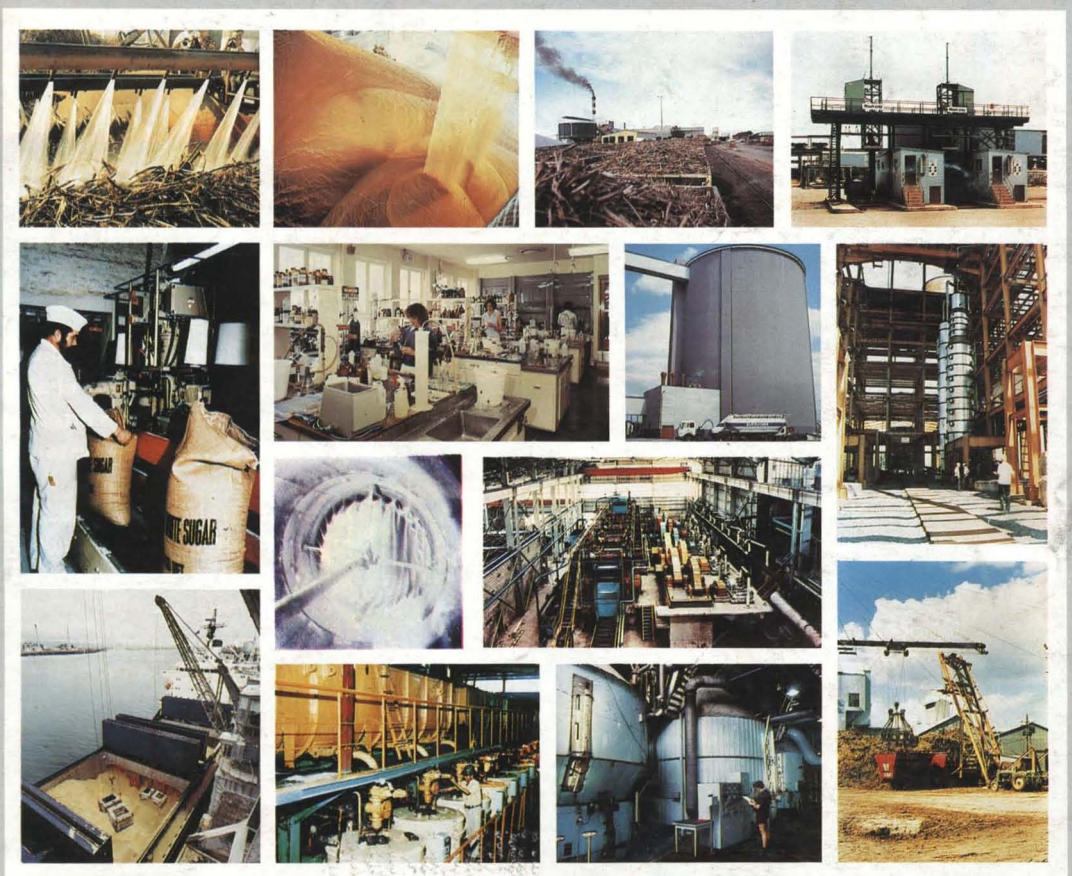
INTERNATIONAL SUGAR JOURNAL



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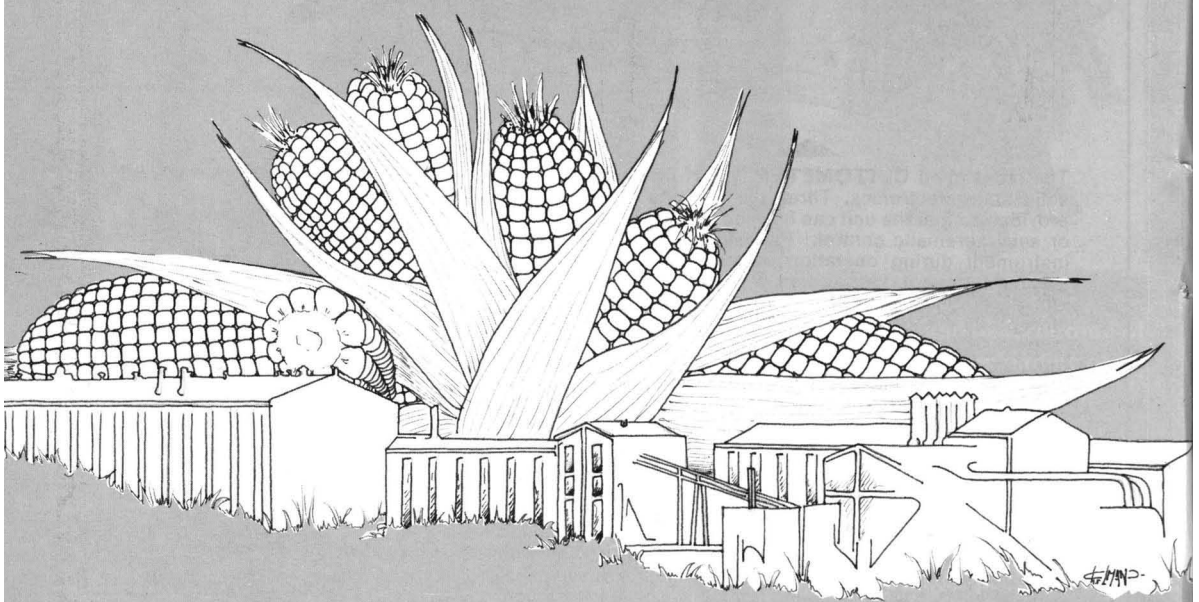

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News and views

ISJ Panel of Referees

Dr. Milo Matic, former Director of the SMRI in South Africa and a member of our Panel of Referees since 1972, has decided to retire from the Panel. On behalf of our readers we offer him our thanks for his contribution to maintaining the high standard of editorial quality and our best wishes for continued good health.

We are fortunate that his successor as Director of the Sugar Milling Research Institute, Dr. A. Bernard Ravnö, now General Manager of the Sezela sugar factory of C. G. Smith Sugar Ltd., has agreed to take Dr. Matic's place on the Panel. Dr. Ravnö is well known to our readers as a contributor to the International Society of Sugar Cane Technologists as well as to the South African Sugar Technologists Association of which he has been President since 1983/84. He has led the SMRI team during a period of both severe stringency and increasing sophistication in the sugar industry so that he brings a broad knowledge of modern cane sugar technology to the Panel. We applaud his generosity in giving his time to the scrutiny of contributions to this Journal.

Brazilian sugar and alcohol targets for 1987/88[1]

The Brazilian Sugar and Alcohol Institute has officially forecast 1987/88 sugar output at 7,922,000 tonnes, tel quel (approximately 8,300,000 tonnes, raw value) and alcohol production at 13,273 million litres[2]. Domestic sugar consumption is estimated at 6,767,000 tonnes (approximately 7,350,000 tonnes, raw value), which would be up 500,000 tonnes, raw value, from estimated consumption in 1986/87. However, sugar prices have been raised three times since December — by 23%, 39% and then 85% — and this could affect sugar consumption. Exportable production is estimated at 1.15 - 1.16 million tonnes, whereas Brazil has contracted to sell about 1.8 million tonnes in the 1987/88 crop year; this would leave a gap of 650,000 tonnes, unless sugar consumption is lower than expected.

Alcohol consumption is expected to be 13,157 million litres, 116 million litres below expected production. However, sales of new cars running on alcohol in Brazil are reported to have declined by 50% in March compared with a year earlier, and alcohol fuel prices have risen from 11.30 Cruzados per litre on April 14 to 19.00 Cruzados per litre on May 7, a rate higher than inflation, so that it is possible that consumption could be lower than estimated.

World sugar balance, 1986/87[3]

Even though there might be individual differences, totals of production on a world crop-year basis and for the years September 1 to August 31 (used by F. O. Licht to facilitate comparisons) tend not to differ too greatly. However, 1986/87 seems to be an exception as Brazilian sugar output during May/August 1986 was extremely low by comparison with earlier years. By contrast, production in September/November 1986 was significantly higher, boosting 1986/87 (September/August) production to 9.6 million tonnes against 8.5 million tonnes for the crop year figure of June/May 1986/87.

But the higher world production figure in Licht's third estimate of the world sugar balance is not only due to such technical factors but also to a reassessment of production prospects. Indian output has proved to be significantly higher than estimated earlier and is now expected to reach 9.2 million tonnes, up 1.6 million tonnes from 1985/86. Production in exporting countries has been reduced by more than 7 million tonnes between 1981/82 and 1985/86 while during the same period that in importing countries rose by 4.6 million tonnes. Even this is an understatement of the rising trend since it does not include the addition to sweetener supplies in the form of HFS production in the US and elsewhere. The US sugar program, with its curtailment of the US market for imports, has resulted in traditional suppliers becoming more dependent on the Soviet market to earn critically needed foreign exchange from sugar. The situation for such countries could become worse if the USSR, with a significant beet sugar industry of its own, should succeed in improving efficiency and the writing is clearly on the wall. In a spite of a 3.4% decline in the sugar beet crop in 1986, the Soviet sugar industry managed to produce significantly more beet white sugar than in the previous year, partly through higher sugar content but also by strengthening of the farm to factory transport system which limited losses. Rises in sweetener production in importing countries underlines that exporters have every reason to be concerned about the future of the world market.

The consumption estimate is unchanged from Licht's previous balance at 102.9 million tonnes, an increase of 2.5% over 1985/86. This results mainly from increases in Brazil, China, India, Pakistan and the USSR so that little is translated into import demand and trade is expected to fall roughly 5% to reach the lowest level since 1978/79. Licht concludes that final stocks will increase slightly over that at end-August 1986 and, although they represent a slight decline relative to consumption, this will probably not be sufficient to bring about any significant recovery in prices. Details of the estimates appear below.

	1986/87	1985/86
	tonnes, raw value	
Initial stocks	37,756,000	40,075,000
Production	103,890,000	98,727,000
Imports	27,211,000	28,577,000
	168,211,000	167,379,000
Consumption	102,920,000	100,396,000
Exports	27,837,000	29,227,000
Final stocks	38,100,000	37,756,000
" " % consumption	37.02	37.61

Record Indian sugar production forecast[4]

Indian sugar production in the current crop year, ending September, is expected to be a record 8.5 million

1 F. O. Licht, *Int. Sugar Rpt.*, 1986, **119**, 225 - 226, 242.
2 See *I.S.J.*, 1987, **89**, 102.
3 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 249 - 254.
4 *Reuter Sugar Newsletter*, June 1, 1987.

tonnes compared with last season's 7 million tonnes, according to S. L. Jain, Secretary-General of the Indian Sugar Mills Association. In the first seven months of the current season, i.e. up to the end of April, output reached 7.80 million tonnes against 6.59 million tonnes in the 1985/86 season. By May 15 the total had risen to 8.1 million tonnes. Jain predicted that India would overtake the Soviet Union and Brazil as the world largest sugar producer, but he did not forecast when this would occur.

The previous record output of 8.43 million tonnes in 1981/82 put India second only to the USSR but production then slid to little more than 5 million tonnes before recovering strongly over the past two years, largely thanks to incentives to growers. Higher domestic production has sharply reduced Indian sugar imports this year from the record 1.75 million tonnes in 1985/86 but Jain gave no estimate of the final quantity or value of imports in 1986/87.

Mexico sugar situation

Mexico will continue to be self-sufficient in the foreseeable future as the sugar industry improves the use of production capacity and efficiency, according to a USDA Attache report quoted by F. O. Licht GmbH[5]. According to private sources, the gap between sugar production costs and retail prices has been narrowed, as the government has cut subsidies to the sugar industry. At this time the government and private sector have 75% and 25%, respectively, of total sugar production capacity and the government plans to return an additional 25% to private companies. The transfer is hindered, however, by increased operation costs associated with excess workers, mainly in administrative positions, in the publicly-owned factories.

Sugar consumption in Mexico increased only slightly in 1986 compared with the 3.1% rate of previous years; this was due to accelerated domestic inflation (105%) and depressed real consumer income. For 1987 the government has projected an inflation rate of 80% and economic growth of 3% as long as sufficient external credits are available to promote overall investment. Sugar consumption is expected to remain steady.

The government will continue to reduce subsidies by closing small inefficient factories, increasing sugar prices at all levels and interest rates for credit to cane growers. In the 1986/87 crop year Azúcar S.A. closed two small factories (La Libertad in Vera Cruz and Nueva Zelandia in Tabasco), and a special program is to be launched to modernize and improve factory operations. The Sugar Cane Growers' Association has contemplated the possibility of buying some factories — basically, those that Azúcar S.A. would close — to prevent unemployment among its members, but, given the government's prevailing difficult economic conditions, it is not considered the association would receive sufficient resources to maintain operations.

Indonesia sugar shortfall[6]

There was a major change in the Indonesian sugar situation from the beginning of 1981. Stocks in the closing months of 1980 had fallen to very low levels and sugar was in short supply at retail outlets. The government then announced plans for the rehabilitation of 27 factories, almost all on islands other than Java, which were to be partly financed by the International Bank for Reconstruction and Development and other agencies.

To encourage cane farmers, prices were increased substantially, putting the return from cane roughly in line with that from rice. At the retail level, prices for sugar rose by about 70%, which naturally had a damping effect on consumption. Massive imports in 1981 and 1982 boosted stocks, which were gradually eroded in 1984 and 1985, though it should be mentioned that it is widely believed that, in addition to sugar imported into Indonesia through normal channels, there is a good deal of smuggling. The extent to which this may be true is impossible to gauge but certainly it would be difficult to control entry into a country consisting of so many islands.

Production has not been expanding to the extent which the authorities had hoped. Sugar and cane yield have both been disappointing and the rebuilding program has not reached its targets. As a consequence it was found necessary to have recourse to imports on a substantial scale in order to ensure that supplies remain adequate until deliveries from the 1987 campaign, which commenced in April, came on stream. The Indonesian authorities have announced that they have acquired a total of 160,000 tonnes of world market sugar. Recent reports from Indonesia have mentioned a renewed expansion in consumption. Even if the purchases bridged the gap until domestic supplies were available it would seem likely that further imports will be needed next year.

World sugar prices

Trading activity was light during May and, while there was some stimulation of the market with reports of sales by Venezuela and purchases by Peru and the USSR, the general trend was for prices to slide in the absence of major bullish factors. As a consequence, the London Daily Price for raw sugar fell from $182.50 on May 1 to $169.50 on May 29, while the corresponding white sugar price fell from $193.50 to $183.50. From the beginning of June sugar prices fluctuated but with a downward trend, perhaps as a result of growing realization that the hoped-for fall in stocks in 1987 was proving to be only slight. Chinese purchases from Australia and elsewhere caused a small improvement in the middle of the month but this was not sustained and the LDP finished the month at $171 per tonne and the LDP(W) at $181.

Guatemala distillery[7]

In March Guatemala inaugurated an alcohol plant with a capacity of 120,000 litres/day although production is initially limited to 70,000 litres/day, utilizing about 4000 tonnes of molasses per year. Production is for blending with gasoline on a 10% basis, but efforts will be made to achieve exports also.

5 F. O. Licht, *Int. Sugar Rpt.*, 1986, **119**, 208 - 209.
6 *Carnikow Sugar Review*, 1987, (1758), 26.
7 *Amerop-Westway Newsletter*, 1987, (162), 11.

Waste water treatment in sugar and related industries

Application of the Biothane USAB system

By A. J. M. L. Borghans, W. A. Enger, W. M. A. van Gils and R. J. Zoetemeyer
(Gist-brocades N.V., P.O. Box 1, 2600 MA Delft, Holland)

Introduction

Biothane is the registered trademark of a unique upflow anaerobic sludge blanket (UASB) process for purification of waste waters. This process was originally developed by the Dutch sugar company CSM but in 1984 Gist-brocades took over the know-how and marketing of the Biothane system.

During the past decade, the technology has been developed to commercial application[1-4] and by now more than 50 full-scale systems are in operation or under construction. Although CSM was motivated to develop the technology for its own use in the beet sugar industry, the versatility of the process for application to other food product waste waters quickly became evident. Today industrial-scale Biothane systems are utilized in treating soluble carbohydrate and protein type waste waters from the beet sugar, liquid sugar, potato, potato starch, wheat starch, alcohol distillation, candy-making, brewing, yeast production, molasses fermentation and cannery industries. Even chemical industry waste waters have been treated by the Biothane process. In addition, highly successful pilot-scale studies have shown the system's potential application to treatment of waste waters from corn wet milling, cheese, whey, other dairy industries and paper products industries.

Process description

The heart of the Biothane process is the specially-designed series of internal settlers which are incorporated directly into the top of the digester vessel as shown in Figure 1.

The baffle plate arrangement, when properly sized and spaced, allows effective degassing of the biomass (sludge) and encourages development of readily settling, granular sludge particles. Since this sludge can be retained in the digester vessel for relatively long periods of time (weeks) while the hydraulic retention time can be extremely short (hours), the digester vessel is of relatively low volume capacity and the entire system becomes very space-efficient.

An example of the sludge density profile which normally develops within the digester is shown in Figure 2. These data were obtained at three different times during the course of a pilot study on fructose waste water from a corn wet milling operation. The very sharp density discontinuity at a level of about 1/4 of the digester height separates the sludge bed (70 - 90 kg/m^3 density) from the overlying sludge blanket (10 - 30 kg/m^3 density). Near the top of the digester the solids concentration rapidly approaches zero.

It is the achievement of this type of remarkable sludge concentration profile which enables the process to function efficiently without the need to resort to the use of attachment media designed to restrain sludge in place physically. Since the biomass is not externally recirculated, it can develop within the range of conditions always most suitable for methanogenic bacteria and is not subject to shearing stresses or mechanical agitation. It is believed that this set of circumstances helps foster the evolution of the readily settling granular structure, a condition which, in turn, improves still further the sludge retention capability of the digester.

Waste water enters the digester from a series of inlet pipes at the bottom and immediately upon contact with the sludge bed, begins to have its biodegradable components converted to biogas (mainly methane and carbon dioxide). The sludge flocks with attached gas bubbles are buoyant enough to rise as a current upwards through the digester to the settler baffle plates. The degassed sludge enters the settler section at which point it can fall against the hydraulic flow. The downward-moving flow of digested sludge operates as a counter-current within the digester and serves to enhance the mixing process required for efficient bacterial contact with the incoming waste water.

The upward flow of water parallels that of the sludge around the baffle plates and into the settler. The cleaned water continues upwards through the settler, exiting over a weir into collection

1 Lettinga *et al.: Biotechn. Bioeng.*, 1980, **22**, 699 - 734.
2 Pette & Versprille: *Proc. 2nd Int. Symp. on Anaerobic Digestion*, 1981.
3 Pette *et al.: Proc. 35th Ind. Waste Conf.*, 1980.
4 Sax: *Paper presented to 56th Ann. WPCF Conf.*, 1983.

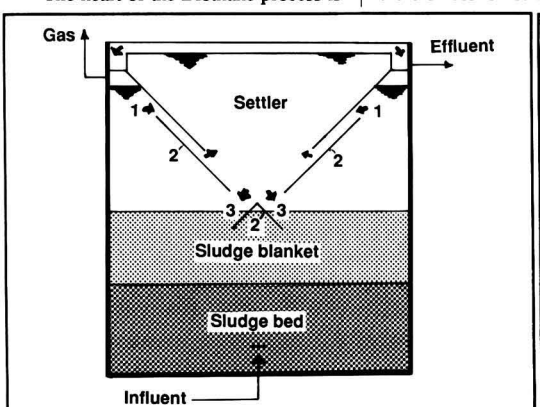

Fig. 1. Schematic drawing of a UASB reactor: (1) Sludge - liquid mixture inlet, (2) Gas screens, (3) Settled sludge return opening

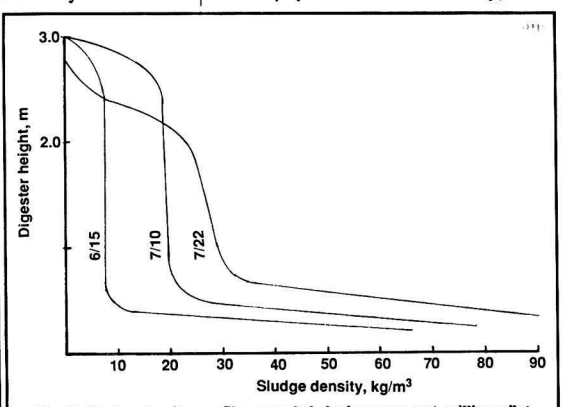

Fig. 2. Sludge density profiles sampled during corn wet milling pilot study

Table I. Biothane installations in sugar- and sugar-related industries

Factory	Capacity, tons COD/day	Digester volume, m^3
Beet sugar		
CSM, Halfweg, Holland	3	200
CSM, Halfweg, Holland	13	800
S.U., Groningen, Holland	20.7	1425
CSM, Breda, Holland	16.2	1300
Zuckerfabrik Brühl, Germany	18	1500
CSM, Vierverlaten, Holland	29	1700
S.U., Puttershoek, Holland	28	1800
Sugana, Enns, Austria	25	3040
Frankenzucker, Ochsenfurt, Germany	21.5	2300
S.U., Roosendaal, Holland	15	1200
Liquid sugar		
CSM, Breda, Holland	0.5	30
R.A. de Jong, Franeker, Holland	1.1	100
Beer fermentation		
Heileman, La Crosse, USA	66	4600
Anheuser-Busch, USA	0.1	6
Alcohol fermentation		
Nedalco Bergen-op-Zoom, Holland	11	700
Frankenzucker, Ochsenfurt, Germany	21.5	2300
Prachinburi, Thailand	45	3000
Chachoengsao, Thailand	45	3000
Burirum, Thailand	45	3000
Ubolratchathani, Thailand	45	3000
Khon-Kaen, Thailand	45	3000
Nongkhai, Thailand	45	3000
Chiengmai, Thailand	45	3000
Uttaradit, Thailand	45	3000
Nakornsawan, Thailand	45	3000
Karnchanaburi, Thailand	45	3000
Rajburi, Thailand	45	3000
Surajthani, Thailand	45	3000
South Point Ethanol, USA	19.7	2100
Yeast fermentation		
Anheuser Busch, USA	54	5000
Dixie Yeast, USA	15.9	1800

Table II. Average operational results from three Biothane plants in Holland

Factory	CSM, Halfweg	CSM, Breda	S.U., Groningen
Reactor volume, m^3	800	1300	1425
Hydraulic flow, m^3/hour	260	275	250
HRT, hour	3	4.8	5.7
Influent COD, ppm	2600	2400	4000
COD load, kg/m^3/day	18	12	16.5
COD reduction, %			
total	70	75	75
soluble	85	85	85
Gas production, m^3/hr	170	200	300.
Gas composition, % CH_4	82	82	76

troughs carrying it out of the digester vessel. The gas bubbles, once detached from the sludge, are trapped in pockets underneath the baffle plates and eventually are withdrawn once the build-up in pressure is sufficient to overcome a back-pressure intentionally induced to form and maintain the gas space.

It should be noted that the digester vessel contains no moving parts and is virtually maintenance-free and simple to operate. This also serves to make the process highly energy-efficient. Because the hydraulic retention time is so short, any instabilities which might tend to develop within the digester can be detected quickly and corrective action can be taken to prevent an upset condition. The system, therefore, is highly responsive to automated control.

The Biothane process utilizes bacteria which operate in the mesophilic temperature range, and the conversion of waste water biodgradables occurs most efficiently at temperatures of 32°C to 38°C. However, in many cases the system can be designed to accomodate waste waters at temperatures as low as 27°C without the need for routine addition of heat. As with all anaerobic systems the pH within the digester should be maintained in the range 6.7 to 7.8 for most efficient operation, but the release of carbon dioxide gas and the subsequent formation of carbonates normally aids in establishing sufficient buffering capacity to allow a tolerance to a lower incoming waste water pH.

During some pilot studies, it was possible to operate the system without chemical addition with a waste water pH as low as 5.8. The process is designed for the treatment of soluble biodegradables, and concentrations of suspended solids much in excess of the expected generation of new anaerobic sludge (usually about 5% of the COD load) should be removed or hydrolysed upstream of the system to achieve highest operating efficiencies within the digester. The need for nutrients in the form of nitrogen (N) and phosphorus (P) generally occurs in a ratio within the range of 350 (COD) : 5 (N) : 1 (P) to 800 (COD) : 5 (N) : 1 (P) depending upon the degree of pre-acidification of the waste water. As with anaerobic systems generally, it is also important that other mineral elements, such as iron, are present along with a supply of micronutrients.

Experience with sugar industry waste waters

The Biothane system was developed

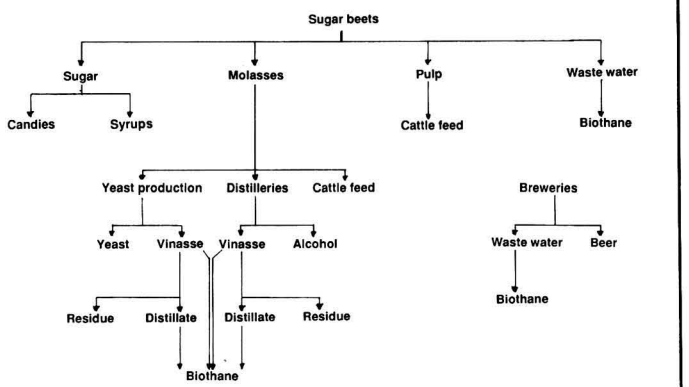

Fig. 3. Flow scheme of the various products in the beet sugar industry; in principle the scheme can also be used for the cane sugar industry

in the Dutch sugar industry and for this reason the Biothane organization has a lot of experience in treating waste waters from sugar- and sugar-related industries. There are already 30 full-scale Biothane plants operating or under construction to treat this type of waste water. A survey of these plants is given in Table I; although they all treat sugar- and sugar-related industry waste waters, there are some important differences in the various waste water characteristics, e.g. COD, BOD, salts etc, and analysis of production processes and waste water is necessary to sort out these typical characteristics and the applicability of the Biothane process as an anaerobic treatment of the various waste waters.

As shown in Figure 3 the main products in the beet sugar industry are sugar, pulp and molasses. Whereas pulp is often used as cattle feed the sugar and especially the molasses can be used as raw materials for various other industries. Apart from its use for consumption, the sugar is applicable in syrups and candy-production; the molasses is widely used in fermentation industries like yeast production and distilleries. Although molasses is not used in breweries the waste water is associated with other fermentation industries.

Even after consumption of the major part of the sugars by different fermentation processes, the waste (vinasses or distillery slop) is not suitable for disposal on land or in water; because of a highly developed cattle industry in Western Europe and especially in Holland it is sometimes feasible to concentrate the fermentation broth and use it as a cattle feed.

The Biothane system has been shown to be very suitable for treatment of the various water streams given in Figure 3. Even at high loadings e.g. 15 - 20 kg COD/m³/day over 90% BOD reduction can be achieved. Details of installations in some of the most important industries are given in Table I. Average operational results from the Biothane plants at CSM sugar factories at Halfweg and Breda, and Suiker Unie, Groningen, during the beet campaign of 1985 are given in Table II.

Design data and flow scheme of the 13 Biothane plants in Thailand treating distillery slops from sugar cane molasses are summarized in Table III.

Table III. Design data of 12 Biothane plants in Thailand

A. *Design parameters*

Digestive volume, m^3	3,000
Influent flow, m^3/day	450 (peak 600)
Internal recirculation flow, m^3/day	1,950
Hydraulic retention time, hr	30
Total COD load-capacity, kg/m^3/day	15
Approximate space requirement, m^2	120
Dilution flow, m^3/day	max. 1350

B. *Water purity*

	Influent		Effluent		Reduction,
	Concentration, ppm	Load, kg/day	Concentration, ppm	Load kg/day	%
Total COD	100,000	45,000	40,000	18,000	60
Soluble COD	80,000	36,000			
Suspended solids	14,000	6,300			
Suspended solids (as COD)	20,000	9,000			
Total BOD_5	35,000	15,750			80-90

C. *Gas production from anaerobic digester*

COD available, kg/day	45,000
COD converted, kg/day	29,000
Total gas flow, m^3/day	12,600
% Methane	70-85
Methane produced, m^3/day	9,450
Caloric value, kcal/day	80,797,500

Product news

BMA arc screens

Arc screens have been used in the sugar industry for some years, particularly for separation of bagacillo from cane juice and similar applications. BMA have now introduced their own screens which are available in five sizes from 850 to 2000 wide and with throughputs of 25 to 100 m^3/hr.

Further details:

Braunschweigische Maschinenbauanstalt AG,
P.O. Box 3225,
D-3300 Braunschweig,
Germany.

Carbon monoxide monitoring and control

The AK 2 CO meter operates by measuring the heat produced in the catalytic oxidation of CO to CO_2. The built-in diaphragm pump sucks in a constant measured air stream and forces it through the instrument. The air, freed from dust particles and interfering gases by passage through filters, is brought to constant temperature in a heater. If CO is present, there is a further increase in the oxidation temperature which is detected by a thermo-battery; this produces a thermo-electric voltage proportional to the CO concentration. The voltage is amplified and converted to D.C. which indicates the CO concentration in ppm. Four adjustable switching stages can be used to solve numerous control and warning tasks. The meter is housed in a splash-proof steel casing that can be fixed to a wall.

Further details:

Drägerwerk AG,
Postfach 1339,
D-2400 Lübeck 1,
Germany.

New literature from Tate & Lyle

Tate & Lyle Process Technology have produced a new series of leaflets about their Talo range of control systems and equipment, instrumentation, and decolorization and filtration processes. Copies are available from Tate & Lyle Process Technology, 55 Liddon Road, Bromley, Kent BR1 2SR, England.

New loadcell conversion service

Richard Simon and Sons has introduced a service to convert existing mechanical bagging weighers to electronic load cell operation with microprocessor control for improved performance and greater management information.

The company has offered a similar service for its own weighers to existing customers for some time but is now able to provide a cost-effective conversion kit for almost any type or make of mechanical weighing system by utilizing the proven technology of the UBM range of direct loadcell automatic nett and gross bagging weighers.

The service is designed to offer the full benefits of electronic operation, in terms of greater speed and accuracy with a comprehensive range of management and diagnostic information, without incurring the cost of purchasing a brand new weigher.

Further details:

Richard Simon & Sons,
Park Lane,
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Nottingham NG6 0DT, UK.

Liquid level alarm

The Series 521 control from Sensall offers the user two-wire simplicity with current loop operation and a unique self-diagnostic test capability. It includes no moving parts, requires no maintenance, and offers high reliability in problem liquids, while offering a new special feature — automatic self test which is a unique patented feature.

All Sensall point level sensors operate through the use of two piezoelectric crystals. Ultrasound passes through the gap between the crystals in a wet condition but will not cross the gap when no liquid is present. Self-testing is through the use of two additional crystals attached to the main sensing

crystals. Every ten seconds the self-test circuitry automatically connects these "self-test" crystals. The result is a simulation of what happens when there is a liquid in the gap.

The unit is checked on a periodic basis, testing the entire system from crystals through electronics and wiring in a simulated wet condition without immersing the sensor. If the device is not working properly, a signal is produced which can be separately discriminated or perceived like an actual alarm to prompt appropriate action.

The two-wire transmission capability allows for low installation cost, current system compatibility, and no AC field wiring. Solid-state design, low-power circuitry and explosion-proof housing assure high reliability, long life and the option of using the Series 521 in intrinsically safe or explosion-proof installations.

When used with the optimum sensor from Sensall's broad application-oriented line, the Series 521 can cope with virtually any liquid.

Further details:

Sensall,
250 Marcus Boulevard,
Hauppauge, NY 11788,
U.S.A.

Effects of frost on alcohol production from cane juice

By Franco A. Fogliata, Horacio G. Ayala, Enrique Moreno, Sonia Lopez and Carlos Torné
(INTA Famaillá and Universidad Nacional de Tucumán, Argentina)

Introduction

The production of alcohol from sugar cane to be used as a fuel in automobiles, has increased markedly in many sugar producing countries of the world, among them the Argentine Republic. As this sugar producing area is sub-tropical, frosts frequently affect the quality of the juice insofar as sugar production is concerned.

The present study has been made to learn the effect that frost will have on the quality of juice to be used for the production of alcohol, assessing this quality in terms of the quantity of alcohol obtained per tonne of cane.

Material and method

The study was carried out during the 1985 crop, after a severe frost that affected a particular area of Tucumán province in the month of July. Only one variety (NA 56-79) was used, with samples of similar age from three zones very well distingushed by the intensity of the frost: free of frost, mild frost (–3°C) and severe frost (of –6°C to –8°C).

The samples were collected weekly for analysis of the first expressed juice for Brix, pol, purity, reducing sugars, pH, titratable acidity (with N/10 NaOH) and dextran (by the Roberts technique[1]) as well as juice % cane, fibre % cane, bagasse % cane, non-fermentable reducing sugars, etc.

Once the must had been fermented with the addition of 10 g of yeast per litre of juice, its pH and acidity were determined, as were the refractometric index, density and the alcohol % produced by volume at 15.5°C. The theoretical alcohol was obtained by multiplying the total reducing sugars % cane by the Gay-Lussac factor (0.6475).

The weight of CO_2 produced during the fermentation was used as an indirect measure of the alcohol production and, in addition, the development of the micro-organism population present in the normal juice and the juice deteriorated by frosts.

Results and discussion

Data obtained for juice from frozen and unfrozen canes were assembled and analysed to provide relationships illustrated by Figures below.

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Effects of acidity in must and fermented must

Both pH and total acidity of the must showed a good statistical association with the pH and acidity of fermented must. This tendency indicates that the volatile acids and non-volatile acids produced in the juice deteriorated by frost go forward to the fermented must and afterwards to the alcohol during distillation since the acidity of that alcohol correlates well with the acidity of the must and fermented must (See Figures 1 to 3).

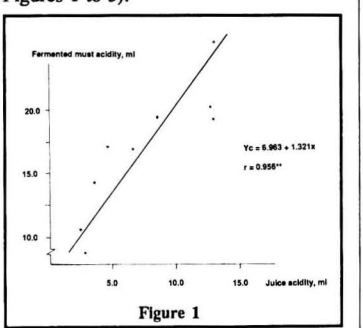


Figure 1

Friloux *et al.* reported[2] that after severe frost the deterioration of the sugar cane produced a remarkable increase of the acetic acid and lactic acid content of the juice extracted.

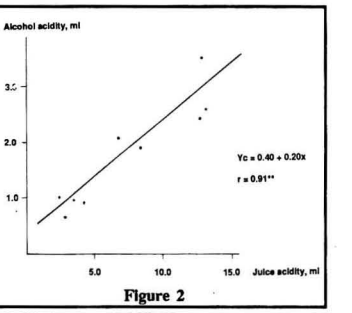


Figure 2

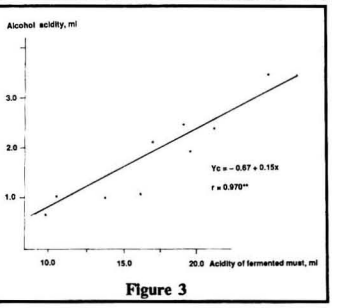


Figure 3

CO_2 production according to the acidity

The CO_2 production that resulted from the must fermentation was taken as an indirect indicator of alcohol production because it is a reliable technique which has been used for many years.

It was found that an antagonistic relationship existed between the acidity of the must and the weight of CO_2 produced during the fermentation. (Figure 4).

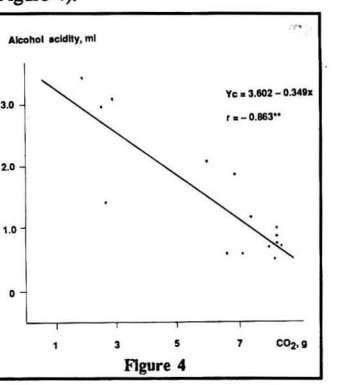


Figure 4

1 *Tech. Rpt.* (Sugar Processing Research Inc., USA), 1981, (1), 9 pp.
2 *Sugar y Azúcar*, 1965, **60**, (1), 43 - 46.

When the juices and deteriorated must contained more acidity, less alcohol is produced and the lower is the final rendement of the fermented must (Figure 5). The results were obtained with samples of cane and of juice that did not withstand storage, that is to say, began to deteriorate within a few hours of cutting.

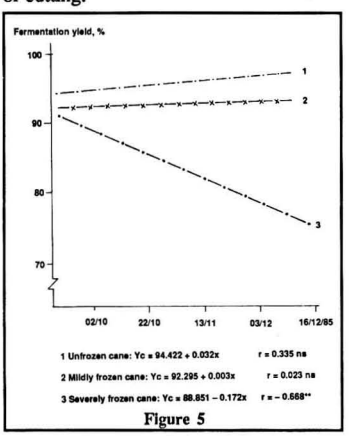


Figure 5

The increase of the acidity is a direct consequence of the destruction of the sugars with time at high temperatures and humidity in the field; as deterioration accelerates less fermentable sugars remains in the plant.

The non-fermentable sugars and acidity

Among the non-fermentable reducing sugars are many carbohydrates such as dextran (a polymer of glucose) and also combinations of aminoacids with reducing sugars, the result of microbial action under the conditions of juice deterioration.

Increase in non-fermentable reducing sugars is directly related to the acidity in the fermented must and to the acidity in the alcohol (Figure 6). Of these non-fermentables it is probable that dextran is the major component because of the large quantities found in juice deteriorated by frost. This is reflected in the strongly negative correlation between dextran and litres of alcohol per tonne of cane that can be observed in Figure 11.

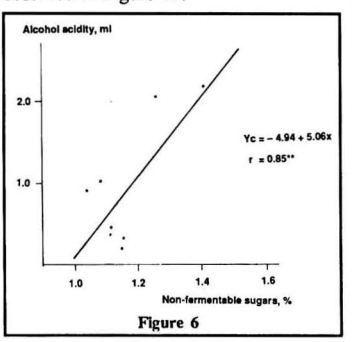


Figure 6

Alcohol production related to acidity

Figure 7 indicates the negative relationship between the values of acidity in the must and the production of alcohol as a proportion of the theoretical potential yield.

The theoretical amount of alcohol is directly calculated from the total reducing sugars in the plant (Figure 8) and everything that affects this content will be a negative and highly significant influence, making it evident that when the frost causes marked deterioration of the juice, especially in the warm and wet months that follow the winter, the obtainable alcohol per tonne of cane diminishes. This is important because it will help to define the period of the season to mill cane for alcohol in years of constant frost, to avoid damage to the economy of the distillery.

The values of acidity related to the refractometric index of alcohol

The refractometric index of an aqueous alcohol solution is an indirect measure of its density from which is

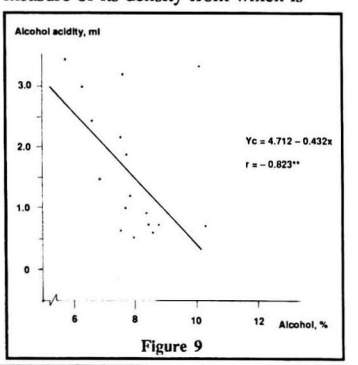


Figure 9

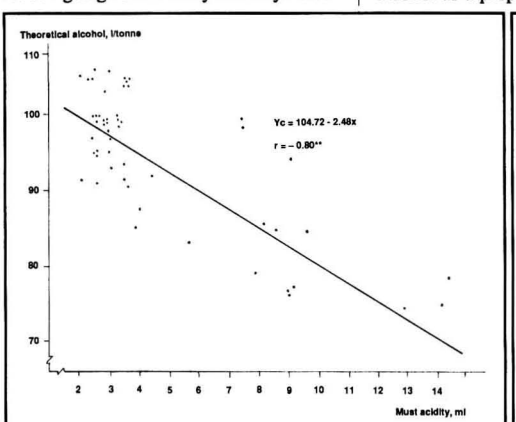


Figure 7

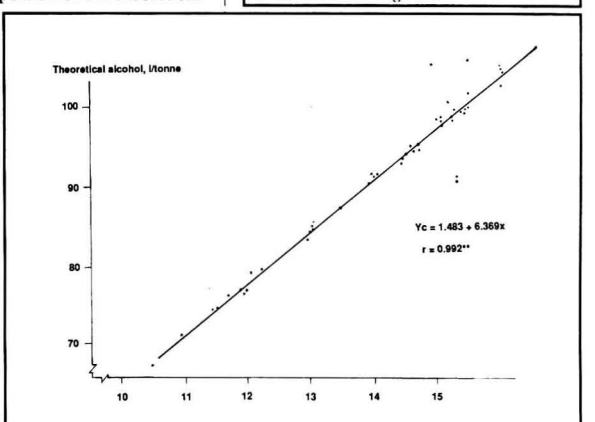
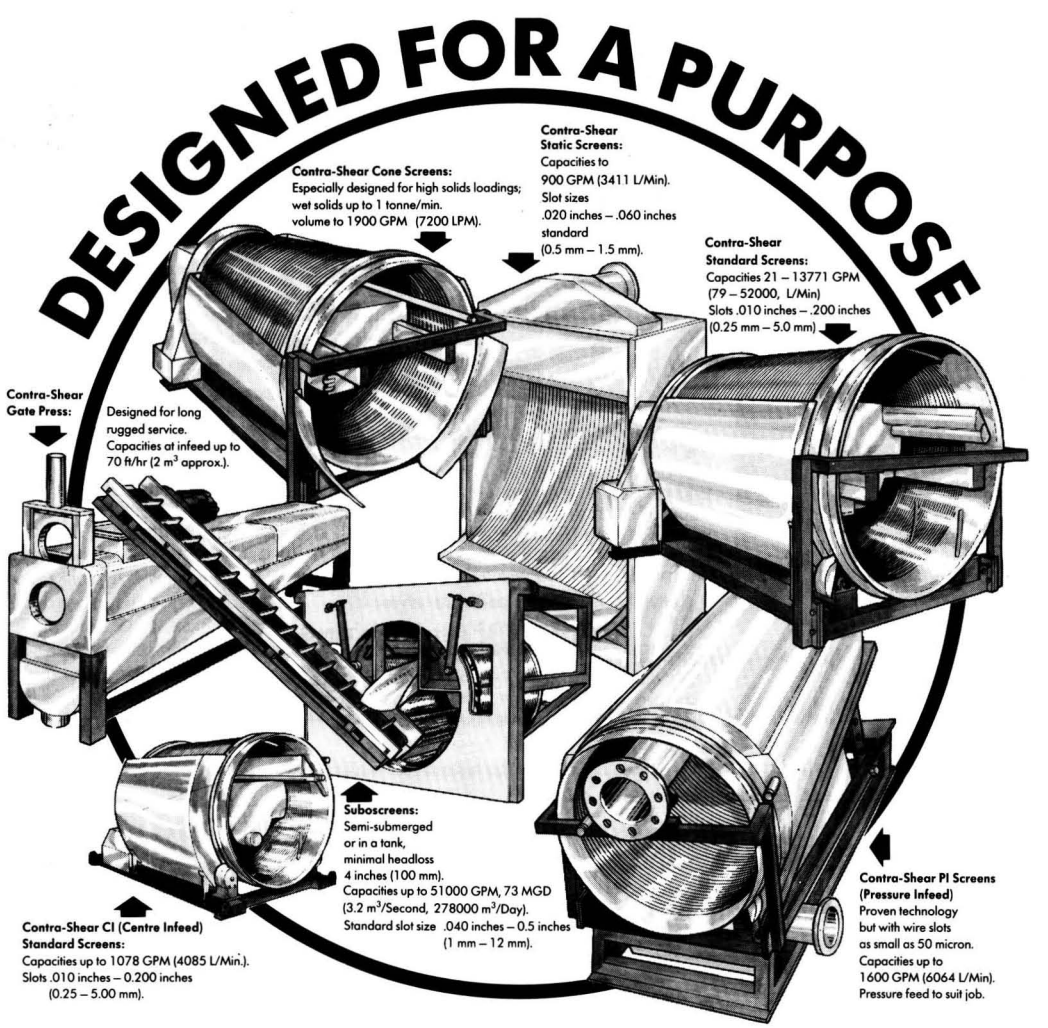


Figure 8



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obtained the alcohol content by volume. Figure 9 shows that there exists an highly significant inverse relationship between acidity in the fermented alcohol and the % of alcohol by volume. Poor juice and must quality, that affect the processes of fermentation and distillation, are also reflected in the final production of alcohol. In the same way, when the pH of the fermented must increases from 3.6 to 4.5 there is a notable increase of the alcohol content by volume. This quantitative evaluation of the alcohol present based on the refractive index is a good guide to what can be expected on an industrial scale.

In Figure 10 is presented the positive statistical relationship between weight of CO_2 produced in the fermentation and the % alcohol by volume obtained.

The non-fermentable reducing sugars and the production of theoretical alcohol

It has been shown above that the non-fermentable reducing sugars were directly linked to high values of acidity in fermented must and alcohol. It is logical to expect that an increase in non-fermentable sugars would be directly linked to high values of acidity in the fermented must and alcohol. At the same time, increases in non-fermentable sugars and dextran have a high negative correlation with alcohol yield as a proportion of the theoretical maximum (Figure 11). As these parameters are increased the alcohol yield is diminished. Decrease in the sugar available for the fermentation reduces the scope of action of the yeast to optimize the process of fermentation.

Conclusions and summary

The damage done by frost to the quality of the cane juice and to sugar production is well known to the Argentine sugar industry[3,4]. Up to now, however, the effect that frost can have on the quantity and quality of alcohol, as a consequence of the notable alteration that occurs in the quality of the must originating from juices deteriorated by the frost, was unknown.

In this work has been summed up the information collected during the 1985 season from samples of cane of the same variety and age collected from zones of Tucumán province which were clearly differentiated by the intensity and duration of the frost of that year. The division of the zone was done on the basis of temperature records, where Santa Lucía did not suffer frost, Famaillá was only mildly affected by frost down to –3°C and Monteagudo was severely affected with temperatures down to –8°C.

Samples of the variety NA 56-79 were collected weekly from August to December, i.e. from a month after the frosts of July. Besides analysing the chemical variables of the juice and of the cane, production and quality of alcohol were analysed, from both the aspect of fermentation and that of its distillation under laboratory conditions.

Highly significant statistical associations have been found among the components of juice and must from deteriorated cane with those parameters that affect the quality and quantity of the aqueous alcohol mixture produced (the phlegm). The values of pH and acidity in juice, fermented must and alcohol as well as the non-fermentable dextran and weight of CO_2 produced, have a close relationship with the alcohol produced whether as a proportion of the theoretical maximum or in terms of % of alcohol by volume as measured by refractometric index.

When the juice deterioration is more evident, its components have a negative effect on the quantity and quality of alcohol because of the high level of total acidity content.

3 Fogliata: *Rev. Ind. Agríc. Tucumán*, 1966, **44**, (2/3), 35 - 64.

4 Fogliata *et al.*: *Est. Exp. Agríc. Tucumán. Misc.*, 1977, (61), 43 pp.

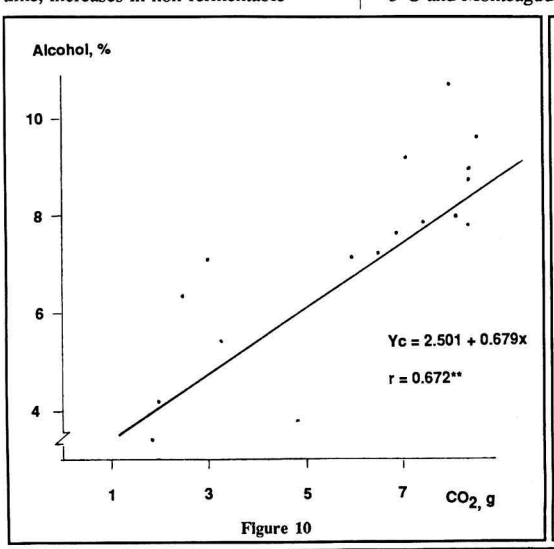

Figure 10

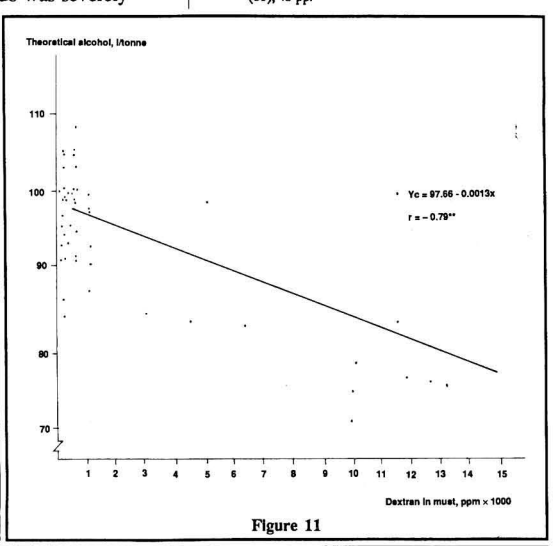

Figure 11

Treatment of distillery waste water

By Fayza A. Nasr and Samira S. Nawar
(Water Pollution Control Laboratory, National Research Centre, Dokki, Cairo, Egypt)

Introduction

At a large distillery/sugar factory at Hawamdia near Cairo, the water discharged causes severe pollution problems for the receiving waters.

The factory concerned produces ethanol from molasses by aerobic fermentation using a special yeast. The waste water produced is a brown dark liquor characterized by its extremely high dissolved organic content, which is of the order of 80,000 mg/litre, expressed in terms of COD (chemical oxygen demand). The factory discharges its waste water into the river Nile at a rate of 100 m^3/hr.

To solve this environmental problem an experimental program has been developed using biological treatment methods. It has been recognized that biological removal of high organic content from waste water is more economically realised in anaerobic biological systems[1,2]. These systems are attractive as a means of recovering energy in the form of methane gas while at the same time reducing the pollution load of the waste water. Additionally, as the cell yield in anaerobic systems is considerably lower than that in aerobic systems, the costs of sludge disposal are greatly reduced[3].

The anaerobic-aerobic methane process is one of the modern techniques which depend upon an anaerobic digestion with the evolution of methane-rich biogas followed by an aerobic treatment[4,5]. This process is claimed to remove over 99% of the BOD[6,7] and about 80-90% is released as biogas[8].

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The main objective of the present study was to evaluate the efficiency of anaerobic-aerobic biological treatment followed by chemical coagulation for the treatment of distillery waste water, to permit its reuse in the factory or its safe discharge into the Nile.

Material and method

Anaerobic treatment was conducted in a 3.7-litres continuous up-flow anaerobic reactor (Figure 1). The reactor was operated continuously at four organic loads (3.2, 5.3, 8.6 and 12.8 kg COD per m^3 per day) at a constant retention time of 22 hr. The system was operated at room temperature of 25 ± 3°C. The reactor was seeded with activated sludge collected from the municipal waste water treatment plant. Prior to seeding, the sludge was acclimated to the distillery waste.

The volume and composition of the biogas produced were recorded during the digestion. The methane content of the biogas was analysed by gas chromatography using a Varian 2400 instrument with a flame ionization detector. Gas chromatographic conditions were:

Column:	Stainless steel, 1.83 m long, 3.2 mm i.d.
Packing:	Chromosorb W 80/100
Flow rates:	Nitrogen 20, hydrogen 20 and air 300 ml per minute.
Temperatures:	Detector 150°C, injection 150°C, column 55°C
Carrier gas:	Nitrogen

The aerobic treatment process was carried out on the different anaerobic effluents, using a continuous activated sludge reactor of 13 litres capacity (Figure 1).

The activated sludge was acclimated on the effluents for about 2 weeks and its weight was regulated at about 3 g/litre. The aeration rate was adjusted to maintain a minimum dissolved oxygen of at least 2 mg O_2/litre. The retention period was 30 hours.

Chemical coagulation was carried

1 Frostell: *Chem. & Ind.*, April 1981, 465 - 469.
2 Lettinga: *Paper presented to Int. Sympos. Anaerobic Digestion* (Cardiff), 1979.
3 Kroeker: *JWPCF*, 1979, **51**, 718.
4 Huss: *Sugar J.*, 1979, **41**, (8), 9 - 11.
5 Ellis: *Eff. & Water Treat. J.*, 1979, **19**, (7), 356.
6 Fordyce: *Paper presented to Gen. Meeting, Amer. Soc. Sugar Beet Tech.*, Feb. 1981.
7 Young *et al.*: *JWPCF*, 1969, **41**, 160.
8 Donovan "An energy plus for waste water treatment" (U.S. Dept. of Energy), 1981, 179 - 198.

Table I. Experimental results of anaerobic-aerobic treatment of distillery waste water

		Organic load 3.2 kg COD/m^3/day					
		Effluent (1)			Effluent (2)		
Characteristics	Feed	Min.	Max.	Ave.	Min.	Max.	Ave.
pH	6.5	5.7	6.3	5.9	7.5	8.2	8.0
COD, mg O_2/litre	3000	450	690	465	25	69	42.4
% Removal		77	85	82	90	95	93
BOD, mg O_2/litre	1050	147	231	185	6.7	25	16.7
% Removal		78	86	82	89	96	93.6
T.R., 105°C, mg/litre	2955	951	1124	1010	638	675	651
VOM, 550°C, mg/litre	2283	319	479	376	13.6	43	21.7
% Removal		79	86	83	91	98	94.6
Ammonia, mg N/litre	15.6	21	29	25	17	19	18.3
Total organic nitrogen, mg N/litre	35.6	19	28	24	14.8	23.4	18.6
Phosphorus, mg P/litre	2.9	2.7	2.8	2.8	1.9	2.2	2.1
Gas produced							
Litres/kg COD removed		790	820	800			
Methane, %		61	65	62			

ISJ Abstracts

Cane sugar manufacture

Recent innovations in milling technology for reduction of losses

T. T. Oommen and R. Choda. *Sugar Scene*, 1986, **4**, (9), 12 - 14.

The effect of imbibition on sugar recovery is discussed and developments in cane milling that have contributed to reduced losses are described together with the results achieved. The measures adopted include use of two sets of knives plus a shredder to improve cane preparation, mill roller surface treatment by arcing, and improvement in imbibition.

A mathematical model for sugar extraction from sugar cane

V. P. Plyutto, Vu Min Fyung and Le Suan Khai. *Izv. Vuzov, Pishch. Tekh.*, 1986, (4), 60 - 63 *(Russian)*.

A mathematical model of cane milling has been developed which incorporates 40 variables and assumes that all the juice remaining in the bagasse is diluted by hot imbibition water. While excellent agreement was obtained between calculated sugar losses as a function of the quantity of imbibition water added per unit weight of cane and experimental values obtained at Hashonbin factory in Vietnam, use of the model proved very laborious and experimental simulation was used in which a simplified model was based on milling of the cane by the 3rd and 4th mills only in a 4-mill tandem. Statistical comparison of the original and simplified model showed that the latter was of adequate fit.

Ash balance for pan boiling system

C. H. Chen and H. C. Tseng. *Taiwan Sugar*, 1986, **33**, (4), 24 - 26.

See *I.S.J.*, 1987, **89**, 57A.

Sixty first annual review of the milling season in Southern Africa (1985 - 1986)

J. P. Lamusse. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 9 - 29.

A survey is presented with tabulated data of factory performances in Malawi, South Africa, Swaziland and Zimbabwe. At an average throughput of 253 tch, the average milling extraction in South African factories was 97.47%, with only two factories reporting values of <97% (but still exceeding 96%); on the other hand, boiling house recovery at 87.51% was the second lowest recorded since 1975 and was attributed mainly to lower juice purities.

The use of a "wide-gap" plate heat exchanger on mixed juice heating

A. F. Currie. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 37 - 39.

The AM20-TFM Alfa-Laval wide-gap unit installed at Union Cooperative Ltd. for primary heating of mixed juice contains 65 plates having a conventional herring-bone pattern; the gap on the juice side varies from 6 to 16 mm while the plates are in contact with one another on the steam side. Juice is passed four times through the heater and steam only once; flow is normally counter-current. Because of the gap, the juice working pressure must be higher than that of the steam so as to support the plates and prevent deformation and cracking or leaking. The heat transfer coefficient achieved was more than double that obtainable in a shell-and-tube heater, with an average pressure drop of only 50 kPa. Chemical cleaning every 72 hours with 3% NaOH solution at 85°C gave satisfactory results. The cost of the unit and its installation was lower than that of a shell-and-tube heater of the same capacity.

Modifications to and uprating of the clarification station at Simunye

W. van Duyker, C. Tosio and H. Lung Kit. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 40 - 42.

Modifications to the three Oliver filters used for clarification mud included installation of conductivity probes for level control in the mud trough and in the mud-bagacillo mixer as a replacement for a mud recirculation system; the mixer probe operates the clarifier mud pumps and simultaneously opens and closes the bagacillo screens. Changes were also made to the drive. The internal and external piping in the two Dorr 444 clarifiers was replaced with a new system designed to provide the same hydraulic gradient from all suction points and to improve throughput by increasing the number and size of the suction points. As a result of the changes, the purity drop from clear juice to filtrate and filter-cake losses were greatly reduced, and there was a fall in clear juice turbidity and colour. Juice and mud residence time was cut and flocculant consumption decreased; only one of the clarifiers needs to be operated at a time.

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

A. F. Currie. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 43 - 46.

A description is given of the G 1500 automatic centrifugal, a pair of which were installed at Union Cooperative Ltd. in place of five semi-automatic machines for *A*-massecuite. Problems experienced in operation of the centrifugals and their remedies are discussed and results obtained are reported. Purity rise was higher than in the old machines but fell to a level of 1 compared with a maximum specified of 2.2. A perforated screen gave better results than a slotted one. The new centrifugals have reduced costs and labour requirements while improving massecuite exhaustion.

Program for season-end boil-off balance

P. M. Schorn. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 66 - 68.

A computer program has been written to inform process management at Darnall sugar factory what volumes of *A*-, *B*-and *C*-massecuites have to be boiled and cured at the end of the crushing season

before "jellies" and carryover massecuite stocks are produced. It also allows the progress of the boil-off to be monitored by comparing actual sugar and molasses production with predicted values. Close agreement was found between true and predicted values during the 1986 boil-off.

"Determined loss" — a review of the system for monitoring sugar loss in condenser water at Illovo

J. P. M. de Robillard and B. S. Purchase. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 73 - 75.

Sugar losses in condenser and dunder water at Illovo involves measurement of water flow and proportional sampling for trace sugar analyses at hourly intervals. Because of suspicion that losses may be masked by microbial degradation of sugar within the cooling circuit, the loss monitoring system was tested by adding a stream of *B*-molasses of known composition to the condenser water at a given rate and measuring the effluent flow and sugar concentration every 30 minutes using the resorcinol/HCl method. Results demonstrated the effectiveness of the monitoring system without any appreciable masking by microbial degradation. A sugar loss equivalent to 0.1% of factory throughput causes an increase of 20 ppm per hr in the condenser water sugar concentration, and abnormal losses should be readily detected by COD analyses of effluent samples; these losses are unlikely to exceed 0.2% of factory throughput without being detected.

A review of experience with continuous vacuum pans in Tongaat-Hulett Sugar

P. W. Rein. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 76 - 83.

See *I.S.J.*, 1987, **89**, 28 - 34.

Simulation of the effect of different values of operating variables in a continuous pan

R. G. Hoekstra. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 84 - 93.

Application of the program described earlier[1] to operation of a continuous *A*-pan is described. A set of three simplified equations, derived on the basis of the fundamentals of pan operation, express the relationship between the five main controllable variables, viz. seed rate, massecuite flow rate, average size of the seed crystals and of the crystals in the product, and calandria steam temperature. Any two (but no more than two) of these variables can be fixed at arbitrarily desired values and the other three variables then defined in terms of the equations. The effects of different selections of the 12 compartments in the pan (some of which were fed with dilution water and the rest with syrup), of syrup Brix and of changes in the massecuite crystal content were also simulated; it was found advantageous to reduce dilution water to the minimum or apply it only to the later compartments while allowing for the fact that, contrary to expectation, a lower syrup Brix requires a larger amount of dilution water (reasons for which are explained), and steam pressure must be reduced to increase massecuite crystal content under conditions of a fixed seed feed specification and dilution water selection.

The use of electrical properties measured at radio frequencies for pan boiling and Brix control

D. J. Radford and M. G. S. Cox. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 94 - 102.

While conductivity measurements for boiling control have proved satisfactory for *B*- and *C*-boiling, they are unsatisfactory for boiling of *A*-massecuite and high-grade white sugar (because of a low soluble ash level). The theory and development of a probe for measuring massecuite electrical properties at radio frequencies are described. It gives an output signal equivalent to impedance and provides for continuous variation of the tuning by means of an electrical input signal. When connected to a microprocessor-based controller, it provides simultaneous signals representing resistance and reactance and allows derivation of an optimum control signal representing e.g. crystal content or mother liquor Brix. Basic relationships between the reactance and resistance of massecuites and syrups and their physical properties are given. Experiments on boiling control in batch and continuous pans and on the control of evaporator syrup Brix shows that the RF (radio frequency) probe is less affected by scaling and sugar encrustation than is conductivity measurement; for Brix control the probe is much less expensive than other systems such as nuclear density meters or refractometers.

Operating experience of an activated sludge effluent disposal system

G. W. P. de Mattos. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 116 - 119.

An account is given of the new system installed at Union Cooperative Ltd. for effluent treatment. It comprises four anaerobic lagoons operating two in parallel followed by two in series, the outflow from the last lagoon being pumped to an activated sludge plant. Clear effluent is used in the factory or is transferred to holding dams for maturation and re-use; rainwater run-off is also sent to these dams as dilution and to prevent hydraulic overloading of the anaerobic lagoons. The operation, performance and costs of the new system are discussed. COD removal in 1984/85 was generally about 70% in the lagoons and rose to about 97% in the activated sludge process; initial COD levels fluctuated between about 2500 and 3700 mg/litre. The activated sludge plant can tolerate a fairly wide range of COD feed rates provided the food:micro-organism ratio[2] is relatively low, but flocculants must be added before the sludge clarifier in order to produce a consistently clear final effluent.

1 Hoekstra: *I.S.J.*, 1987, **89**, 35A.
2 Hammer: " Waste and waste water technology" (Wiley, New York), 1977, pp. 387 - 390.

Beet sugar manufacture

Experience in transporting white sugar in special containers

N. A. Emel'yanov, V. B. Zakharevich, V. D. Demchenko, A. V. Kolesnik and V. V. Krivosheya. *Sakhar. Prom.*, 1986, (10), 28 - 31 *(Russian)*.

Experience in the use and handling of 600-kg bulk bags for sugar transportation and storage is reported.

Application of compartmented heater for sugar juice using reheat steam from the 5th evaporator effect

Yu. S. Razladin, O. N. Nedobor, L. D. Pis'mennyi and L. M. Chmutov. *Sakhar. Prom.*, 1986, (10), 33 - 36 *(Russian)*.

Experimental operation of a compartmented raw juice heater of 300 tonnes/hr throughput is described. Under optimum conditions, the temperature was raised from 30° to 45 - 47°C with two passes of 5th effect vapour; performance was noticeably affected by scale formation.

Experience in the operation of the lime section at Khorostkov sugar factory

V. M. Baida *et al. Sakhar. Prom.*, 1986, (10), 40 *(Russian)*.

Khorostkov is the only Soviet sugar factory with a rated daily beet slice of 6000 tonnes. Information is given on modifications to the lime kiln to increase its capacity, on the use of a vibratory screen for milk-of-lime treatment and on changes to the carbonatation gas treatment and cooling plant.

Secondary nucleation and its effect on crystal size distribution in evaporative crystallization of white sugar

M. Schneider and H. Schiweck. *Zuckerind.*, 1986, **111**, 907 - 916 *(German)*.

Optimization of the boiling process aimed at reducing secondary nucleation and conglomeration so as to obtain crystals of greater uniformity depends on a suitable preparative and measuring technique for determination of crystal size distribution; in particular, it must be able to cover the size range below 100 µm chiefly resulting from secondary nucleation. The need to cool massecuite samples to room temperature for measuring purposes creates a problem, since crystal nuclei form and/or crystals already present continue to grow. Because of this, the mother liquor is separated in many procedures; however, crystals small enough to pass through the centrifugal screen may also be removed and the remaining crystals subjected to mechanical stress. The system based on use of the Mikro-Videomat-2[1] does not involve mother liquor separation yet maintains the initial crystal size distribution unchanged for several hours; the lower size limit of measurement is 4µm, and the half mean crystal distance (λ) and specific number of crystals per g massecuite can be found directly. Tests on No. 2 white sugar boiling using crystal footing and slurry, respectively, as seed material are reported, and the supersaturation behaviour discussed with the aid of diagrams. Secondary nucleation occurred in all cases during growing of the grain, but only some of the secondary crystals grew further. Three crystal size ranges were found which differed in their crystallization behaviour: (1) those up to 44 µm characterized by considerable crystal formation, (2) those in the range from 44 to approx. 200 µm, where crystal dissolution prevailed over growth, and (3) crystals >200 µm where growth regained its dominance. There was approximate linear correlation between growth of micro-crystals in range (1) and increase in massecuite consistency; their number increased considerably during Brixing-up, causing problems in spinning through blockage of the voids in the crystal mass. The number of micro-crystals could be reduced by shortening the Brixing-up period or by introducing water drinks.

Investigation of sugar pressure in silos. II. Off-centre discharge

M. Kaminski. *Zuckerind.*, 1986, **111**, 916 - 921 *(German)*.

Three silo models were used in investigations on sugar discharge. All three were 1015 mm high but their inside diameters were different; 25-mm discharge ports were arranged at 8.75 mm intervals so that they were off-centre relative to the silo axis. Measurements of changes in the pressure exerted by the sugar during discharge are discussed for each silo. It was found that off-centre discharge causes an increase in the degree of irregularity of the horizontal pressure distribution; this distribution creates additional flexural moments in the silo walls for which allowance must be made in calculation of the requisite number of steel rods in reinforced concrete. An optimum method of discharging sugar is indicated in which the loads on the walls are no greater than with symmetrical discharge.

Recent progress in sugar factory technology. New processes and improvement of old processes

J. Vetter. *Sucr. Maghrebine*, 1986, (27), 11 - 16 *(French)*.

A survey is presented of the latest approaches to beet sugar factory processes and of specific pieces of equipment, including: an RT5 diffuser provided with a heat exchanger as part of a prescalding system, a computerized scheme for establishing a heat balance, vapour compression for evaporation and pan boiling, continuous vacuum pans and crystallizers, seed massecuite boiling and pulp pressing and drying.

Supersaturation in isohydric boiling of massecuites

F. V. Lishchuk, I. S. Gulyi and V. A. Mikhailik. *Izv. Vuzov, Pishch. Tekh.*, 1986, (4), 31 - 34 *(Russian)*.

The mother liquor Brix was controlled (to within ±0.1% of the target value at not more than 30% massecuite crystal content) as a function of its thermal

1 Schneider & Schiweck: *I.S.J.*, 1986, **88**, 102A

conductivity by means of a thermocouple system incorporated in an automatic laboratory vacuum pan used to study the effects of imbalance between the evaporation and crystallization rates. At constant heat flow, changes in temperature registered by the battery of thermocouples was governed by supersaturation. Changes in crystal content, supersaturation and crystallization rate with time as a function of the amount of seed injected are shown in graph form and discussed as well as the effect of maximum linear dimensions of the crystals on their fractional composition at the end of boiling. Balance between heat and mass transfer in the initial boiling period can be maintained by varying the feed syrup Brix at constant evaporation rate or vice versa; while there are constraints on both methods, the feeding of syrup of gradually increasing Brix is preferred since it allows the initial boiling stage to be conducted at higher supersaturation with a consequent reduction in the crystal growth time; at identical boiling times and practically the same crystal yield, it reduced the amount of heat required by 30 - 40% by comparison with variation of the evaporation rate at constant syrup Brix.

Optimization of design parameters of an electrochemical reaction vessel for pulp press water treatment

A. M. Ostapenkov, V. G. Belik and B. N. Zharik. *Izv. Vuzov, Pishch. Tekh.*, 1986, (4), 64 - 66 *(Russian)*.

A method for calculating the optimum distance between the electrodes in a unit employed to remove floc from press water before it is recycled to diffusion is described. The optimum is that at which electricity consumption and capital costs are minimum to achieve a satisfactory increase in press water purity and hence increase sugar extraction in diffusion. A graph illustrates how the specific costs of electricity to achieve the desired degree of treatment increase while those of electricity needed to overcome hydraulic resistance in labyrinth-type plate vessels fall with increase in the distance between the electrodes.

Investigations of sugar beet storage methods. III. Results of an investigation of sugar beet storage with recirculation ventilation and moistening

-. Dohkoshi, N. Tomiyama, A. Shinsenji and S. Togashi. *Proc. Sugar Beet Res. Assoc.* (Japan), 1986, (26), 175 -179; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (20), Abs. 20 R479.

Results are given of comparative tests on beet storage under different conditions: with recirculation ventilation and moistening and under normal conditions with a large top surface (control pile). It was found that in the ventilated pile the temperature was maintained almost constant and more evenly distributed throughout the entire storage period; the extent of mould formation fell and losses of weight and sucrose were reduced. Moistening allowed the moisture level to be kept constant in the pile, whereas in the control pile it fell at night in the initial storage period as a result of temperature fall. Use of recirculation ventilation and moistening ensures prolonged storage without deterioration in beet quality.

Investigation of sugar beet rot during storage. I. Pathogenicity of moulds isolated from stored beet. II. Spread of moulds during beet storage

I. H. Uchino and K. Kanzawa. *Proc. Sugar Beet Res. Assoc.* (Japan), 1986, (26), 180 - 189. **II.** *Idem: ibid.*, 190 - 193; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (20), Abs. 20 R477, 20 R478.

I. Twenty-six genera of mould classified under 17 groups were isolated from winter-stored beet. The most pathogenic during beet storage were: *Botrytis cinerea*, *Penicillium expansum*, *Phoma betae* and *Fusarium roseum*; they caused the following percentages of rotted beet: *B. cinerea* 71.7, *P. expansum* 7.5, *P. betae* 9.4 and *F. roseum* 6.6. The proportion of the surface of a beet affected within two weeks of inoculation of each pathogen was: 100% by *B. cinerea*, 39% by *P. expansum*, 32% by *P. betae* and 65% by *F. roseum*.

II. On the island of Hokkaido, sugar beets are stored in piles from the end of October to the start of November. The usual pile dimensions are 4.5 m high, 22 m wide and approx. 80 - 150 m long. In some piles the beets are stored for more than 150 days. It has been noted that at different times four genera of mould develop on the surface and/or inside the pile. Within two weeks of covering the pile, *Botrytis* spp. are the first to occur and then gradually spread; they are found in all sections of a pile. *Cladosporium* spp. occur initially on the dry surface of beets, and with extension of the storage period they occur most frequently on the side of the pile. *Penicillium* and *Geotrichum* spp. form on inactive beets at the end of the storage period; they also often occur on the wet top surface of a pile.

Microprocessor system of mass flow coordination at Ropczyce raw sugar factory

M. Staszczak, A. Bratek and E. Kulaszynska. *Gaz. Cukr.*, 1986, **94**, 73 - 75 *(Polish)*.

The computer-based system installed for coordination of mass flow covering the section from the beet hoppers above the slicer to the standard liquor tank feeding the vacuum pans had to meet a number of requirements which are listed. Details are given of the components of the system and of the individual tasks carried out. During initial trials, the system improved the performance of the juice purification station, particularly filtration, and of the melters (as demonstrated by recorder charts) but fluctuations in the beet feeding rate and especially in juice flow to preliming restricted the overall processing rate. However, in the following campaign, the system fully met all requirements during a 72-hr continuous test run. Whereas a similar control scheme at Chelmza factory increased the slicing rate by 4 - 6%, at Ropczyce the system has raised sugar yield.

Sugar refining

Operation of two raw sugar scales in series at Hulett Refineries

C. R. Loker and D. Tayfield. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 69 - 72.

Before 1977, there was poor agreement between the weights as registered by the two Servo-Balans raw sugar weighers at Durban refinery and the values given by the road and rail weighbridges; replacement of the raw sugar weighers with new ones reduced the difference which was nevertheless still unacceptable. In 1985, the two Servo-Balans units were positioned to weigh raw sugar in series and the weighers modified to control the rate of sugar fed to process.The sugar from the weighbridges is conveyed to store or is transferred to process via a variable-speed belt conveyor, bucket elevator and feed bin, below which are the two Servo-Balans weighers (one beneath the other) and, below these, a 700-tonne surge bin (to which sugar from store also passes on its way to process). The sugar drops into a new four-section horizontal melter. Since the weighing cycle time of each unit cannot be kept constant, the discharge valves of the feed bin and the two weigher bins are interlocked so that a full cycle must be completed before the start of the next one; to allow for one of the weighers being out of action, the discharge valve of the unit in question can be locked in open position and the interlocking arrangement switched from the top feed bin to the weigher that is operating. A programmable controller receives inputs from the weighers and the level signal from a surge tank downstream in the process, and transmits a signal to the drive of the variable-speed conveyor so as to control the raw sugar feed rate. The controller is linked to one of the weigh-ers, and feedback of the throughput rate to it is brought about by measuring the time taken to complete each weighing cycle by the unit being monitored; the hourly rate is computed from the cycle and time and the average net weight per cycle and is used by the controller to update its output against a set point. The weighing cycle is measured by two proximity sensors and switches on the weigher. These detect the movement of the mechanism operating the discharge valve. The level input from the surge tank lowers the set point of the controller should the tank level exceed 60% of its capacity. At least once per season a weight of sugar recorded by the weighbridges is compared with that recorded by the Servo-Balans units (an exercise known as "melt-out"), while the monthly performance figures are based on the readings from the weighers; a provisional scale error based on the result of previous melt-outs is applied to the readings. The results achieved with the new arrangement are discussed.

Refined sugar storage trials using various types of 25-kg paper bags

T. L. Excell and P. Mellet. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 112 - 115.

See Anon.: *I.S.J.*, 1987, **89**, 52A.

The changing world of white sugar manufacture

M. C. Bennett. *Sugar J.*, 1986, **49**, (2), 15 - 20.

See *I.S.J.*, 1986, **88**, 5A.

Automatic pan boiling control using rheometer and micro-processor

H. Hashimoto, T. Kawamura, T. Chigusa and T. Satori. *Sugar J.*, 1986, **49**, (4), 9 - 11.

See *I.S.J.*, 1986, **88**, 6A.

Technological parameters of low-grade sugar affination in centrifugals

A. I. Gromkovskii and V. V. Smol'yaninov. *Sakhar. Prom.*, 1986, (11), 12 - 14 *(Russian)*.

Trials on low-grade cane sugar affination with molasses are reported in which optimum conditions were found to be a molasses Brix of 75°, temperature of 85°C and a rate of 1.7 - 2.0% on weight of *C*-massecuite. There was no appreciable rise in final molasses purity.

Choice of powdered active carbons for sugar solution decolorization

Ya. O. Kravets, S. A. Gurova and L. I. Akimova. *Sakhar. Prom.*, 1986, (11), 15 - 17 *(Russian)*.

The physico-chemical properties and decolorizing efficiencies of 18 active carbons (13 of them from outside the USSR) were determined; Norit carbon was used as standard, and the decolorization tests were conducted on a model syrup made up from refinery molasses. Besides adsorptive activity of a carbon and the ash content and pH of an aqueous extract after syrup treatment, the percolation rate of the syrup was also a major parameter studied. The presence of fine particle fractions in most of the imported carbons caused the specific flow rate to fall below the recommended level, so that the syrup Brix had to be reduced to below the standard 62°. Two procedures developed by the Japanese firm Taico for determining the percolation properties of carbon were used as basis for a proposed method which is described. On the basis of the tabulated results, some of the carbons are considered unsuitable for use in the sugar industry and others are recommended in 1:3 mixtures with OU-A Soviet carbon which gave best flow rates.

Rational use of low-grade sugar remelt

V. V. Smol'yaninov, A. I. Gromkovskii and I. F. Bugaenko. *Sakhar. Prom.*, 1986, (12), 10 - 11 *(Russian)*.

Instead of carbonatating *C*-sugar remelt, which has been found to increase the load on processing equipment, lime consumption and degradation sugar losses, it is proposed to affine it and, after sulphitation, to transfer it to the *A*-pan. The positive results of this obtained at a factory processing cane raw sugar are discussed.

Starch based sweeteners

The use of active carbon in the manufacture of glucose and fructose from sucrose

L. I. Tanashchuk and N. A. Arkhipovich. *Sakhar. Prom.*, 1986, (4), 50 - 52 *(Russian)*.

Colouring matter in glucose solutions obtained from sucrose includes products of glucose and fructose degradation in acid and alkaline media, while that in fructose solutions consists mainly of fructose alkaline degradation products; however, carbonatation yields almost colourless fructose solutions which absorb only ultraviolet light, whereas the straw coloured glucose solutions obtained absorb light in both the visible and U.V. spectra. Since anion exchange resin does not adsorb monosaccharide degradation products that are only detectable in U.V. light, tests were conducted on the use of powdered active carbon. Details are given of the experiments, which proved successful with both fructose and glucose, although optimum conditions were different: for fructose, maximum effectiveness was achieved using 1% carbon on dry solids at 40°C and a contact time of 15 minutes, whereas for glucose the optimum was 1.7% carbon, 50°C and 25 minutes. Spectrophotometric measurement at 282 nm was used to analyse the treated solutions.

Fructose enrichment of a glucose:fructose mixture (1:1) by cation exchange chromatography

S. Bhatt and S. Bose. *Proc. 48th Ann. Conv. Sugar Tech. Assoc. India*, 1984, G.29 - G.40.

Zeo-Karb 225 (H) in hydrazine form was used to separate glucose from fructose in studies of the elution behaviour of fructose at different temperatures. At the optimum of 60°C, a fructose-rich glucose fraction and a pure glucose fraction were obtained, the fructose content in the former being maximum at 76.89%.

Production of powdered sugar-starch syrup semiproducts by spray drying

A. V. Zubchenko, G. O. Magomedov and Yu. S. Serbulov. *Izv. Vuzov, Pishch. Tekh.*, 1986, (2), 120 - 122 *(Russian)*.

A study program laid out in the form of an experiment design matrix referred to investigations on spray drying of a mixture of sugar and starch syrup to give an intermediate product of minimum moisture content and optimum composition. From statistical analysis of the results, a nomogram has been constructed for finding the moisture content of the dried product as a function of the solution sugar:starch syrup weight ratio in the range 0.7 - 9.1, starch syrup content in the range 10 - 60% and moisture content in the range 20 - 60%. At an initial temperature of the air used for drying of 130°C, a relative air moisture content of 3% and a compressed air pressure of (2 - 3) $\times$ 10^5Pa, optimum solution parameters were a starch syrup content of 20% and a moisture content of 42%.

Ways of improving starch syrup production

N. D. Lukin, E. K. Sidorova and I. P. Dubinskaya. *Obz. Inf. TsNII Inf. i Tekhn.-Ekon. Issled. Pishch. Prom., Krakhmalo-Patoch. Prom.*, 1986, (5), 35 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (18), Abs. 18 R530.

A survey is presented of types of starch syrups and methods of their pretreatment, using separators, electroflotation and flocculants, before filtration. Results are reported of application of a rotary vacuum filter for neutralized syrups with micro-removal of mud. Syrup treatment with granular carbon and the economics of active carbons used outside the Soviet Union are examined. Details are given of methods for producing various types of starch product in powdered form and their application.

Conditions for fructose crystallization in aqueous solutions

N. I. Odorod'ko and N. A. Arkhipovich. *Rpt. Kiev. Tekhnol. Inst. Pishch. Prom.*, 1986, 9 pp.; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (18), Abs. 18 R534.

Optimum conditions have been worked out for fructose crystallization from aqueous solutions by means of cooling in the range 55 - 24°C. It was established that the crystallization process is considerably affected by syrup pH and that fructose is stable at pH 3.7 - 4.0. A smooth-running scheme is proposed for cooling of fructose syrups which permits the desired exhaustion of molasses and massecuite with normal separating properties. The optimum amount of seed for crystallization has been determined.

Laboratory tests on continuous starch saccharification by means of immobilized glucoamylase

M. Prybyt, W. Wajdecka and H. Sugier. *Biotechnol. Chem. Zywn., Ses. Nauk.*, 1985, 146 - 150; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (23), Abs. 23 R613.

Continuous saccharification of potato starch was studied in a laboratory unit using α-amylase to liquefy the starch and immobilized glucoamylase supported on DEAE-cellulose or porous glass; the enzyme had a higher activity on the former support but had a reduced stability on both supports. The porous glass was more durable than the DEAE-cellulose.

Practical experience with NIR reflectance spectroscopy in enzyme-induced degradation of wheat starch to glucose

P. Weustink. *Starch/Stärke*, 1986, **38**, 335 - 339 *(German)*.

Near-infra-red reflectance spectrometry proved suitable for monitoring of starch liquefaction and saccharification to glucose using alpha-amylase or glucoamylase. DE values were in the range 10 -100 and were measured by means of a Technikon Infra-Analyser 400 using three independent calibrations. The measured values should be checked by manual titration at regular time intervals.

Laboratory studies

Sugar research in South Africa

Anon. *Ann. Rpt. Sugar Milling Research Inst.*, 1985/86, 3 - 4, 8, 13 - 14.

Chemical losses of sucrose under laboratory conditions: In investigations on measurement of the sucrose decomposition rate constant and determination of the effect of temperature and pH on the constant, 10°Bx samples of juice were heated rapidly to 100 - 125°C in a special cell, the pH meter was calibrated at 95°C and the pH of the samples adjusted to 5; the temperature and pH were logged by microcomputer throughout a run, and 2 ml samples were removed through a septum at definite intervals. The inversion rate constant was determined on the basis of both sucrose loss and glucose gain. An increase in the sucrose loss rate by a factor of 2.1 for every 10°C temperature rise was very similar to values obtained by Vukov and Parker. Rate constants for juices from three factories were compared with values obtained for a sucrose-phosphate buffer solution and with published data. There were no significant differences between the constants for the three factories and values found by Vukov, Sapronov and Stadler, so that the effect of impurities at the pH at the operating temperature is considered of little importance; further kinetic work was to be carried out at pH 6 at the operating temperature where catalytic effects should be more measurable. The rate constant value determined by Parker was much lower than the other values. *The prediction of pH values at high temperatures from pH readings obtained at room temperature*: While it is very difficult to measure sucrose inversion during evaporation, inversion losses may be estimated from model equations derived from laboratory experiments provided the juice temperature, pH and residence times are known. However, an accurate estimate of pH is difficult to obtain since no systematic study has been made of pH change with temperature. The pH of almost 100 samples of mixed juice, clear juice and syrup from four factories was measured at three temperatures and the relationship between pH and temperature found for each sample. Excellent correlation was obtained between the temperature coefficient ($\Delta pH/\Delta T$) and pH at 25°C as expressed by $\Delta pH/\Delta T = -0.034 + 0.015pH - 0.0017pH^2$. This model was subsequently tested by determining $\Delta pH/\Delta T$ experimentally for 25 juices and comparing the pH values at 100°C with those calculated using the equation. Excellent agreement was obtained, implying that pH values at vessel operating temperature can be calculated rapidly with good precision from pH determination made at room temperature. *Sugar colorants in affined raw sugars*: Gel adsorption/filtration chromatography was used to separate colorants from a number of raw sugar samples into two crude fractions. Melanoidins and caramels, a mixture of non-polar high-molecular compounds produced in the factory, were too large to enter the pores of the gel and were rapidly eluted from the column. The polar cane pigments, flavonoids and phenolic molecules of low molecular weight were then eluted from the column by modifying the solvent polarity. The two fractions were collected in small beakers, evaporated to dryness and then redissolved in a minimum quantity of water. The pH was adjusted to 7 and the colour measured at 420 nm. Results showed that the colour of the two fractions added together was almost the same as that of the original raw sugar, indicating that little or no loss of colour occurred during fractionation; in some cases the colour contributions of the two fractions were almost equal while in others there was a marked predominance of one of the fractions, indicating that the origin of the colour was not the same for different sugars. The fractionation procedure was to be applied with other analytical techniques to syrup and *A*- and *C*-sugars. *Analysis of high-test molasses*: While total fermentable sugars in high-test molasses (HTM) are currently determined in South Africa using the Lane & Eynon method, importers of HTM have found that non-fermentable reducing substances (NFRS) inflate the value of total sugars as invert, and have requested a more accurate method. In investigations of GLC and HPLC (using resin-based and Dextropak columns), GLC detected a number of disaccharides and trisaccharides in addition to fructose, glucose and sucrose as the major fermentable sugars, and the treatment of the HTM with an excess yeast indicated that these sugars were fermentable. Statistical comparison of the data obtained showed that GLC and resin-based HPLC gave identical results for fructose, glucose and sucrose, while the Dextropak method appeared to overestimate glucose by almost 10%. GLC and HPLC using the Dextropak column gave very similar results for the oligosaccharides, while resin-based HPLC yielded lower results. Correction of the Lane & Eynon method for NFRS brought the values obtained closer to those given by the chromatographic methods, but they were still 1 - 2 units higher, a difference that could result from lack of knowledge of the oligosaccharide response factors or from failure of the chromatographic methods to detect all the fermentable sugars. A procedure for total inversion of the sugars to fructose and glucose prior to GLC or HPLC analysis was to be investigated. *Auto-analysis of phenolics in sugar products*: A colorimetric method developed by Smith in Australia for determination of phenolic constituents is based on the Liebermann reaction and gives a measure of the potential sites on coloured and colourless molecules at which adsorption can take place on resin, bone char or active carbon. Optimum reaction conditions are a compromise between the high acidity needed for maximum concentration of the diazonium ion and the low acidity required for formation of the reactive phenoxide ion. In the original method, the final concentration of sulphuric acid was 0.012N and the solution contained 0.064% sulphanilic acid. Smith increased the sensitivity by decreasing the final acid concentration to 0.008N, but at the expense of slower reaction times and considerable drift in the presence of sugar. At the SMRI it was

found that similar sensitivity but with negligible drift could be obtained by adjusting the sulphanilic acid concentration to 0.16% rather than by decreasing the acidity; the sulphuric acid concentration was as in the original method, while the sodium nitrite concentration was doubled to 0.32%. With automation of the procedure, the response was about 0.05 absorbance units per ppm in the sample solution and was unchanged in sugar solutions up to 25°Bx.

Contribution to determination of optimum 2nd carbonatation alkalinity

K. Cizova. *Listy Cukr.*, 1986, **102,** 212 - 214 *(Czech.).*

Comparative tests were conducted on determination of the optimum alkalinity of 2nd carbonatation juice (at which purity is maximum and the lime salts content minimum) by Czechoslovakian and West German methods (both based on titration against phenolphthalein) and by the potentiometric titration method for effective alkalinity. Results for 15 samples (including comparison of the effective alkalinity with the total lime salts content) showed close agreement between the first two methods, while the effective alkalinity method gave slightly higher values. The method used in West Germany is less laborious and time-consuming than the Czechoslovakian method, which has now been modified to permit use of a smaller volume of juice.

Investigations of high molecular compounds in cane raw sugar

I. F. Bugaenko, M. Garcia F. and V. D. Shcherbukhin. *Sakhar. Prom.*, 1986, (9), 12 - 14 *(Russian).*

Alcohol precipitation was used to isolate high molecular compounds from raw sugar solutions acidified to pH 3.2. The precipitate was dissolved in water and the solution fractionated by passage through NaOH-regenerated anion exchange resin and elution with water and NaOH, yielding a yellow solution of resin-adsorbed compounds which have already been studied[1] and a colourless solution of non-adsorbed material (representing approx. 10% of the total high-molecular compounds in the original solution) which was further analysed. Drying under vacuum at 30°C for 8 hr yielded a greyish powder which was then hydrolysed with H_2SO_4 for 6 hr on a boiling water bath; the hydrolysate was neutralized with Amberlite IRA-400 resin in HCO_3^- form, filtered to remove the resin, concentrated under vacuum and the sugars converted to aldonitryl acetates for analysis by GLC[2]; this revealed the presence of glucose (98% of the total sugars) and arabinose (2%). IR-spectroscopy at a frequency of 700 - 4000/cm of the powder suspended in petroleum jelly indicated the presence of considerable quantities of α-glucan, a neutral polysaccharide.

Rheological properties of refinery molasses

L. A. Sapronova. *Sakhar. Prom.*, 1986, (9), 14 - 17 *(Russian).*

The shear rate and tension were calculated from viscometric measurements at 30 - 70°C of refinery molasses samples of 40 - 76°Bx, 75.8 - 76.5 purity and 0.44 - 0.55% colloids content on Brix. Tabulated and graphed results showed a scatter of dynamic viscosity values not exceeding 2% and values of relative viscosity (dynamic viscosity/viscosity of pure sucrose solution) in the range 1.074 - 1.608. The study demonstrated the Newtonian character of the molasses as typified by the absence of large concentrations of high molecular polymers (not exceeding a molecular weight of 10^6). An equation is developed for log viscosity which includes an empirical value of the activation energy.

Conductimetric ash determination. Inter-laboratory experiments to determine accuracy

P. Devillers. *Sucr. Franç.*, 1986, **127,** 275 - 282 *(French).*

The new official ICUMSA method for conductivity ash measurement differs from the one it supersedes by omitting addition of white sugar of low ash content to the test solution, if necessary, to maintain a concentration of 5 g/100 cm^3. The solution is diluted with twice distilled or deionized water to a concentration at which the conductivity is between 200 and 500 μS/cm and the ash content (g/100 g) is then given by $(16.2 + 0.36\ D) \times C \times f \times 10^{-4}$, where D = dry solids concentration (g/100 cm^3), C = difference between conductivity of the solution and that of the dilution water, and f = dilution factor, i.e the standard concentration of 5 g/100 cm^3 divided by the weight of the sample. Collaborative tests were conducted at laboratories in nine countries to check that the new method gives the same results as the previous one. From tabulated results for beet and cane molasses and syrup samples it is concluded that the two methods give almost the same values, with standard deviations for repeatibility at the same laboratory of about ± 1% and a reproducibility between laboratories of about ± 2%. The KCl reference solutions used are prepared in exactly the same way in both methods. The new method is not suitable for ash determination in white sugar, the official method for which uses a concentration of 28 g/100 g.

Dispersity of colouring matter in raw sugar and products from its processing

L. D. Bobrovnik, G. I. Sheiko, N. V. Dubinina and A. V. Oleinik. *Sakhar. Prom.*, 1986, (10), 15 - 17 *(Russian).*

Colouring matter obtained from raw sugar remelt liquor and *A*-green syrup by active carbon and elution with aqueous acetone or pyridine was fractionated by Sephadex gel chromatography; paper electrophoresis was then applied to the fractions. The optical densities were measured and the curves for each fraction compared between the two initial sources. The molecular weights and colours of the fractions are tabulated. The findings are of significance in deciding on suitable treatment for removal of high-molecular compounds before colour adsorption processes.

1 Bugaenko *et al.: I.S.J.*, 1986, **88,** 84A.
2 Varma *et al.: J. Chromatogr.*, 1973, **77,** 222 - 227.

By-products

Effect of the composition of the nutrient medium on acetone-butanol fermentation

O. S. Korneeva. *Mater. 2-oi Nauch.-Prakt. Konf. Mol. Uchenykh i Spets. Voronezh Tekhnol. Inst. po Aktual. Probl. Prod. Progr.*, 1986, 74 - 76; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (18), Abs. 18 R440.

Fermentation of various molasses-containing media by acetone-butanol bacteria producing amylolytic enzymes was investigated. It was found that addition of molasses to the medium intensified *n*-butanol synthesis. It was possible to replace some of the meal with molasses in fermentation of starch media. Biosynthesis of alpha-amylase from *Clostridium acetobutylicum* was also investigated in view of the economic advantage and suitability of the process. Maximum α-amylase accumulation was achieved by replacing 2% of the meal with bran.

Need for modernization of the sugar industry to save bagasse and to generate surplus power

N. A. Ramaiah. *Bharatiya Sugar*, 1986, **11**, (10), 9 - 11.

The author restates his views on the need to save bagasse for use in paper manufacture by reducing steam consumption and raising the calorific value of bagasse by drying. The possibility of generating surplus power for sale to the public grid is also mentioned.

A positive step for making industrial-quality printing ink from sugar cane wax

S. C. Ray. *Indian Sugar*, 1986, **36**, 147 - 154.

Details are given of laboratory experiments on purification of cane wax to yield a product of suitable consistency for preparation of printing ink, which gave promising results in trials at a printing press.

A good method for preserving (beet) pulp

J. P. Vandergeten and R. Vanstallen. *Le Betteravier*, 1986, **20**, (212), 12 - 13 *(French)*.

The benefit for pulp storage and ensilage of raising the dry solids content using diffusion additives is discussed and advice given on optimum ensilage conditions.

Energy efficiency in the production of ethanol from molasses

A. Beba. *Biomass Util. Proc. NATO Adv. Study Inst.*, 1983, 659 - 668; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (20), Abs. 20 R406.

A review is presented of the fundamentals of alcohol production by fermentation and subsequent distillation, of forms of raw material used, alcohol yields and process energy balance (including the energy consumed in growing the raw material source and in alcohol conversion as well as the energy content of the alcohol), grain supplies in different parts of the world in 1934/38, 1948/52, 1960, 1970 and 1978, and alcohol yields per tonne of molasses, sugar cane, sweet sorghum, corn, sweet potato, tapioca, bagasse and wood pulp. Mathematical models are presented of energy consumption at individual stages of alcohol production as well as an energy balance that takes into consideration the form of raw material and the technology used in alcohol production.

Production of vinegar from cane molasses and tropical fruits

R. Perez P., R. Arroliga, M. Pravia R. and G. Perez. *Bol. Tecn. LABAL*, 1983, **4**, (1/4), 2 - 8; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (20), Abs. 20 R412.

A laboratory study was conducted on the use of a mixture of cane molasses and banana or pineapple pulp as substrate for alcoholic and subsequent acetic acid fermentation. A mash of each mixture to which appropriate nutrients were added initially was subjected to alcoholic fermentation with yeasts for 50 - 80 hr at 30 - 33°C and, after fortification with alcohol to about 9%, was fermented with acetic acid bacteria. Best results in terms of acetic acid were obtained with the molasses and pineapple pulp mixture.

Studies on the fermentative production of L-lysine. Evaporation, preservation and drying of L-lysine fermentation broth

Y. T. Liu and S. L. Sang. *Taiwan Sugar*, 1986, **33**, (4), 13 - 19.

See *I.S.J.*, 1987, **89**, 44A.

Pressed (beet) pulp and its development in Europe

J. P. Vandergeten and R. Vanstallen. *Publ. Trimest. Inst. Royal Belge Amél. Betterave*, 1986, **54**, (1), 7 - 22 *(French, Dutch)*.

The literature on developments in pulp pressing and ensilage is reviewed and the feed value of pulp for fat stock or dairy cattle is examined. Addition of molasses, urea, essential minerals, vitamins and vinasse is discussed, and reference made to tests on production of pulp of high (45%) dry solids content and on compression of pulp of 65% dry solids content.

An update on progress in the production of ethanol from bagasse

B. S. Purchase, S. N. Walford and E. J. Waugh. *Proc. 60th Ann. Congr. S. African Sugar Tech. Assoc.*, 1986, 33 - 36.

See Anon.: *I.S.J.*, 1987, **89**, 77A.

Sugar and energy

J. Olivier. *Biomasse Actualités Suppt.*, 1986, (10), 31 - 32 *(French)*.

It is calculated that a modern unsophisticated sugar factory burns about 180 kg of bagasse per tonne of cane, leaving 120 kg/tonne available for

other needs (assuming bagasse represents 30% of the weight of cane), including generation of approx. 65 kWh of electricity. For a total world production of 60 million tonnes of cane sugar per year (representing 62% of a combined beet and cane sugar production of 96 million tonnes), about 600 million tonnes of cane is processed; the amount of electricity that only 70% of this would supply (the other 30% not being available for various reasons) is shown to represent, in terms of electricity generation, the equivalent of 6 million tonnes of petroleum. It is mentioned that, of other uses of surplus bagasse, only paper and cardboard manufacture have proved at all profitable.

Frost influence on sugar cane quality. A study of its effects on cane destined for alcohol production

F. A. Fogliata, H. G. Ayala, E. Moreno, S. López and C. Torné. *Sugar y Azúcar*, 1986, **81**, (10), 22 - 23, 28, 30 - 31, 34 - 35.

Investigations on fermentation of juice from NA 56-79 cane showed that mild frosts (0 - 3°C) did not significantly reduce the amount of CO_2 given off compared with non-frozen cane, while a succession of severe frosts (between –6° and –8°C) caused a marked fall in it. Highly significant differences in treatment of the three lots of cane in accordance with these temperature conditions related to the effect of increased juice acidity on fermentation and associated CO_2 generation. Juice pasteurization prior to fermentation improved the amount of alcohol produced when expressed on a % volume basis, while the amount of theoretical alcohol per tonne of cane and total reduced sugars % cane fell significantly in severely frosted cane as the season progressed. The greater the frost damage the greater was the fibre and bagasse content % cane and the lower was the alcohol yield per tonne of cane.

A new process for rapid drying and storage of bagasse

J. E. Atchison. *Sugar y Azúcar*, 1986, **81**, (10), 38 - 39, 42 - 44.

In the Bagatex-20 process as used in Brazil for surplus bagasse intended for sale to other industries or for use as boiler fuel, the bagasse in 600- or 900-kg bales is dried rapidly by accelerated, controlled fermentation using a catalyst that is mixed with the bagasse before baling. The heat generated by the process expels moisture by capillary action; within 20 days, the moisture content falls from 50% to 20% after which there is a gradual fall in temperature but the moisture content continues to fall (to 15% after 30 days). The high temperature, low pH, absence of food (as the residual sugar is exhausted by the fermentation) and low moisture content combine to kill the various microbes or inactivate them, so that in effect the bales become pasteurized and may be preserved for very long periods without deterioration of the fibre. Tests have shown no appreciable loss of cellulose, hemicellulose or lignin as a result of the process, and no loss of colour or brightness.

Cultivation of *Kluyveromyces fragilis* yeasts on a molasses substrate

J. Krizanic, V. Cesi and V. Maric. *Prehramb.-Tehnol. Rev.*, 1985, **23**, (4), 129 - 134; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (22), Abs. 22 R355.

K. fragilis cultivation on molasses medium was studied under laboratory conditions at 28°, 32° and 37°C, pH 4.5, a soluble O_2 concentration of 1 - 3 mg/litre, a sugar concentration of ≤2 g/litre and 0.5 and 1.0 g/litre seed yeast. The yeast was propagated in a 14-litre fermenter provided with a stirrer and instruments for temperature and pH control. Best results were obtained at 32°C and 1 g/litre seed concentration. The yeast yield was 9.545 g/litre and 0.449 g/g sugar at a productivity of 1.193 g/litre/hr. The fermenter system and its operational conditions are given as well as the composition of the nutrient medium and the propagation properties of the yeast.

Effect of volatile organic acids in molasses on alcoholic fermentation and yeast yield

I. Langpaulova. *Kvasny Prum.*, 1986, **32**, (5), 103 - 106; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (22), Abs. 22 R362.

Results are reported of investigations on the effect of formic, acetic and butyric acids on alcoholic fermentation and yeast yield using commercial strains of yeast. For strain OK 1/1 (alcoholic fermentation) the threshold concentrations in the substrate (g/litre) were: formic acid, 0.008; acetic acid, 0.025; butyric acid, 0.003. For strain 03/26 (yeast production) the values were 0.003, 0.0015 and 0.002, respectively. Comparison of these values with the contents in the molasses showed that formic acid was present in the largest quantity and may, under defined conditions, have an inhibiting effect on the fermentation process.

Selection of active strains of *Aspergillus niger* and improvements in the quality of seed material for citric acid production

E. Ya. Scherbakova, V. M. Golubtsova and V. P. Ermakova. *Povysh. Effektiv. Pr-va Pishch. Kislot*, 1985, 3 - 20; through *Ref. Zhurn. AN SSSR (Khim.)*, 1986, (22), Abs. 22 R382.

L-130 strain of *A. niger* was selected for citric acid production by surface fermentation of molasses media, and L-4 for submerged fermentation. Selection of the strains was carried out using chemical mutagens: ethylene oxide, ethylenimine, diethyl sulphate, 1,4-bis-diazoacetylbutane, cyclophosphane and U.V. rays. Under laboratory conditions, the new strain L-130 produced 40% more citric acid than the original strain 130. The new one has been introduced at two factories.

Patents

UNITED STATES

Sucrose recovery from molasses

D. Y. Ou, of La Grange, IL, USA, *assr.* UOP Inc. **4,519,845**. February 9, 1984; May 28, 1985.

Sucrose is recovered from beet molasses by passage at 50 - 80°C through a (preferably moving) bed of a combination of (A) an ion retardation resin (e.g. an anionic or cationic monomer polymerized inside the pores of an anion or cation exchange resin, respectively) and (B) a Ca^{++} - or K^+ -exchanged sulphonated styrene cation exchange resin of approx. 8% cross-linkage in a volume ratio A:B of 40:60 - 70:30. Resin (A) is preferably in equilibrium with the mineral salts content of the molasses as a result of successive cycles of contact between the feedstock and water. While ion retardation resins are known to retain mineral salts from molasses while allowing the sugars and betaine to be eluted together, the combination of the two resins permits the sucrose to pass through the system while retaining the salts and betaine, which are then desorbed with water.

Butanol production by fermentation

R. E. Heady and J. R. Frankiewicz, *assrs.* CPC International Inc. **4,520,104**. November 18, 1982; May 28, 1985.

Butanol is produced by continuous fermentation of a glucose or sucrose feedstock, sugar syrup or starch hydrolysate with a strain of *Clostridium acetobutylicum*, e.g. ATCC 4259 or ATCC 39236, at pH 4.5 - 5.5, 34 - 40°C and a dilution rate (0.2 - 0.5/hr) that minimizes contact between the butanol and the inoculum and thus maintains the concentration below 0.05 g/ml of inoculum. Some of the fermentation medium is continuously cycled through a butanol-adsorbing material (e.g granular active carbon molecular sieve or adsorbent resin) at a rate sufficient to maintain the butanol concentration below 0.8% (below 1%) by weight of the medium. The fermentation process may be carried out in two vessels in series.

Gasohol production

M. E. D. Hillman, W. J. Huffman, E. S. Lipinsky and E. Stambaugh, *assrs.* Battelle Development Corporation. **4,523,928**. April 28, 1980; June 18, 1985.

A sugar, e.g. a mono- or disaccharide obtained from cane, beet, bagasse, sorghum or starch hydrolysate, is reacted at 150 - 300°C with a metal salt to form a complex of the metal and/or a metal lactate which is then pyrolysed at 275 - 400°C and 500 - 3000 psig (at least atmospheric pressure) in the presence of water to yield ethanol. The metal salt can be an oxide, hydroxide or a carbonate that decomposes to a metal oxide and CO_2 during pyrolysis. The ethanol is recovered using an organic solvent and is blended with a liquid fuel such as gasoline, diesel fuel or kerosene. The intermediate complex and/or lactate may be separated from the aqueous reaction mixture before pyrolysis so as to reduce the ultimate water separation from the ethanol.

Cane juice purification

M. Exertier, of Orsay, France, *assr.* Rhone-Poulenc Industries. **4,523,959**. September 27, 1983; June 18, 1985.

Cane juice of 10 - 25°Bx and pH 5 - 12 is purified and decolorized by treatment at 15 - 80°C with a hydrophobic adsorbent consisting of a cross-linked polymer or a supported strong anion exchange resin in the form of a mineral support (aluminium or silica) covered with less than 15 mg/m² of cross-linked polymer film, followed by passage (in any order) through a column of anion exchange resin (containing exchange groups such as primary, secondary or tertiary amines or quaternary ammonium salts) and a column of cation exchange resin (containing exchange groups such as carboxylic or sulphonic acids of the general formula -COOH or $-SO_3H$). Aconitic acid, amino-acids, K, Mg and Ca may be recovered by elution with HCl. The process may be applied to low-grade sugar solutions and is intended to allow the juice, after concentration to 65% sucrose by heating under vacuum, to be used as syrup or crystallized without clarification or further purification.

HFS production

J. N. A. Otte, of Ruisbroek, Belgium, *assr.* Dow Chemical (Belgium) S.A. **4,523,960**. December 9, 1983; June 18, 1985.

High-fructose syrup is obtained by successive treatment of a glucose syrup with a strongly acidic sulphonated cation exchange resin, preferably in H^+ form, a weakly basic anion exchange resin, and a weakly acidic cation exchange resin in the form of a cross-linked polymer or copolymer of acrylic or methacrylic acid. At least some of the glucose is then enzymatically isomerized to fructose.

Ultrafiltration of fermented liquor

S. Toyoshi, T. Tanegawa, M. Saeki and T. Kawakita, *assrs.* Ajinomoto Co. Inc. **4,523,999**. December 16, 1983; June 18, 1985.

Liquor obtained from beet molasses or cane molasses or a mixture of these and fermented with an amino-acid such as glumatic acid or lysine or a mixture of these is purified by ultrafiltration after pH adjustment to 2 - 5, since impurities such as humic substances, gums, polysaccharides and proteins have an isoelectric point in this range.

L-Tryptophan production

O. Kurahashi, M. Kamada and H. Enei, *assrs.* Ajinomoto Co. Inc. **4,560,652**. November 24, 1982; December 24, 1985.

L-Tryptophan is produced by aerobic cultivation of a mutant of *Bacillus subtilis* on a suitable carbon source such as molasses, glucose, fructose, sucrose or starch hydrolysate at 20 - 40°C (30°C) and pH 5 - 9 for 1 - 4 days.

Table I, continued

Characteristics	Feed	Effluent (1) Min.	Max.	Ave.	Effluent (2) Min.	Max.	Ave.
Organic load 5.3 kg COD/m³/day							
pH	6.8	5.7	6.3	5.9	7.4	8.5	7.9
COD, mg O_2/litre	4980	896	1045	901	44	136	70
% Removal		79.2	82.4	81	89	95	92.6
BOD, mg O_2/litre	1426	242	342	268	15.4	37	26.5
% Removal		76	83	81	88	94	92.3
T.R., 105°C, mg/litre	4768	1759	1916	1801	1158	1199	1167
VOM, 550°C, mg/litre	3647	638	795	679	41	77	48.4
% Removal		78.1	82.5	81	90	94	93
Ammonia, mg N/litre	26.4	32.6	40.3	36	26.5	27.6	26.4
Total organic nitrogen, mg N/litre	62.3	48.6	56.7	52	32	46	38
Phosphorus, mg P/litre	4.7	4.5	4.6	3.7	3	4.5	3.3
Gas produced							
Litres/kg COD removed		800	870	860			
Methane, %		60	62	61			
Organic load 8.6 kg COD/m³/day							
pH	6.7	5.8	6.4	6	7.8	8.2	8.0
COD, mg O_2/litre	7968	1497	2071	1658	105	348	262
% Removal		74.2	81.2	82.6	88.2	93.2	91
BOD, mg O_2/litre	2523	476	666	542	34.3	83.2	72
% Removal		77.6	81.1	81	87.5	92.8	91
T.R., 105°C, mg/litre	7624	2881	3209	2995	1844	1938	1876
VOM, 550°C, mg/litre	5855	1112	1440	1226	75.6	169	137
% Removal		75.4	81	79	88.2	93.2	91
Ammonia, mg N/litre	38.6	50.2	61.2	55	38.5	40.2	39
Total organic nitrogen, mg N/litre	86.4	63.5	74.5	69	39.7	59.6	49.8
Phosphorus, mg P/litre	7.6	7.5	7.6	7.6	4.7	6.1	5.4
Gas produced							
Litres/kg COD removed		880	910	900			
Methane, %		57	60	60			
Organic load 12.8 kg COD/m³/day							
pH	6.5	6.1	6.5	6.3	7.9	8.2	8.0
COD, mg O_2/litre	11868	2575	3204	2711	226	416	370
% Removal		77	82	82	87.2	91.2	91
BOD, mg O_2/litre	3982	892	1099	948	76.7	148	116.8
% Removal		76	81	80	86.5	91.4	90
T.R., 105°C, mg/litre	11654	4748	5179	4893	2954	3088	3014
VOM, 550°C, mg/litre	8845	1839	2370	2067	145	279	245
% Removal		75.2	79.2	79	88.2	92.1	91
Ammonia, mg N/litre	58.6	79.6	96.7	88	58	59	58
Total organic nitrogen, mg N/litre	138	98	116	90	61.7	88.2	74.2
Phosphorus, mg P/litre	11.8	11.7	11.8	11.8	7.4	9.1	8.1
Gas produced							
Litres/kg COD removed		900	940	920			
Methane, %		56	60	59			

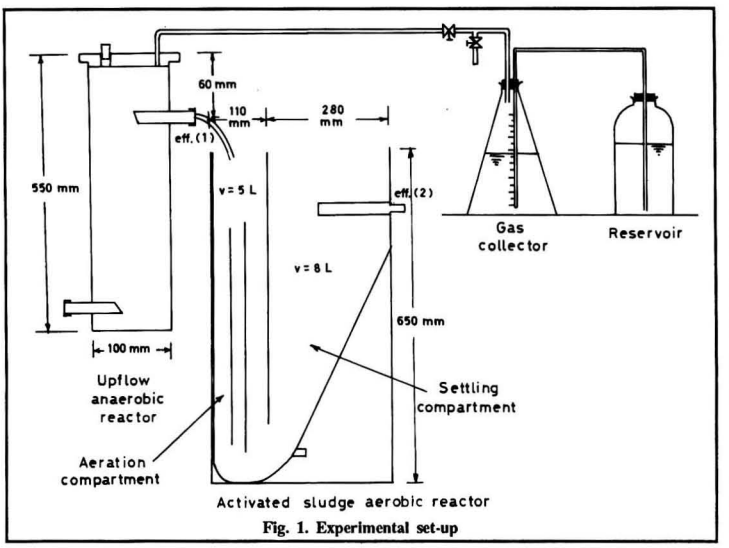

Fig. 1. Experimental set-up

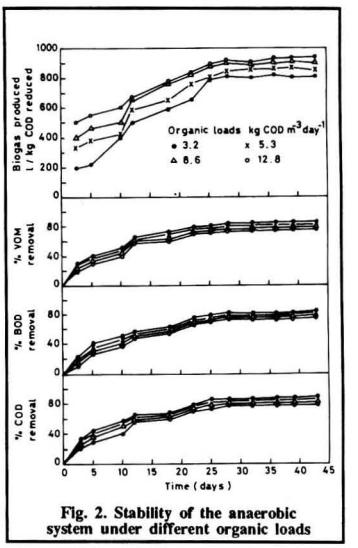

Fig. 2. Stability of the anaerobic system under different organic loads

out using a jar test procedure. This was intended to give the optimum coagulant dosage required. Coagulation was conducted on the effluent from the aerobic process at steady state. Ferric chloride (40% solution, w/w) and aluminium sulphate were used as coagulants.

Chemical analysis was performed according to the American Standard Methods[9].

Results and discussion

Anaerobic treatment: In an attempt to study the effect of organic load on biogas production, the up-flow reactor was subjected to organic loads expressed in terms of kg COD per m³ per day varying in the range 3.2 to 12.8, based on 22 hours retention time. The experimental program extended over a period of 180 days.

Characterization of vinasse waste water indicated that nitrogen and phosphorus contents were equivalent to a COD :N:P ratio of 100:1.2:0.1. It has been found that addition of nutrients is not required for the anaerobic process because the accumulation of nutrients in the system is high. At the same time nitrogen and phosphorus reduction is low, as expected, because bacterial growth is slow in anaerobic fermentation. The same findings were observed by Anderson *et al.*[10] and Russo *et al*[11].

From the results obtained (Figure 2) it can be seen that COD, BOD and VOM removal were low during the first two weeks; this was followed by a gradual increase until it reached its steady state after 25 days. The results, illustrated in Table I, clearly show that, within the range of organic loads used, the overall substrate removal efficiency of the anaerobic reactor, was of the order of 82%. This was not affected by the organic load of the influent, indicating that the reactor removal capacity had not been reached. Concentration of ammonia in the effluent showed a gradual increase from 15.6 to 29.3 mg N/litre, while the concentration of phosphate showed no change.

Figure 2 indicates that the daily gas production increases with the organic load whereas the methane concentration in the gas varies only slightly. The average biogas produced at steady state was 800, 860, 900 and 920 litres/kg COD removed for organic loads of 3.2, 5.3, 8.6 and 12.8 respectively.

The average flowrate of vinasse from the ethanol plant in Hawamdia is of the order of 2400 m³/day; this would give the possibility of producing 2000 m³/day of methane which is reasonable source of energy.

The overall substrate removal efficiency is very high, up to 82%. The effluent, however would need further polishing and so the effect of aerobic treatment using activated sludge was investigated.

Aerobic treatment: In the aerobic process the effluent from the anaerobic step was treated using a continuous activated sludge reactor at a retention time of 30 hr. The results (Table I) showed that about 92% reductions in VOM, BOD and COD may be achieved. Thus the anaerobic-aerobic combined process is capable of reducing the substrate organic content by 96%.

Chemical treatment: As the effluent after anaerobic-aerobic biological treatment still carries some organic and suspended matter, especially from higher organic load effluents (8.6 and 12.8 kg/m³/day), chemical coagulation was attempted. Experiments were carried out to determine the ratio of coagulant dose to flocculation effect and the amount of sludge produced. The optimal

9 "Standard methods for the examination of water and waste water", 16th Edn. (APHA, AWWA, WPCF, Washington), 1985.

10 *Proc. 3rd Turkish-German Enivironmental Engineering Symposium*, (Pergamon Press, London), 1980, 131.

11 *Proc. Symposium of Technology for Developing Countries* (Istanbul), 1982.

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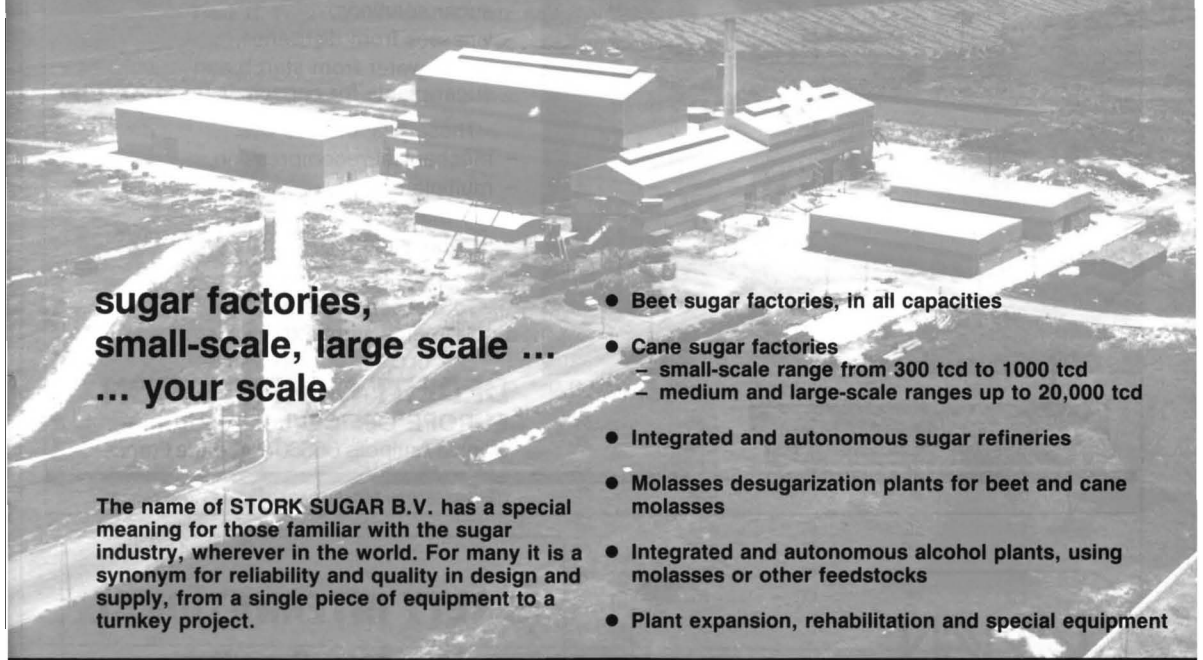

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Table II. Percentage removal of COD, BOD and organic nitrogen after chemical coagulation

Organic load 8.6 kg/COD/m³/day

Coagulant	Dose, mg/litre	COD *mg O_2/litre	COD % Removed	BOD *mg O_2/litre	BOD % Removed	Organic N *mg N/litre	Organic N % Removed	Sludge % by volume
$FeCl_3$	100	133	42.6	45	38.4	39	51	4.1
	200	133	58.2	45	49.2	39	62	4.2
	300	133	62	45	51.6	39	61	4.0
	400	133	62	45	52.2	39	60	4.1
$Al_2(SO_4)_3$, 18 H_2O	100	133	20	45	18.5	39	25	2.5
	200	133	23	45	21.2	39	30	4.5
	300	133	38	45	32	39	36	5.0
	400	133	36	45	32	39	41	5.4

Organic load 12.8 kg/COD/m³/day

Coagulant	Dose, mg/litre	COD *mg O_2/litre	COD % Removed	BOD *mg O_2/litre	BOD % Removed	Organic N *mg N/litre	Organic N % Removed	Sludge % by volume
$FeCl_3$	100	241	40.5	86	36.2	70	48	4.2
	200	241	52.2	86	45.5	70	52	4.5
	300	241	55.5	86	49.2	70	56	4.6
	400	241	56.4	86	52.5	70	58	4.6
$Al_2(SO_4)_3$, 18 H_2O	100	241	15	86	14.8	70	22	3.2
	200	241	19	86	17.5	70	28	4.7
	300	241	30	86	29.2	70	32	5.4
	400	241	28	86	24	70	39	5.8

* Anaerobic-aerobic effluent used in the chemical coagulation tests.

flocculation pH was adjusted according to the work of Leentvaar *et al*[12].

An illustration of the results obtained with alum is given in Table II. COD and BOD reduction values reached 19% and 17.5%, respectively, when 200 mg/litre was used at pH 6. The overall efficiency of the combined treatment reached 98%. The disadvantage of using alum as coagulant is the possibility of sulphate reduction coupled with release of H_2S when the oxygen supply is insufficient[13].

When ferric chloride was used at pH around 5 the data obtained showed successful results (Figure 3). COD and BOD reductions of 52.2% and 45.5% were obtained at a dose of 200 mg/litre. A slight improvement was observed on increasing the dose to 400 mg/litre. On calculating the total efficiency of anaerobic-aerobic treatment followed by ferric chloride coagulation, it was found that 99% reduction in COD was obtained.

Summary

Vinasse has been treated by a continuous anaerobic-aerobic process

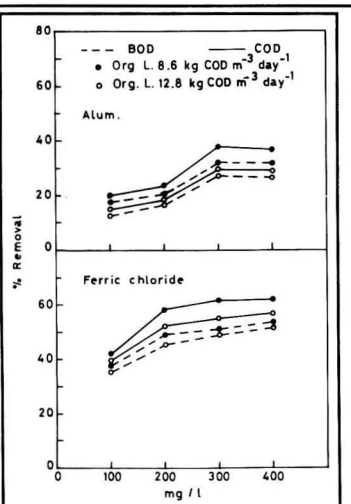

Fig. 3. Effect of chemical coagulation on COD and BOD removal

followed by chemical coagulation. The results obtained showed that the anaerobic-aerobic process may remove 96% of the COD, especially from lower organic load influents. The average biogas produced was about 900 litres/kg COD removed. The effect of anaerobic-aerobic treatment followed by ferric chloride coagulation was found to be a 99% reduction in COD value.

Fiji sugar exports, 1986[14]

	1986	1985
	tonnes, raw value	
Canada	0	19,025
China	30,934	57,933
EEC	174,469	185,670
Japan	0	14,918
Malaysia	66,097	61,932
New Zealand	41,120	36,154
Portugal	0	29,007
Singapore	0	14,504
US	14,736	0
Total	327,356	419,143

Rwanda sugar project study[15]

The African Development Bank is to finance a feasibility study on a sugar project in Acagera. The capacity of the factory is to be 11,000 tonnes a year and the necessary cane will be grown on 1000 hectares, which are to be irrigated. Total costs of the project are estimated at 280 million French francs.

12 *JWPCF*, 1979, **51**, 2457.
13 Idem: *Water Res.*, 1978, **12**, 35.
14 *I. S. O. Stat. Bull.*, 1987, **46**, (2), 22.
15 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 243.

Ethanol from cane molasses by continuous fermentation using immobilized yeast

By Untung Murdiyatmo and Sudijanto Tedjowahjono
(Department of By-products Utilization, Indonesian Sugar Research Institute, Pasuruan, Indonesia)

Introduction

Of recent years interest in the biotechnical production of ethanol has increased in a search for more economical production of alternate chemical feedstocks and liquid fuel. Owing to the high cost of raw material (60% or more of total production cost), high efficiency of conversion of the substrate is essential.

Recently continuous ethanol production using immobilized cells has been studied by Cho *et al.*[1], Kuu & Polack[2], Margaritis & Wallis[3], Wada *et al.*[4] and Williams & Munnecke[5]. By using the immobilized cell system, not only can high cell density be achieved but also there is no need for cell separation or cell recycle, and the risk of contamination is reduced.

Most of the above studies involved a synthetic medium. Data from Cho *et al.*[1] showed that, in continuous fermentation, the ethanol concentration in the mash decreased rapidly if the medium contained only glucose but the level of concentration could be maintained for 11 days if a complete medium was used. The Annual Report of the Taiwan Sugar Research Institute for 1982/83 also mentioned that the operational stability of an immobilized yeast system had been maintained for only nine days. It seems that the nutrient composition of the medium has an important role in maintaining the stability of continuous ethanol fermentation. This experiment was planned to examine some parameters relative to ethanol production from cane molasses using immobilized yeast.

Materials and methods

Micro-organism and culture condition

A local strain of *Saccharomyces cerevisiae* NS was used in this study. The strain was grown in shake flasks for 18 hr at 31°C±1°C in a medium with the following composition (in g/litre): yeast extract 5, malt extract 2.5, $CaCl_2$ 0.4, $MgSO_4,7H_2O$ 0.4, $(NH_4)_2SO_4$ 1.5, NaCl 1, KH_2PO_4 1 and glucose 30. The culture broth was then used for cell immobilization.

Immobilization technique

Sodium alginate (Fluka AG, Switzerland) was used as the immobilizing matrix and the immobilization technique used was a modification of the procedures described by Wada *et al.*[4] and Cho *et al.*[1]. Sodium alginate solution (100 ml, 2%) was mixed with 4 ml of culture broth. The mixture was extruded as drops into a 0.05M $CaCl_2$ solution of pH 4, at room temperature, using a 10 ml syringe with needle No. 14. The drops formed into beads upon contact with the $CaCl_2$. The beads (approx. 2 mm diameter) were stored for 24 hr at 4°C for complete gelation. The gel beads were then incubated in shake flasks at 31°C ±1°C in a medium, one of three media prepared, each with composition as mentioned above, except for alternative glucose concentrations of 30, 50 and 100 g/l.

Cell counts

Cell counts were carried out by dissolving 1 ml of gel beads in 100 ml of 1.36% KH_2PO_4 solution. The suspension was then diluted for cell counting under the microscope using a haemocytometer.

Fermentation medium

Molasses from a local sugar factory was brought to pH 4 with H_2SO_4 and clarified by heating to 86°C - 90°C for 15 minutes, then centrifuged.

Fermentation operation

Batch fermentations were performed in order to examine the activity of the immobilized yeast cells at various pH and temperatures. The ratio of volumes of beads to medium was 2:3.

Continuous fermentations went on in a single column of 55 mm i.d. and 435 ml working volume. Molasses medium (pH 4, total sugar 16 - 17%, urea 0.05%) was pumped continuously by a peristaltic pump (Pharmacia, USA) into the bottom of the column, the fermented mash overflowing at the top. The volume of immobilized yeast beads in the column was 20% of the working volume of the fermenter. The fermentation temperature was 31°C ±1°C.

Analytical methods

Total sugar concentrations were measured spectrophotometrically by the DNS (dinitrosalicylic acid) method[6]. Ethanol was determined by high performance liquid chromatography (Varian, Model 8500).

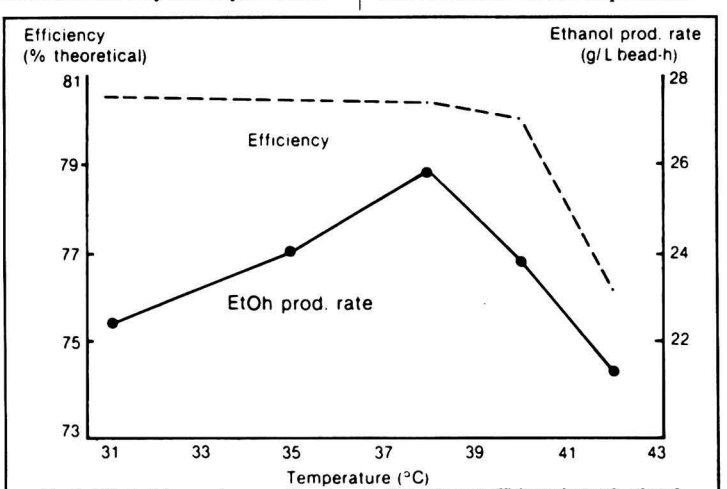

Fig. 1. Effect of temperature on ethanol production rate and efficiency in batch ethanol fermentation from cane molasses

Paper presented to the 19th Congr. ISSCT, 1986.

1 *J. Chem. Technol. Biotechnol.*, 1982, **32**, 959 - 967.
2 *Biotechnol. Bioeng.*, 1983, **25**, 1995 - 2006.
3 *Biotechnol. Bioeng. Symp.*, 1982, **12**, 147 - 159.
4 *European J. Appl. Microbiol. Biotechnol.*, 1980, **10**, 275 - 287.
5 *Biotechnol. Bioeng.*, 1981, **23**, 1813 - 1825.
6 Miller: *Anal. Chem.*, 1959, **31**, 426 - 428.

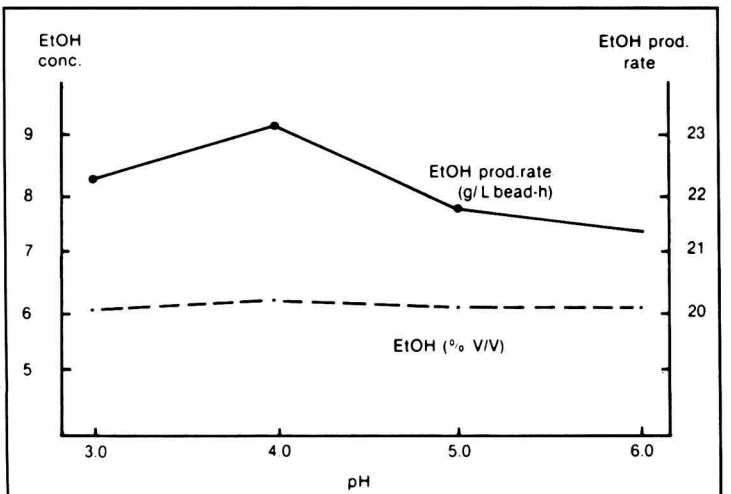

Fig. 2. Effect of initial pH on ethanol concentration and ethanol production rate. (Batch fermentation, at 31°C±1°C, molasses medium with 11.5% total sugar)

Results and discussion

Effect of temperature

Figure 1 shows that in the temperature range of 31°C to 38°C the fermentation efficiency was not affected but, at temperatures above 40°C, the efficiency dropped significantly. The hourly rate of production of ethanol, in terms of g/l beads increased from 22.4 units at 31°C to 25.8 units at 38°C, then decreased to 21.4 units at 42°C. The maximum rate occurred at 38°C; this accords with the study of a free cell system by Williams & Munnecke[5]. The similarity of the results indicates that in the immobilized yeast system the diffusion of ethanol from the beads was not limited by the Ca-alginate gel. This is suported by Tanaka *et al.*[7], who stated that the diffusion coefficient of a substrate with molecular weights less than 2×10^4, into and from 2% Ca-alginate gel beads, was similar to that of water.

Effect of pH

Generally, batch fermentations were carried out at pH 4 - 5. This order of pH was also nominated by Williams & Munnecke[5] as the optimum for the free cell system. Figure 2 shows the relationship between the initial pH of the medium and the concentration and rate of production of ethanol during batch fermentation using immobilized yeast. It is clear that the concentration of ethanol in the fermented mash was not influenced by the pH of the medium. A similar result was explained by Cho *et al.*[1] and Williams & Munnecke[5]; it could be due to the buffering effect of the Ca-alginate complex in the microenvironment of the yeast cell within the gel matrix[1]. At pH 4.0 the production rate was slightly higher than at the other pH values.

Preculture of immobilized yeast

It is necessary to establish a high density of cells in the gel beads before using them for continuous fermentation. Table I shows the effect of glucose concentration on the growth of yeast cells within the gel; of the three levels of glucose 5% was clearly the best and

7 *Biotechnol. Bioeng.*, 1984, **26**, 53 - 58.

Table I. Cell density of gel beads after incubation in the medium with different glucose concentrations

Glucose, % w/v	Incubation time, hr	Viable cells/ml gel bead
3	20	2.4×10^9
5	40	8.0×10^9
10	60	6.2×10^9

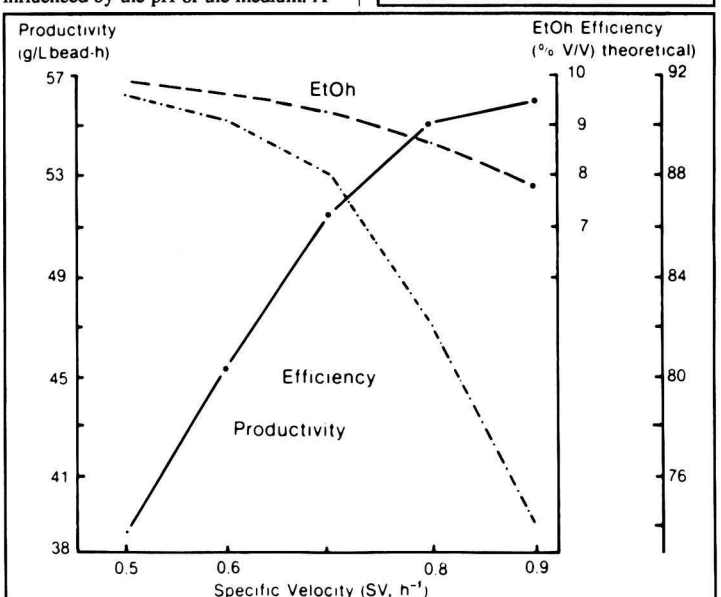

Fig. 3. Performance of 7 days continuous ethanol fermentation from cane molasses at different specific velocity of medium

this level was adopted for preculturing of beads for the continuous tests.

Continuous fermentation

Specific Velocity (SV) of the fermentation medium is defined as the effluent volume discharged from the fermenter (ml/hr) divided by the bead volume (ml); hence SV has the dimension hr^{-1}.

Figure 3 shows the relationship between specific velocity and (1) ethanol concentration in the fermented mash, (2) ethanol productivity and (3) fermentation efficiency. Higher levels of ethanol in fermented mash and higher efficiency could be obtained at lower specific velocity, but the productivity would be very low. The concentration of ethanol ranged from a maximum of 9.8% v/v (91.3% efficiency) at a specific velocity of 0.5 hr^{-1}, to 7.9% v/v (74.2% efficiency) at a specific velocity of 0.9 hr^{-1}. It was noted that, when all the sugar in the medium was utilized by the yeast, the yield of ethanol was 95% of the theoretical limit.

Effect of medium supplementation

Operational stability is a key feature of continuous fermentation. Figure 4 shows that continuous production from cane molasses could be maintained steadily for only nine days. (This agrees with the 1982/1983 data from the Taiwan Sugar Research Institute[8]). The ethanol concentration dropped drastically at the eleventh day, and this was due to a decrease of over 50% in the cell viability. The addition of yeast extract (0.25%) increased the ethanol concentration, but the effect could not be maintained. In continuous fermentation using immobilized yeast, an active growth of yeast cells within the gel matrix is needed to balance the decline in viable cell numbers caused by the death of cells and by leakage from the bead. The addition of yeast extract had some effect but the result was not satisfactory.

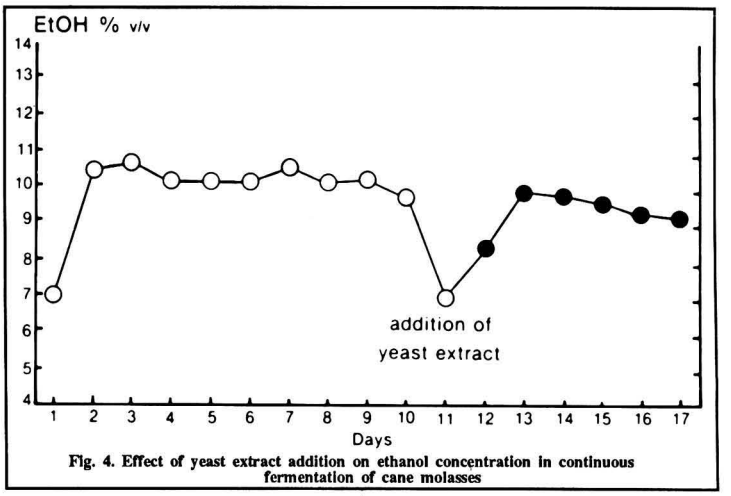

Fig. 4. Effect of yeast extract addition on ethanol concentration in continuous fermentation of cane molasses

Figure 5 shows the performance of continuous fermentation supplemented by a small amount of ergosterol. Ergosterol was added to the medium at a concentration of 1 mg/l and the gel beads (at the bead preparation stage) at a concentration of 10 mg/l beads. With this treatment the efficiency of fermentation could be maintained within reasonable limits for 24 days, with an average efficiency of 91.04%. Ergosterol may play an important role in promoting yeast growth under anaerobic conditions[9]. The other possibility is that ergosterol may replace the role of molecular oxygen needed by the yeast cells in the conversion of sugars to ethanol[10]. At the end of the continuous fermentation it was observed that the physical strength of the gel beads had decreased and the gel had become soft. This might be due to the disturbance of Ca-alginate bonds by certain ions in the molasses, such as Mg, K and phosphate[2].

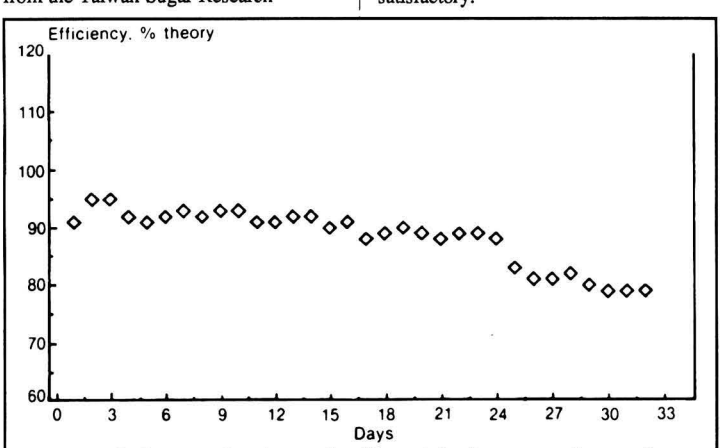

Fig. 5. Performance of continuous ethanol fermentation from cane molasses medium supplemented with ergosterol

Summary

Cells of a strain *Saccharomyces cerevisiae* were cultured in a broth of glucose and other ingredients for 18 hours. The culture was then combined with sodium alginate solution and

8 *Ann. Rpt. Taiwan Sugar Research Inst.*, 1982/83, 30 - 31.

9 Ohta & Hayashida: *Appl. Environ. Microbiol.*, 1983, **46**, (4), 821 - 825.

10 Furukawa *et al.*: *Biotechnol Bioeng.*, 1983, **25**, 2293 - 2317.

extruded into $CaCl_2$ solution to form beads. The beads were then incubated in various nutrient media of which the best, containing 5% glucose, yielded beads with cell counts of 8×10^9/ml of gel. Tested in batch fermentation the immobilized yeast yielded final alcohol concentrations almost independent of pH in the range of 3 to 6, with a moderate maximum rate of production at pH 4. The optimum temperature was 38°C. In a continuous fermentation column at a flow rate of 0.5 units the rate of production of ethanol per unit gel per unit time was 38.8 units and the efficiency of conversion 91.3%. At the maximum rate of 0.9 units the rate of production rose to 55.9 units but the efficiency fell to 74.2%. It was found that the performance of the column deteriorated sharply after nine days; the addition of yeast extract restored the performance but briefly. A further test was conducted using ergosterol in the beads and in the feed; production was then maintained at an average efficiency of 91.04% over 24 days.

BY-PRODUCTS

Production of pulp and fodder from bagasse

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Introduction

Traditionally high yield pulp production has depended upon conventional mechanical or chemical-mechanical pulping processes. Several authors[1,2] have reported on biological pretreatment of wood by white-rot fungi in order to reduce the energy demand during the refining stages of high yield pulping. Plane[3] and Dekker & Wallis[4] worked on the pretreatment of bagasse by steam explosion to obtain pulp and to increase the susceptibility to enzymic saccharification. The advantages of using bagasse as substrate for bioconversion are that it has carbohydrate constituents (cellulose 40% to 50% and hemicellulose 20% to 30%).

A typical feature of white-rot fungi is their ability to degrade cellulose, hemicellulose and lignin. In order to prevent the cellulose from being degraded and to obtain more specific lignin degradation, cellulose-restricted strains have to be used.

The aim of this paper is to present a review of the ability of white-rot fungi *Spotrichum pulverulentum* (Novobranova P 127) and selected cellulose-restricted strains of *Phanerochaete chrysosporium* K-3 in the pretreatment of the bagasse prior to refining to save energy – which is one of the crucial points in the economy of newsprint production – and also to reduce the lignin content to make bagasse more easily digested by ruminants.

Biopulping production

Wild type strain

In order to test the ability of a wild strain to degrade the bagasse, four experiments were performed, each in a 6-litre flask, previously sterilized and inoculated with the fungus spores ($5 - 10 \times 10^6$ spores/100 ml) supplemented with a salt solution[5]. The inoculated samples were incubated at 32°C for 15 days. The different conditions of the experiment

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1 Kirk & Chang: *Proc. EUCEPA Symposium*, 1980, **3**, 25:1.
2 Erikksson & Vallander: *Sverst. Papperstidn.*, 1982, **85**, R33 - R38.
3 *Biotechnol. Bioeng.*, 1984, **21**, 426 - 433.
4 *Biotechnol. Bioengi*, 1982, **25**, 3027 - 3048.
5 Gutiérrez & Fernández: *Proc. 18th Congr. ISSCT*, 1983, 127 - 150.

Table I. Values of yield, residual lignin and polysaccharide in bagasse using the wild strain

Sample	*Final yield on bagasse, %*	*Lignin in bagasse, %*	*Polysaccharide in bagasse, %*	*Lignin loss, %*	*Polysaccharide loss, %*
Bagasse (M_0)	100	23.1	76.0	-	-
CTM pulp	87.7	18.3	68.7	4.8	8.2
Bagasse + 2% NaOH (M_1)	93.0	21..1	71.9	2.0	5.0
Bagasse + 5% NaOH (M_2)	90.9	18.3	72.6	4.8	4.3
Bagasse + 10% NaOH (M_3)	88.8	15.8	73.0	7.3	3.9
Expt. 1: M_0 + fungi	77.0	17.8	59.2	5.3	17.7
Expt. 2: M_1 + fungi	71.6	166.0	55.6	7.1	21.3
Expt. 3: M_2 + fungi	64.0	14.2	49.8	8.9	27.1
Expt. 4: M_3 + fungi	54.5	10.4	44.1	12.7	32.8

were: in (1) bagasse was treated only with fungus to produce biomechanical pulp; and in (2) to (4) bagasse was previously treated with 2%, 5% and 10% NaOH, respectively, at room temperature for 20 minutes. These samples were then washed, adjusted to pH 4.7 with acetic acid and treated with the wild type strain.

Two standard pulps (chemical-mechanical and mechanical) were prepared for comparison. Bagasse samples treated only with 2%, 5% and 10% NaOH were included as references or blanks for the experiments. The values of yield, residual lignin and polysaccharide on bagasse are presented in Table I.

The table clearly shows the decrease in yield owing to the activity of sodium hydroxide, from 100% corresponding to the original bagasse to 88.8% for the sample impregnated with 10% NaOH. After fungal treatment the yield decreased from 77% for the original bagasse to 54.5% for the bagasse previously treated with 10% NaOH. Total lignin losses from both NaOH and fungus treatments were in the range 2% to 12% and those of polysaccharides from 4% to 33%.

In Table II are listed the losses in yield, lignin and polysaccharides due to the fungal activity. It may be seen that the maximum level of lignin loss in any experiment is between 4% and 5.5%, and the loss of carbohydrates is in the range of 17% to 29%, depending on the previous NaOH treatment.

The rotted bagasse samples were later refined and the strength properties were evaluated. In spite of the lignin degradation by the fungus it was not possible to obtain a high yield of pulp of acceptable quality.

Table II. Losses in yield, lignin and polysaccharides due to fungal activity using the wild strain

Sample	Yield loss, %	Lignin loss, %	Polysaccharide loss, %
Bagasse	23.0	5.3	17.7
Bagasse + 2% NaOH	17.0	5.1	16.3
Bagasse + 5% NaOH	20.0	4.1	22.7
Bagasse + 10% NaOH	27.0	5.4	28.9

Cellulose-restricted strain (Cel^-)

The next stage was conducted using cellulose-restricted strains and a suitable solid state fermentation reactor (SSF) of 20 litres capacity. These experiments were carried out in the STFI laboratories in Stockholm, under a collaboration program supported by Sarec between the Professor Eriksson Laboratory in STFI and ICIDCA-Cuba 9 in Cuba.

The Cel^- strains grow very well and homogeneously on bagasse but, after several experiments, it was evident that neither wild nor cellulose-restricted strains were able to grow on unsupplemented bagasse that had been pretreated with NaOH. The reason is that the cellulose-restricted strains depend on free sugar and hemicellulose for growth and lignin degradation in bagasse. Caustic soda pretreatment and further washing with acid remove the supply of sugar.

The best results came from combined treatments using fungal pretreatment followed by chemi-thermo-mechanical pulping using the Cel^- strain 85118-6 derived from *P. chrysosporium* K-3 by mutation and intercrossing[6]. The fungal treatment, without any salt addition, was carried out in a 20-litre SSF. The material was then processed by impregnation and refining according to the Cuba 9 chemi-mechanical process[7,8]. The pulp obtained was called bio-chemi-mechanical pulp (BCMP) and is compared with the Cuba 9 pulp (CMP) in Table III. This table shows the experimental conditions, the properties of the pulps and the energy demand of both processes.

According to these results, the strength properties of the pulps obtained in both processes are comparable, meaning that BCMP technology is able to produce pulp of acceptably high yield and quality. The most important advantage of the BCMP process is the high energy saving during both refining stages (75%) compared with the standard CMP process[9].

Animal feed production

Steam-exploded bagasse has been used to obtain protein by submerged fermentation using the white-rot fungus *P. chrysosporium* Burds (anamorph *S. pulverulentum novobranova*[10]), a heat tolerant white-rot fungus capable of degrading all the main components – cellulose, hemicellulose and lignin. The strain was maintained in frozen wood chips[11]. The bagasse was steam-exploded; the explosion temperature was 245°C for one minute. The dry matter of the exploded bagasse was 30% and the lignin content 30%.

For protein production the fungus was grown in 250 ml flasks on 100 ml of modified Norkrans medium[12] at pH 4.7, with 4% (w/v) steam-exploded

Table III. Hand sheet properties for different biochemical bagasse pulps

Conditions and properties	CMP	BCMP
Rotting time, days	-	20
NaOH on bagasse	Cuba-9 process	Cuba-9 process
Energy demand, kWh/tonne		
Total	3810	1710
1st stage	810	210
2nd stage	3000	1500
Sh°	70	70
Density, kg/m^3	500	540
Tensile strength, Nm/g	40.9	43.3
Tear strength, mN/m^2/g	4.75	4.68
Burst strength, kPa/m^2/g	1.68	2.14
Yield, %	89.0	86.5

6 Johnsrud & Eriksson: *Appl. Microbiol. Biotechnol.*, 1985, **21**, 320 - 327.
7 Gutiérrez *et al.*: *Non-Wood Fiber Pulping Program Rpt.* (Cuba-9 Project), 1979, (10), 99 - 109.
8 Vilamil & Aguero: *TAPPI Non-Wood Plant Fibre Pulping Progress Rpt.*, 1982, (12), 15 - 23.
9 Johnsrud *et al.*: *Holzforschung*, 1985 (In press).
10 Burdsall: *Mycologia*, 1981, **73**, 675 - 680.
11 Eriksson & Johnsrud: *Enzyme Microb. Technol.*, 1983, **5**, 425 - 429.
12 Ayers *et al.*: *Eur. J. Biochem.*, 1978, **90**, 171 - 181.

bagasse. The flasks were inoculated with 2×10^8 conidiospores and grown for 14 days at 28°C on a rotary shaker at 150 rpm. Flasks were harvested every one or two days. Conidiospores were made from rice-grown cultures[11].

The organic matter digestibility (OMD) of steam-exploded bagasse was 60% compared with 12% for untreated bagasse. The incomplete conversion of cellulose to glucose (60%) is probably due to insufficient amounts of ß-glucosidase in the trichoderma cellulose solution[4].

The development of steam-exploded bagasse fermentation under submerged conditions by *P. chrysosporium* P 127-1 is shown in Figure 1. The OMD decreases with the time of fermentation from day 4 on. However, the values are higher than for untreated bagasse after 14 days (20% and 12%, respectively). During the fermentation the amount of reducing sugars decreases from 3.6 g/litre to 0.6 g/litre after 10 days. At the same time, the protein content increases and, after 10 days, 18% of protein was obtained[13]. Figure 1 also shows the protein content and OMD obtained in solid-state fermentation with bagasse according to the method of Agosin & Odier[14].

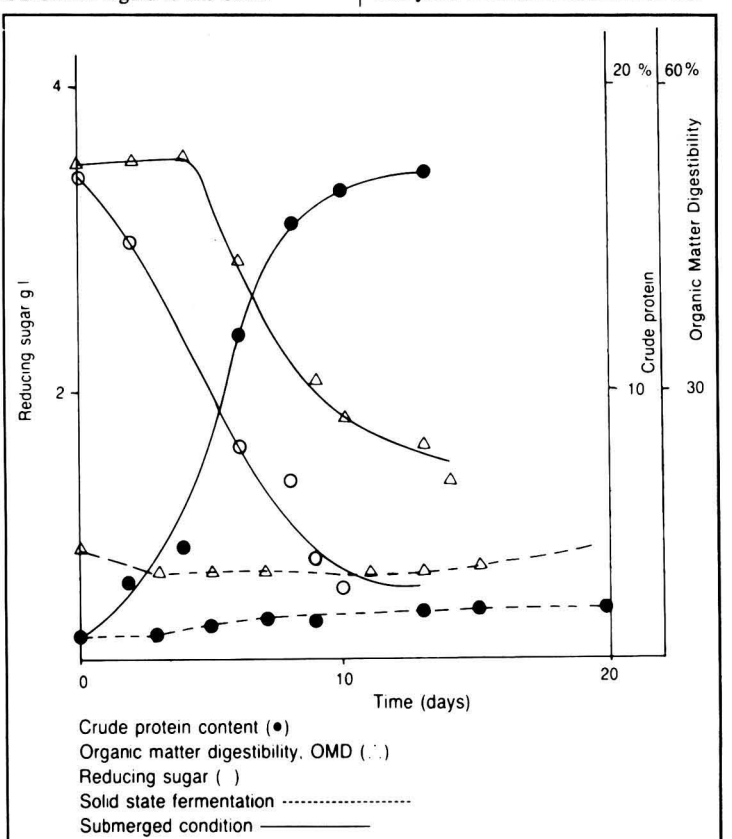

Fig. 1. Development of steam-exploded bagasse fermentation under submerged condition and solid state fermentation condition by *Phanerochaete chrysoporium*

Conclusions

The results obtained during the past five years work have demonstrated that bagasse is efficiently degraded by white-rot fungus *S. pulverulentum* and its cellulose-restricted strains. In conditions suitable for solid-state fermentation (SSF) it has been possible to obtain good quality pulp in high-yield using a two-stage technology (fungal pretreatment with a Cel^- restricted strain, followed by conventional chemi-mechanical pulping) with 60% to 75% energy saving during refining stages of pulp manufacture.

Steam-exploded bagasse was a better substrate for fermentation by *P. chrysosporium* P 127-1 than untreated bagasse in terms of protein content and OMD. The reason for this is that the steam explosion of bagasse causes a decrease in the molecular mass of lignin and hemicellulose, renders cellulose porous and causes a decrease in the degree of crystallinity of cellulose; thus, the bagasse becomes more accessible to the fungus. The use of steam-exploded bagasse for protein production in submerged fermentation is a promising process with possibilities for scaling–up.

Summary

Wild and selected cellulose-restricted strains of the white rot fungus *Phanerochaete chrysosporium* K-3 were tested for their ability to delignify bagasse. The strain 85118-6 was found to be an efficient lignin degrader for pulping purposes. In relation to pulp, the most promising results came from a two-stage process; solid-state fermentation (SSF) followed by cold soda impregnation before refining. The quality of the bio-chemi-mechanical pulp (BCMP) was very close to that of the chemi-mechanical pulp (CMP) in strength, yield and lignin content. The main advantage obtained with BCMP is the energy saving in refining, amounting to 65% to 75% compared with CMP. In relation to the use of bagasse for ruminant food, a good increase in the protein content of steam-exploded bagasse (18% crude protein) was achieved using the wild type strain.

13 Johnsrud & Lopez: *Biotech. Letters*, 1985, (In press).
14 *Appl. Microbiol. Biotechnol.*, 1985, 21, 307 - 403.

Facts and figures

New Central African Republic sugar factory[1]

The first sugar factory in the Central African Republic, at Bambari in Ouaka province, is scheduled to open by the end of the year, with an annual capacity of 6000 tonnes. The factory is part of a US $27 million sugar cane development project backed by a group of bilateral and multilateral donors in 1985. Some 1300 hectares of cane have been planted, and the factory will meet domestic demand for white sugar until 1990.

New Sri Lanka sugar project

The Sri Lanka government is considering a proposal made A/S De Danske Sukkerfabrikker and IFU of Denmark for setting up a sugar factory and plantation in the Mahaweli System C area, where there are about 9000 hectares of land considered to be more suitable for sugar cane cultivation than any other alternative crop. The 480 million rupees project consists of a factory to crush 4000 tonnes of cane per day, a nucleus estate with an area of 5300 hectares and an outgrowers area of nearly 4000 hectares.

Swaziland distillery projects[2]

The Government of Swaziland has approved construction of an alcohol plant at one sugar factory and is expected to permit the other factories to build plants. Construction is expected to be accomplished in 1988 and alcohol production should start in 1989. After 1990, most of Swaziland's molasses will be used for alcohol manufacture.

Sockerbolaget AB 1986 annual report

The registered name of the company was changed on January 1, 1987 from the former Svenska Sockerfabriks AB and restructuring of this Swedish sugar producer took place as it became part of the Volvo Group which had bought the previous holding company AB Cardo. In the 1986 campaign the average beet yield of 42.6 tonnes/ha was lower than the previous 5-year average but the sugar content was a record 19.1% and the factories produced 355,000 tonnes, against 318,000 tonnes in 1985.

Dominican Republic sugar situation[3]

The sugar cane area harvested in the Dominican Republic in 1986 was reduced by 9% to 160,000 hectares but it is expected to increase to 170,000 ha in 1987 because of improved management and better financial conditions for CEA, the largest producer. The government eliminated a surcharge of 18% on the export value of sugar in 1986. The sugar industry is engaged in a country-wide diversification program to produce other crops, cattle and to promote tourism. The Vicini Group has closed one of its three factories and is growing other crops on the former cane land, while the CEA's Central Catarey has been closed and its sugar cane diverted to other factories. It is expected that one more mill will be closed in 1988. For the first time in many years, the CEA has paid all its debts to the cane suppliers. At the same time it is engaged in programs to increase productivity and reduce production costs. Most of the projects for alcohol production have been frozen in anticipation of more favourable conditions with respect to petroleum.

Cuba sugar exports, 1986[4]

	1986	1985
	tonnes, raw value	
Albania	22,154	21,981
Algeria	98,767	80,666
Angola	57,991	51,029
Bangladesh	12,349	0
Bulgaria	302,838	399,531
Canada	168,025	152,279
China	207,241	680,134
Czechoslovakia	105,803	133,678
Dutch Antilles	0	1,083
EEC	12,438	6,995
Egypt	138,569	181,676
Finland	61,744	75,508
Germany, East	271,079	277,152
Ghana	12,388	0
Guinea Bissau	1,083	0
India	0	108,498
Iraq	55,318	130,154
Japan	534,487	511,375
Kampuchea	3,254	0
Korea, North	19,582	24,072
Libya	57,819	113,156
Malaysia	56,311	52,180
Mongolia	4,729	4,717
Pakistan	28,458	0
Peru	40,859	0
Poland	104,786	134,350
Rumania	56,385	62,516
Sri Lanka	12,999	13,195
Sweden	25,129	12,761
Switzerland	3,257	3,013
Syria	50,775	62,989
Tunisia	37,563	76,112
Uganda	5,416	0
USSR	4,019,793	3,709,272
Venezuela	0	123,094
Vietnam	10,487	3,137
Unknown	2,712	2,705
Total	6,602,588	7,209,008

China sugar imports and exports, 1986[5]

Imports of sugar into China in 1986 totalled 1,182,491 tonnes, raw value, compared with 1,908,721 tonnes in 1985. Sugar exports in 1986 rose nearly 100,000 tonnes to 289,645 tonnes, so that net imports of 893,000 tonnes were substantially down from net imports of 1,718,000 tonnes in 1985.

HFS manufacture in India[6]

High fructose syrup is being made on a commercial scale by Maize Products, of Ahmedabad. The plant, which has operated since August 1985, has a capacity to produce 20 tonnes of HFS per day. Prospects for the sweetener in India will depend on the cost of the raw material, maize, and its acceptance by soft drink manufacturers.

Pakistan cane sugar production, 1986/87[7]

Pakistan's 1986/87 cane sugar season, which was completed at the end of April, produced 1,255,929 tonnes, white value, up 14% from 1,102,315 tonnes the year before. Factories in the North West Frontier province were expected to start producing beet sugar by the middle of May and to produce some 20,000 tonnes, white value. A total of 1,274,000 tonnes will, however, be far from sufficient to cover domestic consumption, estimated at 1.6 million tonnes which will necessitated sugar imports of 300,000 tonnes, white value.

British Sugar plc ownership[8]

Associated British Foods has bought its holding in S & W Berisford from the Ferruzzi Group who had bought the shares as part of its unsuccessful bid to acquire British Sugar plc, owned by Berisford. ABF have referred to their Berisford holding as a long-term investment but have refused to discuss its future amid speculation that it intends a take-over bid to obtain control of British Sugar.

1 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 226.
2 *Amerop-Westway Newsletter*, 1987, (162), 12.
3 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 241.
4 *I.S.O. Stat. Bull.*, 1987, **46**, (4), 12 - 13.
5 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 243.
6 *Indian Sugar*, 1987, **36**, 601.
7 F. O. Licht, *Int. Sugar Rpt.*, 1987, **119**, 228, 261.
8 *The Times*, May 14, 1987.

PERSONAL NOTES

Prof. Dr. **Jan Dobrzycki** is to retire at the end of September 1987 after a career spent in sugar technology both as industrial technologist and an acadamic lecturer. Born in Freiburg, Switzerland, in 1917, the son of a University professor, he has lived in Poland since 1919. He studied chemistry at the University of Posen, graduating in 1939, while from 1938 he worked in the Miejska Górka sugar factory until 1954, the last nine years as Works Manager. In 1954 he joined the staff of Lodz Polytechnic under Professor S. Zagrodzki, winning his doctorate in 1961. In 1976 he became head of the Sugar Department and in 1978 was appointed Professor. He is the author of four Polish books on sugar technology and has contributed to studies on juice purification, laboratory and process automation, chemical analysis and the chemical principles of sugar technology. He has been active in the CITS and also ICUMSA over many years as well as a contributor to this Journal on a number of occasions.

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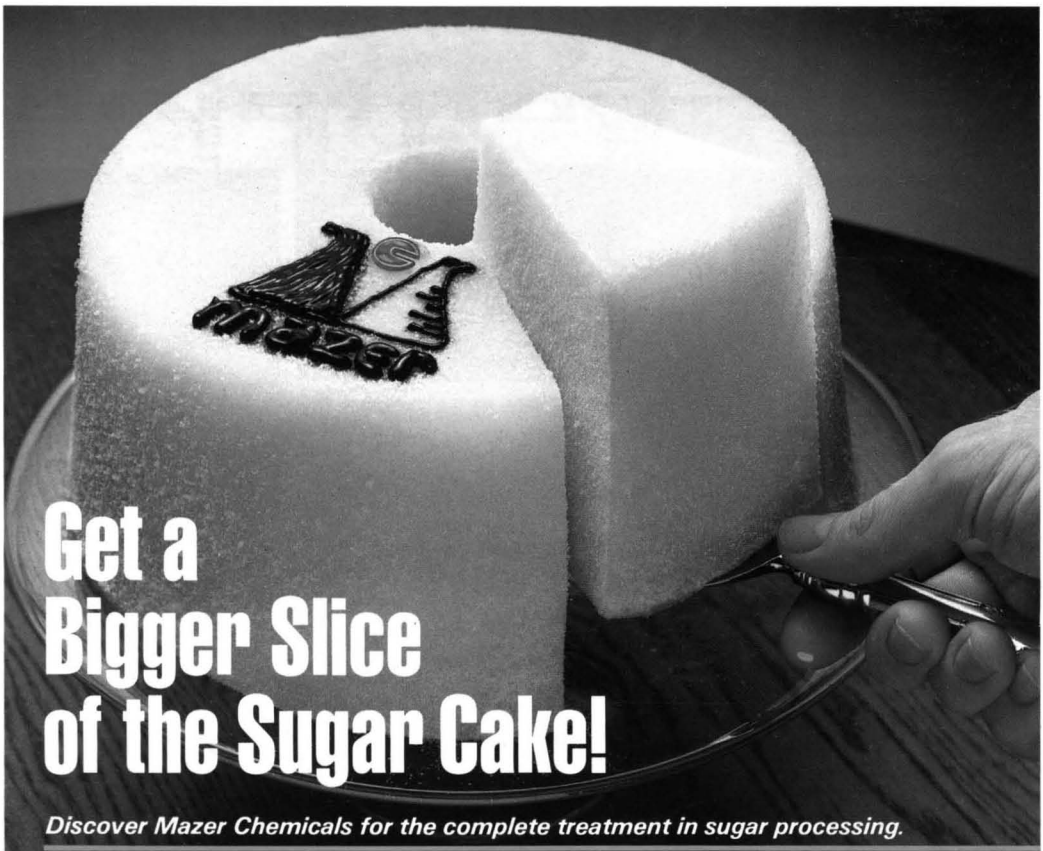

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