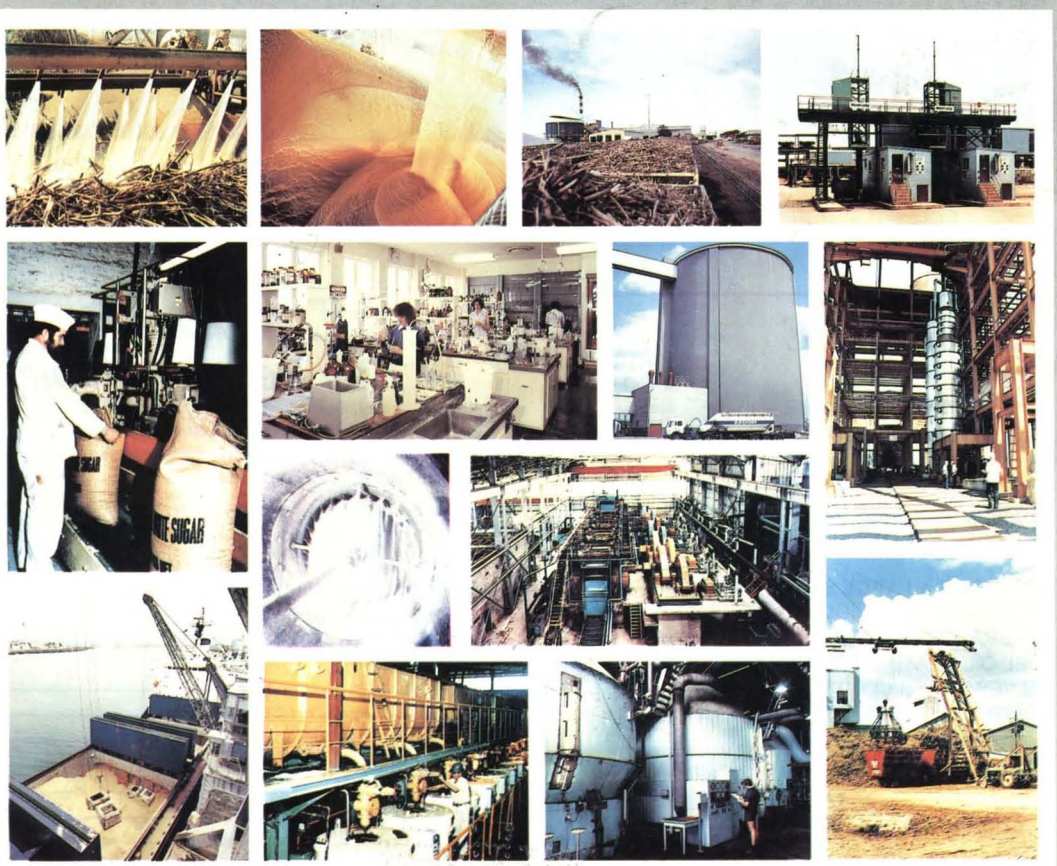
INTERNATIONAL SUGAR JOURNAL



VOLUME LXXXXII/ISSUE No. 1100 AUGUST 1990

INTERNATIONAL SUGAR JOURNAL

UK ISSN 0020-8841
Volume 92
Issue No. 1100
August 1990

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Published by

International Media Ltd.

P.O. Box 26, Port Talbot, West Glamorgan SA13 1NX, U.K.
Telephone: +44-639-887498 *Telex:* 21792 REF 869 *Telefax:* +44-639-899830
US Office: 2790 Foster Avenue, Corning, CA 96021

Annual Subscription: £65.00 post free

Single Copies £6.50 post free

By Air: £32.00 extra

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News and views

World sugar prices

The London Daily price for raw sugar stayed fairly steady during the first third of June after starting the month at $331.20 per tonne, but lack of buyers caused a further fall which was reinforced by news of a higher than expected Cuban crop. Reports from East Europe have told of higher retail prices in the shops with consequent lack of buying by consumers. In Poland, for instance, this has meant that sugar stocks have been made available to the world market to obtain hard currency and the market has become aware that the same pattern could occur elsewhere. As a result of these considerations, the LDP drifted downward, reaching a low of $307 on June 25. At the end of the month news that Mexico would require more than a million tonnes of imports this year brought about a small recovery with the price reaching $313.50.

The London Daily Price for white sugar followed a very similar course, but the premium over raw sugar values fell during the month from $98.30 to a minimum of $74 and then recovered to $87 at the end of June. The LDP(W) consequently fell from $429.50 on June 1 to a minimum in the month of $385 on June 22 and rose to $400.50 on June 29.

Nicaragua sugar situation[1]

The US Administration recently restored Nicaragua's quota for exports of sugar to the United States which was withdrawn when the country was under Sandinista rule. In 1983, the quota was cut from 54,000 short tons to 6000 tons and in 1985 it was eliminated completely. Some 77,000 tons of 1989 production have already been contracted for export, according to the US Agricultural Attache in Guatemala; however, only 32,000 tons has actually been shipped. Given the difference between the world price of sugar and that paid for US imports, Nicaragua would earn approximately $7 million more by selling to the US than under current contracts. Even if there were some problem that prevented Nicaragua from buying back its contracts, it could buy sugar on the world market for domestic consumption and export sugar previously designated for local use.

The privately-owned Nicaraguan sugar factories were nationalized by the Sandinistas and are currently owned by the state. Therefore, any economic gain which results from exporting sugar under US quota would go directly into government coffers. It has been said that the new Nicaraguan government may return the factories to private ownership, but no timetable has been mentioned.

Limitations on Thailand sugar expansion[2]

Dry weather reduced sugar production prospects in Thailand and output at May 23, with only four factories still in operation, had reached 3,348,082 tonnes, tel quel, from 33,554,992 tonnes of cane, to give an extraction rate of 9.98%. By comparison the yield in 1989/90 was 10.632% and the season had closed by the same date with a final outturn of 3,898,519 tonnes, tel quel. This was equivalent to 4,052,000 tonnes, raw value, and it seems likely that the current season's production will fall back to 3,575,000 tonnes, raw value.

For the present, conversions to raw value cannot be too accurate since some of the raw sugar produced will be remelted and refined at the end of the season. In raw value terms, 1,005,000 tonnes will be needed for domestic use and 600,000 tonnes for white sugar exports. Since 1,200,000 tonnes of whites had been produced by the end of April it would seem that end-season remelting will be sharply higher this year. The contrast between this season and last shows how weather has an overriding influence on results. In addition, the government is maintaining its regulation forbidding the number of factories to increase beyond the present total of 46. Some expansion of existing facilities is possible while factories are allowed to apply for relocation. Since rising land values have induced a number to move, it is unlikely that while this is taking place the industry will be able to achieve a substantial increase in output.

USSR agricultural production policy[3]

In 1989 Soviet leaders developed a number of legislative initiatives to improve overall agricultural production, several of which could have an impact on sugar production in the USSR. On the one hand, all enterprises became economically accountable for their finances as of January 1 and, although persistently unprofitable enterprises will not necessarily be forced to shut down, there has been some attempt to improve productivity and reduce losses.

Focus has shifted away from basic crop production to an emphasis on food processing, storage and handling systems. A total of 77,000 million roubles is to be invested over 5 years in the food processing sector. However, Soviet agricultural officials pointed out that the quality and quantity of material diverted to the agricultural sector are so inferior that investment must be twice as great in agriculture as in manufacturing if they are to be on an equal footing.

New laws on leasing and land use are hoped to provide greater security and incentives for production, but questions remain concerning the distribution of other limited inputs such as fertilizer, fuel, etc. Another factor is that sugar beets are not included in the program of domestic crop sales for hard currency; exclusion of sugar beets from the program, coupled with the desire of local organizations to obtain hard currency, may force a shift out of beet production into other "hard currency" crops. If such a shift should occur, the Soviet Union could become more reliant on imports.

Berisford Group ownership

In June the contemplated offer by Tate & Lyle PLC for the acquisition of Berisford International PLC, owners of

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**. 238.
2 *Czarnikow Sugar Review*, 1990, (1796), 58 - 59, (1797), 85.
3 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 313.

British Sugar, was referred to the Monopolies & Mergers Commission by the U.K. Department of Trade and Industry. However, before the Commission could give any opinion on the matter, Tate & Lyle announced that it had completed its investigations in connection with its possible offer. These, particularly as to the value and status of certain Berisford non-sugar assets, together with the possible detrimental effect of the merger on Tate & Lyle's cane sugar refining margin, have led it to believe that it is not in the interests of Tate & Lyle and its shareholders to make an offer for Berisford and has so informed the Commission. Tate & Lyle have also discovered that certain marketing practices of its UK sugar business, Tate & Lyle Sugars – believed to concern sharing of information with British Sugar – may have contravened competition laws.

A number of other groups are believed to be interested in acquiring Berisford, including the Irish entrepreneur Larry Goodman and Associated British Foods, who both have substantial shareholdings in the Group, Générale Sucrière of France and Südzucker of Germany.

South African sugar industry expansion[4]

The South African sugar industry has embarked on a major expansion program; this had previously been contingent on the development of a new alcohol production plant at Felixton, the viability of which is still under study, but it has been decided to proceed without delay in the expansion. Should the alcohol project go ahead, a further expansion will be possible.

The program will coincide with the start of the 1990/91 season and will involve supply of cane by many new small growers. The total project expansion will take several years to mature but it is estimated that eventually the annual output of sugar will be increased by some 300,000 tonnes. As a consequence it will be necessary to establish a new sugar factory in the eastern Transvaal. It will also be possible to make use of spare capacity in some existing factories; the economic viability of others will also be considered.

Sugar production in calendar 1989 totalled 2,293,000 tonnes, raw value, down from 2,469,000 tonnes in 1988. Sugar exports amounted to 924,000 tonnes which included 371,000 tonnes to Japan and 187,000 tonnes to South Korea.

Cuba sugar production, 1989/90[5]

As reported earlier[6], reports of bad weather and mechanical difficulties in Cuba have been prevalent during the 1989/90 crop and estimates of sugar output have been reduced during the season accordingly. The Cuban daily, *Granma*, reported on June 19, however, that production had reached 8,042,748 tonnes, only slightly less than the 8.2 million tonnes of the 1988/89 crop and well over the target of 7.7 million tonnes.

Brazil sugar export plans[7]

Brazil has announced plans to export 650,000 tonnes of sugar, tel quel, from the 1990/91 crop, which compares with actual exports of 1,524,000 tonnes, raw value, in 1989/90. Sugar production in 1989/90 reached 7,120,000 tonnes, tel quel, and alcohol production was 118 million hectolitres, all produced from a cane crop of 222.1 million tonnes. Estimates for 1990/91 indicate that cane production will be the same as the previous crop while sugar and alcohol production are estimated at 7.1 million tonnes, and 122 million hl. Both will be below domestic requirements and alternative options must be analysed to solve the problem. Amongst these is the use of methanol and gasoline as extenders for alcohol fuel, which has been found to give better results than expected.

Indian sugar crop increase forecast[8]

India's white sugar production in the current season, October 1989/ September 1990, is expected to touch a record 10.7 million tonnes, up from 8.7 million tonnes in the 1988/89 season, according to industry sources. An official of the Indian Sugar Mills Association (ISMA) said that production to the end of April was 9.8 million tonnes against 8.33 million tonnes in the same period a year earlier. The ISMA secretary attributed the rise to better climatic conditions and a better recovery rate, while diseases and pests had caused less damage in the current season. The area under cane has increased only marginally, from 3.28 million to 3.37 million hectares, but cane output is expected to rise from 204.6 to 212 million tonnes in 1989/90. Incentives given by the government have also helped increase sugar output; these included government permission to sell up to 80% of early production in the free market and 20% at the lower fixed prices, against the normal ratio of 55 to 45. The industry has been asking for total decontrol of sugar prices but proposals for 1990/911 are limited to free market sales for 75% of production between October 1 and November 15. Consumption is estimated at 10,200,000 tonnes and a surplus of 500,000 tonnes could be available for export against the country's need to import 240,000 tonnes of sugar last year. Permits have been granted for the establishment of 71 new sugar factories and the expansion of another 143; low-interest loans have also been granted for development and modernization projects.

New Iran sugar refinery

Iran's Foreign Minister, Mohsen Nurbakhsh, has said that the Kesht-O San'at sugar refinery in the southern province of Khuzestan, which is presently under construction, will annually produce 700,000 tonnes of refined sugar. The plant will also produce paper and other items from sugar by-products, according to a report on May 29 from the Islamic Republic News Agency.

4 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 334 - 335.
5 *Prensa Latina news agency report*, June 19, 1990.
6 *I.S.J.*, 1990, **92**, 151.
7 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 315.
8 *Reuters News*, May 7, 1990.

The origin of soluble fructans in sugar cane juice

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

Introduction

The main carbohydrate which accumulates in stalks of sugar cane is the disaccharide, sucrose[1]. However, several polysaccharides have been found in sugar cane juices. Arabino-galactans[2], starch-like polymers[3], and glucans[4], are normal components of cane juice. Recently, the occurrence of a hetero-polymer in juices has been reported. This polymer is composed of fructose and another product, chromatographically identified as galactitol[5].

Fructan is the major form of storage carbohydrates in many temperate C3 grasses[6]. Accumulation generally occurs when sucrose supply exceeds demand[7,8]. Trisaccharides such as 1-kestose, 6-kestose and neokestose, branched tetrasaccharides, such as bifurcose, and oligomers with a molecular mass higher than 2.0 kDa, are the common fructans in these plants[6,9]. Sucrose:sucrose fructosyl transferase seems to be involved in their synthesis[10].

However, the origin of fructans in C4 plants, such as sugar cane, is as yet unknown. It has been suggested that fructans accumulate in sugar cane juice as a direct function of the number of mechanical injuries or cuts to the stalks[11] or even as a function of plant age[12]. This could relate production of fructans to impairment or senescence. In addition, a fructanase which hydrolyses fructans has been found in sugar cane juices[5] and this enzyme seems to be synthesized after plant ageing.

We attempt in this work to investigate the possible origin of these fructans as well as some of the regulatory factors involved in the control of fructanase activity.

Materials and methods

Plant material

Sugar cane (*Saccharum officinarum* L.) of variety Cuba 374-72, field-grown, was used throughout this work.

Substrate preparation

Stalks from 12 months-old plants were mechanically crushed, immediately after cutting, and the raw juices were brought to 5% (w/v) trichloroacetic acid and centrifuged for 30 minutes at 20,000 *g* at room temperature. The pellet was discarded and the supernatant was adjusted to pH 8.0 by adding a saturated solution of ammonium carbonate, followed by filtration through Whatman No. 4 paper. Sodium azide was added to the filtrate to obtain a final concentration of 0.02% (w/v).

This clarified juice was then filtered through columns of Sephadex G-10 (15 cm × 2.5 cm), pre-equilibrated with ammonium carbonate solution containing 0.02 % sodium azide. Elution was carried out with the same solution. The first 20 1-ml fractions of eluate were discarded. Fractions 21 to 39 were collected and filtered through Sephadex G-50 columns (30 cm × 2.5 cm), pre-equilibrated as above. Fractions 40 to 70 contained the soluble, high molecular weight polysaccharides (SP fraction) whereas mid-molecular weight carbohydrates (MMWC fraction) eluted from 71 to 120 ml[13]. Carbohydrates were quantitatively measured in the different fractions by the method of Dubois *et al.*[14]. HPLC analysis[15] showed the absence of sucrose and monosaccharides in fractions 40 to 120 ml.

Cell wall isolation

Residues of sugar cane, after mechanical crushing of the stalks, were repeatedly washed with distilled water and ground in a mortar with liquid nitrogen to obtain a very fine, dry powder. After this, 50 g of residue were macerated with 200 ml of 40 mM citrate buffer at pH 6.0, and then centrifuged at 1500 *g* for 10 minutes at room temperature. The pellet was discarded and the supernatant centrifuged again at 3200 *g* for 30 minutes[16] to isolate cell walls. The supernatant was discarded, the pellet resuspended in 20 ml of 40 mM citrate buffer of pH 6.0 containing 2% (v/v)


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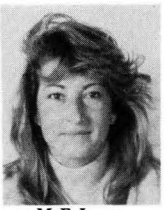
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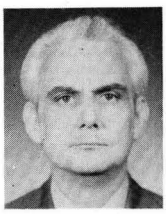

R. de Armas


M. M. Pedrosa


I. Medina


C. Rodríguez


C. Vicente

* Department of Plant Physiology, Faculty of Biology, La Havana University, Cuba.
** Plant Physiology Laboratory, Faculty of Biology, Complutense University, 28040 Madrid, Spain.

1 de Armas: in "La caña de azúcar en Cuba" (Científico-Técnica, Havana), 1987, pp. 385 - 408.
2 Roberts *et al.: I.S.J.*, 1976, **78,** 10 - 12.
3 Covacevich & Richards: *ibid.*, 1977, **79,** 3 - 9.
4 Roberts *et al.: ibid.*, 1985, **87,** 227 - 231.
5 Legaz *et al.: Plant Physiol.*, 1990, **92,** 679 - 683.
6 Meier & Reid: in "Plant carbohydrates", Eds. Loewus & Tanner. (Springer-Verlag, Berlin), 1982, pp. 418 - 471.
7 Pollock: *New Phytol.*, 1986, **104,** 1 - 24.
8 Wagner *et al.:* Plant Physiol., 1986, **81,** 444 - 447.
9 Shiomi *et al.: Agric Biol. Chem.*, 1976, **40,** 567 - 575.
10 Wagner & Wiemken: *Plant Physiol.*, 1987, **85,** 706 - 710.
11 Valdes & Rodríguez: *Ciencias Agric.*, 1982, (12), 118 - 122.
12 Rodríguez *et al.: ibid.*, 1985, (22), 63 - 68.
13 Idem: *ibid.*, 1985, (24), 55 - 61.
14 Dubois *et al.: Anal. Chem.*, 1956, **28,** 350 - 356.
15 Legaz *et al.: Lichen Physiol. Biochem.*, 1986, **1,** 35 - 46.
16 Brunner & Honegger: *Can. J. Bot.*, 1985, **63,** 2221 - 2230.

Tween 80 and incubated at 30°C for 4 hours. After this, the mixture was re-centrifuged at 3200 *g* for 30 minutes and repeatedly washed with buffer to remove detergent. Finally, the clean pellet was lyophilized and tested with methylene blue for the absence of membrane contamination.

Fructanase purification

Crude extract from crushed stalks (100 ml) was brought to 90% saturation with ammonium sulphate (w/v) and stored for 4 hours at 2°C. The suspension was centrifuged at 27,000 *g* for 1 hour at 2°C and supernatant containing the highest fructanase activity was dialysed against 5.0 litres of 1mM citrate buffer of pH 6.0, containing 0.02% (w/v) sodium azide, for 60 hours at 4°C. The buffer was changed 5 times during dialysis. The protein in the dialysate was adsorbed on calcium phosphate gel (75 mg dry gel per mg protein), and the protein was desorbed with increasing concentrations of citrate buffer (pH 6.0) from 1 to 30 mM (5 mM increments). The highest specific activity was obtained in the fraction desorbed with 15 mM citrate.

Enzyme assay

Hydrolase activity was measured in reaction mixtures of pH 6.0 containing 30 µg protein, 20 µmol sodium citrate, 2.5 µmol Mn^{++} (as $MnSO_4$), and 2.0 µg MMWC or 8.0 µg SP in a final volume of 1.3 ml. Reactions were carried out for 30 minutes at 30°C and stopped by adding a sufficient volume of 2N NaOH to give a final pH value of 8.0. Blanks contained no substrate or protein. Fructose produced during the reaction was determined with dinitrosalicylic reagent and the developed colour was measured at 540 nm[17]. Absorbance was transformed by using a straight line calibration made with known concentrations of fructose. Protein was measured by the method of Lowry *et al.*[18], using bovine serum albumin as a standard. One unit of fructanase activity was defined as 1.0 µmol of fructose produced per mg protein per min. Both SP and MMWC were substituted, where indicated, by oligo- or polysaccharides.

SE-HPLC of fructans and cell wall hydrolysates

Both SP and MMWC, eluted from Sephadex G-50, as well as hydrolysates from cell wall preparations, were chromatographed on a 30 cm × 7.8 mm PWSX GO209 HPLC column packed with G5000 PWXL, equilibrated with 40 mM citrate buffer of pH 6.0, using a Spectra Physics SP8800 liquid chromatograph equipped with a SP 4290 computer. Chromatographic conditions were: loading, 10 µl; temperature, 30°C; mobile phase, 40 mM sodium citrate buffer of pH 6.0; flow, 0.3 ml/min; detector, UV set at 280 nm. Blue dextran 2000 was used to measure void volume. Dextran (216 kDa), xylan (10.6 kDa), inulin (0.5 kDa) and sucrose (0.36 kDa) were used as molecular weight standards. The molecular mass of SP and MMWC was determined by plotting log molecular mass *versus* log (V_e/V_o), where V_o is the void volume of the column and V_e is the elution volume of each carbohydrate.

Fructanase action on cell walls

A known amount of dry cell wall preparation (0.25 g) was resuspended in 25 ml 15 mM citrate buffer of pH 6.0 to which 2.5 ml of 1.92 mM $MnSO_4$ was added. In parallel, 0.25 g of cell walls were resuspended in 25 ml of purified fructanase solution, containing 150 µg protein. Mn^{++} was added as above. Both suspensions were maintained for 9 hours at 30°C with continuous stirring. After this, suspensions were heated for 5 min in boiling water and centrifuged at 20,000 *g* for 15 min at room temperature. Supernatants were fractioned in two aliquots of 5.0 ml and 20 ml, respectively. Reducing sugars were measured in the first whereas the second fraction was filtered through Sephadex G-10 and G-50 columns, as above, to separate SP and MMWC.

Results

Substrate specificity

Purified fructanase is able to hydrolyse both SP and MMWC, as natural substrates occuring in sugar cane juice (Table I). However, starch, cellulose, dextran or hemicellulose (the last purified from sugar cane) are not hydrolysed by purified fructanase in standard conditions (Table I). No hydrolysis occurs by increasing the reaction time from 30 min to 2 hours.

Table I. Substrate specificity of purified fructanase from sugar cane juice

Substrate*	Specific activity (units)
SP	4.71
MMWC	3.82
Starch	0.0
Dextran	0.0
Inulin	0.0
Cellulose	0.0
Hemicellulose	0.0

* Reaction mixtures contained 2.0 µg MMWC or 8.0 µg of the other carbohydrates

Activity of fructanase on cell wall preparations

When fructanase is incubated with a suspension of sugar cane cell walls preparation, in the conditions specified above, effective hydrolysis of some fractions occurs. Reducing sugars are produced at a similar rate to that observed after spontaneous hydrolysis (or solubilization), but polymers are also produced after incubation. In this case, those chromatographically identified as SP are produced by fructanase action in an amount 6 times higher than that

17 Sumner: *J. Biol. Chem.*, 1921, **47**, 5 - 9.
18 Lowry *et al.*: *ibid.*, 1951, **193**, 265 - 275.

Table II. Effect of fructanase on isolated cell wall of sugar cane stalks

Incubation media*	SP, mg/g	MMWC, mg/g	Reducing sugars, µmol/g
Citrate buffer + 2.5 mM Mn^{++}	11.02	4.56	50.6
Fructanase in citrate buffer + 2.5 mM Mn^{++}	67.11	1.14	55.0

* Incubation was carried out at 30°C for 9 hours

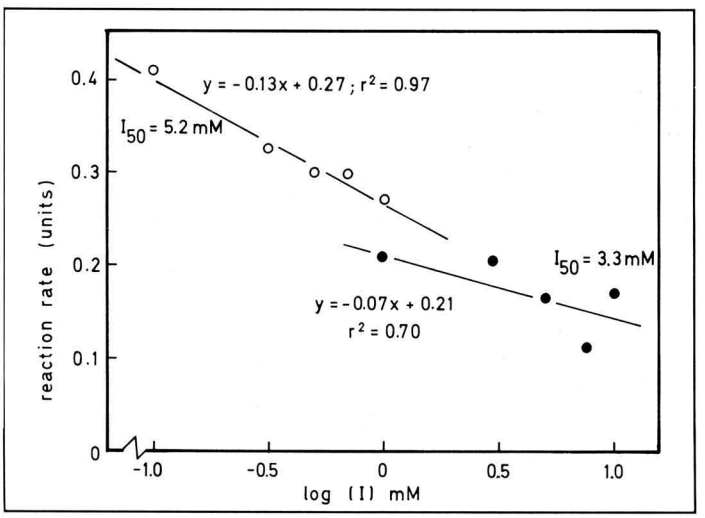


Fig. 1. Inhibition of fructanase by fructose (o) and galactitol (o) and estimation of I_{50} as metabolite concentration which produces 50% of enzyme inhibition

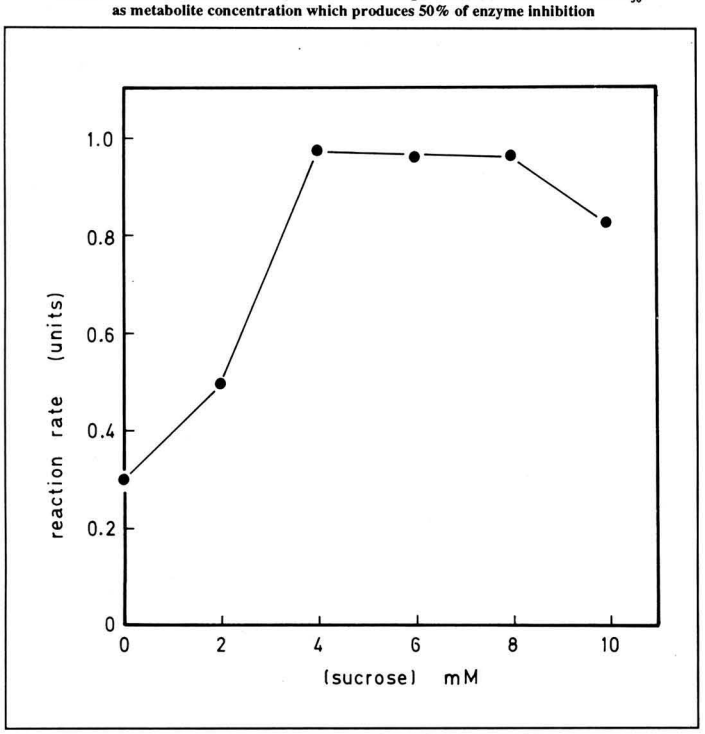


Fig. 2. Effect of sucrose concentration on fructanase activity

obtained after incubation of cell walls in citrate only (Table II). By contrast, the amount of MMWC recovered after fructanase action is a quarter of that recovered from the control.

Fructanase regulation by end-products and sucrose

Since hydrolysis products of both SP and MMWC are fructose and galactitol, the effects of these compounds on fructanase activity have been tested. Variable concentrations of both products, as well as those of sucrose as the major accumulable carbohydrate form in sugar cane juices, were pre-incubated for 5 minutes at 30°C with fructanase before substrate addition.

As is shown in Figure 1, both fructose and galactitol behave as fructanase inhibitors with I_{50} values of 3.3 mM and 5.2 mM, respectively. However, sucrose behaves as a powerful activator of fructanase in a range of concentrations varying from 2.0 mM to 8.0 mM (Figure 2).

Identification of the products of cell wall hydrolysis

Enzymatic hydrolysis of cell walls produces three main polymers, with retention times in SE-HPLC of 16.54, 19.21 and 27.24 minutes. The same molecules are produced by incubating cell wall preparations in distilled water to which Mn^{++} is added. However, the main peak after spontaneous hydrolysis elutes at 27.24 min whereas the main polymer produced after enzymatic hydrolysis is eluted at 16.54 min. Purified SP from Sephadex G-50 is resolved in SE-HPLC in two peaks, the main eluting at 17.83 min and a secondary at 27.53 min. MMWC shows a similar secondary component, with a retention time value of 27.37 minutes, where as the main peak elutes at 18.90 minutes (Figure 3). This implies that SP is a heteropolymer with a molecular mass of about 1734 kDa whereas MMWC has a molecular mass of about 871 kDa. Both purified fractions are contaminated with a limit dextran with a molecular mass of about

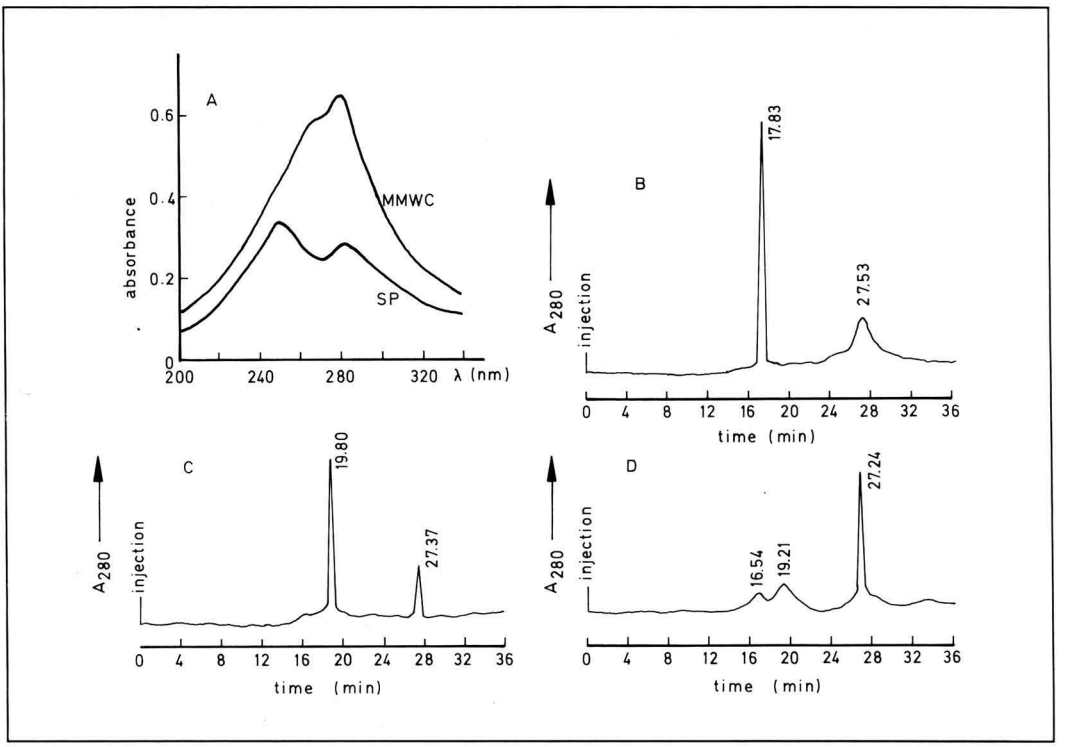


Fig. 3. (A) UV spectra of SP and MMWC at selected wavelengths and HPLC traces of (B) purified SP; (C) purified MMWC; (D) buffer-solubilized cell wall components

8.2 - 9.0 kDa (Figure 4).

Discussion

As is shown in Table I, polymers other than those containing fructose are not hydrolysed by the enzyme purified from sugar cane juice. Even those involved in cell wall structure, such as cellulose and hemicelluloses, are not available substrates for fructanase. Hence, this hydrolase seems to have a very restricted specificity against natural carbohydrate polymers. However, walls of parenchymatous cells of sugar cane stalks seem to contain another polymer different from those normally described for these structures[19], since fructanase is able to produce mainly SP from a fraction of recently prepared cell walls. It could be hypothesized that SP are the only soluble polysaccharides in the juice, probably translocated from the leaves, which adsorb on the cell wall during experimental manipulation. However, this hypothesis is not supported by the fact that incubation of cell wall preparation with fructanase improves SP production to a level at which the amount of SP removed from the cell wall was 6 times higher than that obtained after incubation without enzyme (Table II). It may be concluded that cell wall possesses a structural polymer, containing fructose and galactitol, from which SP can be obtained by controlled hydrolysis by fructanase.

On the other hand, SE-chromatography on Sephadex G-50 of enzymatically hydrolysed cell walls reveals the occurrence of products which are normal components of sugar cane juices, defined as SP and MMWC[13] (Table II). The main characteristic of the hydrolytic process concerns the relative amounts of both polymers produced from cell walls. Whereas SP are mainly produced by enzymatic hydrolysis of some cell wall components, MMWC are removed from these structures by solubilization or spontaneous, non-enzymatic hydrolysis (Table II). In this way, the original hypothesis that fructans, (or SP) could be considered as a defence response of sugar cane to cutting[11] acquires relevance. Mechanical injury produces a local response of fructans formation to achieve scar tissue formation. If the cut

19 Basic *et al.*: in "The biochemistry of plants", Ed. Preiss. (Academic Press, San Diego), 1988, **14**, pp. 297 - 371.

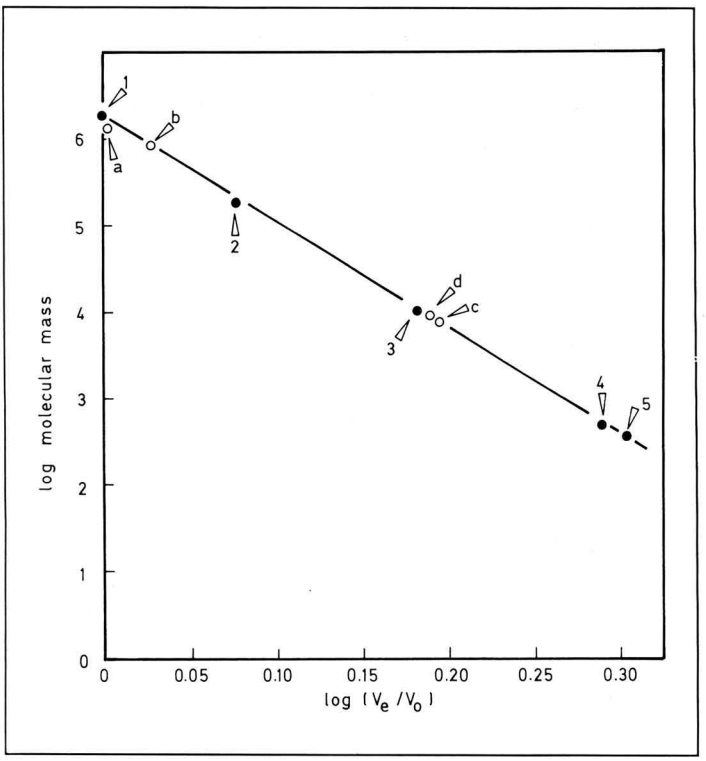


Fig. 4. Determination of molecular weight of both SP and MMWC by SE-HPLC; Standards were (1) blue dextran 2000; (2) dextran; (3) xylan; (4) inulin; and (5) sucrose. Products were: (a) large SP; (b) large MMWC; (c) small SP; (d) small MMWC, (c) and (d) being possibly a limit dextran produced by hydrolysis of the polymers

is produced during industrial ripening when sucrose content is high and the amount of reducing sugars low[1], sucrose activates fructanase (Fig. 2) and SP appear in juices as a product of the hydrolysis of scar tissue polymers.

Apparently, production of SP by hydrolysis of matrix polymers in the cell wall is not accomplished by an increase in the production of reducing sugars (Table II). However, fructanase activity on both SP and MMWC produces fructose[5] as reducing sugar, and galactitol. This implies that hydrolase activity, considered as a depolymerase, only produces reducing sugars after partial hydrolysis of SP to produce MMWC[20], or after MMWC hydrolysis. In this way, it can be accepted that fructanase-catalysed hydrolysis of wall polymer, when it is achieved on this structure, only produces SP. This can explain the low amount of MMWC found after incubation of cell wall preparation with purified fructanase (Table II), even lower than that obtained after incubation in citrate buffer. Whether fructanase activity can be regulated on a solid matrix to avoid production of reducing sugars, which would inhibit the enzyme, or two isozymatic forms of fructanase exist, one of them as cell wall pelletable protein and another as soluble enzyme, activated by sucrose in the cytoplasm of parenchymatous cells, must be investigated in the near future.

Acknowledgements

This work was supported by a grant from the Dirección General de Cooperación con Iberoamerica, Ministerio de Educación y Ciencia of Spain.

20 de Armas *et al.: Proc. 20th Congr. ISSCT*, 1989, in press.

Facts and figures

Guatemala sugar production estimate increase[1]

Sugar industry sources in Guatemala expect production from the 1989/90 crop to rise by 10% to a total of 725,755 tonnes. The increase is the result of better use of the soil and of improved techniques. Exports in 1990 are expected to amount to 362,878 tonnes, a drop of 18,144 from 1989. This is due to an increase in domestic consumption which, however, conceals contraband exports to Mexico where sugar prices are higher.

Rumania sugar crop disruption[2]

Since the revolution in Rumania land tenure has been transferred to private farmers and it is now more difficult to coordinate and forecast the likely levels of production in different crops. Local press reports quoted by Reuters expect new crop production from beet to fall to 300,000 tonnes, or around half national requirements. The Ministry of Agriculture has announced that this reduced level of production would be sufficient only to meet direct consumption needs. Industrial users would require a similar amount over and above this. Under the previous regime sugar for private consumption was rationed but officials have said that the new provisional government would be reluctant to restore restrictions.

1 *GEPLACEA Bull.*, 1990, **7**, (4), Sugar Inf.-2.
2 *Czarnikow Sugar Review*, 1990, (1795), 53.

Design and evaluation of a pan stirrer

By P. R. Purdham and M. G. S. Cox
(Hulett Refineries Ltd. and Tongaat-Hulett Sugar Ltd., Durban, South Africa)

Introduction

A number of papers have been published on the benefits of mechanical stirrers in vacuum pans. The authors generally agree that the main benefits are to be found in improved crystal yields, better crystal quality, higher production rates and energy savings.

During 1987, an Ekato 5-bladed Kaplan stirrer was installed in No. 2 refined sugar pan at the Hulett refinery. The two primary objectives were: first, to allow the use of exhaust steam without sacrificing production capacity, and second, to reduce the conglomerate level of the sugar. These improvements would allow an optimization of the refinery steam balance and a reduction in conditioning time, giving increased bulk sugar silo capacity.

Although these objectives were not met, benefits in lower colour formation during boiling and higher yields were found. Modifications were made to allow the stirrer speed to be varied, the best results being found at the highest speed.

A new stirrer of the marine helical screw type was installed. A variable pitch was incorporated to allow higher speeds and maximize on axial flow as opposed to the mixed flow characteristics of the Kaplan turbine.

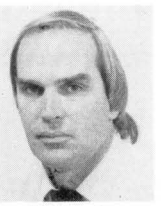
This paper discusses the logic behind the design and the results obtained during evaluation. The performance of the unstirred pan, the Kaplan stirrer and the helical screw stirrer are compared under a range of conditions.

Theory

Rheology of refined sugar massecuites

When designing stirrers for pans, calculation of the massecuite viscosity is important. With low-grade boilings this can be done with a fair measure of accuracy. However in refined sugar pans, the massecuite, with up to 60% crystal content, shows greater non-Newtonian behaviour[1]. Some information is available of estimated viscosities of refined massecuites[2]. These are given in Table I.

P. R. Purdham



M. G. S. Cox

A Newtonian fluid is one in which the viscosity of the fluid remains constant with variation in shear rate. For an impeller moving in a fluid, this would mean that the viscosity would remain constant as the speed of the impeller changes.

One type of non-Newtonian behaviour, where the viscosity of the liquid decreases with increasing shear rate, is called pseudoplasticity. From the initial results obtained on varying the speed of the Kaplan impeller, it was found that the refined sugar boilings behaved in a manner that could be explained by non-Newtonian pseudoplastic rheology. Advantage of this important observation was taken in consideration in the design of a high-speed helical screw impeller.

Table I. Massecuite viscosities

Refined sugar boilings		5 Pa.s.
Recovery sugar boilings:	1st crop	17 Pa.s.
	2nd crop	100 Pa.s.
	3rd crop	3000 Pa.s.

Kaplan impeller vs. *helical screw impeller*

The two basic designs of impeller are the Kaplan turbine and the helical screw. The blades of the Kaplan turbine tend to be wide, with rectangular edges and having the same blade at the root and the tips. The model that was originally fitted at the refinery had three planes as shown in Figure 1.

This design gives a mixture of axial and radial flow and promotes a certain amount of back-mixing in the downtake. It produces excellent thrust and flow characteristics, especially at low speeds. The Kaplan impeller is suited to tubular calandria pans where there is relatively high resistance to flow. It finds widespread use in both refined and low-grade boilings.

The helical screw impeller has narrower, elliptical blades that have a greater angle at the root than at the tips. This gives a higher proportion of axial flow and performs better at higher speeds[3].

Paper presented to Sugar Industry Technologists, 1989.

1 Austmeyer & Kipke: *Zuckerindustrie*, 1979, **104**, 395 - 401.
2 Hill *et al.*: *I.S.J.*, 1969, **71**, 37 - 39, 67 - 71, 109 - 112.
3 Kuijvenhoven: "Aspects of continuous sucrose crystallization" (Delft University of Technology) 1983, Publication WTDH156.

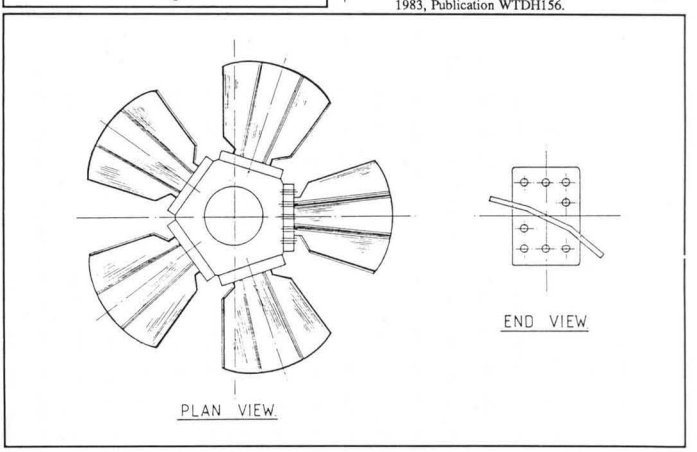


Fig. 1. Kaplan turbine impeller

According to Kuijvenhoven[3], at low speeds and with a Reynolds number < 5000, the Kaplan turbine out-performs the helical screw with regard to flow. At higher speeds, with relatively low massecuite viscosities, the flow characteristics of both impellers become almost the same. However the power requirement for the helical screw is substantially lower. With a given amount of power available, increasing the speed of the helical screw will give a maximization of axial flow.

It may be seen that the region of operation at the high speeds of 135 and 147 rpm, gives the helical screw impeller an advantage over the Kaplan impeller with regard to axial flow per unit of power.

The clearance

One major difference between Kaplan and marine impellers is their response to the clearance between the impeller tip and the wall of the downtake. Kipke[4] shows that, at a tip clearance of 5% of the impeller diameter, the volumetric pumping efficiencies of both types of impeller are the same. The Kaplan impeller gives a fairly constant rate up to a clearance of 20% of the impeller diameter whereas the marine impeller loses efficiency rapidly as the clearance increases. At a tip clearance of 20% of the impeller diameter, the marine impeller has lost half of its pumping efficiency.

The Huletts impeller has a tip clearance of 6.8% of the impeller diameter, with an actual clearance of 82.5 mm and a diameter of 1200 mm.

The ability to operate with large tip clearances explains why Kaplan stirrers can be designed without a bottom bearing, while marine impellers need some form of steadying at the bottom of the shaft.

Table II. Reynolds numbers for refined massecuites* at different impeller speeds

Speed, rpm	Reynolds No.
90	2860
120	5080
135	6420
147	7620

* Density of massecuite taken as 1.4 kg/m³ and viscosity as 5 Pa.s

Materials and methods

Scope of investigations

The evaluation work extended for more than a year, covering a range of massecuites with and without stirrers. The main variables included stirrer type, stirrer speed, blade pitch, steam pressure and sugar grade.

Initially the performance of pans 1 and 2 without stirrers was monitored. Both pans were boiling 1st sugar from the same feed material and these data gave a base level from which to measure improvements. Low pressure steam runs on 1st boilings in pan 2 and normal 4th boilings in pans 3 and 4 were also evaluated before stirrers were fitted.

Pan 2 was then fitted with a Kaplan stirrer running at 120 rpm and a series of tests using different steam pressures were run. After these tests the feed inlet in pan 2 was modified to feed directly into the downtake above the impeller in order to improve mixing. The stirrer was then tested at different speeds (68, 120 and 133 rpm).

The Kaplan stirrer, while giving major improvements in some areas, did not live up to all its promises, especially with regard to boiling with low steam pressure. In view of the possibility of fitting stirrers to all the refinery pans and the savings that could be made if the units were designed and built "in-house", the Refinery Engineering Department designed and fitted a stirrer to Pan 2.

The Huletts stirrer was tested at different speeds (120, 133 and 147 rpm), and coarse and fine blade pitches. All the testwork on the Huletts stirrer was on 1st boiling sugar and with the normal steam pressure of 330 kPa.

Pan and stirrer details

The pan construction and dimensions were as follows:

Strike volume (m³)	52
Diameter (m)	4.4
Calandria	Ribbon
Number of ribbons	12
Downtake diameter (m)	1.37
Calandria open area (m²)	9.0
Downtake open area (m²)	1.7
Heating surface (m²)	
Elements	181
Bottom jacket	7
Side jacket	13
Total	201

The stirrer motor was of dual speed, giving a high speed of 1450 rpm (55 kW) and low speed of 960 rpm (38 kW). The motor was set to trip at 70 Amp in both cases.

The gearbox was a 12.5:1 Radicon CS17 unit, 1000 Nm at 80 rpm, and driven by V-belts from motor to gearbox. The stirrers are compared below:

	Ekato	*Huletts*
Type	Kaplan turbine	Helical screw
Shaft		
Length, m	12.3	12.3
Diameter, mm	140	200
Type	Solid	Pipe
Blades		
Number	5	4
Diameter, m	1.2	1.2
Pitch	Fixed	Variable

Stirrer design

Choice of impeller design

In choosing a helical design, the following points were considered.

(a) In the Huletts ribbon calandria pans, the ratio of the area of the downtake to the open area of the calandria is 0.18 compared with about 0.5 for a typical tubular calandria pan. Maximizing flow through the downtake is thus an important requirement, especially at the end of the boiling cycle.

(b) The viscosity of refined massecuites at about 5 Pa.s is relatively low compared with that of low-grade massecuites. This gives low resistance to flow as described above.

(c) The non-Newtonian behaviour of the massecuite, as described prev-

4 *Zuckerindustrie*, 1980, **105**, 231 - 234.

iously, indicated a design for maximum rotational speed.

Helical screw impeller design

Information on the design of the impeller was obtained from design data for marine impellers[5]. The best efficiency is obtained with three blades for moderate loading and four blades for heavy loading. A choice of four blades was made; this would have less drag than the five-bladed Kaplan design. An "average" width to diameter ratio of 0.3 at 0.7 diameter was chosen, giving a blade width of 370 mm at 0.7 diameter. This is substantially thinner than a Kaplan turbine.

A 0.8 pitch ratio seems to give the transition between high and low efficiencies. This pitch was chosen and provision was made for varying the pitch exactly 10° either way.

During the tests only two blade positions were used; the normal position referred to as "fine" and the +10° setting referred to as "coarse".

Table III. Impeller pitch values

	−10°	Normal	+10°
Tip angle	4.3°	14.3°	24.3°
Root angle	31.9°	41.9°	51.9°
Diametral pitch	0.45	0.8	1.35

Blade profile

The blade profile chosen was that of a distorted ellipse given by:–

Bw = (1/2 + 2d/D) (Width of elliptical outline)

Where Bw = blade width, D = blade diameter, and d = diameter at which width is measured.

As the propeller would be working inside the downtake, the ellipitical outline of the blade tip was truncated, making the blade width 200 mm at the tip. The other constraint was that the maximum width of the blade at 0.7 diameter would be 370 mm, as previously stated. From this an expression of blade width was formulated.

$$Bw = 205\,[1/2 + 2d/D][1 - (325 - d/2)^2/(300)^2]^{1/2}$$

This equation generates the profile in Figure 3 which is superimposed on the Kaplan turbine profile.

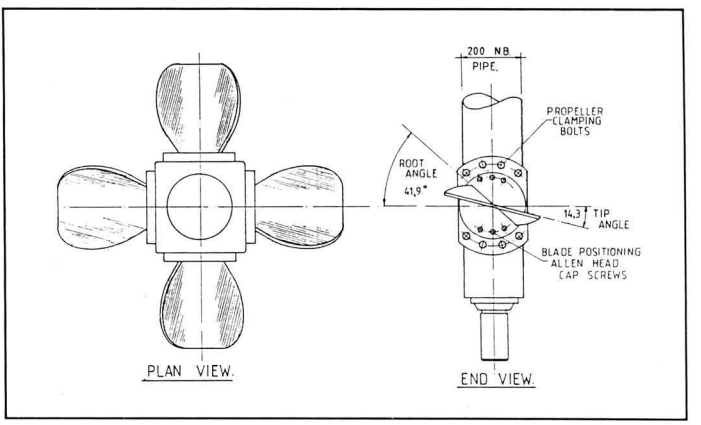


Fig. 2. Helical screw impeller

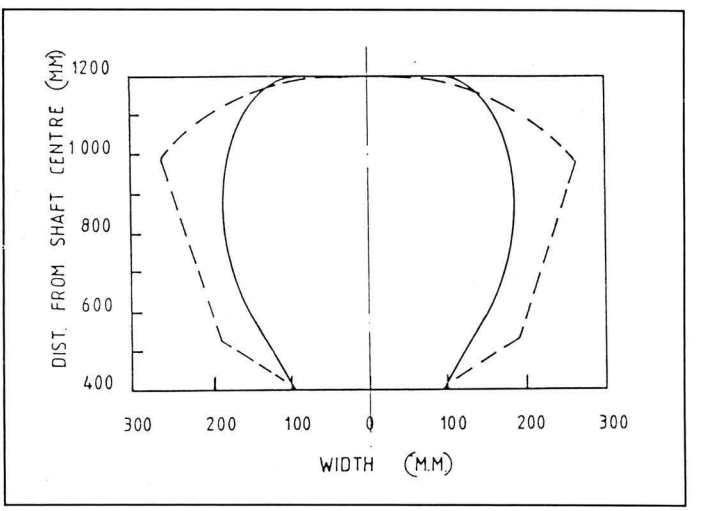


Fig. 3. Impeller blade profiles

Drive shaft design

One of the limitations of the first stirrer installations was the flexibility of the shaft. As speeds were increased the shaft had a tendency to whip. Calculations were done with regard to stress in the shaft due to the torque, and this was found to be well within the limits of yield stress. A check was done considering the shaft as an Euler strut with a compressive load caused by the thrust of the impeller. This again was within permissible limits.

Calculations were done for the transverse vibration of the shaft, considering it as a simply supported beam and neglecting the weight of the impeller. The natural frequency at the lowest mode was found to be 15 Hz which represents a rotational speed of 143 rpm.

5 Baker: "Ship design, resistance and screw propulsion" Charles Birchall and Sons Ltd.), 1951.

ISJ Abstracts

Cane sugar manufacture

Cane diffusion: a high efficiency process

A. G. Salerno. *STAB*, 1987, **5**, (4), 35 - 37 *(Portuguese)*.

The use of cane diffusion in Brazil is briefly reviewed, and an account given of the Zanini diffuser which can be used for cane or bagasse. Details are given of the design, process variables, and operation.

Neutralization of juice with calcium saccharate

D. T. Oliveira, W. Pizaia, F. C. Sampaio and C. E. V. Rossell. *Bol. Técn. Copersucar*, 1987, (38), 16 - 128 *(Portuguese)*.

Use of calcium saccharate instead of milk of lime is not widely practised in Brazil and a description is given of the preparation, distribution and use of the material as well as comparative practical results achieved at Usina Cresciumal whereby lime usage was reduced with almost the same consumption of sulphur and polyelectrolyte, the clear juice was less turbid and the ICUMSA colour of the sugar produced was lower, although the ash was higher. The clarifier mud volume was slightly greater and it was more liquid, which could cause problems in filtration.

Economic factors in the pneumatic conveying of bagasse

Anon. *Ing. Energ.*, 1987, **8**, (1), 93 - 96 *(Spanish)*.

A major advantage of pneumatic conveying is the lower energy consumption than in mechanical conveying. The specific energy consumption and the coefficient of effective operation (representing the proportion of energy in the compressed air that is absorbed by the material) were determined for bagasse having a particle size (i) <20 mm and (ii) <1.5 mm pneumatically conveyed in a 10 m long vertical and horizontal tube. In the vertical tube, energy consumption fell with increase in particle size in case (i) but a minimum was reached at a gravimetric concentration of 0.6; in both cases, the economically optimum flow rate was the minimum constant velocity. In the horizontal tube, the economically optimum rate of 13 m/sec was not the minimum constant with both particle sizes; the minimum constant velocity of 8 m/sec achievable with (i) was insufficient to move the bagasse in case (ii).

Biocides from fermentation wastes. Influence of temperature and time

G. L. Mendoza, E. F. Díaz and S. Acosta D. *Centro Azúcar*, 1987, **14**, (2), 3 - 8 *(Spanish)*.

The adverse effect of *Leuconostoc mesenteroides* in stale cane on juice processing and biocides available to combat the micro-organism are discussed. Amine groups in fermentation waste were reacted with carbon disulphide to yield a product which was then tested as a biocide on pure cultures of *L. mesenteroides*. Results showed that the temperature and reaction time (optimum values of which were established) had a positive effect on the formation of the active ingredient in the biocide and on the free alkali content.

Evaluation of the system for treatment of waste water at Hermanos Ameijeiras sugar factory

I. Morell F., L. Martínez M., L. J. Hernández, T. Hernández M., J. Favelo F., G. Veiga G., A. Portal P. and I. Pérez C. *Centro Azúcar*, 1987, **14**, (2), 9 - 15 *(Spanish)*.

Investigation of waste water treatment in an anaerobic basin followed by a facultative basin showed generally negative results, with increase in the total organic load and in the chloride level. The system is subject to considerable fluctuations in the hydraulic and organic loads. Greater control should be exercised over the discharge of effluent to the ponds before any modifications are carried out.

Approximate determination of the performance curves of the 1 1/2

CORVL pump on Cuban molasses

I. Pedroso M., S. Jáuregui R., O. Cruz F. and W. Vázquez R. *Centro Azúcar*, 1987, **14**, (2), 30 - 35 *(Spanish)*.

The performance of the title pump on diluted and undiluted *A*- and *B*-molasses was investigated; the results, which are discussed, are expected to be of help in the choice of motor for molasses handling.

Statistical analysis of final molasses

I. Camacho R., S. Járegui R., O. Cruz F. and D. Roque F. *Centro Azúcar*, 1987, **14**, (2), 36 - 40 *(Spanish)*.

Statistical analysis by computer of data (Brix, purity, reducing sugars, pol, sucrose, total sugars and ash) obtained for final molasses from two seasons at 10 Cuban sugar factories revealed significant differences between both factories and crops in all but the ash content.

Pitting corrosion of stainless steel in sugar industry heaters

R. Quintero and R. Caro. *Centro Azúcar*, 1987, **14**, (2), 41 - 48 *(Spanish)*.

Three types of Soviet stainless steel were investigated for their susceptibility to pitting in limed juice containing 50, 360 and 800 ppm Cl^-. The results demonstrated how corrosion occurred even at the lowest chloride concentration and increased as it rose.

Computer program for determination of the energy consumption in the pan station of a sugar factory

M. J. Carrillo A., R. Espinosa P., S. Machado B. and M. Sánchez L. *Centro Azúcar*, 1987, **14**, (2), 49 - 52 *(Spanish)*.

Details are given of a computer program which allows determination of the heat and steam consumption in a pan station as a function of the type of massecuite boiled and the type of heat carrier, i.e. whether it is exhaust steam or juice vapour.

Electropurification of mixed juices by means of electrolysis

F. H. Pérez S. and M. J. Castro F. *Centro Azúcar*, 1987, **14**, (2), 53 - 59 *(Spanish)*.

Electrolytic treatment of mixed juice was tested at 0 - 15 volts and 1 - 10 amp using stainless steel, graphite or aluminium electrodes. Results showed that the process gave higher apparent purity and lower colour than conventional liming and heating and eliminated all the bacteria usually found in juices. The Al electrode proved the most suitable, and best results were obtained at an initial pH of 5.5 and a current charge of 5.302 coulomb/litre.

Influence of lighting on payment for abnormal working conditions

B. Arencibia A. and L. Gómez J. *Centro Azúcar*, 1987, **14**, (2), 77 - 82 *(Spanish)*.

The question of payment for work under conditions of poor, normal or brilliant lighting in a sugar factory is discussed and a number of recommendations are made.

Bibliographical analysis of the factors affecting the value of the overall heat transfer coefficient in evaporators

O. Jímenez, H. Pérez A. and B. Traore. *Centro Azúcar*, 1987, **14**, (2), 83 - 91 *(Spanish)*.

Evidence from the literature (33 references) is analysed concerning the effects of 21 variables on the overall heat transfer coefficient in evaporators. It is concluded that there is still a shortage of precise information on a number of aspects, including the effects of surface tension and of Brix.

Steam balance and energy conservation in sugar factories and distilleries

C. A. de Camargo. *Brasil Açuc.*, 1987, **105**, (2/3), 44 - 53 *(Portuguese)*.

Based on a study over 31 months involving 20 installations including both sugar factories and autonomous distilleries, a system was developed whereby the operations at the plants was divided into five modules covering cane preparation and juice extraction, boiler water pumps, turbogenerators, distillery and sugar production. The steam consumption at each is considered in order to create a steam balance.

New techniques and processes which permit raising the bagasse surpluses of sugar factories and distilleries

J. L. Olivério and R. J. Ordine. *Brasil Açuc.*, 1987, **105**, (2/3), 54 - 89 *(Portuguese)*.

The Dedini company, for which the authors work, has since the early 1980's been concerned with technological advances which could provide additional income for sugar producers, particularly in the liberation of surplus bagasse and its utilization, as well as utilization of other materials. A wide range of steps which may be taken to improve thermal efficiency have been considered and the surpluses of bagasse which can be achieved by particular measures are illustrated. The development of boilers and turbines of greater efficiency by Dedini is reviewed, as is the Flegstil process for improved thermal efficiency in distilleries. Methods of raising the surplus of bagasse in distilleries are discussed, and use of this for cogeneration of steam and power described by text and diagrams including details of actual installations. The potential for such surpluses and power output in São Paulo state and in Brazil are discussed.

Natural drying of baled bagasse

J. L. de Sobral, G. V. S. Barbosa, L. F. S. Monteiro and M. F. Silva. *Brasil Açuc.*, 1987, **105**, (2/3), 90 - 93 *(Portuguese)*.

Baled bagasse was stored in a shed and under two kinds of plastic sheeting, and the moisture loss of each was recorded daily. The data were examined statistically and exponential equations derived for the relationships between moisture loss and time. Loss was greatest in the bagasse in the shed but was about half of the original after an average of 50 days.

Proposal of technological change and material balance at Argelia Libre sugar factory. II

I. Galbán D., P. Anzardo P., J. Burianek and R. Rodríguez E. *CubaAzúcar*, 1987, (Apr./June), 3 - 10 *(Spanish)*.

A balance showing the composition of the intermediate products and the mass flow of their components in a modified white sugar scheme was obtained by entering 40 sets of data into a computer. Attention to the *B*-strike and to recirculation of *B*-molasses to intermediate boiling will allow desired levels of white sugar quality and final molasses purity to be achieved.

Effect of pH on corrosion of copper in sugar industry heaters

R. Quintero, R. Caro and V. Palacios. *CubaAzúcar*, 1987, (Apr./June), 15 - 20 *(Spanish)*.

A study of copper tube corrosion in juice heaters (which has increased in factories using liming) showed that a rise in pH and not juice flow rate had the greatest harmful effect.

General corrosion of stainless steels in mixed juice

G. Rodríguez V., C. Segarra and R. Monduí G. *CubaAzúcar*, 1987, (Apr./June), 3 - 10 *(Spanish)*.

Investigations on 10 types of stainless steel showed that all offered good resistance to corrosion, with high-carbon martensitic and austenitic steels giving poorest results. The corrosion rate increased in all cases with a greater C and Cr content and a lower Ni content.

Fourth roller in a mill

L. Rivas. *Rev. Asoc. Técn. Azuc. Méx.*, 1988, **1**, (3), 27 - 31 *(Spanish)*.

The performance of a conventional 3-roller mill and the improvements made possible by adding a fourth roller with a Donnelly chute are discussed. While the compaction coefficient is the most important factor affecting the performance of a fourth roller, the reabsorption factor is the one that will decide the benefits or otherwise of installing one. The greater the compaction and hence the compression coefficient, the higher will be the extraction, particularly with good cane preparation; at the same time, the extra roller will cause a reduction in the mill speed which will in turn decrease the reabsorption factor and contribute to increased extraction. Hence, the extra roller plus the feed chute constitute an inexpensive means of increasing mill performance. Advice is offered on construction and installation of the roller.

Usina Maracaí S.A. - Açúcar e Alcool: Companhia Agrícola Santa Olga

Anon. *STAB*, 1987, **5**, (5/6), 4 - 9 *(Portuguese)*.

The title sugar factory/distillery, located in São Paulo state in Brazil, first operated in 1957/58 and in 1985/86 crushed 400,684 tonnes of cane to produce 47,680 tonnes of sugar and 600,022 tonnes of cane to produce 465,000 hl of anhydrous alcohol. Details are provided of the company's executives, of the location and edaphoclimatic conditions of the cane supply area (some 12,650 ha, of which two-thirds is company owned), varieties, soil preparation, planting and cultivation methods, biological control of borers, harvesting, loading and transport of cane, reception and feeding to the mills, cane washing, preparation and crushing, juice treatment, evaporation, boiling and crystallizer operation, centrifugation and drying of sugar, as well as fermentation and distillation, storage of sugar and alcohol, electricity and steam generation, and laboratory control as well as a table of data from the 1985/86 season.

Evaluation of the performance of different cane wash water systems in Alagoas

M. R. G. F. Lôbo, R. G. de Souza, A. C. Toledo and A. C. Dutra. *STAB*, 1987, **5**, (5/6), 39 - 42, 44, 46, 48, 50 - 53 *(Portuguese)*.

During 1985/86 the performance of three different methods of treating cane wash water, in use at a number of distilleries, was assessed. The best from the point of view of efficiency, ease of operation and low cost was considered to be that at Sumaúma where the water was screened to remove large impurities and sent to a decanter. From this 1800 cu.m./hr of water was returned to the washer while 300 cu.m./hr of the mud was screened for removal of sand, thickened and 20 cu.m./hr of the thickened mud discharged. The water was adjusted to pH 11 - 11.5 with lime and this was shown to influence the bacterial growth, but COD was high. Experiments showed the greater corrosion occurring when the wash water was acid than when it was alkaline.

Twenty years of operation with Cristal 600

E. Díaz G. *ATAC*, 1987, **46**, (3), 43 - 48 *(Spanish)*.

The techno-economic benefits of using Cristal 600 seed slurry in Cuban and other sugar factories since 1968 are discussed and the process used for its preparation is described.

Conversion of a mill from three to four rollers

C. Y. Ospina and C. F. Pérez. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 611 - 619 *(Spanish)*.

Installation of two 4-roller mills (one before and one after an existing tandem of four 3-roller mills) at Risaralda sugar factory in two stages increased the reduced extraction from 90% to 94.3% (after the new No.1 mill was introduced) and then to 95% when the new 6th mill was installed. The 4-roller mills were modifications of 3-roller units. Details are given of the procedure used to add a 4th roller and to calculate the setting of the 4th roller. The advantages of a 4-roller mill with a Donnelly pressure feed chute are indicated.

Systematic maintenance at Ingenio Risaralda S.A.

C. Y. Ospina and T. A. Silva F. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 621 - 631 *(Spanish)*.

The maintenance system used at the title sugar factory is described with the aid of a flow diagram indicating maintenance priorities and workload distribution. The maintenance and lubrication activities for specific pieces of equipment are listed. The scheme allows continued operation of equipment at full nominal capacity.

Comparative evaluation of two surface-active additives on an industrial scale at Ingenio Riopaila S.A.

F. L. Rivillas, H. A. Trujillo and D. A. Ortíz Z. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 659 - 665 *(Spanish)*.

Trials on the use of massecuite surface-active additives in low-grade boiling showed that, although a surfactant already used at Riopaila gives higher sugar recovery and lower molasses losses than would be the case without it (as demonstrated by an untreated control batch), even better results could be achieved by replacing the surfactant with a new one (neither product being named).

Pneumatic agitation in pans

P. Alamo M. and J. Garcés O. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 673 - 683 *(Spanish)*.

The system developed by Air-Gut S.A. for massecuite circulation by agitation with compressed air is described. It has been found to reduce energy consumption, increase heat transfer, cut the boiling time (or allow the use of lower

temperature vapour without altering the time) and improve crystal quality. The system is easy and quick to install without any major pan modifications. (See also *I.S.J.*, 1989, **91**, 15A.)

Analysis of bagasse combustion in the furnace chamber

L. O. Ruiz, P. B. Soler and E. Silva L. *Ing. Energ.*, 1987, **8**, (3), 203 - 208 *(Spanish)*.

An analysis of combustion behaviour of bagasse having a particle size of 1.35 and 6.9 mm showed that combustion took place principally in the diffusion zone, so that established theoretical models are applicable to bagasse. Heat transfer during the diffusion process was less important than convection and radiation. The equivalent aerodynamic diameter of bagasse particles was the most representative bagasse parameter for use in the studies.

Specific heat of bagasse at temperatures between 303 and 323 K

A. R. Recio, L. O. Ruiz and S. M. Shestakov. *Ing. Energ.*, 1987, **8**, (3), 209 - 214 *(Spanish)*.

The specific heat of bagasse depends on the degree of change in its composition during storage, its ash and moisture contents and on temperature. Equations developed for calculation of the specific heat of bagasse at temperatures in the range 303 - 323°K (30 - 50°C) gave values in satisfactory agreement with experimental results. Studies showed that the specific heat fell with increase in pressure applied to bagasse.

Dynamics of the movement of small bagasse particles in a vertical trajectory

G. A. Roca A. and M. A. Boizán J. *Ing. Energ.*, 1987, **8**, (4), 375 - 379 *(Spanish)*.

Studies on bagasse containing 10, 30 and 50% moisture showed that the final velocity of fall in a vertical current of air increased with particle size (0.3 - 2.8 mm) and moisture content and fell with rise in air temperature. The entrainment velocity of a particle of given moisture content was not constant but depended on the air velocity and temperature. The mathematical model developed allowed determination of the entrainment velocity with variation in any of the parameters studied. The trajectories of a particle during movement at a variable velocity were compared with those when the air was not flowing.

Syrup treatment with dextranase and alpha-amylase

Anon. *Mem. An. Estac. Exp. Agro-Ind. "Obispo Colombres"* (Tucumán, Argentina), 1986, 129 - 130 *(Spanish)*.

In tests on treatment of 60°Bx syrup with dextranase and/or α-amylase to reduce the polysaccharide content from an initial 2269 ppm and so improve crystallization and sugar quality, a maximum of 49.4% removal was achieved by 3 hours' incubation of 20 g/tonne dextranase + 6 g/tonne amylase at 60°C; this compared with 47.6% reduction using 40 g/tonne dextranase alone.

Determination of kinetic parameters governing the process of bagasse thermal decomposition and combustion

E. Silva L. and P. B. Soler. *Ing. Energ.*, 1988, **9**, (2), 164 - 168 *(Spanish)*.

Thermographic analysis of bagasse pyrolysis and combustion showed that emission of volatile matter starts at approx. 205°C, while the maximum rate of hemicellulose decomposition took place at 305°C and of cellulose at 350°C. The activation energy was calculated for emission of volatile substances in a nitrogen atmosphere, for combustion of volatile matter in air and for combustion of the clinker formed from bagasse; values for various types of wood are also tabulated for the sake of comparison.

Usina Trapiche S.A.

Anon. *STAB*, 1987, **6**, (1), 48 - 51 *(Portuguese)*.

The title factory/distillery, in Pernambuco state in Brazil, crushes 7000 t.c.d. to produce 750 tonnes of sugar per day and 2000 hl of alcohol. Some 65% of the cane comes from company owned land and the balance from growers. Details are given of edaphoclimatic conditions, varieties, soil preparation, planting, fertilization, weed and pest control, harvesting, loading, transport, weighing, reception and milling of cane, juice purification and evaporation, boiling, crystallization, centrifugalling, refining and drying of sugar, fermentation and distillation, storage of alcohol, bagasse and sugar, steam and electricity generation, water treatment, etc.

Obtaining 30% surplus bagasse by reducing the steam consumption in raw sugar manufacture. II

D. U. Leal, P. Friedman and A. Valdés. *ATAC*, 1987, **46**, (4), 22 - 29 *(Spanish)*.

A sextuple-effect evaporation scheme introduced at Pablo Noriega sugar factory is described which gave a final Brix of 64.8° as against 62.7° in a previous quintuple-effect unit, using exhaust steam in the 1st effect of 2.65 kg/cm^2 pressure by comparison with 2.75 kg/cm^2 in the previous system. A total bagasse saving of 32% was achieved.

Characteristics of sucrose crystal-mother liquor systems. III. Optimization of the crystallization process

J. Buriánek and A. C. Hernández. *CubaAzúcar*, 1987, (Oct./Dec.), 3 - 8 *(Spanish)*.

Algorithms are presented for calculation of the supersaturation coefficient and the massecuite temperature and Brix corresponding to a required supersaturation for optimization of boiling and massecuite cooling. An empirical equation is also presented for calculation of the Brix of saturated solutions as a function of temperature and purity, and a method is described for calculation of the coefficients in the equation as a function of solubility.

Beet sugar manufacture

The permanence of computer system structures

G. Windal. *Sucr. Franç.*, 1990, **131**, 7 - 9 *(French)*.

A brief history is given of the Cheops pyramidal distributed microcomputer system devised by IRIS (the research organization of the French sugar industry) some 15 years ago. The software development for particular sugar factory process stations is outlined, and the Cleopatra system based on a computer network mentioned that is now used in over 50 factories in France and elsewhere. The Cheops system is adaptable to any new software and hardware system and so can be regarded as a permanent structure.

Optimum operation of the boiling house. I. The system. II. Introduction of Cheops at Chevrières and Connantre

I. A. Deleurence. *Sucr. Franç.*, 1990, **131**, 11 - 13. **II.** J. P. Delannoy and P. Stoclin. *ibid.*, 14 - 16 *(French)*.

I. The system developed for automatic control of boiling house operations is outlined, with variants for batch and continuous boiling and for *A*-strikes, with and without thick juice storage and where the pan station is operating on a fixed number of strikes per unit time (particularly during a campaign when thick juice is being stored).
II. The systems at Chevrières and Connantre are outlined with the aid of diagrams.

Control of the evaporator stations (Rameses software). I. The system. II. The user's viewpoint

I. P. Crevits. *Sucr. Franç.*, 1990, **131**, 17 - 20. **II.** P. Moignard. *ibid.*, 20 *(French)*.

I. The Rameses modular program developed by IRIS for automatic evaporator control (and incorporated in the Cheops structure together with the Zoser system for diffusion and the Cheops boiling house control system) is designed to: prevent fluctuations in the boiler load, reduce the speed at which variations occur in the evaporator juice feed, maintain the temperature of bled vapour, stabilize thick juice Brix and keep it at a required level and optimize energy consumption. The individual modules are described and their performances in factory tests discussed. After modifications to improve the control of thermocompression and juice feed, the interval between changes in thermocompression rate ultimately reached more than 1 hr (compared with 5 min at the start of the campaign), resulting in smooth running of the evaporator, while juice feed became very stable and Brix was normally maintained to within ±1 - 1.5° of the target level.
II. Operation of the system at Lillers factory resulted in a constant and higher thick juice Brix, bringing benefits to crystallization and contributing to a reduction in steam consumption. Since the factory stores thick juice, average sugar production was a little higher and manufacturing costs lower. Improved stability of bled vapour pressure increased juice quality.

Latest developments in the Cleopatra system. I. The system. II. Industrial application of CLEOAS at Marle

I. H. Lavogiez. *Sucr. Franç.*, 1990, **131**, 21 - 23. **II.** J. M. Huet. *ibid.*, 23 - 25 *(French)*.

I. The Cleopatra microcomputer network for data management is outlined and recent developments in the software described, including: a graphics system which allows comparison of data curves from one or a number of campaigns on corresponding dates; the ability to transfer data for use by other programs; and standardization of the FCLEOAS heat balance module (used for some years at a number of sugar factories including Marle). Advantages of the system, now used at 40 sugar factories in France and elsewhere, are indicated.
II. There are two versions of the CLEOAS thermal control system used at Marle: an older one built around a minicomputer and allowing 120 measurements to be read every 10 minutes, covering individual process stations, the boiler house and condensers, and a new one-station microcomputer system which provides the main computer with 40 measurements every 10 min. The two versions are independent and do not exchange information, although future workstations will be interlinked. The two systems are used to optimize energy consumption and to control continuous low-grade boiling, a coal-fired boiler, turbo-alternator, mechanical vapour compression, etc.

Beet reception data logging by microcomputer

C. Perrin. *Sucr. Franç.*, 1990, **131**, 27 - 32 *(French)*.

A SCERI computerized beet reception system and its operation are described with the aid of diagrams.

Self-tuning controller improves alkalinity control in first carbonatation

R. A. Germinsky. *Sugar y Azúcar*, 1990, **85**, (3), 13 - 14, 16 - 18.

Problems encountered earlier in automatic control of first carbonatation included inadequate sensitivity of and scale formation on conventional pH sensors and marked fluctuation in the process variables that required manual adjustment. The introduction of the electrodeless (toroidal) conductivity sensor and automatic on-line tuning such as the Foxboro Exact (Expert Adaptive Controller Tuning) system has overcome the major problems. Various aspects of carbonatation and its control are discussed.

American Crystal invests in the environment

F. A. Heinbaugh. *Sugar y Azúcar*, 1990, **85**, (3), 20, 24 - 25.

Odour from waste water at the Moorhead (Minnesota) sugar factory of

American Crystal Sugar Co. was the subject of considerable anger on the part of local residents. Measures adopted, including improvements to the anaerobic reaction vessel, have led to a reduction in the BOD_5 from a maximum of 10,000 mg/litre to no more than 250 mg/litre at a possible daily treatment rate of 1 million gallons. The company aims to complete the treatment of all process water as soon as possible after the end of the campaign (usually within 30 days); all storm water runoff from the 378-acre property must also be treated. At Hillsboro factory, treated low-BOD waste water is discharged onto a 160-acre wetland site (such natural sites are drying at very high rates and so can absorb large amounts of water inexpensively). Other measures introduced to reduce environmental pollution include the burning of low-sulphur coal and the installation of electrostatic precipitators, and the introduction of equipment for particle separation from pulp dryer flue gases.

Affination of beet low raw sugar

M. F. Cleary. *Sugar y Azúcar*, 1990, **85**, (3), 28 - 32.

See *I.S.J.*, 1990, **92**, 72 - 79.

Basic factors limiting progress in sugar manufacture

E. Walerianczyk. *Zesz. Nauk. Technol. Chem. Spoz.*, 1989, **42**, 65 - 80; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (5), Abs. 5 R1484.

The effect was examined of beet harvesting periods and rates, of beet quality, processing system and equipment used on sugar yield and techno-economical indicators of factory performance. Recommendations are made on means of raising beet processing efficiency.

Modelling and simulation of a multiple-effect evaporator system in the sugar industry

M. Bayramoglu, A. Ekmekyapar, I. Ceyhun and S. Colak. *Chim. Acta Turc.*, 1987, **15**, (3), 449 - 460; through *Ref. Zhurn. AN SSSR (Khim.)*, 1990, (5), Abs. 5 1490.

Since a multiple-effect evaporator is a major component of the sugar factory, requiring high-potential steam and producing various qualitities of secondary steam for use in other process stations, a mathematical model was developed which included equations for material and heat balances, heat transfer rate and various thermodynamic relations. Computer outputs were used in a simulation program for calculation of the basic technological data of the system, and investigations were carried out which revealed the presence of process variables having a negative effect on reduction in steam consumption.

The sugar economy of East Germany

Anon. *Zuckerind.*, 1990, **115**, 167 - 173 *(German)*.

A survey is presented of the East German sugar industry, including an account of developments since the end of World War II, the organization of the industry, details of the factories, beet agronomy, the current state of the equipment and technology and sugar economics. Changes that are expected to come about as a result of reforms are discussed.

Kinetics of the crystal sugar cooling process in an industrial pulsating fluidized-bed cooler with cyclically pulsed air flow

Z. Gawrzynski. *Zuckerind.*, 1990, **115**, 182 - 188 *(Grman)*.

Details are given of a sugar drying/cooling system. The sugar falls from a conveyor belt onto a series of rotating plates, one above the other, which throw it down onto an inclined perforated screen. The sugar flows down the screen towards a vertical wall which deflects it, so that it passes back over a horizontal grid beneath the screen and flows down a vertical chute to a cooler where air passes up through it from five rotary distributors as it passes over a horizontal screen to a discharge chute. In trials of a prototype at Strzelin, sugar was cooled from 58 - 75°C to 34 - 49°C with air flowing at 0.42 - 0.5 m/sec and at a temperature of 17.5 - 30.0°C. The heat transfer coefficients were also calculated and techno-economic parameters were compared with those of three other types of cooler (including a Dunford-Elliot drum and two vibratory systems) used in the Polish sugar industry. Calculation of the kinetics was based on laboratory experiments and an equation describing the batch process which has been modified and adapted to continuous cooling.

New principles to improve the quality of cossettes and the efficiency of DDS diffusers

A. F. Johnsen and J. Thomassen. *Zuckerind.*, 1990, **115**, 190 - 195.

See *I.S.J.*, 1990, **92**, 32A.

Chief factors in high energy consumption in sugar factories

L. Chriastel. *Listy Cukr.*, 1990, **106**, 51 - 54 *(Czech)*.

High energy consumption in Slovak sugar factories over the last twenty years (typically a fuel consumption of 6.5% on beet) is attributed mainly to low thick juice purity and the consequent increased amount of low-grade massecuite; at Dunajska Streda factory, a thick juice purity of 86% in 1982 compared with 94.1% in 1958. Poor beet quality and inefficient evaporation are blamed for the situation. Material balances are calculated to show the effect of thick juice pol content (13, 14 and 15% on beet), purity (86 - 94) and Brix (65 and 93°) on massecuite quantity and fuel consumption. The contrasting situation when fuel consumption is expressed on the basis of beet processed and on the basis of sugar produced is demonstrated where thick juice pol content rises. Recommendations are made on remedial measures, including improvement in beet processing quality and in factory practices, including the use of vapour compression.

Pulp separation from raw juice

E. Sarka, F. Kapasny and E. Drahosova. *Listy Cukr.*, 1990, **106**, 55 - 60 *(Czech)*.

The adverse effect of fine pulp particles in raw juice on the content of non-sugars (particularly colloids and reducing matter) and the increase in the pulp content associated with damaged cossettes and continuous diffusers are discussed. Laboratory tests with model juices demonstrated the adverse effects of pulp particles. The performances of a number of juice screens are discussed on the basis of data in the literature and tests conducted by the authors.

Control of a technological operation by an expert system

L. Budicek. *Listy Cukr.*, 1990, **106**, 60 - 62 *(Czech)*.

The REX relaxation expert system, consisting of control programs and sets of data written in DBASE II language, is described and its function as a process control means explained. Its application to control of anaerobic treatment of waste water at Brodek u Prerova sugar factory is discussed.

Wescot juice purification system

L. Tóth. *Cukoripar*, 1990, **43**, 12 - 18 *(Hungarian)*.

In the Wescot system (developed at the Western Sugar Co. in the USA), conventional preliming is followed by rapid clarification after which the juice is subjected to cold and then hot liming in separate vessels; the mud separated in the rapid clarifier is then recombined with the juice in the 1st carbonatation tank. After conventional 1st carbonatation, the juice passes to 2nd carbonatation via a degassing tank and clarifier, the mud from which passes to a tank where it is divided into two halves for recirculation to the clarifier and for recycling to preliming, respectively. Other systems in which preliming mud is separated include the Tasco system of Amalgamated Sugar Co. (which uses hydrocyclones for separation) and Süddeutsche Zucker-AG (in which centrifuges are employed). The Westcot system has been introduced at Scottsbluff and Mitchell sugar factories in Nebraska. Results obtained at Mitchell in 1988/89 showed a slightly higher thick juice purity, a lower thin juice lime salts content, a decreased colour content in thick juice and standard liquor, a reduced molasses yield and purity and a lower energy consumption than in the previous campaign using a conventional system. However, by comparison with the slightly modified Dorr-Oliver system used at Bayard factory (some miles from Mitchell and processing beets of similar quality but also employing a modern Putsch slicer), the new scheme gave only slight improvement in thick juice purity and standard liquor colour, while the thin juice lime salts content was higher, although the energy consumption was lower. The importance of using gravity flow instead of centrifugal pumps and of avoiding preheating between the cold and hot liming stages so as to avoid destruction of the flocs is mentioned.

Trends in the development of sugar crystallization. II. Continuous crystallization

A. Vigh. *Cukoripar*, 1989, **42**, 135 - 143; 1990, **43**, 19 - 22 *(Hungarian)*.

A survey is presented of continuous boiling and massecuite cooling systems and of various aspects of the process, including crystal size distribution and dust formation, formation of conglomerates and the preparation of crystal footing, occurrence of incrustation, automatic control and adaptation of standard vacuum pans to continuous boiling. Descriptions of specific systems are accompanied by diagrams.

Diffusion water preparation and waste heat utilization by direct heat exchange between condensate and carbonatation gas

L. Dömötör and G. Pólya. *Cukoripar*, 1989, **42**, 131 - 135; 1990, **43**, 23 - 27 *(Hungarian)*.

A technique is proposed for treatment of condensate to allow it to be used in diffusion. The temperature of the condensate is reduced from 93°C to 60°C by introducing CO_2 at 35°C from the carbonatation gas scrubber; in accordance with Henry's law, the gas becomes saturated with water vapour as a result of the heat exchange, the ammonia in the condensate is desorbed and the CO_2 is absorbed. It is estimated that up to 67% removal of ammonia is possible by this means which also reduces the pH to a suitable level for diffusion. The thermodynamics and physical chemistry of the reactions are explained and possible energy savings calculated.

Optimum 2nd carbonatation juice alkalinity and lime salts

N. I. Zharinov, V. Z. Semechenko, R. G. Zhizhina, V. V. Folomeeva and T. V. Likhogrud. *Sakhar. Svekla*, 1990, (2), 51 - 53 *(Russian)*.

In a study of the effect of 2nd carbonatation juice pH on the lime salts content during evaporation, samples having a pH above and below the optimum (for minimum sucrose degradation and scale formation) were concentrated in a calorimeter bomb at 115 - 118°C to 45°Bx and then evaporated to 65°Bx. Measurements of pH_{20} of filtered thin juice and of the corresponding thick juice showed that the optima at which the lime salts contents were minimum fell with decrease in raw juice purity from 9.1 and 8.8, respectively, at 87.5 purity to 8.5 and 6.2 at 85.5 purity; only where the pH_{20} exceeded the optimum by 0.7 - 1.0 was there any precipitation of lime salts as against no precipitation from juices of optimum or below-optimum values. In evaporation of juices containing the same quantity of lime salts, the pH at the isoelectric point (at which $CaCO_3$ adsorbed the same number of H^+ and OH^- ions and the lime salts content was minimum) was governed by beet composition and quality, and increase in the concentration of hydroxyl ions above the isoelectric point caused the lime salts precipitation.

By-products

Study of some physico-chemical properties of sucrose-based surfactants of different formulations

G. Lago M. and M. Duarte V. *ATAC*, 1987, **46**, (2), 12 - 16 *(Spanish)*.

The hydrophile-lipophile balance, foam behaviour, surface tension and pH of sucrose ester surface-active agents were determined, and the results are discussed.

Production of *Aspergillus oryzae* biomass using vinasse as a fermentation substrate

W. G. Venturini and R. de Camargo. *STAB*, 1987, **5**, (4), 38 - 41 *(Portuguese)*.

A. oryzae was grown on vinasse with the object of producing single-cell protein and also of reducing the pollution load of the effluent. The vinasse content of the medium was increased progressively and biomass production rose proportionately, while the crude protein content was unaffected. BOD_5 content was reduced by as much as 84.4%.

Processes for vinasse reductions

H. A. Germek and G. F. Feigl. *STAB*, 1987, **5**, (4), 42, 44 - 46, 48, 50 *(Portuguese)*.

A series of studies have been made by groups in Brazil with the aim of reducing the quantity of vinasse which has to be disposed of. One means is its concentration and aspects of this are discussed, including the development of equipment, direct and indirect heating, etc.

Studies of the correlation between the physical properties of molasses vinasse

A. C. D. Coelho, E. Dumoulin and B. Guérin. *STAB*, 1987, **5**, (4), 51 - 54 *(Portuguese)*.

To control the efficiency of an installation for concentration of vinasse, correlations were established between a number of physical properties of the vinasse and its dry matter content in the range 10 - 55%. Linear relationships were found with specific gravity, refractive index and heat capacity, while an exponential relationship was found with boiling point elevation. Measurement of specific gravity or refractive index is thus a good method for estimation of vinasse dry solids content.

Operational control of fermentation

J. Finguerut, H. A. Lucredi, M. A. Furco, R. Altomari and E. V. Rossell. *Bol. Técn. Copersucar*, 1987, (38), 19 - 23 *(Portuguese)*.

Operation control studies at Usina São Martinho showed that fermentative activity is greatly affected by variations in the contents of nitrogen, phosphorus and sulphites. Variation in the N content is accompanied by formation of glycerol and acids in the fermentation vessel.

Effect of the H factor of Vroom on the yield of bagasse pulp by the sulphate process

I. Rodríguez R., I. Hernández L., E. Pérez P. and E. González S. *Centro Azúcar*, 1987, **14**, (2), 64 - 66 *(Spanish)*.

The H factor defines the area below the curve of the relative delignification reaction rate *vs.* time. A method is described for evaluation of H and its correlation with pulp yield at active alkali concentrations of 10 - 11%.

Material and energy balances for the pulp plant of the Jatibonico white paper combine

I. Rodríguez R., M. Rodríguez R., P. Carús M., M. Estrada G. and R. Santos H. *Centro Azúcar*, 1987, **14**, (2), 67 - 72 *(Spanish)*.

Balances are given for the bagasse pulp plant, showing the consumption of water, chemicals and energy. The major cost factor in pulp manufacture was that of chlorine dioxide, while most energy was consumed in the cooking process using steam of 8 bar pressure.

Study of the paper machine stage at Jatibonico

E. González S., M. Morales P., M. López C. and B. Arregoitía O. *Centro Azúcar*, 1987, **14**, (2), 73 - 76 *(Spanish)*.

A matrix has been developed which represents the stages in the paper machine (screening, pressing and drying) and includes all the physical properties of the bagasse pulp to show the effects of the variables on the quality of the paper. The model is intended to help in optimizing the overall system of manufacture. A major need is to control the pressure applied in the first press so as to remove a maximum amount of water.

Experiments concerning the behaviour of bagasse dissolving pulp during its conversion to viscose on a pilot-plant scale. I. Pulp production technology

I. Cepero, R. Acevedo, A. Socarrás, F. Saavedra and J. Sabatier. *CubaAzúcar*, 1987, (Apr./June), 41 - 43 *(Spanish)*.

The effect of bagasse quality on the properties of dissolving pulps was investigated and the suitability of the pulps for viscose rayon manufacture demonstrated.

Biodigester

C. C. Ebeling. *STAB*, 1987, **5**, (5/6), 54 - 58 *(Portuguese)*.

Vinasse is produced in distilleries to the extent of 15 times the volume of alcohol and its treatment in three types of biodigester is discussed. The three types include the traditional type with agitation, the second generation type with upward flow and the third generation type with two or three phases. The last is of low investment cost but gives the highest reduction in BOD (94 - 98%), shortest retention time (6 hours - 3 days) and highest methane content in the gas produced (80 - 85%) while, because of its high calorific value, the gas provides the greatest saving in bagasse when used as boiler fuel.

Treatment of vinasse

A. Ozuna T. *Rev. Asoc. Técn. Azuc. Méx.*, 1988, **1**, (3), 12 - 14, 16 - 17, 19 - 21, 23 - 24 *(Spanish)*.

Preliminary tests are reported on treatment of vinasse to yield a high-protein product suitable for use as animal fodder. The design of a pilot plant is outlined in which the vinasse is concentrated in a triple-effect evaporator and then ground to a powder, with bagacillo being added to act as moisture adsorbent.

The molasses inversion process for high-test molasses (HTM) at Ingenio Riopaila S.A.

F. Luna R., H. Afanador T. and D. A. Ortíz Z. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 633 - 646 *(Spanish)*.

The chemistry of molasses inversion is explained and laboratory and factory trials are described in which 82% inversion of 55°Bx molasses was achieved after 71 hr using pressed yeast added after adjustment of the molasses temperature to 55°C and its pH to 5 with HCl. After inversion, the molasses was concentrated to approx. 84°Bx. Details are given of the equipment used in the process and of the production costs.

Determination of adequate nutrient doses in the fermentation of high-test molasses (HTM)

F. Luna R., H. Afanador T. and D. A. Ortíz Z. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 647 - 657 *(Spanish)*.

HTM has a lower yeast nutrients content for alcoholic fermentation than final molasses, and a series of tests was conducted at Riopaila. In the first experiment, addition of 0.25 and 0.30 g of an equal proportion of urea and diammonium phosphate per litre of molasses solution resulted in an alcohol yield of 1 kg per 4.14 and 3.75 kg molasses, respectively, after 36 hr at 23 - 27°C. By raising the temperature to an average of 32°C in the second experiment, the amount of molasses to yield 1 kg of alcohol was reduced to 3.67 and 3.62 with 0.25 and 0.30 g nutrient mixture, respectively. A final yield of 1 kg per 3.37 kg molasses was achieved in the third experiment by adding 0.40 g urea and 0.20 g of di-ammonium phosphate per litre.

Systems and methods for utilization of sugar industry waste and liquid by-products

H. Tretter. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 685 - 694 *(Spanish)*.

Equipment to handle filter cake, carbonatation mud, vinasse and factory waste water and spray it on the land is described.

Production of calcium lactate by alkaline hydrolysis of final molasses

O. A. Mejía E. and A. Zapata C. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 695 - 704 *(Spanish)*.

Alkaline hydrolysis of final molasses to yield calcium lactate is faster than the fermentation process normally used. Experiments are reported in which quicklime of 92% purity was added to diluted molasses (containing 0.5-1.0 moles of hexose per litre) in a CaO: hexose molar ratio of 1.2 - 1.5:1.0. After thorough mixing, the molasses was hydrolysed at 222 - 228°C (optimum 228°C) at a pressure of 31 - 33 atm (optimum 33 atm) for 1 - 2 hours. Immediately after discharge from the reaction vessel, the mass was filtered and the lactate decolorized with a 20% excess of active carbon (which also removed an unpleasant odour). Hexose conversion to lactate was of the order of 70%. The lactate could be stored indefinitely without any noticeable change in composition or fungal growth. From a technical viewpoint sugar was found to be a better raw material than molasses.

Chemical control of inversion of cane sugar juices for animal feed

J. E. Larrahondo and T. R. Preston. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 705 - 711 *(Spanish)*.

Experiments are reported on prevention of inversion of juices stored for use in animal fodder. Best results, allowing 96 hours of storage without any deterioration, were given by 0.7% w/v of sodium metasilicate. However, leaves of native plants *Salix humboldtiana* and *Cavendishia quereme* were found to contain benzoic acid and its derivatives as a secondary metabolite and delayed major inversion for 48 and 24 hours, respectively. A study of the palatability of juices treated with these plants is suggested.

Development of cattle feed systems based on sugar cane and other supplements

T. R. Preston. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 713 - 725 *(Spanish)*.

Studies conducted in Colombia and other countries on animal fodder based on cane, raw sugar, juice (particularly for pigs, chickens and rabbits), bagasse as well as other plants and crop residues are reviewed.

Biological conversion of cane mud

C. R. Murales. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 727 - 730 *(Spanish)*.

At a sugar factory in El Salvador, a 3-tonne pile of filter cake was treated with 300 cm^3 of an enzymic digester in 1 gal of water. Over the next 60 days there was a noticable reduction in volume, an increase in density, and the N and Ca levels remained unaltered while the P content rose and the K and Mg contents fell; none of these changes occurred in an untreated control pile. There was no offensive odour from the treated filter cake, the temperature did not rise above the ambient and the material had a fine structure; the product was considered a suitable substitute for P fertilizers and

should be tested in cane crops on various types of soil.

Study on edible oil manufacture from cane molasses by microbial means

R. Fournier A., M. L. López V. and B. E. Gómez M. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 741 - 747 *(Spanish).*

Candida curvata and *Rhodotorula gracilis* were cultured on clarified molasses to which was added a malt broth containing zinc peptone, calcium pantothenate, vitamin B-12, magnesium sulphate, inositol and biotin. Other vitamins, phosphates and urea were also used as nutrients. The N:C ratio was maintained at an optimum of 80:1 for best lipid conversion. Both yeasts gave growth and ripening rates greater than 90%. The size of plant to produce 1000 tonnes of edible oil per year and the economics of using final molasses or high-test molasses are calculated.

Enzymatic hydrolysis and inversion of sucrose

A. Calero, H. Perea and A. Cortés. *Mem. 2o. Congr. Soc. Colombiana Técn. Caña Azúc.*, 1987, (2), 749 - 758 *(Spanish).*

Experiments are reported on sucrose inversion with invertase followed by fructose separation from glucose by chromatography on Dowex 50W-X8 cation exchange resin in Ca^{++} form. Optimum hydrolysis conditions to give 100% inversion were 5 hours at pH 4 and 55°C, with a sucrose concentration of 0.4 g/ml and addition of 4 ml invertase to 875 ml. A higher degree of monosaccharide separation was achieved at 30°C than at 40°C.

Sucrose hydrolysis in syrups

Anon. *Mem. An. Estac. Exp. Agro-Ind. "Obispo Colombres"* (Tucumán, Argentina), 1986, 130 - 132 *(Spanish).*

A study of syrup inversion was aimed at preventing crystallization of sucrose in molasses intended for alcohol fermentation (previously a cause of a number of problems). Hydrolysis of 65°Bx syrup with sulphuric acid for 6 hours at pH 3 and 55°C reduced the pol content by 23%; treatment of 55°Bx syrup at 55°C and pH 6 with 0.1% and 0.2% baker's yeast gave maximum reductions of 20.5% (after 4hr 40 min) and 78% (after 6 hr), respectively, while 0.015% and 0.03% invertase used at the same temperature and pH to treat 58.5°Bx syrup caused greatest reductions after 5 hr (68.5% and 100%, respectively).

Experiments on sugar cane irrigation with vinasse

Anon. *Mem. An. Estac. Exp. Agro-Ind. "Obispo Colombres"* (Tucumán, Argentina), 1986, 152 *(Spanish).*

Application of 1 part vinasse to 23 parts water in three irrigations at a total rate of 3.47 m^3/ha increased the yield of NA 56-79 cane by 40% by comparison with application of water alone.

Composition and distribution of scale produced in evaporation of molasses vinasse

G. J. Cárdenas, E. J. Yocca and A. A. Delfini. *Rev. Ind. Agríc. Tucumán*, 1986, **63**, (2), 45 - 59 *(Spanish).*

A laboratory-scale stainless steel evaporator simulating an industrial quadruple-effect evaporator was used in a study of the scale formed by molasses vinasse treatment. While the most dominant component in the original vinasse was K^+ followed in descending order by SO_4^{--}, Ca^{++}, SiO_2, Mg^{++} and P_2O_5, no K^+ was found in the scale in which SO_4^{--} predominated followed by SiO_2 and Ca^{++}; Mg^{++} or P_2O_5 followed depending on whether evaporation was conducted under pressure or partially under pressure and partially under vacuum (which also altered the concentration of the various components in the scale).

Exhaustion and drying of yeast from the Copersucar distillery process

P. H. H. Rheinboldt, K. H. Leimer and C. E. V. Rossell. *STAB*, 198, **6**, (2), 48, 50 - 51 *(Portuguese).*

A process developed by the Copersucar Technical Centre provides greater efficiency, 50% energy savings, lower labour requirement, smaller area, and simpler installations than the conventional process used in the production of alcohol-free dried yeast. It involves four stages: recovery of alcohol, mechanical dewatering, thermolysis and drying in a horizontal fluidized bed dryer of greater capacity (10 tonnes/day) and lower steam consumption than the conventional rotary drum dryer.

Surpluses of electrical energy and excess bagasse for different conceptions and systems of conversion and utilization of energy applicable to the sugar-alcohol industry

J. M. Balbo and A. Padovani. *STAB*, 1987, **6**, (2), 52 - 58 *(Portuguese).*

Alternative cogeneration schemes are considered for the production of electricity and steam in the sugar and alcohol industry of São Paulo. These range from steam generation at 21 kg/cm^2 and 280°C which provides self-sufficiency, through two partial systems to a fourth total generation system in which steam is raised at 60 kg/cm^2 and 450°C. The standard system produces 450 - 500 kg of steam per tonne of cane of which 180 - 230 kg is used to generate 6 - 12 kWh/tonne of cane. By adoption of the first alternative, with a medium-efficiency turbo-generator, 12 kWh/tonne is generated, with 16% of surplus bagasse. The last alternative provides 420 tonnes of steam and 22 kWh/tonne of electrical energy, with 16% surplus bagasse. The Centre-South region of Brazil could produce 700 MW of surplus electrical energy while saving 5,000,000 tonnes of bagasse.

Influence of vinasse on sugar cane production and soil properties

J. Scandaliaris, C. N. Dantur and M.

Roncedo. *Rev. Ind. Agríc. Tucumán*, 1987, **64**, (1), 1 - 44 *(Spanish)*.

Experiments are reported in which application of up to 900 m^3/ha vinasse increased cane yield, with best results (a 20% increase in sugar yield per ha by comparison with the untreated control) being obtained with 150 and 300 m^3/ha. However, the treatment reduced cane quality, with a drop in pol content and purity and increase in ash content and K. While soil pH, electrical conductivity and interchangeable K rose initially with increase in the amount of vinasse applied, these parameters tended later to revert to their original values. Treatment also increased soil nitrate availability and P content but reduced the hydraulic conductivity.

Experiments concerning the behaviour of bagasse dissolving pulp during its conversion to viscose on a pilot-plant scale. II. Viscose

R. Acevedo, O. Quintela, A. Socarrás, S. Prieto and J. Falcón. *CubaAzúcar*, 1987, (July/Sept.), 19 - 24 *(Spanish)*.

The quality of bagasse pulp used for viscose manufacture on a pilot scale was assessed by a standard filtration method and a laboratory method developed at a Cuban rayon plant; the results were compared with those of commercial pulps used for the same purpose. Examination of the effect of the static formation of pulp leaves showed that this improves filtration and hence the quality of the viscose; it was shown to be feasible to use bagasse dissolving pulp for viscose production provided filtration performance was adequate.

Separation of glucose and fructose in an invert sugar

A. Fariñas B. and E. Duarte P. *CubaAzúcar*, 1987, (July/Sept.), 41 - 45 *(Spanish)*.

Experiments are reported in which inverted refined sugar solutions of 22, 25 and 30°Bx were treated (for 1.5 hr at 0 - 5°C with mixing) with CaO at a molar ratio with fructose of 1.8 - 2.4. After subsequent vacuum filtration, the pH of both filtrate and a suspension of the solid was adjusted to 6.5 - 6.7 with CO_2 and filtered to give fructose- and glucose-rich solutions of >90 purity. Best results (>90% fructose recovery and 75% glucose recovery) were obtained at 25°Bx and a CaO:fructose molar ratio of 2; a higher molar ratio increased losses of both monosaccharides as a result of alkaline degradation and increased adsorption by Ca carbonate, while colour also increased.

Influence of complementation of nitrogen and phosphate nutrients on the industrial alcohol fermentation process

J. N. de Vasconcelos. *Brasil Açuc.*, 1987, **105**, (4/6), 41 - 48 *(Portuguese)*.

Studies were made on the laboratory and industrial scale whereby 6 levels of N and 6 levels of P were provided in a fermentation must and the effects on the cell viability, amount of CO_2 liberated and fermentation efficiency measured. Analyses of the fermentate are tabulated. Analyses were also made of musts and fermentates from industrial plants and it is concluded that N and P addition is beneficial within conditions resulting from the raw material and the fermentation process. The maximum efficiency was given by addition of 0.11% of ammonium sulphate and 0.119% of triple superphosphate.

Ultrastructural changes in the cell wall of bagasse as a result of hemicellulose degradation during storage

O. Triana, J. Monzón, F. Saavedra, M. Leonard, D. Cordero and E. Peña. *CubaAzúcar*, 1987, (Oct./Dec.), 9 - 13 *(Spanish)*.

In Cuba, bagasse for use in the cellulose and paper industries is usually stored for 8 - 14 months. Treatment with a fluid prepared from lactic acid-producing microbes has been shown to improve the digestibility of the stored bagasse and hence to reduce the consumption of chemicals; however, investigations showed that 7 - 10% of the hemicelluloses may be lost. A study using transfer electron microscopy indicated ultrastructural changes in the cell wall during storage, although the cell wall in the bagasse stored inside the pile remained largely intact even after 12 months of storage, with the formation of voids in the innermost layers as a result of partial hemicellulose removal. There was no evidence of delignification.

Effect of hydrolysis on alcoholic fermentation. 1. Chemical hydrolysis

M. O. Marques, J. Horii, J. P. Stupiello and E. B. Malheiros. *STAB*, 1988, **6**, (3), 45 - 46, 48 - 50 *(Portuguese)*.

Attempts were made to increase the yield of alcohol from molasses by hydrolysis of the polysaccharides content before fermentation. Evaluation of the treatment effects was by determination of residual reducing substances, and measurement of fermentation and conversion efficiencies. It was concluded that hydrolysis with mineral acids (HCl and H_2SO_4) did not produce any change in any of these criteria while treatment with acid followed by heating under reflux for 1 hour decreased the fermentation and conversion efficiencies while increasing the level of residual reducing substances.

Production of chemical pulp from bagasse by the alkaline sulphite-anthraquinone process with and without alcohol addition

M. C. F. de J. Ramírez C., D. Wang and R. Patt. *Centro Azúcar*, 1988, **15**, (1), 11 - 13 *(Spanish)*.

In experiments, the addition of ethanol gave a moderate improvement in the degree of delignification, yield, brightness and viscosity obtained with the alkaline sulphite-anthraquinone pulping process. However, without ethanol it was possible to obtain sufficient brightness for newsprint without bleaching.

The shaft was redesigned using a thick walled hollow pipe. Although a 150 mm nominal bore schedule 80 pipe would have been sufficient in theory, it was decided to use a 200 mm schedule 80 pipe. This had a natural frequency of 28.5 Hz (276 rpm) at the lowest mode and gave a safety margin to allow a considerable increase in shaft speed.

Kuijvenhoven[3] states that the tip speed should be less than 10 m/sec to prevent crystal damage. This would limit a 1200 mm diameter stirrer to 150 rpm.

Installation in the pan

The general arrangement of the Hulett stirrer in pan 2 is shown in Figure 4. The impeller position is wholly within the downtake. The shaft is supported below the impeller to restrict any sideways movement.

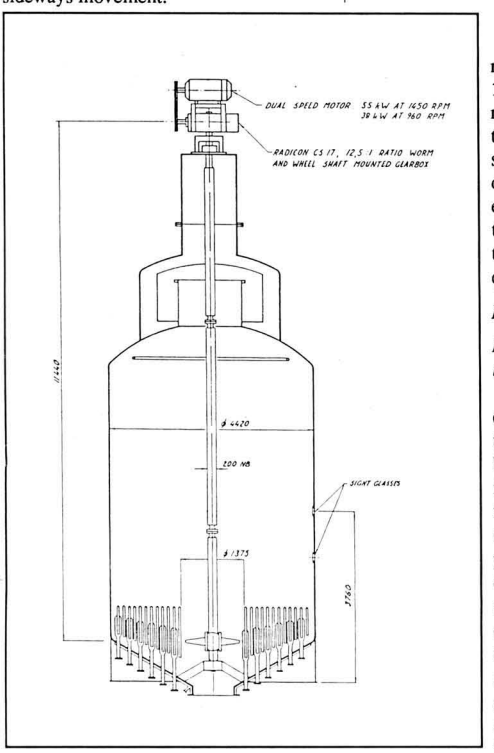


Fig. 4. General arrangement of the Huletts stirrer

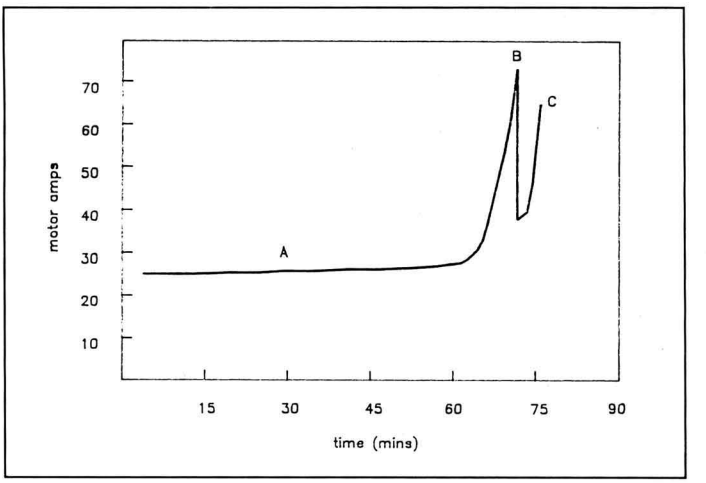


Fig. 5. Typical power consumption curve

The feed pipe is not shown but it is of 100 mm diameter and runs across the top of the calandria with a short bend into the downtake. This is to ensure that the feed is thoroughly mixed into the massecuite as quickly as possible.

Results and discussion

Power consumption by the stirrer

A typical power consumption curve of the stirrer during a pan boiling cycle is shown in Figure 5. The main features are a fairly flat section (A) where the power requirements during the crystallization process are more or less constant, followed by two sharp peaks (B) and (C). The peaks are during the Brixing-up stage. The point (B) is where the motor trips from high speed down to low speed, reducing the current drawn by the motor and (C) where the final low speed trip occurs, terminating the boiling. A summary of the results found for the two impellers is given below in Table IV.

As the stirrer speeds are increased, the power consumption during the crystallization period shows a steady increase, as would be expected. The difference between the two pitch settings on the Huletts stirrer is very marked, the coarse pitch having a 55% greater power consumption at the same speed.

The results found during the evaluation of the stirrers show that in all instances, and contrary to expectations, the massecuite Brix was slightly higher at higher rotational speeds for any given impeller type and pitch.

Taking into consideration that the power drawn is approximately proportional to the cube of the speed, and that power is limited owing to the motor trip, the higher strike Brix indicates lower viscosity of the massecuite at higher speeds.

This observation was borne out by the observed time interval between the stirrer tripping out at high speed and low speed. Once again, contrary to expectation, the time interval at low

Table IV. Stirrer power consumption

Stirrer	Pitch	(A) Boiling, kW	(B) HS trip, kW	(C) LS trip, kW
Kaplan				
68 rpm		6.3	58.1	46.8
120 rpm		22.6	55.6	48.0
133 rpm		32.4	57.7	48.5
Huletts				
120 rpm	fine	14.5	63.4	44.0
133 rpm	fine	18.3	63.4	45.9
133 rpm	coarse	31.8	63.4	45.1
147 rpm	fine	25.0	63.4	43.1
147 rpm	coarse	42.0	64.4	52.7

Table V. Colour formed in the massecuite during 1st boilings

Stirrer	Speed, rpm	Units of colour formed
None	–	62
Kaplan	68	57
Kaplan	120	41
Kaplan	133	34
Huletts (F)	120	31
Huletts (C)	133	31
Huletts (F)	133	41
Huletts (C)	147	26
Huletts (F)	147	22

speed increased with increasing impeller speed. This indicates pseudoplastic non-Newtonian behaviour.

Typical results for the Hulett stirrer are:–

Stirrer speed, rpm	120	133	147
Time from B to C, sec	63	80	99

Colour formation in the massecuite

With the use of high pressure steam in the ribbon calandria pans, high temperatures are reached on the heating surfaces. Poor circulation can cause considerable colour formation. Colour profiles of the massecuite during the boiling cycle with and without a stirrer were measured in order to find where in the cycle the colour was being formed.

Several points are clear from Figure 6. Very little colour formation occurs before the feed is stopped and the pan is tightened. The colour changes during this part of the boiling cycle are almost entirely due to variations in the feed colour. Colour formation begins immediately the Brixing-up period starts, with no stirrer, and continues at an increasing rate until the pan is emptied. With a stirrer, colour formation is minimal during Brixing-up.

Reduced colour formation is apparent in moving from no stirrer to the Kaplan stirrer and then to the Huletts stirrer with increasing rotational speeds. The Hulett stirrer at 133 rpm with fine pitch does not fit into the pattern, and no satisfactory explanation for this could be found.

Sugar quality (colour)

The colour of the sugar is probably the most important quality factor for the refinery. The colour is occluded in the crystal and in the syrup film on the crystal surface.

The varying feed colours make direct comparisions of the sugar colours difficult but it is clear from Table VI that a marked improvement in both product and affined sugars has been achieved. This confirms the supposition that both types of colour, occluded and surface,

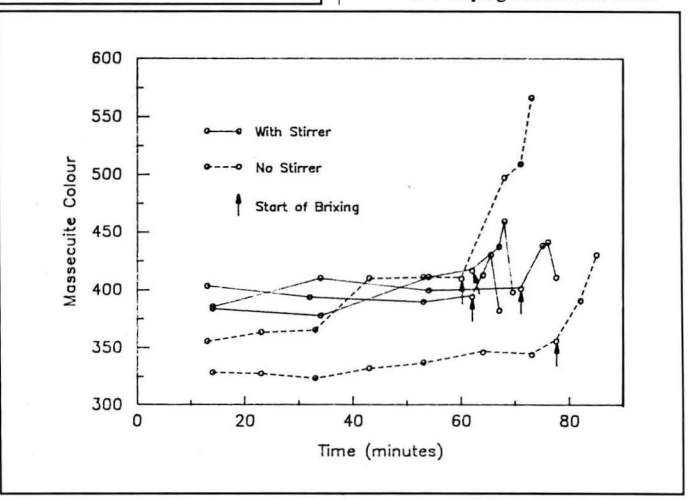


Fig. 6. Massecuite colour profiles during boiling

Table VI. Sugar colours and colour removals

Stirrer	Feed colour	Sugar colour		% Colour removal	
		Product	Affined sugar	Product	Affined sugar
No stirrer	324	32	25	90.1	92.3
Kaplan 68	380	33	24	91.3	93.7
Kaplan 120	386	30	26	92.2	93.3
Kaplan 133	332	28	20	91.6	94.0
Huletts 120F	262	26	21	89.7	92.0
Huletts 133F	242	22	17	90.7	93.0
Huletts 133C	293	22	15	92.3	94.9
Huletts 147F	279	16	12	94.1	95.7
Huletts 147C	317	23	19	92.6	94.0

are lowered by the use of stirrers.

The most significant factor in reducing colour transfer to the crystal seems to be stirrer speed. At the same rpm there is little to choose between the Kaplan and Hulett impellers on the basis of % colour removal.

Sugar quality (physical)

One of the prime objectives was to improve the quality of the crystal produced without affecting the production rate. This may well be hard to achieve as the high crystallization rates in the white pans, especially immediately after seeding, encourage irregular crystal formation. The individual pan boiler's techniques will have a far larger effect on the crystal quality than on the other measured parameters and this may explain why the improvements are not as clear-cut as was hoped.

What can be seen from Table VII is a trend towards lower conglomerate counts and CV values as the stirrer development proceeded. The Huletts stirrer with the blade set at the coarse angle seems to be the best configuration for minimum conglomerate formation, again with increasing speed also an important factor.

Pan yields and massecuite Brix

At the same time as the colour profile results were being obtained, Brix profiles were measured during the boiling cycle. These are shown in Figure 7.

While the stirrer appears to have little effect in the early part of the boil, it markedly affects the final strike Brix. Stirring allows the viscosity to be increased past the point where natural circulation would stop. This enables circulation and heat transfer to continue at a higher Brix.

The massecuite strike Brixes obtained with unstirred pans were about 89.5. This increased to about 90.5 with the Kaplan stirrer and to about 90.7 with the Huletts stirrer. Previous work at the refinery has shown a strong relationship between strike Brix and pan yields. Without stirrers it was not possible to utilize this fact to improve yields, as poor circulation at high Brix caused low heat transfer, local overheating and excessive discharge times.

The use of stirrers overcomes all of these problems and a considerable increase in crystal yields was found as the test program proceeded. This is illustrated in Table VIII.

Table VII. Sugar quality for different stirrer combinations

Stirrer	MA, microns	CV, %	Conglomerate count, %	Bulk density, g/l
No stirrer	565	39	77	848
Kaplan 68	608	34	72	861
Kaplan 120	557	37	72	860
Kaplan 133	554	34	77	855
Huletts 120F	567	32	72	857
Huletts 133F	611	34	74	846
Huletts 133C	567	37	70	849
Huletts 147F	551	33	69	859
Huletts 147C	569	31	61	853

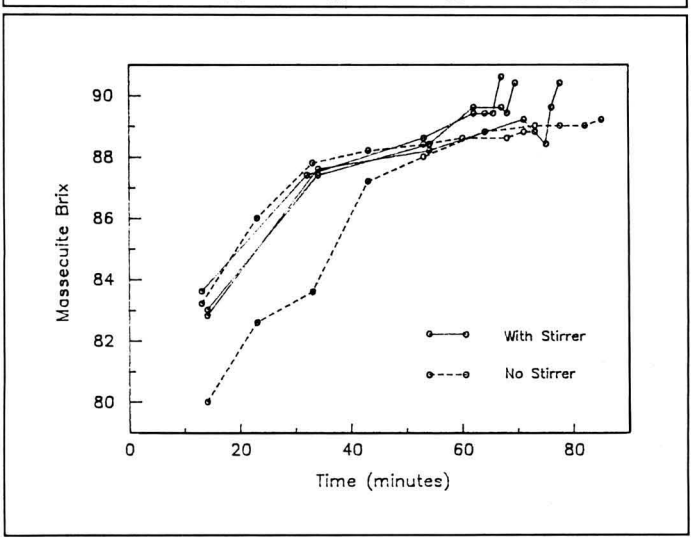


Fig. 7. Massecuite Brix profiles during boiling

Table VIII. Pan yields for 1st boilings

Stirrer	Speed, rpm	Pan yield, %
None	–	55
Kaplan	68	57
Kaplan	120	59
Kaplan	133	60
Huletts (F)	120	60
Huletts (C)	133	61
Huletts (F)	133	63
Huletts (C)	147	60
Huletts (F)	147	60

Again, as was noted previously, the result for the Hulett stirrer running at 133 rpm with fine pitch does not fit the overall pattern.

Evaporation rates and heat transfer coefficients

Table IX shows the improvement in heat transfer that is effected by the use of mechanical circulation. The Huletts stirrer gives better heat transfer than the Kaplan stirrer; this could be due to the higher proportion of axial flow and less back-mixing. Faster stirrer speed also improves matters which again is probably due to more efficient removal of heat from the calandria surface by the faster circulating massecuite.

Table IX. Evaporation rates and heat transfer coefficients

Stirrer	Steam pressure, kPa	Feed Brix	Average evaporation rate, kg/m²/hr	Average HTC kW/m²/°C
No stirrer	310	76.3	56.4	0.78
Kaplan 68	349	75.6	66.4	0.87
Kaplan 120	336	76.5	62.6	0.83
Kaplan 133	346	75.7	64.8	0.85
Huletts 120F	310	74.8	64.9	0.90
Huletts 133F	311	74.2	65.2	0.90
Huletts 133C	309	74.5	64.0	0.89
Huletts 147F	321	73.5	67.2	0.95
Huletts 147C	345	74.0	68.6	0.94

Table X. Predicted results with and without stirrers

		No stirrers	Stirrers
Colours	1st boiling sugar	30	20
	2nd " "	72	48
	3rd " "	98	91
	4th " "	158	148
	Refined sugar blend	56	40
Throughput, tonnes/hr	1st massecuite	101	98
	2nd "	48	42
	3rd "	23	18
	4th "	13	9
Ash %	Return syrup	2.1	3.3

Refinery ash and colour balance

A refinery mass balance model was used to calculate the anticipated benefits to the refinery if all the pans were fitted with stirrers. The basic assumptions used in the model were:–

Melt rate	85 tonnes/hr
Colour removal over carbonatation	54%
Colour removal over ion exchange	65%
Colour gain over evaporation	5%

There is a marked improvement in the colours of the white sugars, most noticeable in the 1st and 2nd boilings. The smaller effect in the 3rd and 4th boilings is due to the concentration effect of the higher pan yields.

The tonnage of refined massecuites is predicted to drop from 185 to 167 tonnes/hr, giving a considerable steam saving and increase in pan capacity.

APPENDIX I. Results summary, 1st boilings

	No Stirrer		Kaplan stirrer, Pan 2			
	Pan 1	Pan 2	120 rpm side feed, LP	68 rpm centre feed	120 rpm centre feed	135 rpm centre feed
Stirrer	No	No	Yes	Yes	Yes	Yes
Data sets	28	20	5	6	15	10
Steam-on time, min	74.4	74.1	146.8	67.7	67.4	68.6
Strike discharge time, min	6.3	7.4	3.9	6.8	5.6	5.4
Steam pressure, kPa	306	313	125	349	336	346
Strike temp., °C	83.9	82.8	82.5	84.2	82.7	84.1
Feed Brix	76.2	76.4	76.1	75.6	76.5	75.7
Massecuite Brix	89.4	89.9	90.7	90.3	90.3	90.5
Pan yield, %	55.2	55.3	57.0	57.0	59.1	60.1
MA, µm	565	564	587	608	557	554
CV, %	38	39	32	34	37	34
Conglomerate count	76	77	70	72	72	77
Bulk density, g/l	850	846	869	861	860	855
Feed colour	328	319	381	380	386	334
Massecuite colour	390	380	444	434	427	368
Sugar colour	33	30	28	33	30	28
Colour formed in pan	62	61	63	54	41	34
Colour removal, %	89.9	90.3	92.7	91.3	92.2	91.6
Evaporation rate, kg/m²/hr	55.6	57.1	29.9	66.4	62.6	64.8
Sugar production, tonnes/hr	31.1	29.8	16.8	33.0	35.2	34.7
H.T.C., kW/m²/°C	0.78	0.78	0.68	0.87	0.83	0.85

Conclusions

(1) The fitting of a mechanical stirrer to Pan 2 has led to a number of improvements in the performance of the pan both in respect of sugar quality, exhaustion efficiency and sugar production rate.

(2) The most consistent improvement in terms of sugar quality has been in lower colours. Reduced colour formation in the pan, and more homogeneous crystallization conditions have lowered the colour in the crystal and in the syrup film. The colour removal has improved from 90% without a stirrer to 94% with the marine stirrer.

(3) Sugar conglomerate counts and CV's have been reduced by about 20% with the MA remaining unchanged.

(4) Pan yields and heat transfer coefficients have improved and, taken together, are worth approximately 10% additional pan capacity.

(5) A marine-type impeller is the most suitable impeller for ribbon calandria pans boiling refined massecuites. This is due to the non-Newtonian behaviour of the massecuite at high Brix.

(6) The most successful operating parameters for the stirrer were a rotational speed of 147 rpm and a blade root angle of 42° and tip angle of 14°.

Acknowledgements

We would like to acknowledge the input of the staff of Hulett Refineries and Tongaat-Hulett Sugar Technology Department and in particular Mr. Prem Sahadeo whose efforts have made this project a success.

APPENDIX II. Results summary – Helical screw stirrer, Pan 2, 1st boilings

Pitch		Fine	Coarse	Fine	Fine	Coarse
Speed, rpm	120	120	135	133	147	147
Feed draught tube		centre	centre	centre	centre	centre
Data sets	12	8	9	7	9	8
Steam-on time, min	74.9	72.4	77.2	78.6	79.4	75.5
Strike discharge time, min	4.5	5.0	4.2	3.9	3.1	4.1
Steam pressure, kPa	309	310	309	311	321	345
Strike temp., °C	83.5	81.4	82.3	77.2	82.3	79.3
Feed Brix	75.8	74.8	74.5	74.2	73.5	74.0
Massecuite Brix	90.1	90.5	90.7	90.7	90.9	90.7
Pan yield, %	56.7	60.0	61.2	63.1	59.8	59.7
MA, µm	557	567	567	611	551	569
CV, %	38	32	37	34	33	31
Conglomerate count	78	72	70	74	69	61
Bulk density, g/l	839	857	849	846	859	853
Feed colour	273	262	293	242	279	317
Massecuite colour	310	293	324	283	301	343
Sugar colour	24	26	22	22	16	23
Colour formed in pan	37	31	31	41	22	26
Colour removal, %	90.9	89.7	92.3	90.7	94.1	92.6
Evaporation rate, kg/m²/hr	57.7	64.9	64.0	65.2	67.2	68.6
Sugar production, tonnes/hr	31.5	33.2	32.6	33.7	31.2	32.5
H.T.C., kW/m²/°C	0.80	0.90	0.89	0.90	0.95	0.94

APPENDIX III. Calculation of performance parameters

Pan yield, %	=	(Nutsch Ash – Massecuite Ash) × 100/(Nutsch Ash – Crystal Ash)
Massecuite production, m³/hr	=	Strike volume/Cycle time
Crystal production, tonnes/hr	=	Massecuite production × 1.47 × Yield/100
Water evaporated, tonnes	=	Strike volume × 1.47 [(Feed Brix/Massecuite Brix) – 1]
Evaporation rate, kg/m²/hr	=	(Water evaporated × 1000 × 60)/(Heating surface area × Steam-on time)
Heat transfer coefficient, kW/m²/°C	=	Evaporation rate × Vapour enthalpy/[(Steam temperature – Massecuite temperature) × 3600]

Calculation of the boiling point elevation of sugar solutions

By Lin Qing Sheng
(Food Engineering Department, South China University of Technology, Guangzhou, Guangdong, China)

Boiling point elevation (BPE) is defined as the difference between the boiling temperature (°C) of sugar solution and that of water at the same absolute pressure. It has been proved that the BPE is affected by the operating pressure, as well as the purity and Brix of the solution. When we are going to perform evaporator calculations, we must know the BPE values. So far, the main method used for this purpose is to consult different tables and diagrams. But this method is sometimes inconvenient, especially when a computer is used for evaporation system heat calculations or design. In these circumstances, we expect that the computer should be able to calculate the BPE values itself from the Brix of the boiling solution and the temperature of the water vapour from it. So it is more and more necessary for us to seek a mathematical formula which relates the BPE values with those factors affecting it.

Under vacuum conditions, the BPE of a pure solution may be calculated by the formula recommended by Hugot[1] as

$$e\ (°C) = 0.025\ B\ [1 - 0.5h/(229 - h)]\ (30 + B)/(103.6 - B) \quad \ldots\ (1)$$

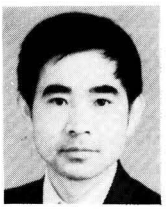
where B is the Brix of the sugar solution and h is the vacuum in cm of mercury.

This formula can only be used under vacuum conditions. In order to overcome this defect, the present paper introduces a formula which may be used whether the pressure is higher or lower than atmospheric pressure.

Here, the BPE data provided by MacDonald & Rodgers[2] are employed (see e_1 values in Table I). These are the data for sugar solutions of 90 purity and varying concentrations at atmospheric pressure. By the aid of regression analysis, an approaching formula is obtained as equation (2). In Table I, the comparison shows that the precision of equation (2) is satisfactory.

$$e' = [5.84 \times 10^{-7}\ (B - 40)^2 + 0.00072]\ B^2 \quad \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ (2)$$

where e' = BPE value of the sugar solution at atmospheric pressure, °C, and B = Brix of the sugar solution.



Lin Q. S.

Table I. BPE of sugar solution in °C (1 atm., 90° purity)

Brix	e_1	e_2
10	0.16	0.12
15	0.26	0.24
20	0.39	0.38
30	0.72	0.70
25	0.54	0.53
35	0.94	0.90
40	1.21	1.15
42	1.34	1.27
44	1.49	1.41
46	1.66	1.57
48	1.85	1.74
50	2.05	1.96
52	2.29	2.17
54	2.56	2.43
56	2.85	2.73
60	3.50	3.43
58	3.16	3.06
62	3.87	3.85
64	4.27	4.33
66	4.74	4.85
68	5.28	5.44
70	5.88	6.10
72	6.50	6.83

e_1 = BPE data from MacDonald & Rodgers[2]
e_2 = BPE calculated from equation (2)

Equation (2) is only valid for solutions at atmospheric pressure. In order to establish one which can be used at any pressure, the Tishenko equation may be used. This equation is written as :–

$$e = Ke' \quad \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ (3)$$

where $K = 0.016204\ T^2/r$ ... ... (4) and e = BPE in °C of the sugar solution at a desired pressure (or at desired vapour temperature), K = a coefficient dependent on T and r, T = Boiling point of water at the desired pressure, (or vapour temperature of boiling solution) in °K and r = Insensible heat of vapourization of water at the desired pressure, kJ/kg.

Now, the final problem is the calculation of K which is a function of T and r. With the aid of thermodynamic knowledge, the two independent variables in equation (4) may be reduced to either a pressure variable P or a temperature variable T. If T is chosen, the simplification may employ the Watson equation. The Watson equation relates T and r as:–

$$r = r'[(1 - T_r)/(1 - T_{r'})]^{0.38} \quad \ldots\ \ldots\ (5)$$

where r' = Insensible heat of vaporization of water at atmospheric pressure (2256.9 kJ/kg), $T_{r'}$ = reduced temperature of the boiling water at atmospheric pressure, T'/T_c and T' = the temperature of boiling water at atmospheric pressure (373°K). T_c = Critical temperature of water (647.3°K) and T_r = Reduced temperature of the boiling point of water at the desired pressure, T/T_c.

Substituting the known quantities in the Watson equation, we obtain

$$r = 267.2\ (647.3 - T)^{0.38} \quad \ldots\ \ldots\ (6)$$

Combining equation (4) and equation (6), we have

$$K = 6.064 \times 10^{-5}\ T^2/(647.3 - T)^{0.38} \quad \ldots\ \ldots\ (7)$$

Then, substituting in equation (3) from equation (2) and equation (7) gives

$$e = 6.064 \times 10^{-5}\ T^2B^2/(647.3 - T)^{0.38} \times [5.84 \times 10^{-7}\ (B - 40)^2 + 0.00072] \quad \ldots\ \ldots\ (8)$$

In equation (8), the independent variable T is in absolute temperature °K. Sometimes, it is preferable to express the temperature in the Celsius thermometric scale. If so, equation (8) can be changed to

$$e = 6.064 \times 10^{-5}\ [(273 + t)^2B^2/(374.3 - t)^{0.38}] \times [5.84 \times 10^{-7}\ (B - 40)^2 + 0.00072] \quad \ldots\ \ldots\ \ldots\ \ldots\ \ldots\ (9)$$

At any desired Brix of sugar solution and temperature of saturated water vapour, it is easy to get the BPE values by using equation (8) or (9).

1 "Handbook of cane sugar engineering" (Elsevier, Amsterdam), 1986.
2 *I.S.J.*, 1947, **49**, 205 - 208.

Results calculated from equation (9) are shown in Table II.

Although the inference employs the BPE data of sugar solutions of 90 purity, equations (8) and (9) have practical value because they are sufficiently precise for use in engineering. Also, the independent variable T (or t) in equation (8) [or (9)] may be replaced by the pressure variable, P, if necessary by employing certain thermodynamic formula.

Table II. Boiling point elevation in °C calculated from equation (9)

Brix	Vapour temperature, °C												
	60	65	70	75	80	85	90	95	100	105	110	115	120
10	0.10	0.10	0.10	0.10	0.11	0.11	0.12	0.12	0.12	0.13	0.13	0.14	0.14
15	0.18	0.19	0.20	0.21	0.21	0.22	0.23	0.24	0.24	0.25	0.26	0.27	0.28
20	0.29	0.30	0.31	0.32	0.33	0.34	0.34	0.37	0.38	0.39	0.41	0.42	0.44
25	0.40	0.42	0.43	0.45	0.46	0.48	0.50	0.51	0.53	0.55	0.57	0.59	0.61
30	0.53	0.55	0.57	0.59	0.61	0.63	0.65	0.68	0.70	0.72	0.75	0.77	0.80
35	0.68	0.71	0.73	0.76	0.78	0.81	0.84	0.87	0.90	0.93	0.96	0.99	1.03
40	0.87	0.90	0,94	0.97	1.00	1.04	1.08	1.11	1.15	1.19	1.23	1.27	1.32
45	1.12	1.17	1.21	1.25	1.30	1.34	1.39	1.44	1.49	1.54	1.59	1.64	1.70
50	1.47	1.53	1.58	1.64	1.70	1.76	1.82	1.88	1.94	2.01	2.08	2.15	2.22
55	1.95	2.02	2.09	2.17	2.24	2.32	2.40	2.49	2.57	2.66	2.75	2.84	2.94
60	2.60	2.69	2.79	2.89	2.99	3.10	3.20	3.32	3.43	3.55	3.67	3.79	3.92
65	3.47	3.59	3.72	3.86	3.99	4.13	4.22	4.43	4.58	4.74	4.90	5.06	5.23
70	4.62	4.78	4.96	5.14	5.32	5.51	5.70	5.90	6.10	6.31	6.52	6.74	6.97

Sugartech 1990

More than 100 people gathered at the Grand Hotel in Eastbourne on June 25 for the 1990 Technical Conference of British Sugar plc; these included 59 guests from 15 overseas countries. They were welcomed at a reception given by British Sugar on the Monday evening and by Dr. Malcolm Branch, the Conference Chairman, at the opening on the following morning. The first session, devoted to emerging technology, was chaired by Nick Broughton, British Sugar's Head of Research & Development, who introduced the speakers. The first paper, "Cooling crystallization of raw juice", was presented by Professors G. Mantovani and G. Vaccari and was followed by "Enhancements to three-boiling scheme" by P. D. Thompson, A. Murphy and G. A. Punter. The next paper was a description of the "Tasco chromatographic separator at Twin Falls factory" by K. P. Chertudi whose colleague M. Kearney described "The use of infinite series for optimizing placement and operation of chromatographic separators". The final paper of the session was by K. L. Carter and P. D. Thompson and reported "Total energy integration at Ipswich factory".

The next session was chaired by H. J. Davenport, Director of Operations Services, and included two miscellaneous papers, the first presented by G. Holland and M. E. Buckley of Irish Sugar plc and S. Frampton of Nalfloc on "Experiences in the use of biocides for microbiological control in the raw factory". The second, presented by R. Rosenqvist, decribed "Cathodic corrosion protection of a diffuser". Purification was the theme of the third session, on the following morning, chaired by B. M. Piercy, Director of Production; it started with an account of "The Canadian experience with DDS purification" presented by M. K. Faviell, J. R. Logie and B. L. Karren. This was followed by a discussion of "Lime usage and juice purification" by D. Sargent, "New developments in the purification of beet sugar" by R. F. Madsen, and the "Balance of cations and anions in sugar beet processing" by P. W. van der Poel.

The fourth session in the afternoon was chaired by C. C. Dalton, Technical Business Development Manager, and included a presentation by J. I. Harland on "Dietary fibre from sugar beet – a profitable route to better health" and a discussion of "Alternative utilization of sugar beet pulp" by M. Vogel. The "Anaerobic fermentation of beet pulp and enzymes involved" were discussed by Professor K. Buchholz while M. Bruder presented a paper on "Solid-state fermentation of sugar beet pulp".
The Conference Dinner was held in the evening, during which the assembly was addressed by Mr. Peter Jackson, Managing Director of British Sugar, and Mr. Faviell responded on behalf of the overseas visitors.

The Conference resumed on Thursday morning, with K. L. Carter, Group Production Manager, in the chair, and the final session of miscellaneous papers included descriptions of Sockerbolaget's "Automatic enzymatic determination of true sucrose in beet and molasses" by J. Tjebbes and "Animal feed dryer odour abatement trials" by R. A. Leakey, R. Parslow and J. W.

continued on next page

ICUMSA, 20th Session 1990

The United States' National Committee on Sugar Analysis, under the Chairmanship of John Richmond, hosted the 20th Session of the International Commission for Uniform Methods of Sugar Analysis (ICUMSA), which was held in the International Centre of the Broadmoor Hotel, Colorado Springs, USA, during the week of June 3 - 8, 1990. The Mayor of Colorado Springs, Robert Isaac, welcomed the 125 delegates representing 27 sugar-producing countries, wishing them an outstanding conference and a wonderful visit.

The 20th Session was presided over by Dr. Murray Player (Australia), who was supported by Bob McCowage (Australia), the General Secretary, and Raymond Phillipson (UK), the Treasurer. This was the first Session to be held since the major reform of ICUMSA, instituted by the President following the request so to do at the 19th Session in 1986. The President had appointed nine General Referees to head new Subjects, which were related primarily to sugar industry products. These General Referees were seen as being at the forefront of the Industry's interface with suppliers, customers and authorities. They were supported by twenty Referees of Subjects which are more traditional to ICUMSA and which are scientific or basic in their nature.

The 20th Session was a test of how well the new structure had been working. The new General Subjects addressed the analytical needs of public authorities as well as those of factories processing cane and beet. The place within ICUMSA of analytical methods for Starch Hydrolysis Products was questioned and it was decided to retain this subject area for the time being as it provided a forum for discussion with other organizations also interested in these products.

The reports of Referees for scientific subjects produced stimulating discussion, particularly in areas of the newer chromatographic technologies. New density data were adopted, replacing the ninety years-old data of Plato. New refractive index data were also approved for sucrose and reducing sugar solutions.

Among the most important decisions of the Session was the acceptance of proposals to adopt the IUPAC protocol for the design, conduct and interpretation of collaborative studies. These proposals were presented by the Referee for Subject 3, Mary An Godshall (USA). It was also decided to adopt the ISO method format for the Commission's new publication of analytical methods which is expected to be completed during the 21st Session.

Previously, much of the work of ICUMSA's Publications Department had been carried out by officers of British Sugar plc. It was decided that the Commission should bear the cost of this work and appointed John Dutton (UK) as a paid consultant to assist in the production and marketing of publications and to strengthen contacts with other organizations like ISO, Codex Alimentarius, AOAC and OIML.

The question of making ICUMSA an English-language-only organization, in an effort to obviate the high cost of simultaneous translation at Session meetings, was rejected and it was resolved that, in future, such costs could be borne by delegates as a conference fee instead of its being funded out of the Session levy.

The President presented a report on the adoption of the 1986 Recommendations regarding the Sugar Scale and the deletion of the 0.1° deduction option in polarimetry of raw sugars. This showed that the slow response of organizations like the EEC and OIML had delayed the full implementation of these recommendations and it was resolved to pursue universal adoption during the 21st Session.

It is hoped to publish the full text of Recommendations adopted in our next issue, while the publication of the *Proceedings* is expected early in 1991. The Commission accepted Cuba's invitation to hold the 21st Session in 1994 in Havana.

Sugartech 1990

continued from previous page

Judkins. P. Christodoulou then gave an account of "Experiences of juice purification with beets of Mediterranean origin" and was followed by G. Windal who described the RAMSES method for "Automatic control of the evaporator station". The last paper of the session was presented by P. Bonnenfant on "Continuous vacuum pan modelling", and the Conference was then closed by Dr. Branch who summed up the interesting work which had been described and the challenges which faced the industry in the future.

Facts and figures

Cane wax plants in Cuba

The AIN news agency in Cuba has reported that 24 plants are to be set up in that country for the production of crude and refined wax from cane. Two plants of each type are currently in operation and six more will be by the end of the year. The wax is to be used as a coating, for products such as cheese and other foodstuffs.

China sugar imports, 1989

China's State Statistical Bureau has reported that the country imported 313,700 tonnes of sugar in 1989. No analysis by origins was given in the report from the Xinhua news agency report of May 22.

Taiwan sugar industry contraction[1]

Long-term plans of the Taiwan Sugar Corporation (TSC) call for reducing production to an amount sufficient for domestic consumption and the US quota. Processing capacity at its 23 sugar factories was reported to be only 62%

1 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 240.

in 1988/89. TSC has diversified into by-products utilization (alcohol, yeast and L-lysine from molasses, board and paper pulp from bagasse), raising animals, soybean oil extraction, etc., with only 65% of its 1989 revenue from sugar.

Second Cuban furfural plant[2]

The first plant in Cuba for furfural manufacture from bagasse went into operation in July 1988 at Central Amancio Rodríguez in Las Tunas province, with a capacity of 1000 tonnes/year. A second plant is now under construction at Central Jesús Suárez Gayol, in Camagüey province, with a capacity of 5000 tonnes/year.

Barbados sugar exports, 1989[3]

Exports of raw sugar from Barbados in 1989 totalled 55,469 tonnes, down from the 67,813 tonnes exported in 1988. The principal destination was again the EEC which took 43,736 tonnes (54,663 tonnes in 1988), while 8934 tonnes went to the US (8852 tonnes in 1988) and 2799 tonnes to Canada (4298 tonnes).

Alcohol production in Brazil, 1990/91[4]

Brazil's production of alcohol in the crop year April 1990/March 1991 is estimated at 122 million hectolitres, slightly up from the previous year's 118.4 million hl. Alcohol consumption is expected to fall from 125.7 million hl in 1989/90 to 113.1 million hl, the decrease being due to the use of methanol and gasoline in the alcohol fuel.

New bagasse pulp projects in Thailand and Egypt[5]

A new bagasse pulp plant, owned by Siam Pulp & Paper Co., was due to start operations during the second quarter of 1990 in Kanchanabury, Thailand. It is to produce 25,000 tonnes/year of chemical thermo-mechanical pulp, and next year will supply a new paper-making machine. It has also been announced that construction and assembly of a new bagasse pulp plant in the south of Egypt is in its final stages, with a capacity of 60,000 tonnes/year of unbleached pulp.

Argentina sugar exports, 1989[6]

	1989	1988
	tonnes, raw value	
Brazil	57,973	0
Chile	10,693	3,714
China	10,600	123,497
EEC	0	11,700
Tunisia	0	11,999
Uruguay	10,725	2,000
USA	73,273	66,942
Unknown	8,426	0
	171,690	219,852

Dominican Republic sugar crop reduction[7]

Production of sugar in the Dominican Republic in 1990 is expected to fall to not more than 580,000 tonnes, raw value, from 735,000 tonnes last year. Reasons for the reduction include lack of resources for factory repairs, electricity shortages and arson in the cane fields which began in April and intensified after the May 16 presidential election. The State Sugar Council (CEA) nevertheless expects to be able to fulfil its US supply quota.

Australian cane area limit raised[8]

The Queensland Primary Industries Minister announced in May that an 8% increase would be made in the permissible cane area to be sown for the 1990/91 season. If growers were to take the opportunity to plant more cane the output of raw sugar in the 1990/91 season could rise to 4.0 million tonnes against the 3.6 million tonnes of the 1989/90 season extracted from a crop of 27.6 million tonnes of cane.

West Indies Sugar Technologists Conference, 1991

The 24th Conference of the West Indies Sugar Technologists will be held during April 8 - 12, 1991, at the Oceana Hotel in Kingston, Jamaica. It was in 1976 that Kingston last hosted the WIST Conference; since then they have taken place in Guyana, St. Kitts, Trinidad and Barbados. It is planned to arrange interesting field and factory tours in addition to the presentation of papers. These must be provided by October 31, 1990 and a leaflet giving details of requirements may be obtained from Dr. Michael Shaw, Agricultural Division, Sugar Industry Research Institute, Kendal Road, Mandeville P.O., Jamaica.

Indian sugar industry expansion[9]

The government of the Indian state of Uttar Pradesh has decided to set up 32 more sugar factories to cope with sugar cane production in the state. In the current crushing season the factories were not able to cope with the increased cane supply and cane was sent to two factories in Haryana state. On the other hand, 28 of the state's 104 factories stopped crushing for a period owing to a lack of cane. Of the total cane supply some 22 - 32% is crushed by the sugar factories while 10 - 15% is used to make khandsari and 40 - 45% to make gur. The remaining 17% is used as seed cane, for animal feed and as chewing cane. A number of new sugar factories are also expected to go on stream in Gujerat state during the next three years with a total capacity of one million tonnes per year. Three will be located in Surat district, two each in Baruch and Valsao districts and one in Baroda. Setting up of a further four factories in the cooperative sector is also being considered.

Venezuela sugar industry privatization[10]

The President of the Venezuelan Investment Fund has said that the government is planning to privatize many of the country's state-owned sugar factories as soon as possible. The privatization program comes within a general program of economic liberalization.

2 *GEPLACEA Bull.*, 1990, **7**, (5), Sugar Inf.-2.
3 *I.S.O. Stat. Bull.*, 1990, **49**, (3), 3.
4 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 278.
5 *GEPLACEA Bull.*, 1990, **7**, (5), Sugar Inf.-3.
6 *I.S.O. Stat. Bull.*, 1990, **49**, (5), 1.
7 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 314 - 315.
8 *Reuters News*, May 21, 1990.
9 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 317, 349.
10 *Venpres news agency report* (Venezuela), June 12, 1990.

Mexico sugar imports and exports, 1989[11]

	1989	1988
	tonnes, raw value	
Imports		
Argentina	13,017	0
Brazil	26,174	0
China	13,018	0
Colombia	12,257	0
Cuba	67,610	0
EEC	134,944	0
Guatemala	102,572	0
Korea, South	15,938	0
Philippines	12,204	0
Poland	14,970	0
Thailand	14,102	0
USA	158,486	0
Yugoslavia	12,157	0
Total imports	597,449	0
Exports		
Bulgaria	0	13,261
Chile	0	5,978
China	0	261,394
Egypt	0	14,674
Finland	0	26,087
Guyana	4,339	0
Haiti	6,440	0
Morocco	54,000	60,109
Mozambique	0	7,826
USA	114,818	166,392
USSR	140,387	373,339
Venezuela	14,200	58,695
Other countries	0	13,696
Total exports	334,184	1,014,481

Taiwan sugar production, 1989/90

The Taiwan Sugar Corporation has announced that the 1989/90 season (November/May) resulted in a preliminary output of 490,000 tonnes, tel quel, reflecting a drop of 20.5% from the 616,500 tonnes produced in 1988/89. The decline is attributed to damage to the cane crop from flooding following typhoons. Target sugar production for the 1990/91 crop has been set at 540,000 tonnes.

Guyana shortfall in its EEC quota[12]

Guyana is reported to have declared *force majeure* on a 13,000-tonnes shortfall in its EEC quota of nearly 160,000 tonnes, white value. Reasons given are strikes and unseasonable rains which hampered harvesting and reduced sugar content. It is the second consecutive year that a shortfall has been declared and there is a fear that the Community might not accept the declaration, and might reduce the quota, reallocating it to other producers. Although Guyana failed to fulfil its EEC quota it has met its quota to the USA.

Australian export sugar refinery possibility[13]

Reuters reports that Bundaberg Sugar Co. Ltd. has said it is investigating a joint venture with local sugar factories to build an export sugar refinery in North Queensland. Expansion plans also include the further development of the company's Moreton Mill to produce food-grade raw sugar and the expansion of refining capacity at the Millaquin refinery. Bundaberg Sugar said it had dismissed production of white sugar in the past but that it was now important to reconsider participation in the white sugar export trade.

Sudan sugar situation[14]

The 1989/90 season ended in May with a production of 387,100 tonnes of sugar, white value, equivalent to about 420,000 tonnes, raw value. The new Sudanese government declared early last year that sugar imports would be suspended and that consumption had to be covered entirely by domestic production. On the basis of a fixed per caput consumption of 13.5 kg/year, requirements of 385,000 tonnes will be roughly in balance with availability. Production in 1990/91 is estimated at 437,000 tonnes, white value (475,000 tonnes, raw value), while consumption is not expected to increase, so that there should be a small surplus. To obtain higher production, a major rehabilitation program is being undertaken and the four sugar factories at Guneid, New Halfa, Sennar and Assalaya will be modernized using finance provided by the World Bank, Arab and Saudi development funds, West Germany and the Sudan government. This rehabilitation program is expected to be completed in 1991/92.

Sockerbolaget AB Annual Report, 1989

The 1989 campaign in Sweden yielded 388,000 tonnes of granulated sugar from beets, which surpassed the previous year's record production. The root harvest amounted to 52.3 tonnes/ha, which few believed possible under Swedish cultivation and climatic conditions. The sugar content was high as well, and the sugar yield per hectare rose to 9.2 tonnes, some 10% above the previous year's record figure and 21% above the mean for the period 1984/88. Spring and early summer conditions were favourable for growth and the mild and moist autumn provided ideal harvesting conditions. Factory throughput rose to 31,460 tonnes/day, 1000 tonnes more than in 1988. In Jordberga a solid fuel fired steam boiler and a new turbine were put into operation, while a new tower diffuser was installed at Ortofta. The factories have substantial over-capacity so that other investments were for improvement of product quality, safeguarding the external environment and necessary machinery replacements.

Australia sugar exports, 1989[15]

	1989	1988
	tonnes, raw value	
Canada	524,724	495,405
China	226,672	485,685
Egypt	25,540	0
Japan	696,107	723,964
Korea, South	516,371	461,795
Malaysia	398,447	554,715
New Zealand	101,847	63,861
Singapore	141,107	109,276
USA	135,280	74,673
USSR	282,410	0
Venezuela	87,259	0
Other countries	13,512	10,659
	3,149,276	2,980,033

Philippines sugar factory closure

The Talisay-Silay Milling Co. Inc. sugar factory at Talisay in Negros Occidental has closed.

11 *I.S.O. Stat. Bull.*, 1990, **49**, (5), 26 - 27.
12 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 316.
13 *Amerop Newsletter*, 1990, (199), 13.
14 F. O. Licht, *Int. Sugar Rpt.*, 1990, **122**, 348 - 349.
15 *I.S.O. Stat. Bull.*, 1990, **49**, (5), 2.

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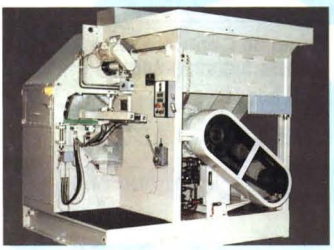

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