MONITORING CANE QUALITY WITH QUICK AND CHEAP ANALYTICAL INDICATORS ON CANE JUICE

By

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Abstract
SUGAR FACTORY process efficiency is affected by some non-sugars, like reducing sugars, ash content or some polysaccharides, which influence how sucrose can be recovered as commercial sugar. These non-sugars depend on what is very generally named ‘cane quality’, which includes different aspects, such as cane maturity, cleanliness (as opposed to trash or soil), and freshness (as opposed to post-harvest deterioration). Their measurement is often tedious and/or expensive. For several campaigns, pilot-scale and on-site studies have been conducted in Reunion island to find simple analytical indicators related to cane quality. Some potential indicators have been investigated for their correlation with one parameter of cane quality (namely harvest delay, trash content or soil content), their usual variability in ‘good’ conditions have been tested (for fresh, clean cane of different varieties and places), and the real variability in the industry has been studied, in relation to the performances of both sugar factories in Reunion. In summary, pH seems to be a good indicator of deteriorated cane, turbidity could monitor for soil content, and direct conductivity is well correlated with leaves and tops content. These simple indicators, chosen for their easy measurement in routine laboratories, could be used as incentive criteria for growers’ payment, or to optimise the process according to cane quality variation.

Introduction
Since sugarcane is bought according to its quality, millers have been looking for means to predict the future yield that would be obtained from each grower’s consignment. In most countries, cane is paid according to its sucrose content, taking into account fibre % cane and juice purity to anticipate possible losses at extraction and crystallisation stages.

This is often found insufficient to induce growers to deliver good quality cane.

In Réunion island, due to higher labour cost, growers do not see the need to supply fresh and clean cane, and the mills have to face more and more trash coming in with cane.

On the other hand, it is widely thought that leaving cane on the field a few days after harvesting is a good way to see sucrose % cane increase. Although several studies prove that this effect is only due to water evaporation, most growers go on with this traditional behaviour, and cut-to-crush delay is frequently a problem when the season comes to summer. For these reasons, it would be useful to get some indicators to evaluate quality of individual consignments of cane at the point of delivery.

Some indicators already exist, such as reducing sugars (which can be due either to high content of leaves and tops in the load, or to cane deterioration after harvest), or dextran content (Ravelo et al., 1991).

However, most of the analytical methods to determine these elements are either tedious (Lane & Eynon reducing sugar, dextran haze or Roberts methods), or expensive (chromatographic methods for sugars, enzymatic or antibody methods for dextrans), if not both. It would not be possible to analyse exhaustively any consignment.

In South Africa, however, the choice has been to analyse each cane consignment for ethanol content in order to get an incentive criterion for low cut-to-deliver delay (Lionnet and Pillay, 1988).

This system was significant for burned cane but, in Reunion, most of the cane is cut green, and previous trials show that the development of ethanol was highly dependent on the harvesting mode (burned/green, clean/trashed) (Bacci and Guichard, 1994).
For these reasons, plus the fact that gas chromatography is very expensive, ethanol has not been found pertinent as a cane freshness indicator in Reunion. The door was open to find something different: cane quality assessed by cheap analytical criteria, which can be determined on juice samples of individual cane consignment at the point of delivery.

**What should be a good quality indicator?**

- It must be closely related to the character that it is supposed to be an indicator of (called hereafter linked parameter). This can be seen by pilot-scale trials.
- It must not have a wide variability due to other parameters than the linked parameter (noise), such as cane variety, agricultural factors, or geographical place. This condition is much more difficult to assess. It has been tested with exhaustive measures on fresh and clean cane of several provenances and varieties, used for breeding evaluation (Sens and Decagny, 2001).
- Then, its real variability in industrial conditions and the response to the linked parameter should be high, which is the final aim.

Moreover, a fourth condition here would be cheapness and quickness of laboratory operation. It should be easily operated on a routine basis in a matter of minutes, and can be used as a warning flag, on a threshold basis for instance, even if they are not very accurate indicators.

**An indicator for freshness**

Some indicators often used are: ethanol, polysaccharides, reducing sugars, dextrans, or total acidity. From this latest one comes the simple idea of looking at pH. Although it is not very sensitive, trials show (Figure 1) that pH is closely related to cut-to-crush delay, and it does not vary too much on fresh cane: the pH in press juice of 95% of the cane under 3 days of delay is between 5.26 and 5.59. This situation is illustrated in Figure 1.

![Evolution of pH of 2 varieties of cane after harvest](image)

**Fig. 1—Evolution of pH in press juice versus days after harvest for the 2 major varieties of cane in Reunion. The zone between 5.2 and 5.6 shows 2 x standard error around the mean pH for fresh cane (4 different varieties, 7 different geographical zones, different periods of the season, less than 3 days after harvest).**

It was also calculated from trials carried out at CERF in 2000 that each 0.1 of pH decrease indicates that 5% of the mass of sucrose in cane has been lost from the harvest time.

During the season 2002, 2450 samples of press juice from commercial cane, representative of all of Reunion Island, have been tested for pH just after extraction. It was found (Figure 2) that 74% of the cane was under 5.4 pH (mean for cane after 2 days of delay). Moreover, about 5% of the cane is under 5.0 pH and more than 10% is under 5.1.
Although the pH may present a significant difference between varieties and some other parameters, it might be used as a 'warning flag' if the pH is under 5.0 or even 5.1 to designate cane deliveries which are suspected to be deteriorated.

The procedure for evaluation of pH as an indicator of cane quality has been well detailed here. The following indicators will only be given a brief description.

**Fig. 2—Repartition of pH measurement on 2450 samples of commercial cane representative of the whole production area in Reunion in 2002.**

### An indicator for trash

The same procedure has been used to evaluate conductivity as an indicator for cane trash.

The high content of ash in tops and leaves of sugarcane is well documented (Chen and Chou, 1993). As it is very stable in time related to dry matter, conductivity ash is a specific indicator of vegetal trash, unlike reducing sugars, for instance, which are also affected by cane deterioration.

This is easy to verify by adding known quantities of green leaves or tops to clean cane and analysing the juice for conductivity ash (see example in Figure 3).

**Fig. 3—Conductivity ash of press juice from cane spiked with different quantities of green leaves.**

\[
y = 0.544x + 0.917 \\
R^2 = 0.965
\]
Due to the high number of samples coming into the laboratory of the cane testing service (CTICS in Reunion) – about 40/hour, the ash analysis has been replaced for routine on press juice by a simple direct conductivity.

Although less precise, this measurement is much more rapid as no dilution is made. A threshold of 5 mS would point out cane with a high trash level (which represents almost 25% of 2000 cane samples analysed for conductivity in 2002).

**An indicator for soil**

Soil in cane is considered to be a major problem causing wear and reduced performance of the recovery process (Wieneese and Reid, 1997). It may also be a source of error when cane payment is based on press analysis, because the calculation generally assumes that all the insoluble solids (fibre) are in the press cake and the extracted juice is composed of a pure liquid phase, whereas a significant mass of soil particles may go through with the juice.

The original indicator is ash % cane by incineration, which is tedious. Another consequence of soil in cane is the higher level of insoluble solids in the juice, from which arose the idea to use turbidity. Turbidity of the press juice, directly adapted from the ICUMSA method for clarified juice (ICUMSA, 1994), may be used as a quick and easy indicator.

It is only a measure of optical density at 900 nm against water as blank. As shown by trials at the CERF in 2003, it is well correlated to the percent of soil spiked into clean shredded cane (Figure 4).

Whereas the press juice of clean cane without any soil shows turbidity between 140 and 180, the turbidity increases 10 to 16 units for each 1% of soil. In commercial cane delivered to the factory, in rainy periods, turbidity of individual juice may reach up to 300 and much more, which may indicate a level of soil above 10% on cane.

![Turbidity of juice versus % soil in cane](image)

**Fig. 4**—Turbidity of press juice of cane spiked with different quantities of soil. Results of 4 different tests (different cane samples and different soil provenances) and average tendency.

**Conclusions**

Several criteria may be used to determine some aspects of cane quality. When a very simple indicator is needed, in order to get a quick result on an individual consignment of cane, the following may be determined on press juice with little labour: direct pH to get freshness of cane, direct conductivity (mS) to get its cleanliness relative to leaves and tops, direct turbidity (absorbance units) to get its soil content. All those results may be obtained without any dilution or manipulation of the juice sample.

The above figures are given for Reunion island, but a few trials may allow it to be adapted to any local conditions. Therefore, some decision may be made to get a special treatment for deteriorated cane, to warn suppliers who deliver bad quality cane, to reward those who bring best quality, etc.

Such tools may be very useful before the development of quick (but, for now, expensive!) near-infrared measurements make them obsolete.
EVALUATION DE LA QUALITÉ DES CANNES PAR DES ANALYSES DE JUS SIMPLES ET PEU COÛTEUSES

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Résumé

Les réducteurs, les cendres, les polysaccharides et autres non-sucre affectent la performance des sucreries; ces non-sucre influencent la récupération du saccharose comme sucre commercial. Ces non-sucre affectent ce qu'on appelle généralement «la qualité des cannes», un terme qui comprend des facteurs différents, tel la maturité des cannes, leur propreté (paille et terre), et le vieillissement. Il est souvent difficile et coûteux de mesurer tous ces non-sucre. A la Réunion on a étudié les relations entre plusieurs indicateurs chimiques simples et la qualité de la canne, depuis plusieurs années. On a choisis des indicateurs intéressants et on a établit leurs corrélations avec un seul paramètre de la qualité des cannes, par exemple le vieillissement ou la paille et la terre; on a aussi obtenu la variabilité des paramètres en comparant de bonnes cannes et des cannes de mauvaise qualité (par exemple cannes propres contre cannes sales). On a étudié la variabilité à l'échelle industrielle, en se servant des performances obtenues dans les deux sucreries de la Réunion. On trouve que le pH est une bonne indication de la détérioration; le trouble indique la présence de la terre, et la conductivité indique la présence des feuilles et des bouts blancs. Ces paramètres assez simples, qui peuvent être déterminées dans les laboratoires de la sucrerie, pourraient être des critères pour corriger le paiement de la canne ou pour guider la fabrication.
MONITOREO DE LA CALIDAD DE LA CAÑA A TRAVÉS DE INDICADORES RÁPIDOS Y ECONÓMICOS PARA EL JUGO DE CAÑA

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Resumen

La eficiencia en los procesos de los ingenios azucareros se ve afectada por algunos no-sacáridos, como los azúcares de reducción, el contenido de cenizas o algunos polisacáridos, que influyen sobre cómo la sacarosa puede recuperarse como azúcar comercial. Estos no sacáridos dependen de lo que generalmente se denomina ‘calidad de la caña’, que incluye distintos aspectos, tales como la madurez de la caña, su limpieza (en oposición a su contenido de cenizas o tierra), y su frescura (en oposición al deterioro post-cosecha). Su medición con frecuencia es tediosa y/o muy costosa. En la isla reunión y para campañas diversas, se han llevado a cabo estudios a nivel piloto e in-situ, con el objetivo de identificar indicadores analíticos simples relacionados con la calidad de la caña. Se han investigado algunos de los potenciales indicadores, para ubicar su correlación con algún parámetro de la calidad de la caña (específicamente los retrasos en la cosecha, el contenido de basuras y el contenido de tierra), se han realizado pruebas con respecto a su variabilidad normal en condiciones ‘buenas’ (para caña fresca y limpia en distintas variedades y lugares), y se ha estudiado la variabilidad real en la industria, con relación a su desempeño en los dos ingenios de reunión. En suma, el pH parece ser un buen indicador de caña deteriorada, la turbidez podría monitorear el contenido de tierra, y la conductividad directa está bien relacionada con el contenido de hojas y materias superiores. Estos indicadores simples, elegidos para su fácil medición en los laboratorios de rutina, podrían usarse como criterios de incentivo para el pago a los cultivadores, o bien para optimizar el proceso de conformidad con la variación de la calidad de la caña.