MINIMISING POST-HARVEST BIOLOGICAL LOSSES OF SUCROSE
BY APPLICATION OF ORGANO-SULFUR BASED
BIOCIDE DURING MILLING OF CANE

By

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Abstract

SUCROSE losses after the harvest of sugarcane and during the subsequent milling operation are
one of the most serious problems in many sugar processing mills in India. The sucrose losses
are as high as 10.0 kg per tonne cane ground, depending upon the nature of cane variety, time
lag from harvest to milling, and ambient temperature. The loss profile of some commercial
cane varieties grown in a sub-tropical region was evaluated based on their Commercial Cane
Sugar (CCS)%, invert sugar, dextran and acidity value. Biological losses of sucrose during
milling were assessed in a sugar mill by estimating the rise in invert sugars, acidity and
dextran from primary to mixed juice. A rapid action biocide-cum-invertase inhibitor,
organosulfur (dithiocarbamate) based formulation was mist sprayed continuously on prepared
cane (@ 10 ppm on cane), and quality parameters of primary and mixed juice were evaluated
at periodic intervals. In one sugar mill, invert sugars, titrable acidity, and dextran /100 brix in
primary juice were 6.66, 18.97 and 2566 and, in mixed juice, 8.85, 18.77 and 1733 before
biocide treatment. The sugar recovery at this stage was 9.30% cane. These quality parameters,
after 2 hours of continuous biocide spraying on prepared cane, were 4.20, 17.12, 2435 in
primary and 4.92, 15.18, 414 in mixed juice, respectively. There was appreciable reduction in
biological losses with an increase in sugar recovery of 0.2 units. Similar treatment in an
another sugar mill for a period of seven days showed drastic reduction in biological losses
with over 0.5 unit increase in sugar recovery.

Introduction

The prevailing sugarcane harvesting and supply management system operating in India, especially
in the sub-tropical belt, is a serious impediment to attaining higher sugar recovery. In the majority of sugar
factories, time lag between harvesting and milling of cane ranges between 3 to 7 days, which entails huge
losses in recoverable sugar due to deterioration and souring of harvested cane.

The biological losses such as inversion, acid and dextran formation are largely responsible for loss
in recoverable sugar after harvest. Whatever the quality at time of harvest, rapid deterioration begins from
the moment the cane is harvested.

The deterioration proceeds -by- enzymic, chemical and microbial processes and is further
aggravated by water loss and multiplication of undesirable microbes. Initially, the enzyme invertase, which
occurs naturally in cane and is released at the time of milling, converts sucrose to invert sugars, thus
lowering the purity.

Bacteria such as Leuconostoc are often associated with the deteriorated cane, entering through the
cut ends and thriving at the expense of stored sucrose. This microbe has the ability to synthesise alpha-
glucan polysaccharides (dextran) from sucrose through an extracellular enzyme called dextranucrase.
The level of dextran synthesis varies with the geographic location, climate, cane variety, quality of cane, cut-to-
crush delays, method of harvesting, and sanitary conditions inside the mill.

The primary extracted juice in some cases contains a very high amount of dextran due to certain
physiological conditions, post-harvest delays, or mechanical injuries. Dextran, in addition to its adverse effect
on sugar recovery, is undesirable for its negative effect on filtration, evaporation and crystallisation during
sugar manufacturing (Clarke, 1997; Purchase, 2001; Solomon, 2002; Solomon et al., 1995, 2001).

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In this communication, losses in sugar recovery due to biological factors (inversion and microbial) due to supply of stale cane are reported. Studies were also directed at minimising these biological losses by application of a rapid action biocidal formulation on the milling tandem.

Material and methods

Large scale mill trials with a rapid action carbamate-based biocide formulation were carried out in Sakhti Sugar Ltd., Dhenkanel and Badamba mills. The biocidal formulation was sprayed continuously at cutter-leveler stage (before fiberiser). The analysis of cane and process juice (primary and mixed) for quality parameters (Brix, Pol and purity), reducing sugars, titrable acidity and dextran were carried out by the methods described by Chen and Chou (1993).

Results and discussion

Assessment of sucrose losses by biological agents

Sugar losses after harvest were assessed in a sugar mill receiving a high proportion of stale cane in the supplies. Activities of acid invertase and dextranucrase were followed during different stages of cane transport and milling process. The results of this study are presented in Figure 1.

Our findings show relatively high activities of invertase and dextranucrase in harvested cane, which increased further during milling of cane. The losses in recoverable sugar increased appreciably during transition from primary juice to mixed juice stage, and almost all the parameters viz., dextran, reducing sugars and acidity showed marked increase in mixed juice. Based on these figures it was calculated that approximately 5.0 kg sucrose was lost /tonne cane crushed.

![Graphs showing progression of biological losses and activities of invertase and dextranucrase in cane and milled juice in a sugar processing unit (I-cane yard, II-cane carrier, III-primary juice, IV-mixed juice, V-clear juice).]
Minimisation of post-harvest sucrose losses

Studies have shown that initiation of sucrose losses due to biological factors (viz., dextran, acid and inversion) starts soon after the cane is harvested.

This is also indicated by the rise in invertase and dextransucrase activity in harvested cane analysed after different periods of storage. Thus, there is a need to minimise these biological factors in harvested cane in order to check sucrose losses in upstream milling and processing operations.

The efficacy of various biocides on microbiological quality of milled juice was evaluated by More et al. (2002) and Chavan et al. (2002).

Small scale trials conducted at two sugar factories showed that continuous application of a rapid action dithiocarbamate biocide formulation @ 10 ppm on prepared cane could minimise biological losses and improve sugar recovery (Table 1 and Figures 1, 2 and 3).

The biocidal formulation also suppressed invertase and dextransucrase activity in primary and mixed juice. This approach is different from conventional practices of biocide application in milled juice.

Rapid action carbamate-based biocide trial No. 1

Table 1- Minimisation of biological losses during milling process by application of DTC on prepared cane.

<table>
<thead>
<tr>
<th>Parameter/ Juice</th>
<th>Brix</th>
<th>Pol% Juice</th>
<th>Purity</th>
<th>IS/100 Bx</th>
<th>Acidity/100 OBx</th>
<th>Dextran/100 Bx</th>
<th>Recovery</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Regular factory operations- No Treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>17.90</td>
<td>14.23</td>
<td>79.41</td>
<td>6.66</td>
<td>18.97</td>
<td>2566</td>
<td>9.11 (9.30)</td>
</tr>
<tr>
<td>Mixed</td>
<td>13.85</td>
<td>10.90</td>
<td>78.70</td>
<td>8.85</td>
<td>18.77</td>
<td>1733</td>
<td></td>
</tr>
<tr>
<td>2 h after continuous application of rapid action carbamate formulation @ 10 ppm cane</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Primary</td>
<td>18.89</td>
<td>15.39</td>
<td>81.47</td>
<td>4.20</td>
<td>17.12</td>
<td>2435</td>
<td>9.67 (9.50)</td>
</tr>
<tr>
<td>Mixed</td>
<td>14.49</td>
<td>11.55</td>
<td>79.71</td>
<td>4.92</td>
<td>15.18</td>
<td>414</td>
<td></td>
</tr>
</tbody>
</table>

Note: Cane supplies contained 4-6 days stale cane and burnt cane.
Location: Sakhti Sugars, Badamba (Orissa).

Rapid action carbamate-based biocide trial No. 2.

Figs. 2 and 3—Improvement in sugar recovery following continuous application of DTC on prepared cane. Location: Shakti Sugars Ltd., Dhenkanal (Orissa).
The following improvement in juice quality was recorded after application of a dithiocarbamate formulation on prepared cane:

- Increase in Brix value of PJ and MJ.
- Increase in Pol % juice of mixed juice.
- Decrease in reducing sugars from PJ to MJ.
- Reduction in dextran in PJ and MJ.
- Reduction in titrable acidity from PJ to MJ.
- Increase in purity.
- Improvement in sugar recovery % cane.

Based on the studies carried out by our group, sugar losses due to post-harvest delay could be minimised by taking the following precautions:

- The field quality of cane needs to be monitored carefully, especially in those areas where supplies contain physiologically or mechanically damaged cane. These may bring in higher microbial load and dextran in primary juice leading to loss in recoverable sugar during subsequent milling operations.
- Minimum time lag between harvesting to milling and use of effective biocides is important to minimise sucrose loss after harvest and milling operation. Continuous application of thio-carbamate-based formulation (@ 10 ppm) on prepared cane has shown excellent results.

REFERENCES


LE CONTROL DES PERTES BIOLOGIQUES DE SACCHAROSE APRÈS LA COUPE DES CANNES, PAR L'UTILISATION DE PRODUITS A BASE DE SOUFRE ORGANIQUE

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MOTS CLEFS: Pertes, Broyage, Biocide, Récupération.

Résumé

La perte de saccharose pendant la récolte et le broyage des cannes est un problème sérieux en Inde ; on peut perdre 10 kg de saccharose par tonne de canne, dépendant de la variété, du délai entre la coupe et le broyage, et de la température. On s’est servi du « Commercial Cane Sugar, CCS », des sucres réducteurs, du dextran et de l’acidité pour étudier ces pertes. Aux moulins on s’est servi de l’augmentation de sucre inverti, de l’acidité du dextran, du jus primaire au jus mélange. Un biocide a action rapide, qui attaque aussi l’invertase, a été pulvérisé sur la canne (10 ppm sur la canne). Le jus primaire et le jus mélange ont été analysés. Les résultats obtenus dans une sucrerie montrent des concentrations de 6.66, 18.97 et 2566 pour le sucre inverti, de 18.97 et 2566 dans le jus mélange, sans addition de biocide. Après 2 heures d’addition de biocide, des concentrations de 4.20, 17.12 et 2435 dans le primaire et de 4.92, 15.18 et 414 dans le jus mélange furent obtenus. Ce résultat augmente la récupération du sucre par 0.2 unités. Dans une autre sucrerie, l’addition de biocide pendant 7 jours a montre une augmentation de 0.5 en récupération.

MINIMIZACIÓN DE LAS PÉRDIDAS BIOLÓGICAS POST-COSECHA MEDIANTE LA APLICACIÓN DE BIOCIDES CON BASE DE SULFURO ORGÁNICO DURANTE LA MOLIENDA DE LA CAÑA

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PALABRAS CLAVE: Pérdues Post-Cosecha, Molienda, Biocide, Recuperación de Azúcar.

Resumen

Las pérdidas de sacarosa son uno de los problemas más graves en muchos de los ingenios azucareros en la India. Las pérdidas de sacarosa son de hasta 10.0 kg por tonelada de caña molida, dependiendo de la naturaleza de la variedad de caña. El espacio de tiempo entre la cosecha y la molienda y la temperatura ambiente. Se evaluó el perfil de pérdida de algunas variedades comerciales de caña que se cultivan en regiones sub-tropicales, basándose en su % de Caña de Azúcar Comercial, el azúcar invertido, dextrana y valor de acidez. Las pérdidas biológicas de sacarosa durante la molienda fueron evaluadas en un ingenio, mediante la estimación del incremento en los azúcares invertidos, la acidez y la dextrana para los jugos primario y mezclado. Un inhibidor de acción rápida, biocida-cum invertase, formulación basada en sulfuro orgánico (ditiocarbamato), fue rociada en forma continua sobre la caña preparada a razón de 10 ppm en caña), evaluándose a intervalos periódicos los parámetros de calidad del jugo primario y mezclado. En uno de los ingenios azucareros, los azúcares invertidos, la acidez titulable y la dextrana/100 brix en el jugo primario fueron de 6.66, 18.97 y 2566 y, en el jugo mezclado, de 8.85, 18.77 y 1733 antes del tratamiento con biocide. La recuperación del azúcar en este etapa fue de 9.30% de caña. Estos parámetros de calidad, después de 2 horas de rocio continuo con biocide sobre la caña preparada, fueron de 4.20, 17.12, 2435 en el jugo primario y de 4.92, 15.18 y 414 en el jugo mezclado, respectivamente. Hubo una reducción significativa en las pérdidas biológicas con un incremento en la recuperación del azúcar de 0.2 unidades. Tratamientos similares en otro ingenio azucarero por un periodo de siete días, mostraron una reducción drástica en las pérdidas biológicas con un incremento de más de 0.5 unidades en la recuperación de azúcar.