INHIBITION OF OLIGO- AND POLYSACCHARIDES FORMATION DURING THE MICROBIOLOGICAL DETERIORATION OF CANE AND ITS JUICE

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ABSTRACT

The microbiological deterioration of cane and its juice, aggravated by mechanical harvesting, is one of the main causes of sucrose losses today. The microorganisms degrade the sucrose and also cause production of diverse impurities, which reduce crystallization rate and recovery of sucrose from industrial products. In this paper, the effect of disinfection of chopped prepared cane with a new product obtained from molasses degradation (Maillard) is shown. By spraying a 200 ppm solution of the disinfectant on the cane (10 dm³/t), the destruction of sucrose in juice can be reduced by about 70% and the oligo- and polysaccharides formation by 70 to 90%.

Key words: Cane, disinfection, Maillard.

INTRODUCTION

With cane harvest mechanization a qualitative step has been taken in sugar industry productivity. However, the microbiological deterioration of cane has increased together with sucrose losses and the occurrence of soluble impurities, practically non-eliminable by the traditional purification methods. Among such compounds, oligo- and polysaccharides are especially harmful because they inhibit the sucrose crystal growth causing a noticeable reduction of factory efficiency (Ravelo17, Hormaza11, Imrie19).

It has been shown that the microbiological deterioration is aggravated by burning, the number of cuts made on the cane, the climatic conditions and the time elapsing between cutting and milling (Ravelo18, Foster9). Furthermore, there is a high correlation between the level of these substances in the cane and their increase during juice extraction (Ramos20).

According to estimates, sucrose losses due to cane deterioration can range between 1 and 3% of the initial content, depending on the harvest method used, for 48 to 72 h-delay (Hernández6). For longer periods (15 h), 13% losses have been
Several disinfectants have been recommended to counteract the action of microorganisms on cane and its juice. In the case of cane, formaldehyde (Egorov, Bose) and hypochlorite (Bose) have been used mainly; even though other substances have been employed too (Desau). Recently, even the application of gamma radiations to sterilize the raw material has been tested (Acosta).

A number of disinfectants have been recommended for microbial control at the milling station, being among the best known: formaldehyde and formulations basing their activity on the quaternary or dithiocarbamate content (Acosta, Bonson, Hernández). However, for a disinfectant to be used in the sugar industry, it must have high efficiency in low doses and be non-toxic and non-pollutant.

A way of obtaining disinfectants fulfilling these prerequisites can be found in the degradation reactions of carbohydrates. Several authors have observed an antimicrobial activity in mixtures from the thermal degradation of monosaccharides (Sourtii) as well as from the amino-carbonilic reaction (Maillard) (Shibasaki).

Even though, based on the latter reaction, Mizuo has proposed a fungicide mixture, few studies have been reported up to now on reaction conditions, type of reactants and characteristics of compounds formed, all of which determine the activity of the final product (Hjörleifsson).

In general, disinfectants produced through the Maillard reaction (classified as non-traditional) have found modest use in the food industry due to the narrow spectrum of their anti-microbial activity (Delara). However, their high hindering power on the growth of certain microorganisms and on the activity of a number of enzymes obtained with some reaction mixtures is very attractive (Jemal, Kobayashi).

This paper presents the results of the application to cane and its juice of a disinfectant obtained from amino-carbonilic reaction (Ramos), an inhibitor of the formation of oligo- and polysaccharides (IFOPOL), which noticeably reduces the destruction of sucrose.
min (determined with the aid of radioisotopes) and was immediately analyzed due to its high instability.

For the determination of polysaccharides, gel filtration was used according to the method reported in previous papers (Ravelo17). Sucrose was determined according to the Eynon Lane method and Bx was determined refractometrically (Rodríguez24).

**Determination of the effect of IFOPOL application to shredded cane**

Samples of chopped cane were used, randomly selected at the cane carrier. They were shredded and divided into two piles of 1 kg each. One of them was immediately sprayed with 10 cm³ of solution of the disinfectant at a concentration of 100 ppm, both being left for 5 min before extracting their juice. Extracts were made up to one liter with boiled water and left for 5 h at room temperature (about 25°C). The content of polysaccharides and sucrose in juice was determined at the beginning and at the end of incubation.

**Evaluation of disinfectant application on chopped cane**

Cane was sprayed at the cleaning center using the equipment described by Rivero23, which allows the application of 10 dm³ of 200 ppm per t of cane while filling railroad cars. During the evaluation, only the cane filling one half of each car was sprayed and the rest was used as reference. Eight cars were selected at random during the season and after this treatment were left out of the milling flux for 48 h. Cane was sampled for analysis during loading and unloading of the railroad cars.

**Industrial evaluation of the disinfectant during cane preparation**

The disinfectant solution was sprayed at a rate of 10 dm³ per t of cane at the outlet of the knives (2 sets), the area of maximum turbulence of cane billets. The IFOPOL solution was prepared daily at a rate of 2 liters for 10 m³ of return water. The impurity content of cane and its juice was determined throughout the season.

**RESULTS AND DISCUSSION**

The inhibitor was developed through the amino-carbonic reactions using molasses as a carbohydrate source in such conditions (Ramos23) that a highly anti-microbial mixture was obtained. The product remains active for at least two years and can be directly used after dilution to its working concentration. Diluted solutions remain active for several days.

The doses and concentrations of the disinfectant appropriate to achieve the highest inhibition levels on the formation of oligo- and polysaccharides were determined in
former studies by Ravelo\textsuperscript{18} using piles of chopped or shredded cane (Ramos\textsuperscript{20}), the use of reaction mixture solutions at concentrations higher than 10 ppm for chopped or shredded green cane and higher than 100 ppm for burnt cane being recommended.

Table 1 illustrates the inhibition of polysaccharide formation and sucrose decomposition in juice achieved by spraying 10 cm\(^3\) of 100 ppm IFOPOL solution to 1 kg of shredded cane and leaving its juice rest for 5 h. As can be appreciated, sucrose losses diminish between 50 and 100\% and polysaccharides formation between 80 and 100\%.

**Table 1. Effect of spraying shredded cane with IFOPOL solutions on the microbial deterioration of cane juice.**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Non-fumigated</th>
<th>Fumigated*</th>
<th>Inhibition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δ(poly)** Δ(suc)** Δ(poly)/Δ(suc)</td>
<td>Δ(poly) Δ(suc)</td>
<td>poly. suc.</td>
</tr>
<tr>
<td>1.</td>
<td>0.88 2.29 2.6</td>
<td>0.20 0.0 77 100</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>1.07 1.80 1.7</td>
<td>0.23 0.32 78 82</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>0.76 1.41 1.9</td>
<td>0.07 0.65 91 54</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>1.35 1.42 1.1</td>
<td>0.08 0.64 94 55</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>0.91 1.00 1.0</td>
<td>0.08 0.46 91 54</td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td>0.93 1.76 1.9</td>
<td>0.19 0.29 80 83</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td>1.03 2.18 2.1</td>
<td>0.15 0.69 85 68</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>0.75 1.38 1.8</td>
<td>0.11 0.68 85 51</td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>0.87 2.49 2.7</td>
<td>0.02 0.68 98 73</td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>0.67 1.91 2.9</td>
<td>0.07 0.52 90 73</td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>0.92 1.76 2.0</td>
<td>0.12 0.49 87 69</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>0.19 0.47 0.6</td>
<td>0.07 0.22 7 16</td>
<td></td>
</tr>
</tbody>
</table>

* 10ml of 100 ppm IFOPOL solution per kg of burnt shredded cane.

** Δ (suc), Δ (poly) = differences in concentrations of sucrose and polysaccharides.

Table 2 shows the inhibition achieved on the formation of oligo- and polysaccharides in cane 48 h after loading railcars and fumigating half of their content. As can be noticed, in the conditions the disinfectant was applied (eight cars randomly selected at different moments of the season) a 70\% average inhibition of the formation of both compounds was achieved.

To obtain the best inhibitory effect on microbial activity at the tandem, IFOPOL solutions were not applied directly to the juice but at the outlet of the knives, in doses
Table 2. Inhibiting effect of IFOPOL solutions (200 ppm) sprayed to burnt chopped cane while loading railroad cars.

<table>
<thead>
<tr>
<th>Car No.</th>
<th>Polysaccharides</th>
<th>Oligosaccharides</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Normal</td>
<td>Fumigated</td>
</tr>
<tr>
<td>1.</td>
<td>1600</td>
<td>300</td>
</tr>
<tr>
<td>2.</td>
<td>3478</td>
<td>49</td>
</tr>
<tr>
<td>3.</td>
<td>1096</td>
<td>269</td>
</tr>
<tr>
<td>4.</td>
<td>1420</td>
<td>414</td>
</tr>
<tr>
<td>5.</td>
<td>2078</td>
<td>583</td>
</tr>
<tr>
<td>6.</td>
<td>977</td>
<td>319</td>
</tr>
<tr>
<td>7.</td>
<td>1643</td>
<td>338</td>
</tr>
<tr>
<td>8.</td>
<td>2033</td>
<td>1256</td>
</tr>
<tr>
<td>X</td>
<td>1557</td>
<td>451</td>
</tr>
</tbody>
</table>

| % Inhibition | 71 | 71 |

and concentration similar to that for chopped cane. This way, it was possible to achieve a high degree of contact of the solution with the surface of prepared cane, at concentrations that would have implied a high disinfectant consumption, had it been directly applied to the juice.

Table 3 shows a statistical study of the variation of oligo- and polysaccharide content during juice extraction covering the whole season. As can be seen, during the days the disinfectant was continuously applied in doses of 10 m³ at 200 ppm per 1,000 t of cane, an average inhibition of the formation of both metabolic products higher than 90% was achieved.

Obviously, to attain best results it is best to apply the disinfectant when loading the cars and also during the preparation of cane for milling. Reaching this degree of disinfection would imply the consumption of 4 m³ of IFOPOL per 1,000 t of cane.

On the other hand, taking into account that the kinetics of sucrose microbial destruction shows a practically linear behavior within 7 h after juice extraction (Hernández⁹⁵) then sucrose losses at the tandem (15 min retention time) can be estimated from an average sucrose loss for 5 h reported in Table 1. These calculations indicate 0.73% sucrose loss in cane (considering 12% in mixed juice). This value is higher than those reported by other authors (between 0.1 and 0.23% as previously discussed) but it corresponds to the higher degree of infection generally observed in burnt chopped cane milled at the factory. Now, the formation of polysaccharides in juice also shows a typically linear behavior during the first 5 h.
TABLE 3. Effect of the application of IFOPOL solutions during cane preparation.

<table>
<thead>
<tr>
<th></th>
<th>Variation of impurities concentration during juice extraction (%Bx)*</th>
<th>% Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Non-fumigated</td>
<td>Fumigated**</td>
</tr>
<tr>
<td></td>
<td>( \bar{d} )</td>
<td>Sd</td>
</tr>
<tr>
<td>Polysaccharides</td>
<td>0.35</td>
<td>0.29</td>
</tr>
<tr>
<td>Oligosaccharides</td>
<td>0.29</td>
<td>0.27</td>
</tr>
</tbody>
</table>

* Average cane polysaccharides content along the season was 0.35 in both cases. There were no significant differences in the 40 days of fumigation.

** 10 dm³ of a 200 ppm IFOPOL solution put of cane at the outlet of the knives.

\( \bar{d} \) = Average value of the difference between impurity.

Sd = Standard deviation.

n = Number of paired samples analyzed.

t = Calculated t value.

sig = Significant at 95% reliability.
of juice microbiological deterioration (Ravelo20), so that it is not possible to use this parameter instead of acidity (Hernández10) to estimate sucrose losses. For this purpose the factor (sucrose/polysaccharide) obtained as average in Table I (2.0) and the average formation of polysaccharides along the season reported in Table 3 for non-disinfected juice (0.049% P/P considering 140 average Bx) can be used. According to these calculations, average sucrose losses of similar magnitude (0.8%) are obtained at the milling station (equally considering a 12% average of sucrose in mixed juice).

According to these calculation, the factory under study—1,000 t of cane a day capacity—loses some 100 t of sugar during the season (150 days) due to infection at the tandem. These losses can be reduced by 70% by the application of IFOPOL. Undoubtedly, the reduction of losses – harder to estimate but on a similar or higher order – associated to microbiological deterioration of cane must be added to this effect (Wong28, Hernández2). On the other hand, the 70 to 90% reduction of the concentration of oligo- and polysaccharides in juice can affect a substantial reduction of sucrose losses in final molasses. Such losses occur when oligo- and polysaccharides cause the formation of highly elongated microcrystals which escape through the screens of the centrifugals (Ramos22).

CONCLUSIONS

The disinfectant, developed from the degradation of molasses (involving Maillard reaction), can be applied to chopped and prepared cane to prevent up to 70% sucrose losses at the tandem and to inhibit the formation of oligo- and polysaccharides in cane (more than 70%) and its juice (more than 90%).

REFERENCES


LE CONTROL DE LA FORMATION DES OLIGO-ET POLYSACCHARIDES PENDANT LA DETERIORATION MICROBIOLOGIQUE DE LA CANNE ET DES JUS

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RESUME

La deterioration microbiologique de la canne est accelerée par la mechanisation de la recolte. C'est une des causes principales des pertes de saccharose. Les microbes attaquent le saccharose et produisent plusieurs impuretes qui retardent la crystallisation et diminuent le recouvrement du sucre. Ce papier presente des resultats concernant la desinfection de cannes tronconnees avec un nouveau produit base sur la degradation (Maillard) de la melasse. En repandant une solution de 200 ppm de desinfectant, par pulverisateur, sur la canne (10 dm³/t) la perte de saccharose dans le jus est reduite par 70%. La formation des oligo- et polysaccharides est aussi reduite par 70-90%.
INHIBICION DE LA FORMACION DE OLIGOSACARIDOS Y POLISACARIDOS DURANTE EL DETERIORO MICROBIOLOGICO DE LA CANA Y SUS JUGOS

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RESUMEN

El deterioro microbiológico de la caña y sus jugos, agudizado por la mecanización de las cosechas, resulta hoy día una de las principales causas de las pérdidas de sacarosa. La acción de los microorganismos no solo produce la degradación de este disacárido sino provoca la formación de diversas impurezas que disminuyen su velocidad de cristalización y la posibilidad de extraerlo de los productos industriales. En este trabajo se muestra el efecto de la desinfección de las mieles (Maillard). Fumigando la caña con soluciones a 200 ppm del desinfectante (10 dm³/t) se logra disminuir la destrucción de sacarosa en los jugos alrededor del 70% e inhibir la formación de polisacáridos y oligosacáridos de un 70 a un 90%.