DRD – Dedini Refinado Direto
(Dedini Direct Refined)

Improvements In Refined and Crystal White Sugar Production

XXVII ISSCT Congress
Veracruz, Mexico
March 7-11, 2010

Fernando C. Boscariol / Paulo E. Mantelatto
Dedini S/A Indústrias de Base
fernando.boscariol@dedini.com.br
DRD Process for Direct Refined Sugar (Original Purpose)

DRD application to assist the production of white crystal sugar

Clarified juice

14,000 IU
Syrup

11,500 IU
Clarified Syrup

70%
3,500 IU

70%
30%

11,500 IU

A MASSECUIITE

A runoff syrup

A

<150 IU
Crystal White Sugar

B MASSECUIITE

B runoff syrup

B-SUGAR

C MASSECUIITE

C-SUGAR

MOLASSES
Flow Sheet of DRD Process

Clarified Syrup → Pressure Filter → DRD 1 → DRD 2 → DRD 3 → Decolourized Syrup

FO F1 F2 F3
Over View of DRD Process Pilot Plant
## Basic characteristics of the ion exchange resins

<table>
<thead>
<tr>
<th>Properties</th>
<th>DRD-1</th>
<th>DRD-2</th>
<th>DRD-3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Matrix</strong></td>
<td>Polystyrene</td>
<td>Acrylic</td>
<td>Polystyrene</td>
</tr>
<tr>
<td><strong>Functional group</strong></td>
<td>Sulphonic acid</td>
<td>Quaternary ammonium</td>
<td>Quaternary ammonium</td>
</tr>
<tr>
<td><strong>Ions form as shipped</strong></td>
<td>$\text{Na}^+$</td>
<td>$\text{Cl}^-$</td>
<td>$\text{Cl}^-$</td>
</tr>
<tr>
<td><strong>Total exchange capacity</strong></td>
<td>$\geq 1.8 \text{ eq/L resin (Na}^+\text{ form)}$</td>
<td>$\geq 0.8 \text{ eq/L resin (Cl}^-\text{ form)}$</td>
<td>$\geq 1.0 \text{ eq/L resin (Cl}^-\text{ form)}$</td>
</tr>
<tr>
<td><strong>Moisture holding capacity</strong></td>
<td>47 - 54% (Na$^+$ form)</td>
<td>66 - 72% (Cl$^-$ form)</td>
<td>58-64% (Cl$^-$ form)</td>
</tr>
</tbody>
</table>
DRD Application to Clarifier Syrup Obtained from High Coloured Clarified juice from RB-92579

Objective: Production of Crystal White Sugar <150 IU

Aspect of Clarified Juice from RB-92579 Dark Colored
DRD Application to Clarifier Syrup Obtained from High Coloured Clarified Juice from RB-92579

Objective: Production of Crystal White Sugar <150 IU

Aspect of Clarified Juice from RB-92579 Dark Colored

16 000 to 18 000 IU

Syrup

<150 IU
Trial DRD Test in Caeté and União Sugar and Ethanol Mill – NE of Brazil

Caeté and União DRD pilot trials

<150 IU
Objective: To study the behavior of the DRD process in the colour removal of high coloured syrup that were obtained of different quantity of RB-92579 milled.

Apply this system to assist production of white crystal sugar, with colour < 150 IU
Variation of Syrup Colour vs. Quantity of Cane
RB-92579 Milled – Caeté Sugar and Ethanol Mill
Variation of A-Sugar Colour vs Quantity of Cane RB-92579 Milled – Caeté Sugar and Ethanol Mill

A-Sugar Colour (IU)

Quantity RB92579 (%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%


Sugar Colour Daly Quantity RB92579

DEDINI
Indústrias de Base
Colour Syrup, Magma and White Sugar – Caeté Sugar and Ethanol Mill - Season 2008
Flow Sheet of DRD Process

Legend of Samples

- F0: Clarified Syrup
- F1: Pressure Filter
- F2: DRD 1
- F3: DRD 2
- F4: DRD 3
- F4: Decolourized Syrup

Legend of Samples:
Variation of Syrup Colour and Quantity of Cane

<table>
<thead>
<tr>
<th>Variety</th>
<th>10/18/2008</th>
<th>%</th>
<th>10/19/2008</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB 92579</td>
<td>1538</td>
<td>16.72%</td>
<td>1374</td>
<td>14.73%</td>
</tr>
<tr>
<td>SP 813250</td>
<td>2922</td>
<td>31.74%</td>
<td>1477</td>
<td>15.84%</td>
</tr>
<tr>
<td>SP 791011</td>
<td>2050</td>
<td>22.28%</td>
<td>4366</td>
<td>46.81%</td>
</tr>
<tr>
<td>SP 716049</td>
<td>145</td>
<td>1.58%</td>
<td>80</td>
<td>0.90%</td>
</tr>
<tr>
<td>SP 874764</td>
<td>583</td>
<td>6.34%</td>
<td>24</td>
<td>0.26%</td>
</tr>
<tr>
<td>VA190-212</td>
<td>24</td>
<td>0.26%</td>
<td>6</td>
<td>0.07%</td>
</tr>
<tr>
<td>RB 867515</td>
<td>1663</td>
<td>18.07%</td>
<td>601</td>
<td>6.44%</td>
</tr>
<tr>
<td>N.F.</td>
<td>47</td>
<td>0.52%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

N.F.: not informed

Obs: The analysis of turbidity presented problems.

---

<table>
<thead>
<tr>
<th>Sample 52</th>
<th>COMPOSITE SAMPLE</th>
<th>Sample 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>F0</td>
<td>F1</td>
</tr>
<tr>
<td>Brix (%)</td>
<td>58.00</td>
<td>54.10</td>
</tr>
<tr>
<td>pH</td>
<td>5.74</td>
<td>7.68</td>
</tr>
<tr>
<td>Optical Density (420 nm)</td>
<td>101</td>
<td>745</td>
</tr>
<tr>
<td>Purity</td>
<td>84.05</td>
<td>85.03</td>
</tr>
<tr>
<td>Polarization</td>
<td>48.75</td>
<td>46.26</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample 53</th>
<th>COMPOSITE SAMPLE</th>
<th>Sample 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>F0</td>
<td>F1</td>
</tr>
<tr>
<td>Brix (%)</td>
<td>62.40</td>
<td>48.40</td>
</tr>
<tr>
<td>pH</td>
<td>5.85</td>
<td>7.07</td>
</tr>
<tr>
<td>Optical Density (420 nm)</td>
<td>966</td>
<td>766</td>
</tr>
<tr>
<td>Purity</td>
<td>84.22</td>
<td>83.61</td>
</tr>
<tr>
<td>Polarization</td>
<td>52.55</td>
<td>40.47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample 54</th>
<th>COMPOSITE SAMPLE</th>
<th>Sample 55</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analysis</td>
<td>F0</td>
<td>F1</td>
</tr>
<tr>
<td>Brix (%)</td>
<td>52.80</td>
<td>53.20</td>
</tr>
<tr>
<td>pH</td>
<td>5.88</td>
<td>6.47</td>
</tr>
<tr>
<td>Colour (IU)</td>
<td>11110</td>
<td>10006</td>
</tr>
<tr>
<td>Turbidity (420 nm)</td>
<td>885</td>
<td>570</td>
</tr>
<tr>
<td>Purity</td>
<td>88.68</td>
<td>88.91</td>
</tr>
<tr>
<td>Polarization</td>
<td>48.84</td>
<td>47.30</td>
</tr>
</tbody>
</table>

Dr. Experiments in Caeté Sugar and Ethanol Mill

Some Examples
## DRD Experiments in the Caeté Sugar and Ethanol Mill (São Miguel – AL - Brazil)

### Volume of ion exchange resin (L)

<table>
<thead>
<tr>
<th>CYCLE 14</th>
<th>V (L)</th>
<th>F0 (IU)</th>
<th>F1(IU)</th>
<th>F2 (IU)</th>
<th>F3 (IU)</th>
<th>F4(IU)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>320</td>
<td>10118</td>
<td>7347</td>
<td>71111</td>
<td>5317</td>
<td>2793</td>
</tr>
<tr>
<td></td>
<td>1009</td>
<td>9425</td>
<td>8885</td>
<td>8591</td>
<td>8341</td>
<td>4643</td>
</tr>
<tr>
<td></td>
<td>2048</td>
<td>11110</td>
<td>10006</td>
<td>9594</td>
<td>9100</td>
<td>5388</td>
</tr>
<tr>
<td></td>
<td>2704</td>
<td>9650</td>
<td>9928</td>
<td>9663</td>
<td>9604</td>
<td>6400</td>
</tr>
<tr>
<td></td>
<td>3976</td>
<td>9650</td>
<td>9928</td>
<td>9663</td>
<td>9604</td>
<td>6400</td>
</tr>
<tr>
<td></td>
<td>5566</td>
<td>10292</td>
<td>9605</td>
<td>9284</td>
<td>8779</td>
<td>5612</td>
</tr>
</tbody>
</table>

*V* = syrup feed volume (cumulative);

*F₀* = colour of syrup feed to the sand press filter;

*F₁* = output syrup colour from the sand press filter (filled with sand);

*F₂* = output syrup colour from cationic column DRD1 (filled with 200 L resin);

*F₃* = output of first anionic column DRD2 (filled with 200 L resin); and

*F₄* = output of second anionic column DRD3 (filled with 150L of DRD3 resin).
DRD Experiments in the Caeté Sugar and Ethanol Mill (São Miguel – AL- Brazil)

DRD Operation System in the Caeté Sugar and Ethanol Mill

[Graph showing DRD operation system with cycles on the x-axis and colour (IU) on the y-axis, with lines and markers indicating efficiency, inlet colour, outlet colour, and average efficiency.]
Visual Aspects of the syrup treated with DRD System – Step by Step

F1: 8,856 IU
F2: 6,647 IU
F3: 3,808 IU
F4: 1,846 IU
Colour vs. Bed Volumes fed along of DRD Process- Caeté Sugar and Ethanol Mill.

Test to determine the capacity of colour adsorption in resin 1/68 cycles

\[ F_0 = \text{clarified syrup colour}; \quad F_1 = \text{outlet of Sand filter}; \quad F_2 = \text{outlet of column DRD-1}; \quad F_3 = \text{outlet of column DRD-2}; \quad F_4 = \text{Outlet of column DRD-3} \]
Colour load accumulated in the ion exchange resins vs. bed volumes fed - Caeté Sugar and alcohol Mill.

Determine the capacity of colour adsorption in resin 1/68 cycles

\[ y = 3005.6x \]
\[ R^2 = 0.9894 \]

\[ y = 2851.1x \]
\[ R^2 = 0.9956 \]

\[ F_3 = \text{outlet of column DRD-2}, \quad F_4 = \text{outlet of column DRD-3} \]
Overall efficiency of colour removal by the DRD-Dedini system vs. cane variety RB92579 processed - Caeté Sugar and Ethanol Mill

None correlation was observed

\[ R^2 = 0.0016 \]
### DRD Experiments in União Sugar and Ethanol Mill
#### Some Examples

<table>
<thead>
<tr>
<th>Variety</th>
<th>1/11/2008</th>
<th>%</th>
<th>1/12/2008</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RB 92579</td>
<td>396</td>
<td>7.17%</td>
<td>396</td>
<td>7.17%</td>
</tr>
<tr>
<td>SP 813250</td>
<td>355</td>
<td>6.44%</td>
<td>355</td>
<td>6.44%</td>
</tr>
<tr>
<td>SP 791011</td>
<td>96</td>
<td>1.75%</td>
<td>96</td>
<td>1.75%</td>
</tr>
<tr>
<td>SP 716949</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>SP 784764</td>
<td>2138</td>
<td>38.76%</td>
<td>2138</td>
<td>38.76%</td>
</tr>
<tr>
<td>VAT00.212</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>SP 813250ED</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>RB 867515</td>
<td>0</td>
<td>0.00%</td>
<td>0</td>
<td>0.00%</td>
</tr>
<tr>
<td>N1</td>
<td>2530</td>
<td>54.12%</td>
<td>2530</td>
<td>45.88%</td>
</tr>
</tbody>
</table>

**Note:** It's not informed.
**DRD Experiments in the União Sugar and Ethanol Mill (Primavera- PE- Brazil)**

<table>
<thead>
<tr>
<th>Volume of ion exchange resin (L)</th>
<th>150 DRD2 + 150 DRD3</th>
<th>200</th>
<th>200</th>
<th>150</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYCLE 2</td>
<td>V (L)</td>
<td>F0 (IU)</td>
<td>F1 (IU)</td>
<td>F2 (IU)</td>
</tr>
<tr>
<td>258</td>
<td>11282</td>
<td>8831</td>
<td>7518</td>
<td>4192</td>
</tr>
<tr>
<td>714</td>
<td>13889</td>
<td>9478</td>
<td>9560</td>
<td>6163</td>
</tr>
<tr>
<td>1854</td>
<td>11775</td>
<td>8280</td>
<td>8925</td>
<td>5965</td>
</tr>
<tr>
<td>3222</td>
<td>13819</td>
<td>12025</td>
<td>11945</td>
<td>9931</td>
</tr>
<tr>
<td>3734</td>
<td>14802</td>
<td>10246</td>
<td>13104</td>
<td>10054</td>
</tr>
<tr>
<td>4646</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**V** = syrup feed volume (cumulative);

**F₀** = colour of syrup feed to the sand press filter;

**F₁** = output syrup colour from the sand press filter (filled with sand);

**F₂** = output syrup colour from cationic column DRD1 (filled with 200 L resin);

**F₃** = output of first anionic column DRD2 (filled with 200 L resin); and

**F₄** = output of second anionic column DRD3 (filled with 150L of DRD3 resin).
DRD Experiments in the União Sugar and Ethanol Mill (Primavera- PE- Brazil)
DRD Experiments in the União Sugar and Ethanol Mill (Primavera-PE-Brazil)
**Test to determine the capacity of colour adsorption in resin 1/65 cycles**

- **F₀** = clarified syrup colour; **F₁** = outlet of Sand filter partially filled DRD 3 (150 L) and DRD-4 (150 L); **F₂** = outlet of column DRD-1; **F₃** = outlet of column DRD-2; **F₄** = Outlet of column DRD-3
Colour load accumulated in the ion exchange resins vs. bed volumes fed - União Sugar and Ethanol Mill

Experiments to determine the capacity of colour adsorption in resin 1/65 cycles

\[ y = 3329x \]  
\[ R^2 = 0.9888 \]

\[ y = 2851.1x \]  
\[ R^2 = 0.9956 \]

\[ y = 2022.7x \]  
\[ R^2 = 0.9668 \]

\( F_0 \) = clarified syrup colour; \( F_1 \) = outlet of Sand filter partially filled DRD 3 (150 L) and DRD-4 (150 L); \( F_2 \) = outlet of column DRD-1; \( F_3 \) = outlet of column DRD-2; \( F_4 \) = Outlet of column DRD-3
(1) **DRD System** *(Olivério and Boscariol, 2006 and 2007)*, refined sugar obtained from decolourised syrup: \( y = 0.007 \cdot x + 17.65 \);

(2) *Thompson* et al. (2006) refined sugar;

(3) White crystal sugar – *Us. Mogiana (SP)*: \( y = 47.73 \cdot \exp(1.31 \cdot 10^{-4} \cdot x) \);

(4) White crystal sugar – *Us Sta Isabel (SP)*: \( y = 19.96 \cdot \exp(2.10 \cdot 10^{-4} \cdot x) \);

(5) White crystal sugar – *Us. Caeté (AL)*: \( y = 46.88 \cdot \exp(0.98 \cdot 10^{-4} \cdot x) \);

(6) White crystal sugar – *Us. União Indústria (PE)*: \( y = 42.20 \cdot \exp(1.31 \cdot 10^{-4} \cdot x) \);

(7) Controlled cooling crystallization of liquor obtained from raw sugar (VHP and VVHP) and cane syrup, *(Mantelatto, 2005)*: \( y = 0.0214 \cdot x + 8.80 \).

\( x \): Colour of syrup (IU), \( y \): Colour of crystal (IU).
Colour of Sugar vs. Colour of Syrup for various processes of Crystallization – White Crystal and Refined.

Colour of Sugar x Colour of Syrup

- (1) DRD
- (2) THOMPSON
- (3) MOGIANA
- (4) STA ISABEL
- (5) CAETÉ
- (6) UNIÃO
- (7) Cooling Crystallization

White Crystal Sugar

Sugar Refined

SYRUP COLOUR (IU) vs. SUGAR COLOUR (IU)
Conclusions

- The colour accumulated in the resins presented a linear behaviour with the BV fed to the columns.

- The different slopes of the curves indicate different load factors depending on the characteristics of the resin and also the affinity between colour compounds and functional group of the resins.

- Considering that anionic resins can operate up to 60-70% of saturations, anionic DRD resin can reaches level of load colour as 60 000 – 65 000 IU. Values relatively high when compared with conventional resins.

- Thus, demonstrating the capacity to bear high rates of colour adsorption, even for syrup containing high initial colour loads.
Conclusions

- None relationship was detected between colour removal efficiency of resins and quantity of cane variety RB-92579 in the cane being supplied to the factory.

- As indicated by the data, the extra colour loading introduced by RB-92579 has no effect on the colour removal efficiency of the resins.

- It was observed that the resin system was capable of maintaining a removal efficiency in the range of 50 to 70%, even when processing this variety of cane with higher clarified juice colour.

- It was shown that the DRD-Dedini system could be used successfully both assist the production of white sugar and the production of refined sugar by using clarified syrup as the feed to the decolourisation process.

- The colour removal factor in the crystallisation of juice coming from the DRD system was excellent, when compared with the other systems presented.
Conclusions

- Finally, DRD technology proved to be an improvement to the white sugar process, even for high colour syrups.

- From the study conducted, in addition to the studies previously conducted (Olivério and Boscariol, 2006 and 2007), it could be concluded that the DRD system can be advantageously used both in the production of granulated refined sugar and for the production of white crystal sugar (colour < 150 IU)
Thank You!

DRD – DEDINI REFINADO DIRETO (DEDINI DIRECT REFINED) IMPROVEMENTS IN REFINED AND CRYSTAL WHITE SUGAR PRODUCTION

CONTACT

Fernando C. Boscariol
Dedini Indústrias de Base
fernando.boscariol@dedini.com.br