

AN ANALYTICAL OVERVIEW OF THE HISTORICAL EVOLUTION OF SOME PERFORMANCE INDEXES OF THE COLOMBIAN SUGAR MILLS

By

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Review, Standardisation.**

Abstract

IN 1993, the Colombian sugar industry recognised the importance of creating a reliable Standard Measuring System (SMS) for the sugar factories, with the purpose of developing tools for management processes. This system included sampling, analytical procedures and calculation modules. It was generated in conjunction with experts from Sugar Research Institute in Australia (Ken Miller and Geoffrey Bentley), the chief chemist of each sugar factory and the technical staff from Cenicaña. Since January 1998, the Factory Process Research Program at Cenicaña, together with the staff of the 10 main Colombian sugarcane mills, began the construction of an integrated database, focusing on the registry of 42 process variables measured and/or calculated in each factory. Each variable reported by the sugar mills was based on monthly weighted averages. The predetermined set of variables comprised those related to cane quality, sucrose balance (related to undetermined loss), energy usage and time use efficiency. Because the SMS has a very strong dynamic behaviour, a parallel program for assessing the quality of the reported information was established (Calero, *et al.*, 2006). Over this 10 year period, the improvement in sucrose % cane and factory efficiencies is notable. From 2002 until now, the increment in 0.25 units in sucrose % cane and 1 percent unit in overall recovery (OR) represent an additional production of 69 860 tonnes of sugar for a cane crush of 20 million tonnes per year.

Introduction

The Colombian Sugarcane Research Center (Cenicaña) is a private, non-profit corporation, founded in 1977 by the Association of Sugarcane Growers of Colombia (Asocaña) representing the sugar agro-industry located in the Cauca River Valley. Cenicaña carries out research programs on varieties, agronomical practices and factory processes, and has support services in economic and statistical analyses, information and documentation, computer technology, technical cooperation and technology transfer. It provides laboratory analytical services, administers the Automated Weather Network (AWN) stations, and continually updates the digital cartography of the cultivated area.

The sugar industry in Colombia has three cane growers' associations, one research centre, one cane technicians' association, two trade firms, 13 sugar mills and a large number of cane grower enterprises. Five sugar mills established distilleries to produce ethanol at the end of 2005 in response to Law 693 of 2001, which mandated oxygenating vehicular gasoline with 10% (by volume) of fuel ethanol.

Factory performance indices

The standardised monthly inter mill benchmarking started in January 1998. Thirteen sugarcane mills report 42 indices relating to sugarcane quality, time efficiency, sucrose extraction,

boiling house recovery (BHR), overall recovery, and energy usage. This paper shows the trends of the monthly average values of ten mills, during the first ten years of the SMS.

Crushed cane and sugar production

In 1999, the variety CENICAÑA Colombia (CC) 85-92 became the first commercial variety in the area planted by the Colombian sugar industry in the Cauca River Valley. Crushed cane has grown from approximately 17 million tonnes of cane annually in 1998 to a maximum value just under 21 million tonnes in 2004. The monthly average of cane crushed was 1 600 000 tonnes, with a minimum of 609 228 tonnes in October 2008 as a result of the blockade of eight sugar mills by cane cutters. Monthly values around 2 million tonnes are frequently obtained in August and September during the dry season (Figure 1).

A greater stability is observed during the years 2002 and 2006 when around 20 million tonnes per year were crushed. This fact is explained by the dry periods experienced during these years with an annual average rainfall of 1000 mm. This was the lowest value registered in the 34 AWN stations placed throughout the Cauca River Valley (Informe anual, Cenicaña, 2008).

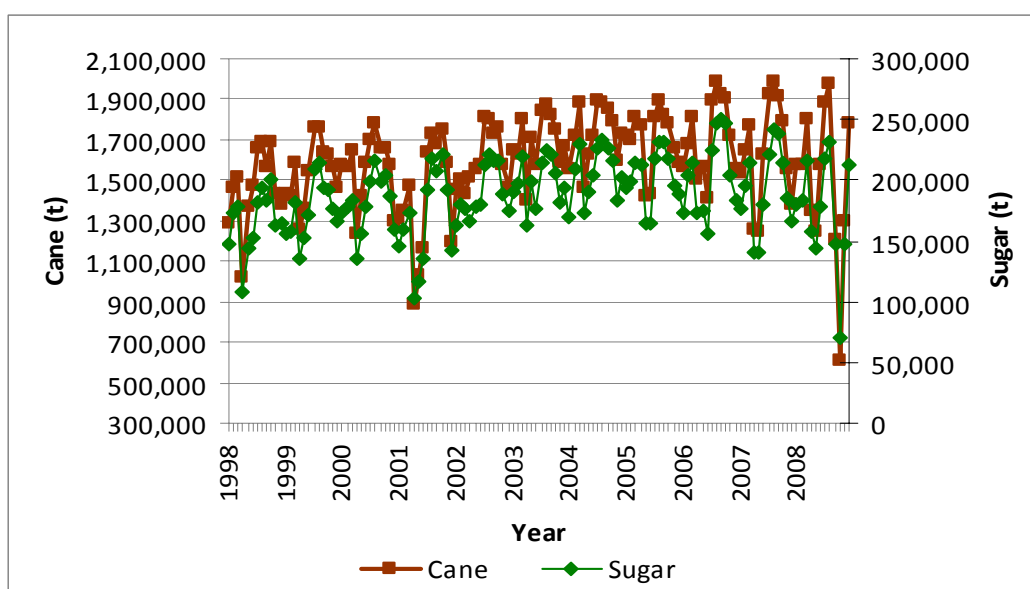


Fig. 1—Monthly averages for cane and sugar production in Colombia.

The increased availability of the cane variety CC85-92 from 2002 led to a productivity increase on average of 10% more cane per hectare (tch). Moreover, there was an increase in milling throughput of 7% per day and a 2% increase in the overall time efficiency.

The sugar production per year ranged between 2 million tonnes and 2.4 million tonnes. The Colombian sugar industry produces refined sugar in seven refineries and, raw sugar, white sugar, special direct white sugar (colour below 150 IU) and organic sugar. The amount of sugar depends on the crush rate, cane quality and the factory efficiencies.

The monthly average crush rate was 186 911 tonnes cane per hour, and this ranged between 70 853 and 249 981 tonnes cane per hour. As in the case of total cane crushed, the minimum value was obtained in October 2008, because of the blockade (Figure 1). The yield expressed as kg of sugar of 99.7 pol per 100 kg of cane has varied from 11.30 to 11.93 with a yearly average value of 11.70.

Cane quality

The trend to higher content of sucrose % cane (Figure 2) and lower industrial fibre % cane (Figure 3) coincided with the fact that from 2001 the cane variety CC 82-92 became the most

harvested in the industry. In 2008, this variety was harvested in 70% of the cane area. Between 1998 and 2001, the average sucrose % cane and fibre % cane were 13.18% and 15.10% respectively and between 2002 and 2008 the averages were 13.43% and 14.77%. The maximum content of sucrose in cane, 14.62%, was reached in September 2006. During 1996–2002, the Factory Process Research Program at Cenicaña developed a project called ‘Reduction of Sucrose losses between field and factory’. One of the main objectives of this project was to determine the rate of sucrose deterioration due to storage time which ranged from 0.0015–0.02 sucrose % per hour (Briceño, 2006). The mills reduced the storage time from an average of 50 h–60 h down to 30–42 h (Larrahondo and Briceño, 2001).

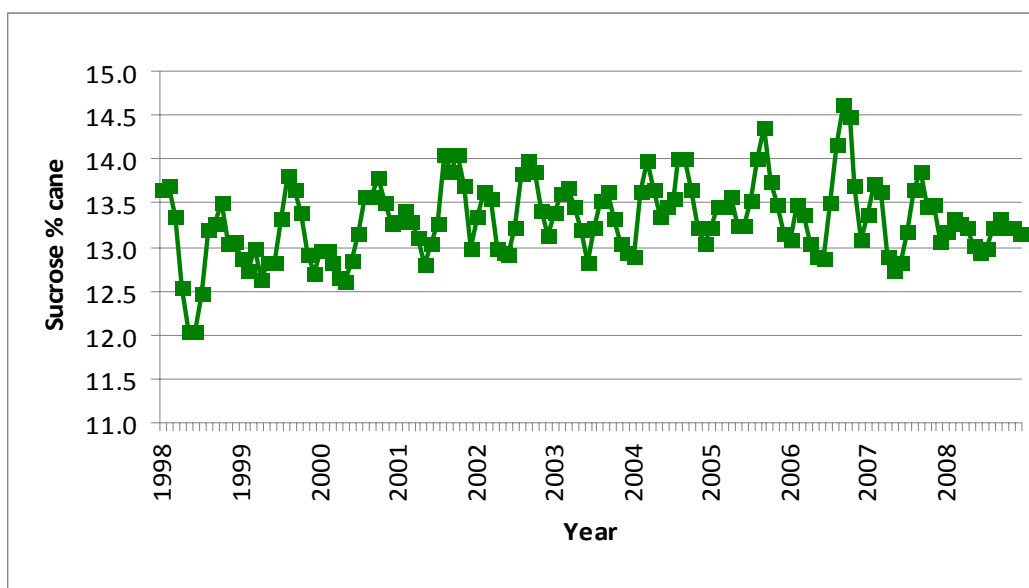


Fig. 2—Monthly averages for sucrose % cane in Colombia.

The industrial fibre includes the cane fibre and the insoluble mud solids measured in mixed juice. The higher values of fibre reported in April, May and December are associated with the rainy periods experienced during these months (Figure 3).

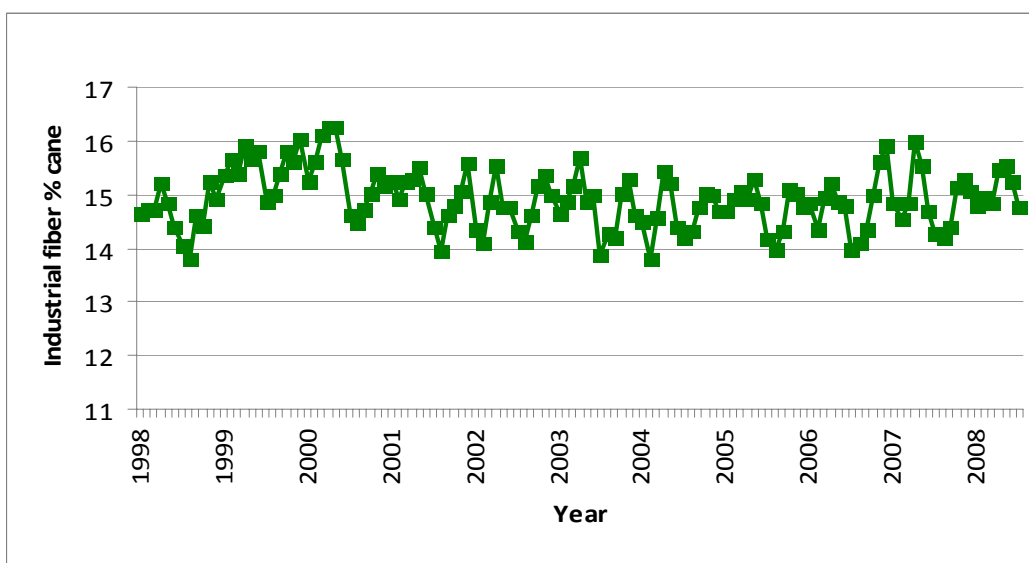


Fig. 3—monthly averages for industrial fibre % cane in Colombia.

Reduced extraction at 12.5% fibre.

All the sugar factories have milling tandems and, of the ten mills, three have knives only, three mills have knives and medium duty shredders, two have knives and heavy duty shredders and two have heavy duty shredders only.

The trend of reduced extraction is shown in Figure 4 and is one of the most stable of those analysed with an average of 96.65% and a coefficient of variation of 0.20.

The mobile laboratory to evaluate the performance of individual milling tandems and software developed for Cenicaña to model the extraction processes (Carvajal, *et al.*, 2006; Gómez *et al.*, 2003) had contributed to the stabilisation of the reduced extraction.

The extraction efficiency is directly related to changes in the content of industrial fibre % cane. In the period 2002–2006, industrial fibre was 0.13 percentage points higher and the extraction was lower than the values reported in the two year period 2007–2008.

However, the magnitude of the difference in the extraction was higher than that observed due to the fibre increase only. This may be explained in terms of imbibition % cane, which was reduced on average.

The imbibition rate is not always a function of the industrial fibre content as would be expected. Low imbibition rates with high industrial fibre content are reported during rainy periods, while high imbibition rates with low industrial fibre content are reported during dry periods.

This trend would indicate that imbibition is a function not only of the industrial fibre content but also of the availability of steam which is affected by the bagasse quality expressed in terms of moisture and ash content.

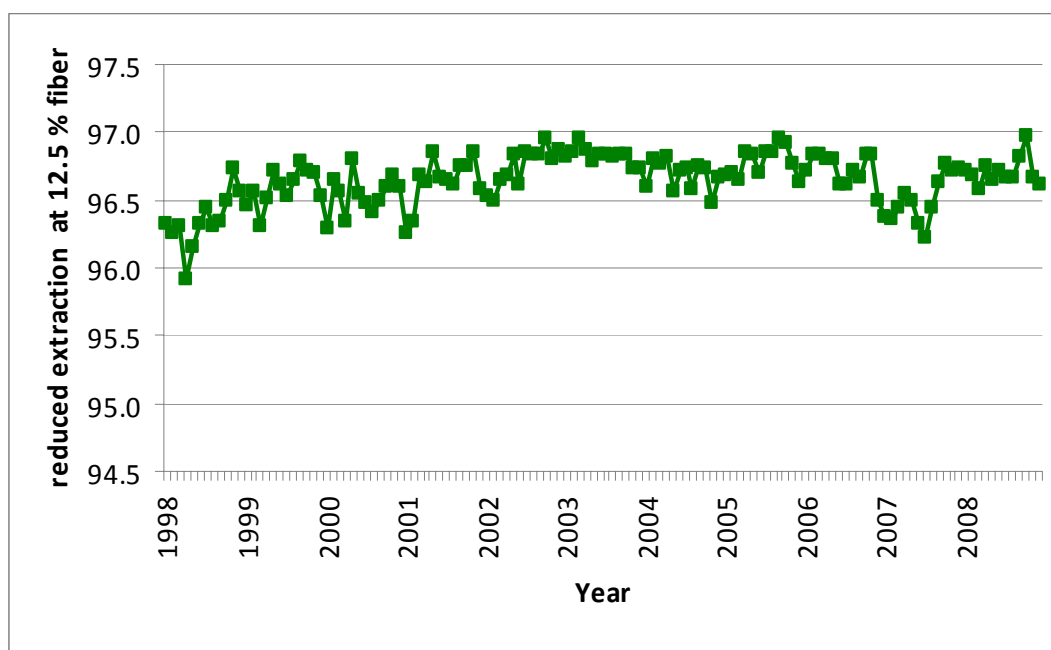


Fig. 4—Monthly averages for reduced extraction at 12.5% fibre.

Boiling house efficiency

Since 2001, the BHR has shown good stability and higher efficiencies, with only one data point below 90% as illustrated in Figure 5. Since August 2007, the BHR has stabilised around 92% due to the projects undertaken to reduce the undetermined losses.

In 2006, after the installation of the five distilleries for fuel ethanol production and, as a consequence of the different problems in the fermentation, some of them related with the high

content of volatile acidity of the substrate, Cenicaña conducted a project focused on reducing the undetermined losses (Calero *et al.*, 2009).

The pathway followed in the project covered microbiological, physical and chemical analyses from first expressed juice to syrup, critical analysis of the control strategies used for process variables, process residence time, and suggestions for geometry and size of the pans.

This project helped to reduce the drop in purity between first expressed juice and raw juice from 1.9 in 1998 to 1.3 in 2008 and the drop in purity between clear juice and filtrate juice from 2–3 units to 1–2 units in some mills.

From Figure 6, it is clear that, while the determined losses (bagasse, cake and final molasses) remain relatively constant at around 11%, the undetermined loss shows a decreasing trend.

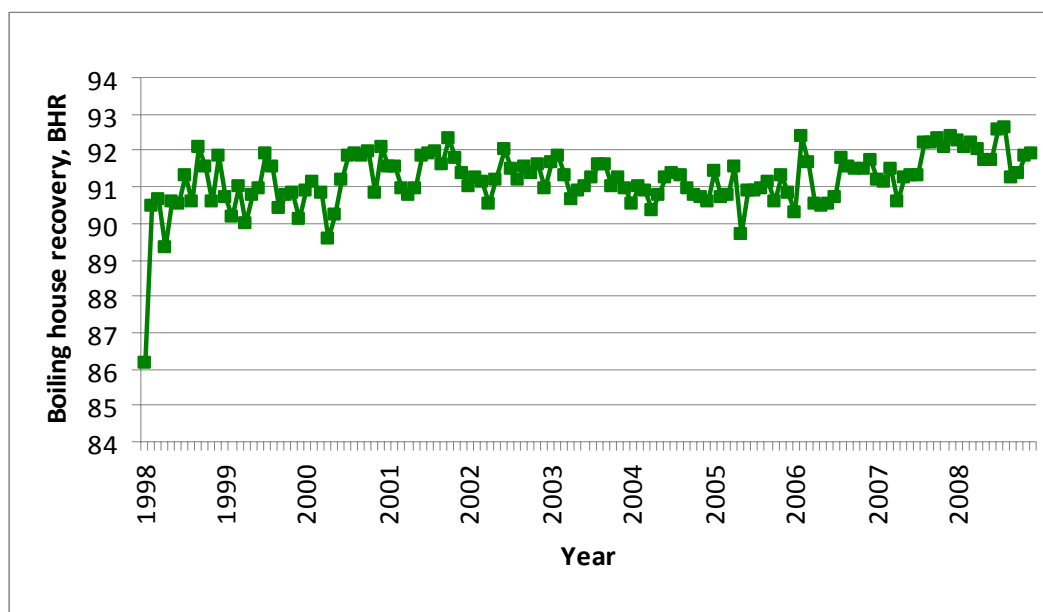


Fig. 5—Monthly averages for boiling house recovery (BHR) in Colombia.

During the 10 year period under review, the industry has also changed the clarifiers. Three mills have the latest generation SRI clarifiers, but RapiDorr and Dorr 444 clarifiers are also used.

The use of continuous vacuum pans has been adopted in four mills; two for B massecuite and two for A massecuite as well as the use of vertical crystallisers in two of the mills.

These changes have contributed to maintaining the pol loss in final molasses relatively constant despite the changes in cane quality due to the increased percentage of cane harvested mechanically. This has increased from an average of 15% in 1998 to 30% in 2008. Two mills are harvesting around 50% mechanically.

In addition to the technological changes, the main results of the projects to reduce the pol loss in final molasses (Gil *et al.*, 2001a) and the determination of target purity in final molasses (Gil *et al.*, 2001b) include:

- the improvement in the slurry preparation;
- a methodology for measuring the crystal size; and
- a methodology to evaluate the exhaustion of C massecuite.

These results have contributed to reduce the pol loss in final molasses from 6.44% pol in cane in 1998 to 5.99% pol in cane in 2005.

After 2005, five of the ten mills stopped producing final molasses and diverted B molasses to ethanol production.

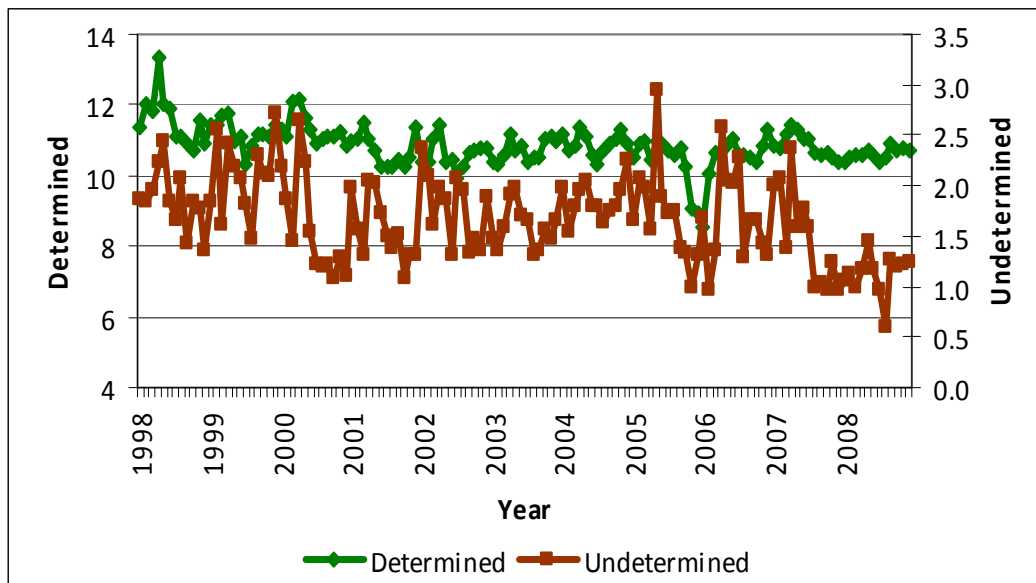


Fig. 6—Monthly averages for determined and undetermined losses % pol in cane.

Overall recovery

Overall recovery performance has been stable at values higher than 87% from the middle of 2001 as illustrated in Figure 7.

During the past seven years, OR increased one unit on average in spite of the increasing trash material processed with the cane and the adverse climatic conditions of the last two years

This improvement in the factory performance represents, for an average crushing year season of 20 millions tonnes of sugarcane, an additional production of 27 000 tonnes of sugar.

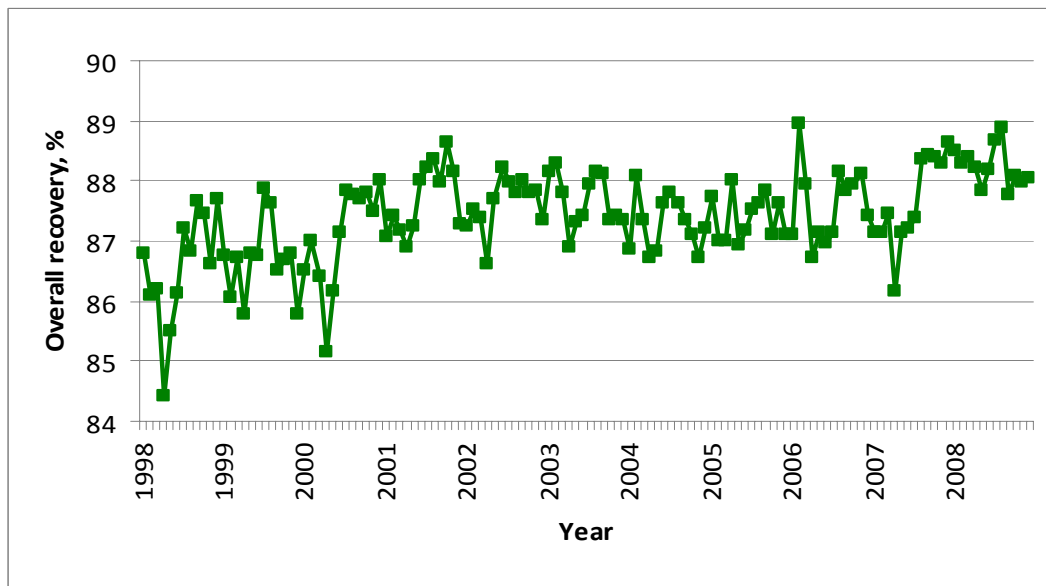


Fig. 7—Monthly averages for overall recovery in Colombia.

Conclusions

The use of standardised monthly inter mill benchmarking has become a valuable tool for the periodic comparative analysis of information among sugar mills and a fundamental tool for continuous improvement of the industry.

During the past ten years, the sustained improvement in sucrose % cane and factory efficiency was excellent. Since 2002, the increase in sucrose content of 0.25 units and in overall recovery of one unit represents an extra production of 69 860 tonnes of sugar for an average season of 20 million tonnes of cane.

Despite the fact that Colombian field productivity is the highest in the world, and is a product of more than 35 years of research on agricultural packages and varietal breeding, the assessment of sugar factory performance is much more recent and the development of the technology is still at an early stage. Using the developed standardised measurement system detailed in this paper, researchers at Cenicaña, technicians from the sugar and ethanol factories, consulting enterprises and so on, are able to formulate reliable factory improvement strategies, increase production capacity of the plants as well as periodic benchmarking assessments.

Many opportunities are open to the Colombian sugar sector. First, its important contribution to the 'National plan for oxygenated gasoline', which, at July 2009, is covering 85% of the total demand of bioethanol, and the expected demand for increased production capacity in the future. Finally, cogeneration in sugar mills is becoming an interesting business option, after the Colombian Regulatory Committee on energy and gas developed a set of requirements for Colombian agents to obtain the category of electrical generator.

Acknowledgments

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**UNE ETUDE ANALYTIQUE DE L'EVOLUTION DE LA
PERFORMANCE DES SUCRERIES COLOMBIENNES**

Par

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Amerique du Sud*efcastillo@cenicana.org**MOTS CLEFS: Analyses, des Performances,
Revue, Standardisation.****Résumé**

EN 1993, l'industrie sucrière colombienne a reconnu l'importance de la création d'une fiabilité Standard Measuring System (SMS) pour les usines à sucre, dans le but de développer des outils pour la gestion. Ce système comprenait l'échantillonnage, les procédures analytiques et des modules de calcul. Il a été généré en conjonction avec des experts du Sugar Research Institut en Australie (Ken Miller et Geoffrey Bentley), le chimiste en chef de chaque usine et le personnel technique de Cenicaña. Depuis janvier 1998, le Factory Process Research Program à Cenicaña, avec le personnel de dix usines colombiennes, a commencé la construction d'une base de données intégrée, en se concentrant sur le registre de 42 variables de processus mesurés ou calculés dans chaque usine. Chaque variable donnée par les usines est une moyenne pondérée mensuelle. L'éventail de variables prédéterminés comprend ceux liés à la qualité, bilan saccharose (perte indéterminée), utilisation et efficacité de l'emploi du temps. Parce que le système SMS a un comportement dynamique très fort, un programme parallèle pour évaluer la qualité de l'information a été établi (Calero, *et al.* 2006). Pendant cette période de 10 ans, l'amélioration du saccharose % canne et de l'efficacité à l'usine est remarquable. Depuis 2002 jusqu'à présent, on trouve une augmentation de 0.25 de saccharose % canne et de 1% en récupération générale (OR) ce qui représentent une production supplémentaire de 69 860 tonnes de sucre pour 20 millions de tonnes de canne par an.

REVISION ANALITICA DE LA EVOLUCION HISTORICA DE ALGUNOS INDICES DE DESEMPEÑO DE LOS INGENIOS AZUCAREROS COLOMBIANOS

Por

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Colombian Sugar Cane Research Center- Cenicaña, Cali, Colombia, South Americaefcastillo@cenicana.org**PALABRAS CLAVES: Análisis, Desempeño, Revisión, Estandarización.****Resumen**

EN 1993, la industria azucarera colombiana reconoció la importancia de crear un sistema confiable de medición estandarizado (SMS) para los ingenios azucareros, con el propósito de desarrollar herramientas para la gestión de procesos. Este sistema incluyó, muestro, procedimientos analíticos, y un módulo de cálculos. Este sistema fue desarrollado con apoyo de expertos del Sugar Research Institute de Australia (Ken Miller y Geoffrey Bentley), los jefes de laboratorio de los ingenios y personal técnico de Cenicaña. Desde 1998, el Programa de Procesos de Fábrica de Cenicaña en conjunto con personal técnico de 10 de los principales ingenios azucareros colombianos, empezaron la construcción de una base de datos, que registra 42 variables de proceso medidas y/o calculadas en cada ingenio. Cada variable reportada por los ingenios está basada sobre promedios ponderados mensuales. Estas variables comprenden aquellas relacionadas con calidad de caña, balance de sacarosa, uso de energía y eficiencia en el uso del tiempo. Debido al carácter dinámico del SMS se estableció un programa paralelo para valorar la calidad de la información reportada. Durante estos primeros 10 años, se destaca el incremento en la sacarosa % caña y las eficiencias en las fábricas. Del año 2002 a la fecha, el incremento en 0.25 unidades en la sacarosa % caña y en una unidad porcentual de la recuperación total (OR) representa una producción adicional de 69 860 toneladas de azúcar para una molienda típica de 20 millones de caña por año.