtaining white sugar of a quality conforming to the official colour standard (in the USSR), a study was made of the possibility of raising the quality of products used for 1st massecuite boiling, e.g. by supplementary affination of *C*-sugar with syrup or sulphitation juice, recycling the affination syrup to supplementary liming and 2nd carbonatation and use of high-Brix remelt liquor in the initial boiling stages.

Improvement in processes and equipment for juice purification and filtration

Yu. D. Golovnyak *et al. Sakhar. Prom.*, 1987, (6), 13 - 17 *(Russian)*.

The current status and trends in development of processes and equipment used in the Soviet Union for raw juice purification and carbonatation juice filtration are discussed and the equipment described, and details are given of variants of a scheme for fractional cold and hot liming that allow for differences in beet quality and for fluctuations in basic processing parameters.

Adsorption and ion exchange treatment of products of sugar manufacture

Yu. D. Golovnyak *et al. Sakhar. Prom.*, 1987, (6), 18 - 21 *(Russian)*.

A survey is presented of experimental work conducted on the use of active carbon and ion exchange resins and on pre-filtration using candle filters for the treatment of sugar factory and refinery products in the Soviet Union.

The effect of temperature on sucrose degradation and crystallization rate

Z. I. Beregovaya and Yu. D. Kot. *Sakhar. Prom.*, 1987, (6), 26 - 29 *(Russian)*.

Investigations into the effect of massecuite boiling temperature in the range 65 - 80°C at 5°C intervals showed that the degree of degradation rose and the amount of colouring matter increased with rise in temperature, the effects being greater at a lower purity (66.4) than at a higher (77.8); the effective boiling time was shorter at 60 - 65°C than at 72 - 76°C, the amount of massecuite boiled was greater, the sugar losses about half and the specific productivity of the heat exchange surface greater, while crystallization properties were improved and the possibility presented of using low-heat steam for 2nd and low-grade massecuite boiling.

Automation of processes in beet sugar manufacture

K. F. Gerbut, B. A. Eremenko and B. G. Susorov. *Sakhar. Prom.*, 1987, (6), 33 - 35 *(Russian)*.

A survey is presented of the development of automatic controls in Soviet sugar factories and of the current status of automation and of future prospects.

Removal of lime salts by ion exchange to create scale-free conditions in an evaporator

V. A. Tikhomirov, M. I. Egorova, V. V. Spichak and Yu. M. Maletin. *Sakhar. Prom.*, 1987, (6), 37 - 39 *(Russian)*.

KU-2-8 cation exchange resin in Na^+ form was used to delime 2nd carbonatation juice in trials at a Soviet factory; up to 97 - 99% deliming was achieved, which would be sufficient to prevent scale formation in evaporation.

1 *I.S.J.*, 1983, **85**, 6 - 10, 43 - 48, 76 - 81.

Starch-based sweeteners

Separation of fructose from carbohydrate mixtures by batch and semi-continuous chromatographic operation

P. E. Barker and S. Thawait. *Chem. Eng. Res. & Dev.*, 1986, **64**, 302 - 307; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (7), Abs. 7 R532.

For chromatographic separation of fructose from a mixture of carbohydrates, 10 stainless steel columns 108 mm in diameter and 750 mm tall were linked to form a single battery; they were filled with Zerolite SRC 14 resin in Ca^{++} form of 150 - 300 mm particle size. Experiments on separation of the carbohydrates and of the fructose were conducted under semi-continuous and batch conditions. The effect of solution volume and concentration (20 - 60%) on performance was studied. The separation efficiency fell with rise in temperature above 60°C. It was found that use of the semi-continuous system doubled column throughput by comparison with the batch method.

Viscosity equation for pure glucose solutions

V. S. Shterman, M. S. Zhigalov and I. N. Nesterova. *Sakhar. Prom.*, 1987, (5), 49 - 52 *(Russian)*.

An equation is presented for calculation of log dynamic viscosity of glucose solutions as a function of temperature and concentration over the temperature range 20 - 80°C and Brix range 0 - 80°, both in 10 unit intervals.

Adsorption of monosaccharide degradation products by granular active carbons

L. I. Tanashchuk, N. A. Arkhipovich and T. V. Gutnichenko. *Sakhar. Prom.*, 1987, (5), 52 - 54 *(Russian)*.

In a process developed by the Kiev Technological Institute of the Food Industry for glucose and fructose manufacture, most of the colouring matter formed as acid degradation products during sucrose hydrolysis enters the glucose solution. While powdered active carbon has a number of drawbacks as adsorbent, investigations with various grades of granular carbon showed that up to 92% of the degradation products could be removed by a 3-stage process at an optimum load for one particular grade of 1.2 ml/g/min.

Starch sugar – competition for sweetener market in Europe

T. Cronin. *Paper presented at Int. Sugar Tech. Conf.* (Irish Sugar plc), 1987, 50 pp.

Various aspects of starch-based sugar production, consumption and marketing in the EEC, Canada, Japan and the USA are discussed and details given of the basic technology; mention is made of the fact that because of changes in the EEC policy, processors are using wheat as raw material in preference to maize, although the costs of production are much greater than those of conventional wet milling of maize.

Crystar crystalline fructose

W. S. Martin. *Sugar Bull.*, 1987, **65**, (18), 6 - 10.

A representative of A. E. Staley Mfg. Co. describes the properties and possible applications of Crystar crystalline fructose of 99.5 purity which, as a 1:1 blend with sucrose, is sweeter than sucrose or fructose alone.

Experimental study of a simulated counter-current adsorption system. III. Sorbex operation

C. B. Ching, D. M. Ruthven and K. Hidajat. *Chem. Eng. Sci.*, 1985, **40**, 1411 - 1417; through *S.I.A.*, 1987, **49**, Abs. 87-980.

Further tests were carried out on separation of fructose and glucose by a system comprising 12 identical beds (100 cm long and 5.1 cm in diameter) packed with Duolite cationic resin in Ca^{++} form. In previous tests the fructose-rich product had high purity but was much more dilute than the feed solution. To overcome this disadvantage, the system was operated as a Sorbex system (known as Sarex in this application), in which the counter-current bed was divided into four sections and desorption carried out by adjusting the flow rates in each section. Glucose and fructose concentration profiles were calculated from a detailed numerical simulation and from a simplified equivalent steady-state countercurrent model; since the two methods gave similar results, the simpler model could be used for design calculations in order to save computer time. System operation was studied experimentally under four stated sets of conditions. Glucose and fructose purities and recoveries in each case are tabulated and compared with calculated values. Under suitable conditions, 90 - 95% recovery and product concentrations of about 4% w/v at 93 - 94 purity could be obtained (comparable to those in a commercial Sarex system), demonstrating the practical feasibility of operation in this way.

An improved adsorption process for the production of high-fructose syrup

C. B. Ching, C. Ho and D. M. Ruthven. *AIChE J.*, 1986, **32**, 1876 - 1880; through *S.I.A.*, 1987, **49**, Abs. 87-981.

By applying a temperature profile to a counter-current adsorption separation system (see preceding abstract), the concentration of the extract product may be increased relative to the maximum concentration attainable under isothermal conditions. To achieve the required temperature profile in a simulated counter-current system, it is necessary to heat and cool the columns in sequence as the feed and product draw-off points are switched through the bed. The practical feasibility of operating the system in this way for the separation of glucose-fructose mixtures was demonstrated. By maintaining a temperature difference of 30 - 35°C across the bed, an extract product containing 28% fructose and only about 1% glucose was obtained, at steady state, from a feed containing 25% by weight of each sugar.

Laboratory studies

Improvements in the design of a sugar colorimeter

J. T. Rundell. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 21 pp.

The fundamentals of colour measurement are briefly recounted and a review is presented of existing instruments, including visual ones, spectrophotometers and special absorptiometers such as the Tate & Lyle instrument[1] which has undergone three major modifications besides a number of minor ones. Shortcomings encountered with the absorptiometer and how they have been overcome are discussed. Probably the largest single source of error is associated with the interference filter used to obtain the band of light used for the measurement. Wavelength is the most critical parameter, while turbidity causes error because of the large angle of acceptance of photo-detectors; the effective wavelength of the absorptiometer is trimmed by tilting the filter, which has also brought a number of other benefits, while use of a silicon photocell in place of a vacuum photocell has reduced the acceptance angle and hence the amount of scattered light, provided a lower impedance and enabled absorbance to be read directly. Other beneficial changes mentioned include the use of a logarithmic detector and of a quartz-iodine lamp as light source; alternative filters can also be used.

Large colorant and polysaccharide molecules in raw cane sugars

M. A. Godshall, M. A. Clarke, C. D. Dooley and E. J. Roberts. *Paper presented to 46th Ann. Meeting Sugar Ind. Tech.*, 1987, 19 pp.

Comparison of high molecular weight material in washed and unwashed raw sugars revealed significant proportions of the material (colorants and polysaccharides) inside the sugar crystal. While only some 30% of the colorant remained after affination, an average 66% of this residual material had a M.W. >20,000 while an average 70% of the total polysaccharide in raw sugar remained after affination. As much as 50% of the total colorant/turbidity is not measured by the standard ICUMSA procedure involving use of Millipore filtration, so that the method is not always a good indicator of raw sugar refining quality. Visual examination of the residue on a prefilter gave an indication of the amount of particular trash present in a sugar, some of which can plug filters in process. Comparison of the colour removed by a 8 μm filter with that removed by a 4.5 μm filter demonstrated the very high M.W. colorant/turbidity present. Gel permeation chromatography using two detectors provided evidence that the high M.W. material passes through process into refined sugar and showed the differences in the M.W. profiles of sugar colorant.

Organochlorine pesticide residues by cyclic steam distillation

A. G. Ober, I. Santa Maria and J. D. Carmi. *Bull. Environ. Contam. Toxicol.*, 1987, **38**, (3), 404 - 408; through *Anal. Abs.*, 1987, **49**, Abs. 6G20.

Gamma-HCH, heptachlor, aldrin, heptachlor epoxide and dieldrin were extracted from slices of sugar beet with hexane after cyclic steam distillation. The extracts were analysed by GC on a column (3.5 m × 2.0 mm) packed with 1.5% of OV-17 and 1.95% of QF-1 on Chromosorb W HP (100 - 200 mesh) with 19:1 Ar:CH_4 as carrier gas (35 ml/min) and electron capture detection. Recoveries, except for heptachlor, were from 80 to 96% and the coefficient of variation was <4%.

Chromatographic behaviour of palmitic acid sucrose esters on silica gel thin layers

Z. Solijic and I. Eskinja. *J. Serb. Chem. Soc.*, 1987, **52**, 105 - 110.

Tests were conducted on separation of sucrose palmitates by TLC on silica gel G and H using various solvent systems. Results showed that on silica gel G mono-, di- and tri-palmitates separated into as many as 7 higher isomers, but sucrose-palmitate mixtures generally neither separated nor moved from the start. By contrast, separation of sucrose and palmitate was achieved on silica gel H; since only four spots usually formed, it was concluded that the mixture separated into its original components (sucrose and sucrose mono-, di- and tri-palmitate) rather than into isomers. The most suitable of a number of spray reagents mentioned in the literature were 2% anthrone in concentrated sulphuric acid and 1 g of urea in 48 cm^3 of *n*-butanol and 4.5 cm^3 of orthophosphoric acid; both reagents gave clear, distinct spots.

A comparison of sample preparation procedures for high-performance liquid chromatographic determination of sucrose in molasses

A. W. Wight, J. M. Datel and W. H. van der Walt. *Food Chem.*, 1986, **22**, (1), 27 - 35; through *S.I.A.*, 1987, **49**, Abs. 87-702.

Sucrose was determined in 12 samples of molasses (six cane and six beet) by two HPLC methods. These differed only in sample preparation: method 1 included clarification with neutral lead acetate solution, deionization by mixed-bed resin and filtration, while method 2 used filtration only. Small but significant differences between results by the two methods and method × sample interactions were observed. Method 1 gave the higher value for 9 samples. The causes of the differences have not yet been established.

High-performance liquid chromatography of sugars

A. Meunier, M. Claude and R. Rosset. *Analysis*, 1986, **14**, (8), 363 - 377; through *Anal. Abs.*, 1987, **49**, Abs. 7D141.

A review is presented (with 34 references) of the literature on the title subject.

1 Hill & Rundell: *Analyst*, 1965, **90**, 681 - 691.

By-products

Selection of yeast strains for alcoholic fermentation of molasses media enriched with vinasse non-sugars

M. de Miniac. *Ind. Alim. Agric.*, 1987, **104**, 425 - 439 *(French)*.

Experimental investigations are reported which demonstrated how the osmotic pressure of non-sugars in vinasse adversely affects fermentation by reducing the rate of yeast growth and ethanol productivity, upsetting the fermentation balance through glycerol biosynthesis and causing sufficient variation in the composition of higher alcohols as to render their extraction sometimes more difficult. Since recycling of vinasse non-sugars is a suitable method of reducing the energy consumption in vinasse evaporation, a number of yeast strains were tested for their susceptibility and possible resistance to non-sugars. By comparison with certain strains of *Saccharomyces cerevisiae, S. bayanus, Kluyveromyces fragilis, Candida pseudotropicalis* and *Schizosaccharomyces pombe* (most of which, especially those obtained from the wine industry, proved to be susceptible to the effect of non-sugars) and strains of baker's yeast (which gave an average alcohol production of only 3.5°GL), a number of natural mutants isolated from beet molasses fermentation gave an average of 6.07°GL after 24 hours' fermentation of a medium containing 20% non-sugars. Further tests with 14 of the best performing yeasts demonstrated the effect of strain on the quality of alcohol produced, so that selection should take account of whether rectified or fuel alcohol is required.

Determination of the heat of formation of yeasts

H. Mittrücker. *Lebensmittelind.*, 1987, **34**, 119 - 121 *(German)*.

It has been found that enzymatic reactions differ from other reactions in that there is a distinct optimum temperature, any rise above this being accompanied by a fall in yeast yield and quality. Hence there is need for maintenance of the optimum level by an adequate cooling system. Since yeast formation is an exothermic process and the reaction enthalpy constitutes 40 - 70% of the total amount of heat that must be removed, it is important to make an accurate measurement of it so that an adequate cooling system can be designed. Laboratory and full-scale experiments were conducted on yeast cultivation on a vinasse substrate; these showed the increasing difficulty of fermenter cooling with rise in unit volumetric capacity, since the cooling jacket surface area increases at a much lower rate with the diameter of a cylindrical vessel than the volumetric capacity. The heat of reaction was found to be 25% greater than the value originally used to design the cooling system, but measurements of various heat parameters allowed modification of the system whereby the temperature was maintained at an optimum and both yield and quality of the end-product improved.

The effect of final molasses on rice polishing diets for fattening chickens

M. Sanz. *Cuban J. Agric. Sci.*, 1987, **21**, 75 - 80.

While replacement of up to 30% of the maize with rice polishings in poultry feed improved performance in trials with chicks of both sexes, final molasses had a laxative effect and should not be added with more than 10% rice polishings substitution.

Automated analysis of unfermented sugars in molasses worts from alcohol manufacture

V. M. Zozulya *et al. Sb. Nauch. Tr. Vses. Proekt.-Konstrukt. i NII Avtomatiz. Pishch. Prom.*, 1986, (25), 7 - 13; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (11), Abs. R429.

The basic technical features are presented of a newly developed rapid analyser for unfermented sugars and details are given of its metrology which allows for the complex carbohydrate composition of molasses worts and for the presence of colouring matter. Comparative assessment is made of the analyses of industrial worts using a laboratory method and the analyser. The advantages of using the analyser together with its built-in microcomputer at alcohol distilleries and biochemical plants treating molasses are noted.

Fermentation pattern of *Zymomonas mobilis* strains on different substrates – a comparative study

P. Gunasekaran, T. Karunakaran and M. Kasthuribai. *J. Biosciences*, 1986, **10**, (2), 181 - 186; through *S.I.A.*, 1987, **49**, Abs. 87-749.

Fermentation of sugars to ethanol by four strains of *Z. mobilis* was studied. Optimum pH was 7 (rather than 4 - 6) for all strains; optimum sugars concentration was 15% w/v for two strains and 20% w/v for the other two. Ethanol yields and concentrations obtained were generally greater in a cane juice medium (18% initial sugars w/v) than in a synthetic medium (20% sucrose w/v); yields from cane juice were about 89% of theoretical with three strains and 79% with the fourth after 48 - 66 hr. On a molasses medium (10% sugars w/v) ethanol yields were poor (31 - 51%); with increasing sugars concentration from 3 to >15% w/v the yield decreased.

Effects of volatile organic acids in molasses on alcoholic fermentation and yeast biomass production

J. Langpaulova. *Kvasny Prum.*, 1986, **32**, (5), 103 - 106; through *S.I.A.*, 1987, **49**, Abs. 87-752.

The effects of the presence of formic, acetic or butyric acid in beet molasses were tested. For *Saccharomyces cerevisiae* strain LK 01/1 the maximum concentrations which did not affect the yields of alcohol and biomass were (in g/100 ml): formic acid, 0.08; acetic acid, 0.25; butyric acid, 0.03. Strain 03/26 was more sensitive to these acids, the corresponding maximum limits being 0.03, 0.15 and 0.02 g/100 ml, respectively. Analyses of molasses produced in

Czechoslovakia showed that in some cases the formic acid concentrations were above these limits and could therefore inhibit fermentation.

Hydrolysis of sugar cane bagasse with hydrochloric acid, promoted by metallic cations

U. Schuchardt and H. C. Duarte. *J. Chem. Technol. Biotechnol.*, 1986, **36**, (7), 329 - 335; through *S.I.A.*, 1987, **49**, Abs. 87-790.

Lithium chloride + commercial-grade (37%) HCl was very effective in the hydrolysis of bagasse which had been prehydrolysed with 31% HCl. After 20 minutes at 50°C the yield of reducing sugars was 67%, making post-hydrolysis unnecessary. If the reaction was continued, the sugars started to re-oligomerize and decompose. Zinc chloride was a milder promoter of acid hydrolysis; even after reaction for 30 min at 50°C, post-hydrolysis was necessary, but it did not decompose the reducing sugars, so final yields were high (up to 65%). Ferric chloride was less effective in hydrolysis of cellulose but was a good promoter of hydrolysis of sugar oligomers.

Optimization of the extraction conditions of cane wax from filter press mud

A. M. Azzam and M. Z. Ebrahim. *Fette Seifen Anstrichmittel*, 1986, **88**, (4), 151 - 154; through *S.I.A.*, 1987, **49**, Abs. 87-796.

Cane wax was extracted from filter cake by Shell X-2 solvent under the following ranges of conditions: 25 - 80°C; weight ratio of dried mud to solvent, 1:2 - 1:8; extraction time 1 - 5 hr; particle size of dried mud 360 - 2600 μm. Conditions which gave maximum extraction of wax were: 75°C, solvent ratio 1:4, time 4 hr and mud particles <900 μm.

Continuous cultivation of baker's yeasts

J. Pietkiewicz and W. Lesniak. *Zesz. Probl. Post. Nauk Rol.*, 1986, (297), 307 - 320; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (12), Abs. 12 R344.

Results are given of studies on single- and multi-stage continuous cultivation of baker's yeasts with automatic dosing of the molasses medium as a function of the concentration of oxygen dissolved in the wort. The quality of the yeast in all the systems studied was low but rose after ripening. The quality of the yeast obtained in single-stage cultivation was improved by adding a second fermenter, of low volumetric capacity; the first stage of the resultant two-stage scheme was used for multiplication and growth of the yeast cells at a high yield, while ripening of the yeast took place in the second vessel.

Control of the concentration of carbon sources in baker's yeast cultivation based on the dissolved oxygen status

T. Miskiewicz. *Zesz. Probl. Post. Nauk Rol.*, 1986, (297), 299 - 305; through *Ref. Zhurn. AN SSSR (Khim.)*, 1987, (12), Abs. 12 R347.

A theoretical investigation was conducted into the relationship between the concentrations of carbon source and dissolved oxygen in the feed medium and the growth of baker's yeast. A mathematical model was developed which showed that the maximum yeast yield was obtained by maintaining a constant oxygen content in the medium and controlling the carbon source flow into the fermenter. Laboratory studies were carried out on the yield of *Saccharomyces cerevisiae* I-Sc/191 cultured on a medium containing 0.4, 0.8, 1.2, 1.6, 2 and 3 moles/litre of carbon source at 30°C and pH 5 with maintenance of oxygen at 45% saturation of the medium with it; beet molasses containing 300 g/litre reducing matter (on glucose and corresponding nutrients) was used as medium, the oxygen content in which was maintained constant as a basis for carbon source control. Increase in the carbon source concentration from 0.4 to 2.0 moles/litre accelerated yeast growth from 0.08 to 0.19/hr, while an excess of carbon source concentration reduced the growth rate to 0.18/hr. Maximum yeast yield of 100.4 g/mole carbon source was obtained at a concentration of the latter of 0.4 moles/litre.

Influence of molasses on degradation of biologically active atrazine residues

M. Todorovic, D. Kalinovic, J. Vrbanic and B. Konstantinovic. *Mikrobiologija*, 1985, **22**, (2), 113 - 124; through *S.I.A.*, 1987, **49**, Abs. 87-1053.

For weed control in irrigation canals, herbicides are often applied at high rates per unit area. Some of them, e.g. Atrazine S-50, decompose slowly and, if they enter the soil, may have a toxic effect on crops. The possibility of accelerating the decomposition of atrazine residues by application of molasses was investigated. The effects of the following treatments of soil on the populations of certain groups of mico-organisms were compared: (a) covering with 10 litres of molasses/m^2, (b) treatment with 20 kg atrazine/ha, (c) both molasses and atrazine, and (d) neither, to serve as control. Treatment (a) increased the population of micro-organisms which have a beneficial effect on plant growth; treatment (b) had an adverse effect which could be partly overcome by inclusion of molasses as in treatment (c). Bioassay using oats plants confirmed the favourable effect of molasses.

Ethanol production from sucrose by immobilized *Zymomonas mobilis* cells in polyurethane foam

G. Amin, H. W. Doelle and P. F. Greenfield. *Biotechnol. Letters*, 1987, **9**, (3), 225 - 228; through *S.I.A.*, 1987, **49**, Abs. 87-1059.

The possibility of using polyurethane foam as a support for immobilizing *Z. mobilis* cells for conversion of sucrose to ethanol was investigated. Results achieved demonstrated the good performance of the immobilized organism: 90% conversion, productivity of 20 g ethanol/litre reactor vol/hr, and a final ethanol concentration of 6.3% by vol. at a dilution rate of 0.4/hr.

Patents

UNITED KINGDOM

Sucrose fatty acid polyester

Dai-Ichi Kogyo Seiyaku Co. Ltd., of Kyoto, Japan. **2,161,806.** June 28, 1985; January 22, 1986.

Sucrose fatty acid polyesters are produced by heating, at 120 - 180°C (90 - 110°C) (140 - 160°C) under vacuum with stirring, a molten mixture of sucrose, a fatty acid lower alkyl ester at not less than 4 (4 - 15) (8 - 15) moles per mole of sucrose, a basic transesterification catalyst and a fatty acid alkali metal soap at 3 - 15% (5 - 10%) by weight of sucrose which may be partially or entirely replaced with a sucrose fatty acid ester at 1 - 10% (3 - 8%) by weight of the fatty acid lower alkyl ester. The polyesters are purified by acidifying to pH <6 and molecular distillation from which they are recovered as the residue.

Sugar esters manufacture

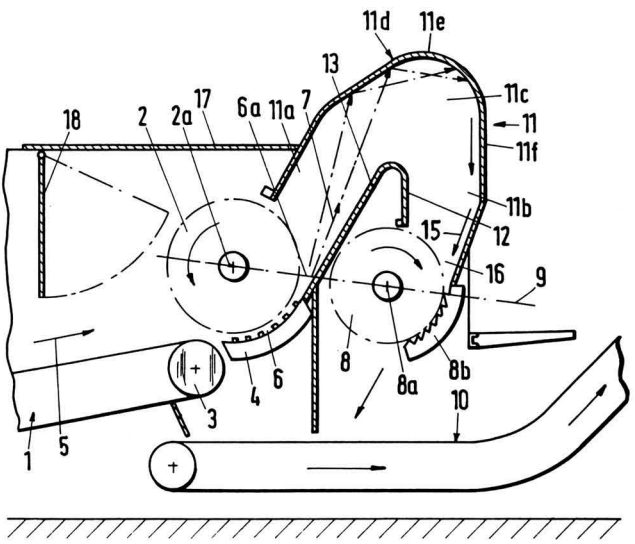
State of Nebraska Dept. of Economic Development, of Lincoln, NE, USA. **2,162,844.** July 31, 1985; February 12, 1986.

One or more organic acid chlorides having at least 2 (2 - 22) carbon atoms (e.g. acetyl chloride or palmitoyl chloride) is added to a mixture of sugar (sucrose, fructose, glucose, etc.) and a substantially anhydrous liquid solvent (acetic, propionic or butyric acid) (preheated to at least 90°C) in an amount of at least 0.1 mole of chloride per mole of sugar, and the mixture agitated in the presence of a catalyst (e.g. potassium palmitate, carbonate or chromate, or calcium propionate) to cause esterification at 30 - 55°C between the sugar and organic chloride and yield a product of superior emulsifying properties for use in foodstuffs and pharmaceuticals.

Cane preparation

Braunschweigische Maschinenbauanstalt, of Braunschweig, Germany. **2,184,643.** October 29, 1986; July 1, 1987.

Apparatus for cane preparation prior to milling or diffusion includes an adjustable-speed conveyor 1 which feeds the cane to a cutter 2 for pre-comminution. The cane is drawn into gap 6 between the cutter and a washboard 4 and is ejected in the direction of arrow 7 for further comminution by a shredder 8 located slightly below and immediately adjoining cutter 2; the axes of rotation 2a, 8a of the cutter and shredder are in a plane 9 which is horizontal or is inclined to the horizontal at an angle between 0° and 45°. An inverted U-shaped casing 11, with one portion 11a extending over gap 6a and the other portion 11b constituting a feed shaft for shredder 8, is closed at the top and has an impact and deflection plate 11d from which the cane rebounds at a greatly reduced velocity onto side wall 11f and passes to inlet gap 16 of the shredder in the form of an even bed.



Abstracts of the following applications for UK patents have appeared in previous issues of this Journal, and the applications have been granted subsequent to preparation of our abstracts. The *ISJ* reference to our abstract and the date when the patent was granted are listed below.

2,123,671	*I.S.J.*, 1986, **88**, 44A.	April 16, 1986
2,145,007	*I.S.J.*, 1986, **88**, 109A.	January 28, 1987
2,145,094	*I.S.J.*, 1986, **88**, 110A.	July 8, 1987
2,145,815	*I.S.J.*, 1986, **88**, 121A.	July 29, 1987
2,147,217	*I.S.J.*, 1986, **88**, 121A.	March 4, 1987
2,148,298	*I.S.J.*, 1986, **88**, 121A.	November 26, 1986
2,152,057	*I.S.J.*, 1987, **89**, 22A.	January 7, 1987
2,155,604	*I.S.J.*, 1987, **89**, 22A.	September 30, 1987
2,155,605	*I.S.J.*, 1987, **89**, 22A.	September 23, 1987
2,155,934	*I.S.J.*, 1987, **89**, 22A.	July 1, 1987

In addition, the following application was withdrawn subsequent to preparation of our abstract:

2,003,741	*I.S.J.*, 1983, **85**, 61.

Table V. Organic acids in cane juice and molasses — average of two determinations

Acid	Cane juice		Guadeloupe molasses		Louisiana molasses	
	mg/l	% D.W.	mg/g F.W.	% D. W.	mg/g F.W.	% D.W.
Oxalic	42.5	0.0250	2.27	0.30	3.73	0.503
Glycolic	62.1	0.0370	2.32	0.31	NM	NM
Malic	103	0.0600	2.64	0.36	NM	NM
Shikimic	15.7	0.0090	0.52	0.070	0.47	0.060
Lactic	ND	ND	ND	ND	ND	ND
Citric	97.0	0.0570	3.01	0.40	NM	NM
Cis-Aconitic	12.5	0.0070	3.64	0.49	2.97	0.400
Fumaric	3.0	0.0020	0.31	0.04	0.29	0.40
Trans-Aconitic	210	0.1200	12.8	1.74	20.4	2.75

D.W. - dry weight
mg/g F.W. = milligrams per gram of fresh weight
ND = not detectable
NM = not measureable

aconitate in plants[22-29]; nevertheless, it seems to be normal component of some species, even if its accumulation mechanism is not well known.

Interest in this acid stems from its suspected role in grass tetany[22]. Previous workers have found that *trans*-aconitate was the predominant organic acid in grasses and maize[22-25]. *Trans*-aconitate metabolism has been investigated[26-29] and an aconitate isomerase has been found in sugar cane leaves[27] and two forms of citrate dehydrase utilizing citrates as substrate for *trans*-aconitate synthesis in maize have been reported[28,29]. In the current study, occurrence of *cis*- and *trans*-aconitic acids in sugar cane products was observed with more important quantities of the latter. In terms of percentage on dry solids there were more organic acids in molasses than in cane juice (Table V), confirming the findings of Martin[5]. The data were generally lower than those of the literature[6,7,20,30] mainly based on Louisiana cane products. Even for the Louisiana molasses analysed, only the sum of *cis*- and *trans*-aconitic (3.15% D.W.) lies within the usual range of variation (3-6% D.W.) for Louisiana molasses[5,21,30]. Tropical molasses are known to contain much less aconitic acid than Louisiana molasses[5,6]. The difference was appreciable for *trans*-aconitic acid but slight for *cis*-aconitic acid, showing the influences of variety, growth conditions, and physiological age of plant on *trans*-aconitic metabolism, as suggested by previous workers[22,23,25,29].

Sugar cane juice and Guadeloupe molasses were fermented and then distilled, and the behaviour of the organic acids in the distillery waste water or vinasse was studied. The organic acids spectra in the vinasses was the same as in cane juice or molasses with lactic acid in addition (Table VI), showing that lactic acid was produced during rum fermentation. In all vinasses analysed, lactic acid was the major acid produced, and *cis*- and *trans*-isomers of aconitic acid were present. The *trans*-isomer amount was higher than that of the *cis*-isomer.

Table VI. Organic acids in vinasse (mg/litre) — average of two determinations

Acid	Cane juice vinasse	Molasses vinasse 1	Molasses vinasse 2	Molasses vinasse 3	Molasses vinasse 4
Oxalic	7.5	66	97.5	29	21
Glycolic	NM	1560	1900	930	1860
Malic	NM	NM	62.5	NM	NM
Shikimic	1	96	81	72.5	72.3
Lactic	1680	7240	6260	4460	3700
Citric	ND	570	2000	338	383
Cis-Aconitic	62.4	24	480	350	345
Fumaric	NM	NM	14	43	41
Trans-Aconitic	217	28	845	734	784

ND = not detectable
NM = not measureable

There were more organic acids in vinasse from molasses fermentation than in vinasse from cane juice fermentation, and important variations of organic acid concentrations were observed into the molasses vinasse group. Lactic acid values ranged from 3700 to 7240 mg/litre, *trans*-aconitate values ranged from 28 to 784 mg/litre, and no relationship was evident between the variations in amounts of different organic acids. No data are available in the literature on organic acids composition of ethanol fermentation by-products to establish a comparison, but it can be suggested that the variations observed were probably related to the raw material composition (cane juice, molasses), and to the micro-organisms (yeasts, bacteria) partricipating in the rum fermentation.

The anaerobic digestion process has been used to decrease the organic pollution of rum industry waste water or vinasse. Only *trans*-aconitic acid clearly remained in the digester effluents (Table VII), showing the efficiency of this process for elimination of organic acids

22 Stout *et al.: Agron. J.*, 1967, **59**, 21 - 24.
23 Clark: *Crop Science*, 1968, **8**, 165 - 167.
24 Molloy: *J. Sci. Food Agric.*, 1969, **20**, 238 - 241.
25 Clark: *Comm. Soil Sci. Plant Anal.*, 1976, **7**, 585 - 600.
26 MacLennan & Beevers: *Phytochem.*, 1964, **3**, 109 - 113.
27 Altekar *et al.: Indian J. Biochem.*, 1965, **2**, 132 - 133.
28 Brauner & Teel: *Plant Physiol.*, 1981, **68**, 1406 - 1408.
29 Idem: *ibid.*, 1982, **70**, 723 - 727.
30 Fort *et al.: Sugar*, 1952, **47**, (10), 33 - 35.

Table VII. Organic acids in digested vinasses (mg/litre) - average of two determinations

Acid	Digested molasses vinasse 1	Digested molasses vinasse 2	Digested cane juice vinasse
Oxalic	23	40	15.2
Glycolic	ND	ND	ND
Malic	ND	ND	ND
Shikimic	ND	ND	ND
Lactic	ND	ND	ND
Citric	ND	ND	ND
Cis-Aconitic	4.1	3.5	NM
Fumaric	2.0	NM	NM
Trans-Aconitic	75.5	59	13

ND = not detectable
NM = not measureable

pollution. The process also produces methane which can be recovered to decrease rum production costs. These are believed to be the first data on organic acid behaviour during the anaerobic digestion of ethanol fermentation waste water.

Conclusions

Organic acids were quantified in sugar cane and its industrial by-products (cane juice, molasses, vinasse, effluent from the vinasse anaerobic digester) by HPLC using a reverse phase C18 column. The method was rapid and reproducible. *Trans*-aconitic was the major acid in cane juice and in cane molasses. *Cis*-aconitic, glycolic, malic, shikimic, fumaric, citric and oxalic acids were also quanitfied in these samples. Lactic acid was the most important acid in vinasse from cane juice and molasses fermentation, showing that this acid was produced during rum manufacture. All the organic acids except *trans*-aconitic were eliminated from the vinasse by anaerobic digestion. The diversity of samples tested in the current study show that the HPLC method can be of great interest in work on cane processing (sugar manufacture, fermentation, refining, etc.)

Acknowledgment

We particularly wish to thank Dr. Margaret A. Clarke, Managing Director of Sugar Processing Research Inc., New Orleans, for giving us a sample of Louisiana molasses on which to perform our experiments.

Summary

The major organic acids in sugar cane and its industrial by-products were analysed by high performance liquid chromatography. *Trans*-aconitic acid was the most important in sugar cane juice and molasses. Lactic acid was the major acid in waste water or vinasse from cane juice or molasses rum fermentation. It is concluded that the HPLC method can be easily used to study sugar cane processing, from raw material to industrial final products or by-products.

ICUMSA News

Introduction

Now that the 19th Session Proceedings are available and the Referees and their Associates virtually in place, it is time to consider seriously the goals to be sought for the 20th Session in 1990. We have approximately two years before Referees will be completing their reports for our next meeting. It is therefore important that planning and discussion take place without further delay so that enough time remains for method development and collaborative testing.

Goals for the 20th Session

The most important goal, as I see it, is to have agreement on what methods are appropriate for the analysis of each of the products supervised by the General Referees. This is not to say that we have not always had such agreement, but because the differentiation between products was not as clear as it is now, it is appropriate to review these matters. In the past there may not have been sufficiient appreciation of the commodities traded and the realities of the market place. The new General Refereeships are intended to provide a proper forum for discussion of issues affecting the analysis of particular products. For example, those people and the countries engaged in the trading of white sugar should all enter into the discussions on methods affecting that product. In the first instance we will be attempting to put our house in order by bringing methods up to a high standard of method format with appropriate collaborative testing where that has not already been carried out. We will also look towards the future, asking ourselves about the direction the analysis of this product should take.

With the achievement of the above goal in respect of each of the products with which ICUMSA is concerned, we then have the basis for issuing a new methods book. I do not believe we should wait until all product methods have official recognition before publishing a new book of methods. This is always a lengthy and continuing process. Because new instrumental methods emerge all the time, any book of methods will have some things which are becoming out of data as soon as the book is issued. This is as it should be, because we are a dynamic organization which welcomes new developments as an opportunity to make improvements to existing methods. The question of how frequently we should issue a new methods book should be discussed. Also, the question of how the public can become informed of our methods without having to buy the book needs to

be considered.

The task of writing a history of our organization in time for our centenary is another goal to receive attention in the present Session. Because this project is still in the conceptual planning stage, those who wish to have an input should register their interest without delay.

Appointment of a Steering Committee

As foreshadowed, a Steering Committee has been appointed to oversee the allocation of the 19th Session Recommendations among the new subjects and to consider priorities in the light of the above goals and the resources available to do the work. Dr. A. Emmerich, Mr. J. Dutton and Dr. M. A. Clarke have agreed to serve on this committee, with the President as Chairman. Because it is too cumbersome to conduct an extended dialogue between the President and all National Committees, it is envisaged that the matters being considered by the Steering Committee will be given wide publicity and those people with an interest or point of view to express should contact the Steering Committee where due consideration can be given to the various opinions before decisions are taken.

In the case of the allocation of the 19th Session Recommendations, a Circular has already been sent out to the Chairmen of National Committees and Referees setting out the President's view on where each might be assigned. This view is to be considered a preliminary assessment and to provoke discussion. People who wish to contribute to this discussion are invited to write to me or to other members of the Steering Committee.

Working group on collaborative studies

In the previous issue of ICUMSA News, Dr. M. A. Clarke presented a report of the outcome of the IUPAC Workshop on Harmonization of Collaborative Analytical Studies held in Geneva on May 4 - 5, 1987. Dr. Clarke presented the Final Report of the ICUMSA Working Group in August and copies of this report are available from the Chairmen of National Committees or from the General Secretary. The conclusions of this working group can best be summed up in the three resolutions put to the Commission for consideration. These resolutions are :

Resolution 1.

That the recommendations of the May 1987 IUPAC Workshop on Harmonization of Collaborative Analytical Studies be accepted as minimum requirements for collaborative chemical analytical studies (always under the assumption that these recommendations are accepted by ISO and AOAC).

Resolution 2.

That a Methods Review Committee be established to review the format and procedures of all collaborative studies proposed by ICUMSA referees, to ensure that these are in accordance with IUPAC requirements, and therefore eligible for acceptance by ISO and AOAC, and that this Methods Review Committee be within the province of the Referee for Subject 3 on methods format and collaborative studies.

Resolution 3.

That the existing ICUMSA Official Methods (as of the 1977 ICUMSA Methods Book and from 1982 and 1986 ICUMSA Sessions) be examined to determine their accordance with IUPAC requirements, and that those methods meeting these requirements be published as soon as possible, to encourage their acceptance by ISO and AOAC, and that this examination be initiated by the Referee of Subject 3 on Methods format and collaborative studies.

The above resolutions seem very logical and can probably be implemented immediately even if they are not officially adopted until 1990. Future discussion of this report and matters arising from it should be directed to Mrs. Godshall, Referee for Subject 3, "Methods format, collaborative testing and statistical treatment of data".

Referee appointments

I wish to advise the appointment of Dr. Donal F. Day of the Audubon Sugar Institute as Referee for Subject 10, "Enzymatic and immunological methods", and of Mr. Stanley E. Bichsel as Referee for Subject 18, "Sucrose".

It is with regret that Dr. Margaret Clarke has indicated that she was unable to continue as General Referee for Subject 7 but I am pleased to announce the appointment of Dr. Charles Tsang of SPRI to fill that vacancy.

The appoinment of a General Referee for Subject G9, "Starch derived sweeteners", is still being discussed and it is not intended to make an appointment for Special Projects until some project is nominated.

Murray Player,
January 1988

A history of ICUMSA, the First 100 Years

By Ron Plews

The published Proceedings of ICUMSA states on its dustjacket that the Commission is the only international organization concerned solely with the analytical methods for the sugar industry and, as such, in 1997 this will have been true for one hundred years. It seemed appropriate, therefore, to celebrate this special anniversary with a publication describing the work and progress of ICUMSA since its inception. The President has charged me with the responsibility of editing this unique history. Ten years appears to provide ample opportunity to collect, collate, consult and write such a volume but it is important that the task be started now.

The subtitle "The First 100 Years" has been coined deliberately to indicate that the Commission is not a relic of the past or in any way an anachronism but,

on the contrary, intends to remain in the forefront of analytical chemistry and physics associated with sugar and the industry. With the help and commitment of its members the Commission will continue to extend its influence on the legislation and governing bodies of analytical methodology throughout the world since, like so many organizations of scientific culture, ICUMSA has proved over many years that there are no political barriers to international cooperation in the pursuit of scientific advancement. If the work is to succeed it is essential that contributions be made by many current and former members who can recount or highlight the various ways in which the movement has developed. The help of ICUMSA's elder statesman will be particularly useful.

At this very early stage the format and content of the book is embryonic and suggestions on these aspects will be welcome. I believe the work should be essentially a serious record of scientific achievement without being simply a collection of facts. Perhaps there should be space devoted to humour or our conventions where personal experiences may be recounted. A chapter which chronicles the presidents of ICUMSA with a profile of each may also be considered. Copies of relevant reports or correspondence not included in the Proceedings, will be of great value. Photographs (and/or negatives) which convey the spirit of comradeship which has existed within the Commission throughout its existence will also be welcome. Any thoughts or reactions to these suggestions will be greatly appreciated.

I am grateful for the help and suggestions already received from David Gross, Charles Davis, Albert Carruthers, Murray Player, John Dutton, and John Watson. In particular, Charles Davis advises that events should be examined in the context of the time in which they happened and not in the context of the present. He also suggests that it is advisable to develop the history as a sequence of events revealing themes and trends rather than a series of isolated incidents. Dr. Emmerich has also agreed to lend his support and his contributions from Braunschweig records of earlier meetings will be invaluable.

It would be helpful if each National Committee would agree to take on the responsibility of contributing an article on the involvement of its particular country. For example, it would be useful to know when each particular country joined ICUMSA and what particular contribution each feels it has made towards developing analytical methods. If an ICUMSA Session has been held in a particular country, perhaps the programs and documents can be contributed to the pool of resource material.

Some subjects have come and gone yet others are in the spotlight now just as much as they were several generations ago. Maybe some of the arguments are still the same. We need the contribution of members to bring to light what has been done and the reason it was done. Documenting the developments and progress of ICUMSA since 1987 promises to be a fascinating challenge and, with the aid of colleagues from all over the world, there is every reason for the project to be a resounding international success.

PROCESSING

Composition and processing of burned and unburned cane in Hawaii*

By C. M. Kinoshita
(Experiment Station, Hawaiian Sugar Planters' Association, Aiea, Hawaii, USA)

Introduction

Although harvesting unburned sugar cane has been described as a means to significantly reduce cane deterioration losses and increase the amount of fibrous boiler fuel produced[1], the significant benefits of burning cane prior to harvesting — most notably lower harvesting, transporting, and processing costs — have prompted the Hawaiian sugar industry (and most other highly mechanized cane sugar industries worldwide) to continue that practice whenever possible. While the reasons for burning cane prior to harvesting are in many ways more compelling than ever before, questions relating to burning *versus* not burning continue to be raised. Two questions frequently asked are: (1) how much additional fibre would be available if unburned cane were processed, and (2)

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* Published as Paper No. 634 in the journal series of the Experiment Station, HSPA.

1 Payne: *I.S.J.*, 1986, **88**, 191 - 193.

what effect would milling trash normally consumed in cane fires have on cane processing and sugar production? To help answer these questions, we conducted two series of tests on unburned and burned cane. The first tests were conducted to determine the composition of unburned field cane; the second were undertaken to determine the amount of fibre consumed in cane fires.

Procedure

Unburned field cane

To determine the composition of unburned field cane, 21 circular plots (on 11 plantations) of standing unburned cane were hand-cut immediately prior to burning and harvesting the field and segregated into five components — sound net cane, sour cane, dead cane, green leaves and tops, and dry leaves — and each component weighed. Sub-samples of each component were analysed for fibre, refractometer solids and pol and, periodically, for sucrose and reducing substances (for comparison with pol readings).

Comparison of burned and unburned cane

Ten of the 21 unburned cane plots were located in fields on seven plantations with variety field trials. After harvesting the plots of unburned cane and burning the field, variety trial check plots (of the same variety as the unburned cane) were hand-cut and weighed, and sub-samples of the burned cane were analysed for fibre, refractometer solids and pol.

Results and discussion

Composition of unburned field cane

Key test results for unburned cane are summarized in Table I. Fibre and pol constituted 18% and 12% of the total mass of unburned field cane, respectively. Sound net and sour cane, combined, contained 84% of the fresh weight, more than 98% of the total pol, and 58% of the total fibre in unburned cane; the other components, dead cane, green leaves and tops, and dry leaves, contained 16% of the fresh weight, less than 2% of the pol, and 42% of the fibre in unburned cane. Although dry leaves represented only 9% of total unburned cane on the basis of fresh weight, they contained roughly one-third of the total fibre.

Table I. Composition of unburned cane (%) by component (sound net cane, sour cane, dead cane, green leaves and tops and dry leaves) and by constituent (fibre, refractometer solids and pol). (Values rounded-off to closest 0.1)

	Component (%)					
	Sound net cane	Sour cane	Dead cane	Green leaves and tops	Dry leaves	Total
Constituent						
Fresh weight[a]	78.4	5.6	1.9	4.8	9.3	100
Fibre						
in component[b]	12.3	14.2	22.3	21.0	65.6	18.0[c]
contribution by component[a]	53.6	4.5	2.4	5.6	34.0	100
Refractometer solids						
in component[b]	16.3	10.8	6.3	6.9	6.5	14.5[c]
contribution by component[a]	88.5	4.2	0.8	2.3	4.2	100
Pol						
in component[b]	14.6	6.8	1.4	2.3	0.7	12.0[c]
contribution by component[a]	95.1	3.2	0.2	0.9	0.5	100

[a] Component's contribution to total amount of constituent.
[b] Amount of constituent in component.
[c] Weighted average.

Based on 21 test plots on 11 plantations. Varieties H 57-5174, H 59-3775, H 62-4671, and H 69-8235. Average age at harvest = 23.7 months (std. dev. = 3.8 months; average fresh weight yield = 338 tonnes/hectare (std. dev. = 78 tonnes/hectare).

Comparison of unburned and burned cane

Major results of the unburned *versus* burned cane test are summarized as ratios in Table II. Fresh weight yields were, on average, 14% higher in the unburned cane plots than in the corresponding burned cane plots; fibre yields were 51% greater. Although the refractometer solids and pol yields for unburned cane were, on average, almost identical to those for burned cane (ratios of 1.0 indicate equal yields of constituents in burned *versus* unburned plots), the similarities between average burned *versus* unburned yields for refractometer solids and pol were probably fortuitous (as suggested by the relatively high coefficients of variation — standard deviation divided by mean — of both).

If one assumes that (1) the amount of pol lost in cane fires is negligible and (2) while absolute yields of fibre, pol, etc., may vary from locale to locale within a field, the relative yields (i.e. ratios of fresh weight:fibre:pol) are essentially constant within a field, then the last two unburned to burned cane ratios — fresh weight per unit of pol and fibre per unit of pol — should provide good estimates of the amounts of total material and fibre consumed in cane fires. The first assumption is supported by extensive test data for hand-cut burned and unburned cane[2] which indicate that cane fires, *per se*, do not cause measurable sucrose loss, and is logically valid

2 Verret: *Hawaiian Planters' Record*, 1920, **23**, 241 - 252.

Table II. Yield ratios – unburned cane divided by burned cane

	Fresh weight	Fibre	Ref. solids	Pol	Purity	Fresh weight per unit of pol	Fibre per unit of pol
Average	1.14	1.51	1.03	0.99	0.96	1.15	1.54
S.D.	0.21	0.24	0.16	0.15	0.03	0.09	0.19

Based on 10 unburned *versus* burned cane tests on 7 plantations. Cane fires were mostly rated fair or good.

(except perhaps for very dry cane where the fire may cause significant cracking of the rind and therefore juice loss to occur) since those components that are most likely to be consumed in cane fields, i.e, dead cane, green leaves and tops, and dry leaves, contain very little pol (moreover, burned cane samples were prepared for analysis very soon after burning, thus minimizing the chances of sugar deterioration in the samples). The second assumption is supported by variety test data (mostly for burned cane) which show less variation within a field in pol:cane ratio than in cane or sugar yields. The fresh weight per unit of pol and fibre per unit of pol were 15% and 54% higher, respectively, in the unburned cane plots than in the corresponding burned cane plots. On the basis of those ratios, it would appear that about 13% of the total fresh weight and 35% of the total fibre in cane are consumed during fires. Hence, if standing cane were not burned, the amount (mass) of cane material delivered to the factory would increase by 15% and the amount of fibre by 54%. For those who opt to mill all fibre delivered to the factory, the amount of bagasse produced would increase by approximately 54%.

Effect on harvesting and processing

Although no data on harvesting, transporting, and processing cane were collected during this study, an extensive study in 1971 by Sloane & Rhodes[3], involving five Hawaiian factories, indicated that harvesting unburned cane required roughly 50% more labour and equipment hours than harvesting burned cane, and hauling, roughly 40% more. (Problems associated with harvesting and hauling unburned cane would be especially acute following heavy rains on irrigated plantations where soil infiltration rates are typically ~5 cm/hr versus ~30 cm/hr on unirrigated plantations.)

In most areas worldwide, when unburned cane is harvested, the cane is erect and cut by hand or mechanically with some of the trash extracted (which, left in the field, may at times have beneficial effects); as a result, the amount of extraneous matter including soil, in the harvested cane is usually quite small, even when harvested unburned. By contrast, in Hawaii, where the cane is always recumbent at harvest and generally push-rake or V-cutter harvested (methods which usually involve substantial pushing and piling of the cane to facilitate its loading into haulers and which do not permit detrashing in the field), much soil is entrapped in the mass of cane harvested, even under favourable conditions — the amount of soil increasing as the amount of leafy trash in cane increases. Hence, harvesting cane without prior burning would tend to increase the amount of extraneous matter, including soil, in the cane delivered to the factory; in turn, more soil would eventually pass through the cleaning plant and become part of mixed juice and bagasse. For example, in the 1971 test, the ratio of insoluble solids/refractometer solids in mixed juice roughly doubled when unburned cane was processed; such an increase in soluble solids would severely hamper processing. Re-analysis of data from previous wet- *versus* dry-cleaning tests conducted in Hawaii indicates a roughly linear relationship between insoluble solids in mixed juice and ash in bagasse, such that a doubling of insoluble solids in mixed juice would translate to a doubling of ash in bagasse; this would substantially increase bagasse boiler opacity and adversely affect bagasse combustibility.

Cane cleaning practices have changed dramatically in the Hawaiian sugar industry during the past decade, so the results relating to overall field and factory recovery — sugar manufactured divided by sugar in the field — in the 1971 test (which showed slightly more sugar manufactured per acre harvested for unburned cane) may not apply today. Table III examines, roughly, the effect of processing unburned cane (with all attached cane trash) on recovery if, as suggested by the data in Table II, the amount of fibre per unit of pol processed increased by 54% and prepared cane purity decreased by 4%. (Two scenarios for unburned cane are considered — equivalent pol/fibre ratio in bagasse and equivalent extraction.) Boiling house recovery would probably decrease by about 2.5 points; recovery from prepared cane to commercial sugar would probably decrease by 2 to 5 points, depending on the effect of milling trash on extraction.

Two items are worth mentioning at this point: (1) The expected decrease in boiling house recovery is primarily due to the lower mixed juice purity projected when cane with high trash content is processed. While there is no question

Table III. Burned *versus* unburned cane – effect on recovery (assuming equivalent bagasse pol:fibre ratio or equivalent extraction)

	Burned cane[a]	Unburned cane	
		Equivalent bagasse pol	Equivalent extraction
Pol:fibre, prepared cane	0.846	0.549[b]	0.549[b]
Pol:fibre, bagasse	0.0383	0.0383[c]	0.0249
Purity, mixed juice	86.12	82.85[d]	82.85[d]
Purity, final molasses	36.36	36.36[c]	36.36[c]
Purity, sugar	99.16	99.16[c]	99.16[c]
Extraction	95.47	93.03	95.47[c]
Theoretical recovery, boiling house	91.23	88.60	88.60
Actual recovery % theoretical, boiling house	97.43	97.43[c]	97.43[c]
Total recovery	84.86	80.31	82.41

[a] 1984 industry averages.
[b] Assumes 54% more fibre per unit weight of pol than for burned cane (see Table II).
[c] Assumed equal to value for burned cane.
[d] Assumes unburned to burned cane mixed juice purity ratio is equal to unburned to burned cane purity ratio (Table II).

3 *ibid.*, 1972, **58**, 173 - 182.

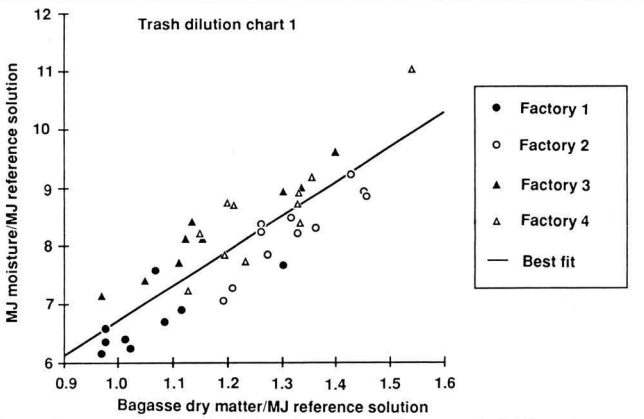

Fig. 1. Bagasse dry matter per unit mixed juice refractometer solids *versus* mixed juice moisture per unit mixed juice refractometer solids (1986 data)

that mixed juice purity would decrease significantly as shown in full-scale tests in Hawaii and elsewhere[3,4] (although in those tests less trash was processed than would be encountered in unburned Hawaiian cane if no trash were removed prior to milling) and, while the projected change in mixed juice purity is comparable to that predicted by Scott *et al.*[5], based on laboratory-scale tests (for the incremental trash expected), whether mixed juice purity would decrease as markedly as being projected here for these conditions has yet to be verified in controlled full-scale tests. (2) Although factory recovery is expected to decline when processing unburned cane, whether this would translate to less sugar being manufactured per acre harvested depends on the effect of not burning cane on deterioration (sucrose loss due to deterioration following burning would favour harvesting unburned cane or, at least, minimizing the interval between burning and processing) and on the amount of sugar lost during harvesting, loading, transporting, and cleaning (these data are lacking). The degradation in refinability would be more pronounced than in the 1971 test if the unburned trash were processed with cane (as opposed to partially removing and discarding the trash as was done in that test); this would clearly be in conflict with industry's current effort to improve sugar quality substantially.

The increased amount of fibre to be processed would require higher milling rate and more power to process the cane material. Also, as shown in Figure 1, with wet cleaning, the amount of water entering the extraction plant (and eventually becoming part of mixed juice) is nearly proportional to the amount of fibre processed; more steam would be expended to evaporate the additional water. Computations for a typical Hawaiian sugar factory suggest that if fibre rate increased by 54%, the steam rate necessary to process the additional cane material (and maintain the same electricity generation rate) would have to increase by 21%. A substantial portion (nearly 40%) of the additional bagasse produced would apparently be consumed in processing the additional cane material, not generating surplus power. Many of the factories are not equipped at this time to handle the increased fibre and moisture without decreasing processing rates.

Summary

Not burning sugar cane prior to harvesting has been proposed as a means to significantly reduce sucrose loss due to cane deterioration and increase the amount of fibrous boiler fuel produced. Studies described herein indicate that, although processing unburned cane may increase the amount of bagasse produced by more than 50%, the amount of steam and power consumed in the factory would also increase markedly, leaving only about 60% of the additional bagasse as surplus. Steam rate would have to increase by more than 20% to process the additional cane material (and maintain the same electricity generation rate). Factory recovery (prepared cane to commercial sugar) would probably decrease by several points; however, whether this would result in less sugar being manufactured per acre harvested is difficult to project, as information on the effects of not burning cane on sucrose losses during handling and cleaning and due to deterioration is lacking at this time. These and other concerns and uncertainties have caused the Hawaiian sugar industry to take a cautious approach to not burning cane prior to harvesting.

Acknowledgment

The author wishes to recognise the invaluable assistance received from Messrs. E. A. Kennett, President and Chief Executive Officer, Hilo Coast Processing Company and S. Masumoto, Chief Staff Engineer, Alexander & Baldwin Inc., during the preparation of this paper.

4 Lamusse: *I.S.J.*, 1979, **81**, 231 - 236.
5 *Proc. 52nd Congr. S. African Sugar Tech. Assoc.*, 1978, 51 - 53.

Heat of melting of sucrose

By Peter A. Sopade*, Malcom W. Kearsley* and Geoffrey A. Le Grys†

Introduction

In food processing, detailed understanding of thermal processes requires a knowledge of the thermal properties of the particular food system. With respect to sucrose, the only published information about the heat of melting of sucrose was that determined by Tian[1] and reported by Hirschmüller[2]. Although the enthalpy of melting of the sucrose crystals was not specifically determined, Hirschmüller noted that this enthalpy had the same value (= 56.4 J/g) as the content of heat of amorphous sucrose at 20°C minus the content of heat of crystallized sucrose at the same temperature. Even though Tian used a calorimetric method, it is difficult to justify equating heat of dissolution with that of melting of a crystalline material. With the advent of modern, sensitive and accurate analytical methods such as differential scanning calorimetry (DSC), it becomes apparent that routine determination of thermal properties is possible. A detailed review of the use of DSC in analysis is available elsewhere[3].

Materials and methods

Sucrose of analytical grade was obtained from BDH Chemicals Ltd., England. A Mettler TA 3000 calorimeter with DSC-20 unit was used. The scan rate was 10°C/min. and the scan interval was 40° - 225°C. The in-built automatic integrator was used for calculation of the endothermic area. Indium was used as calibrant for both temperature scale and energy flows. Using the calibrant, independent measurements of melting point and enthalpy of benzoic acid and triphenylmethane were within 2°C and ± 2 J/g of literature values[3,4], respectively. For further comparison purposes, a Perkin-Elmer DSC-7 was also used under similar conditions for determination of the enthalpy and melting point of sucrose.

Results and discussion

Figure 1 shows a typical endotherm, obtained using the Mettler instrument, as sucrose crystals were calorimetrically heated. From peak integration, the heat of melting (or fusion) was found to be about 135 ± 2 J/g. Although the melting temperature, 186° ± 4°C, was identical to that reported by Hirschmüller[2], the heat of melting obtained in this study was higher by a factor of about 2.4. The reason for such a large disparity is unclear although it was considered that the old determination under-estimated this parameter. It is most likely that more heat energy is required for the change of state (melting) than for dissolution of the sucrose crystals.

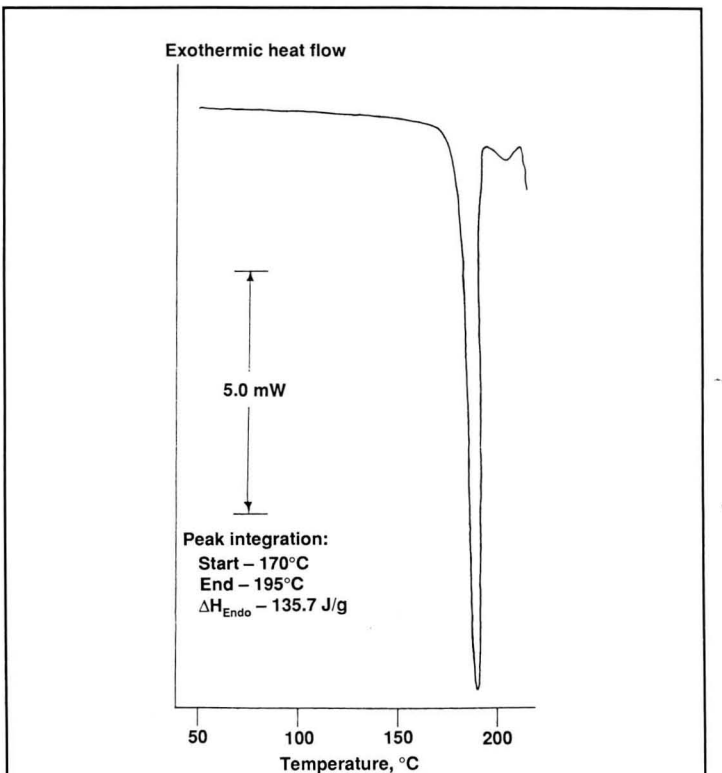

Figure 1. A typical DSC endotherm for sucrose crystals

Summary

The heat of melting (or fusion) of sucrose crystals was measured to be 135 J/g and melting temperature was about 186°C. Although the melting temperature is identical to that reported in the literature, the heat of melting obtained in this study is higher than the reported value.

Acknowledgement

The authors are grateful to Professor R. C. Righelato, Director of Research of Tate & Lyle Group Research and Development, for permission to publish this work.

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1 *Comptes rend. Acad. Sciences.*, 1929, **187**, 164 - 167.
2 In "Principles of sugar technology", Vol. I. Ed. Honig. (Elsevier, New York), 1953, pp. 2 - 74.
3 McNaughton & Mortimer: in "IRS; Physical Chemistry Series 2, Vol. X". (Perkin-Elmer Corp., USA.), 1975.
4 Weast: in "CRC Handbook of Chemistry and Physics", 66th Edn. (CRC Press Inc., USA), 1986.

Facts and figures

Zaire sugar expansion[1]

Sugar production in the 1987 crop year (June/December) is estimated at 76,000 tonnes, raw value, compared with 69,487 tonnes in the year before. Production in 1988 is expected to rise to 91,000 tonnes.

New Indian cane varieties[2]

Two new varieties of sugar cane are undergoing trials to ascertain their suitability for cultivation in different parts of India. They were bred at the Coimbatore Sugarcane Breeding Institute and have been given numbers Co 8338 and Co 8341; they have yielded 70 tonnes per hectare and have a sucrose content of about 18%.

Cuba sugar purchase[3]

Cuba is reported to have bought recently a substantial amount, which could be as much as 250,000 tonnes, of Western Hemisphere raw sugar, which may be earmarked for the Soviet Union, according to trade sources.

New dam prevents big Australian cane loss[4]

The first water to flow from the Burdekin Dam irrigation scheme was to be used to break desperate drought conditions which threatened to cost the local sugar industry an estimated $Aus 40 million in 1987. The water was to be used to irrigate late plantings in order to guarantee next season's sugar cane crop. Water was to start flowing into the Haughton River via a channel on August 1 but it was expected to take a month to replenish the rivers and its weirs. Giru and the surrounding area, which supplies cane to the Invicta sugar factory, have been in a severe drought condition but the Queensland Water Resources Commission was committeed to supplying water for the current season.

Spanish sugar cane expansion[5]

The Spanish Ministry of Agriculture has authorized the enlargment of sugar cane cultivation in the provinces of Granada and Málaga, where cane is a traditional crop which, however, has so far been neglected. Pilot schemes are being established and a plan is to be designed for the entire zone, to reconvert and improve the existing plantations. Currently, most of the sugar cane crop is grown in the two provinces on an area of 3000 hectares. Spain is the only European country to grow sugar cane and cane sugar production in 1986/87 amounted to 16,000 tonnes.

Cuba sugar production 1986/87[6]

Cuba produced 7,217,630 tonnes, raw value, of sugar during the 1986/87 crop year, a figure similar to output in the previous season, according to official statistics forwarded to the International Sugar Organization. Cuban sources have commented that the 1986/87 crop was severely affected by a long drought and unseasonal rains, the effects of which may extend to the 1987/88 crop. In 1984/85 Cuba produced 8.2 million tonnes of sugar.

Barbados sugar situation[7]

The Barbados government cannot maintain the current sugar price support system, according to a Latin American Commodities report. It is not intended to abandon the industry, however, and a program of financial aid is to be introduced. Sugar production in 1987 fell to 83,431 tonnes, tel quel, the lowest level this decade. The cane area was reduced by almost 20%.

Cuban aid for Liberia[8]

A Cuban group visiting Liberia has agreed to help revitalize the country's sugar industry. A survey of the Liberia Sugar Corporation's plantation in Maryland county is to be conducted and a technical report submitted to the government. The Corporation was managed by Taiwan staff but these left when Liberia recognized the People's Republic of China in 1976.

Portuguese beet to be processed in Spain[9]

The Portuguese government has begun talks in Lisbon with Spanish companies in order to make possible the processing of Portuguese beet in Spain. This will permit the Portuguese growers, who do not have the necessary facilities for processing, to raise their sugar production as they are still well below the quota of 60,000 tonnes per year allocated by the EEC authorities. By contrast, in Spain there are too many beet sugar factories and some of them have been closed.

Threat to South African sugar factory[10]

All sectors of the South African sugar industry are perturbed by government proposals to expropriate 7200 hectares of prime cane land in the Hambanati/Tongaat area for industrial development and provision of housing. The land is one of the most fertile and productive areas of the Natal sugar belt and its removal from cane growing could cut supplies to the Maidstone factory of Tongaat-Hulett Sugar Ltd. and seriously prejudice the future viability of this factory, which is one of the largest in South Africa. Closure of the Maidstone factory would cause both unemployment in the area and also harm cane growers who currently supply Maidstone but are too far from other factories for transport of their cane to be economical. Other factories would not necessarily have sufficient capacity to be able to crush Maidstone's cane and the situation could lead to considerable loss of foreign exhange earnings since most of Maidstone's sugar is exported. The sugar industry has made representations against the move to the South African Commission for Cooperation and Development.

New sugar drying plant in Australia[11]

The start of the 1973 crushing season at Macknade sugar factory marked the successful commissioning of a totally new sugar drying station designed and installed by its staff. Bundaberg Foundary built the dryer drum to Macknade's specification, while Queensland Conveyor Services supplied the sugar conveyor belts. Other notable features are the use of a Hagglunds hydraulic drive to rotate the drum and Moisture System near infra-red light analyser to measure aspects of sugar quality on the conveyor belts.

Pakistan sugar import tenders

Pakistan is reported[12] to be planning to invite tenders for the supply of 500,000 tonnes of refined sugar in order to tide it over an expected shortfall in its domestic production. Against consumption estimates of 1.8 million tonnes, production is projected to reach only 1.3 million tonnes, owing to low sucrose content in the cane because of a shortage of rain this season.

Polish sugar factory modernization[13]

Reconstruction of the Lublin sugar factory in Poland has been completed at a cost of 500 million zloty. A computer system has been introduced and the campaign will now last only 95 days instead of about 130 days.

US record sugar crops forecast[14]

Despite some recent weather damage to the sugar cane crop, the US Department of Agriculture's production report indicates total US 1987 sugar output could reach a record 7 million short tons or more, topping the previous record of 6,953,000 tons in 1975/76. Beet harvest conditions were nearly ideal in the Red River Valley of North Dakota and Minnesota and for the California crop. The Department has estimated the sugar beet crop as 27.7 million tons, up 10% from 1986; quality is excellent and sugar content is high (in the Red River Valley). Sugar cane production is set at 30.9 million tons, up 2% from 1986, lower yields now being expected in some areas of Hawaii and Louisiana.

EEC abandonment of bio-alcohol plan[15]

The European Commission has abandoned plans to convert surplus grain and sugar into alcohol after meetings in which support and opposition for the scheme were argued. Those in favour, led by the Commission President and Agriculture Commissioner, wanted a subsidy scheme to be drawn up but those against, led by the Commissioners responsible for the internal market, for energy and for competition, won on the basis that the wheat subsidy would have to be raised from 390 to between 872 and 920 ECU per

1 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 497.
2 *Indian Sugar*, 1987, **37,** 128 - 129.
3 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 518.
4 *Australian Canegrower*, 1987, **9,** (8), 31.
5 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 547.
6 *GEPLACEA Bull.*, 1987, **4,** (11), Sugar Inf.–2.
7 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 548.
8 *S. African Sugar J.*, 1987, **71,** 316.
9 F. O. Licht, *Int. Molasses & Alcohol Rpt.*, 1987, (15/16).
10 *S. African Sugar J.*, 1987, **71,** 318.
11 *Australian Canegrower*, 1987, **9,** (10), 6.
12 *Financial Times*, November 5, 1987.
13 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 563.
14 *Public Ledger's Commodity Week*, November 14, 1987.
15 *Financial Times*, November 11/12, 1987.

tonne, that more energy could be produced by simply burning the crops than converting them to alcohol, that alcohol was an environmentally unattractive additive for petrol, and that producing alcohol from grain would result in substantial amounts of gluten and starch entering production to further erode available cereal markets. Further, the bio-alcohol would cost 49 ECU per hectolitre to produce against its market price of only 9 ECU; nevertheless, EEC officials expect France to go ahead with support for alcohol manufacture.

South African floods[16]

Severe floods in Natal at the end of September resulted in stops of about a week at most sugar factories which were out of cane. Damage was particularly severe at Glendale where all access roads to the factory were washed away and the mill could not crush in October. Severe damage was also reported at Umzimukulu and Gledhow factories, at both of which the ground floor was flooded and damage caused to electrical equipment and, at Gledhow, to sugar stored in warehouses. Surprisingly, in view of the amounts of flood-damaged and deteriorated cane processed during October, there was only a marginal drop in mixed juice purity and sucrose content was 12.45% against 12.78% in September.

New coal-fired steam plant, at UK refinery[17]

Tate & Lyle's Thames refinery in London is to return to coal for its power requirements, with a new computerized steam and power plant which will also be able to feed the surplus electricity it generates into the national grid. Tate & Lyle used coal for steam raising and power generation until the early 1960's, when it switched to oil, and for the past 15 years it has used natural gas. However, government grants for new coal-fired plant, advances in coal-burning technology and a highly competitive coal supply contract has led to the company spending more than £10 million on new coal-burning equipment, construction and commissioning of which has begun.

Sri Lanka sugar situation[18]

With the debut of two sugar factories at Sevanagala and Pelwatte in 1986, joining the state-owned factories at Hingurana and Kantalai, sugar production rose by 90% to reach more than 34,000 tonnes, the new factories contributing 57% of this. These, and a third new factory at Moneragala, are due to reach full capacity by 1995 but nevertheless production will be limited to 60% of the country's annual requirements of about 300,000 tonnes. This policy has been decided because of the high investment required for setting up sugar projects and the availability of sugar at a lower price than the cost of domestic output.

Sugar rationing in China[19]

Sugar rationing has been introduced in China owing to a stagnating domestic production, low stocks and soaring consumption. It took effect on December 1, 1987, in Beijing but occurred earlier in some other cities. A family of three may buy 1 kg of sugar per month, with larger families limited to 1.5 kg. The Central government had ruled out price rises to boost domestic production because it would have too great an impact on a wide range of food items. Foreign diplomats said that nation-wide rationing could last a year, drastically limiting sugar consumption and possibly having an impact on China's net import demand.

International Society of Sugar Cane Technologists

The first Newsletter to be published by the organizers of the 1989 ISSCT Congress has been received from Brazil. It carries biographical information on the Honorary President, J. G. S. Ometto, the General Chairman, L. E. C. Maranhao, the General Vice-Chairman, Dr. R. Antoine, and the General Secretary Treasurer, Prof. J. P. Stupiello, whose address is given as P.O. Box 532, Piracicaba, SP, Brazil 13400. Details are given of the new Executive Committee elected by the Council, and of Workshops to be held under the aegis of the Society during 1988. Resolutions passed during the 19th Congress in Jakarta in August 1986 are published, and an application form for membership of the Society for the 20th Congress is enclosed with the Newsletter. Copies are available from Professor Stupiello at the address above.

Morocco sugar production, 1987[20]

The areas of beet and cane were increased for the 1987 season by 9.3 and 3.9%, respectively, to 60,709 and 12,900 hectares. While the weather was not favourable, the yields rose to 45.1 and 64.5 tonnes/ha for beet and cane, so that the crops processed amounted to 2,736,471 and 833,023 tonnes, respectively, from which were obtained 223,939 tonnes of raw sugar and 202,361 tonnes of white sugar, i.e. a total of 426,300 tonnes against the previous years's total of 407,660 tonnes, tel quel. In 1987 the cane sugar sector contributed 73,280 tonnes, of which 17,700 tonnes was as raws and the remainder whites, while the beet sugar sector produced 353,020 tonnes of sugar including 206,239 tonnes of raws and 146,781 tonnes of whites.

HFS plant sale to the USSR[21]

Sumen Sokeri Oy., the main Finnish sugar company, apparently sold a HFS plant to the Soviet Union and is confident that this will bring further business. This could threaten the level of Soviet sugar imports as the USSR is a large net importer of sugar and has a large animal feed sector which could absorb the by-products of the wet milling process. On the other hand, the Soviet Union frequently also needs to import grains. However, if the recent improvements in the Soviet grain harvest can be continued and if world market sugar records another of its periodical price booms, than there is every likelihood that a sizable HFS industry could become established.

Australian sugar factory sale likely[22]

CSR Limited has announced its intention to sell its Pleystowe Mill to the proposed Mackay Sugar Cooperative Association, subject to the need for 75% affirmative vote by shareholders of the Mackay district's five cooperative sugar factories to merge their assets and form a "super cooperative". The provisional price is said to be $Aus 24.75 million, excluding 1987 crop proceeds. Further sums of up to $Aus 7 million might be payable if the sugar price exceeds $Aus 260 per tonne in real terms over the five seasons from 1988. It is thought likely that the cooperatives will agree to the merger and that the sale will go through, in which case funding will be made available for the purchase by the Queensland and Australian governments.

Cuban cane crop expected to be poor[23]

The 1988 cane harvest, which started in mid-November, faces a serious shortfall of cane which will affect production of sugar and by-products. A Sugar Ministry economist said that difficulties would again be faced in meeting obligations to the Soviet Union and other Comecon countries and fulfilling domestic needs while still having enough sugar to sell outside Comecon. Although 200,000 extra workers were mobilized at the end of the 1987 harvest for cleaning and planting the 1988 crop, the damage caused by prolonged drought, broken by heavy unseasonable rains, has clearly affected the crop. Only 18 factories have enough cane to operate for 150 days, the optimum production period, it is reported, while 23 will be hard pressed to crush for even 100 days.

Cuban technical aid for the Madagascar sugar industry[24]

Cuba, which currently trains sugar technologists from Madagascar, is to increase its assistance to that country by providing aid to improve cane varieties and to assist in the production of animal fodder from sugar cane by-products and the generation of electricity using bagasse.

PERSONAL NOTES

Dr. Michael C. Bennett has been appointed Group Technical Director of Tate & Lyle PLC. He will be based at the company's headquarters in London, and will be responsible for advising on long-term technical developments and capital projects relating to the Group's sugar industry interests; he will also provide a technical audit of capital proposals.

Rodney Goodwin, who edited the *Czarnikow Sugar Review* for more than 25 years, bringing to it his own individual style and wide experience in sugar affairs, has retired from full-time employment with Czarnikow after being for more than 37 years with the company. He has agreed to act as a special consultant so that his expertise will continue to be available to Czarnikow and their clients. With the December 1987 issue of the *Review*, **Christopher Pack** has taken over the editorship after many years of close involvement in its production.

16 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 567.
17 *The Times*, December 1, 1987.
18 *Public Ledger's Commodity Week*, December 5, 1987.
19 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 583 - 584.
20 *Sucr. Maghrebine*, 1987, (32), 17 - 23.
21 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 592.
22 *Australian Canegrower*, 1987, **9,** (11), 8.
23 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119,** 598.
24 *GEPLACEA Bull.*, 1987, **4,** (12), Sugar Inf. 2.

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LIQUIDATION...Former Godchaux-Henderson 2000 TPD Sugar Refinery...Reserve, Louisiana, USA

SUGAR PROCESSING, EVAPORATION CENTRIFUGING

(1) Nadler 2,000 cu.ft. vacuum pan, stainless contacts, agit. & condenser, 1971
(7) Vacuum pans...capacities from 950 up to 2,000 sq.ft....w/agit. & condensers
(1) 14,000 sq.ft. triple effect evaporator
(6) Crystallizers/melters...500-1500 cu.ft.
(2) BMA #K850 continuous centrifugals.
(11) Broadbent 48" × 30" sugar centrifuges, SS baskets
(1) SS Feed tank for centrifuges, 9' × 50', w/agit.
(2) Industrial 600 sq.ft. SS rotating leaf pressure filters
(32) Char filters...w/approx. 2,000,000 # bone char
(4) 300 cu.ft. Ion exchange resin tanks
(2) American 300 sq.ft. spiral heat exchangers, SS

GRANULATION, PULVERIZING, FILLING

(1) Rotating soft sugar continuous blender, SS, 5' x 10'
(1) Mikro #8MA atomizer pulverizer, Ni-resist, 100 HP
(20) Rotex 40" × 80" 2-deck sifter screens
(7) AAF rotoclone dust collectors, SS, fan up to 100 HP
(1) Link-Belt 9' × 36' Roto-Louvre cooler, w/Roto-clone collector
(3) Hersey 6' × 25' 2-drum rotary granulator/cooler combinations
(1) Wet sugar blending system, SS contacts, approx. 1200 cu.ft., w/10 horiz. SS mixing screws, hyd. drives
(1) Liquid sugar blend station...APV plate type exchangers/pasteurizer, SS, BAC cooler, SS, 23,000 gal. FRP tanks, 12,000 gal. horiz. epoxy tanks, sucrose tanks
(2) Hesser fillers for 5 lb. bags, automatic, w/bundler

SUPPORT AND GENERAL PLANT EQUIPMENT

(1) Combustion Eng. boiler, 130,000 #/hr.
(3) Turbo generators; 1500, 625 kW
(1) Worthington air compressor, 14' × 13 HBB, 75 HP
(1) Joy #WGDL-9 vert. air compressor, 75 HP, 1980
(2) C-P horiz. air compressors, 100 HP
(2) Alvey palletizers for...25lb./50 lb./100 lb. bags
(1) St. Regis #76 swivel stacker
(1) Parsons scale, 4,000# drop
(3) Redler conveyor loops, 40 - 55 TPD
(1) Hoffman vacuum blower, 20 HP
(1) Nash CL402 vacuum poump, 25 HP
(1) "Magliner" loading ramp, 16,000#, 5' × 36'

LIQUIDATION...Former Lantic 5000 TPD Beet Sugar Factory Near Montreal, Quebec, Canada

SUGAR BEET RECEIVING AND PREPARATION

(1) Marcel Mouyard beet receiving system with hoppers, conveyor, stone catcher, etc., 1982
(1) Silver 36" "Super" beet piler, 1983
(1) BMA-Harland beet pump, 450 HP motor
(1) Putsch sharpening station for slicer blades
(1) Tare Laboratory, 1982, testing equipment by Biologie
(4) Truck scales, 50, 80 ton

DRYING, DEWATERING, PELLETIZING

(2) California CPM pellet mills, 150 HP
(3) California pellet mills, 75 HP
(1) California pellet conveyor type cooler, #5HRS22DD, 2-pass approx. 4' × 25', perforated belt, cyclone separator
(3) Trough belt conveyors for pellets; 18" × 35'; 18" × 60'; 18" × 225' (w/traveling stacker)
(1) BMA 66" SS curved dewatering screen

LIME SYSTEM

(1) Eberhardt vertical lime kiln, rated 200 tons per day w/rotary lime slaker, milk tank, skip hoist loader, pumps
(1) Mikro #4TH pulverizer, stirrup hammers, 75 HP
(2) Siemens CO_2 gas pumps, SS contacts, Terry 350 HP
(2) Sihi CO_2 gas compressors, SS contact parts, common base and 430 HP motor
(1) Nash CL3001 CO_2 compressor, SS contact parts, 400 HP motor, steel skid packaged

CLARIFICATION

(1) BMA 3600 TPD clarifier with controls and accessories
(1) Dorr-Oliver 1400 TPD clarifier, 20' dia. × 5-cell
(3) BMA rotary vacuum "mud" filters, 10' × 12'6", scraper
(3) Putsch vertical pressure leaf filters, approx. 90 sq.m.
(5) BMA vertical pressure leaf filters, approx. 60 sq.m.
(1) Ion exchanger system w/rubber lined tanks, piping, pumps, controls, etc.
(5) Sihi vacuum pumps with 120 HP motors
(1) Sihi vacuum pump with 75 HP motor

EVAPORATORS, CRYSTALLIZERS, VACUUM PANS

(1) BMA evaporation system, approx. 90,000 sq.ft. total surface area, w/(20) juice preheaters, sizes up to 2,000 sq.ft. and (5) vapor bodies. SS tubes. W/control panel, pumps, piping, etc.
(8) BMA 1200 cu.ft. vacuum pans w/agitators, drives and automatic controls. Copper tubes.
(5) BMA 9' × 30' horiz. crystallizers
(6) Sweetland size #12 filters, can take up to 72 leaves, now set for 36 leaves

CENTRIFUGES

(2) BMA automatic batch centrifuges, Type P1000 w/timers, controls, etc., 1200 RPM, 44" baskets, heavy duty. ***NOTE:*** The above centrifuges were overhauled and updated in 1978-79.
(2) Silver 36" continuous centrifuges, new 1980

SUPPORT AND MISCELLANEOUS ITEMS

(1) Servo-Balans molasses scale, 650# per batch capacity
(1) Servo-Balans raw sugar scale, 1981
(1) Raw sugar trough belt conveyor, approx. 24" wide × 250'
(1) Keystone-Volcano 160,000#/hr steam boiler, 230 psi, #6 oil/gas, w/controls, etc., 1982
(1) Lot mobile equipment with front end loaders, forklifts, trucks, etc.

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