REDUCTION OF SUGAR LOSS DUE TO 'CUT-TO-MILL' DELAY BY THE APPLICATION OF A UNIQUE NEW CHEMICAL COMPOSITION CALLED SUCROGUARD

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Abstract

In India, the loss of sucrose content in cane as a result of 'cut-to-mill' delays can be extremely high during the summer months. A novel chemical formulation, Sucroguard, developed and patented in India, was tested to determine its effectiveness in controlling post-harvest cane deterioration. Results showed that a 10 ppm dose reduced invert sugars and tiratable sugars in primary juice, and reduced the total mesophilic bacterial count by 50%. It was found that the use of Sucroguard could result in a net benefit per million tons of cane of US$720 000.

Introduction

The major causes of sucrose loss through inversion are harvest-to-crush delays and temperature. In India, cane is harvested manually as green cane. It has been observed from data on invert sugars and titrated acidity of primary juice that these sugar losses can be very high, reaching a magnitude of more than 25 kg per ton cane in summer in Uttar Pradesh State, and even higher in the coastal regions of Tamil Nadu and Andhra.

In addition, deterioration further increases if the cane supplies are from fields with problem soils, burnt fields, fields where nitrogenous fertilizers have been applied in excess, or fields affected by pests and diseases. Delays in processing burnt cane are more harmful than in unburnt cane, with observed losses being two to three times higher. It has been reported that, after burning, purity decreased from an initial value of 83 to below 70 over a period of 14 days (Clarke, 1994; Clarke, 1997a,b).

Possible reasons for post-harvest deterioration of sugarcane

There are several practices, both on the farm and at the mill, that cause delays and affect sugar recovery:

- A lack of up-to-date scientific knowledge among the cane management staff and workers encourages the tendency to blame cane quality rather than inefficiency for low recovery of sucrose. This is entirely due to the fact that cane quality measurements begin only at the mixed juice stage, and major losses have already occurred prior to this. The lack of accountability until this point in the process makes it easy to assume that cane of low quality was delivered to the factory. The Cane Delivery Officer blames low quality on unpredictable weather conditions. This practice has never allowed any study in this area, as there is no interest in measuring the amount of sugar in cane deliveries.

- The absence of scientific harvesting schedules based on cane maturity is a problem that is aggravated by poor germination rates which call for re-sowing, particularly in Uttar Pradesh. The cane in a particular field can thus be at different levels of maturity. This situation is exacerbated when different varieties are planted in the same field, based on seed-cane availability.
- Unplanned cutting orders and the supply of additional transport to satisfy members, without considering the current yield of the cane, can result in the cane becoming stale in the cane yard.
- The prevalent practice of harvesting the cane two to four days prior to transportation to the cane centres/mills causes a drop in cane quality. Delays in transportation due to the unavailability of trucks and trolleys, damage to vehicles caused by bad road conditions, and a lack of preventive maintenance of vehicles also add to the sugar losses.
- Scarcity of manual labour for harvesting is a problem that is becoming more and more serious. In states such as Uttar Pradesh, farmers have to harvest their own cane. The family members of small-scale farmers cut the cane, thus the harvesting starts a few days prior to the cutting order date, as per the farmer's convenience. On the cutting order date, the cane is supplied to the cane centre for further transportation to the factory. In the western states of India, where the factories do the harvesting, there is much more discipline and relatively less problems. This may be one of the major reasons for higher sugar recovery in these states.
- It has been observed that when excess crop is available, the khandsari units refuse some cane deliveries and, due to political pressure, factories have to accept and crush this cane. On the other hand, when the cane is in short supply these units offer better prices, taking away factory cane and causing factory stoppages due to want of cane. In both situations, the factory loses precious sugar recovery.
- Factory shutdowns caused by mechanical failure and other unforeseen circumstances are also a cause of cane deterioration.

Inversion and dextran control in harvested cane

Field management - physical methods

- Harvesting of immature or over-mature cane should be avoided to cut down the post-harvest sugar losses. As the level of maturity increases the extent of sucrose loss is minimised. It is therefore necessary to implement harvesting schedules based on cane maturity, especially in the low recovery areas.
- It has been shown that topped cane deteriorates faster than cane with the crown of leaves attached. Topping should be avoided if a delay in crushing is anticipated. The cane can be stripped of trash, leaves and roots before milling.
- There is no substitute for good communication that results in quick and efficient transport. Management should enforce the rule of 'first cane in is first cane out'.
- It is also important to identify sugarcane varieties with high sucrose content and that are less inclined to post-harvest inversion (biochemical and microbiological). These varieties should also be screened for rind hardness and wax content.
- Cleanliness in the cane yard is most important. The transport and storage of cane also affects the process of dextran formation, i.e. the degree of damage from loading equipment, and the size and shape of the container. The cane should always be stored in small bundles in a properly ventilated place. Excessive mechanisation in the form of grab loaders, chains and slings tends to bruise cane, which hastens deterioration.

Despite all the physical means of controlling post-harvest deterioration, there will always be some harvest-to-crush delay. Even a delay of 24 hours, which is considered good factory management, is likely to cause some loss of sugar, especially in hot climatic conditions. The use of chemicals to avoid this loss has often been attempted in the past; however, other than the present study, only one was found to have been commercially successful (Ravelo *et al*., 1991a,b; Rivero and Ramos, 1991; Susana *et al*., 1991).

In 1991, the Cuban Sugar Research Institute (ICINAZ) developed a new compound, Ifopol, from sugarcane molasses, which has strong bactericidal properties. The use of Ifopol was found to completely inhibit the formation of dextran and alcohol, even 96 hours after treatment. The microbial count was reduced considerably with Ifopol treatment, leading to a substantial decline in the formation of dextran, starch and alcohol in green and burnt cane.

The effects of Ifopol are more pronounced than those of a 100 ppm solution of cetyl trimethyl ammonium bromide (CTAB). Mixing Ifopol at rates of 10-100 ppm in juice fully inhibited the formation of oligosaccharides (which diminish processing efficiency and raw sugar quality) for more than three days (Ravelo *et al*., 1991a,b; Susana *et al*., 1991). Rivero and Ramos (1991) observed that using Ifopol at 100 ppm reduced the content of both polysaccharides and oligosaccharides by 3.5 times. The recommended dosages for green and burnt cane are 10 and 100 ppm, respectively.

Materials and methods

Sucroguard
Sucroguard is a patented formulation (Indian Patent No. 181740 dated 07.03.1995) manufactured by VM Biotech, Bicholim Goa, India.

Sucroguard at 10 ppm should be applied to the cut ends of the cane immediately after cutting, by dipping the cut ends into the dilute solution. A dilute solution of 100 ml Sucroguard in approximately 30 litres of clean water is sufficient for treating 10 tons of cane.

Sampling
Because Sucroguard is aimed at restricting cane deterioration, analysis of first expressed/primary juice is important. Arrangements must thus be made to reliably collect hourly composite samples of primary juice. This is essential as variations in cane quality, even from the same field, are very common. The use of a preservative, such as 0.5% mercuric chloride, is recommended.

Analysis
Samples should be analysed for Brix, Pol, reducing/invert sugars, acidity, pH and, if possible, for alcohol and dextran content.

In the tests reported below, analyses were performed as follows:
- Brix by brixometer, using correction factors.
- Pol by standard method, using polarimeter and correction table.
- Invert sugars by standard Enon-Lyne method.
- Acidity by titration against standard 0.1 N NaOH, using pH 8.3 as the end point.
- Microbial counts were taken by the standard plate count method, using 10-fold serial dilution and paper plate techniques on sucrose-dextrose yeast extract agar medium.

Laboratory test 1: conducted at 1250 tons cane/day factory in Andhra Province
Two bundles of cane of approximately 100 kg each were taken to the laboratory, where one bundle was dipped in Sucroguard solution immediately after harvesting. Both bundles were kept in the laboratory for 24 hours, after which they were crushed in the laboratory mill and analysed for all parameters. The results are compiled in Table 1.

Table 1. Results of test using two 100 kg bundles of sugarcane (treated and untreated) with 10 ppm sucroguard solution as medium to prevent deterioration. Test conducted at 1250 tons cane/day sugar factory in Andhra Province, India.

Particular	Brix	Pol	Purity	RS %	RS per 100 Brix	TA per 100 Brix
Control	18.04	16.75	90.74	0.86	4.77	10.53
Sucroguard	21.01	19.22	90.74	0.36	1.72	09.52
Difference	02.97	02.47	~	0.50	3.05	01.28
	16.46%	14.45%	~	58.14%	63.94%	12.16%

RS = reducing sugars
TA = titratable acidity

Laboratory test 2: conducted at Shakti Sugars, Erode, Tamil Nadu
Two loads of approximately 1000 kg each were collected from one field. One load was treated with Sucroguard (1 ml diluted in 3.5 litres of clean water). Both loads were kept in a shed and were later crushed in a small mill. A juice sample from each crushing was analysed. A total of five sets of experiments were conducted, in which Sucroguard was applied by hand spray to three sets, and the cut ends of the cane in the remaining two sets were dipped into a Sucroguard solution. The results are compiled in Table 2.

Table 2. Results of tests in which sucroguard solution (1 ml in 3.5 litres water) was applied to sugarcane by spraying and dipping to prevent deterioration. Tests were conducted at Shakti Sugars, erode, Tamil Nadu, India.

Date	Post-harvest duration (hours)	Control					Sucroguard treated					Deviations	
		Brix	Pol	Purity	RS per 100 Brix	% recovery	Brix	Pol	Purity	RS per 100 Brix	% recovery	Reduction in RS per 100 Brix	Rise in % recovery
Sprayed 16.4.97	36	19.66	16.61	84.49	5.54	11.70	20.08	17.20	85.40	4.13	12.14	1.41	0.44
17.4.97	48	19.71	15.72	79.76	11.40	10.70	18.94	15.70	83.00	11.10	10.96	0.27	0.23
28.4.97	24	17.36	14.01	80.70	7.95	9.63	17.46	14.30	81.70	6.82	9.86	1.13	0.23
Average		18.91	15.45	81.65	8.28	10.69	18.83	15.71	83.34	7.35	10.99	0.94	0.30
Dipped 18.4.97	36	18.90	15.80	83.60	7.83	11.10	19.01	16.30	85.90	6.89	11.60	0.94	0.53
20.4.97	24	19.20	16.20	84.60	8.13	11.40	19.80	17.20	87.00	6.93	12.29	1.20	0.85
Average		19.05	16.02	84.09	7.98	11.26	19.40	16.77	86.40	6.91	11.95	1.07	0.69

Chemical dosage: 10 ppm (1 ml Sucroguard diluted in 3.5 litres water for 1 ton cane)

Mill test 1: conducted at 1250 tons cane/day factory in Andhra Province
Harvesting started at around 07h00; Sucroguard spraying started at around 12h00; loading started after 18h00 and crushing started at 14h00 the following day. There was thus a delay of only about 20 hours, which is far less than that achieved with the normal functioning of the factory. Composite samples of primary juice were collected and analysed for Brix, Pol, purity, invert sugars and acidity. The samples were collected hourly from the control, and half-hourly from the Sucroguard-treated cane. The results are tabulated in Table 3.

Table 3. Results of tests in which sucroguard solution was applied to sugarcane to prevent deterioration. Tests were conducted at a 1250 tons cane/day sugar factory in Andhra Province, India.

Particulars	Brix	Pol	Purity	RS %	RS per 100 Brix	TA per 100 Brix
Control 1	20.99	17.83	84.94	1.41	6.722	10.00
2	19.09	16.23	85.01	1.13	5.940	12.05
3	19.46	16.93	86.99	1.17	6.029	11.31
4	20.74	17.35	83.65	1.11	5.011	11.09
Average	20.07	17.83	85.15	1.20	6.001	11.11
Sucroguard 1	21.89	18.81	85.92	0.643	2.937	09.59
2	22.39	18.99	84.81	0.717	3.205	08.48
3	22.09	19.03	86.14	0.463	2.012	09.05
Average	22.12	18.94	85.62	0.608	2.718	09.04
Diff. over control	+2.05	+1.85	+0.47	˜0.596	˜3.282	˜2.07
	10.21%	10.83%		49.50%	54.7%	18.63%

RS = reducing sugars
TA = titratable acidity

Table 4. Results of tests in which sucroguard solution was applied to sugarcane to prevent deterioration. Tests were conducted at Shakti Sugars, Erode, Tamil Nadu, India.

Parameters		Control					Sucroguard treated					Deviation due to treatment				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Cane crushed	Tons	150.04	257.50	198.03	168.98	161.59	231.08	251.83	191.49	182.76	140.65					
Primary Juice	Brix	17.08	17.26	17.21	16.98	17.36	17.51	17.40	17.18	17.36	17.16	+0.43	+0.14	-0.03	+0.38	-0.20
	Pol	14.15	14.00	13.97	13.77	14.31	14.65	14.06	14.31	14.16	14.14	+0.50	+0.06	+0.34	+0.39	-0.17
	Purity	82.85	81.11	81.17	81.10	82.43	83.67	80.80	83.29	81.57	82.40	+0.82	-0.31	+2.12	+0.47	-0.03
Mixed Juice	Brix	13.00	13.34	13.17	13.44	13.74	13.33	13.27	13.31	13.67	13.54					
	Pol	10.60	10.65	10.56	10.73	11.23	10.98	10.58	10.95	10.95	11.08					
	Purity	81.54	79.84	80.18	79.84	81.73	82.37	79.73	82.27	80.10	81.83					
RS% 100 Bx	PJ	5.58	7.42	8.48	6.54	5.59	5.32	6.67	7.25	6.34	6.24	-0.06	-0.75	-1.23	-0.20	+0.75
	MJ	5.58	7.57	8.43	7.22	6.19	5.92	6.86	7.27	6.80	6.13					
CaO ppm/100 Bx	PJ	5409.0	6025.0	6043.0	6537.0	5876.0	5411.0	6437.0	5995.0	6740.0	6352.0	+2	+412	-48	+203	+476
Acidity/100 Bx	PJ	12.09	11.39	11.06	11.00	13.25	11.04	11.26	11.64	11.89	12.24	-1.05	-0.13	+0.58	+0.89	-1.01
Recovery %		9.83	9.44	9.63	9.11	9.80	10.06	9.35	9.92	9.34	9.68	-0.23	-0.09	+0.29	+0.23	-0.17
Pol % cane		11.42	11.10	11.32	10.75	11.38	11.64	11.00	11.48	11.00	11.21	+0.22	-0.10	+0.16	+0.25	-0.17
Total losses		1.59	1.66	1.69	1.64	1.58	1.58	1.65	1.56	1.66	1.53					
Total bacterial count			8	10		8		8	10		8					
Colonies per ml (x10)			33.3	7.66		22.16		10.3	4.37		11.17		70%	43%		50%
												Bacterial growth protection %				

Chemical dosage: 10 ppm (10 ml diluted in 3.5 litres water for 1 ton of cane)
Duration of post-harvest period: 24 to 30 hours

Mill test 2: conducted at Shakti Sugars, Erode, Tamil Nadu

Fields to be harvested were selected in such a way that they sent an even number of loads to the factory. Half of each load of harvested sugarcane was treated with Sucroguard, either by spraying the dilute solution using a hand spray or by dipping the cut ends into the Sucroguard solution. The loads were separated in the cane yard of the factory and crushed simultaneously in two mills of 2500 tons cane/day each. Continuous samples of primary juice were collected and analysed for all parameters. For microbiological analysis, samples were collected in sterilised containers when half the quantity of each load was crushed. A total of five sets of 400 tons each, with and without Sucroguard treatment, were taken into account for the trial. The results are tabulated in Table 4.

Discussion and conclusions

From the experiment data it is evident that:

- Dipping the cut ends of harvested sugarcane is the most beneficial method of applying Sucroguard.
- A 10 ppm dose of Sucroguard is sufficient to control post-harvest deterioration.
- There is an approximate 50% reduction in total mesophilic bacterial count.
- There is a reduction in invert sugars in primary juice, clearly indicating that Sucroguard controls the microbes that cause inversion.
- There is a reduction in titratable acidity of primary juice, i.e. acid-forming microbes are also controlled. The lesser acidity will require less lime and will thus help in better recovery.

Economic implications

For treating one million tons cane, 10 tons Sucroguard will be required. The price of the chemical will be approximately US$80 000, and the labour cost will be US$180 000. In India the cost of labour is much less than in the USA.

The minimum expected sugar gain would be more than 0.3%, or 3000 tons sugar. Assuming a sugar price of US$300 per ton, this would equate to a gain of US$900 000. The net benefit per million tons cane would be US$720 000.

Chopper harvested sugarcane is in the form of billets, thus there are multiple cut ends which accelerate cane deterioration. However, the high speed of this type of harvester may balance out the more rapid deterioration of billets, in which case the benefit from using Sucroguard may not be as sizable as that from other methods of harvesting. The application of Sucroguard would nevertheless be very easy with mechanical harvesters, as entire cane billets can be dropped into the Sucroguard solution. This would be more beneficial than dipping the cut ends only, since microbes present on the skin of sugarcane will also be reduced drastically.

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