A Comparative Study of Polysaccharides within the Jamaican Sugarcane Industry

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ABSTRACT

Polysaccharides in factory processes have been noted as possible causes of some processing problems in the Jamaican sugar industry. A study was conducted to ascertain whether and to what extent there might be differences in total polysaccharides (TPS), starch, and dextran in two leading commercial varieties within the industry, and establish their levels in factory processes. Two varieties, BJ7504 and BJ82119, were selected from each factory area and analyzed. Syrup, C massecuite and molasses were collected from each factory and analyzed for polysaccharides.

The results indicated that there was no statistically significant difference in TPS levels between the two varieties tested industry wide. Syrup at Worthy Park Estate tended to have lower levels of TPS than in other areas while TPS in C massecuite at Worthy Park tended to be much higher than in other areas. Starch, a major polysaccharide at the factory level, was much higher at Worthy Park, than it was at other factories. Varying quantities of the polysaccharide sarkaran were found in molasses from all the factories. Sarkaran levels were highest in April and May in most factories. Polysaccharides were found in varying quantities industry wide and could be a possible source of some of the processing problems faced at some factories.

INTRODUCTION

Total polysaccharide (TPS) may include starch, dextran, sarkaran, levans, pectins, cellulosans, hemicelluloses and gums. Soluble polysaccharides other than starch which occur in sugarcane and its products may be grouped into three main categories. The first group comprises structural polysaccharides originating in the standing cane plant, and includes hemicelluloses, pentosans and pectins. The second group comprises polysaccharides formed by bacteria before or during the processes of sugar manufacture and refining, e.g. dextran and levan. Thirdly, there is evidence that polysaccharide sarkaran, similar to dextran may be formed in harvested cane in the absence of bacterial infection, presumably by the action of natural enzymes present in the cane juice in the parenchyma of the stalk (Clarke 1986).

Polysaccharides such as starch and dextran have been known to cause processing difficulties in raw sugar mills. Studies by Du Boil (2000) have confirmed sarkaran as being a significant contributor to processing problems in sugar factories. The presence of these compounds generally results in high process viscosities that may prove disadvantageous to the processing plant operation.

Studies by Madhu *et al*(1984) and Godshall *et al* (1994) have linked the presence of polysaccharide in juices to the variety of cane, maturity period, harvest and transport conditions, agronomic and environmental conditions etc. Studies of polysaccharides have been ongoing, but methods to adequately identify and quantify specific polysaccharides have proven difficult to develop. Therefore

investigations into the effect that each polysaccharide has on the sugar process will prove difficult until proper methods become available to identify and quantify them.

In 2003 the Sugar Industry Research Institute started investigations into the levels of total polysaccharide (TPS) in C massecuite at the Worthy Park Sugar factory. This was initiated by personnel at Worthy Park who were concerned about the difficulty being experienced in the boiling house associated with abnormally high viscosities in the massecuite. The study showed that the levels of TPS remained fairly constant early in the crop but, by about mid-March into April, the levels of TPS began an increase that extended to the end of crop. Investigations showed that this phenomenon seemed to coincide with high rainfall (generally greater than 100mm/month) following a long dry spell. Subsequent studies at Worthy Park Estate investigated cane varieties, rainfall, and the age of the cane as possible factors contributing to the TPS levels in cane. The increase in TPS as the crop progressed showed strongest statistical correlation with cane age (P value 0.0001) and less strong correlation with rainfall (P value 0.175). Variety (P value 0.406) was not found to be a statistically significant factor (Reece, 2006).

To determine whether the processing problems at Worthy Park Estate were unique to that area, attempts were made at determining the levels TPS in other factory areas.

The objectives of the study were to:

1. Ascertain if there were, and to what extent, there might be differences in total polysaccharides, starch, and dextran in two leading commercial varieties at the same age growing in various locations within the industry.
2. Determine if the levels of TPS, starch, dextran and sarkaran at various stages of processing were within the same range at different factories.

MATERIALS AND METHOD

To ascertain the possible impact of cane varieties, BJ7504 and BJ82119 were selected on the basis that BJ7504 had exhibited high levels of TPS while BJ82119 showed lower levels in earlier studies. Samples comprised 12 randomly selected stalks of 12 month-old green cane from each field of the specified variety in each factory area. This was further divided into three sample sets containing four stalks each. Samples were divided into three 4-stalk sub-samples thus increasing the number of tests made in the SIRI Central Laboratory where they were analyzed within twenty four hours of harvest to determine various parameters. Tests were carried out over the period April 24 to May 9 2007.

Samples of syrup and C massecuite were collected from factories in operation on April 18, 2007. Weekly final molasses samples were also collected and stored for analysis.

Cane samples, C massecuite and syrup were analyzed for total polysaccharide, brix, pol dextran, and starch. TPS was analyzed using the Midland Gravimetric method. Dextran levels were determined by the DASA NIR method and the Midland Assay method. Other analyses were carried out using procedures outlined by ICUMSA

Weekly final molasses samples from all factories were collected and combined to make a monthly sample for the respective factories, yielding an average of five samples for each factory.
Molasses was acidified and high molecular weight polysaccharides isolated by precipitation with varying alcohol concentrations (80% to 100%). A 1mL dosage of pullulanase enzyme (Sigma EC232-983-9) containing about 3.75 PUN (pullulan units) for 20 mL aliquot pullulan standard (up to 0.5 mg) was used to hydrolyze the precipitate after incubation at 55ºC for one hour.
Sarkaran levels in molasses were determined by HPAEC-PAD analysis of the hydrolyzed precipitate.

RESULTS AND DISCUSSIONS

Variety Comparison

Results showed that TPS levels in BJ82119 tended to be marginally higher than in BJ7504 in five of the seven factory areas. This relationship was reversed in the Worthy Park and St. Thomas areas. The TPS values obtained for both varieties were lowest in the samples taken from Worthy Park Estate (**Table 1, Fig. 1**). There was no statistically significant difference (P = 0.969) in the TPS values between varieties tested (**Table 1**). These results varied from earlier reports of trials conducted only at Worthy Park Estate, where TPS values between varieties tested were found to be significantly different (Reece, 2006). It must be noted however that, in the case of Worthy Park, the results confirm earlier reports, in which BJ7504 tended to have higher levels of TPS than BJ82119.

Table 1: Results of TPS analysis in juice from two mature cane varieties.

Juice	TPS		Dextran		Starch	
	ppm on soluble solids		ppm on soluble solids		ppm on soluble solids	
Factory	**BJ 7504**	**BJ82119**	**BJ 7504**	**BJ82119**	**BJ 7504**	**BJ82119**
Frome	19280	19960	1822	1593	1437	1038
Monymusk	16617	16933	9929	8843	1858	759
Appleton	14005	15058	3037	5028	1287	936
Worthy Park	10601	7432	6737	7167	1409	1398
St Thomas	17460	14989	19164	16230	1107	239
Bernard Lodge	12220	16120	11757	12800	650	597
Long Pond	15890	16023	7341	7857	2421	962
Average	15153	15217	8541	8503	1453	847

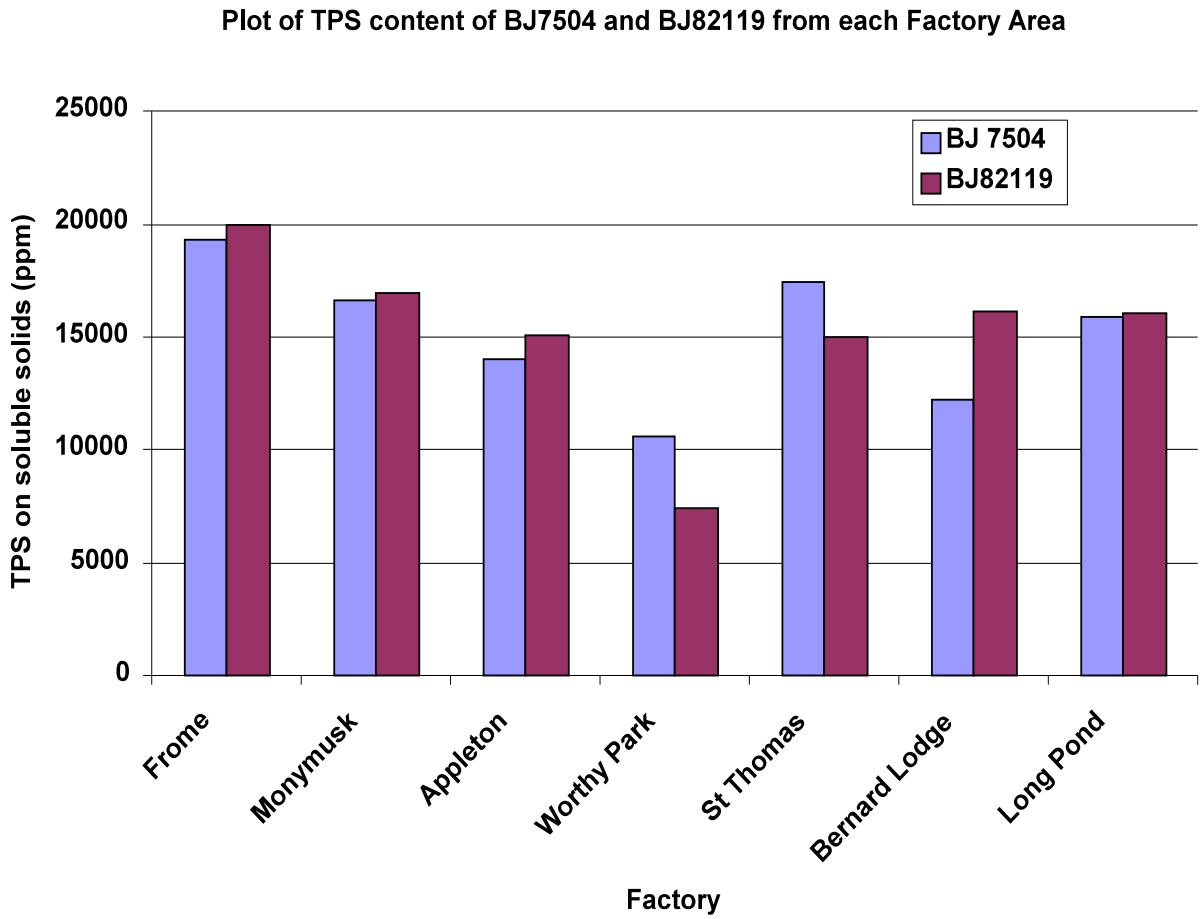

Figure 1: TPS in BJ7504 and BJ82119 in all factory area

Starch

Starch levels were more consistent within each variety at all locations (**Table 1, Fig. 2**). BJ7504 consistently showed levels of starch higher than BJ82119 in all seven factory areas with highest levels recorded at Long Pond. The fact that BJ7504 consistently showed higher starch levels regardless of the area grown suggests that this characteristic may be linked to individual varieties. Statistical analysis of the data shows that the difference in starch levels in the two varieties tested was significant (P = 0.017).

Dextran

Levels of dextran in the juice samples varied significantly from location to location but were consistent between both varieties at each location (**Fig. 3**). Samples received from the St. Thomas area exhibited the highest levels of dextran in both varieties. Samples from the Frome area showed the lowest levels of dextran among the samples tested. Since dextran levels are linked to microbial activity in the cane after harvest the dextran

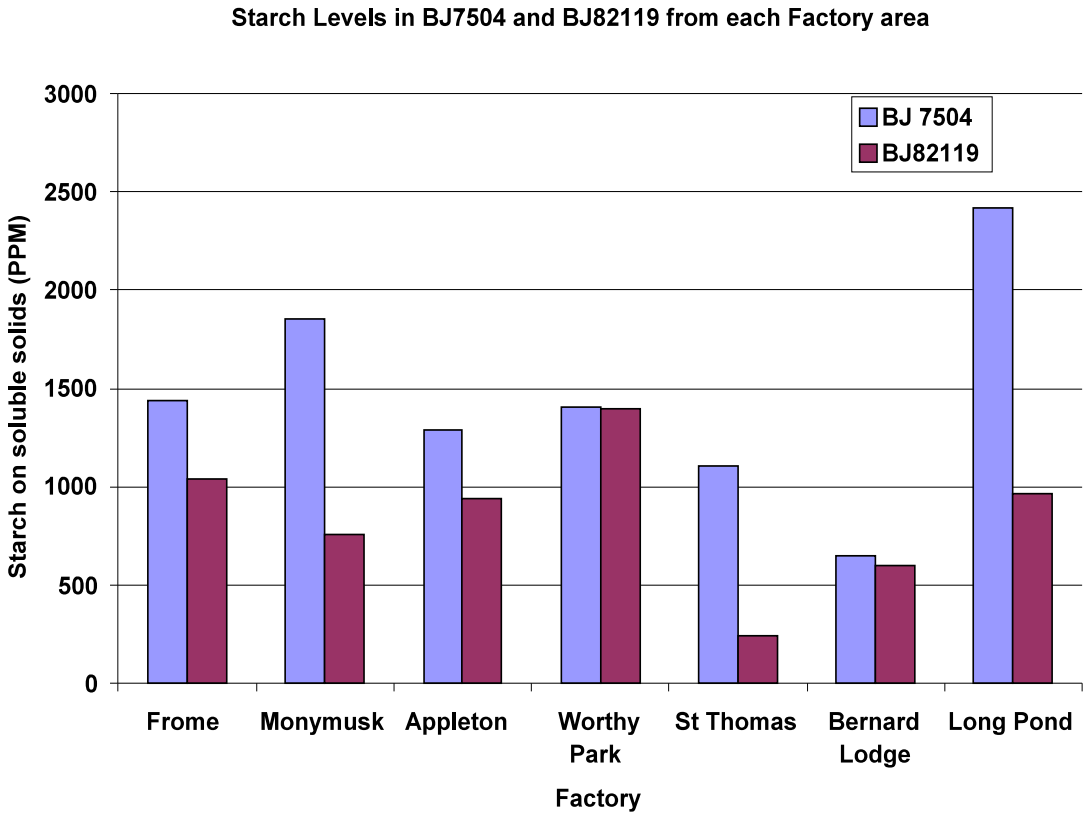

Figure 2: Starch levels in juice samples of BJ7504 and BJ82119 from each factory area.

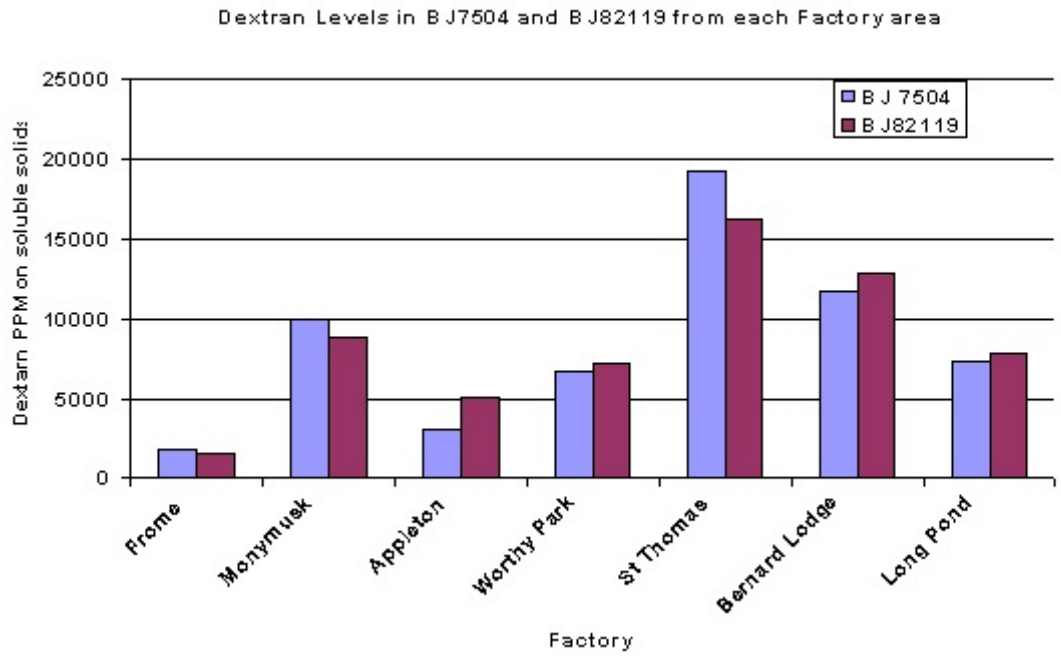

Figure 3: Dextran levels in juice samples of BJ7504 and BJ82119 from each factory area.

levels shown may be due to varying conditions (perhaps during transportation) of the cane between the field and the central laboratory. It should be noted that even under ideal conditions associated with commercial harvesting, levels of microbial polysaccharide will vary. It was anticipated that levels of dextran in the juice from these samples would have been relatively low, since attempts were made to exercise due care in the cutting and transporting of samples in timely manner for analysis.

TPS in syrup and C massecuite

Samples of syrup and C massecuite collected from all seven factories were analyzed for TPS, dextran and starch, **Table 2**.

Table 2: TPS levels in c massecuite and syrup at all seven factories.

	Syrup				C Massecuite			
Process	ppm on soluble solids				ppm on soluble solids			
Factory	TPS	Starch	Dextran	Residual TPS	TPS	Starch	Dextran	Residual TPS
Frome	18360	691	3985	13685	30984	8185	1485	21314
Monymusk	23937	1183	-	-	33575	9305	852	23418
Appleton	21014	555	4209	16250	35567	6336	4004	25227
Worthy Park	15311	1626	-	-	46694	13359	662	32673
St Thomas	-	-	-	-	34841	4144	3256	27441
Bernard Lodge	18428	830	3572	14025	40124	-	-	-
Long Pond	22483	650	4483	17350	25604	5979	2068	17556
Average	19922	922	4062	14938	35341	7885	2055	25402

At the syrup level, samples from Worthy Park showed the lowest level of TPS (15,311 ppm). However, by the C massecuite stage Worthy Park showed the highest level of TPS on soluble solids (46,694ppm). This was over 10,000 ppm above the average of 35,341 ppm . It must be noted that the samples taken from all the factories were grab samples. This would mean that the syrup sample would not necessarily be directly linked to the C massecuite sample taken.

There was no ready explanation for development of the high levels of TPS in C massecuite at Worthy Park. This clearly needs further investigation.

Starch, dextran and sarkaran

Assessment of both syrup and C massecuite showed Worthy Park also having significantly higher levels of starch than the other factories. The analysis for dextran in the process material was incomplete for syrup. Data was only generated for the syrup from four factories. These factories averaged dextran levels of 4062 ppm on soluble solids.

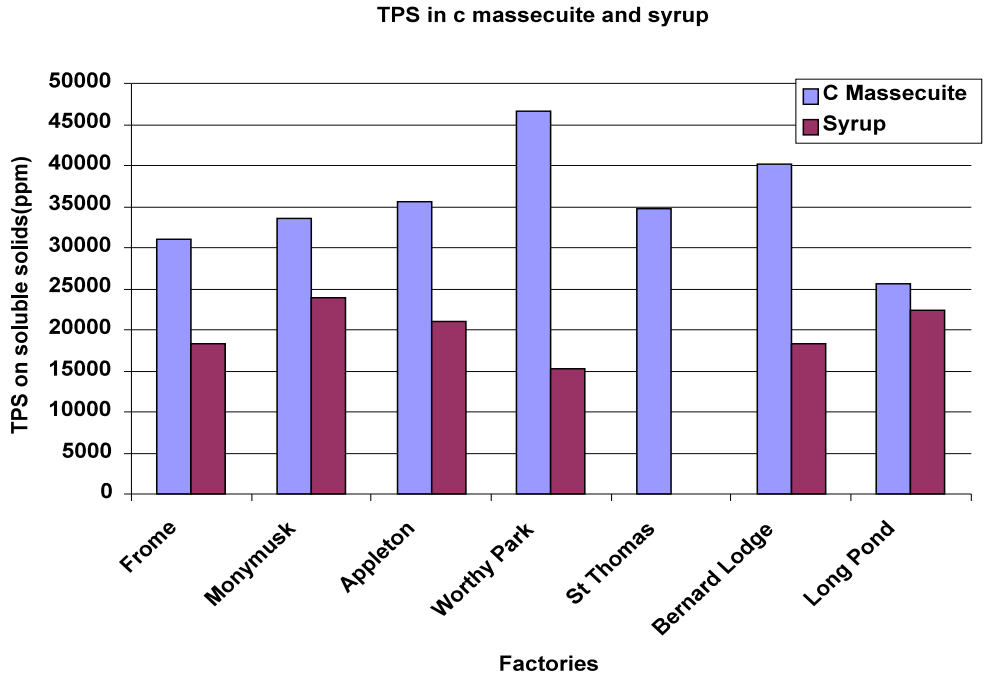

Figure 4: TPS in c massecuite and syrup

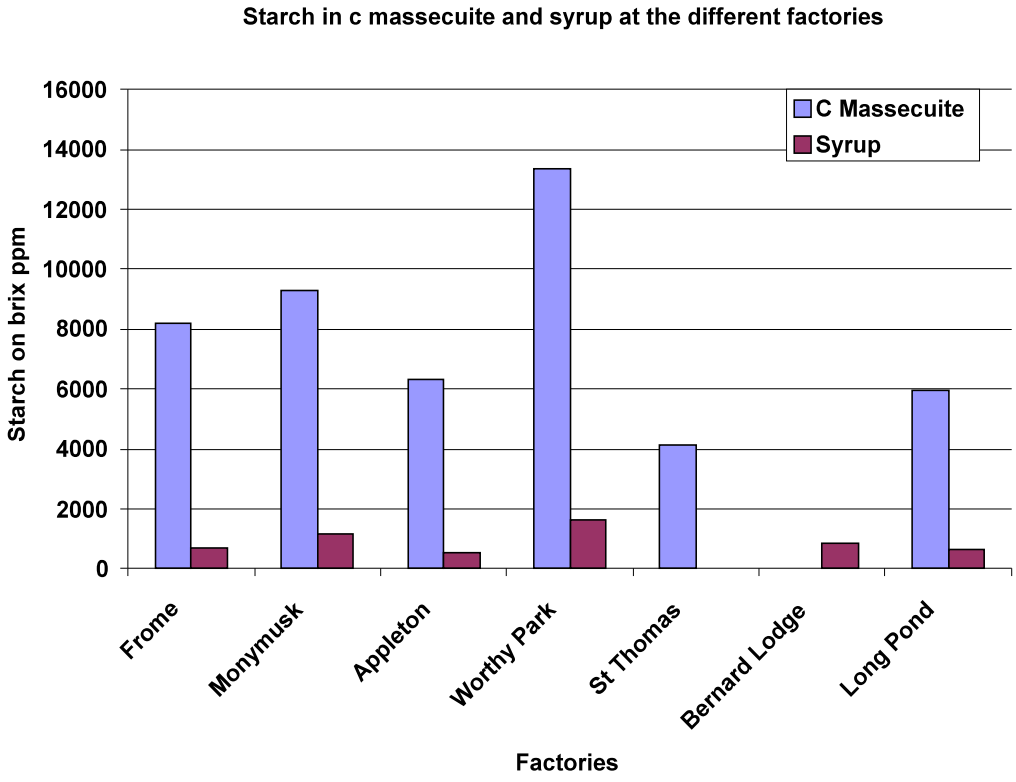

Figure 5: Starch in massecuite and syrup at the different factories.

Dextran levels in C massecuite showed Worthy Park and Monymusk having the lowest levels of dextran on soluble solids, 662 ppm and 852 ppm respectively.

Sarkaran was found in molasses samples from all factories and ranged in levels from as low as 650ppm to as high as 2400ppm (**Fig 8**).

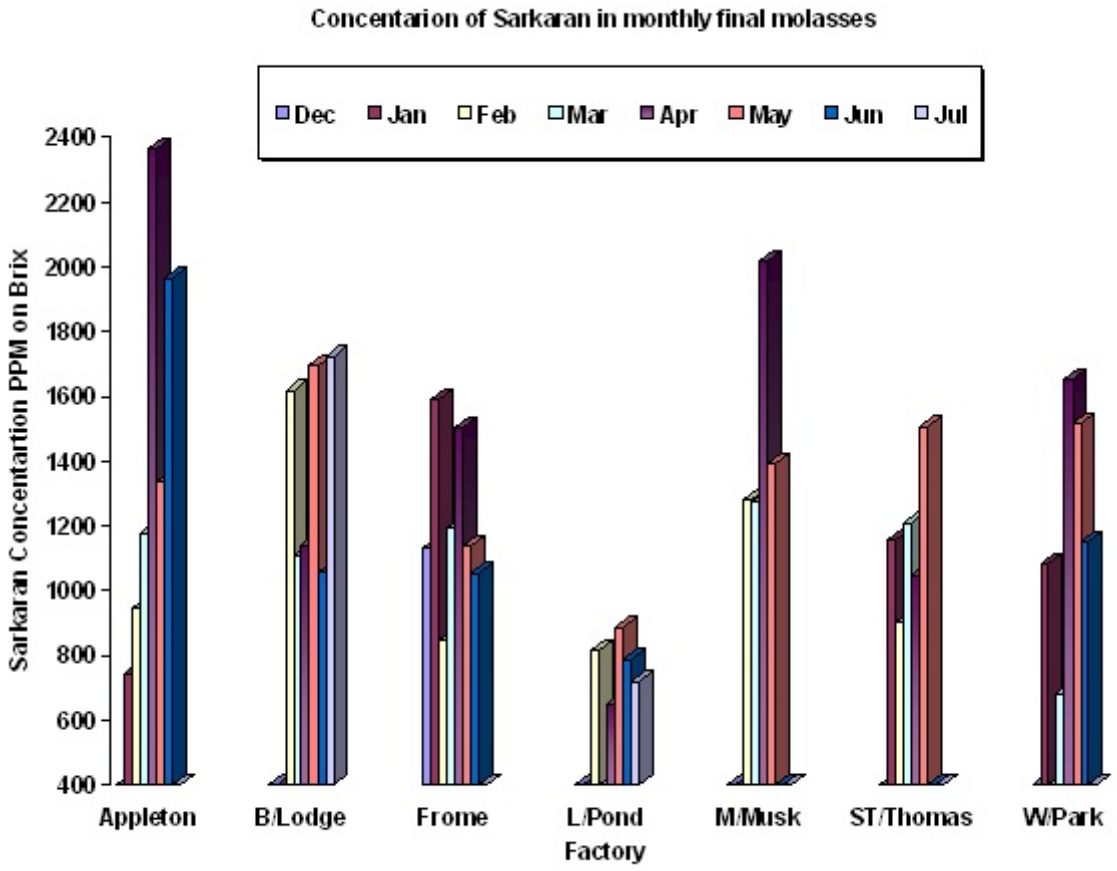

Figure 6: Monthly molasses sarkaran concentrations

Quantities reported for sarkaran, confirmed the presence of the polysaccharide, which may be in sufficient quantities to cause problems encountered during cane processing. The sarkaran levels seem to peak at most factories in the months of April and May, just around the end of the peak sucrose levels in the season. Long Pond Factory showed the lowest levels of sarkaran overall while Appleton Estate saw progressively higher levels from month to month except the month of May when there was a sharp decline.

SUMMARY & CONCLUSION

The study found no statistically significant differences in levels of TPS between field samples of two of the industry's leading sugar cane varieties, BJ7504 and BJ82119. The observed occurrence of viscosity in juice as the crop progresses at Worthy Park (not reported elsewhere) could therefore not be ascribed to any particular sugar cane variety examined in this study. However starch levels in BJ7504 were found to be significantly higher than in BJ82119, this suggests that it may be more meaningful to look at the individual components of the TPS complex within varieties at harvest.

While the study gives some indication of the trends in the TPS, dextran and starch levels, data obtained did not allow for any definitive conclusion at this time. Starch emerged as one of the major polysaccharides encountered in processing. This tended to be much higher at Worthy Park than at other factories. In addition, polysaccharide components varied within each factory and from factory to factory. A comprehensive assessment of each polysaccharide component may be necessary to accurately identify the true source of the processing problems experienced.

The data identifies the stage at which polysaccharide builds up to undesirable levels during processing and therefore indicates where future investigative work must be directed.

ACKNOWLEDGMENT

The authors thank the management and staff at SIRI, personnel from all the participating factories for support on this project and, in particular, the Sugar Technology team at SIRI for its tireless input.

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