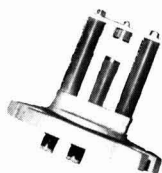
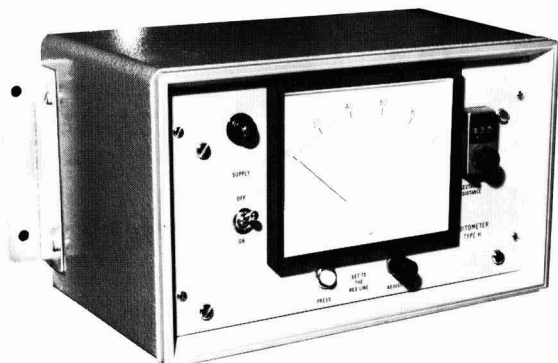


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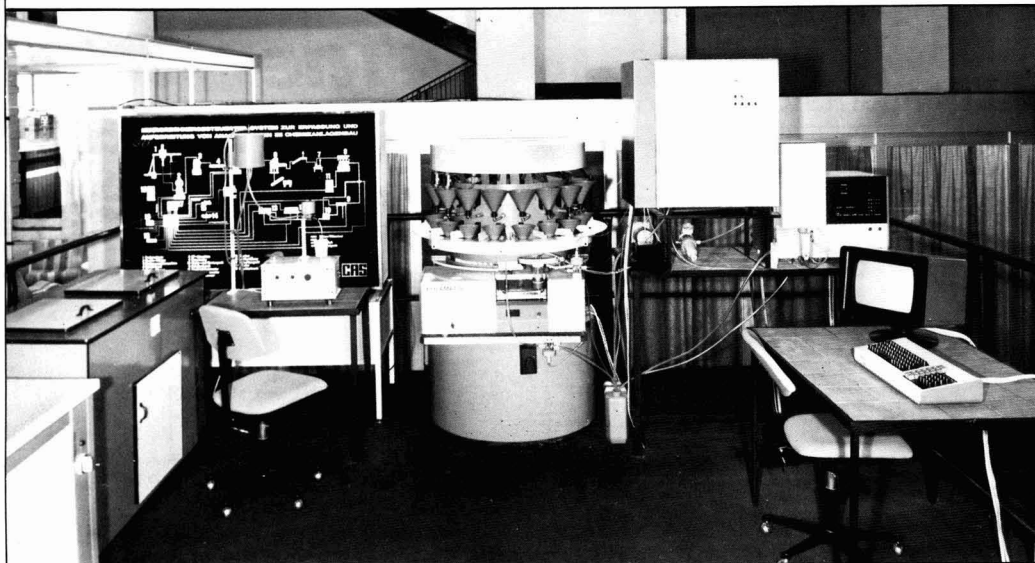
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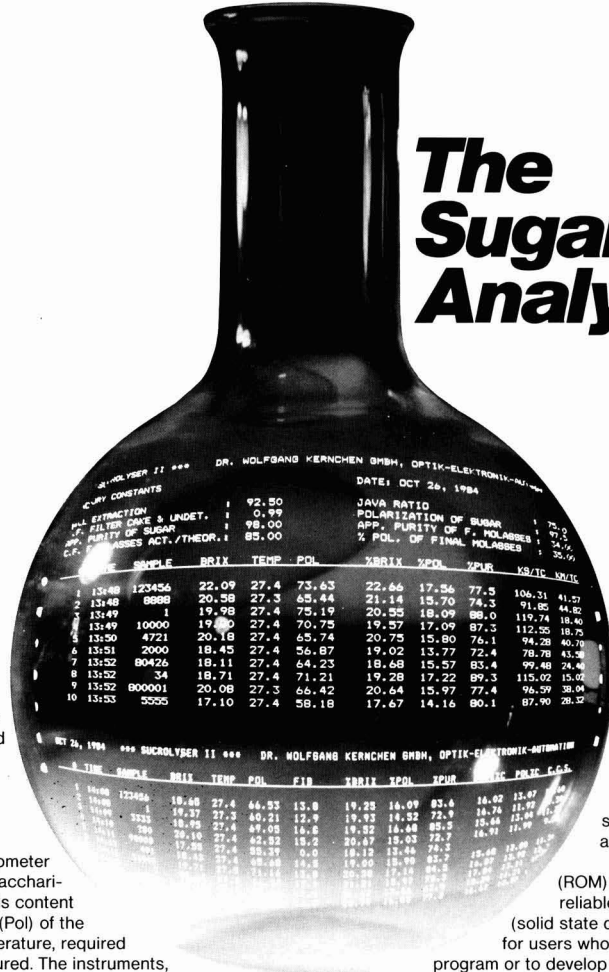
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# INTERNATIONAL SUGAR JOURNAL


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## CONTENTS September 1985

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161 Notes and comments

\* \* \*

*Technical articles*

- 163 Collaborative study on the determination of trace elements in dried sugar beet pulp and molasses. Part IV. Arsenic**  
By A. W. M. Huijbregts, D. Hibbert, R. T. Phillipson, H. Schiweck and G. Steinle
- 167 Imbibition optimization**  
By Michael D. Sullivan
- 172 The analysis of sugars in beet. Part I. Samples preparation**  
By A. P. Mulcock, S. Moore and F. Barnes
- 176 Single-cell protein production from cane juice and molasses by thermotolerant yeasts**  
By Rita Kar and L. Viswanathan

\* \* \*

171, 178-180 Brevities and statistics

179 International Commission for Sugar Technology (C.I.T.S.)

180 Copersucar international symposium on sugar and alcohol

\* \* \*

*Abstracts section*

89A Cane sugar manufacture

91A Beet sugar manufacture

95A Laboratory studies

97A By-products

\* \* \*

xvi *Index to Advertisers*

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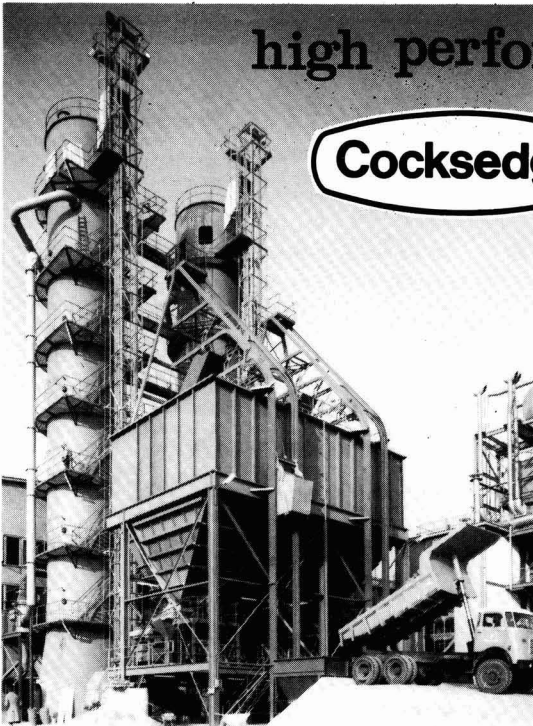
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# Notes and comments

## The cyclical nature of the sugar market<sup>1</sup>

The first of the oil crises a decade and a half ago undermined the value of money and caused many to believe that high prices for commodities would be a continuing feature. And so it was for a time. In the sugar market the expression "structural change in the market" began to circulate. It was much used at the Brussels symposium held in November 1971 and there were calls to expand production so that markets should not be lost.

Now we are seeing the other side of the coin. Surpluses have built up in all commodities and once again, but for exactly opposite reasons, it is being suggested that there has been a structural change in the market. What basis can there be for this? There has been the development of new generations of sweeteners, both caloric and high intensity. They have had an effect on sugar consumption, but that is hardly a fundamental change in the structure of the market unless their availability fluctuates with the movement in the world market price for sugar. Certainly the expansion in usage of fructose syrups in the USA and to a lesser extent elsewhere was encouraged by the high sugar prices of a decade ago, but their natural outlet has largely been filled and it seems unlikely that their market share in the future will fluctuate greatly in response to sugar prices.

Similarly the argument that the present financial problems of the world are such that they will inhibit consumption, whatever the price, is an important one as it does imply a limitation to the growth factor. But on consideration it has to be recognised that this is already involved in the consumption trend and if this indicates that production at present levels is too high, then it will have to be trimmed. In free market conditions this is no new factor.

What is a new factor, and one which is likely to become increasingly

important, is the development of alternative uses for beet and cane. For the time being the most important one is the production of ethanol pioneered by Brazil, but further developments in the chemical field can be expected in the future. This can only bolster sugar prices all the time they are low, though of course in times when they are high there might well be some switching back from other industries.

It is hard, then, to envisage any new factor which could eliminate the cyclical nature of the sugar market. In that case the next question must clearly be, when might one anticipate the next peak in sugar prices?

There has been a certain pattern about the past price cycles. The first post-war price boom occurred in 1956 after stocks dropped to 26% of consumption. Six years later, in November 1962, a new price rise took place in response to an erosion in stocks. In 1969 there were some indications that a further upward movement might be in store for the market. Certainly annual price averages improved, but quotations never did rise as had been forecast.

If the previous cycle had been repeated one might have expected the price peak to have come in 1969 or 1970. What were the changed circumstances, if any, which affected the market?

In the crop years 1966/67, 1967/68 and 1968/69 Cuban production averaged 5.3 million tonnes. If output had been at that level again in 1969/70 the world's stock to consumption ratio would have been reduced to a reasonable 26.0%. As it was, that was the season in which Cuba attempted to produce ten million tonnes and in fact exceeded an output of 8.5 million tonnes. The stock ratio was, in fact, 29.5%.

There was little else that was changed in the statistical position; the general pattern of production and consumption in other countries remained largely unaltered. The only thing that had changed was that an

additional quantity of more than three million tonnes had been added to the stock.

So the upward price movement was deferred. The following season Cuba reverted to a more normal level of output and world consumption continued to grow. This made the expected tight supply situation, when it eventually came, even more acute.

Towards the end of 1970 prices started to move up once more. For most of 1971 there were no dramatic moves but there was an upward surge at the year's end. From an opening level of just over 25%, which certainly did not permit any leeway, stocks by the end of 1971/72 had dropped to 22.5% of consumption.

There then followed a lengthy period of high prices which continued into 1976. Two oil crises fundamentally altered values of currencies which reduces the value of comparisons. Nevertheless the peak of more than 65.00 cents per lb reached in 1974 was an astonishing price to reach less than eight years after a spot quotation of 1.23 cents per lb had been registered.

Even when prices began to fall during and after 1974 the market remained in a fundamentally buoyant mood. Though stocks stood consistently at more than 35% of consumption, at no time did the spot price fall below 6.05 cents per lb during this period. When, in 1979/80, supplies showed signs of falling once more another upward price drive took place. This time the New York spot price rose above 43.00 cents per lb during the second half of 1980, just six years after the previous high point had been established.

Since then there has been a steady decline in sugar prices coupled with apparently expanding stocks, except for one period during the middle of 1983 when fears that weather conditions might damage crops brought a resurgence in demand. Speculative interest entered the market and there

<sup>1</sup> C. Czarnikow Ltd., *Sugar Review*, 1985, (1738), 67-68.

was a sudden upward burst in prices before their descent recommenced.

The high prices which occurred during the early years of the past decade, and which continued for so long, encouraged by talk of a structural change in the market, led to expansionist plans in many producing regions of the world and the corrective measures which might have been taken once the decline had started were no doubt negated by the sudden upsurge in 1983. In any case one has only to look at the current stock level to recognise how delayed a sustained price increase will have to be. Nevertheless corrective measures are now being taken in several important sugar producing countries, while veracity of world stock figures is to be doubted. In this connexion it will be noted that the upward price movement which started in 1979 was from a notional basis of a much higher stocks to consumption ratio than was apparently the case with the price surges of one and two decades earlier.

In summary, therefore, it seems that the cyclical nature of the market will continue but that the next upward movement will be delayed by the extended nature of the last boom and the upward surge in prices in the market two years ago.

#### ACP—EEC sugar price conflict

As has become normal, ACP representatives denounced as inadequate the increase of 1.15% they were offered in the price paid for their sugar by the European Economic Community. They were told, however, that the offer was final and the Farm Commissioner, Mr. Frans Andriessen, pointed out that it was a better offer than that given to European beet and raw sugar producers who received no price increase at all; a 1.3% increase was being granted for white sugar but this was in fact an increase of 3.5% in the refining margin. It was later announced<sup>2</sup>, however, that the 1.3% increase would be granted and would apply to cover shipments sent since May.

#### EEC agricultural policy reform

On July 24, the EEC commissioners agreed to submit to the Agricultural Ministers of member countries proposals aimed at recouping the deficit accumulated on sugar export sales over the past few years. The loss on selling to the world market of surplus B-quota sugar, bought at a higher price, is theoretically to be covered by a levy up to 2% on A-quota production and up to 39.5% on B-quota sugar production. The continuation of very low world market prices, combined with the large amounts of sugar sold, have meant that the deficit has not been covered and the accumulated loss has already reached 445 million e.c.u. (\$333 million) and could reach 700 million e.c.u. by June 1986.

While maintaining quotas at their existing levels, the Commission proposes therefore to raise the levies to 2.5% and 40%, respectively, which is intended to provide sufficient funds to eliminate the deficit over the next five years<sup>3</sup>. The proposals will be debated by the Farm Ministers in due course.

C. Czarnikow Ltd. doubts, however, whether the moves are adequate<sup>4</sup>. "It is difficult to see how, with world market prices around present levels, such levies could do more than meet current year running costs so that the accumulated deficit would still have to be carried forward from year to year.

"The suggestion has been made that if producers are made more financially responsible for the excess sugar they are producing they will curtail production. Of course, there is sense in this argument, but there are also two other procedures which could be adopted. The Commission has already in recent years limited annual price increases to less than the inflation rate and all the time the present massive surpluses exist it is to be hoped that this procedure continues. But is it really too late to consider quota reductions?"

#### World sugar prices

The general downward drift in the London Daily Price for raw sugar continued in July and from a level of \$87 per tonne it sank in the first week to \$82. The gradual weakening of the US dollar during the period had its effect after this, however, and the price started to firm in the second week. During the third week news that Brazil was delaying shipment of some 500,000-600,000 tonnes of sugar and diverting more cane to alcohol, plus rumours of additional purchases by the USSR helped to bring the LDP to around \$100. On July 26 there was a sharp rise to \$114 per tonne, encouraged by talk of drought hitting the Caribbean, particularly the Dominican Republic and Cuba, and growing confidence in Brazil's resolve to reduce exports in 1985/86. Greater credence has been given to suggestions that stocks may have been run down more than has been realised, as low prices have encouraged consumers to operate on a hand-to-mouth basis. The price rose to \$125 on July 29 but fell back, to end the month at \$114.50 per tonne.

White sugar values had remained very steady during the first half of the month; after starting on July 1 at \$134 the LDP stayed within the range \$129.50 to \$133.50 up to July 17. The same influences affected it as the LDP and it started to rise, reaching \$139 on July 25. A rise to \$153 on July 29 then occurred, followed by a fall to \$147 at the end of the month.

Sugar at 3-5 cents/lb is attractive as a cheap commodity into which speculators can move their funds away from the weakening dollar; thus a market demand can arise which is unrelated to supply and demand for the product, and it is important that producers continue to make efforts to reduce outturn to avoid another surplus in the coming twelve months.

<sup>2</sup> *Financial Times*, August 1, 1985.

<sup>3</sup> *ibid.*, July 25, 1985.

<sup>4</sup> *Sugar Review*, 1985, (1739), 82.



# Collaborative study on the determination of trace elements in dried sugar beet pulp and molasses. Part IV. Arsenic

By A. W. M. Huijbregts, D. Hibbert, R. T. Phillipson, H. Schiweck and G. Steinle

## Introduction

In continuation of parts I to III (concerning the determination of mercury<sup>1</sup>, fluorine<sup>2</sup> and lead<sup>3</sup>), part IV of our present series of collaborative studies deals with the determination of arsenic in dried sugar beet pulp and molasses.

Although arsenic acts as an essential nutrient, which can promote growth and feed efficiency in pigs and poultry, it can also be very toxic, depending on the amount and chemical form ingested<sup>4</sup>. The maximum level of arsenic permitted by the European Economic Community in sugar beet pulp has been set at 4 mg/kg, referred to a moisture content of 12%<sup>5,6</sup>.

Very little information about levels of arsenic in sugar beet products has been published. Steinle<sup>7</sup> has reported average values for the arsenic content of dried pulp (0.32 mg/kg), pulp nuts (0.41 mg/kg), molassed dried pulp (0.43 mg/kg), molasses (0.27 mg/kg) and white sugar (0.05 mg/kg).

In the present study the same method was used for sample preparation and sub-sampling as has already been described in our first paper<sup>1</sup>. The participating laboratories developed their own individual analytical methods and used these for replicated analyses of the samples examined. Samples of dried pulp and molasses were exchanged between the collaborating laboratories to verify the reliability of their methods.

All three participants used an analytical method based on the formation of arsine prior to determination by atomic absorption spectrometry. The results obtained on the exchanged samples were compared with those obtained by the silver diethyldithiocarbamate method<sup>8</sup> and by neutron activation analysis.

## Experimental

### Sample digestion

Because of the high proportion of fibrous substances and the varying amount of silicious material in dried



A. W. M. Huijbregts



D. Hibbert



R. T. Phillipson



H. Schiweck



G. Steinle

pulp and because of the very high soluble carbohydrate content of molasses, it is important that the digestion procedures should be of sufficient length and severity to ensure satisfactory analytical results. The three participating laboratories used their own digestion procedures. Süddeutsche Zucker-AG (SZ) used aqua regia, while British Sugar plc (BS) used a mixture of nitric and sulphuric acids. For the determination by atomic absorption spectroscopy the Instituut voor Rationele Suikerproductie (IRS) used nitric acid (pulp) or aqua regia (molasses) followed by an additional oxidation step using hydrogen peroxide. The digestion for the determination with diethyldithiocarbamate was carried out with a mixture of nitric, sulphuric and perchloric acids.

### Determination of arsenic content

For the analysis of arsenic in the final extract, a small quantity of the extract was brought into the system for generation of arsine by sodium

borohydride (BS, IRS) or stannous chloride and zinc/hydrochloric acid (SZ). An atomic absorption spectrophotometer was used, fitted with an arsenic electrodeless discharge lamp (BS, SZ) or a hollow cathode lamp (IRS).

The arsine vapour was passed by means of a stream of argon (BS, SZ), or argon containing 1% oxygen to promote atomization<sup>9</sup> (IRS), into an argon/hydrogen flame (BS, SZ) or into the absorption cell, which was heated by an air/acetylene flame (IRS).

### Detailed methods

Method (a) of the Instituut voor Rationele Suikerproductie (IRS) was as follows:

#### Apparatus

Atomic absorption spectrophotometer: Instrumentation Laboratory Model 451 (Allied Instrumentation Laboratory, IJsselstein, Holland), equipped with a Model 440 atomic vapour accessory and a deuterium background compensation system. Spectrophotometer settings: wavelength 193.7 nm; lamp current 8 mA; slit 1 mm; burner somewhat reducing air/acetylene flame. Atomic vapour accessory settings: argon/oxygen (99/1) flow 1.5 dm<sup>3</sup>/min, argon flow 5.5 dm<sup>3</sup>/min.

Hollow cathode arsenic lamp (Allied Instrumentation Laboratory).

#### Reagents

Nitric acid — concentrated (65%, p.a. grade, Merck No. 456)

- 1 Koster *et al.* *I.S.J.*, 1975, 77, 229-305; *Zucker*, 1975, 28, 555-562; *Sucr. Belge*, 1975, 94, 385-393.
- 2 Idem: *I.S.J.*, 1979, 81, 4-8; *Zuckerindustrie*, 1979, 104, 49-53; *Sucr. Belge*, 1979, 98, 3-9.
- 3 Idem: *I.S.J.*, 1981, 83, 291-296; *Zuckerindustrie*, 1981, 106, 895-900; *Sucr. Belge*, 1981, 100, 333-340.
- 4 Underwood: "Trace Elements in Human and Animal Nutrition", 4th Edn. (Academic Press, New York) 1977, pp. 1-3.
- 5 *O.J. European Communities*, No. L38 (11-02-1974), 31.
- 6 *O.J. European Communities*, No. L4 (09-01-1976), 24.
- 7 *Zucker*, 1977, 30, 535-540.
- 8 "Methods of Analysis — A.O.A.C.", 13th Edn. (A.O.A.C., Washington), 1980, pp. 385-387.
- 9 Welz & Melcher: *Analyst*, 1983, 108, 213-224.

Nitric acid—dilute, 1 volume concentrated nitric acid and 7 volumes deionized water  
Hydrochloric acid—concentrated (37%, p.a. grade, Merck No. 317)  
Aqua regia—mixture of 1 volume concentrated nitric acid and 3 volumes hydrochloric acid  
Hydrogen peroxide solution—(30%, p.a. grade, Merck No. 7209)  
Sodium borohydride—pellets (p.a. grade, Merck No. 6371)  
Sodium hydroxide—pellets (p.a. grade, Merck No. 6498)  
Sodium borohydride solution (prepared fresh daily)—12.5 g NaBH<sub>4</sub> dissolved in 250 cm<sup>3</sup> sodium hydroxide solution (10 g NaOH/dm<sup>3</sup>)  
Octyl alcohol—(p.a. grade Lamers & Pleuger, Den Bosch, Holland)  
Stock arsenic solution (1000 µg/cm<sup>3</sup>)—prepared from arsenic standard (Titrisol, Merck No. 4939) with deionized water.  
Working arsenic solution (10 µg/cm<sup>3</sup>):—10 cm<sup>3</sup> of the stock solution and 50 cm<sup>3</sup> of concentrated nitric acid are brought to volume with deionized water in a 1 dm<sup>3</sup> volumetric flask; stored in a refrigerator, this solution is stable for at least 1 month.

#### Digestion

The digestion of pulp and molasses is carried out as described for lead<sup>3</sup>.

#### Determination

**Calibration:** A range of standards is prepared by pipetting respectively 0, 5, 10, 15, 20 and 25 mm<sup>3</sup> of the working arsenic solution into a reaction bottle containing 20 cm<sup>3</sup> of dilute nitric acid. Two drops of octyl alcohol are added and the reaction bottle is placed in the atomic vapour system. Then 5 cm<sup>3</sup> sodium borohydride solution is pipetted into the reaction bottle. The solution is stirred continuously and the liberated arsine transferred to the absorption cell in a stream of argon/oxygen (99/1) until the reaction

is complete. Duplicate determinations are carried out and a graph is constructed of the mean peak area of each pair of standard solutions against their arsenic content.

**Samples:** From the final sample solution 20 cm<sup>3</sup> is transferred to the reaction bottle. After addition of two drops of octyl alcohol the analysis is carried out as described for the standard solutions. The determination is carried out in duplicate.

**Blank:** A duplicate blank determination is carried out, using the digestion and determination procedure described, without sample.

**Calculation:** The arsenic contents of the sample solutions and of the blank solution are determined from the calibration graph. The arsenic content of the blank solution is subtracted from the results obtained on the sample solutions to calculate their arsenic contents.

Method (b) of the British Sugar plc (BS) was as follows:

#### Apparatus

Atomic absorption spectrophotometer: Perkin-Elmer 305 B (Perkin-Elmer Ltd., Beaconsfield, Bucks, U.K.) fitted with a deuterium background corrector. Instrument settings: wavelength 193.7 nm, slit setting 4 (0.7 mm), burner with argon/hydrogen flame.

System for the generation of arsine as a means of determining arsenic by atomic absorption (Perkin-Elmer).

Arsenic electrodeless discharge lamp and power supply (Perkin-Elmer).

The argon is connected to the arsine generating equipment.

#### Reagents

Nitric acid—concentrated (69-71%, Aristar, BDH)  
Sulphuric acid—concentrated (98%, Aristar, BDH)  
Hydrochloric acid—concentrated

(36%, Aristar, BDH)  
Ammonia solution—(35%, Aristar, BDH)  
Sodium borohydride—pellets (Spectrosol, BDH)  
Stock arsenic solution (1000 µg/cm<sup>3</sup>)—1.320 g of arsenious oxide As<sub>2</sub>O<sub>3</sub> is dissolved in 25 cm<sup>3</sup> of 20% w/v potassium hydroxide solution; the solution is neutralized with 20% v/v sulphuric acid to a phenolphthalein end point and diluted to 1 dm<sup>3</sup> with 1% v/v sulphuric acid solution.  
Standard arsenic solution (10 µg/cm<sup>3</sup>)—5 cm<sup>3</sup> of the stock solution is brought to volume with distilled water in a 500 cm<sup>3</sup> volumetric flask.  
Working arsenic solution (0.1 µg/cm<sup>3</sup>)—5 cm<sup>3</sup> of the standard solution is brought to volume with distilled water in a 500 cm<sup>3</sup> volumetric flask.

#### Digestion

The sample (about 1 g) is weighed into a 150 cm<sup>3</sup> conical flask. Distilled water (10 cm<sup>3</sup>) and concentrated nitric acid (10 cm<sup>3</sup>) are added. After boiling gently for 10 min the contents of the flask are cooled and 10 cm<sup>3</sup> of concentrated sulphuric acid is added. Then the contents of the flask are heated until the liquid begins to darken, after which concentrated nitric acid is added in 1 to 2 cm<sup>3</sup> portions; after each addition (approximate total addition, 6 cm<sup>3</sup>) the contents are again heated.

Heating is continued until digestion is complete and the sulphuric acid begins to fume. After cooling, 10 cm<sup>3</sup> of distilled water is added and the contents are heated again to fuming. After cooling, the contents are transferred to a 100 cm<sup>3</sup> graduated flask and made up to the mark with distilled water.

If necessary the solution is filtered.

#### Determination

**Calibration:** A calibration graph is constructed by taking three conical reaction flasks and adding 0, 2 and 4 cm<sup>3</sup> respectively of the working arsenic

solution. The volume of each flask is made up to 27 cm<sup>3</sup> and 15 cm<sup>3</sup> of concentrated hydrochloric acid is added. A magnetic stirrer is added to the flask before it is connected to the arsine generation apparatus. The solution is stirred continuously and the flask flushed with argon for 1 min. A sodium borohydride pellet is released from the side arm and the liberated arsine and hydrogen are collected in the balloon for about 30 sec or until the reaction is complete. Then the collected hydrogen and arsine are released into the flame and the peak height is recorded. The peak heights are plotted against their arsenic contents to obtain a straight line.

**Samples:** A suitable aliquot of the sample solution (containing preferably not less than 0.02 µg and no more than 0.4 µg As) is pipetted into the conical flask of the arsine generation apparatus. The aliquot is neutralized with ammonia solution using phenolphthalein as indicator. The total volume in the flask is made up to 27 cm<sup>3</sup> and 15 cm<sup>3</sup> of concentrated hydrochloric acid is added. The peak height, corresponding to the amount of arsenic in the flask, is determined in the same way as for the standard solutions. All determinations are carried out in duplicate.

**Blank:** A duplicate blank determination is carried out, using the digestion and determination procedure described, without sample.

**Calculation:** The arsenic contents of the solutions are determined by reading the mean peak height from the calibration graph. After correction for the blank solution the arsenic contents of the samples are reported.

Method (c) of Süddeutsche Zucker-AG (SZ) was as follows:

#### Apparatus

Atomic absorption spectrophotometer: Perkin-Elmer Model 300 S

(Bodenseewerk Perkin-Elmer & Co., Ueberlingen, Germany), equipped with a deuterium background compensation system. Instrument settings: wavelength 193.7 nm, lamp current 8 mA, slit 0.59 mm, burner with argon/hydrogen flame (argon 25 dm<sup>3</sup>/min, hydrogen 8 dm<sup>3</sup>/min).

Arsine generating equipment (Perkin-Elmer).

Arsenic electrodeless discharge lamp and power supply (Perkin-Elmer).

The argon is connected to the arsine generating equipment.

#### Reagents

Nitric acid—concentrated (65%, Suprapur, Merck No. 441)

Hydrochloric acid—concentrated (32%, p.a. grade, Merck No. 319)

Aqua regia—mixture of 1 volume concentrated nitric acid and 3 volumes hydrochloric acid.

Hydrochloric acid—(30%, Suprapur, Merck No. 318)

Potassium iodide solution—20 g potassium iodide (Suprapur, Merck No. 5044) made up to 100 cm<sup>3</sup> in distilled water.

Zinc—powder (p.a. grade, Merck No. 8789)

Stock arsenic solution (1000 µg/cm<sup>3</sup>)—prepared from arsenic standard (Titrisol, Merck No. 9939) with distilled water.

Standard arsenic solution (10 µg/cm<sup>3</sup>)—1 cm<sup>3</sup> of the stock arsenic solution and 10 cm<sup>3</sup> hydrochloric acid (1 mol/l Merck No. 9970) are brought to volume with distilled water in a 100 cm<sup>3</sup> volumetric flask.

Working arsenic solution (1 µg/cm<sup>3</sup>)—10 cm<sup>3</sup> of the standard arsenic solution and 10 cm<sup>3</sup> hydrochloric acid (1 mol/litre) are brought to volume with distilled water in a 100 cm<sup>3</sup> volumetric flask.

#### Digestion

The digestion of pulp and molasses is carried out as described for lead<sup>3</sup>.

#### Determination

**Samples:** A 10 cm<sup>3</sup> aliquot of the

sample solution is pipetted into a conical reaction flask and 30 cm<sup>3</sup> hydrochloric acid (30%), 1 cm<sup>3</sup> potassium iodide solution and 1 cm<sup>3</sup> stannous chloride are added. After connexion to the arsine generating equipment, the flask is flushed with argon. Zinc (2 g) is released from the side arm and the liberated arsine and hydrogen are collected in the balloon until the reaction is complete (3 min). The collected hydrogen and arsine are then released into the flame and peak height is recorded.

**Calibration:** A 10 cm<sup>3</sup> aliquot of the sample solution and 0.5 cm<sup>3</sup> of the working arsenic solution (corresponding to 0.5 µg arsenic i.e. 0.05 µg/cm<sup>3</sup> sample solution) are pipetted into a conical reaction flask and 30 cm<sup>3</sup> hydrochloric acid (30%), 1 cm<sup>3</sup> potassium iodide solution and 1 cm<sup>3</sup> stannous chloride are added. After connexion to the arsine generating equipment, the peak height, corresponding to the amount of arsenic in the flask, is determined in the same way as for the sample solutions.

**Blank:** A duplicate determination is carried out, using the digestion and determination procedure described, without sample.

**Calculation:** The peak heights of the sample and the sample with addition of arsenic (0.05 µg/cm<sup>3</sup>) are plotted against the added arsenic contents. From this graph the arsenic contents of the samples are reported after correction for the blank solution (standard addition method).

#### Results

##### Evaluation of methods

Based on the results of 23 (IRS), 15 (BS) and 16 (SZ) duplicate analyses of pulp, the standard error of the mean of a duplicate determination has been found to be 0.04, 0.05 and 0.03 mg/kg respectively, at mean concentrations of 0.58 (IRS), 1.09 (BS) and 0.74 mg/kg (SZ). These values imply confidence

limits between duplicate tests ( $P=0.05$ ) of  $\pm 0.08$  (IRS),  $\pm 0.10$  (BS) and  $\pm 0.07$  mg/kg (SZ). The limits of detection of the methods are 0.1 mg/kg (IRS), 0.1 mg/kg (BS) and 0.05 mg/kg (SZ).

Replicate analyses were carried out by the three participating laboratories on fourteen samples of dried pulp, molassed pulp or pulp nuts. The samples were ground before distribution, but were sub-divided by the individual receiving laboratories. The samples originated from various sugar factories in the three countries concerned. The results by the three methods were compared with results obtained with the silver diethyl-dithiocarbamate method used by IRS.

The samples were also sent to the Central Laboratory of TNO (Dutch Organization for Applied Scientific Research), Delft, Holland, for independent determination of arsenic by neutron activation analysis.

The reliability was additionally checked by analysing the National Bureau of Standards standard reference material NBS-1571 (orchard leaves).

This standard has a certified arsenic content of  $14 \pm 2$  mg As/kg. The results obtained are given in Table I.

Statistical evaluation (Friedman test)<sup>10</sup> showed that the results obtained

Product	Campaign	Number of factories	Arsenic content (mg/kg sample*)		
			Mean	Minimum	Maximum
Pulp nuts and molassed pulp	1981/1982	23	0.5	0.1	1.8
	1982/1983	22	0.5	0.1	2.0
	1983/1984	21	0.5	0.1	2.4
Pressed pulp	1983/1984	10	0.2	<0.1	0.2
Molasses	1982/1983	10	<0.1	<0.1	0.1

\*for pressed pulp the results have been converted to the basis of a moisture content of 12%.

by SZ were significantly higher than those obtained by the other methods. However mean differences with the other methods were within 0.5 mg/kg and the value obtained by SZ for the NBS-standard material was in agreement with the certified arsenic content.

Between the results obtained by IRS and BS and those obtained by the silver diethylthiocarbamate method and by neutron activation analysis, no significant differences could be detected.

#### Tests on routine samples

Composite samples of pulp nuts, pressed pulp and molasses (IRS) and molassed dried pulp and pulp nuts (BS and SZ), produced at various factories in the three participating countries, have been investigated in duplicate.

Samples examined were all composite samples, but representing different production periods, viz. 1 week (pulp nuts and pressed pulp IRS), 2 weeks (SZ) or an entire campaign (BS and molasses IRS). The results obtained during several campaigns are summarized in Table II.

It is clear from the results that the EEC upper limit of 4 mg As/kg material (at a moisture content of 12%) is exceeded neither by any of the mean values nor by any of the individual results. The arsenic concentrations in pulp nuts and molassed pulp are somewhat higher than in pressed pulp. Table III shows the influence of the fuel used in the pulp dryers on the arsenic content of the product.

It is immediately obvious that those factories using coal as fuel for their dryers show the highest figures for trace amounts of arsenic in the finished pulp. However, by careful selection of coal with a relative low arsenic content, the levels of arsenic in pulp from coal-fired dryers are kept below the EEC limit of 4.0 mg/kg.

#### Summary

Methods for the determination of arsenic in sugar beet pulp and molasses, using atomic absorption spectrometric detection after arsine formation, have been collaboratively studied. Each participating laboratory developed its own method of analysis. Limits of detection ranged from 0.05 to 0.1 mg As/kg.

Fourteen samples of dried pulp were distributed and subjected to replicate

10 Sachs: "Angewandte Statistik" (Springer Verlag, Berlin-Heidelberg, New York), 1973, pp. 422-426.

Sample No.	Type	Laboratory			Mean	Standard deviation	IRS SDDC*	TNO NAA**
		IRS	BS	SZ				
1	Dried pulp	0.3	0.3	0.8	0.5	0.3	0.4	
2	Molassed pulp	0.3	0.5	0.7	0.5	0.2	0.3	
3	" "	0.4	0.5	0.7	0.5	0.2	0.4	
4	" "	—	0.3	0.9	0.6	0.4	0.3	
5	" "	0.1	0.2	0.5	0.3	0.2	0.1	
6	" "	1.6	1.4	1.0	1.3	0.3	1.2	
7	" "	4.8	5.4	5.8	5.3	0.5	4.6	
8	Pulp nuts	0.7	0.9	1.1	0.9	0.2	0.6	
9	" "	0.5	0.6	0.5	0.5	0.1	0.5	
10	" "	0.4	0.3	0.6	0.4	0.2	0.3	
11	" "	0.4	0.3	0.7	0.5	0.2	0.3	
12	" "	0.4	0.4	1.1	0.6	0.4	0.4	
13	" "	0.3	0.3	0.5	0.4	0.1	0.3	
14	" "	2.2	1.9	2.9	2.3	0.5	1.9	
NBS-1571 (14 ± 2 mg As/kg)	Orchard leaves	11.8	—	13.5	12.7	13.7	—	

\*SDDC = silver diethylthiocarbamate method  
\*\*NAA = neutron activation analysis



analyses in the participating laboratories. These samples were also analysed by neutron activation analysis and by absorptiometric determination after complexing of arsenic with silver diethyldithiocarbamate.

Good agreement was found between the different methods. Only in one laboratory were the results obtained by atomic absorption spectroscopy somewhat higher.

The methods were applied to samples of pulp produced at various sugar factories in Holland, the United

**Table III. Arsenic content related to dryer fuel**

Dryer fuel	Number of factories	Arsenic content (mg/kg dry matter)		
		Mean	Minimum	Maximum
Coal	8	2.0	1.0	3.5
Oil	8	0.4	0.1	0.8
Gas	7	0.5	0.1	1.4

Kingdom and West Germany over a period of several years. The levels of arsenic found in these samples were in general considerably lower than the EEC limit for arsenic in sugar beet pulp.

The trace amounts of arsenic in

dried pulp were related to the fuel used in the pulp dryers.

Arsenic contents of pressed pulp ( $\leq 0.2$  mg/kg material converted to a moisture content of 12%) and of molasses ( $\leq 0.1$  mg/kg material) were only 5% of the EEC maximum.

## Imbibition optimization

Milling developments at the Ookala Factory of Hamakua Sugar Company, Hawaii

By Michael D. Sullivan\*

### Introduction

In 1983 the milling train at the Ookala factory of the Hamakua Sugar Company consisted of one set of knives, a knife-type shredder ("Unigrator"), 2-roll crusher and four 3-roll mills (42 in  $\times$  84 in) with underfeed rolls. The operating results were:

Rate: 218.7 short tons prepared cane per hour.

Extraction: 93.2% pol in cane.

Bagasse:

Pol: 2.15%.

Moisture: 50.69%.

In 1984, after modification, the mill train consisted of an improved set of knives, an in-house designed and built heavy-duty shredder with feed drum, 2-roll crusher with feeder roll, three 3-roll mills (42 in  $\times$  84 in) fitted with 20 in chain driven feeder rolls and a final 4-roll mill (42 in  $\times$  84 in) made by fitting the old 3-roll mill with a pinion-driven 38-in fourth roll. These changes were made principally with the object of improving the effectiveness of



M. D. Sullivan

imbibition. For the 1984 season the results obtained were:

Rate: 243.7 short tons prepared cane per hour.

Extraction: 96.99% pol in cane.

Bagasse:

Pol: 1.21%.

Moisture: 44.52%.

A discussion of the principles involved, the equipment design, the operation and the implications for the future development follows.

### Imbibition

The efficiency of mixing of the applied imbibition liquid with that in the bed of fibre in a mill is defined by

the equation<sup>1</sup>:

$$Ic = \frac{Ebx}{Ebxc}$$

where

Ic = Imbibition coefficient

Ebx = Brix extraction

Ebxc = Theoretical Brix extraction (assuming that the imbibition juice mixes perfectly with the juice in the fibre)

As pointed out by Murry & Holt<sup>2</sup> the "coefficient may be either greater or less than unity. A value greater than unity indicates that the mill is extracting more Brix than for perfect mixing of the imbibition liquid and a value less than unity that the mill is extracting less Brix than for perfect mixing. Values greater than unity are not unusual in the earlier mills of the

\*Chief Engineer, Ookala Factory, Hamakua Sugar Company.

1 Munro: "An investigation into the crushing of bagasse and the influence of imbibition on extraction." (University of Queensland, PhD thesis, 1964).

2 "The Mechanics of Crushing Sugar Cane." (Elsevier, Amsterdam) 1967, pp. 11-12.

train". This is caused by expulsion of juice from large pieces of cane where there is no possibility of mixing with the imbibition liquid.

For the first mill, since no imbibition is added, a coefficient corresponding to the Imbibition Coefficient is a measure of the non-uniformity of Brix in the cane. It is called the Brix Distribution Coefficient and is nearly always greater than unity.

For mills after the first, the imbibition coefficient is a useful measure of the effectiveness of the imbibition. The target value would be 1.0 which means perfect mixing.

Theoretical calculations shown in Chart I assume mills properly designed for load, feedability and drainage and are based upon a Brix distribution coefficient of 1.0 for a first mill and an Imbibition Coefficient of 1.0 for a second mill on which is applied imbibition water at a rate of 200% on fibre. The results give a bagasse of 1.17% pol and 39.7% moisture corresponding to a pol extraction of 96.75%.

The importance of imbibition efficiency in this exercise can be

illustrated. If the Imbibition Coefficient were 0.4, which is often found in some last mills, the pol extraction would be only 91.06%. Thus, imbibition efficiency is very important.

There are three main factors influencing the Imbibition Coefficient: (1) cane preparation, (2) imbibition application, and (3) juice extraction.

These were addressed from a practical standpoint in the work done at the Ookala factory of Hamakua Sugar Company, in preparation for the 1984 season.

**Cane preparation**

If imbibition is to be used effectively, the first prerequisite is to separate the cane structure in order to permit mixing of the imbibition liquid and the juice remaining in the bagasse. Cell rupture should be as complete as practical, but the fibres should remain in long strands so that the bagasse retains maximum permeability, in order to allow access of the imbibition liquid to the juice escaping under pressure from the rolls.

The arrangement of the cane preparation equipment evolved and

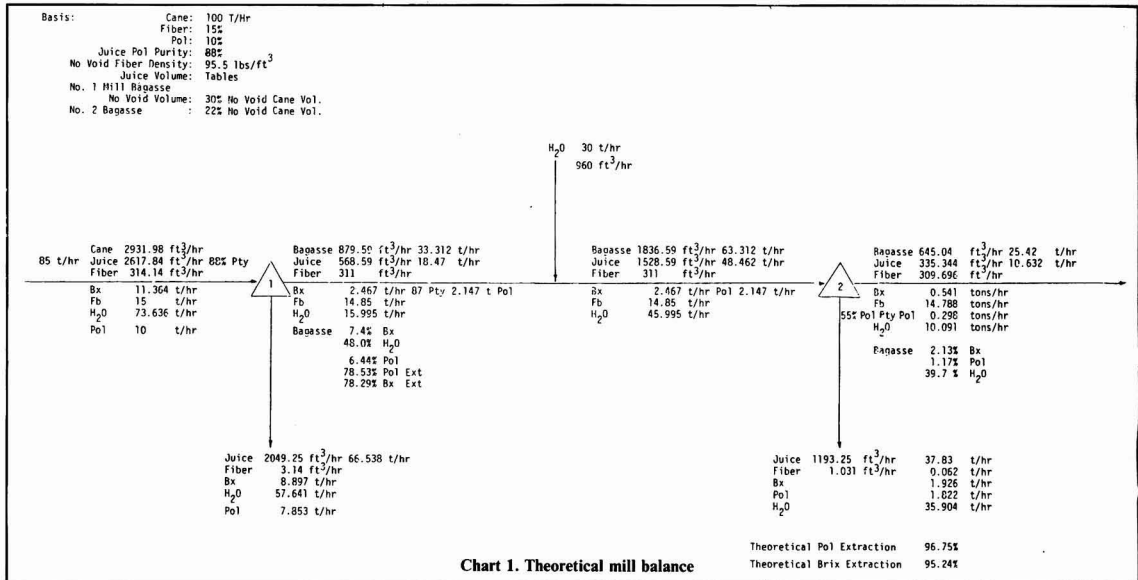
built in the shops at Ookala is shown in Figure 1.

**Cane leveller:** The cane leveller has 18 arms equally spaced across the carrier in four rows, is of 60 inches sweep diameter and driven by a 30 hp motor at a tip velocity of 500 fpm. The leveller runs counter-directional to cane flow and presents a level blanket of cane 30 inches deep to the preparation devices.

**Knives:** The knife set consists of 60 knives in eight rows cutting at a spacing of three inches across the carrier. Sweep diameter is 66 inches and the machine is driven by a 450 hp steam turbine at a tip velocity of 11,230 fpm. Power used was approximately 1.5 hp per tch. The clearance above the apron is 9 inches which is just over half that between the feed drum and the deck of the apron.

When the shredder is adequately powered for the 1986 season better preparation for shredding can be obtained by use of only 30 knives spaced at six inches across the carrier cutting at a tip velocity of 10,000 fpm.

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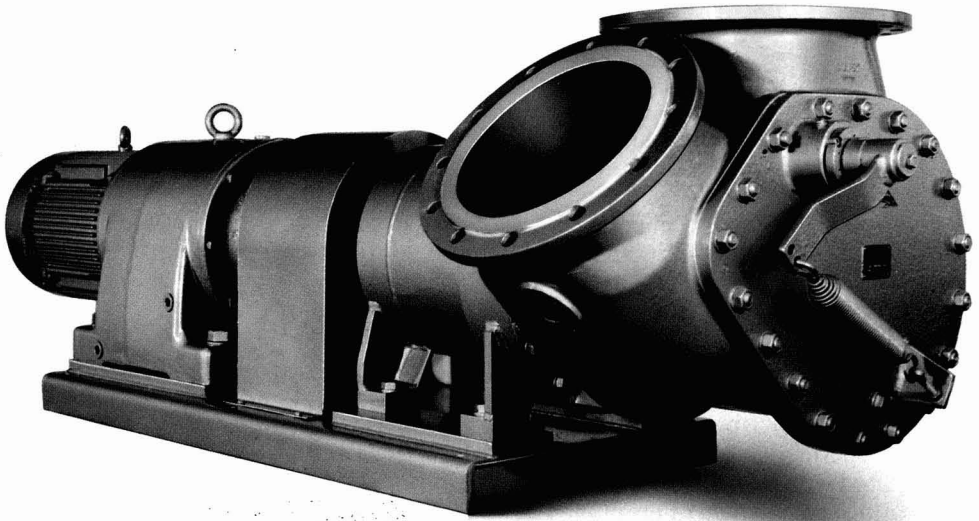
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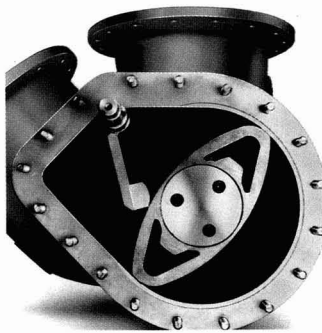
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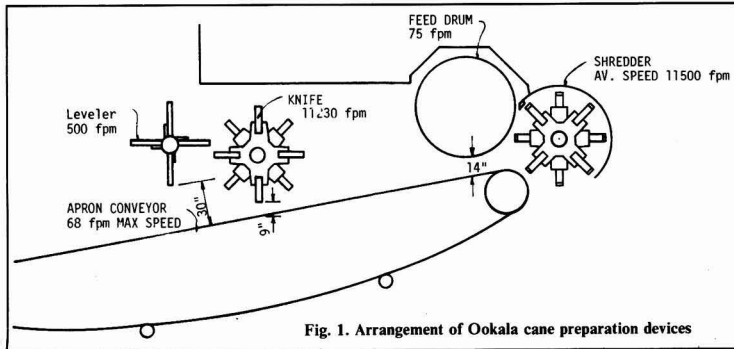


Fig. 1. Arrangement of Ookala cane preparation devices

knife has a mass of 18 pounds with the centre of the mass located at 7 1/2 inches from the pivot point. The pivot points are located on a 3 1/2 inches diameter pitch circle. The knives are permitted to swing in the same plane as the direction of travel. The knives run in the same direction as cane flow.

**Shredder and Feed Drum (Fig. 2):** The feed drum is of 72 inches outside diameter with twenty-four one-inch square bars spaced equally around the periphery of the drum. The drive is of 30 hp.

The shredder has 120 40-lb hammers mounted on the same type of swivel blocks as the knives.

*Imbibition application*

Cane fibre will hold approximately six times its weight in liquid at complete saturation. Application of imbibition to bagasse at two times the weight of fibre thus gives a fibre that is under-saturated. The imbibition then tends to remain at the point added and little scattering occurs, especially laterally. It is necessary,

therefore, to distribute the imbibition uniformly over the bagasse. At Ookala application is made in the form of a spray where bagasse issuing from the discharge roll falls into the boot of the intermediate carrier.

Unfortunately, the blanket of bagasse breaks and air is admitted, which prevents uniform contact of the liquid with the fibre. Ideally, the entire extraction process should be carried out in the absence of air. One step in this direction has been taken and the preparation equipment is filled with steam to eliminate air while the cane is being disintegrated.

Imbibition water is added at boiling temperature. This softens the fibre and permits maximum reduction in volume on passing through the rolls.

Application of imbibition at the discharge of the first and second mills is made in a distributor where the bagasse is compressed between the plates which direct the bagasse away from the carrier runners, and before the blanket breaks.

*Juice extraction*

The first step taken to improve juice extraction in the milling tandem was to convert the last mill into a four-roll design. A fourth roll, of 38 inches diameter, was mounted in the modified cheeks of the three-roll mill in 10-inch diameter bearings and was pinion driven from the top roll. The roll had 1 1/2-inch pitch, 40-degree angle grooving (the same as the feed roll; the top and discharge rolls were of 1/2-inch pitch).

The first three mills were fitted with feeder rolls of 20 inches diameter, chain-driven from the feed roll. They had 1-inch pitch circumferential grooving only. These mills had 1 1/2-inch pitch, 40-degree angle grooving. Messchaert grooves, of three inches pitch, were used only on the feed rolls of the last two mills. All rolls were cross grooved and were maintained in condition by welding. Because the first three mills had been misaligned previously it was not possible to apply the optimum pressure. The last mill was realigned.

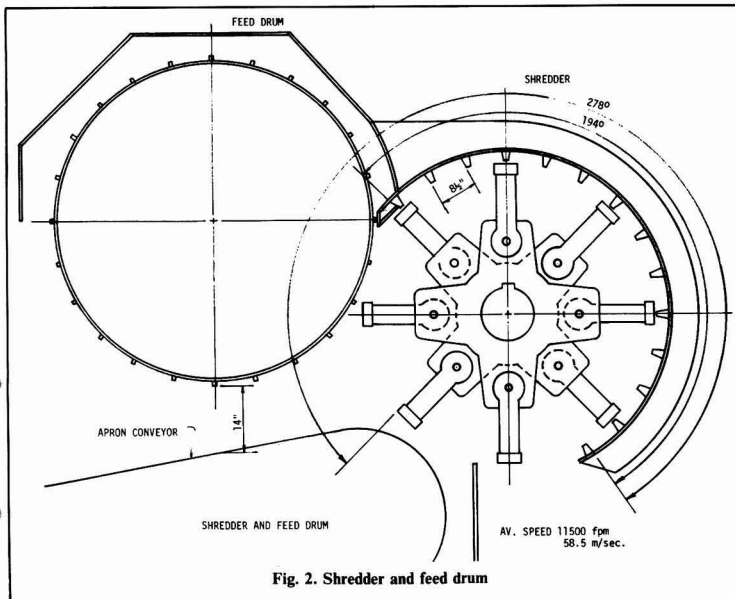


Fig. 2. Shredder and feed drum

**Milling performance tests**

A series of ten milling performance tests were made during the 1984 season. Data from these tests are shown in Tables I-III. Average operating data for the tests were:

Rate: 260 short tons of cane per hour

**Cane:**

Fibre %	13.38
Refractometer solids %	11.04
Water %	75.58
Purity of juice	87.0
Dilution % fibre	189

The data given in these tables show the superiority of the No. 4 4-roll mill over the three 3-roll mills. The imbibition coefficient of the No. 4 mill was 0.71, higher than either the No. 2 or No. 3 mills, whereas normally the last mill has the lowest coefficient. The coefficient for the No. 2 and No. 3 mills was, however, lower than would have been the case had it been possible to apply higher pressures.

The feed roll compression ratio of the No. 4 mill was 2.729, compared with 1.445 and 1.515 for the No. 2 and No. 3 mills, respectively. The very high figure for the No. 4 mill means that almost all of the juice was being expressed on the feed side of the mill.

The final results giving a bagasse moisture of 44.31% and a pol of 1.24% indicate high performance in spite of deficiencies in the first three mills. This can be attributed to optimization of the three main factors, cane preparation, imbibition and mill effectiveness. In the case of the mills the chief contributor was the 4-roll last mill. The imbibition coefficient of 0.71 is possible because most of the juice is recovered at the feed roll which gives much better mixing of the bagasse with the water. A previously undesirable feature of the 4-roll mill has been that so much juice was expressed that it flowed over the top of the top roll. In this case, by proper selection of roll speeds, loads, compression ratios and groovings, the juice flows over the feed roll or even over the fourth roll, but not over the top roll.

Mill	No-void feed volume, ft <sup>3</sup> /min	No-void bagasse volume, ft <sup>3</sup> /min	Bagasse moisture, %	Imbibition coefficient	Juice volume extracted, ft <sup>3</sup> /min	Imbibition liquid volume, ft <sup>3</sup> /min
Crusher & 1	127.01	42.48	54.82	0.98	84.43	47.52
2	90.08	40.61	55.60	0.67	49.47	41.95
3	82.55	35.03	51.24	0.66	47.52	35.14
4	70.16	28.21	44.31	0.71	41.95	

Mill	Approach	Feeder	Feed	Trash Plate	Discharge
1	241	174	56.25	119	29.81
2	250	216	62.32	138	28.54
3	207	177	54.48	124	25.03
4	224	113	25.71	103	18.67

Mill	1	2	3	4
Grooving	1½ in, 40°	1½ in, 40°	1½ in, 40°	4th & feed 1½ in, 40°; Top & discharge ¾ in, 40°
Pressure, short tons/ft	63	58	66	90
Mill speed, fpm	37	43	34	37
Mill work ratio	1.89	2.18	2.18	1.38
Feeder to feed work ratio	3.09	3.47	3.25	4.41
Feeder compression ratio**	—*	0.417	0.466	0.619
Feed compression ratio**	—*	1.445	1.515	2.729
Trash plate compression ratio**	—*	0.653	0.666	0.678
Overall compression ratio**	4.26*	3.16	3.29	3.76
Reabsorption factor***	1.43	1.42	1.40	1.51

\*Crusher and No. 1 (no bagasse analysis from crusher)  
 \*\*Compression ratios are Feed no-void volume—Escribed volume nip nominated  
 \*\*\*Reabsorption Factor is Bagasse no-void volume—Discharge escribed volume

**Conclusions**

Based on the results described here, it is reasonable to expect that an imbibition coefficient of 0.787 could be obtained on a 4-roll No. 2 mill. A milling tandem consisting therefore of only three 4-roll mills is possible.

In Chart 2 is shown the achievable mill balance for such a tandem. The performance indicated is a pol extraction of 96.77% with a bagasse pol of 1.26% and moisture of 40.34%.

**Acknowledgements**

The author thanks Dr. John H. Payne, of Honolulu, Hawaii, for preparing this paper for publication, and the Management of Hamakua

Sugar Co. for permission to publish the paper.

**Summary**

Modifications were made to the milling train at Ookala sugar factory in Hawaii with the intention of improving the effectiveness of imbibition by better cane preparation, more uniform imbibition application and better juice separation. The steps taken and the resultant benefits are described.

**Optimisation de l'imbibition**

On a modifié le train des moulins à la sucrerie de Ookala en Hawaii avec l'intention d'améliorer l'efficacité de l'imbibition. Pour cela on fait appel à





# Cane sugar manufacture

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## BMA basket alternative

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Anon. *Ann. Rpt. Bureau Sugar Expt. Stations* (Queensland), 1984, 32.

Tests were conducted on a solid basket having a main working angle of 30° introduced by BMA as an alternative to the 34° open-mesh basket for low-grade work. The loading pot working gauze area was approx. double that of the original. Results showed that, for the same massecuite and magma purities, the new basket had a 50% greater capacity at normal speed and reduced molasses purity by 0.9 units. Increased basket speed did not increase the separation rate and was accompanied by a considerable rise in power consumption.

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## Swinging bagasse ploughs

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D. J. Carliell *S. African Sugar J.*, 1984, 68, 417, 419.

See *I.S.J.*, 1985, 87, 79A.

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## The (Darbonne) sugar factory in Haiti

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D. Cardarelli. *Ind. Sacc. Ital.*, 1984, 77, 151-152, 154, 156 (Italian).

Details are given of the power plant and electrical equipment installed in Darbonne cane sugar factory in Haiti, and a brief description is given of the sugar manufacturing process used.

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## Processing of high-fibre sugar cane

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S. J. Clarke. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 10 pp.

Investigations were conducted on processing of L 79-1002, L 79-1003 and CP 65-357 cane (the last being the standard variety in Louisiana) of 28.0, 17.5 and 13.4% fibre contents, respectively. L 79-1002 is the highest yielding variety, typically providing 212 tonnes/ha compared with 58 and 94 tonnes/ha for CP 65-357 and L 79-1003. L 79-1002 and L 79-1003 gave no undue difficulties in

processing, but their Preparation Index values were much higher than for CP 65-357 and the power consumption in shredding very high. Extraction and sugar recovery were very much lower in the case of L 79-1002 than with CP 65-357, and clarification required an abnormally high quantity of lime. Details are given of three processing variants for L 79-1002 and two for L 79-1003 that were investigated. The possibility of using the Tilby separator to produce pith from the high-fibre canes which could then be processed as normal prepared cane was also indicated. However, it is pointed out that high-fibre varieties probably will not play a significant role in sugar production but only find application where high biomass yield and by-products utilization are important factors.

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## Computers in the sugar industry

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J. Gibbs. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 3 pp.

The use of computers for process control in sugar factories is briefly discussed as well as their application to processing of data on cane extraneous matter (so as to establish the effects of harvesting system and cane burning) and of yield analytical data in order to provide a comprehensive survey of cane agronomy in Barbados.

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## The induction generator—a low-cost alternative for cogeneration in sugar factories

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S. B. Carrington. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 7 pp.

The author explains how an induction generator works and how it could be driven by a prime mover to produce electricity for sale during the crop periods.

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## The quantity and quality of bagacillo required for rotary vacuum filters and means for

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## collecting it

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J. G. H. Badley. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 8 pp.

The desirable quantity and quality of bagacillo for use as filter aid are discussed, and means of separating it from bagasse and conveying it to a point at which it is added to clarifier mud are described.

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## Mill sanitation. A comparison and evaluation of biocidal treatment versus biostatic treatment

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S. A. Brooks, C. Corbin and P. D. Smith. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 8 pp.

Investigations at two sugar factories are reported, in which the effectiveness of three biocides was determined. Results showed that a quaternary ammonium compound added in the imbibition water at one factory to give an average level of approx. 2 ppm from April 5 to the end of the season reduced sugar losses by approx. 92%, whereas simultaneous addition at three points along the mill tandem of 5 ppm of a dithiocarbamate as a shock dosage at 30-minute intervals gave sugar losses that were almost double the level without biocide. At the other factory, a primary diamine added continuously to the 4th mill juice at 6.94 ppm from February 26 to May 2 reduced the sugar losses by 34%, but the initial losses were already less than half those at the other factory.

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## Taper locking devices

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J. W. Goodman. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 13 pp.

The advantages of taper locks over keyways as fasteners to connect shafts and hubs are discussed, and a brief description is given of use of a pair of taper locks to fasten a spur wheel to a new mating shaft at a sugar factory. Other suggested applications for the locks in the sugar industry are listed,

including fastening of cane mill roller shells to their shafts.

### Barometric condensers and ejection water cooling

M. C. Hutson. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 13 pp.

The fundamentals of barometric condenser design and operation, incondensable gas removal and ejection water cooling are discussed. Restatement of the principles involved is considered necessary in view of a tendency for factories to increase crushing rates while continuing to use their original spray pond or cooling tower systems, with the result that the temperature of the condenser injection water rises with consequent possible problems.

### The development of water conservation at Andrews factory. II

M. Biddlestone. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 7 pp.

As a result of an earlier study, a number of minor modifications were introduced for the 1984 crop which, it was predicted, would permit a self-sufficiency in water. Key components of the initial development were the utilization of all condensates, cascading of boiler feed surplus to process reserve and operation of an exhaust steam condenser. For most cooling purposes, water was used in a closed circuit. The operation of the facilities is described, clearly showing the dramatic effect that non-process water has on the overall balance. The modifications mentioned are calculated to have contributed almost 30 short tons of water/hr that otherwise would have been bought from the public supply. For the 1985 crop, the steam condensing capacity was to be increased, drift eliminators fitted to the evaporative cooler and the water from the low-grade crystallizer recirculated, as a result of which a

considerable reduction in water usage was expected.

### An appraisal of the Fischer & Porter Chameleon mass flow system presently located at Portvale (1984)

M. Biddlestone and R. Whitehead. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 3 pp.

Before the 1984 crop, it was decided to install a Chameleon mass flow system at Portvale sugar factory and to carry out a complete evaluation of the reliability and accuracy of the system in parallel with a newly purchased Fletcher & Stewart mechanical juice scale and a Lea V-notch imbibition recorder. Desirable features of such a system are indicated, and an approximate assessment is made of the system. For a number of reasons it was not possible to make quantitative studies of the accuracy of the system, but its reliability was evaluated. Results showed that reliance can be placed on it provided adequate services are available and a method of accurate checking is incorporated. A list is given of requirements in regard to installation of the system in a cane sugar factory.

### The Carrington Mark I cane sampler

R. A. Armstrong, M. Biddlestone and S. B. Carrington. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 6 pp.

A sampling system which was devised for Carrington sugar factory comprises a circular saw located to the side of the cane carrier and projecting about 1 inch into the cane mat, the set of the teeth and the direction of rotation (at 1000 rpm) being counter to the flow of the cane. The cane sample, of approx. 1 kg, passes down a discharge chute (not vertical because of obstructions on the outside of the carrier). A jet of air prevents the sample lodging in the chute. Results from the last few weeks

of the 1984 season showed that a sample slightly greater than 1 kg would be preferable. Analyses of the 125 samples taken were insufficient for statistically significant conclusions to be drawn on the accuracy and reproducibility of the unit; in addition, sampling took place at a time when the canes were of higher-than-normal fibre content. It was found that the cane fibre content as determined by analysis and calculated cane pol appeared to be somewhat higher than values given by the factory mass balance, that the theoretically recoverable sugar, expressed as tonnes of cane/tonne of sugar as determined from the samples, was very similar to values given by the factory mass balance, but that there appeared to be no obvious direct correlation between extraneous matter content of a cane load and the data derived from the factory sample. Modifications to be made to the sampler for the 1985 season are mentioned.

### Requirement of vacuum pan capacities in the present context

S. K. Pandey. *Indian Sugar*, 1984, 34, 281-286.

With installation of continuous centrifugals for the curing of B- and C-masseccutes, there is need for increased pan station capacity, and the author calculates the required capacity for a hypothetical 3-masseccute system based on a number of assumptions.

### Combustion characteristics of dried and pelletized bagasse

J. F. Stubbington and H. Fenton. *Combust. Sci. Technol.*, 1984, 37, (5/6), 285-299; through *Ref. Zhurn. AN SSSR (Khim.)*, 1984, (23), Abs. 23 R454.

Comparison is made between dried bagasse in bulk and in the form of large and small briquettes in terms of rate of ignition, and duration and nature of combustion.

# Beet sugar manufacture

## Two-stage treatment of sugar factory effluent in aeration basins

A. P. Parkhomets, N. A. Savdun and A. N. Khvoshchinskaya. *Sakhar. Prom.*, 1984, (11), 32-34 (*Russian*).

Investigations of treatment of Class III effluent (having a COD up to 4454 mg/litre and a BOD up to 3310 mg/litre) conducted over a number of years in a laboratory two-stage activated sludge system are reported and some results tabulated. Each stage included simultaneous aeration and mixing with the activated sludge followed by settling, a mud regenerator being used after Stage 1. Treatment in Stage 1 gave a 68-80% reduction in BOD, while Stage 2 gave a final reduction of 88-93%. The genera and (in a few cases) species of micro-organisms found are noted.

## Results of comparative tests on A2-POB-30 and OS-25/30 M prescalders at Salivonkovskii sugar factory

A. P. Parkhod'ko *et al.* *Sakhar. Prom.*, 1984, (11), 41-43 (*Russian*).

Results are reported of comparative trials in which two types of cossette prescaler were operated in conjunction with a tower diffuser. The A2-POB-30 is formed basically from the head section of a DDS diffuser; few details are given of the other prescaler, which proved less efficient in regard to percolation of the juice through the cossettes, and resulted in higher diffusion losses at lower daily throughput by comparison with the A2-POB-30 model.

## Prevention of rotting of sugar beet during factory storage

V. A. Knyazev. *Sakhar. Prom.*, 1984, (11), 43-46 (*Russian*).

Factors leading to rotting of stored beet and hence increased losses are discussed and various preventive

measures are recommended. Optimum conditions are given as a pile temperature of 0-5°C and a relative humidity of 90-95%; storage should be carried out at an early date in order to avoid piling excessive amounts of extraneous material which could raise the temperature of the beet. Forced ventilation, use of anti-frost panels and treatment of the beets with fungicide are recommended. In tests with various mixtures, pyrocatechol + Ethrel reduced the amount of rotting by 60% compared with the control, while pyrocatechol + sodium maleic hydrazide reduced it by 52% after 64 days' storage (no details are given of dosage rates or concentrations).

## Effect of pre-washing of sugar beet on its processing properties and changes in them during storage

V. V. Spichak *et al.* *Sakhar. Prom.*, 1984, (11), 46-50 (*Russian*).

Tests during 1982/83 showed that pre-washing of beet decreased storage losses and reducing matter content and raised juice purity by comparison with untreated controls, which suffered greater deterioration, particularly in the form of rotting.

## Investigations of a model Brieghel-Müller prelimer

J. Dobrzycki and L. Ryngajllo. *Gaz. Cukr.*, 1984, 92, 121-123 (*Polish*).

Investigations of the performance of a 5.75 dm<sup>3</sup> laboratory-scale Brieghel-Müller prelimer are reported. Water and NaCl acted as juice and milk-of-lime, respectively; variations were made in the angle of the upper deflecting baffles relative to the fixed cross-partitions (0°, 20° and 40°), in water flow rate (5, 10 and 15 dm<sup>3</sup>/hr) and in the speed of the paddles (17, 23 and 27 rpm). Results showed considerable variation in the retention time of "juice" portions, ranging from 10 to 30 min in contrast to a rated 20 min. It was also found that altering the

paddle speeds in conjunction with changes in the flow rate had little favourable effect on mixing in the individual compartments, in contrast to changes in the angle of the baffles, so that the flow rate should be kept as constant as possible.

## Juice residence time in an evaporator and increase in colour

K. Vukov, L. Körmeny and H. M. Loko. *Gaz. Cukr.*, 1984, 92, 126-128 (*Polish*).

See *I.S.J.*, 1983, 85, 378.

## Energy problems in sugar manufacture

E. Otorowski. *Gaz. Cukr.*, 1984, 92, 129-130 (*Polish*).

Measures for reducing steam and hence fuel consumption in sugar factories are discussed, with mention of the role of steam turbines, vapour compression, rational use of vapour bleed, more fuel-efficient pulp drying, and recovery and re-utilization of waste steam.

## A dismantlable system for beet pile ventilation

O. Mikus and L. Kristufkova. *Listy Cukr.*, 1984, 100, 249-255 (*Czech*).

Details are given of typical results achieved with forced ventilation of stored beet in a number of countries, and trials with two systems are reported. The results were used as basis for a definitive system that can be dismantled and which consists of pipeline sections 20 m long through which air is blown at the rate of 40 m<sup>3</sup>/hr/tonne of beet. The costs of the system are indicated, showing a considerable saving in terms of reduced storage losses.

## Experiences in raising the processing quality of beet in Hungary

A. Vigh. *Listy Cukr.*, 1984, 100,

259-262 (Czech).

By 1975/76, the average beet sugar content in Hungary had fallen to 11.5% after a steady decline over a number of years; added to that was the adverse effect of a protracted campaign (150 days) resulting from inadequate processing capacity, with consequent prolonged beet storage and associated high losses. An investigation undertaken on behalf of the sugar industry indicated that the poor sugar content and low processing quality of the beets was caused by excessive N fertilization, since payment was made solely on weight basis. The situation has gradually improved with adoption of payment on a sucrose basis in 1979 and with construction of the new factory at Kaba (of 6000 tonnes/day slicing capacity). Mention is made of a pilot fertilization advisory scheme set up at Petohaza sugar factory comparable to the system used in Austria and which is based on soil analysis of electro-ultrafiltration; other sugar factories are expected to adopt the scheme.

#### Model of a sugar factory with low fuel consumption

P. Christodoulou. *Ind. Sacc. Ital.*, 1984, 77, 133-145, 148-150 (Italian).

The possibility of reducing live steam and corresponding fuel oil consumption in a white sugar factory of 9000 tonnes daily beet slice to below 30% and 2.1% on beet, respectively, is discussed; the calorific value of the fuel is assumed to be 10,000 kcal/kg. Benefits of vapour compression are considered, and factors examined include whether and where to use thermal or mechanical compression. Optimum utilization of energy in the various process stations is investigated, and a number of models are then presented of evaporation schemes, all of which meet the targets mentioned above, three of them providing the lowest and identical value of 24.70% steam consumption, corresponding to a fuel consumption of 1.82%. Scheme (i)

is based on a quintuple-effect evaporator with 1st effect vapour compression (the 1st effect consisting of two bodies), use of 3rd effect vapour bleed for pan boiling, and condensate pre-evaporation for use as boiler feed water. Electricity consumption is 2.6-3.53 kWh depending on compressor load. Scheme (ii) is also based on quintuple-effect evaporation with 1st effect vapour compression, but 2nd effect vapour is bled for pan boiling. Power consumption for compression is 2.6 kWh. Scheme (iii) is as (ii) with thin juice deliming (hence higher heat transfer coefficients) and with thin-film evaporation for the 4th and 5th effects. The total evaporator heating surface areas and their distribution between effects are also different for each scheme, falling from 18,450 m<sup>2</sup> in (i) to 17,100 m<sup>2</sup> in (ii) and 13,200 in (iii). Also contributing to the reduction in steam consumption is the production of cold raw juice which is then heated with waste heat, the avoidance of excessive temperatures in juice purification, boiling on standard liquor of high Brix (as a result of higher thick juice Brix), washing of sugar in the centrifugals with remelt followed by water, use of high-pressure boilers, processing of high-quality beets and maintenance of steady operating conditions.

#### Use for processing beet tails and pieces of a vibro-extractor

P. P. Loboda, V. L. Zav'yalov, A. L. Ignatenkov and N. N. Gladen'kii. *Sakhar. Prom.*, 1984, (12), 25-26 (Russian).

Details are given of a vertical vibratory system for extraction of juice from beet tails and pieces after they have been crushed. The feed is carried up the vessel, on trays attached to vertical reciprocating shafts, against a top-fed stream of condenser water at 65°C. Some of the solids-juice mixture is recycled via a heat exchanger which raises its temperature to 75°C. Juice is discharged via a screen to the main

diffuser, while the solids are sent in batches to the factory pulp mixer after dilution with water. Tests at a sugar factory with a unit of 2 tonnes/hr throughput showed that the extracted juice, of 81.3 purity, contained 5.7% sugar compared with 11.6% in the original beet pieces; 1.56% sugar was found in the exhausted pulp. The economics of the system, which is rated at 5.5 kW, are indicated.

#### Investigation of conditions under which foaming occurs in spray-concentration of liquid sugar products

Yu. I. Volovik, G. G. Moseichuk and E. K. Rybchenko. *Sakhar. Prom.*, 1984, (12), 28-30 (Russian).

The final stage of a patented process for production of a liquid product from 2nd carbonatation juice involves concentration to 73% dry solids in a spray-dryer. Investigations, carried out to find a means of reducing foam which forms at this point, showed that the most suitable method was raising of the syrup temperature to a level that is governed by its purity.

#### Effect of the geometrical parameters of vapour generating tubes on the hydrodynamics of the combined regime in falling film evaporation

V. N. Gorokh and A. I. Sagan'. *Sakhar. Prom.*, 1984, (12), 30-33 (Russian).

The effects of tube geometry, thermo-physical parameters and quantitative factors on the hydrodynamics of the combined process, in which counter-current conditions occur in the upper tube section and co-current in the lower section, are examined. The investigations showed that reducing the length:diameter ratio of the tubes extends the limits under which the combined regime will operate and thus increases the heat transfer rate. The question of optimum tube length and factors affecting it are discussed.



### Optimum control of the technological processes in the beet processing and pulp drying sections

A. P. Ladanyuk, V. I. Bezv, F. V. Negoda, O. I. Voronyanskii and S. A. Sergeev. *Sakhar. Prom.*, 1984, (12), 35-37 (Russian).

Equations of major importance for control programming of the processes at the beet pulp end and in the pulp drying section are presented and their application to non-linear programming explained. Analysis of the disturbance factors in beet processing, particularly change in beet quality, shows that controlled variables occur in a quasi-static regime, so that a static model is appropriate. With pulp dryer parameters as controlled variables, drift occurs, so that the mathematical model must fit adaptive control. The economic effects of automatic process control in the two sectors are indicated.

### Rational scheme for feeding of formalin into diffusers

A. M. Rudyachenko. *Sakhar. Prom.*, 1984, (12), 38-39 (Russian).

A scheme for automatic formalin dosing into diffusers at set time intervals is described.

### Effect of an electric field on the juice-cosettes mixture

I. G. Bazhal, I. S. Gulyi, V. A. Zaets, I. M. Katrokha and M. P. Kupchik. *Elektron. Obrab. Materialov*, 1984, (3), 74-77; through *Ref. Zhurn. AN SSSR (Khim.)*, 1984, (23), Abs. 23 R435.

From results of laboratory investigations, relations have been obtained between time and rate of heating of a juice-cosettes mixture on the one hand and, on the other, the rectified voltage pulse frequency, and between current density and field strength, whereby consumption of the electricity applied to the mixture in a given time and for its initial heating will be lower with rise in quality of the

rectified voltage. The mathematical dependence of juice-cosettes resistivity and conductivity on temperature has been determined.

### pH values in juice purification

O. C. Akyar and E. Kayimoglu. *Zuckerind.*, 1984, 109, 1081-1088 (German).

See *I.S.J.*, 1983, 85, 378.

### Juice coloration by phenols in some sugar factories

K. Vukov, K. Hangyal and E. Bara-Anyos. *Zuckerind.*, 1984, 109, 1089-1092 (German).

The major role played by phenols in beet juice colour formation is discussed with reference to data in the literature. Oxidation of the phenols by phenoloxidase is the main reaction causing increase in colour, and two-year investigations have shown that the activity of this enzyme decreases during storage of healthy beet grown under normal conditions; however, drought during the growth period causes the activity to increase during the initial month of storage. Microbial activity was blamed for a modest rise in enzyme activity in the second month of storage after a fall in activity during the first month. Tabulated values of the Sorgato exponent  $m$  defining the slope of spectral curves show that about one-third of the colouring matter formed by sugar degradation emanates from phenols. By far the greatest portion of melanins are irreversibly precipitated with lime; soluble melanins and iron-polyphenol complexes are reversibly adsorbed from 1st carbonatation mud, depending on the active alkalinity. Some of the non-oxidized polyphenols are later converted to soluble melanins, mainly as a result of oxidation by atmospheric oxygen during 1st carbonatation juice filtration. Some of the polyphenols form darkly coloured complexes with iron dissolved during evaporation, and may play a role in coloration of sugar house products.

Carbonatation of raw sugar melt provided considerable decolorization; 75% of the colouring matter of high molecular weight (approx. 4000) and 30% of the dissolved iron were removed.

### The composition and biochemical activity of the thermophilic microflora isolated in beet sugar extraction

R. Nystrand and G. Haska. *Zuckerind.*, 1984, 109, 1093-1098.

Of 840 organisms isolated from diffusion juice in Swedish sugar factories in 1977/80 that were then examined for their morphological characteristics, Gram reaction and spore-forming ability, 481 proved to be thermophilic; these were characterized according to their activities at 55° and 70°C on different substrates and classified as: Gram-positive non-sporulating rods, Gram-positive sporulating rods, Gram-negative rods, Gram-positive cocci, Actinomycetes and yeast. The proportion of organisms in each group that degraded sucrose was established, and ranged from 44% of the Gram-positive sporulating rods at 55°C to 100% of the Gram-positive cocci at both temperatures. L-lactic acid, acetic acid and ethanol were the commonest metabolites of sucrose. Although 35% of the isolates were sporulators, they were considered of little importance, whereas the Gram-positive cocci (a closely related group unlike the others) included one dominant species, tentatively named *Saccharococcus thermophilus*, although another Gram-positive organism, *Lactobacillus* sp., took over as the dominant one when hydrogen peroxide replaced formalin as disinfectant. The Gram-positive group represented 80% of the isolates.

### The cation balance in beet molasses ion exclusion

H. Zaorska and K. Lisik. *Zuckerind.*, 1984, 109, 1110-1114 (German).

The cation balance was determined in the last three cycles out of a total of 27 in which delimed molasses diluted to 50% dry solids was treated with Lewatit TSW 40 cation exchange resin in Na<sup>+</sup> form in order to reduce the Na<sup>+</sup> and K<sup>+</sup> contents in the sugar-rich fraction. Results showed that the ion exclusion process reduced the Na<sup>+</sup> content from 24.07% in the initial feed to 2.36% in the sugar fraction and the K<sup>+</sup> content from 74.51% to 0.03%. Pre-delimiting is essential for prevention of blockage of the active groups in the resin by Ca<sup>++</sup> ions; this has the added advantage of obviating the need for resin regeneration and thus avoiding the problems associated with highly contaminated waste water.

#### Effect of longitudinal mixing on the efficiency of sugar extraction from beet

A. I. Fel'dman, L. V. Zotkina, S. P. Tsygankov and V. M. Lysyanskii. *Pishch. Prom.*, 1984, 30, 20-23 (Russian).

In an investigation of mass transfer and longitudinal mixing of the liquid and solid phases in a tower diffuser, movement was considered in terms of a one-parameter diffusion model for one phase and of ideal displacement for the other. Residence time distribution curves were obtained in experiments using carrot and aluminium sulphate as indicators. Statistical analysis of the results gave coefficients of longitudinal mixing for both phases and showed that mixing took place at values within the ranges  $(1.6-5.2) \times 10^{-3}$  m<sup>2</sup>/sec for the liquid and  $(3.0-6.6) \times 10^{-3}$  m<sup>2</sup>/sec for the solids. Average flow rate was 0.25 m/min (0.00417 m/sec) for the solids and 0.164 m/min (0.00273 m/sec) for the liquid. It was found that reduction of longitudinal mixing of the solid phase by suitable modifications to the transport system would reduce the total diffusion time substantially and thus permit increased throughput.

#### The effect of frequency and

#### amplitude of temperature fluctuations on massecuite recrystallization intensity

L. I. Trebin, Yu. I. Skripko, Yu. M. Zhurbitskii and A. P. Lapin. *Pishch. Prom.*, 1984, 30, 24-26 (Russian).

Theoretical consideration of the effect of temperature fluctuations on crystal size in recrystallization gave results that were confirmed by industrial-scale investigations at a sugar factory. These showed that temperature reduction in the range 1-35°C (from an initial value of 50°C) at intervals ranging from once per hour to once per 59 hours over a total period of 60 hours had a positive effect on crystal growth, the effect increasing with the extent of temperature fall and the frequency of fluctuation; the maximum increase in size was one of 39% to 0.6930 mm.

#### Influence of secondary crystals on light reflection from the surface of a massecuite

V. N. Kushkov, V. G. Tregub and V. A. Miroshnik. *Pishch. Prom.*, 1984, 30, 26-29 (Russian).

Earlier investigations had shown that the intensity of diffuse reflection increased with increase in massecuite crystal content and with decrease in crystal size. The possibility of applying this finding to control of secondary crystal formation was examined by crushing white sugar crystals in a ball mill, screening for size fractionation, mingling each fraction with saturated sugar solution (the smallest crystals acting as secondary crystals) and placing the samples in a plane-parallel glass cuvette located in the path of light from an incandescent lamp. Results, analysed statistically, showed that secondary crystals (because of their small size) had a substantial effect on light reflection from the three-component system primary crystals-secondary crystals-mother liquor. Based on this, it would be possible to set up a control system to provide an early warning of the approach of a massecuite to a given supersaturation

limit.

#### Longitudinal mixing of beet cossettes in inclined twin-scroll diffusers

E. V. Minenko, A. I. Fel'dman, V. M. Lysyanskii and B. N. Zharik. *Pishch. Prom.*, 1984, 30, 32-36 (Russian).

Longitudinal mixing of cossettes (which adversely affects diffusion) was studied in a DDS-30 and a DDS-42 diffuser (of 3000 and 4200 tonnes/day throughput, respectively); results obtained by other authors for a DDS-30 and a DDS-14 diffuser (the latter of 1400 tonnes/day throughput) are also discussed. The use of sliced carrot as indicator permitted determination of the mean integral residence time of the cossettes and of the coefficient of longitudinal mixing for the entire diffuser length as well as for specific section lengths. It was found that the coefficient for the overall length had values approximately the same, regardless of the difference in diffuser dimensions; however, there were marked differences between the diffusers as regards the values for the head section, where considerable mixing took place (conditions became much more stable in the subsequent sections). Greater mixing in the head section of the DDS-30 than in the DDS-42 was attributed to inadequate filling of the lower part of the trough in the former diffuser, while a sharp increase in mixing towards the end of the trough was blamed on faulty design of the discharge system.

#### Conversion of the firing of the lime kiln at Sarkad sugar factory

K. Juhasz and T. Molnar. *Cukoripar.* 1984, 37, 145-151 (Hungarian).

Details are given of the modifications to the lime kiln at Sarkad sugar factory for firing with a mixture of coke and natural gas instead of coke. The savings achieved with a 40:60 coke:gas mixture are indicated.

# Laboratory studies

## Glass electrodes for pH control in the sugar industry

S. K. Guha, A. P. Bhattacharjee and N. Halder. *Maharashtra Sugar*, 1984, 9, (12), 19, 21, 23-24, 27.

Studies are reported on various compositions of glass with a view to suitability for use in electrodes. One glass, containing 60-63% SiO<sub>2</sub>, 20-25% Li<sub>2</sub>O, 5-8% BaO, and 2-5% each La<sub>2</sub>O<sub>3</sub> and CeO<sub>2</sub>, was made up into electrodes subsequently tested under factory conditions. No loss of sensitivity was found after 3 months' continuous use in sulphitation at pH 7.0 and 70°C.

## Separation of mono-, di- and trisaccharides by gas chromatography on the capillary SCOT (support-coated open-tubular) column

L. Gruchala and E. Wasowicz. *Chem. Analityczna*, 1983, 28, (3), 275-281; through *S.I.A.*, 1984, 46, Abs. 84-1548.

Sugars were separated as their trimethylsilyl derivatives on a capillary column coated with SE-30 on Silonax 101, with temperature programming at 4°C/min from 110 to 260°C. The following sugars could be separated in 40 min: pentoses (arabinose, lyxose, xylose, ribose); hexoses (fructose, mannose, galactose, glucose); disaccharides (maltose, sucrose, lactose, trehalose, cellobiose, melibiose, gentiobiose); and the trisaccharide raffinose. Reducing sugars gave separate peaks for the two anomers, and in some cases a third peak for the open-chain form. Sucrose, trehalose and raffinose gave one peak each. Retention times and response factors relative to mesoinositol are tabulated.

## Methods used for the determination of cane quality and recommendations by the International Commission for Uniform Methods of Sugar Analysis (ICUMSA)

D. Smith. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 4 pp.

A brief survey is presented of methods of cane sampling and analysis, followed by recommendations made at the 1974, 1978 and 1982 Sessions of ICUMSA.

## Adsorption of mineral impurities in beet sugar factory products by powdered active carbons

A. L. Shoikhet and I. V. Zakharova. *Sakhar. Prom.*, 1984, (12), 19-21 (*Russian*).

Laboratory experiments are reported in which filtered, sulphitated 2nd carbonation juice samples were treated with 2% (on dry solids) active carbon at 70-75°C for 15 minutes with constant mixing in a glass vessel. Various brands of carbon were tested. Tabulated results showed that all the carbons had little demineralizing effect, but reduced the colour contents considerably, up to 72% decrease being achieved with OU-A carbon having alkaline reaction; the decolorizing efficiency was raised to 90% with 4% of this carbon. Acidification of the carbon suspension with HCl increased decolorization, but this treatment also allowed ash components in the carbons to pass into solution, although this could also take place without acidification where the carbon had an abnormally high water-soluble ash content.

## A phase diagram of the sucrose-water system

D. E. Sinat-Radchenko. *Sakhar. Prom.*, 1984, (12), 22-23 (*Russian*).

A three-dimensional phase diagram has been constructed for sucrose-water based on values given in the literature for sucrose solubility, vapour pressure, boiling point and freezing point. The temperature range is from -20° to +180°C and concentration up to 100% solids; the water vapour pressure ranges from 0.1 to 1000 kPa on a logarithmic scale. Interpretation and

use of the diagram are explained, particularly in relation to stages in massecuite boiling.

## Sucrose thermostability with different methods of heating solutions of it

L. A. Kupchik, L. I. Trebin and A. P. Lapin. *Pishch. Prom.*, 1984, 30, 11-12 (*Russian*).

The extent of sucrose degradation was investigated as a function of heating method. Solutions of 65% concentration and 60, 70, 80, 90 and 99 purity were heated for 4 hours at 109°C by (i) external heating, (ii) electrical heating at an industrial frequency using graphite and titanium electrodes, and (iii) heating in a high-frequency electromagnetic field at 2400 MHz; heat flow was adjusted so that the outputs were identical. Samples were taken hourly from the boiling flask and analysed for pH, optical density and sugar content. Results showed almost identical changes in the three variables with the different methods, except in the case of the 99 purity solution heated by method (ii) using titanium electrodes; the Ti evidently acted as a catalyst of sucrose degradation, with a consequent fall in pH by more than 4 units and a 0.8 unit decrease in sucrose concentration.

## A galactomannan in carbonated beverage floc from raw cane sugar

T. Miki. *Carbohydr. Res.*, 1984, 129, 159-165; through *Ref. Zhurn. AN SSSR (Khim.)*, 1984, (24), Abs. 24 R507.

Results are presented of studies on a galactomannan isolated from polysaccharides in Australian raw sugar. It consisted of D-mannose and D-galactose in a molar ratio of 2.3:1.0, had a specific rotation  $[\alpha]_D^{20}$  of +97.3° in water and a molecular weight of approx.  $3.5 \times 10^6$ . The galactomannan was mainly linked  $\alpha$ -(1-6) by D-mannopyranose radicals, 86% of which were linked 0-2. All the D-

galactopyranose and some of the D-mannopyranose radicals were present as non-reducing constituents in the side chains which may link  $\alpha$ -(1-2) with the main chain.

#### Development of a mathematical model for calculation of mixed juice pol

F. Gonzalez and M. Carbo. *Technol. Quim.*, 1982, 3, (1), 36-46; through *Ref. Zhurn. AN SSSR (Khim.)*, 1984, (24), Abs. 24 R508.

Using the method of multiple linear correlation and programs for the Reglin computer, a mathematical model has been obtained which permits calculation of mixed juice pol from laboratory analytical data.

#### Computerization of the laboratory at the Illovo mill

K. Taylor. *Sugar J.*, 1984, 47, (6), 17-22.

See *I.S.J.*, 1985, 87, 86A.

#### Determination of volatile fatty acids in molasses by gas-liquid chromatography of their benzyl esters

K. W. Healey and J. Carnevale. *J. Agric. Food Chem.*, 1984, 32, 1363-1366.

The use of GLC to determine formic, acetic, propionic and *n*-butyric acids in cane molasses is described. The acids were isolated by selective elution from silicic acid using 95:5 dichloromethane: ethanol. The benzyl esters, prepared by reacting the tetrabutylammonium salts of the acids with benzyl bromide in acetone, were analysed on a column of 20% DEGS on Chromosorb W, using benzyl *n*-valerate as internal standard. Recovery of the acids, added to samples of Australian molasses at the rate of 0.258-6.060 mg/0.8 g, averaged  $99.7 \pm 3.6\%$ . Results for commercial molasses from Australia, Indonesia and the Philippines showed that formic acid and acetic acid were predominant (1.1-4.1 and 3.1-3.7 mg/g,

respectively), while propionic and *n*-butyric acids were present in only trace quantities.

#### Thermodynamic constants of sucrose acid dissociation

L. G. Belostotskii, A. E. Arkhipets, R. Ts. Mishchuk and L. P. Reva. *Izv. Vuzov, Pishch. Tekh.*, 1984, (5), 21-24 (*Russian*).

Potentiometric titration in a nitrogen atmosphere was used to determine the activity constants of sucrose at temperatures in the range of 20-80°C and concentrations of 0-60%. The results were then statistically analysed by a trial-and-error method, from which equations were developed for calculation of dissociation constants  $pK_1$  and  $pK_2$  at different ionic strengths and temperatures of solutions in which sucrose was regarded as a dibasic acid. A formula is also presented for calculating the ionic product of water which allows for the effect of sucrose on the activity of water.

#### Effect of various factors on the electrical conductivity of sugar solutions

A. V. Karpenko, V. T. Garyazha, Yu. M. Zhurbitskii and L. I. Trebin. *Izv. Vuzov, Pishch. Tekh.*, 1984, (5), 66-69 (*Russian*).

The effects of concentration (50-70%), of temperature (37.8-69.2°C) and of purity (58.6-80.0) on conductivity were determined in laboratory experiments using model sugar solutions prepared by mixing a known quantity of syrup of required concentration with molasses; the resistance was measured at constant temperature for each sample. From statistical analysis of the results, regression coefficients were obtained and the mean variances calculated. It is shown that, while concentration has a dominant effect on conductivity, the influence of purity (fall in which is accompanied by a rise in conductivity) is greater than that of temperature.

#### Colorimetric method for total nitrogen determination in products of beet sugar manufacture

N. B. Kazakova, R. F. Kambarova, I. P. Shamritskaya and N. V. Preobrazhenskaya. *Izv. Vuzov, Pishch. Tekh.*, 1984, (5), 119-120 (*Russian*).

A modification of the Kjeldahl method is described which has been applied to total N determination in molasses. The test sample is ashed and the degraded nitrogenous matter converted to ammonium sulphate using a mixture of concentrated sulphuric acid, potassium sulphate and mercuric oxide. The  $NH_4^+$  ion concentration is then measured colorimetrically using Nessler's reagent; this measurement is free from interference by the mercuric oxide. N is determined down to 0.05 mg/litre at an accuracy of  $\pm 2.4\%$ . Ammonium chloride is used to construct a calibration graph. The method is rapid and simple, and recommended for routine analysis.

#### Detection of mono-, di- and trisaccharides in the presence of sucrose in intermediate and end-products of the sugar industry

A. Preuss, E. Schulte and H. P. Thier. *Lebensmittelwiss. + Technol.*, 1984, 17, (3), 163-166; through *Ref. Zhurn. AN SSSR (Khim.)*, 1985, (1), Abs. 1 R400.

A simple capillary column GC method is used to determine various saccharides in the presence of sucrose. The sugars are derivatized to their trimethyl silyl ethers and can then be analysed without prior fractionation. The following saccharides accompanying sucrose were separated: glucose, fructose, galactose, inositol, melibiose and raffinose. The use of phenyl- $\beta$ -D-glucose as internal standard facilitates quantitative determination. The detection limit for the sugars was 50 ppm, with a standard deviation of  $\pm 10-15\%$ , indicating high reproducibility.

# By-products

## The recovery of potassium salts from the salt residue produced in vinasse combustion

A. Martini and G. Iaquaniello. *Ind. Sacc. Ital.*, 1984, 77, 112-114 (Italian).

When vinasse is burnt, a residue results which contains a mixture of K, Na, Ca and Mg salts, principally K chloride, sulphate and carbonate and Na carbonate. A proposed system is described for recovery of these salts from solution in separate stages; the chief advantage of the scheme over simple mechanical extraction of the combined salts (with their subsequent use as fertilizers) lies in the possibility of recovering K sulphate in "reasonably" pure form for use as fertilizer and/or in the preparation of chemical products. The suggested scheme incorporates a number of concentration stages interspersed with cooling crystallization and settling.

## Fermentation trials with potassium desalted molasses

Anon. *Taiwan Sugar*, 1984, 31, 114-117.

Experiments were conducted on alcohol fermentation of cane molasses that had been treated in Australia to reduce the potassium content. Results showed that reduction in the K content increased the alcohol content in the fermented broth, 80-90% reduction giving better results than 30-40% reduction; however, decrease in K had no significant effect on torula yeast propagation, while it adversely affected L-lysine fermentation. The type of manufacturing process used in the factories supplying the molasses (carbonation, sulphitation or defecation) affected the alcohol fermentation.

## Complex utilization of beet sugar factory by-products and wastes

L. G. Belostotskii, V. E. Skriplev, A. Ya. Gerbut and N. A. Klimakhin.

*Sakhar. Prom.*, 1984, (11), 29-32 (Russian).

Use and disposal of beet pulp, molasses, filter cake, trash, flume-washer mud and lowest-grade effluent (including muds) are discussed; mention is also made of press-water utilization in diffusion.

## Sugar factory muds— not only lime

R. Vanstallen and J. P. Vandergeten. *Le Betteravier*, 1984, 18, (191), 11 (French).

The typical composition of filter cake is indicated, and the value of this waste product as a fertilizer in view of its CaCO<sub>3</sub>, N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and MgO contents discussed. However, since current spreaders cannot apply cake (of approx. 55-60% solids) at a rate below 15 tonnes/ha, the practice should be restricted to acid soils.

## Fast food for animals— or how to feed them on agricultural by-products

C. Kerman. *Inter Tropiques Agric.*, 1984, (07), 30-31 (French).

Utilization of agricultural waste material as animal fodder in tropical countries is discussed. Cane by-products are included, and a table is presented showing the quantity of cane tops, bagasse and molasses produced per ha. The advantages of molasses and ways in which it can be used as fodder are noted.

## Feeding cane to cattle

J. Boule. *S. African Sugar J.*, 1984, 68, 362.

Available knowledge on the use of cane as cattle fodder is summarized. It is pointed out that cattle should not be restricted to the cane stalks, since they require the long fibres found in cane tops for efficient rumen functioning. Apart from crop residue cane, it is suggested that some farmers would consider use of cane as fodder more

economically viable than its normal processing when the sugar market is depressed. Spraying chopped cane with urea and ammonium sulphate (usually dissolved in molasses) prevents souring and makes it more palatable; silage palatability can also be improved by this means.

## Pig fattening with sugar cane molasses. I. Performance traits and consumption pattern

J. Ly and M. Castro. *Cuban J. Agric. Sci.*, 1984, 18, 35-42.

Comparative feeding trials in which pigs were given one of three rations, containing 89% maize meal (on dry matter), 80% high-test molasses and 82.3% final molasses, respectively, showed that the daily weight gain of the animals was greatest with the maize meal ration and lowest with the final molasses. The hypertonic nature of the molasses was the probable cause of a reduction in molasses intake and of an increase in water ingestion, resulting in very wet faeces.

## Continuous ethanol fermentation using immobilized yeast cells

M. Nagashima *et al.* *Biotechnol. Bioeng.*, 1984, 26, (8), 992-997; through *S.I.A.*, 1984, 46, Abs. 84-1599.

Growing cells of *Saccharomyces cerevisiae* immobilized in calcium alginate gel beads were used in fluidized-bed reactors for continuous fermentation of cane molasses to ethanol. Techniques were developed which enhanced productivity and the stability of the enzyme. A pilot plant with a total column volume of 4000 litres was constructed. In it, broth containing 8-10% ethanol by volume was produced continuously from non-sterilized diluted cane molasses for more than half a year. The productivity was 0.6 vol. ethanol/unit reactor vol. per day, and the conversion was 95% of the theoretical when the broth contained 9.5% ethanol by vol.



### Conservation of molasses by disinfectants

S. Sato, E. Aquarone and M. L. Brazzach. *Revista Farmacia e Bioquim., Universidade São Paulo*, 1982, **18**, (2), 113-126; through *S.I.A.*, 1984, **46**, Abs. 84-1563.

Tests were carried out on disinfection of molasses to prevent deterioration in storage or during export. Cane molasses samples were treated with various concentrations of K benzylpenicillin, chloramphenicol or hexachlorophene, and stored for 48 hr or 15 days before being fermented to alcohol. Best results were obtained with 15 or 30 mg chloramphenicol/litre. High concentrations of the other disinfectants, e.g. 20 mg hexachlorophene/litre, did not increase the yield of alcohol; instead, they were toxic to the yeast used for fermentation.

### Biomass production and biological purification of distillery wastes in a two-step process

R. S. Waehner, A. M. Giulietti and E. R. Fraile. *Rev. Argentina de Microbiologia*, 1983, **15**, (1), 47-50; through *S.I.A.*, 1984, **46**, Abs. 84-1605.

Cane vinasse was supplemented with ammonium sulphate and dipotassium phosphate, and used for culture of *Candida utilis* or *Paecilomyces variotii*. Biomass outputs were 24 and 18 g/litre, respectively, and COD decreased by 36 and 75%, respectively. The resulting effluents were used in the second stage, in which *Aspergillus niger* was cultured. Total decreases in COD were 93 and 92%, respectively.

### Aerobic microbial treatment of sugar cane stillage by *Candida utilis* and *Paecilomyces variotii* in two-step continuous cultures

R. Bottaro C., R. S. Waehner and A. M. Giulietti. *Biotechnol. Letters*, 1984, **6**, (3), 195-198; through *S.I.A.*, 1984, **46**, Abs. 84-1606.

Vinasse was used first for culture of *C. utilis*, and the supernatant was used to grow a *Paecilomyces* strain without addition of nutrients. A total decrease of 87% in COD and a mixed biomass output of 2.3-2.6 g/litre/hr were attained (see also preceding abstract).

### Enzymatic saccharification of sugar beet pulp

A. P. Moloney, A. O'Rorke, P. J. Considine and M. P. Coughlan. *Biotechnol. Bioeng.*, 1984, **26**, (7), 714-718; through *S.I.A.*, 1984, **46**, Abs. 84-1638.

Culture filtrates of *Talaromyces emersonii* UCG 208 grown on beet pulp can convert the polysaccharide components of the pulp to soluble sugars. This saccharification process is facilitated if the pulp is milled or incubated with NaOH or peracetic acid before addition of enzyme. Treatment of unmilled pulp with commercial pectinase before incubation with *Talaromyces* filtrate was also very effective; under stated conditions, complete hydrolysis of total polysaccharides was achieved.

### Molasses feeding for swine and bagasse or cane tops with molasses for cattle or sheep

L. G. Blaylock. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 5 pp.

An outline is presented of trials on molasses feeding to pigs (in which no more than 20% molasses, especially if fed together with starter/grower pellets, proved suitable), on molasses feeding to dairy and beef cattle, on NaOH-treated bagasse or cane tops feeding instead of hay as beef cattle fodder, on bagasse feeding to lambs, and on cane tops ensilage for use as cattle and lamb fodder.

### Compost-fertilizer trials on sugar cane in Barbados

S. G. Hunte. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984,

8 pp.

Application of 2 tonnes/acre of Bio-Compost (produced from a mixture of bagasse, filter cake and chicken litter and containing 11% Ca, 1.3% P, 1.25% N, 1.0% K and nine other elements) to plant cane increased yield by up to 20% in small- and large-scale trials. Other potential benefits from the compost, and the monetary savings on imported fertilizers and chemical sprays are indicated.

### Resource value of filter cake

D. I. T. Walker. *Proc. 2nd Ann. Conf. Barbados Sugar Tech. Assoc.*, 1984, 4 pp.

The value of filter cake as fertilizer, particularly for its P content, in cane and other crops is discussed. Composting of the cake and incorporation of fly-ash to provide a 5:9:5 N:P:K mixture is mentioned.

### Contribution to improvement in conditions of continuous fermentation with recycle for ethanol production from beet juice with *Saccharomyces cerevisiae*

M. J. Boudarel and A. Ramirez. *Ind. Alim. Agric.*, 1984, **101**, 1151-1158 (French).

A fermenter of 10 litres effective volume was used in laboratory experiments that simulated industrial-scale continuous fermentation of beet juice with yeast recycling. The aim was to increase productivity and then scale-up, and to find suitable bactericides to prevent contamination of the wort. *S. cerevisiae* was used to ferment juice containing 120 g/litre sugar in a mixer vessel injected with air at a controlled rate. Yeast was recycled from a settler. Best results were obtained with 2 volumes of air per volume of medium/hr, a recycle rate of 80% and a biomass concentration of 50 g/litre; under these conditions, all the sugar was consumed with 4 hours, yielding 13.5 g/litre/hr ethanol. Extrapolation

to a fermenter of 350 m<sup>3</sup> effective capacity gave an overall increase in productivity of 27% by comparison with the preceding year, the same amount of sugar being fermented in 27-30% less time. In France, most distilleries operate on batch fermentation and produce 1.7-2.0 g/litre/hr ethanol. Peracetic acid at 3 ppm and hydrogen peroxide at 10 g/litre were effective as bactericides; lactic bacteria constituted the major wort contaminant.

#### Separation and analysis of wax from Egyptian sugar cane filter press cake

A. M. Azzam. *Fette, Seifen, Anstrichmittel*, 1984, **86**, (6), 247-250; through *Ref. Zhurn. AN SSSR (Khim.)*, 1984, (23), Abs. 23 R455.

The separation and chemical composition of wax in filter cake at four Egyptian sugar factories have been investigated. Continuous extraction was used for separation with various solvents: toluene, naphtha, acetone, fractionated benzene, denatured and rectified alcohol. Highest yield (14.55%) was obtained using toluene, while extraction with rectified alcohol gave 12.65%. The raw wax was decolorized with NaOCl, HNO<sub>3</sub>, Cl<sub>2</sub>, SO<sub>2</sub> and acetone, respectively. Purified wax was isolated from the volatile liquid oil fraction using fractional crystallization at 0-70°C; highest yield was obtained at 30°C. The wax obtained at 20-45°C was hard and friable, whereas at <20°C it ranged from granular to powdered and was much lighter in colour. The raw and purified wax had properties similar to those of carnauba and other hard waxes. Potential applications of the Egyptian wax include its use for manufacture of paper, inks, coatings,

lacquers, pharmaceutical and cosmetic preparations and fertilizers.

#### Efficient pressed pulp utilization with Betafertil

K. Metzler. *Die Zuckerrübe*, 1984, **33**, 336-339 (*German*).

The value of Betafertil as a source of essential protein, minerals and trace elements for addition to beet pulp silage intended as animal fodder is discussed.

#### Improvement of ethanol productivity from cane molasses by a process with high yeast cell concentration

L. H. Wang *et al.* *Taiwan Sugar*, 1984, **31**, 153-157.

Batch fermentation is normally used for alcohol manufacture from cane molasses in Taiwan; average yield is 1.5 g/litre/hr at an initial molasses sugar concentration of 16-18% and an initial cell count of 0.6-1.0 × 10<sup>7</sup> per ml. Experiments are reported which were aimed at increasing the cell count and hence ethanol yield; by using the fermenter as an extra seed tank before the start of fermentation, the cell count was increased to 2.5 × 10<sup>7</sup> per ml and the fermentation time reduced from 43 to 36 hours, but productivity was slightly lower than with the control, while ethanol concentration (v/v) was slightly higher. Experiments were also conducted on continuous fermentation with yeast recycle. Results of laboratory trials showed that increasing the dilution rate to an optimum at which the fermentation efficiency was 80-81% gave an ethanol yield of 3.2-3.7 × 10<sup>-11</sup> g/cell/hr at a viable count of 1.25-3.05 × 10<sup>8</sup> per ml, and alcohol concentration was in the range

6.2-11.7%. In pilot plant trials, however, yeast cell separation was inadequate, so that alcohol yield was only 2.53 g/litre/hr; while this was better than with batch fermentation, it is considered essential to improve cell separation if the process is to be commercially viable.

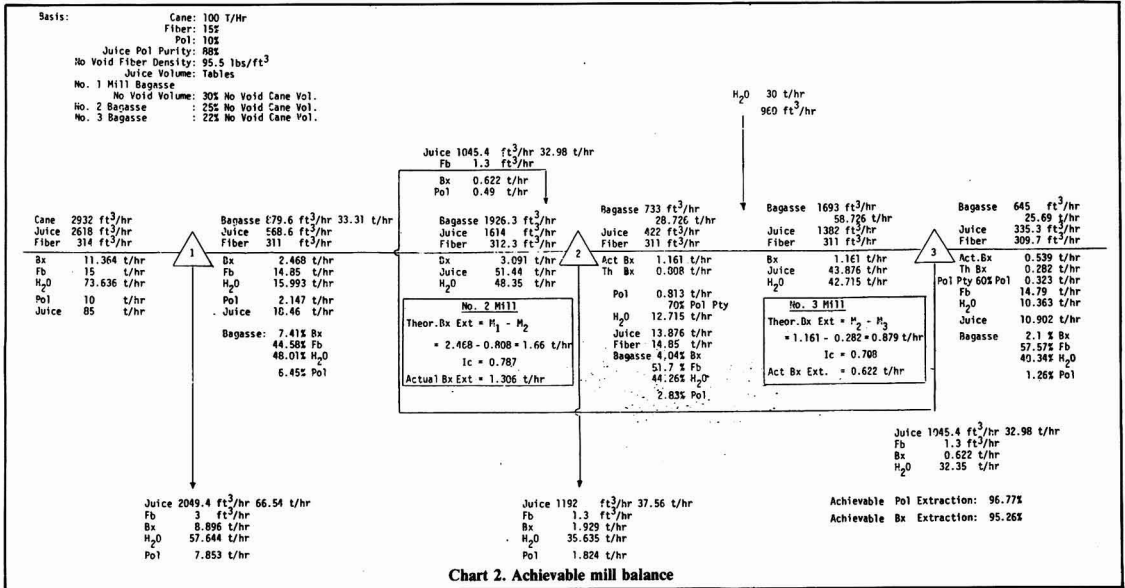
#### Ethanol as a fuel additive in Zimbabwe

C. M. Wenmam and J. Tannock. *Sugar J.*, 1984, **47**, (6), 13-16.

A distillery set up at Triangle Ltd. in 1980 produces ethanol at a rated daily output of 120,000 litres; it is designed for the use of molasses and cane juice as feedstock, although use of B-molasses from the 2-boiling system at Triangle plus C-molasses from a neighbouring sugar factory minimizes the amount of juice needed. Production in 1983 represented 12% of the gasoline requirement in Zimbabwe. The entire output is sold to a government-controlled fuel procurement agent which resells it to various oil companies for blending with gasoline. Since the return on costs increases with greater efficiency of sucrose conversion to ethanol, there is need for good process control and evaluation of losses in fermentation and distillation. HPLC is of great benefit in the determination of fermentable sugars as one of the most important control factors; the basic system used provides information on fermentation of separate batches, the effect of vinasse recycle and of yeast recycle, and on ethanol losses in vinasse. The problem of vinasse disposal is discussed; several approaches have been made, but no final answer yet found. Advantages and disadvantages of the various measures tried are discussed.

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In the case of United Kingdom patents, copies may be obtained on application to The Patent Office Sale Branch, Block C, Station Square House, St. Mary Cray, Orpington, Kent, England (price £1.95 each). United States patent specifications may be obtained by application to Box 9, Patent and Trademark Office, Washington, DC 20231, U.S.A. (price \$1.00 each).



une meilleure préparation de la canne, à une application plus uniforme de l'imbibition et à une meilleure séparation du jus. On décrit les mesures prises et les avantages qui en ont résulté.

**Imbibitionsoptimierung**

Der Mühlenganz in der Zuckerfabrik Ookala auf Hawaii wurde modifiziert mit dem Ziel, die Effektivität der Imbibition durch bessere Rohrpräparation, gleichmäßigere Imbibitionswasserzugabe und bessere Saftabtrennung zu verbessern. Die unternommen Schritte und die erhaltenen Resultate werden beschrieben.

**Optimización de la imbibición**

Se han hecho modificaciones al tandém de molinos en la azucarera Ookala en la Hawaii con el fin de mejorar la efectividad de la imbibición por preparación mejor de la caña, más uniforme aplicación de la imbibición, y separación mejor del jugo. Las medidas tomadas y los beneficios que han resultado se describen.

**Brevities**

**Panama sugar production, 1985<sup>1</sup>**

Sugar production in the 1985 season reached 167,000 tonnes, compared with 176,500 tonnes in 1984. According to a Latin American Commodities report, the shortfall occurred entirely in the state-owned sector which produced 87,800 tonnes, whereas the two privately-owned sugar factories surpassed their 1984 output by 2600 tonnes to reach 79,260 tonnes. The state-owned La Victoria Corporation wishes to convert its Felipillo factory, which was closed two years ago, into an alcohol-producing enterprise, and various foreign companies have been carrying out feasibility studies.

**New Polish sugar factories<sup>2</sup>**

Poland is to build another four medium-sized sugar factories within the next 15 years to shorten the beet campaign, according to the East Bloc agricultural news agency DLO. Two are planned for the province of Lublin and one each for Oppeln and Gorzow, and they should permit reduction from the present 102 days campaign to 96 days; the optimum would be 80 days. An article in a Polish newspaper reported that the Glinojock factory, which was scheduled to open in 1980, is not now expected to commence operations until 1986.

**New Nicaragua sugar factory<sup>3</sup>**

The Victoria de Julio sugar factory, of 7000 t.c.d. capacity and costing \$220 million, has been built

in Nicaragua and is expected to produce about 110,000 tonnes of raw sugar during a season of 203 days. The share of equipment and construction labour contributed by Cuba, valued at around \$73.8 million, has been donated by the Cuban government to the people and government of Nicaragua.

**Nigeria cane area expansion<sup>4</sup>**

The cane area of Nigeria increased slightly to 14,000 ha in 1984/85 and will increase to 16,000 ha in 1985/86 with the introduction of more cane land for Savannah. The government is studying a proposal to add up to 11 new plantations over the next few years in an effort to become self-sufficient in sugar.

**Colombia program for alcohol from cane<sup>5</sup>**

Colombia is to launch a massive program of production of fuel alcohol from sugar cane modelled on the Brazilian formula, according to a spokesman of the state oil company Ecopetrol. He said that technical feasibility studies would be made in association with Colombia's cane growers but no date has been fixed for the start of the program.

1 F. O. Licht, *International Sugar Rpt.*, 1985, 117, 328.  
 2 *World Sugar J.*, 1985, 7, (11), 26.  
 3 *Cuba Economic News*, 1985, 21, (145), 8-9.  
 4 *Amerop-Westway Newsletter*, 1985, (139), 24.  
 5 *Reuter Sugar Newsletter*, May 30, 1985.

# The analysis of sugars in beet

## Part I. Samples preparation

By A. P. Mulcock, S. Moore and F. Barnes

(Microbiology Department, Lincoln College, Canterbury, New Zealand)

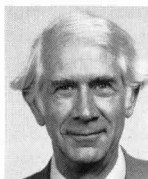
### Introduction

The fact that reserves of oil and coal on this planet are finite has always been accepted but the immediacy of the threat to internal combustion engines and petro-chemicals was shown with frightening realism during the oil crisis of the seventies. New Zealand being an island with a small population and an agrarian economy found itself in a particularly vulnerable situation.

In New Zealand a research program aimed at finding ways of closing the gap between the country's needs and available oil supplies using indigenous liquid fuels for cars and tractors was immediately begun. One of the projects involved the production of ethanol from crops grown in this country. After some preliminary investigations into the agronomy and economics of several crops it became clear that beet (*Beta vulgaris* L.)—either fodder beet or sugar beet—was the crop most likely to be suitable for large scale cultivation for ethanol production by fermentation.

In 1979 the Liquid Fuels Trust Board provided funding for scientists at Lincoln College to undertake varietal trials and yield assessment of beet cultivars and subsequently in 1980 funds were made available for the erection of a pilot plant to study extraction, fermentation and waste disposal aspects of ethanol production from beet. These programs, along with one on extended above-ground storage of harvested roots, led to a demand for a large number of sugar analyses on plant tissue, fermenting liquor and effluents.

Early analyses were performed using an optical refractometer; however, interfering compounds made the method unreliable. The production of derivatives for G.L.C. analysis was found to be too time-consuming for the considerable numbers of samples that had to be tested. Further examination of the problem showed that high performance liquid chromatography could give the results required quickly



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and accurately using relatively small samples.

The research programs served by the analytical technique generated more than 6900 samples between 1980 and 1983. Some samples were extracted more than once to check the techniques used. These duplicates along with other standards and repeats have entailed 19,000 injections into the HPLC unit and required the use of 18 columns.

This series of papers sets out the techniques and methods evolved to cope with sugar analyses needed for the ethanol from beet project.

The methods used in the first year of the field trials for harvesting and preparation of samples for sugar analysis are set out below.

### Sampling and processing

During field sampling between 5 and 60 plants were harvested depending on the size of the plots in the trial. Because of the harvesting program there was considerable variation in the time between removal of plants from the field and their further preparation. The type of storage used was either a cool store at 4°C or storage outside in the shade. The beet were first washed to removed any soil or other foreign matter and then weighed for fresh yield data. Of the beet harvested, 20% were processed (i.e. 1 to 12 beets). The leaves were removed and each root was cut in half longitudinally, one half was

ground for sugar analysis and the other half coarsely chopped for dry matter yield. The percentage dry matter was determined by weighing the coarsely chopped beet, heating to dryness in an oven at 80°C and weighing again. Every endeavour was made to keep preparation time to a minimum and the delay between harvesting and grinding of a sample for sugar analysis never exceeded 48 hr.

To examine what effects the above procedures had on final sugar content determination a search of the literature of beet preparation was undertaken. From investigations by Vukov<sup>1</sup> and McGinnis<sup>2</sup>, the estimated coefficient of variation, CV, for the sugar content of a single beet is 21%.

$$\text{For a sample of } n \text{ beets } CV = \sqrt{\frac{12}{n}}$$

Table I: The CV of sugar content for sample sizes of beet.

Number of roots	CV
1	21.0
5	9.4
10	6.6
50	3.0

Vukov recommended collecting 30-40 plants for analysis in order to obtain acceptable CV values.

In a personal communication, Mr. D. R. Brisbane of Beet Sugar Developments Ltd, indicated in 1980 that field sampling did not always yield precise results, even if performed according to the recommendations of Vukov, and the only way that an accurate result could be obtained was to harvest the whole field plot and extract the sugar.

It has been shown<sup>3</sup> that harvesting disturbs the metabolism of the root, causing vigorous respiration especially during the first few days of storage, with a subsequent 50% decline to a

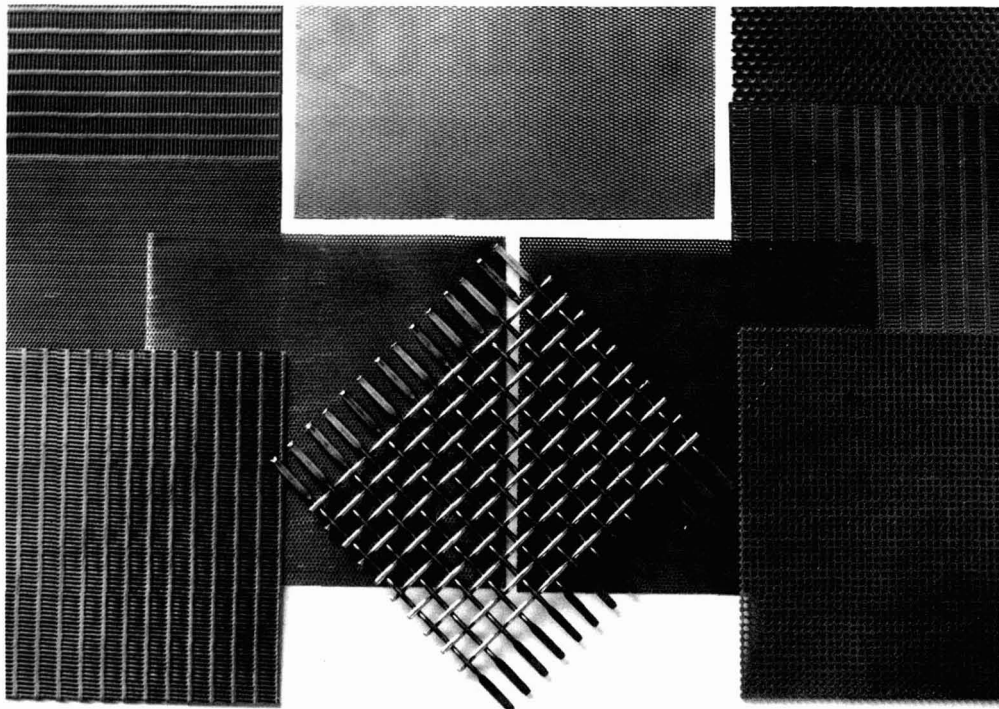
1 "Physics and chemistry of sugar beet in sugar manufacture" (Elsevier, Amsterdam) 1977, p. 19.

2 "Beet sugar technology", 2nd Edn. (Beet Sugar Development Foundation, Fort Collins, CO, USA) 1971, p. 76.

3 Oldfield *et al.*: *British Sugar Beet Review*, 1979, 47, (3), 7-10.



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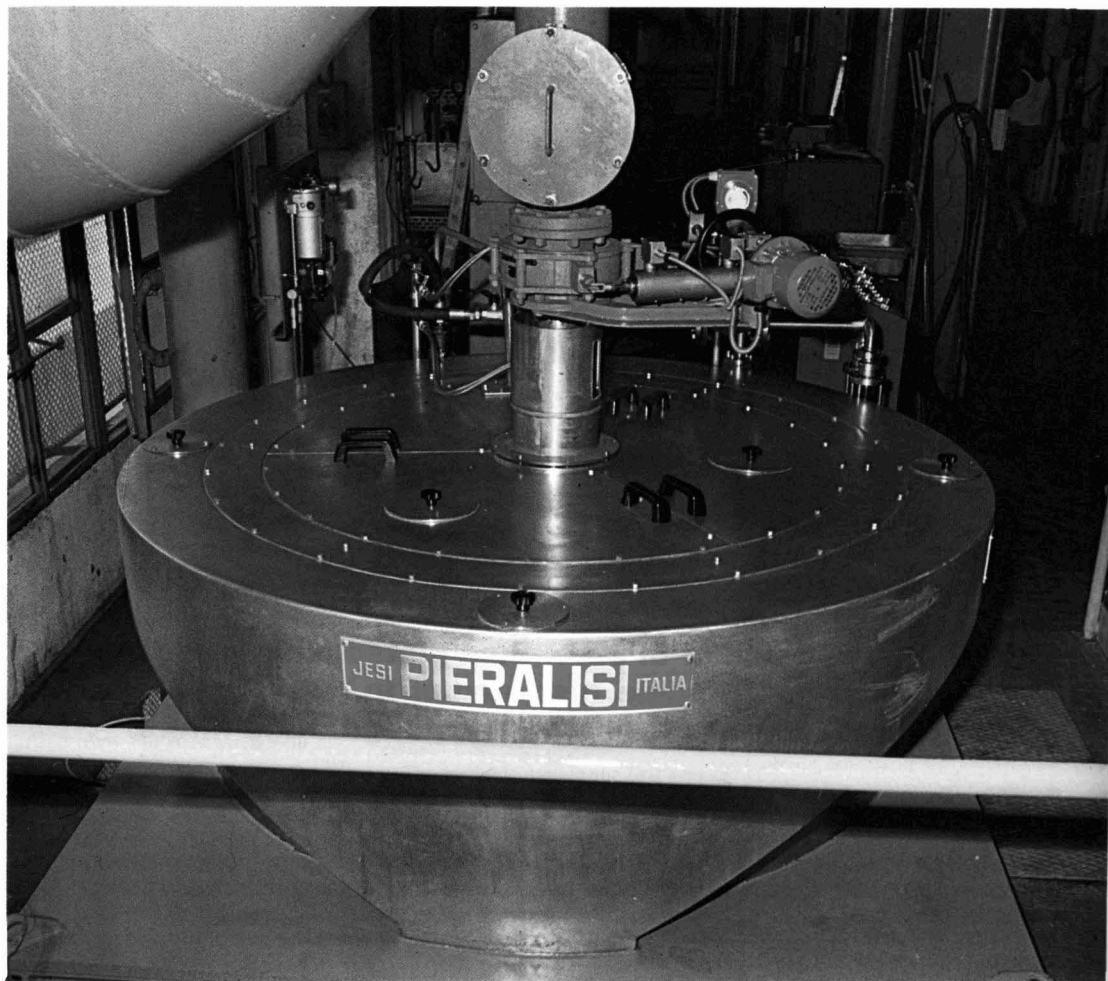


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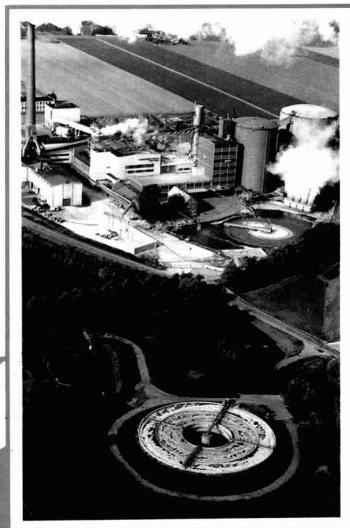
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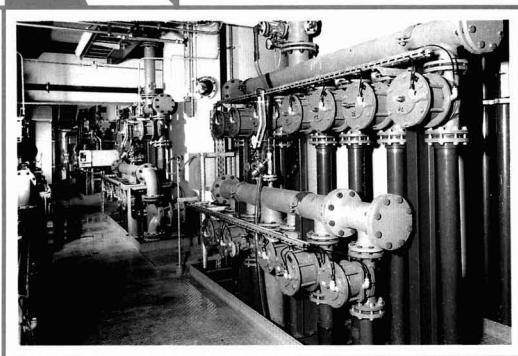
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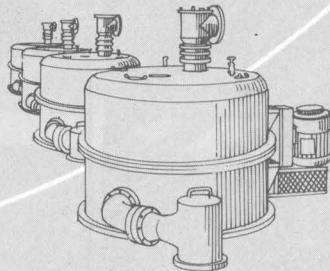
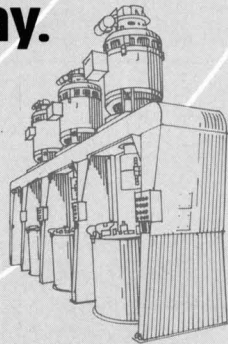
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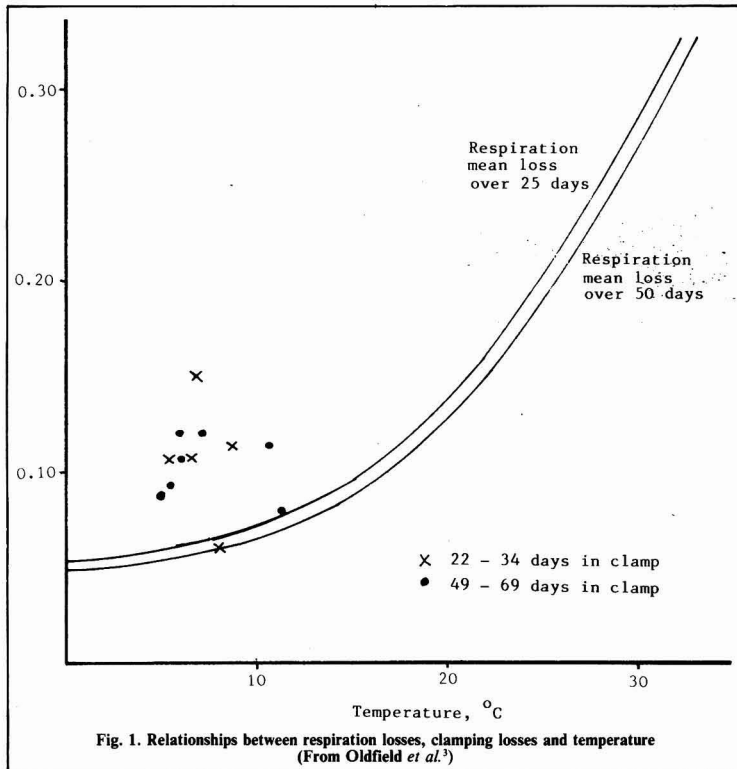


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fairly steady rate, averaging 0.05% of the total sugar per day at 7°C. Respiratory losses vary dramatically with changes in temperature (Fig. 1) and beet damage.

**Brei preparation**

Initial tests with a bowl chopper showed that some of the sample was crushed to a pulp and a significant amount of juice settled out, causing a



Surface damage resulting from abrasion and bruising of the beet, combined with cutting and breakage, can more than double respiration losses<sup>4,5</sup>. Kapor<sup>6</sup> found that the quantity of sugar lost from beet which had been dropped from a height of six metres, was more than eight times that for beet dropped from one metre.

Not only is sucrose directly consumed as the respiratory substrate, but it is also hydrolysed to yield fructose and glucose<sup>7</sup>. In addition, rapid moisture losses of 35% to 75% may occur under very warm harvesting conditions and when beet are stored in small heaps<sup>8</sup>.

sugar concentration gradient through the bed of beet.

To overcome this problem, a soil shredder was modified for brei preparation. The shredder (Arnold France Ltd., Christchurch, N.Z.) was a type of hammer mill, powered by a 3 h.p. electric motor. It ground the beet to a homogeneous mixture. Furthermore, all the beet roots taken from the field could be ground in one batch and the problem of juice separation was lessened since the disintegrated beet was not retained in contact with the chipping hammers. Because the soil shredder could handle large volumes of beet, it was

considered that beet processed in it might be suitable for dry matter analysis. If this were the case, this would mean the total field sample could be ground and subsamples taken for dry matter and sugar analyses.

The results of tests with the modified soil shredder and the bowl chopper methods were considered sufficiently close to use the modified soil shredder for the whole sample and sub-sample for both dry matter and sugar analyses.

An added advantage was that the shredder accomplished the comminution much more quickly (in only 1.3 minutes) than the bowl chopper (7 minutes).

**Frozen storage**

Almost as soon as beet is minced it begins to turn brown and is soon black in colour. Thus, chemical changes both oxidative and enzymatic begin at once. Since beet have some soil on them when they are comminuted, the sample will be thoroughly inoculated with bacteria and fungi. Under warm conditions microbial growth will quickly commence and the organisms will use the freely available sugars as an energy source.

About 200 g of each minced sample was packed into a 400 ml plastic container which was closed with a screw-on or press-on lid prior to freezing for storage at -17°C. Samples taken from storage were thawed in the laboratory in a water bath at 30°-35°C. They were of differing consistency and some were slimy, which could have been due to microbial growth. Thus the time between mincing and freezing was shown to be important. Temperatures recorded within the freezer used showed that if a large number of samples was placed in it at one time in bulk, possibly 24-48 hr could elapse

4 Idem: *J.S.J.*, 1971, 73, 326-330.  
 5 de Vletter & van Gils: *ibid.*, 1974, 76, 233-237, 266-269.  
 6 *Zeitsch. Zuckerind.*, 1975, 100, 447-451.  
 7 Oldfield *et al.*: *Compt. rend. Comm. Int. Tech. Sucr.*, 1979, 430-469.  
 8 Nash: "Crop conservation and storage in cool temperature climates", 1st Edn. (Dept. of Agriculture, University of Edinburgh) 1978, p. 227.

before they were frozen and microbial and enzyme activity reduced to a negligible amount.

To investigate the effect of delays before and after freezing five freshly collected beet were ground in the soil shredder and the brei was divided into two sub-samples.

One sub-sample was spread out 25 mm deep on a plastic tray which was held at 22°-24°C. After sitting for 0, 1, 2, 4 and 6 hours, duplicate portions (approx. 150 g) were taken from the tray, put in freezer containers and at the same times 8 g of each of these were taken and analysed immediately. The remainder of the container was frozen at -17°C. The frozen containers were later thawed in a water bath at 30°-35°C for approximately 15 minutes at which time the brei could be stirred with a spatula. Three further analyses were performed on 8 g samples; these were:

1. Immediately after thawing.
2. Three hours at room temperature (approximately 20°C) after thawing.
3. Six hours at room temperature after thawing.

The second sub-sample was immediately divided and put into ten containers and these were held at 22°-24°C.

Duplicate containers were removed from this warm environment at 10, 15, 24, 30 and 47 hr and an 8 g sample from each container was analysed immediately. The remainder of the container was frozen. These containers were thawed at a later date and analysed immediately and also after 3 and 6 hr incubation at room temperature.

All analyses were carried out using the blender/ultrasonicator method (see Appendix).

Results for fructose and glucose concentrations are expressed as equivalent sucrose, the amount of sucrose that needs to be hydrolysed to produce a particular amount of fructose and glucose. The molecular weight of sucrose (342) is 95% of the molecular weight of glucose (180) plus fructose (180). Therefore the concentration expressed as equivalent sucrose is equal to 95% of the actual concentrations of glucose plus fructose.

The first set of samples were

equivalent to minced beet that had been left before being put in containers. The other set of samples simulated containers that had not been immediately frozen. However, whether ground beet was left in containers or spread out, most changes that occurred were likely to be due to the fact that the temperature was above that which would allow chemical reactions to occur relatively rapidly. Therefore a direct comparison of all results may be made. The results of the analyses are set out in Table II and the results "Immediately after thawing" are plotted in Figure 2.

The results in Table II and Figure 2 do not show any consistent trend with time, other than that the 30- and 47-hr samples had increased fructose and glucose concentrations. The reason for this may have been that reactions taking place required a minimum time at 22°-24°C to occur. These reactions continued after thawing.

The trends down the columns of Table II indicate gradual decrease in total sugar concentration with a sharp drop in the 47-hr sample. Also after 47 hr the fructose and glucose

Table II. Sugar concentrations in ground beet held at 22-24°C expressed as equivalent sucrose % by weight of wet beet

Sample treatment	Hours left unfrozen (duplicate samples)	Before freezing			Immediately after thawing			3 hr after thawing			6 hr after thawing			
		Fructose/glucose	Sucrose	Total	Fructose/glucose	Sucrose	Total	Fructose/glucose	Sucrose	Total	Fructose/glucose	Sucrose	Total	
A	0(1)	0.39	11.84	12.23	0.67	10.62	11.29	0.89	11.81	12.70	0.79	11.56	12.35	
	0(2)	0.64	11.97	12.61	0.70	11.79	12.49	0.78	11.55	12.33	0.69	11.16	11.85	
	Exposed to air	1(1)	0.64	11.39	12.03	—	—	—	0.74	10.72	11.46	1.20	10.84	12.04
		1(2)	0.62	10.99	11.61	0.73	11.62	12.35	0.74	10.59	11.33	0.80	11.40	12.20
		2(1)	0.81	11.63	12.44	—	—	—	0.74	11.55	12.29	0.98	11.41	12.39
		2(2)	0.76	11.95	12.71	0.62	9.70	10.32	0.95	11.01	11.96	0.71	10.18	10.89
		4(1)	0.85	12.54	13.39	0.74	12.44	13.18	0.80	12.40	13.20	0.89	11.95	12.84
		4(2)	0.82	12.05	12.87	0.71	11.60	12.31	0.77	11.77	12.54	0.75	10.67	11.42
		6(1)	—	—	—	0.91	11.74	12.65	0.81	12.26	13.07	0.87	12.52	13.39
		6(2)	—	—	—	0.83	11.99	12.82	0.86	11.98	12.84	0.91	12.27	13.18
	B	10(1)	—	—	—	0.81	11.33	12.14	0.87	11.86	12.73	0.85	11.68	12.53
		10(2)	—	—	—	0.77	11.60	12.37	0.82	11.81	12.63	1.10	11.92	13.02
Put into pottles		15(1)	—	—	—	0.89	11.21	12.10	0.72	10.02	10.74	0.78	10.81	11.59
		15(2)	—	—	—	0.72	10.36	11.03	0.90	11.09	11.99	0.67	10.89	11.56
		24(1)	0.78	11.37	12.15	0.76	10.78	11.54	1.11	10.38	11.49	0.55	10.24	10.79
		24(2)	0.84	11.09	11.93	0.99	11.02	12.01	0.84	11.19	11.96	0.71	10.85	11.56
		30(1)	0.50	9.90	10.40	0.64	10.26	10.90	0.92	10.10	11.02	1.20	10.03	11.23
		30(2)	0.55	11.23	11.78	0.60	9.83	10.43	0.46	9.88	10.34	1.13	10.07	11.20
		47(1)	—	—	—	2.17	6.99	9.16	—	—	—	2.80	6.43	9.23
		47(2)	—	—	—	3.17	4.93	8.10	2.70	5.45	8.15	3.35	5.34	8.69



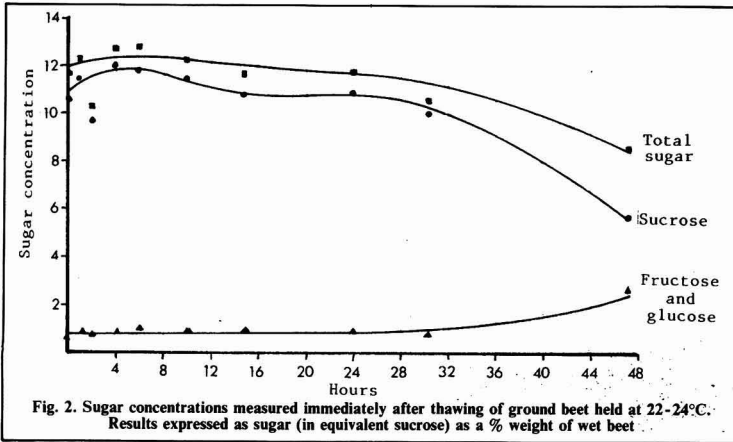


Fig. 2. Sugar concentrations measured immediately after thawing of ground beet held at 22-24°C. Results expressed as sugar (in equivalent sucrose) as a % weight of wet beet.

concentrations had increased greatly. The 30-hr samples that were left out after thawing showed the start of a rapid increase in fructose and glucose concentrations. Although sugar concentrations overall decreased the longer the samples remained unfrozen, a small increase in the total sugar occurred in 4- and 6-hr samples.

The experiment showed that if minced beet was left unfrozen for up to 24 hr a small rise in fructose plus glucose occurred but the total sugar remained unaffected. A drop in the total sugar did occur if the beet was left unfrozen for more than 30 hr. Beet samples that had been received for analysis in a slimy, discoloured condition were similar to those that were held for 47 hr; these showed high fructose and glucose and low total sugar concentration similar to that recorded in this experiment.

From the experiment it can be concluded that beet should be frozen within six hours of grinding and in this connexion it should be noted that large numbers of samples packed in cartons for freezing may remain unfrozen for many hours.

**Appendix**

*Blender ultrasonicator extraction method*

As a result of the experiments described above a method of extraction

of sugars was adopted which was designed to maximize the efficiency of extraction while still allowing a sufficiently large throughput to cope with the volume of samples brought for analysis. The method is summarized

below (see Figure 3).

From a thawed pottle of beet approximately 8 g of beet was weighed accurately and transferred to the blender cup of a Sorvall Omnimixer (Ivan Sorvall Inc., Newtown, CT, USA). To this, 50 ml of 80% ethanol was added and the cup was stoppered, then heated in a water bath at 55°C for 5 min while undergoing ultrasonic treatment. The cup was then attached to the blender and for a further 5 min underwent heating and ultrasonic treatment while being blended at 16,000 rpm. On completion of the blending the contents of the cup were filtered into a 100 ml volumetric flask. The residue was rinsed with distilled water and the filtrate on cooling to room temperature was diluted to 100 ml. A subsample of the filtrate was centrifuged at 1500 rpm for 10 min to finally produce an extract suitable for analysis by HPLC.

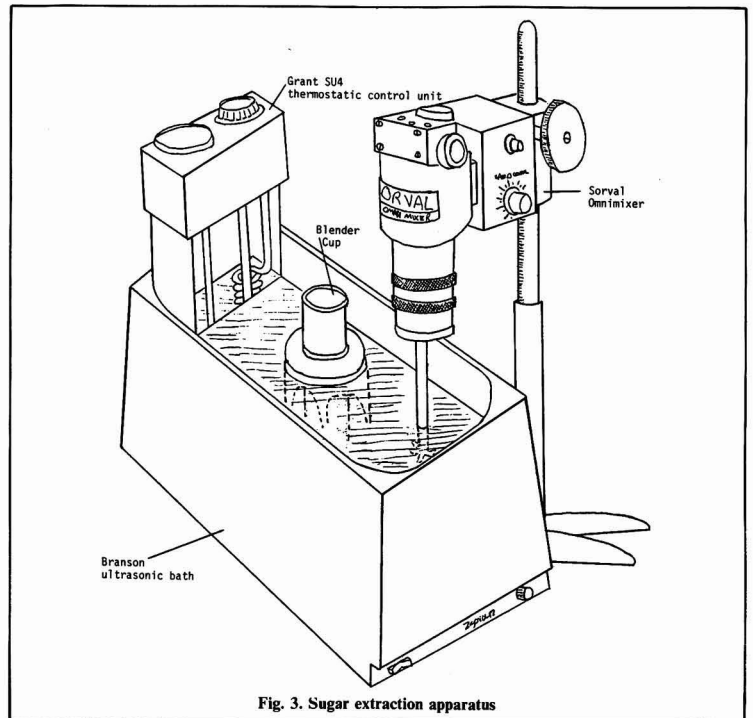


Fig. 3. Sugar extraction apparatus

# Single-cell protein production from cane juice and molasses by thermotolerant yeasts

By Rita Kar and L. Viswanathan

(Biochemistry Division, National Sugar Institute, Kanpur, India 208017)

## Introduction

In recent years, realization of the inadequacy and inefficiency of conventional methods of producing food has led to a spurt in investigations on single-cell protein<sup>1-5</sup>. Yeasts are highly efficient producers of protein and have long been used as microbial food<sup>6</sup>. Aerobic propagation of yeast produces a large amount of heat, necessitating efficient cooling during the fermentation, particularly in tropical and subtropical countries. The fermenting wash can sometimes reach temperatures in excess of 40°C which are detrimental to the behaviour of common yeasts. On the other hand higher temperatures are potentially capable of providing faster fermentation rates. Hence it would be beneficial to employ thermotolerant strains for the production of food yeasts, thus eliminating the necessity for cooling. Such processes are not common at present, however, mainly owing to lack of appropriate organisms. The use of a thermophilic yeast for this purpose has been reported but lower yields were obtained above 30°C<sup>7</sup>.

In the present work four thermotolerant yeast strains were tested for biomass production on cane juice and molasses media with two different sugar concentrations at 30°C and 40°C. The composition of the biomass formed was also determined.

## Materials and methods

### Molasses medium

Cane molasses was diluted to 12° Brix and supplemented with 0.2% (NH<sub>4</sub>)<sub>2</sub>SO<sub>4</sub> and 0.02% KH<sub>2</sub>PO<sub>4</sub>. After adjusting the pH to 5.4, the medium was steamed for 15 minutes and then centrifuged at 5000 rpm for 20 minutes. The supernatant was sterilized by autoclaving at 15 psig for 15 minutes.

### Cane juice medium

Cane juice from the first mill of a 5-mill tandem was diluted to about 12% and 6% total sugar concentrations and the medium was prepared as



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L. Viswanathan

above. Both cane juice and cane molasses were obtained from the Experimental Sugar Factory of this Institute.

### Organisms

Of a number of thermotolerant yeast strains isolated in this laboratory, four strains were used in this investigation. Strains A and B were of *Candida tropicalis*, strain C was of *C. krusei* and strain D belonged to *Pichia ohmeri*<sup>8</sup>. The strains grew well over the temperature range of 30-40°C and were maintained on 1:2:2 yeast extract:peptone:dextrose slants by subculturing at monthly intervals. The inoculum was added at 10% by volume of the medium. The cells were grown in a rotary shaker at 150 rpm for 24 hours at 30°C and 40°C.

Total reducing sugars were estimated by the method of Eynon & Lane after inversion<sup>9</sup>. DNA was estimated by the method of Burton<sup>10</sup> and RNA by a modified method of Dische & Schwartz, as described by Herbert *et al.*<sup>11</sup>. Protein was estimated by the method of Lowry *et al.*<sup>12</sup>.

### Results and discussion

In all the experiments reported in Tables I to IV, the yield of biomass increased when the initial sugar concentration was lowered from about 6% to about 3%. Activities of mitochondrial and respiratory enzymes in yeasts have been shown to vary inversely with the concentration of glucose<sup>13</sup>. Thus in the presence of excess sugar, the tricarboxylic acid (TCA) cycle remains in low profile and most of the glucose is metabolized through glycolysis. Molecular growth yield is lower when glycolysis operates as

major metabolic pathway as compared with the TCA cycle, thus resulting in low yield of biomass. The thermotolerant strains studied appear to be much more sensitive to higher sugar concentration than the conventional yeast strains.

With the lower initial sugar concentration, strains A and C (*tropicalis* and *C. krusei*) exhibited satisfactory yields of biomass (17% and 24.5% on sugar utilized) when grown on the molasses medium. The percentages of protein in the biomass produced (about 30% and 52%) were also encouraging (Table I). The fact that lower sugar concentrations gave better yields suggests that these strains will perform better in continuous fermentation processes, where sugar concentrations can be kept low. These experiments employed only a batch process in rotary flasks and conditions were not fully optimized. Much better yields can be expected in a continuous fermentation process. Strain D (*P. ohmeri*) had a remarkably higher protein content of about 65% though the yield of biomass was lower. Other strains of *Pichia* have been reported to yield good growth and protein contents of about 60% on continuous fermentation at normal temperatures<sup>14</sup>.

- 1 Blaxter: "New Horizons for Chemistry and Industry in the 1990's" (Society of Chemical Industry, London) 1970, pp. 67-72.
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- 11 "Methods in Microbiology," Vol. 5B. Eds. Norris & Ribbons (Academic Press, New York) 1971, pp. 287, 316.
- 12 *J. Biol. Chem.*, 1951, 193, 265-275.
- 13 Polakis *et al.*: *Biochem. J.*, 1964, 90, 369-374.
- 14 Shimamatsu *et al.*: German Patent, 1974, 2,418,755 (Cl. C. 12dc), 07; Japan Pat. Appl. 7,343,618 (19 April 1973).

Table I. Biomass production on molasses medium at 30°C

Strain	Total sugars, g/100 ml		Dry weight of biomass, mg/ml		Biomass yield, g dry wt./100 g sugar consumed	Composition of biomass, mg/g dry wt.		
	Initial	Final	Initial	Final		Protein	RNA	DNA
A	5.76	0.40	0.73	5.68	9.23	363	32.9	6.2
	2.52	0.19	0.60	4.60	17.17	305	27.0	4.3
B	6.08	0.34	0.27	6.59	11.01	226	45.6	2.0
	3.50	0.28	0.58	5.09	14.13	224	39.4	2.0
C	5.33	2.23	0.38	2.71	7.51	554	92.7	4.1
	2.66	1.60	0.23	2.83	24.53	519	79.2	2.3
D	6.80	3.71	1.27	2.58	4.24	572	42.2	5.7
	3.31	2.57	0.93	1.84	12.29	654	45.3	4.2

Table II. Biomass production on molasses medium at 40°C

Strain	Total sugars, g/100 ml		Dry weight of biomass, mg/ml		Biomass yield, g dry wt./100 g sugar consumed	Composition of biomass, mg/g dry wt.		
	Initial	Final	Initial	Final		Protein	RNA	DNA
A	6.75	4.00	0.80	3.50	9.82	156	35.6	4.6
	3.83	0.33	0.77	5.37	13.14	187	37.6	2.9
B	7.20	0.71	0.33	7.50	11.09	215	52.2	2.8
	3.60	0.36	0.50	6.27	17.90	192	33.3	2.2
C	5.33	3.78	0.27	1.40	7.09	433	80.1	8.5
	3.16	1.70	0.27	2.24	13.69	619	65.0	5.9
D	6.50	4.20	0.67	2.30	7.09	441	38.6	9.5
	3.60	1.17	0.83	3.88	12.75	419	41.2	6.9

Table III. Biomass production on cane juice medium at 30°C

Strain	Total sugars, g/100 ml		Dry weight of biomass, mg/ml		Biomass yield, g dry wt./100 g sugar consumed	Composition of biomass, mg/g dry wt.		
	Initial	Final	Initial	Final		Protein	RNA	DNA
A	8.00	0.48	0.63	4.72	5.45	345	82.2	5.6
	3.97	0.07	0.30	3.57	8.46	330	79.5	5.3
B	7.47	0.27	0.67	5.14	6.25	327	64.4	4.7
	3.40	0.09	0.47	4.80	13.08	282	62.1	4.4
C	7.78	5.60	0.23	4.28	18.81	410	99.5	5.9
	4.59	2.86	0.19	4.19	23.12	373	98.4	5.8
D	5.63	0.73	0.30	2.68	4.90	588	75.6	3.4
	3.02	0.78	0.10	2.15	9.38	611	58.7	2.7

Table IV. Biomass production on cane juice medium at 40°C

Strain	Total sugars, g/100 ml		Dry weight of biomass, mg/ml		Biomass yield, g dry wt./100 g sugar consumed	Composition of biomass, mg/g dry wt.		
	Initial	Final	Initial	Final		Protein	RNA	DNA
A	7.18	1.93	0.53	3.93	6.66	299	34.8	3.3
	4.03	0.31	0.27	4.00	9.95	386	48.9	4.1
B	5.90	0.87	1.30	5.30	7.95	396	69.3	3.8
	3.20	0.16	0.41	4.60	13.82	273	41.2	3.0
C	7.57	3.78	0.60	2.97	6.33	606	65.4	8.9
	4.06	1.84	0.23	2.50	10.36	619	64.8	5.1
D	8.00	6.09	0.93	2.93	10.47	420	68.0	5.8
	3.60	1.27	0.40	3.20	12.02	304	54.6	4.4

On molasses medium, an increase in temperature to 40°C drastically lowered the yield of biomass only in the case of strain C (Table II). There were only small changes in the other strains at lower initial sugar concentration. The extent of utilization of sugars was drastically reduced in strains A, C and D when the initial sugar concentration was high. This suggests that these strains are probably more sensitive to catabolite repression at the higher temperature. However such a difference was not found when the initial sugar concentration was kept lower. In this case sugar utilization improved in strain D on increasing the temperature from 30°C to 40°C. However biomass yields even at 40°C can be considered to be satisfactory and can be expected to be increased further by continuous fermentation process. The protein contents of strains C and D at about 62% and 42% were also quite good at 40°C. Considering the data obtained at 40°C on molasses medium, strain C appears to be the best for biomass and protein yields.

The growth patterns on cane juice medium were generally qualitatively similar to those on molasses medium (Tables III and IV). Decrease in the initial sugar concentration improved utilization of sugar and increased biomass yield. With higher initial sugar concentration, sugar utilization was sensitive to increase in temperature in strains A and D.

Yields of biomass at 40°C, were generally lower with cane juice medium as compared to molasses medium. Concentration of some growth factors required by certain strains of yeast are known to be limiting in some types of molasses particularly in beet molasses. These factors, especially the heat-stable ones, are concentrated in molasses during processing in the sugar factory, and their concentration in cane juice may therefore be expected to be below the optimal level. This may explain the better yields obtained on molasses medium at 40°C. It has been observed in the present investigation,

and in the literature too, that thermotolerant yeast species have been reported to differ in the levels of protein production with respect to temperature. Thus a heat tolerant strain of *C. tropicalis* has been reported to show a lower protein level when grown at 34–39°C than in cultures grown at 28–29°C, but the level of essential amino acids in the cell was higher<sup>15</sup>. However, on a thermotolerant species of *Saccharomyces fragilis* where optimum temperature for protein synthesis was 40°C, even higher temperatures did not have adverse effects<sup>16</sup>.

On the basis of the above observations and considering the high protein contents in some cases, further experiments with lower sugar concentrations and some modifications in the fermentation process will certainly be useful.

A major problem in the use of yeast as single-cell protein is its high ribonucleic acid content. This is an inherent property of yeast and the only solution appears to be the development of suitable techniques for the removal of RNA before use of the yeast in feed stuffs. Cold acid treatment of yeast cream, followed by neutralization and hot salt extraction have been found to reduce the nucleic acid content to 1.5%, as compared with a normal RNA content of 7–8% for a commercial dried yeast<sup>5</sup>.

A comparison with the limited information available in the literature and referred to above, indicates that there is considerable variation in the performance of different strains at higher temperatures. This study has been limited to a small number of typical isolates of thermotolerant strains. It is certain that a systematic screening of more strains will eventually provide suitable cultures of industrial importance for single-cell protein production at higher temperatures.

#### Summary

Four thermotolerant yeast strains

were tested for their ability to produce single-cell protein from molasses and cane juice at 30°C and 40°C at two different initial sugar concentrations. Percent yields of biomass were higher in all the cases with lower initial sugar concentrations. A strain of *Candida krusei* performed well at 40°C yielding about 10.4 to 13.7 g dry biomass per 100 g of sugar consumed during growth in rotary shake flasks. The biomass contained about 62% protein.

#### Production de protéine monocellulaire aux dépens de jus et de mélasses de canne par de levures thermotolérantes

On a essayé quatre espèces de levures thermotolérantes au point de vue de leur faculté de produire de la protéine monocellulaire à partir de mélasse et de jus de canne. On a opéré à 30°C et à 40°C et à deux concentrations initiales différentes. Le rendement en biomasse fut dans tous les cas plus élevé avec une concentration initiale en sucre plus basse. Une espèce de *Candida krusei* avait une bonne performance à 40°C et elle donnait entre 10.4 et 13.7 g de biomasse sèche par 100 g de sucre consommé lorsqu'on opérait dans les flacons agités et rotatifs. La biomasse renfermait environ 62% de protéine.

#### Einzellerprotein-Erzeugung aus Rohrsaft und Melasse durch thermotolerante Hefen

Vier thermotolerante Hefestämme wurden auf ihre Fähigkeit untersucht, Einzellerprotein aus Melasse und Rohrsaft bei 30 und 40°C und zwei verschiedenen Anfangs-Zuckerkonzentrationen zu bilden. Die prozentuale Biomasseausbeute war in allen Fällen bei geringen Anfangskonzentrationen höher. Ein Stamm der *Candida krusei* erzeugte bei 40°C 10.4–13.7 g Trockenmasse je 100 g abgebauten Zuckers während des Wachstums im sich drehenden Schüttelkolben. Die Biomasse enthielt ungefähr 62% Protein.

#### Producción de proteína monocelular sobre jugo y melaza de caña por

#### levaduras termotolerantes

Cuatro razas termotolerantes de levadura se han ensayado con respecto a su aptitud para producir proteína monocelular sobre melaza y jugo de caña a 30°C y 40°C a dos concentraciones iniciales diferentes de azúcar. El rendimiento de biomasa fué en todos casos más grande con una concentración más bajo en azúcar. Una raza de *Candida krusei* funcionó bien a 40°C con un rendimiento de 10.4 a 13.7 g de biomasa seca por 100 g de azúcar consumido durante el crecimiento en frascos agitados y girados. La biomasa contuvo unos 62% de proteína.

15 Krasnikov et al.: *Mikrobiol. Zh.*, 1975, 37, 377-379.  
16 Pozmogova et al.: *Mikrobiologiya*, 1979, 48, 39-43.

## Brevities

#### New Pakistan sugar factories<sup>1</sup>

Two new sugar factories are to be erected in Baluchistan at a cost of 700 million rupees (\$44.4 million), and a 10,000-hectare cane area is planned to supply them. Pangriro Sugar Mills Ltd. at Nasirabad will have a white sugar production capacity of 51,000 tonnes/year while Sind Abadgars Sugar Mills Ltd. will have a capacity of 61,500 tonnes/year.

#### Ball bearing cane mill tandem in Cuba<sup>2</sup>

The first mill tandem to be equipped with ball bearings for the mill rollers, designed and built in Cuba, has been installed at Central Panchito Gómez Toro. Power savings of 20–30% are permitted by the bearings, technical features and performance evaluation of which were described at the 44th Congress of the Asociación de Técnicos Azucareros de Cuba in October last.

#### CSR Limited 1985 Annual Report

Profits of the CSR Sugar Division were \$A 15.4 million, \$10.3 million less than the previous year; the fall was almost entirely due to lower profits from raw sugar milling consequent upon the low world market price for sugar, Australia being one of the few countries dependent on the world market for more than 50% of exports. The cane crushed reached a record 6,520,000 tonnes and 938,000 tonnes of sugar, net titre, were produced. Higher output and tight control reduced unit milling costs by 2%. Refined sugar sales from the Australian refineries totalled 681,000 tonnes with 7000 tonnes exported, while NZ Sugar Company sales totalled 159,000 tonnes.

1 *Amerop-Westway Newsletter*, 1985, (139), 24.  
2 *Cuba Economic News*, 1984, 20, (144), 17-18.

# International Commission for Sugar Technology (C.I.T.S.)

Following an invitation by the Hungarian sugar industry, the Scientific Committee of the CITS held its annual meeting in Budapest during June 3-5, 1985. Members of the Committee were accompanied by some of their colleagues so that the number attending approached 60. The practical organization of the meeting was in the capable hands of Dr. Hangyal and Dr. Vukov.

Professor G. Mantovani, President of the Scientific Committee, was chairman of the working sessions where the following papers were presented and discussed: "Nouvelles formules exprimant la valeur technologique des betteraves", by P. Devillers (IRIS, France); "Technological value of beets remaining in the soil some days after topping", by H. Zaorska, K. Szwajcowska and K. Lisik (Lodz Polytechnic, Poland); "Verwendung von Rübenbruchstücken", by J. Studnický and A. Dandar (Bratislava, Czechoslovakia); "Influence of the extraction parameters on the physical properties of pulp", by N. H. M. de Visser (CSM Suiker, Holland); "Kontinuierliche Züchtung von Starterkulturen zur heissen Silierung von Press-Schnittzeln", by F. Hollaus and G. Pollach (Fuchsenbigl, Austria); "Halbautomatische Aschenbestimmung", by J. Dobrzycki and M. Ludwicki (Lodz Technical University, Poland); "Détermination des anions inorganiques et des cations monovalents dans l'industrie sucrière à l'aide de chromatographie d'ions", by R. Waegeneers (Raffinerie Tirlémontoise, Belgium); "Analyse des jus de sucrerie par chromatographie d'ions — Possibilités et projets futurs", by J. Degeest (Raffinerie Tirlémontoise, Belgium); "Recent progress in white sugar colour studies", by N. W. Broughton, J. V. Dutton, B. J. Houghton and A. Sissons (British Sugar plc, UK); "Ueber die Umwandlungen der Farbstoffkomponenten im Zuckerhaus", by E. Bara-Anyos and K. Vukov (Budapest, Hungary); "Utilisation d'une électrode

pour doser le gaz carbonique dans les produits de sucrerie", by J. P. Lescure and J. P. Ducatillon (IRIS, France); "Tyrosinase- und Invertaseaktivitäten in Zuckersäften", by K. Buchholz (Braunschweig, Germany); "Versuche zur verbesserten Erfassung von Extraktionsverlusten", by G. Pollach and W. Hein (Fuchsenbigl, Austria); "Die Alkalität des Dünnsaftes und ihre Veränderung im Laufe der Verdampfung und Kristallisation", by E. Gryllus and K. Hangyal (Hungary); "Teilweiser Anionenaustausch im Dünnsaft", by C. A. Accorsi (Ferrara) and F. Zama (SADAM, Italy); "Incrustation above the liquid level in sucrose crystallizers", by A. Pot and L. H. de Nie (Suiker Unie, Holland); "Face by face kinetics and habit modification of sucrose crystals in the presence of raffinose", by G. Vaccari, G. Sgualdino and G. Mantovani (University of Ferrara) and D. Aquilano and M. Rubbo (University of Turin, Italy); "Zur Agglomeratbildung der Saccharose", by D. Schliephake (Braunschweig, Germany); "Zum Betrieb des Verdampfungskristallisationsturms", by K. E. Austmeyer (Braunschweig, Germany); "Premiers résultats sur l'épauement des masses cuites de bas produit obtenus par des mesures cinétiques de la cristallisation du saccharose", by V. Maurandi and A. Rossi (Eridania) and G. Mantovani and G. Vaccari (University of Ferrara, Italy); "L'application de la simulation numérique de la cuisson à la

conception du processus et de la régulation des appareils à cuire", by P. Bonnenfant (GTS, France); "Cost of kWh generated in a sugar factory, taking into account the exergy efficiency", by P. Christodoulou (Hellenic Sugar Industry, Greece); "L'utilisation systématique de l'électricité du réseau dans l'industrie sucrière", by J. C. Giorgi (IRIS, France); and "Existence d'une couche protectrice d'oxyde de chrome sur les tubes d'évaporation en acier ferritique", by F. Heitz (GTS, France).

Meetings were also held of the Sub-Committees on crystallization and on colour. The Sub-Committee on measurements and process control met in Malmö, Sweden, on June 11.

The Hungarian sugar industry kindly invited the participants to a dinner, where they were welcomed by Professor Dr. I. Toth-Zsiga, General Secretary of the Confederation of the Food Industry. The Committee members and their colleagues also visited the sugar factory at Petohaza where they were able to observe the efforts made in the past decade by the Hungarian sugar industry to modernize its equipment.

At the administrative meeting of the Scientific Committee, the members were informed about the preparative work which is being done in connexion with the next General Assembly of the CITS, to be held in Ferrara, Italy, during June 8-12, 1987.

## Brevities

### Paraguay distillery<sup>1</sup>

A distillery is to be erected near Concepción in the north of Paraguay, financed by the B.I.R.D. and built by Brazilian technicians at a cost of 110 million guaraní (\$500,000). It will produce 5000 litres/day from sugar cane and 2500 litres/day from manioc, giving a total production of 1,300,000 litres a year.

### Costa Rica distillery<sup>2</sup>

A distillery at a sugar factory started producing fuel alcohol in January and has a capacity of about 240,000 litres/day. It uses blackstrap molasses as raw material.

### Biogas plant for Indian distilleries<sup>3</sup>

The Indian government is supporting, by provision of up to 33% of the capital cost, installation of bio-gas plants for treatment of vinasse from distilleries and sugar factories-cum-distilleries, up to a maximum of 2.5 million rupees. Installation of two such plants has been supported at Ankaleshwar in Gujerat state and at the Pravara S.S.K. Ltd. in Pravaranaagar, Maharashtra state. Technico-economic feasibility studies are being made at a number of other distilleries.

<sup>1</sup> *Amerop-Westway Newsletter*, 1985, (139), 24.

<sup>2</sup> *Sugar y Azúcar*, 1985, **80**, (5), 10.

<sup>3</sup> *Sugar Scene*, 1985, **3**, (5), 18.



# Copersucar international symposium on sugar and alcohol

Nearly 500 people, including 175 from other countries, gathered in Brazil during June 24-27 to participate in the first international symposium on sugar and alcohol organized by Copersucar, the Central Cooperative of Sugar and Alcohol Producers of the State of São Paulo. The program was almost completely in accordance with that planned and described in our May 1985 issue, and provided an opportunity for statement and argument, for expression and assessment of opinions.

In general these seemed to be rather gloomy as far as sugar is concerned, with few expecting any improvement in near-term prospects, although the outlook for expansion in alcohol manufacture from sugar crops, especially cane, seemed to be brighter, provided oil interests do not bring

pressure on politicians to inhibit the replacement of gasoline by alcohol. The opening of additional outlets for cane alcohol arises from the sensitivity of governments to environmental issues and the resultant move to eliminate lead; however, the World Bank's studies had identified only 12-20 countries where alcohol manufacture was economical and even in some of these, benefits would be marginal.

Certainly, much of the troubles affecting the sugar industry was considered to stem from the protectionism practised not only by the developed countries (USA, the EEC, Japan, etc.) but also by developing nations whose high-cost sugar industries are supported by import levies or restrictions which result in artificially restricted consumption growth.

The growing threat from the new synthetic, non-caloric sweeteners was thought mainly to be to the corn-based high fructose syrups and the latter were thought to have almost peaked in respect of sugar substitution, although they could serve as a feedstock for alcohol manufacture and so take part of the potential outlet for cane and beet.

A thorough account of the Brazilian experience with alcohol manufacture from cane and molasses was presented by a number of speakers and will have provided the audience with considerable food for thought as to the possibility of emulation in their own countries. Copersucar are to be congratulated on the excellent arrangements for the symposium and the subsequent visit to their Technical Centre in Piracicaba on June 28.

## Brevities and statistics

### Zimbabwe sugar exports, 1984<sup>1</sup>

	1984	1983	1982
	— tonnes, raw value —		
Algeria	0	44,690	55,949
Botswana	37,430	37,038	32,074
Burundi	0	1,054	0
Canada	40,277	30,576	0
EEC	24,858	38,614	20,402
Morocco	15,815	0	0
Mozambique	0	8,473	0
Portugal	36,060	29,138	24,777
USA	13,926	32,397	94,092
USSR	14,972	0	0
Zaire	0	1,054	0
Unknown	0	2,982	1,215
	183,338	226,016	228,509

### Cane alcohol in US<sup>2</sup>

Gulf Star Fuels are to open a new alcohol distillery at Belle Chasse, a district of New Orleans, on the site of the former Red Star yeast plant. The distillery, to open in September, will produce 3.5 million US gallons a year from sugar cane, for blending with gasoline. American Fuel Technologies Inc. are to change from corn to a molasses feedstock for their alcohol plant at Federalsburg, Maryland.

### US Commodity Credit Corporation sugar sales

On June 11, the US Department of Agriculture announced its sales policy for refined beet sugar owned by the Commodity Credit Corporation, setting the minimum sales price at 105% of the

current price support loan rate plus reasonable carrying charges. The sales would be made in quantities and at prices which will not be disruptive to the market. The CCC has acquired 28,337 short tons of sugar from Great Western Sugar Company in August 1985, forfeited on non-payment of loans, bringing the total acquired to 136,800 short tons.

### Bagasse paper factory in India<sup>3</sup>

The Sangamner cooperative sugar factory in Ahmednagar district, Maharashtra state, is setting up a paper factory at a cost of 90 million rupees with a daily production capacity of 25 tonnes of white paper, using bagasse as raw material. Its capacity is to be doubled in its second year.

### New UK sugar beet contract

British Sugar plc and the National Farmers' Union have announced jointly the terms of the 1985/86 beet contract. Prices are for beet at 16% sugar content. The basic contract will follow the same pattern as for 1984/85, i.e. a uniform price and quantity to cover all quota production, plus a quantity of C-sugar with a fall-back price should production not exceed the total A- plus B-quota of 1,144,000 tonnes, including 50,000 tonnes carried over from 1984/85. This fall-back price is £27 per tonne, while a uniform price of £26.60 per tonne will apply for total production up to 1.2 million tonnes, including the first 56,000 tonnes of C-sugar carried over to 1986/87. For production up to 1.24 million tonnes a uniform price of £26 per tonne will apply. The agreement reflects the very competitive nature of the sugar and animal feeds market in the UK.

### China sugar production, 1984/85<sup>4</sup>

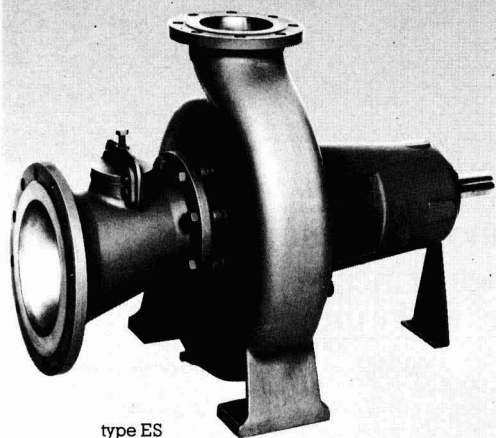
Sugar production in the 1984/85 crop reached a record total of 4,250,000 tonnes, white value, up more than 700,000 tonnes from the year before. Sugar output in Guangdong, Yunnan, Gansu and Shanxi provinces and the Guangxi, Inner Mongolia, Xinjiang and Ningxia autonomous regions hit an all-time high in 1984/85. Cane sugar production in southern China was 760,000 tonnes up from the year before. However, production of beet sugar in Heilongjiang and Jilin, China's major beet sugar producers, dropped by 8.5% owing to adverse weather conditions.

### US sugar fraud<sup>5</sup>

14 individuals and 13 companies have been indicted on charges of illegally diverting more than 44,000 short tons of foreign sugar onto the domestic market. The rules of the US Department of Agriculture are alleged to have been violated in respect of the sugar re-export program whereby sugar imported free of import quotas must be refined and re-exported within 90 days. By making false claims to the US Customs authorities, it is alleged that the defendants concealed the fact that the sugar had not been exported and sold it on the US market where the price is more than 21 cents a pound against a world price of less than a quarter of this.

- 1 *I.S.O. Stat. Bull.*, 1985, 44, (3), 50.
- 2 *Amerop-Westway Newsletter*, 1985, (139), 25.
- 3 *Sugar Scene*, 1985, 3, (5), 17.
- 4 F. O. Licht, *International Sugar Rpt.*, 1985, 117, 389.
- 5 *Reuter Sugar Newsletter*, June 24, 1985.

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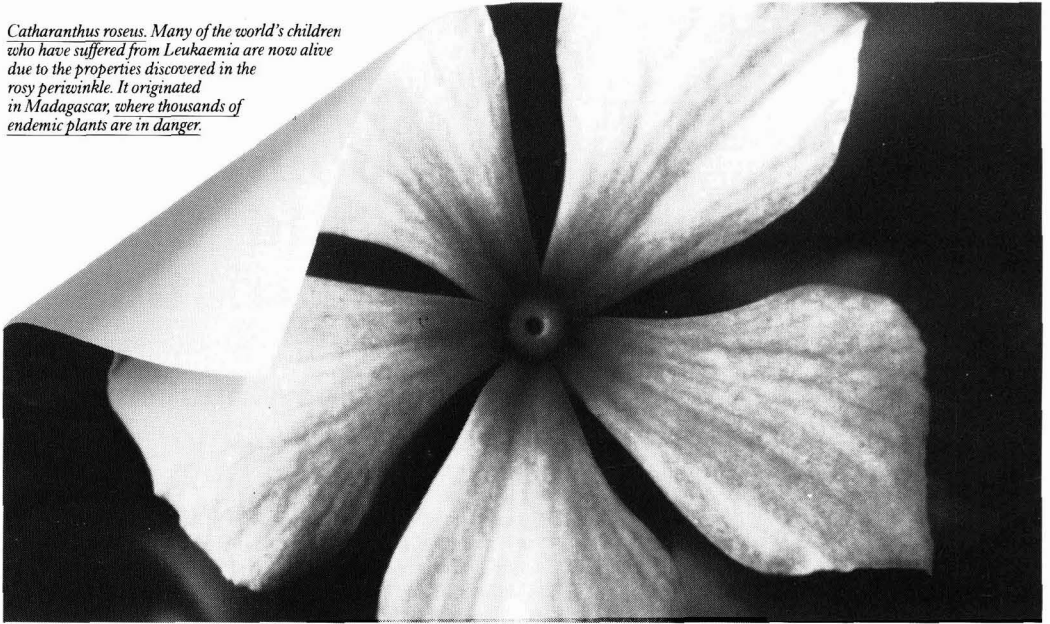
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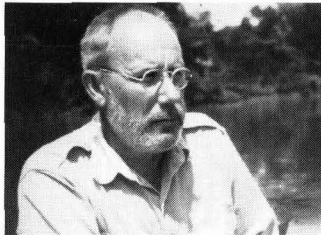


Photo: Courtesy of Richard Evans Schultes

*Dr. Richard Evans Schultes, director of the Botanical Museum at Harvard University, has spent 13 years in the Amazon jungle collecting the 'magic' plants of myth and legend and making them available to Western medicine and science. "The drugs of the future," he says, grow in the primeval jungle."*

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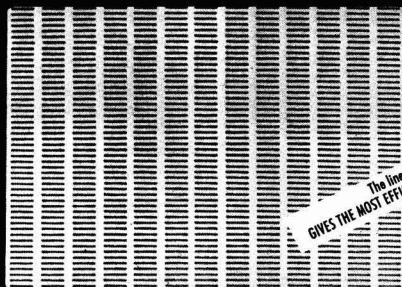
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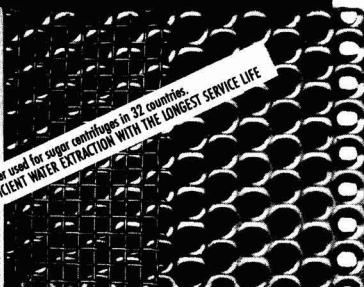
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## Index to Advertisers

BMA Braunschweigische  
Maschinenbauanstalt AG ..... viii

Chemieanlagen Export-Import ..... i  
Cocksedge & Co. Ltd. .... iv

Fontaine & Co. GmbH ..... x

IPRO Industrieprojekt GmbH ..... xi

Dr. Wolfgang Kernchen GmbH ..... ii

Mazer Chemicals Inc. .... v

Pieralasis Nuova M.A.I.P. S.p.A. .... ix

SKF ..... vi, vii

Speichim ..... Cover IV

Sugar Manufacturers Supply Co. Ltd. .... Cover II

Sulzer Delta B.V. .... xiii

Western States Machine Co. .... xii

World Commodity Publishing Inc. .... xiii

World Wildlife Fund ..... xiv

Peter Zingg ..... xvi

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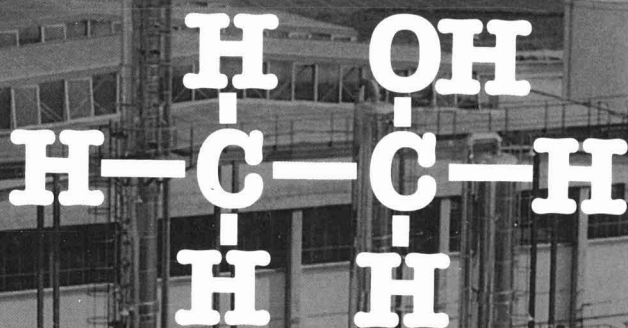
<b>GEOGRAPHY OF SUGAR CANE:</b> <i>Blume</i>	(1985)	£51.40
<b>WSJ DIRECTORY OF THE WORLD SUGAR INDUSTRY</b>	(1984)	£230.00
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<b>BEET SUGAR TECHNOLOGY (3rd ed.):</b> <i>McGinnis</i>	(1982)	£37.50
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<b>THE EFFICIENT USE OF STEAM:</b> <i>Ed. Goodall</i>	(1980)	£48.75
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<b>PHYSICS AND CHEMISTRY OF SUGAR BEET IN SUGAR MANUFACTURE:</b> <i>Vukov</i>	(1977)	£64.75
<b>SUGAR BEET NUTRITION:</b> <i>Draycott</i>	(1972)	£16.15
<b>HANDBOOK OF CANE SUGAR ENGINEERING:</b> <i>Hugot, transl. Jenkins</i>	(1972)	£143.80
<b>PROCEEDINGS 16th (1974) SESSION ICUMSA</b>	(1975)	£7.80
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<b>INTRODUCTION TO CANE SUGAR TECHNOLOGY:</b> <i>Jenkins</i>	(1966)	£52.20
<b>TECHNOLOGY FOR SUGAR REFINERY WORKERS (3rd ed.):</b> <i>Lyle</i>	(1957)	£18.95

## SUGAR BOOK DEPARTMENT

International Sugar Journal Ltd.

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