WHOLE CROP PROCESSING AT BROADWATER MILL: IMPACTS ON PROCESS OPERATIONS

By

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Abstract

DURING THE processing of the whole cane crop (comprising typically 20% of the total mass as tops and leaves) at Broadwater Mill during the 2009 season the presence of specific impurities and increased quantities of soluble impurities in the mixed juice adversely affected several process stations of the factory. The clarification and filtration stations experienced increased mud solids loadings and reduced efficiency in clarification, and the production rates at both the pan and fugal stations were substantially reduced. Quantifiable changes in evaporator station capacity due to changes in scaling rates were not experienced but this may have been a consequence of the short duration of the whole crop trials (two weeks). The sugar production was characterised by increased colour and ash. Investigations were undertaken at each of the process stations to quantify the impact of whole crop processing and to measure changes to fundamental parameters so that the causes of the reduced efficiencies could be differentiated. These results have been used to define procedures to mitigate the impacts of crushing the whole crop on factory processing operations.

Introduction

During the period July to August 2009, Broadwater Mill processed cane with widely differing quantities of trash. The crushing arrangements in general provided three days of changeover between the different cane supply types and then three days of evaluation of performance. This paper reports on the factory control data for sugar recovery and pol losses, the observations on key factory parameters, and the results of evaluations undertaken to better define the impact of trash on factory processing operations and performance.

Overview of trials

Kent *et al.* (2010) provided details of the test program for the different cane supplies. The three cane supplies (designated BE, BU and GU) are described in Table 1 and the periods for the trials are provided in Table 2. Fine weather was experienced throughout the test program.

The average data for the three cane types indicate that the GU cane had a lower pol and higher soluble impurity content than the BE and BU canes. Relative to the BE cane, the pol content in the GU cane was 12% lower and the soluble impurities were 21% higher. The test period was characterised by a trend of increasing pol (and CCS) in the cane supply. Crushing rates at Broadwater on GU cane were reduced by ~18% compared with crushing of BE and BU cane.

For the trials, no changes were made to the physical plant, leaving changes to the addition rates of chemicals as the only means of overcoming processing difficulties. The study was carried out in order to identify the changes needed to the process house to allow crushing of whole cane at appropriate rates.

Table 1—Description of the three cane types.

Cane type	Designation	Description	Typical fibre content
BE	Burnt extracted	Burnt and harvested with extractors on	15.5 to 16
BU	Burnt unextracted	No instructions given to harvesting contractors; typically burnt and trash harvested	16.5 to 18.5
GU	Green unextracted (whole crop)	Cut green and all trash harvested	21 to 22

Table 2—Schedule for test program.

Test	Cane supply type	Start	End
1	BU	20 Jul 2009	23 Jul 2009
2	GU	27 Jul 2009	30 Jul 2009
3	GU	30 Jul 2009	02 Aug 2009
4	GU	02 Aug 2009	05 Aug 2009
5	BE	08 Aug 2009	11 Aug 2009
6	BE	11 Aug 2009	14 Aug 2009
7	BU	16 Aug 2009	19 Aug 2009

Kent *et al.* (2010) showed that sugar recovery reduced by about 0.9 units for each 1 unit increase in cane fibre content caused by increased trash content. Increased pol losses were recorded in bagasse, mud and molasses. Table 3 provides the average pol losses measured for mud and molasses during the processing of the three cane types.

Table 3—Pol losses in mud and molasses.

Cane type	Pol loss in mud%pol in cane	Pol loss in molasses%pol in cane
BE	1.1	8.1
BU	1.2	9.6
GU	1.7	11.6

General observations from the data indicate that the filter performance itself (in terms of moisture%mud and pol%mud) was largely unchanged among the cane types. The main factor causing the increased pol loss in mud%pol in cane was the increased mud solids loading in the GU cane (typically in excess of 3.0 t/h) compared with the mud solids loading in BE cane (typically 1.8 t/h). Three factors are likely to have contributed to the increased mud solids viz., some GU cane was harvested from flood affected paddocks and silt was retained on the leaves; secondly, when harvesting GU cane, soil pick up is more likely as the harvester operator is less able to view the ground level for setting the basecutters and thirdly, any soil in the harvested biomass is less likely to be shaken free in the harvester transfer system due to the high trash loading.

Increased pol loss in molasses occurred mainly through increased molasses production owing to the increased loading of soluble impurities entering with the cane supply containing higher trash levels. The molasses production%cane was ~16% higher for GU cane compared with BE cane. As well, C molasses purities were higher, by 2 to 2.5 units, for GU cane compared with BE cane. Factors contributing to the increased purity of C molasses are discussed later in the paper.

The sugar produced from GU cane showed increased ash and colour and a possibility of decreased filterability.

During the processing of each of the cane types the operation and performance of the process stations were observed and key data gathered from the factory records and control parameters. During test periods 4, 6 and 7 (refer Table 2), QUT undertook several assessments to better define the impact of the cane type on specific operational parameters. The observations on the performance of each processing stations are discussed in the following sections.

Clarification and mud filtration

The secondary mixed juice is limed to a pH of 7.8 using lime saccharate, superheated to approximately 104 ^{o}C before being flashed and clarified. Normally flocculant A2115 is used and the dosing rate is adjusted by operator intervention according to the trend of ash%cane provided by the NIR cane analysis. The filtrate return from the filter station is normally directed to the secondary mixed juice tank. Phosphoric acid (85% strength) is pumped into the top of the secondary mixed juice tank based on ratio control to the secondary mixed juice flow rate. Phosphate levels in the first expressed juice are generally above 300 ppm as P_2O_5.

The clarifier at Broadwater is a 7.3 m diameter multi tray clarifier which has been upgraded to a SRI New Generation (NG) design. The filter station comprises four rotary vacuum filters providing 166 m^2 of filter area.

Factory laboratory records for mud solids rate were found to correlate well with the NIR ash%cane data. Mud solids loadings on cane during the processing of GU cane were typically 40 to 60% higher than for BE cane. After taking into account the reduced crushing rate for GU cane and an increased underflow rate from the clarifier the target settling rates for the clarifier were 24 cm/min for GU cane and

29 cm/min for BE and BU cane. During the processing of GU cane clarification performance worsened (producing higher juice turbidities) despite the mill using higher dosing rates of flocculant. The following conclusions were drawn from factory observations and the results of batch settling tests:

- For BE and BU cane, the flocculant dosing rate was typically 5 to 6 ppm on juice and juice turbidities were in the range 5 to 10 NTU.
- For GU cane, the flocculant rates were increased to the range 10 to 20 ppm on juice and, even at these high levels, juice turbidities were 20 to 30 NTU.
- Batch settling tests for BE cane consistently achieved settling rates of 40 to 50 cm/min. For GU cane settling rates were more typically 10 to 30 cm/min.
- The addition of 50 ppm phosphate (as P_2O_5) was beneficial in reducing juice turbidity for all cane types.

The overall conclusion was that the clarifier at Broadwater is appropriately sized for a mud solids loading of 1.8 t/h (0.7% on cane) and any additional loading (e.g. through poor retention at the filters, wet weather, flood affected cane, GU cane) is beyond its capacity. Much improved clarification performance is needed for GU cane and further investigations of liming procedure, saccharate concentration and flocculant specification should be undertaken. The high mud solids loadings in GU cane will be a major limitation to performance with the existing clarifier if crushing rates are increased to be closer to BE cane rates.

Evaporator station

The evaporator station at Broadwater comprises a quintuple set of total area 9810 m^2 (Moller *et al*., 2003). Figure 1 shows the heat transfer coefficient (HTC) trends of each of the evaporators for the 2009 crushing season. Also highlighted on this chart are the chemical cleaning processes undertaken by Broadwater staff and the periods of different cane supplied to the factory.

The processing of the GU cane only occurred in a single two week period so the observations must be treated as conjecture, particularly as scaling propensity and effectiveness of cleaning are influenced by so many operational factors. Observations on the evaporator station that may indicate the impurities in juice from GU cane had an impact on the heat transfer performance and scale formation are:

- the much higher scaling rates in evaporator 3 during the processing of GU cane
- the difficulty in achieving an effective clean in evaporator 4 at the end of the processing period of GU cane, and in two subsequent cleans.

These results may indicate that the impurities extracted with GU cane produced a scale which formed at the processing conditions in evaporator 3 and this scale may be of different composition than usually formed with BU cane. This scale was observed to have different characteristics that those normally found at

Broadwater, which may indicate that the scale may be more complex, requiring an alternative chemical cleaning procedure. The scale observed in evaporator 3 was green and had a shiny crystalline structure.

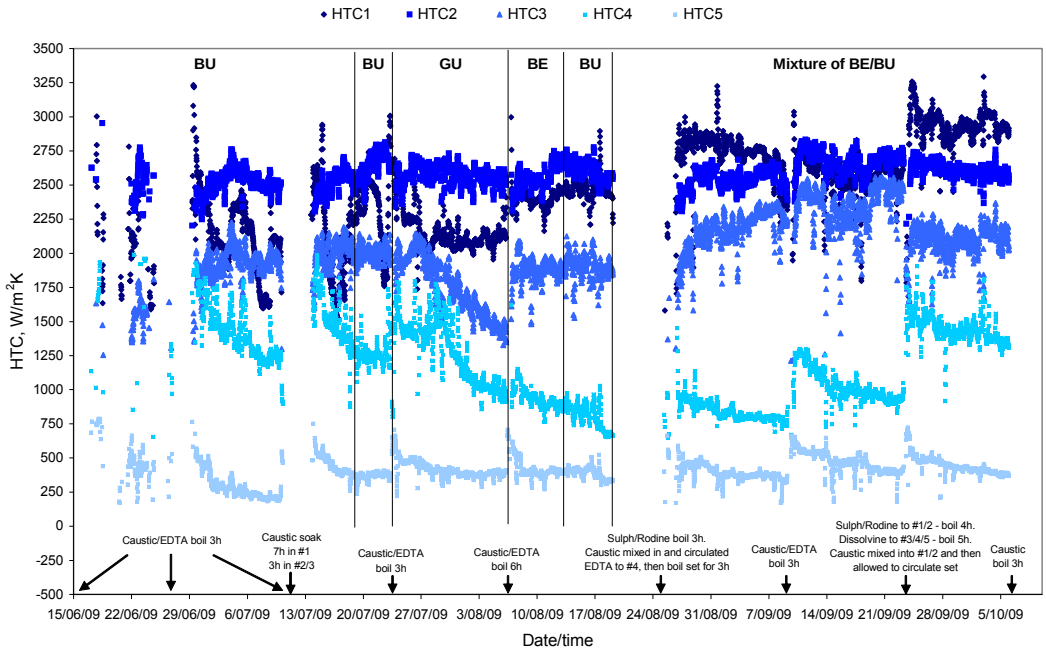

Fig. 1—Heat transfer coefficients for the evaporators during the 2009 season.

Pan stage operations

The pan stage at Broadwater comprises five batch pans for high grade massecuite production and a batch seed pan and SRI continuous pan for C massecuite production. During the trials the factory was using the three massecuite boiling formula with both the A sugar and B sugar being transported to the Harwood refinery.

During whole cane processing the high grade strike pans were severely affected by low evaporation rates, poor circulation and slow boil-on rates for feed liquor and molasses. The pan stage operators felt the A massecuite boilings were affected worse than the B massecuite boilings. The C massecuite boilings were least affected, and this is probably a consequence of the constant low head boiling in the continuous pan. Table 4 shows the average data for the pan stage products for each test during the processing of the different cane types, and the average for each cane type.

The data in Table 4 show that:

- During the processing of the GU cane very little boilback of A molasses onto the A strikes was undertaken and, on average, the A massecuite purity was higher during the processing of GU cane than

for either of the other cane types. The higher purity A massecuites were necessary to try to alleviate the effects, as best as possible, of the higher viscosity mother molasses in the A massecuites during the processing of the GU cane, as discussed below.

- The difficulties with boiling the A and B massecuites and in particular in heavying the A and B massecuites to good dropping weight during the processing of GU cane resulted in reduced exhaustion for the A and B massecuites. Difficulties were also experienced in fugalling the massecuites from GU cane. The purity differences (massecuite – molasses) for the A and B massecuites were smaller during the processing of the GU cane (refer Figure 2).

Table 4—Analysis of pan stage products.

Test	Cane type	Liquor purity	A mass purity	B mass purity	C mass purity	A mol purity	B mol purity	C mol purity
1	BU	87.9	86.4	81.4	67.4	69.5	65.7	45.9
2	GU	85.9	84.8	80.8	68.5	69.9	67.4	44.0
3	GU	87.2	86.7	82.1	67.8	72.8	68.3	46.1
4	GU	87.2	86.6	83.2	71.3	74.2	71.9	50.5
5	BE	89.3	86.0	79.1	65.8	68.1	65.7	46.1
6	BE	90.3	85.1	82.1	66.5	70.1	65.7	43.1
7	BU	87.9	83.2	79.5	65.4	68.7	65.7	42.8
Average	BE	89.8	85.6	80.6	66.2	69.1	65.7	44.6
Average	BU	87.9	84.8	80.5	66.4	69.1	65.7	44.3
Average	GU	86.8	86.1	82.0	69.2	72.3	69.2	46.9

As a consequence of the reduced exhaustion of the A and B massecuites during the processing of the GU cane, the C massecuite purity was increased to ~69, being 3.0 units on average higher than the purity of the C massecuite when processing BE and BU cane.

Given all other factors that affect exhaustion of C massecuites (e.g. C massecuite production rate) being equal, an increase in C massecuite purity of this magnitude would likely result in an increase in C molasses purity of 1.5 to 1.8 units.

The average increase in C molasses purity was ~2.3 units and the higher value most likely results from the increased C massecuite production loading during the processing of GU cane and the subsequent decrease in residence time in the crystallisers.

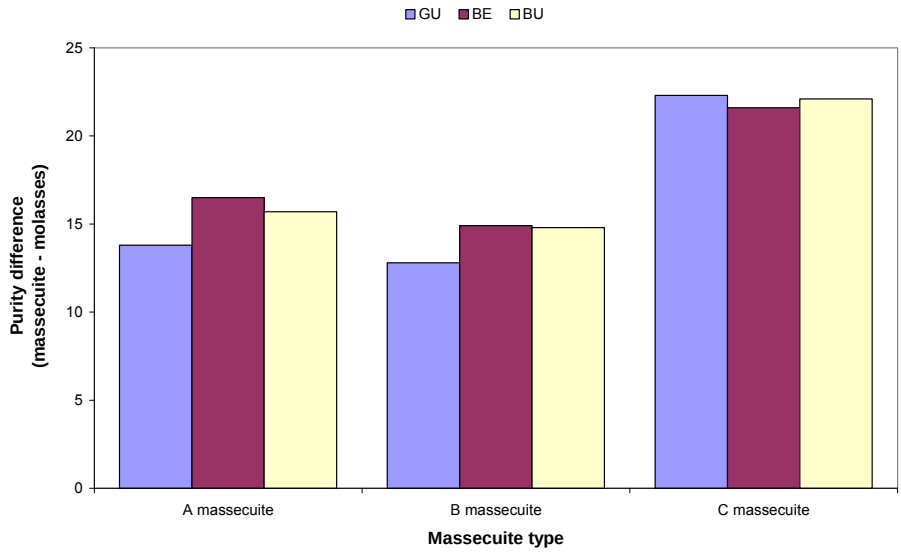

Fig. 2—Purity differences between massecuite and molasses.

The exhaustions of the C massecuite strikes in the continuous pan were comparable for all three cane types (refer Figure 2). As stated previously, the consistent low boiling level in the continuous pan is probably the main reason why the exhaustion of the C strikes was maintained at adequate levels for the GU cane.

During the processing of GU cane, the batch A and B strike pans were all affected to the extent that the strike level had to be reduced to about 80% of the boiling level when BU and BE canes were being processed. The batch pans required a boilout with water more frequently (often after successive strikes) and the use of surfactant increased during the processing of the GU cane.

Table 5 summarises the main operational parameters for pan 1 (the main A strike pan) during the processing of the three cane types. These results show the strong reduction in heat transfer performance that was experienced during the processing of GU cane and the impact on the pan's production rate.

Table 5 —Summary of the main operational parameters for pan 1.

Cane Supply type	Massecuite quantity at end of strike (t)	Massecuite quantity at which the calandria pressure is at the mains pressure (t)	Steam rate at start and at pan full (t/h)	HTC at the start and end of a strike ($W/m^2/K$)	Typical cycle time (h)	Estimate of boil-on rate of massecuite (t/h)
GU	72	~ 60	12 → 6	640 →200	4.5	9.3
BE	90	~ 75	13 → 8	650 →380	3.6	15.3
BU	90	~ 75	13 → 7	670 →300	4.3	12.7

* Includes lost time for boilout of pans between strikes

High grade fugal operations

The high grade fugal station at Broadwater comprises a continuous fugal and three batch machines. During the processing of GU cane the continuous fugal was not used owing to difficulties in reaching the target pol (~99.2). The batch high grade fugals use two separate wash water additions, typically 4 seconds apart.

Table 6 shows the typical wash times used during the fugalling of the A and B massecuites for the different cane types. The wash times for both A and B massecuites for GU cane are twice as long as for the massecuites produced during the processing of BE cane. The B massecuites from the BU cane required longer times than the B massecuites from the BE cane but these times were shorter than for the GU cane. The longer wash times for the GU cane are attributed to a higher viscosity of the mother molasses and smaller mean size of crystal.

The purging characteristics of two A and two B massecuites were assessed during the processing of each cane type by spinning a sample of the pan drop massecuite in the QUT laboratory basket centrifugal under standard conditions of 2000 rpm (equivalent to ~460 Gs) for 4 minutes. Figure 3 shows the purities of the sugars separated in the laboratory fugal.

Table 6—Wash water application times for the batch fugals.

Cane type	Fugal wash times (s)	
	A massecuite	B massecuite
GU	8 and 7	14 and 10
BE	4 and 3	7 and 5
BU	5 and 3	12 and 9

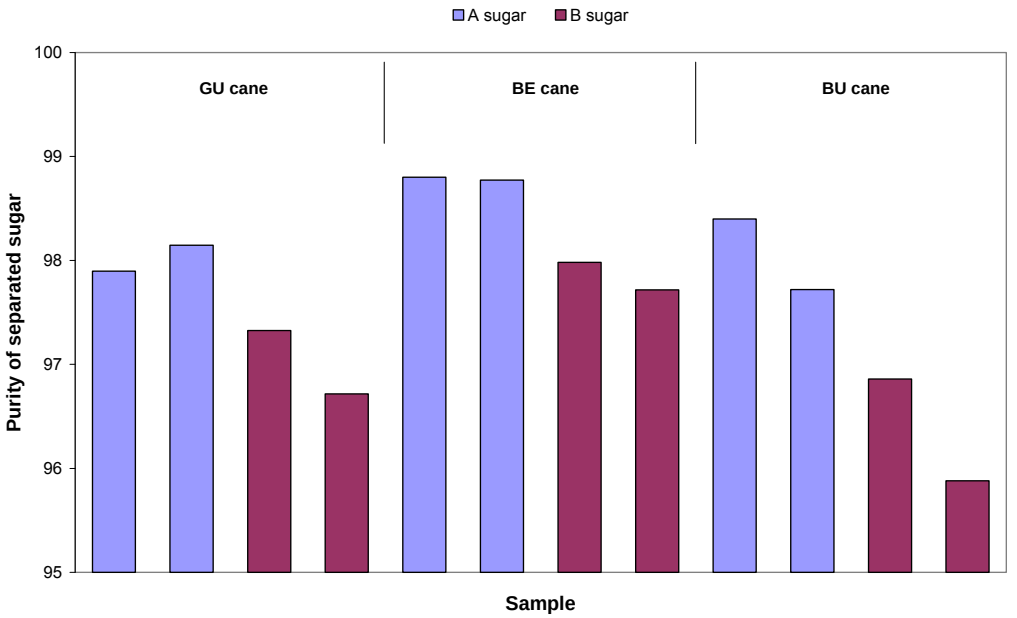

Fig. 3—Purity of sugar from purging characterisation test.

The purging characteristics of the A and B massecuites during the processing of the GU cane were inferior to the massecuites during the processing of the BE cane. The lower purity of the separated sugar for GU cane reflects the reduced drainage of the mother molasses from the crystal bed and indicates that greater wash water addition would be required to obtain the target sugar polarisation during the processing of GU cane. The purging characteristics of high grade massecuites have been shown (Broadfoot and Miller, 1995) to be influenced to the greatest extent by the mother molasses viscosity and also by the mean size and spread of sizes in the crystal bed. The purging qualities of the A and B massecuites for the BU cane were also inferior to those from the BE cane, particularly for the B massecuites. These changes are reflected in the wash times in Table 6.

Rheology of the mother molasses

The rheology of the mother molasses from the pan drop A and B massecuites was measured at 65 °C using the Brookfield RVT viscometer with small sample adapter (spindle 29). The data in Table 7 provide the flow index values and the consistencies at two conditions viz. consistency adjusted to the process temperature and the consistency adjusted to the average dry substance and purity for the mother molasses, at 65 °C.

Table 7—Rheological properties of mother molasses from A and B massecuites.

Cane type	Sample	Date	Flow index	Corrected consistency (Pa.s^n)	
				At process temperature	At standard conditions*
GU	A mass	3/08/2009	0.64	7.4	25.1
	A mass	4/08/2009	0.78	4.2	5.9
	B mass	4/08/2009	0.72	9.5	30.5
	B mass	5/08/2009	0.78	4.9	8.6
BE	A mass	11/08/2009	0.92	1.1	1.0
	A mass	12/08/2009	0.93	0.9	1.3
	B mass	11/08/2009	0.91	1.9	3.1
	B mass	12/08/2009	0.93	2.3	3.7
BU	A mass	17/08/2009	0.91	1.5	1.6
	A mass	18/08/2009	0.93	1.7	1.0
	B mass	17/08/2009	0.92	3.1	3.0
	B mass	18/08/2009	0.94	2.3	2.4

* Standard conditions at 65 °C for mother molasses in A massecuite: dry substance 81, purity 69 and in B massecuite: dry substance 83.5, purity 63.

The mother molasses from both the A and B massecuites were more non-Newtonian (lower flow index) and of substantially higher consistency during the processing of GU cane. Typically the flow index for mother molasses in A and B massecuites is in the range 0.90 to 0.94 and consistency values are 0.7 to 1.7 Pa.s^n for A massecuites and between 1.7 and 5 Pa.s^n for B massecuites at the process temperature.

The data in Table 7 show the consistency values at the process temperature for the mother molasses from both A and B massecuites for GU cane were much higher than for the like massecuites for BE and BU cane. As well, the consistency values at the process temperature for BU cane were higher than for the like massecuites for BE cane.

At the same conditions of dry substance, purity and temperature the consistency values of the mother molasses for GU cane are much higher than for the corresponding samples for the BE and BU cane. The consistency values of the corresponding mother molasses for BE and BU cane are similar.

The viscosity of the mother molasses from the C massecuites was measured at 65 °C using the Brookfield RVT viscometer with small sample adapter (spindle 27). The data are presented in Table 8 in a similar form to that for the mother molasses from the high grade massecuites.

Table 8—Rheological properties of mother molasses from C massecuites.

Cane type	Date	Flow index	Corrected consistency (Pa.s^n)	
			At process temperature	At standard conditions*
GU	4/08/2009	0.70	39.2	128.8
	5/08/2009	0.75	22.9	147.1
BE	11/08/2009	0.85	24.0	43.1
	12/08/2009	0.86	28.2	60.4
BU	17/08/2009	0.81	24.4	53.2
	18/08/2009	0.83	27.7	39.7

* Standard conditions at 65 °C for mother molasses in C massecuite: dry substance 88, purity 49.

The flow index for the mother molasses was lower for GU cane than for the BE and BU cane and analysis of variance found this difference was significant at the 5% level. There is no significant difference in the consistency values of the mother molasses at pan discharge at the process temperature among the different cane types. However, the consistency values which are corrected to the same dry substance, purity and temperature are significantly higher (at the 5% level) during the processing of GU cane than during the processing of BE or BU cane.

It is clear that the mother molasses in the massecuites for GU cane were more non-Newtonian and of higher consistency than the mother molasses for BE and BU cane. These changes have adversely affected the pan boiling and fugalling operations.

Crystal shape and presence of impurities

During the test program for all three cane types the crystals showed elongation on the c axis which is typical of elongation due to the presence of dextran and oligosaccharides. Dextran was measured at 0 mg/kg in the product sugar. It was noted that the crystals became more square with subsequent processing through the test period 5 August to 18 August i.e. that the crystals produced during the processing of BU cane were less elongated than for BE cane, which was less elongated than for

GU cane. The crystals produced during the processing of GU cane were elongated on the c axis to about 2:1. The reason for the change in elongation with the change in cane type is unclear and it may be linked to specific impurities extracted from GU cane; it may be a consequence of the improved quality of the cane supply (higher pol in cane) that occurred during the test period; or it may be due to lower glucose and fructose concentrations in the molasses from the GU cane (Bubnik *et al*.,1991).

There appeared to be little change in the quantity of coloured impurities included within the crystal lattice for the sugar produced from the different cane types.

Composition of A molasses

Samples of A molasses ex the fugals were obtained on different days during the processing of the three cane types (two samples for each cane type during tests 4, 6 and 7) and subsequently analysed at QUT laboratories for total polysaccharides; sucrose, glucose and fructose by HPIC and oligosaccharides and other sugars by HPIC-PAD. The samples were also analysed by an external laboratory for reducing sugars by the Lane and Eynon method. The results showed:

- There was little difference in the total polysaccharide content of the samples among the three cane types.
- Both the glucose and fructose concentrations were lowest for the GU cane and highest for the BU cane. Similarly the total reducing sugars concentration was lowest in the A molasses from the GU cane and highest in the A molasses from the BU cane. These results are unexpected as trash and tops contain higher concentrations of reducing sugars per unit mass than cane stalk (Ivin and Doyle, 1989; Lionnet, 1995; Kent *et al*., 2003; Muir *et al*., 2009) and it was expected that the GU cane would have the highest content of reducing sugars (and glucose and fructose). The differences in the concentrations were significant at the 95% confidence level. No explanation is given for the lower reducing sugar content of the A molasses from the GU cane. There is a possibility that the composition of the impurities in the cane changed over the course of the test period and this influenced the result. This matter requires further investigation to determine firstly the reducing sugar content of the mixed juice for the different cane types and secondly how the reducing sugar content changes with clarification, evaporation and pan boiling operations.
- The HPIC-PAD results for the oligosaccharides and other sugars showed that the A molasses samples from the GU cane contained the lowest concentrations of oligosaccharides and other sugars and the A molasses from the BU cane had the highest concentrations.

Overall, the analyses of the A molasses samples provided no indication of any constituents that may cause the strongly non-Newtonian behaviour and higher consistencies of the mother molasses associated with GU cane.

Sugar quality

The routine sugar analysis results, along with additional sugar analysis results conducted especially for these tests, were used to examine the sugar quality. Pol, moisture, ash, filterability, starch, fine grain, colour and dextran measurements were examined. It is noted that no ash, filterability or dextran measurements were made during the first three test periods. The results of the sugar quality parameters are shown in Table 9. Dextran levels of 0 mg/kg were measured in tests 4 to 7 and so no analysis of this parameter is shown. No statistically significant differences were observed, although it is noted that the ash and colour were highest from the GU cane type and the filterability was lowest from the GU cane type. Fine grain was also highest for GU cane but this value is very dependent on pan stage operations at the time of the trials. Likewise the starch in sugar is very dependent on the amylase addition to process.

Table 9—Sugar quality results.

Test	Cane type	Pol (%)	Moisture (%)	Ash (%)	Filterability (%)	Starch (mg/kg)	Fine Grain (%)	Colour (IU)
1	BU	99.17	0.20			135	28	1760
2	GU	99.19	0.23			257	11	2049
3	GU	99.27	0.22			98	36	1848
4	GU	99.27	0.17	0.18	37	101	39	2055
5	BE	99.24	0.18	0.15	69	274	19	1902
6	BE	99.30	0.20	0.14	75	136	23	1525
7	BU	99.23	0.17	0.15	74	181	27	1622
Average	BE	99.27	0.19	0.14	72	205	21	1713
Average	BU	99.20	0.18	0.15	74	158	27	1691
Average	GU	99.24	0.21	0.18	37	152	29	1984

Table 10 provides a comparison of the average colour/impurity ratios in liquor and sugar for the three cane types. While the colour/impurity ratio of sugar is higher for GU cane the difference is not statistically significant.

Table 10—Average colour impurity data for liquor and sugar.

Cane supply type	Liquor Colour/impurity	Sugar Colour/impurity
BE	1644	3172
BU	1496	2727
GU	1652	3607

The colours of liquor and sugar were measured at pH 9 and pH 4 as a guide to determine whether any differences in colour removal efficiency would be expected in the refinery. Within the very limited data the Indicator Values (colour at pH 9/colour at pH 4) for liquor and sugar were slightly lower during the processing of the GU cane compared to the processing of BE cane. Generally factory produced colourants

are of high molecular weight and have low Indicator Value. Overall the differences were small.

Options to assist the processing of GU cane

The processing of GU cane impacted on the performance of the clarification stage and the pan/fugal stations to a significant extent. The effects on the evaporator station appeared to be mainly increased scaling on effect 3. Owing to the short processing period on GU cane (two weeks) any impact on juice processing capacity at the evaporators was not evident.

The major processing issues on the pan stage are the reduction in heat transfer performance and subsequently the inability to maintain acceptable boil-on rates and exhaustion of massecuites when processing GU cane. For the batch fugal station the major impact is the high viscosity of the mother molasses on the purging and the washing efficiency.

The evaluation trials and analyses have not established the cause of the high viscosity of the mother molasses and it is not clear yet whether improved clarification performance will alleviate the problem and to what extent. It is assumed at this stage that improved clarification will result in reduced viscosity but it is likely that mother molasses having high viscosities will continue to be symptomatic of processing GU cane.

The changes in processing plant and procedures which are outlined in Table 11 are recommended to allow GU cane to be processed at higher rates and with increased sugar recovery and improved sugar quality.

Conclusions

During the processing of the whole cane crop at Broadwater Mill the operations of the process stations were adversely affected. Pol losses in mud and molasses increased and the colour and ash of the sugar production increased.

Whole cane introduced higher mud solids loadings and higher soluble impurity concentrations in cane. These two factors were the major reasons for the increased pol losses in mud and molasses respectively.

The stations most affected were clarification, crystallisation and centrifuging. The higher mud solids loading in whole cane contributed to the poor clarification performance.

The pan and fugal stations were adversely affected by higher viscosities of the mother molasses in massecuites produced from whole cane. Analyses of A molasses samples from the different cane types failed to isolate any impurity constituent that may be the cause of the increased viscosity.

Changes in processing plant and procedures are described which would allow whole cane to be processed at higher rates and with increased sugar recovery. Improvements in sugar quality should also be achieved.

An alternative option is to install a trash separation plant to pre-process the whole cane as received at the factory and so reduce the quantity of trash processed through the milling train.

Table 11—Recommended changes in processing plant.

Process section	Recommended changes	Comments
Clarification plant	New NG clarifier	Clarifier should be sized for juice upflow velocity being 50% (or lower) of the achievable settling velocity for upgraded clarification procedures
	On line phosphate measurement using NIR to adjust the phosphoric acid addition rate	
	Control of flocculant addition rate in response to NIR ash	
	Changed liming procedure	More work is required to define the preferred liming method and temperature. It appears that further improvements can be made
Filter station	Install additional mud filter area	Aim is to increase mud solids retention and reduce the mud solids loading on the clarifier. The increased mud loading with GU cane necessitates that increased filter area is provided.
Evaporator station	No changes determined at this stage	
Pan stage	Adopt the CBA boiling scheme so only A sugar is product sugar (Broadfoot, 2006)	Ideally the B massecuite would be processed through a continuous pan and continuous fugal. The system can be implemented using batch pans but preferably the massecuite will be processed through a continuous fugal.
	Install the SRI jigger system (Rackemann and Broadfoot, 2007) into the base of key batch pans (e.g. pan 1)	
Fugal stage	Install dual valving on the molasses outflows from the batch fugals to divert the A molasses rich stream to the liquor tank or for preferential use as A molasses boilback on the A strikes.	This facility will be less essential if the CBA boiling scheme is adopted.

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