

BIOCIDES AT UNION CO-OPERATIVE LIMITED

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Abstract

Union Co-operative Limited has historically had a problem with the mixed juice purity being lower than the direct analysis of cane purity, indicating sucrose loss. Tests were conducted to identify the cause. Based on this work, biocides have been dosed in recent years, resulting in the mixed juice purity becoming higher than the direct analysis of cane purity. This indicates reduced losses in the extraction plant. Biocide costs have been a small portion of the revenue earned from the extra sugar recovered.

Introduction

The mixed juice (MJ) purity has been lower than the direct analysis of cane (DAC) purity for many years at Union Co-operative Limited (UCL). Efforts were made to ensure that the diffuser and mills were kept clean to reduce or eliminate bacteria that could degrade sucrose. These involved cleaning with hot water and steam on a daily basis and, when that did not help, every shift. This did not help. Further tests were undertaken to ensure that the sampling and analyses of MJ and DAC were correct. When these efforts were not successful tests were done to analyse the level of bacterial activity in the factory.

Background

The first biocide trials started in November 1977 but were inconclusive. Further trials were done in August 1987 using a dithiocarbamate but again without success. In September 1987 a different dithiocarbamate was considered, steam and hot water being used during both periods. The results were again inconclusive and sanitation was continued with steam and hot water only. In November 1987 calculations were done to show the potential savings if the (MJ-DAC) purity was improved if a biocide was dosed but again steam was chosen. This was due to the cost of the biocide.

Referring to figure 1, it can be seen that the (MJ-DAC) purity has been negative for many years and the sudden increased drop in 1991 prompted the work outlined in this paper.

The year 1991 started with the (MJ-DAC) purity being negative, as can be seen in figure 2. Steam and hot water were used again, to ensure that the mills, DSM screens and diffuser were kept clean but without success. In June 1991, bacterial analyses (plate counts) were done on the press water and, based on the recommendations made by the biocide supplier, a dithiocarbamate was dosed to the press water at a

rate of 20 ml biocide/ton cane three times a day manually. There was no improvement. In July 1991 further tests were done and a quaternary ammonium compound (QAC) type biocide was evaluated in week 26 as a manual 20 ml/ton dose to the press water. The results were immediately apparent when the (MJ-DAC) purity rose from approximately -0,65 to being slightly positive.

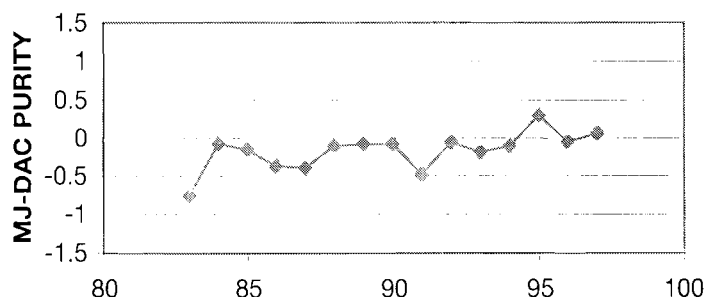


Figure 1. Years 1962-1997

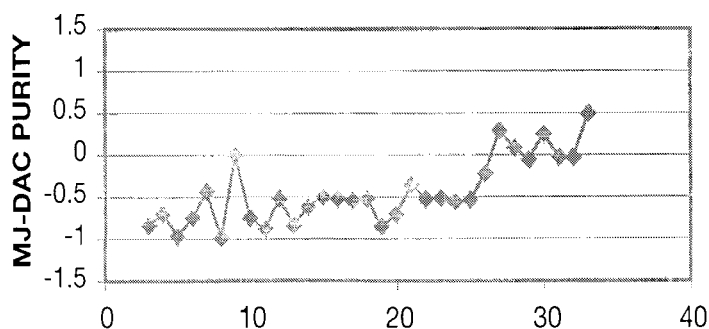


Figure 2. 1991: Week Number

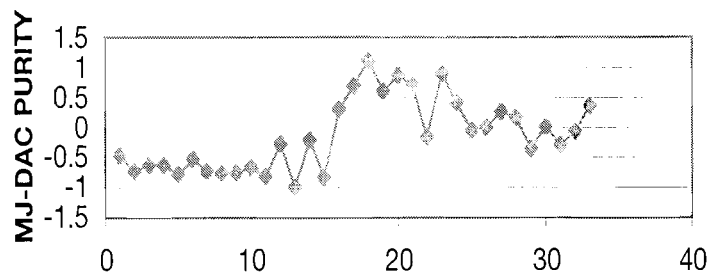


Figure 3. 1992: Week Number

In 1992 UCL reverted to steam and hot water due to the cost of biocides. There was no improvement with the (MJ-DAC) purity remaining negative. During week 16 the QAC biocide was again slug dosed to the press water. A further 20 ml/ton dose was also split between the mud mixer and the MJ tank

in an effort to improve the filtrate purity. The result of this is that the (MJ-DAC) purity improved from approximately -0,65 to a positive figure. This is clearly illustrated in figure 3. At this stage it was thought that the steam and hot water were not reaching all the areas infested with bacteria in the diffuser and dewatering mills. There was also concern regarding safety when using steam and hot water. During this period work was done on the press water settling tank which showed that there was a large purity drop across the tank and a vast increase in bacterial levels. This resulted in the settling tank being removed from service.

The diffuser temperature was maintained between 82 and 87 degrees Celsius and the scalding juice at 92°C.

Application

UCL decided to apply biocides on a routine basis for 1993, based on the results of the previous two seasons. The dosing system was changed to one ton semi-bulk bins and dosing pumps were installed. The "standard" dose was 20 ml biocide/ton cane, dosed by the pump in one hour, three times a day to the press water. The effect of the drought cane on the (MJ-DAC) purity was severe, resulting in very high dosage rates (up to eight times higher than standard) being applied and also the use of alternating biocide types (e.g. QAC and dithiocarbamates). The success was fairly limited.

The next two years saw an effort to control the (MJ-DAC) purity on a daily basis to reduce costs without sacrificing the positive (MJ-DAC) purity. Adjusting the dosing pump speed and dosing time on a daily basis to ensure that the (MJ-DAC) purity stayed positive achieved this. The control in 1995 was very consistent as can be seen in figure 4.

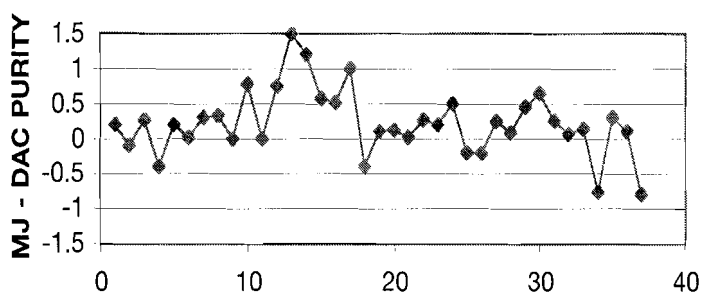


Figure 4. 1995: Week Number

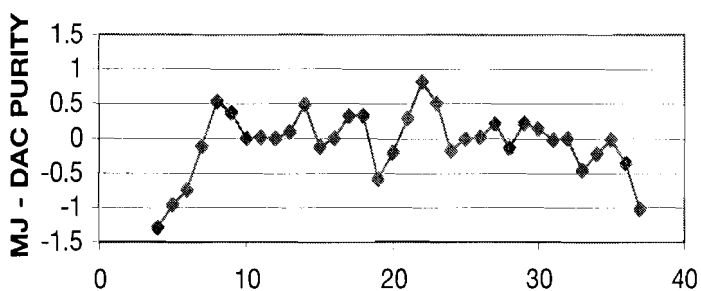


Figure 5. 1996: Week Number

UCL had a bad start to the 1996 season with the (MJ-DAC) purity down to -2,08. This was attributed to cane that was burnt 6 to 8 weeks before the start of the season and prompted extra dosing. The (MJ-DAC) purity started to rise even though the old burnt cane was still being crushed as can be seen in figure 5.

Referring to figure 6, it can be seen that the control of (MJ-DAC) purity in 1997 was good but the dips in (MJ-DAC) purity during weeks 25 and 26, and week 31 resulted in debate as to why these dips had occurred. The obvious causes such as no biocide in stock and faulty dosing pumps were eliminated. The possibility that small growers cane was sampled in preference to the main suppliers was investigated as this might have resulted in a skewing of the DAC results. It is possible to selectively sample cane to skew the results of the DAC figures, for example by only sampling the bad cane would lead to the depression of the DAC purity as opposed to the MJ purity.

This, however, is not a valid reason as the small growers supplied cane over a five month period. Frost cane was investigated as it can have a major effect on purity. Selective sampling of cane was considered but the usual 45% of all cane had been sampled during this period.

It was eventually established that the lack of biocide application at the correct dosage rates was the cause of the problems. This highlights the need for senior production management to control the application of the biocide to ensure minimal costs and maximum benefits. Various biocide trials were done from week 34 to the end of the season. Total biocide dose for the season was 16,4 ml biocide/ton cane or 13000 kg. This was split between press water (12 ml biocide/ton cane) and mixed juice and mud mixer.

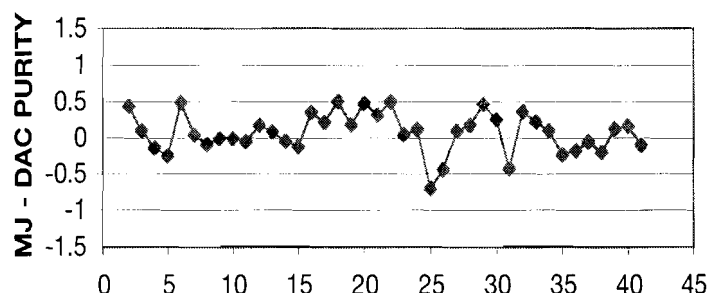


Figure 6. 1997: Week Number

Further biocide trials commenced at the start of the 1998 season, to find more cost effective biocides, as more chemical suppliers were interested in this work. (See figure 7). Two dithiocarbamates were tried without success at weeks 1 and 3. Week 5 saw a trial with a QAC that had worked in the past but was not effective this year. A new QAC was tried in week 10 that was successful and used to the end of the season. It should be noted that each biocide caused an increase in the (MJ-DAC) purity before falling again, indicating that the micro-organisms were getting accustomed to each biocide, possibly as sub-lethal doses were used.

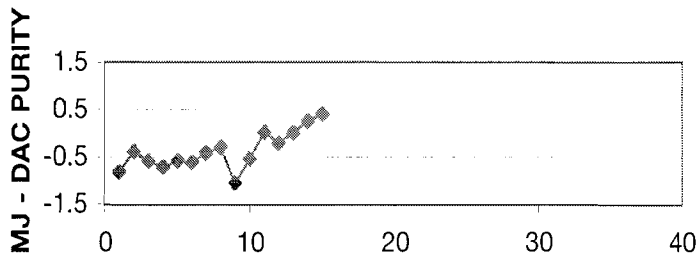


Figure 7. 1998: Week Number

A trial was done to investigate the efficiency of the QAC biocide. This involved taking samples from various places in the factory, then dosing 20 mg biocide/ton cane to the press water, waiting 90 minutes, taking samples, waiting a further two hours and again taking samples. The results of the analyses for total aerobic bacteria are listed in table 1.

It is clear that the bacteria levels counts have reduced to a much smaller number indicating the biocide has been effective during the three hours covered by the trial. Yeasts and acid producers show the same trends.

Further work has shown that the best dosing system is a slug dose rather than a continuous dose through a pump. A continuous system always results in a far higher dosage rate to achieve the same result. The QAC biocide from the previous year worked best again.

Economic justification

Taking 1991, 1992 and 1998 as a baseline where biocides were not used or did not work, and the same production staff were involved, the average (MJ-DAC) purity is -0,6%. From the 1997 season the following calculation can be done:

Tons cane: 795 065

Extraction: 96,9 %

Boiling house recovery: 91,93 %

DAC purity: 87,81 %

MJ brix: 116 267 tons

MJ pol: 102 164 tons (actual (MJ-DAC) purity difference = 0)

If MJ-DAC purity = -0,6 then MJ purity = 87,21 %

Therefore pol in MJ = 101 397 tons

Difference in pol = 102 164 – 101 397 = 767 tons

Recover 767 x 0,9193 = 705 tons pol in sugar or 708 tons sugar which would have been lost.

This 708 tons sugar at an average selling cost of R 1 577 per ton = R 1 116 516

The cost of the biocide was 13 000 kg x R 10,50 per kg = R 136 500

i.e. Total revenue = R 980 016

This excludes factors such as improved boiling house recovery and reduced undetermined loss due to the higher MJ purity. It should also be noted that this is sugar that has been paid for by UCL as UCL pays on D.A.C., not MJ, and has been lost in the factory. The actual profit for this sugar will be far higher than “normal” sugar.

Discussion

Various authors have commented at length regarding the need for mill sanitation, recommending a combination of biocides, steam and hot water. Chen¹ states that steam or hot water is only 60% effective around mills and that the remainder should be taken care of with a biocide. Tilbury *et al*² report that 62% of the sugar loss around a mill is due to microbiological growth in the mill and their experiments showed that the loss can be reduced by 17 to 35% with biocide treatment. Losses due to dextran formation alone are in the order of 0,01 to 0,1 % of the raw sugar produced (Clarke *et al*³).

It is clear that the benefits of biocide dosing have been known for many years even though the application of biocides has not been done to any large extent in the local industry. A combination of biocide and hot water is recommended as the best for mill sanitation.

Laboratory kill tests have been done at various times to check the efficiencies of the biocides. In these tests the QACs have an efficiency of 80 to 98 % while the dithiocarbamates have efficiencies of 40 to 70 %. It is important to note that these results vary from year to year and between factories for each type of biocide.

Microbiological counts have been done at various places throughout the factory and the results have verified that the trends have been downwards, e.g. in the press water the total aerobic bacteria have reduced from 105000 in 1991 to 800 colony forming units per millilitre in recent years.

Further tests have been done to investigate the source of the bacteria. It has become evident that they come into the factory with the cane at levels of 26 to 100 colony-forming units per millilitre indicating that contamination of the factory will always occur.

Table 1. Total Aerobic Bacteria Counts (Colony forming units per ml)

Sample Time	PW	S 15	S 8	S 1	DJ	LJ	CJ
11h00	$1,2 \times 10^6$	240	440	700	640	70	80
12h30	$1,7 \times 10^5$	10	840	110	50	20	<10
14h30	5×10^3	220	210	50	10	<10	<10

PW press water

S 15 etc. stage 15 etc. of the diffuser

DJ draft juice

LJ limed juice

CJ clear juice

The biocide selection criteria used have involved the efficacy against micro-organisms, the safety and ease of handling, FDA approval of ingredients and cost effectiveness.

Conclusion

The dosing of biocides at UCL has improved the (MJ-DAC) purity to the point that it is generally positive with the control of dosage rates limiting the cost of the biocide. This is done in conjunction with hot water. Biocides are now an integral part of the quality control at Union co-operative Limited. The financial justification shows an excellent pay-back.

Acknowledgements

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REFERENCES

1. Chen, JCP (1964), Sugar, pp 65, 80.
2. Tilbury et al, (1977), ISSCT, pp. 2749- 2768
3. Clarke et al (1980), ISSCT, p. 2195

Note: Above references from Chen JCP, 1985. Cane Sugar Handbook, John Wiley & Sons, New York, pp.87, 88, 515.