MICROBIOLOGICAL CONTROL IN A CANE SUGAR MILL: IMPLICATIONS ON SUGAR QUALITY AND ON LOSSES

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Abstract

At Bois-Rouge raw sugar is produced for the food industries of the European community. As are colour and grain size, the microbial population of sugar is a major quality parameter. Microbiological control and sanitation are therefore important aspects of production. A general view of microbial populations in the factory is given. Correlation with specific analyses such as pH, glucose and fructose levels help in locating trouble spots in the production process. Factory sanitation programmes have been adapted and introduced and biocides are evaluated. Process personnel have also been involved. The results, which show a clear improvement in recovery, are given.

Keywords: Sugar quality, sanitation, micro-organisms, undetermined losses

Introduction

In any sugar factory, one of the first aims is to reduce the undetermined losses to a minimum. Indeed, apart from physical loss, it is difficult to account for the weekly losses that occur during the inversion of sucrose in the factory process. The inversion loss can be chemical (effect of temperature, pH, retention time and brix) and/or biochemical. Great improvements have been made during the past two years to assess the influence of the losses by chemical inversion (for example, at the evaporation stage). At Bois-Rouge, with a cane diffuser, we want to define the impact of the losses due to bacterial degradation and try to answer the following:

- Is there an acceptable population level for bacteria at various stations of the factory and, if so, what is the acceptable level?.
- At which stage in the factory process does the growth of any particular type of microbe take place?
- How to supply adequate biocid to the factory process?

Over a period of 20 weeks of crushing, we have sought answers to the above questions by following the progress of five major categories of microbiological populations through the factory process. These populations affect the process directly (eg *Leuconostoc* and thermophile germs) and also impact on sugar quality (eg yeast, mould and flat sour thermophilic bacteria). Our second main questions are therefore:

- How can we meet the quality system imposed by our clients?
- Is our present processing system really suited to our needs?

Material and method

Calculation of sucrose losses have been done according to the usual South African method and are directly comparable with South African results.

Sampling: To minimise the delay between the laboratory sampling and analyses, all samples are taken in the morning (Catch, 500 ml), kept at 7°C and taken to the Official Veterinary Laboratory of Reunion, which is qualified (France) to perform the microbiological analysis procedure (ISO 9002). The time delay before the start of the analysis is estimated to be one hour, with results being available four days later. In this paper, the number of germs given is for 10 g of product.

Products: Mixed syrup (MS) and A and B-molasses are taken in their storage tanks. The scum of the MS is taken from the top of the tanks and diluted with distilled water at the factory laboratory.

Results and discussion

Influence of rainfall

The influence of rainfall on the the increase in number of flat sour and thermophilic bacteria was evident at the shredded cane stage (Figure 1). When more than 10 mm of rain fell, contamination was more pronounced, and an average for thermophilic bacteria of 81 counts/annum increased to between 200 and 2 565 counts.

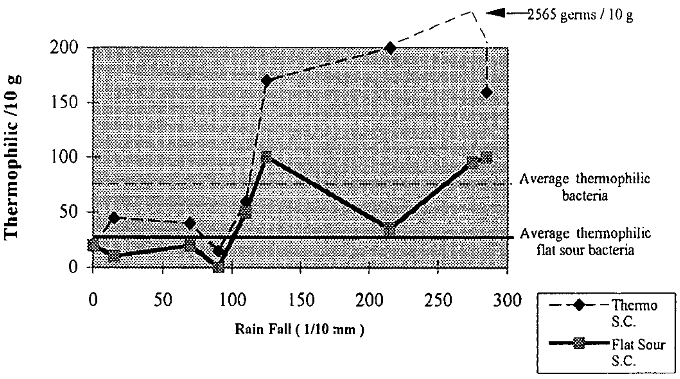

FIGURE 1: Thermophilic bacteria in shredded cane

It was not possible to follow this type of effect with the mesophilic germs because the mean level was already extremely high.

It is suspected that the change in sugar quality between 1994 and 1995 was due partly to the weather. Rainfall for 1994 was lower than that of 1995 (Table 1). For the 1995 season, the only harvest month with no rain was the last one.

Table 1

Rainfall during the crushing seasons of 1994 and 1995 (1/10 mm)

Crushing season	July	August	September	October
1994	725*	1 010	450	1 035
1995	765*	2 685	1 420	190

Rainfall 1 mm = 1 litre per m^2
* results are given from the first crushing day

This number of micro-organisms entering the cane have an impact on processing and on sugar quality. These two points will be developed later.

The distribution of microbes in the factory

Figures 2 to 5 show levels of some of the microbes found at different stages in the the factory.

Thermophilic population. The minimum level of thermophilic bacteria is found in cane entering the factory (Figure 2) and a level of between 600 and 800 is found at the juice stage. It seems that this level remains more or less constant during extraction and clarification, and could be considered a reference level. Declining cane quality, frequent breakdowns or process conditions increase the number of thermophiles, and use of a biocid then becomes necessary.

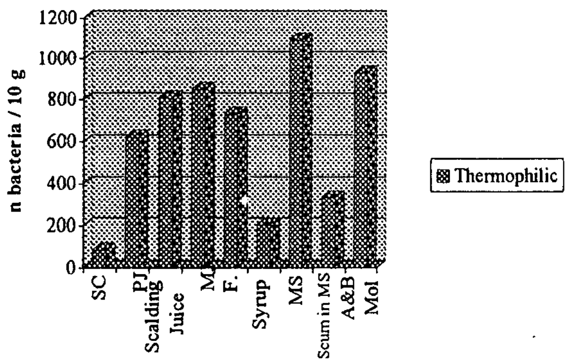

FIGURE 2: Thermophilic bacteria distribution

In the factory is is unusual to find a population higher than 1 000 in the MS, especially if the level was brought down (200) during the evaporation.

Thermophilic flat sour. The flat sour bacteria are glucose +, ie in a petri dish they were distinguished by the presence of a yellowish halo around the colonies, due to of the degradation of glucose into different organic acids. These bacteria represent about 10 to 20% of the global thermophilic population in the mill, and do not seem to have much effect in the process. At the syrup stage these bacteria are fairly abundant, and it was observed that there was a significant increase in population in the MS storage tank, similar to the thermophilic bacteria.

Mesophyllic population. This is the most abundant group in the process, numbering more than 20 000 bacteria per 10 g of product entering continuously. The group decreases with heating (80°C) of the juice at the inlet of the diffuser. This family does not necessarily destroy the sucrose and exists mostly in a dormant state (Figure 3).

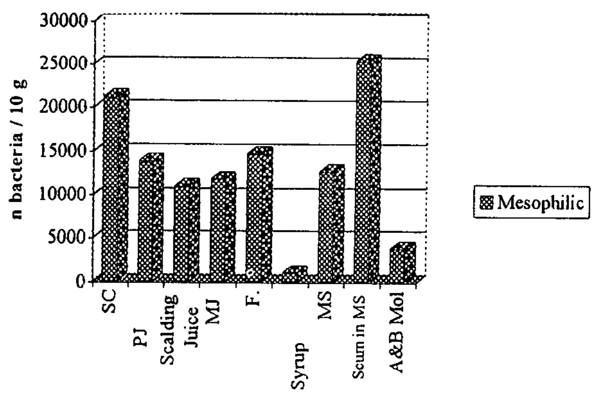

FIGURE 3: Mesophilic bacteria distribution

The fact that the numbers increase in the filtrate (F) is not surprising, for several reasons. Mud is difficult to treat with the recirculation at the filter stage (Antier, 1996). The filtration station at Bois Rouge is not efficient because of insufficient vacuum and poor mechanical conditions.

From the outlet at the evaporator station, the number of mesophiles again increase to excessive levels; an average of 12 500 is reached in the storage tanks and, on the surface, the concentration reaches 25 000 in the MS. In the A and B-molasses vessels, levels remain at an average of 3 500, although these vessels are not insulated.

Yeast. This is the major type of mesophyllic population to enter the factory with the cane, but it seems that this micro-organism has difficulty in surviving in the diffuser and at the clarified juice stage (Figure 4).

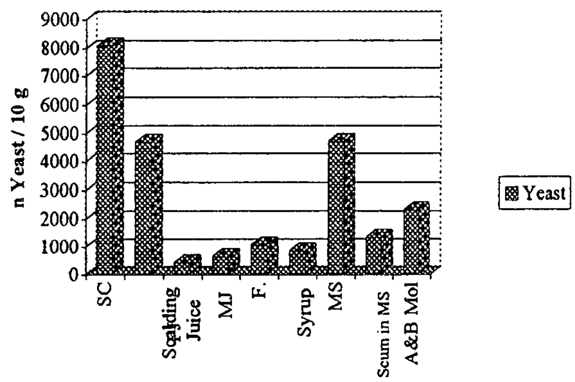

FIGURE 4: Yeast distribution

On the other hand, it is probably the microbial group which can resist the high temperatures at the evaporators. Yeast could be in a dormant, sporulated form thus being protected. After evaporations, the osmophilic yeasts can develop in a sucrose solution with high concentrations and thus have no difficulty multiplying in the syrup tanks.

Leuconostoc sp. The presence of these bacteria usually indicate sanitation problems. Great effort must be made to control this micro-organism at the mill tandem with the press juice (PJ) and also at the filtration station with the filtrate juice (F) (Figure 5).

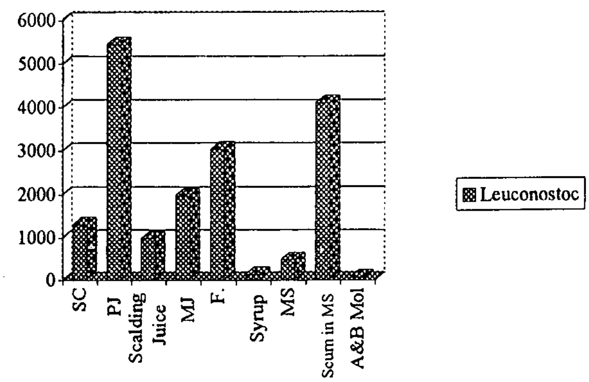

FIGURE 5: *Leuconostoc sp.* distribution

At syrup storage, its influence is normally restricted (Chen and Chou, 1993), and it was therefore surprising to find such a high level of *Leuconostoc* at the top of the MS storage tanks. The formation of scum (due to the increased surface area coming into contact with the air and facilitating the solubility of atmospheric oxygen) and a slight decrease in average brix helped the development of the bacteria.

We can now already highlight three observations:

- Micro-organisms that enter the factory in great numbers (mesophilic and especially yeasts) are not necessarily those that will multiply most in the factory. It is therefore necessary to have an adequate policy for the management of the cane from the cutting to the storage stage, to minimise the level of micro-organisms.
- That the levels of micro-organisms differ with the stage of process is an argument for the use of an optimised sanitation programme. The biocid used must be adapted to the station and must have an impact on micro-organsims which have a tendency to develop at a particular stage (thermophilic in the diffuser, mould and *Leuconostoc* in press juice (PJ) and *Leuconostoc* in the filtration station).
- At Bois-Rouge, in addition to the problem at the filtration station, it is obvious that treatment of the MS and its method of storage must be improved.

The third point is particularly important because, at this stage, undetermined losses and sugar quality are interconnected.

Sugar quality in relation to sanitation

Table 2 gives a comparison between the most favourable and the most drastic microbiological specifications applicable to our different clients. Concerning pathogenic bacteria, the risk must be non-existent (Balogh, 1992). ICUMSA reports that testing for pathogenic bacteria in refined sugar stopped in 1970 because none were ever found. To date, we have not detected this type of bacteria in routine testing. In spite of this, we do the analysis twice a week. In addition, the laboratory also carries out an analysis on the sulfato-anaerobic thermophilic bacteria; here also results have been negative throughout the season.

Table 2

Microbiological Statutory Requirements for 10 g of special raw sugar

	Thermophyllic	Flat sour	Mesophyllic	Yeast	Mould	*Leuconostoc*
Favourable requirements	200	75	1 000	200	100	No specification
Drastic requirements	150	5	200	10	10	No specification
Average C94	60	29	269	43	11	–
Average C95	173	24	804	347	37	206
Average over the last 2 months	133	19	355	147	28	11

In 1994, sugar quality at Bois-Rouge was good. Unfortunately, adequate control of the microbiological populations was lost in 1995. The problem mainly concerned yeast, where the average on sugar was 347 instead of between 0 and 200. Mesophile levels were also a cause of concern.

Heavy rainfall in 1995 cannot explain everything. The degradation of the sugar quality and the increase in undetermined losses are attributed to management practices and the design of the MS storage tanks. Four tanks for storage of MS are used. Tanks 1 and 2 are used to collect the syrup from the fifth vessel evaporator and the return of the B and C remelt, and Tanks 3 and 4 receive the filtered MS before their use in the A-vacuum pans.

A microbiological analysis (Figure 6), tank by tank, shows clearly that the MS degrades increasingly as storage progresses.

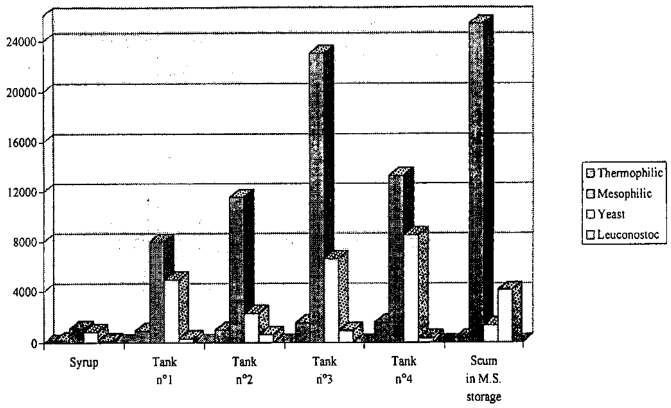

FIGURE 6: Degradation of syrup during the storage

The scum on the top of the tanks is the source of infection for the mesophilic bacterias and the *Leuconostoc* sp. When the flow of material between tanks is mismanaged, purity may drop by up to 2 points. An increase in glucose concentration of +27% and in fructose of +23% was measure in tank 4 by HPLC. Tank 4 was badly managed, being used only receive MS while the feed to the pans was from tank 3.

Actions taken to reduce the growth of micro-organisms were:

- A test was performed to choose the most efficient biocid. Biocids A and C were selected as shown in Table 3.
- A network was installed to distribute the biocids to the tanks. The system, which uses a specific rotating jet-head has the advantage of being economical and guarantees distribution of the biocids over all surfaces where micro-organisms are most likely to develop.
- The MS residence time in the tanks was reduced by better flow management.

Table 3

Biocide test on Mesophilic population* and *Leuconostoc* sp.

Dosis	A	B	C	D
0 ppm	5 000* – 150	5 000* – 150	5 000* – 150	5 000* – 150
5 ppm	1 150* – 50	1 550* – 175	1 500* – 95	2 250* – 100
15 ppm	500* – 0	150* – 0	0* – 50	450* – 100
50 ppm	0* – 0	100* – 0	0* – 0	0* – 0

Biocide A = Hydrazine Biocide B = Isothiazolone
Biocide C = Dimethyl dithiocarbamate
Biocide D = Polymeric biguanide hydrochloride

As seen in Table 2, the microbiological quality of the sugar improved considerably over the last two months of the season.

Table 4

Comparison between undetermined losses in 1994 and 1995

	% Invert in MJ	Increase in invert sugar between MJ and MS	Invert % sugar	Undetermined loss % sucrose in cane
1994	0,25	118%	0,19	3,89
1995	0,33	103%	0,11	1,96

After improvements were completed, undetermined losses were reduced in 1995 as shown in Table 4, where the difference in level of invert represents the progress made despite an increase in MJ.

Conclusions

As emphasised by Legendre (1992) sugar quality begins in the field, with the harvesting system, and continues with the management of the cane yard. Climatic conditions can minimise or accentuate the problem of contamination of the cane, and thus the levels of microbial populations entering the factory can have spectacular peaks.

Microbial assessments of different parts of the factory should be obtained during the season and used to improve the microbial quality in juice, syrup and sugar. The experience acquired indicated the type of micro-organisms for which appropriate corrective actions must be found. This is also linked to biocide. Each factory should develop a Sanitation Management Program which will minimise the undetermined losses.

To answer the specifications of our clients, it is now urgent to demonstrate that the sugar industry is concerned with quality, that written procedures exist and that factory personnel are aware of every aspect of quality production. This microbiological study has helped to make personnel at Bois-Rouge aware of and concerned about sanitary aspects, making it an important criterion during the out of season maintenance programme.

Acknowledgements

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