INDUSTRIAL QUALITY OF MECHANICALLY AND MANUALLY HARVESTED SUGARCANE

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ABSTRACT

The present work aimed at checking the quality of the raw material supplied to the industry using 2 chopper harvesters, (MF – 201 and SANTAL – 116) and manual harvest with mechanical loading.

To do so, a different methodology from the one regularly used was applied. The main parameter was ton pol/ha placed at the sugarmill track for each studied treatment. The sugarcane losses in the field and impurities were evaluated in an indirect way.

The technological parameters included in this study were: cane pol, fiber % cane, juice % cane, reducing sugar % juice, purity, ton/ha of harvested sugarcane and ton pol/ha.

In general, the manual harvest presented the highest values of cane pol, purity, ton/ha of harvested sugarcane and ton pol/ha. The values of fiber % cane were higher for the chopper harvester MF – 201, than for manual harvesting of the variety CB41–76. There was no difference for the manual harvesting of the variety CB41 – 76 and also for the various harvest systems for the variety CB56 – 155. The reducing sugar % juice was lower for the manual harvest than for mechanical harvests for the variety CB41 – 76. For juice % cane, there were differences only between manual harvest and harvest with the FM–201 for the variety CB41–76. No difference was registered for the variety CB56 – 155. In the mechanical treatments there was no difference in behavior for the variety CB56–155, which was standing. For the variety CB41–76, which was slightly inclined, the treatment with MF–201 resulted in a better yield in ton pol/ha, than with SANTAL – 116.

INTRODUCTION

With the shortage of workers and the necessity of reducing production costs, the sugarcane agro-industry was compelled to introduce into Brazil the mechanical harvester.
However, although mechanical harvesters were a solution to the shortage of workers, they gave rise to a new problem. They altered the quality of raw material with effects on the various stages of industrialization.

Therefore, many studies were done mostly concentrating on the evaluation of losses of sugarcane in the field and the impurities of the sugarcane raw material transported to the industry.

In the present work, a different methodology from the usual one was tested, where the quality of raw material supplied to the industry was evaluated, ton pol/ha being the main parameter.

Cochran and Clayton defined the trash according to its effects in the sugarcane industrialization, as any material contributing to the decrease of the production of the recoverable sugar and affecting the sugarmill performance, decreasing the purity of the mixed juice, increasing the energy consumption, reducing the extraction coefficients of the mills and increasing production costs.

Fors classified the trash resulting from mechanical harvesting as vegetal and mineral. Vegetal were trash tops, leaves, roots and defibered pieces of sugarcane. The mineral trash were the loose soil or soil adhered to the roots, stones, sand and pieces of metal.

The amount of trash depended on the width of sugarcane rows, presence of transversal furrows and prevailing humidity.

Nichols demonstrated that leaves introduced as trash, retained less sugar than normal bagasse. It did not, therefore cause high losses in the recovered sugar, but caused an increase in expenses for transportation and processing as extraneous matter.

Waddell and Price stated that the loss caused by the straw in industrial process comes mainly from its high content of fiber, ashes and soluble impurity. Besides, its high volume caused difficulties in feeding the mills and would absorb juice during the milling process, thereby, increasing the losses of sugar in the bagasse.

Mayoral and Vargas pointed out that the main trash components in the Puerto Rico sugarcane are the green or dry leaves, tops, soil, stones, and mild and immature sprouts from the base of the stool. The most important losses caused by this material to the production was the great wearing of the equipment, aside from the higher loss of sugar in the bagasse, in the filtercake and in the molasses.

Humbert and Paine in studying the effects of sugarcane harvest in wet weather in Hawaii, concluded that with the rain the burning was not satisfactory and there was an increase in the trash taken to the sugarmills. With the presence of trash, there was an increase in fiber, leading to a smaller extraction and therefore,
a decrease in the milling capacity. Moreover, the soil adhering to the sugarcane wore out the sugarmill equipment.

These caused problems to the juice clarification, leading to the need of greater investments to enlarge the capacity of this stage. There was also a decrease in the juice purity, reducing the sucrose recovery and increasing the amount of material of low quality to be handled.

The vegetal and mineral material reduced the sugar quality and therefore increased the refining costs.

Dudley et al. in studying sugarcane harvest in Puerto Rico, stated that tops going to sugarmills together with the raw material introduced in the process non-crystallizable sugar. These reducing sugars decreased juice purity and increased losses in sucrose.

Morin, in studying mechanical harvest of sugarcane in Tucuman found the following figures for sugarcane juice quality:

<table>
<thead>
<tr>
<th></th>
<th>Purity %</th>
<th>Pol Cane</th>
<th>Production Yield</th>
<th>R.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Without trash</td>
<td>86.54</td>
<td>13.09</td>
<td>11.16</td>
<td>0.414</td>
</tr>
<tr>
<td>With trash</td>
<td>82.86</td>
<td>10.39</td>
<td>9.73</td>
<td>0.673</td>
</tr>
</tbody>
</table>

Elias, in studying the effects of mechanical harvest in the sugarcane industrial quality at the Regional Experiment Station of Cattle Breeding of Familia, worked with four varieties: CP48-103, NA56-62, NA56-79 and NA63-90. The variety presenting the lowest impurity content was NA56-79, being followed by NA56-62, CP48-103 and NA63-90.

It should be emphasized that values achieved for NA56-79 were considered normal, since losing the straw at maturation was a characteristic of this variety. The values obtained showed that a large amount of impurity corresponded to a smaller juice extraction.

Ayala et al. in studying the influence of harvest types on sucrose loss in the factory obtained values showing that there was a considerable increase in the bagasse percentage in the mechanically harvested sugarcane. This increase was proportional to a bigger or smaller neatness in the mechanical harvest, i.e., it was directly related to trash. In the trials made, there were increases in the bagasse % cane for the mechanically harvested sugarcane.

Bagasse increase would result, among other consequences, in a decrease of the milling capacity and increase of mechanical wearing of the sugarmill equipment which could not easily be measured but were very important during the harvest.

Arceneaux and Davidson in the U.S.A. found that for a 7.5% trash there was a reduction of 2.12% in the extraction. The purity of extracted juice decreased
to 2.17 degrees for each 10% of impurity. If impurities had green leaves, the purity reduction was 3.02 degrees for each 10% of trash.

MATERIALS AND METHODS

The following main equipment were used in the study:

1. MASSEY – FERGUSON CHOPPER HARVESTER (MF – 201) CANE-
COMMANDER: with V8-510 PERKINS engine; maximum power from 142
hp 9106 (106 kw) at 2000 rpm, DOWMATE hydrostatic transmission.

2. SANTAL–116 CHOPPER HARVESTER: with MWM–6 engine and GAR-
RET turbine, maximum power from 135 hp (101 kw) at 2300 rpm, with oil
radiator and protector against straw in the turbine.

3. TOLEDO WEIGHING–MACHINE: with capacity for 56,000 kg, precision of
5 kg. model 2,890.

The work was carried out at Barra Sugarmill S/A Sugar and Alcohol, in Barra
Bonita, State of Sao Paulo.

Two sugarcane varieties were used: C856–165, 9th cut and C841–76, 5th
cut.

Field Conditions of Varieties

C856–165

The plantation was at the 9th cut. The rows were in a superior level in
relation to the inter-rows, therefore, cutting in the base was feasible.

The plantation was burnt at 6:00 p.m. on August 16 and the harvest took
place on August 17, 1978 from 6:30 a.m. to 4:00 p.m.

Visual observation after burning showed an insignificant amount of green
leaves.

C841–76

The plants were slightly inclined towards the row at the 5th cut, this area
being duly cultivated to enable basal harvest of stalks by the machines conducting
earth to the rows.

Through the cultivation and ratoon stage (5th cut) the sugarcane row was in
a superior level if compared to the interrow.

The plantation was burnt at 5:30 a.m. on September 20, 1978 and the cutting
period went till 5:30 p.m. In a visual appreciation of the area, some green leaves
were observed.
The statistical delineation of the area was through the method of randomized blocks with 5 replications.

**Treatments**

The treatments were:

1. Harvest with MF-201 equipment,
2. Harvest with SANTAL-116 equipment and
3. Manual harvest with mechanical loading

For all treatments, the regular operating conditions of the sugarmill were followed:

The trials were characterized by the following:

1. Harvest of plots and transportation of sugarcane to the mill were by trucks.
2. Measurement of the plot areas and weighing of loads at the sugarmill scales to enable the calculation of ton/ha of the harvested sugarcane.
3. Unloading of sugarcane for sampling at the sugarmill yard for manually harvested cane and on the transportation track, for mechanically harvested cane.
4. Removal of 5 compound samples in each load for the technical analysis, totalling 25 samples per treatment.

For the technical analysis, the samples were passed through a shredding machine and the juice of a sub-sample of 500 g of shred material was taken through the hydraulic press PINETTE-EMIDECAU-CODISTIL at a pressure of 245 kgf/cm² applied for one minute.

With the extracted juice, the following were measured: the pol through Schmitz’ method, Meade and Chen¹⁰ without dilution; the reducing sugars, (Lane and Eynong), and the refractometric brix.

The pol cane was calculated from the pol juice and the fiber % cane from the fibrous residues of the pressing according to PLANALSUCAR¹³.

With the data achieved for ton/ha of harvested cane and pol cane, it was possible to calculate the harvested ton/pol/ha.

Juice purity, was calculated.

The juice % cane was calculated from the extract juice at hydraulic pressure of 245 kgf/cm² applied for one minute.

**RESULTS AND DISCUSSION**

The average of the harvest types in the various determinations accompanied
**TABLE 1.** Means and variation coefficients of technological determination for the variety CB41-76 manually and mechanically harvested

<table>
<thead>
<tr>
<th>Determination</th>
<th>Manual</th>
<th>Santal-I</th>
<th>MF-201</th>
<th>C.V. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane Pol</td>
<td>13.90 a</td>
<td>12.24 b</td>
<td>11.70 b</td>
<td>3.06</td>
</tr>
<tr>
<td>Fiber % Cane</td>
<td>11.59 a</td>
<td>12.15 a,b</td>
<td>12.80 b</td>
<td>3.00</td>
</tr>
<tr>
<td>Juice % Cane</td>
<td>71.12 a</td>
<td>68.93 a,b</td>
<td>68.46 b</td>
<td>1.97</td>
</tr>
<tr>
<td>Reducing Sugar % Juice</td>
<td>0.56 a</td>
<td>0.68 b</td>
<td>0.79 c</td>
<td>8.24</td>
</tr>
<tr>
<td>Purity</td>
<td>91.17 a</td>
<td>88.00 b</td>
<td>86.61 b</td>
<td>1.15</td>
</tr>
<tr>
<td>ton/ha</td>
<td>99.44 a</td>
<td>76.14 b</td>
<td>106.10 a</td>
<td>6.17</td>
</tr>
<tr>
<td>ton pol/ha</td>
<td>13.81 a</td>
<td>9.32 c</td>
<td>12.42 b</td>
<td>6.88</td>
</tr>
</tbody>
</table>

Means followed by different letters are statistically different (Tukey – 5%).

**TABLE 2.** Means and variation coefficients of technological determinations for the variety CB56-155 manually and mechanically harvested

<table>
<thead>
<tr>
<th>Determination</th>
<th>Manual</th>
<th>Santal-I</th>
<th>MF-201</th>
<th>C.V. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cane Pol</td>
<td>12.54 a</td>
<td>11.02 b</td>
<td>10.74 b</td>
<td>5.08</td>
</tr>
<tr>
<td>Fiber % Cane</td>
<td>12.03 a</td>
<td>12.13 a</td>
<td>12.25 a</td>
<td>2.03</td>
</tr>
<tr>
<td>Juice % Cane</td>
<td>67.87 a</td>
<td>66.87 a</td>
<td>66.75 a</td>
<td>1.35</td>
</tr>
<tr>
<td>Reducing Sugar % Juice</td>
<td>1.12 a</td>
<td>1.31 a,b</td>
<td>1.43 b</td>
<td>10.41</td>
</tr>
<tr>
<td>Purity</td>
<td>88.45 a</td>
<td>83.89 b</td>
<td>84.12 b</td>
<td>2.54</td>
</tr>
<tr>
<td>ton/ha</td>
<td>103.72 a</td>
<td>95.37 a,b</td>
<td>91.29 b</td>
<td>6.23</td>
</tr>
<tr>
<td>ton pol/ha</td>
<td>13.02 a</td>
<td>10.48 b</td>
<td>9.80 b</td>
<td>7.04</td>
</tr>
</tbody>
</table>

Means followed by different letters are statistically different (Tukey – 5%)

by the respective variation coefficient are shown on Tables 1 and 2 for the varieties CB41-76 and CB56-155.

**Cane pol and purity**

The cane pol analysis is of great importance since it is an important parameter for the judgment of the sugarcane sucrose content.

The purity consists of the percentage relationship between pol and juice brix, being one of the points mostly used in the appraisal of raw material quality.
For the two studied varieties, the manual harvest presented the higher cane pol and purity contents, being different from mechanical harvests, which presented the same amounts.

This variation was probably due to the best utilization of raw material by the manual harvest.

Fiber % Cane, Juice % Cane and Reducing Sugars % Juice

High fiber % cane content presented a negative effect on the milling capacity and on sucrose extraction.

The reducing sugars, as well as the pol cane, were of great importance as parameters to indicate the sucrose inversion among the treatments.

For the variety CB41-76, which was slightly lodged, the MF-201 harvested cane gave the highest fiber content and the lowest amount of juice % cane, compared to the manual harvest. Between the mechanical treatments, there was no difference. Concerning reducing sugar % juice, the MF-201 equipment gave the highest content, followed by the SANTAL-116, the smallest value being with the manual harvest.

This occurred probably due to the presence of a larger amount of tops in the material harvested by MF-201.

Concerning the behavior of the variety CB56-155 which was erect, there were differences only to reducing sugar % juice. The manual harvest had a lower content when compared to that of the MF-201 harvest which did not differ from the SANTAL-116.

Ton/ha of harvested cane

For the slightly inclined variety, the MF-201 equipment presented a behavior similar to the manual harvest, regarding the ton of harvested sugarcane, but was different from the SANTAL-116, which left more sugarcane in the fields.

For the standing variety (CB56-155) there was a similarity of behavior between the mechanical treatments and between manual and SANTAL-116.

Ton pol/ha

For the two varieties, the manual harvest presented the highest values of ton pol/ha being different from the mechanical harvests.

Between the mechanical harvests for the standing variety, the behavior concerning ton pol/ha was similar.

For the variety CB41-76 (slightly inclined), the MF-201 presented a higher value for ton pol/ha than the SANTAL-116.
CONCLUSIONS

The manual harvest provided under the experiment conditions, the best values for the technological parameters (pol cane, fiber % cane, juice % cane, reducing sugar % juice and purity), and, provided higher tonnage of harvested sugarcane and tonnage of sugar per hectare.

Between mechanical treatments there was no difference of behavior in the analyzed parameters for the variety CB56–155, which was erect.

Concerning the variety CB41–76, slightly inclined, the treatment with MF–201 equipment presented a better operational behavior.

REFERENCES

CALIDAD INDUSTRIAL DEL CORTE MECANIZADO Y CORTE MANUAL DE LA CAÑA DE AZUCAR

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RESUMEN

Este trabajo está encaminado a verificar la calidad del material suplido a la industria usando 2 cosechadoras combinadas (MF-201 y SANTAL-116) y corte manual con alce mecanico.

Para esto se usó una metodología diferente de la convencional, donde el parámetro principal es ton pol/ha entregado en el molino para cada una de las pruebas, evaluando las pérdidas de caña en el campo e impurezas.

De este modo los parámetros tecnológicos incluidos en este estudio son: caña pol, % de fibra, % de jugo, % de azúcar reductora en el jugo, pureza, ton/ha de caña cosechada y ton pol/ha.

Los valores encontrados fueron analizados estadísticamente y discutidos resultando las siguientes conclusiones:

— en general, el corte manual presenta los valores más altos de pol en la caña, pureza, tons/ha de caña cosechada y ton pol/ha.

— el % de fibra en la caña fue más alto para la cosechadora combinada MF-201 si la comparamos al corte manual, para la variedad CB41-76. No hubo diferencia para los distintos tipos de cosecha en la variedad CB56-155.

— en lo que concierne a % de azúcares reductores en el jugo el corte manual presentó los contenidos menores, en comparación a la cosecha mecanica, para la variedad CB41-76.

— para % de jugo, hubieron diferencias únicamente entre la cosecha manual y la cosecha con la MF-201, para la variedad CB41-76. No se registro diferencia para la variedad CB56-155.
— en los tratamientos mecanicos no hubo diferencia en el comportamiento de la variedad CB56—155 la cual era erecta.

— para la variedad CB41—76, la cual era ligeramente inclinada, el tratamiento con la combinada MF—201 resulto en un mejor rendimiento en ton pol/ha que la SANTAL—116.