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Audubon Sugar Institute
Factory Operations Seminar

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Size Dependent Quality of Louisiana Bagasse

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LSU AgCenter, Audubon Sugar Institute

Bagasse is an interesting feedstock, as it is a valuable fuel during the season and a burden at the end of the season. Nearly anything can be made from bagasse, but nearly nothing with profit. The main issues with bagasse are its density and quality. While there is great interest from multiple parties to work with bagasse, the interest is hampered and wanes, once ash levels are presented. A size separation as is common for wood chips and other biomass might yield higher quality bagasse, benefitting its potential use and utilization.

Fresh bagasse was sampled from all factories in Louisiana during the 2017-2018 season. The samples were collected on dates throughout the season to account for the widespread effects of weather on cane quality. Before that, old bagasse was sampled during the summer of 2017 from all mills which had excess bagasse stored on-site. Care was taken for sample uniformity: bagasse from last season only and deep enough below the surface to diminish surface effects. The purpose is to 1) provide a basic overview of current bagasse properties and 2) assess the potential of screening on bagasse quality.

The simplest measure of bagasse quality is moisture and ash, which in turn govern the heating value (expressed here as gross calorific value or GCV). Typically the heating value is described via an empirical determination e.g. from Chen and Chou's Cane Sugar Handbook GCV [kJ/kg] = 19410*(100-%Ash-%Moisture)/100 - the higher the moisture and ash, the lower the GCV. Some bagasse conversion technologies (especially with wet processing) can tolerate high moisture, but nonetheless practically all benefit from a high GCV or low ash and low moisture.

Sieving the bagasse with screens of 4-mm, 2-mm, 1-mm and 0.5-mm openings, separated it in five fractions. Average size distribution for **fresh bagasse**: coarse fraction (>4 mm) made up 11.9%, 2 to 4 mm 13.9%, 1 to 2 mm 21.5%, 0.5 to 1 mm 33.2 and the finest fraction 19.5% on average of the total dry mass (fig.1a). **Old bagasse** size distribution similar (fig.1b).

Considering the bagasse as a whole, **fresh bagasse** collected during 2017/2018 exhibited moisture levels ranging from 48.2 to 57.3% with an average of 50.7%. Ash levels (%based on dry bagasse) were observed from 3 to 12.2% averaging 6.6%. GCV ranged from 7741 kJ/kg to 10046 kJ/kg with an average of 9362 kJ/kg and is governed predominantly by the moisture level. **Old bagasse** had moisture levels ranging from 15.4 to 81.1% with an average of 53.2%. Ash levels (%based on dry bagasse) were observed from 5.63 to 9.52% averaging 7.54%. Again, GCV is governed by moisture levels but much more variable than for fresh bagasse, dependent on storage and weather. Separating the old bagasse into covered and open storage we find the average moisture is 41.9% and 70.0% respectively.

Considering each size fraction, the average moisture level in bagasse was found to be independent of the particle size, i.e. the fractions had practically the same moisture level as the overall sample. This was surprising as due to the different surface area a dependency on size was expected. Ash on the other hand is strongly dependent on particles size, with a strong trend toward higher ash in the finer size particles. **Fresh bagasse** exhibited on average 2.6%, 3.2%, 4.4%, 6.4% and 16.6% ash within each size fraction, averaging 6.6% overall (based on

dry bagasse) (fig.2a). **Old bagasse** shows the same trend (fig.2b). As the moisture level does not change with size, ash governs the GCV of the individual size fraction, which changes from 105.1%, 105.1%, 102.8%, 99.7% and 92.1% of the average total value of 9362 kJ/kg.

As the GCV of fine bagasse is 7.9% smaller than the total value, the impact of screening bagasse on the excess bagasse was looked into. If a mill with 10% excess would screen their entire bagasse to 4 mm and burn preferentially the finer fraction (retaining and feeding back the greater-than-4-mm fraction) the excess would be reduced to 9.5%. This change is not significant and as such it will not be possible to eliminate excess bagasse with screening. However, the excess bagasse in this case would be uniformly sized and exhibit an ash level of only 2.6% (compared to 6.6% prior to screening), making it more suitable for alternative commercial conversion.

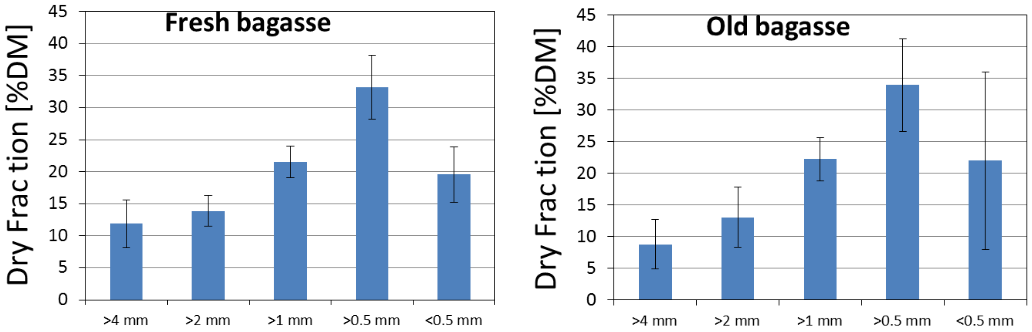

Figure 1a Size distribution of fresh bagasse **1b** Size distribution of old bagasse

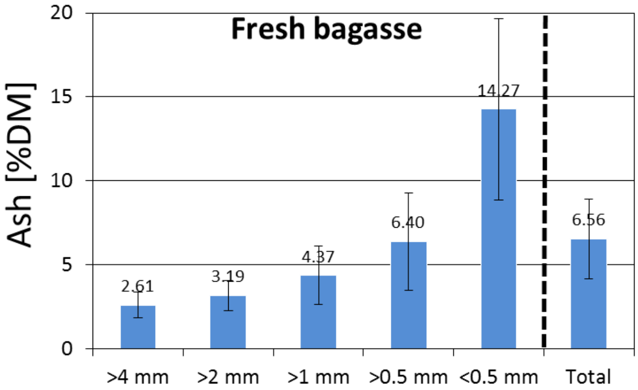

Figure 2a Ash level distribution of fresh bagasse

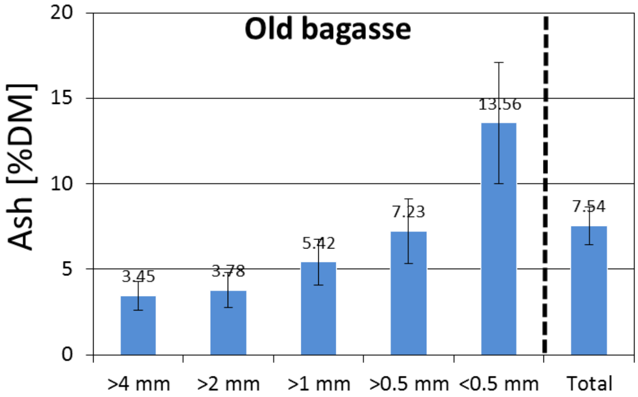

Figure 2b Ash level distribution of old bagasse

MILLING AND BOILER TEST RESULTS -- 2017

Harold Birkett and Jeanie Stein

Mill performance tests and boiler efficiency and compliance tests are conducted nearly every year at the request of individual factories. Progress continues to be made in both milling and boiler operations. Results from testing over the 2017 crop follow.

MILLING

Six mill performance tests were requested during the 2017 crop. Results provided to factories included preparation index, pol % cane and bagasse, individual mill extraction and overall tandem extraction.

Table 1. Prepared cane analyses for all mill tests.

Factory	Moisture % Prep Cane	Fiber % Prep Cane	Pol % Prep Cane	Ash % Prep Cane	Preparation Index, %
K	68.14	13.45	13.81	2.70	82.72
A	70.28	12.08	13.62	2.11	82.24
C	69.58	12.58	13.34	1.53	72.03
H	70.92	13.01	11.15	3.02	84.28
F	71.62	13.59	12.36	2.01	86.66
G	71.35	12.91	13.30	1.60	80.66
Average:	**70.32**	**12.94**	**12.93**	**2.16**	**81.43**

Table 1 above shows prepared cane analyses for moisture, fiber, pol, ash and preparation index. Moisture % prepared cane averaged 70.32 and varied from 71.62 to 68.14. True fiber % prepared cane averaged 12.94 with a low of 12.08 and a high of 13.59. Pol % prepared cane ranged from 11.15 to 13.81 with an average of 12.93. The ash of the incoming cane averaged 2.16% and ranged from 1.53% to 3.02%. Preparation index averaged 81.43% with a range of 72 to 87%.

Table 2 below gives first mill bagasse analyses for moisture, open cells and pol extraction. Moisture % first mill bagasse averaged 58.14 and varied from 54 to 62%. Open cells % first mill bagasse ranged from 89 to 93 and averaged 91%. The actual pol extraction of the first mill ranged from 60 to 74 and averaged 65%.

Table 2. Analytical results from first mill.

Factory	Moisture % 1st Mill Bagasse	Open Cells % 1st Mill Bagasse	Pol Extraction %, 1st Mill
K	56.75	92.93	63.74
A	--	--	--
C	54.45	91.44	73.83
H	59.08	90.50	60.01
F	--	--	--
G	62.27	89.18	61.33
Average:	**58.14**	**91.01**	**64.73**

--No sample

Table 3 presents results from the analyses of last mill bagasse along with overall pol extraction. Bagasse moisture varied from a low of 46% to a high of 54% and averaged 50.38%. Pol % bagasse averaged 2.18 and varied from 1.87 to 2.64. Last mill bagasse was analyzed for the amount of open cells. Results range from 98.81% to 99.52% and averaged 99.22%. The average bagasse ash was determined to be 3.84% and varied from 1.98% to 5.96%. The overall tandem pol extraction averaged 94.60%, ranging from 93.05% to 96.19%. Reduced pol extraction varied from 93.69% to 96.04% and averaged 94.84%.

Table 3. Results from analyses of last mill bagasse along with extraction.

Factory	Moisture % Bagasse	Pol % Bagasse	Open Cells % Bagasse	Ash % Bagasse	Tandem Pol Extraction, %	Reduced Pol Extraction, %
K	53.85	2.10	99.47	5.96	94.24	94.70
A	49.04	1.89	--	3.55	96.19	96.04
C	50.25	2.09	99.40	1.98	95.48	95.51
H	51.35	1.87	99.52	4.35	94.53	94.78
F	46.18	2.64	98.81	4.67	93.05	93.69
G	51.58	2.48	98.89	2.55	94.12	94.33
Average:	**50.38**	**2.18**	**99.22**	**3.84**	**94.60**	**94.84**

--No sample

BOILERS

This past crop (2017) assistance was given to five factories who were required to compliance test five specific bagasse boilers as permitted by the Louisiana Department of Environmental Quality. Another factory also requested assistance in determining the efficiency of all five of their bagasse boilers. In all, twenty boiler tests were conducted. Operating conditions and results provided included preheated air temperature, flue gas temperature, bagasse moisture, bagasse ash, oxygen % flue gas, excess air %, efficiency % and pounds steam produced per ton of bagasse burned (Table 4). The effective moisture has also been calculated and is shown in Table 4.

Table 4. Temperatures and results of bagasse boiler testing.

Factory	Preh. Air, °F	Flue Gas, °F	Moist. % Bag.	Ash % Bag.	Effec. Moist., %	O_2, %	Excess Air, %	Effic, %	Lbs Steam/ Lb Bag.
A	517	484	49.01	3.55	50.81	8.60	67.48	59.33	2.39
A	540	464	49.01	3.55	50.81	12.37	142.81	56.06	2.26
A	480	451	49.01	3.55	50.81	9.95	89.26	60.15	2.43
A	510	447	49.01	3.55	50.81	5.40	33.30	63.16	2.55
A	574	423	49.01	3.55	50.81	7.27	52.36	63.68	2.20
K	309	294	50.92	1.86	51.89	15.36	273.14	58.83	2.34
K	313	295	50.57	2.27	51.74	15.68	296.31	58.96	2.35
K	319	296	51.23	1.74	52.14	15.34	271.93	59.61	2.37
S	405	368	53.38	4.82	56.08	9.19	77.48	60.91	1.96
S	404	368	52.46	9.36	57.88	9.66	84.78	59.24	1.73
S	410	373	52.67	4.34	55.06	9.20	77.65	61.77	2.04
A	576	424	52.40	3.15	54.10	7.01	49.84	62.47	2.04
A	580	425	49.08	3.11	50.66	6.78	47.43	64.90	2.29
A	582	425	49.50	2.52	50.78	6.62	45.79	64.99	2.30
J	603	430	50.86	4.31	53.15	6.84	48.10	63.02	2.20
J	603	439	52.98	2.62	54.41	6.15	41.21	62.35	2.15
J	615	433	49.89	3.00	51.43	6.15	41.32	63.74	2.23
D	361	369	51.27	5.16	54.06	11.77	127.31	60.39	2.24
D	385	378	51.77	2.48	53.09	12.46	145.74	59.69	2.32
D	420	401	46.92	9.57	51.89	11.53	121.52	60.36	2.24
Average:	**475**	**399**	**50.55**	**3.90**	**52.62**	**9.67**	**106.74**	**61.18**	**2.23**

Table 4 gives the results of all boiler tests conducted during the 2017 crop. Preheated air temperature varied from 309° to 615°F and averaged 475°F. Flue gas temperatures ranged from a low of 294°F to a high of 484°F and averaged 399°F. Bagasse samples were collected during each test run and analyzed for moisture and ash. Moisture % bagasse averaged 50.55 (ranging from 46.92 to 53.38) while the ash % bagasse averaged 3.90 (and ranged from 1.74 to 9.57). Because bagasse fuel content is so critical to boiler efficiency, it is useful to look at its effective moisture (which is the moisture taking the ash into account). The effective moisture % bagasse averaged 52.62 or about 2% higher than the regular moisture. Oxygen levels varied from 5.4% to 15.68% and averaged 9.67%. Excess air levels ranged from 33% to 296% and averaged 107%. Efficiency ranged from 56% to 65% and averaged 61%. Each pound of bagasse burned produced between 1.73 and 2.55 pounds of steam, averaging 2.23, for the crop. This number has increased since the early days of boiler testing when the average pounds steam produced per pound of bagasse burned hovered around 2.00.

Mill extraction and boiler efficiency continue to improve even as many factories process more cane.

CORE LAB

Harold Birkett and Jeanie Stein

A comparison of pol % cane is shown in Table 1 below. A plot of true versus corer pol % cane of billeted cane is also given in Figure 1.

Table 1. Comparison of true versus corer pol % cane.

	Pol % Cane	
Sample Number	True	Corer
Billeted:		
1	12.49	12.46
2	11.66	11.40
3	14.18	13.97
4	13.52	13.78
5	13.13	13.03
6	14.21	14.16
7	13.03	13.27
Average:	13.17	13.15
Hand-cut:		
8	14.37	14.24
9	10.68	11.16
10	9.88	10.09
11	15.02	14.46
12	13.01	12.62
13	14.74	14.30
14	12.16	12.57
15	13.52	13.50
16	13.45	13.60
Average:	12.98	12.95
All Samples Average:	**13.07**	**13.04**

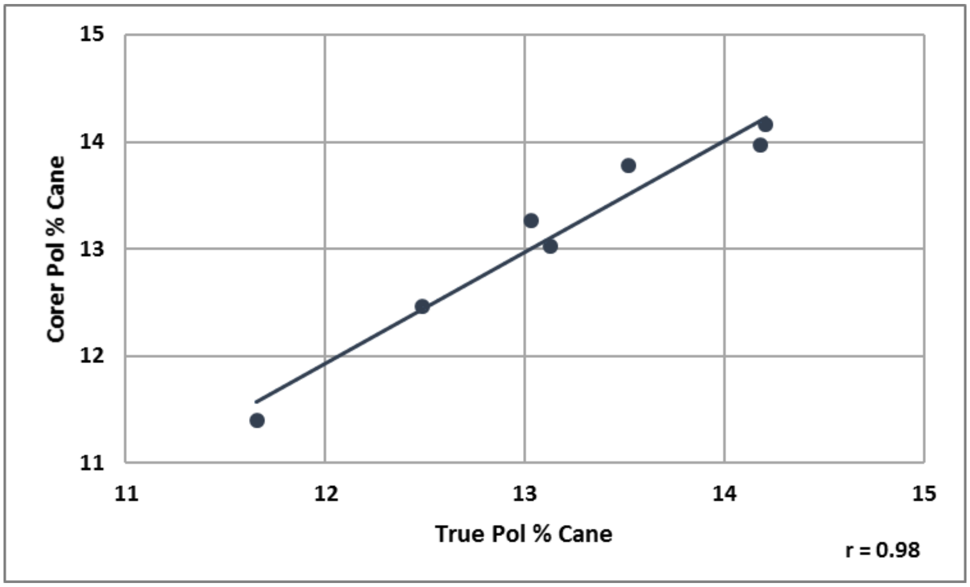

Figure 1. True pol % cane versus corer pol % cane of billeted cane samples.

Crystal Size Analysis for Louisiana Sugar Mills
2017/18 Season

Young Moon, Daira Aragon, Franz Ehrenhauser, Giovanna M. Aita

Crystal size analysis has been provided as a service to all Louisiana sugar mills since 2007 at the Audubon Sugar Institute (ASI). The crystal size analysis of A-, B-, C-sugars, massecuites and seed slurries is conducted at ASI with a Cilas 1180 laser diffraction particle size analyzer. During the 2017/18 season more than 500 samples were collected and analyzed for their size and distribution.

C-Sugar Samples

The C-sugar analysis results of each mill for the 2017/2018 season is summarized in Table 1 and their average mean is shown in Figure 1. The average crystal size for C-sugar was 219 micrometers with a 10-percentile (D10%) of 59 micrometers, a 50-pencentile (D50%) of 203 micrometers and a 90-percentile (D90%) of 407 micrometers. Overall C-sugar crystal size increased compared to the 2016/17 season. The mean crystal size increased from 214 to 219 microns. This change is attributed to an increase in D10% from 41 to 59 micrometers; whereas, D50% and D90% increased on average by 1 and 2 micrometers, respectively. This observation is reflected in an improved CV of 0.60 compared to the 2016/17 season's value of 0.65.

Figure 2 shows the average mean C-sugar crystal sizes of each Louisiana sugar mill during the 2017/18 season. Figure 3, Figure 4, and Figure 5 show the average 10-percentile (D10%), 50-percentile (D50%), and 90 percentile (D90%), respectively. Each sugar mills show different values of the average mean C-sugar crystal size ranging from 188 to 250 micrometers (Figure 2). Furthermore, the average 10-percentile, 50-percentile, and 90-percentile of C-sugar crystal size of all sugar mills ranged from 32 to 70 micrometers (D10%), from 155 to 251 micrometers (D50%), and from 391 to 438 micrometers (D90%), respectively.

Table 2 summarizes the average CV-values for the 2014/2015-2017/2018 seasons. A slight improvement in the size distribution of C sugar crystal can be observed. The average mean C-sugar crystal size increased from 196 micron (2014/2015 season) to 219 microns (2017/2018 season) along with D10% from 31 to 59 micrometers and 50-percentile from 180 to 203 micrometers. The value of CV gradually decreased from the 2015/16 season to the 2017/18 season from 0.71 to 0.60 indicating that the C sugar crystals were more consistent in its size distribution matter.

These sugar crystal size distribution data using a particle size analyzer (Cilas 1180) on C sugar samples along with C massecuites and seed slurries enables sugar mill operators to assess the crystallization process, the centrifugal operation and seed slurry preparation for the consistent and optimized process of their sugar process.

ACKNOWLEDGEMENTS

The authors would like to thank the American Sugar Cane League and the Louisiana sugar mills for their support and contributions to this research.

Table 1. 10-percentile, 50-percentile (median) and 90-percentile, Mean and CV-values of C-Sugars during the 2017/18 season. (Average values ± standard deviation)

Mill	# of samples	D 10% [µm]	D 50% [µm]	D 90% [µm]	Mean [µm]	CV
A	18	52 ± 14	204 ± 22	411 ± 14	219 ± 16	0.62 ± 0.5
B	13	49 ± 24	210 ± 50	422 ± 21	224 ± 32	0.64 ± 0.11
C	7	32 ± 13	155 ± 48	395 ± 25	188 ± 30	0.75 ± 0.11
D	10	65 ± 10	251 ± 25	438 ± 9	250 ± 16	0.55 ± 0.04
E	27	53 ± 19	211 ± 28	418 ± 16	224 ± 18	0.62 ± 0.07
F	10	68 ± 6	230 ± 22	428 ± 10	239 ± 14	0.56 ± 0.03
G	11	47 ± 13	172 ± 21	391 ± 11	198 ± 15	0.66 ± 0.06
H	17	70 ± 8	201 ± 37	407 ± 24	222 ± 25	0.58 ± 0.05
I	44	69 ± 11	204 ± 30	399 ± 28	221 ± 23	0.57 ± 0.04
J	23	58 ± 12	203 ± 22	409 ± 14	220 ± 16	0.61 ± 0.05
K	14	62 ± 10	170 ± 29	366 ± 33	194 ± 24	0.61 ± 0.05
Overall	194	59 ± 16	203 ± 36	407 ± 26	219 ± 25	0.60 ± 0.07

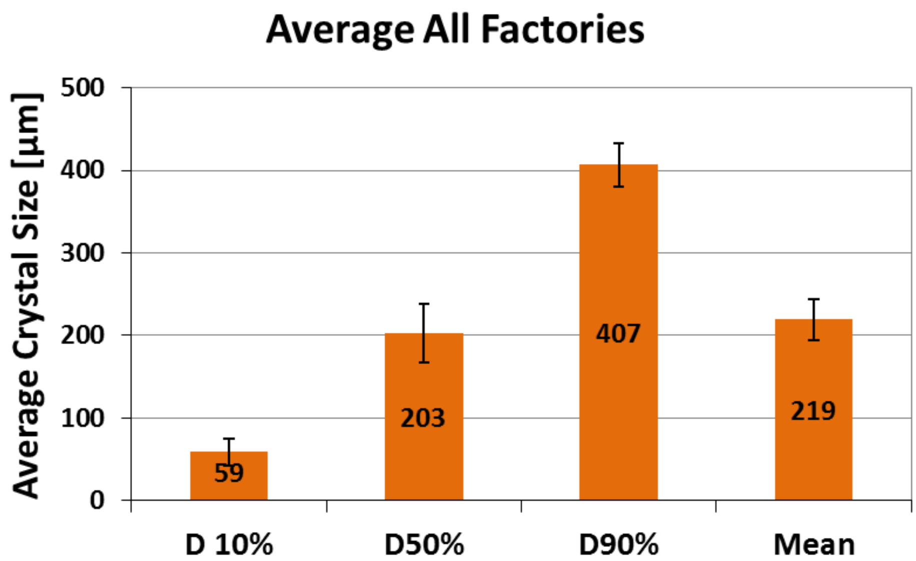

Figure 1. Average crystal size of C-sugar for mills A-K during 2017/18 season.

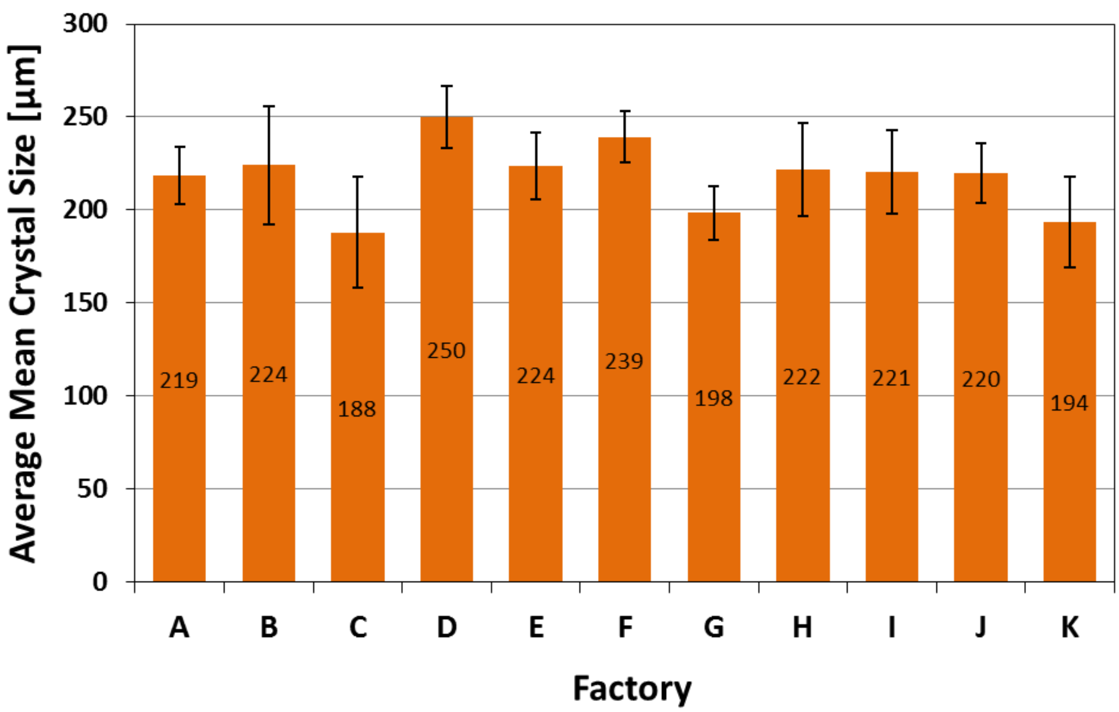

Figure 2. Average mean crystal size of C-sugar for mills A-K during 2017/18 season.

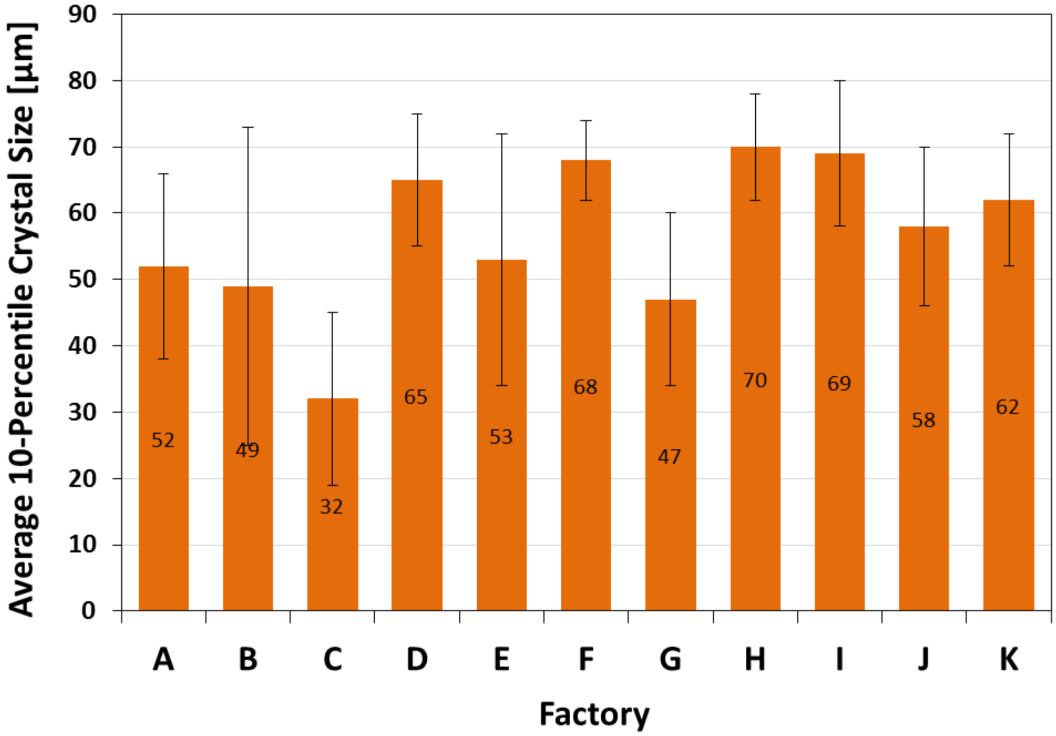

Figure 3. Average 10-percentile crystal size of C-sugar for mills A-K during the 2017/18 season.

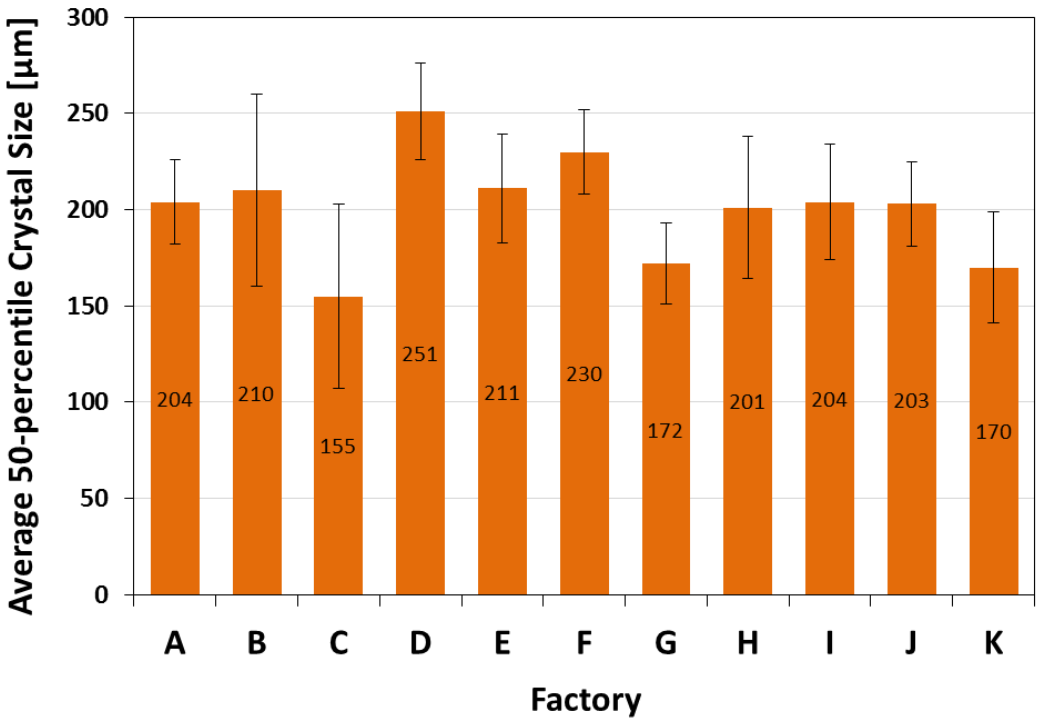

Figure 4. Average 50-percentile crystal size of C-sugar for mills A-K during the 2017/18 season.

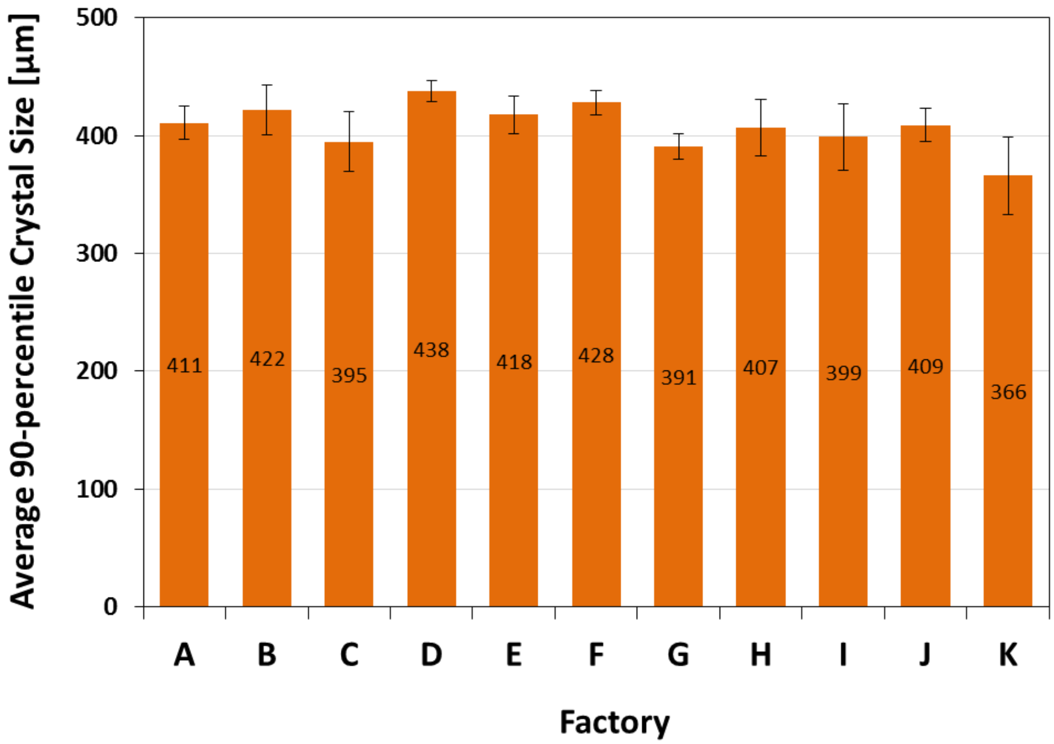

Figure 5. Average 90-percentile crystal size of C-sugar for mills A-K during the 2017/18 season.

Table 2. Summary of yearly 10-percentile, 50-percentile (median) and 90-percentile, Mean and CV-values of C-Sugars during the last 4 seasons.
(Average values ± standard deviation)

Year	# of samples	D 10% [µm]	D 50% [µm]	D 90% [µm]	Mean [µm]	CV
2014/15	127	31 ± 12	180 ± 34	392 ± 28	196 ± 25	0.70 ± 0.07
2015/16	377	32 ± 15	184 ± 50	405 ± 41	203 ± 35	0.71 ± 0.11
2016/17	247	41 ± 16	202 ± 47	409 ± 44	214 ± 34	0.65 ± 0.10
2017/18	194	59 ± 16	203 ± 36	407 ± 26	219 ± 25	0.60 ± 0.07

THE 2017 MOLASSES SURVEY

C. Verret & I. Tishechkina

INTRODUCTION

The loss of sugar in molasses is generally the largest loss suffered by a sugar mill. It is important that reliable data on molasses exhaustion be obtained. The Audubon Sugar Institute (ASI) undertook analyses of molasses samples for the mills in Louisiana from 1980-1997. It was briefly discontinued after the 1997 season and reintroduced in 2000 and is currently providing this service to the Louisiana sugar industry.

Since 2001, the Audubon Sugar Institute has analyzed the molasses provided weekly by each of the Louisiana raw sugar factories. The results of our analyses are used to calculate a "target purity (TP) and a true purity for the molasses. The TP is the theoretical concentration of sucrose (sugar) where, regardless of effort, no further sugar can be crystallized. The model that is used to calculate the TP originates from South Africa (Rein, 2007), and has been confirmed as representative of the Louisiana industry (Saska et al., 2010).

The true purity is determined by HPLC and is free of the interferences (reducing sugars) that can offset the accuracy of polarimetric determinations (particularly in molasses where purities are very low). The formula for TP is given below, where *RS* is the total reducing sugar (glucose + fructose) via HPLC (ICUMSA, 2002) and *Ash* is the approximate sulfated ash via conductivity (Saska et al., 1999).

$$TP = 33.9 - 13.4 \cdot Log_{10} \frac{RS}{Ash}$$

The TP is subtracted from the true purity to give a target purity difference or TPD. The TPD is used by the factories to determine how well they are recovering sugar from their massecuite (which is reflected by residual sugar in the molasses). "True purity" is the sum of the non-crystallizable sugar and that which was crystallized, but was lost across the centrifugals. For this reason, the nutsch should be assayed in order to determine how much sugar is lost across the centrifugals. Generally, a lower TPD indicates greater efficiency as it relates to recovery of sugar.

MATERIALS AND METHODS

Composite samples of final molasses (seven day) were sent to us weekly from each of the 11 mills in Louisiana. The 2017 survey season stretched from 10-01-17 until 01-14-18. A total of 180 molasses and syrup samples and 10 juice samples were analyzed in duplicate for the 2017 season. Including standards, this totaled to 588 samples for 2017 season. Analyses included:

1. Refractometer Brix (ICUMSA GS4-13)
2. Sucrose, glucose and fructose by HPLC (ICUMSA GS7/4/8-23)
3. Sucrose via polarimetry*
4. Conductivity ash (ICUMSA GS1/3/4/7/8-13)

*Because we measure sugar using HPLC, we perform a direct polarization of molasses, syrup and juice samples are clarified using Octapol™ (Baddley Chemical) so that we can obtain a pol/sucrose ratio.

Double-blind quality control (QC) was performed each week. Briefly, a large sample of molasses is collected during the first week of the season. This sample is sub sampled into enough small containers to last the season (approximately 28-30 samples). Each week, two of these subsamples are pulled and included randomly into the weekly sample set. Each sample in the weekly set is mixed thoroughly and subsampled into containers identical to those used for the QC. A number is applied to each container, and the identity of each sample is kept in confidence until the analyses are complete.

RESULTS/DISCUSSION

The 2017 season operated for 16 weeks. The 2017 season maximum TPD weekly average was 13.8 and the minimum was 7.4. Throughout the season, the TPDs demonstrated the usual trend of decreasing TPD. The Industry average TPD for 2017 was 8.6. (Figure 1)

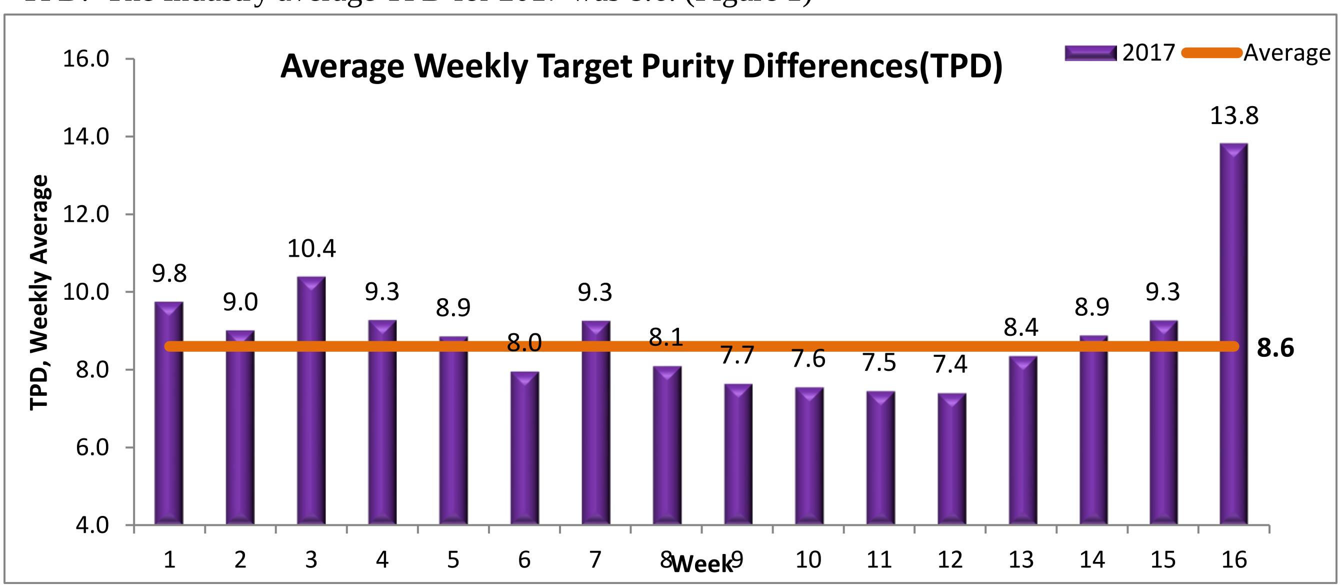

Fig. 1 – 2017 Average Weekly Target Purity Difference

The conductivity ash component for the 2017 season has a minimum value of 13.0. Towards the middle of season, the ash increased to the maximum value of 16.5. The conductivity ash weekly average was 15.2. (Figure 2)

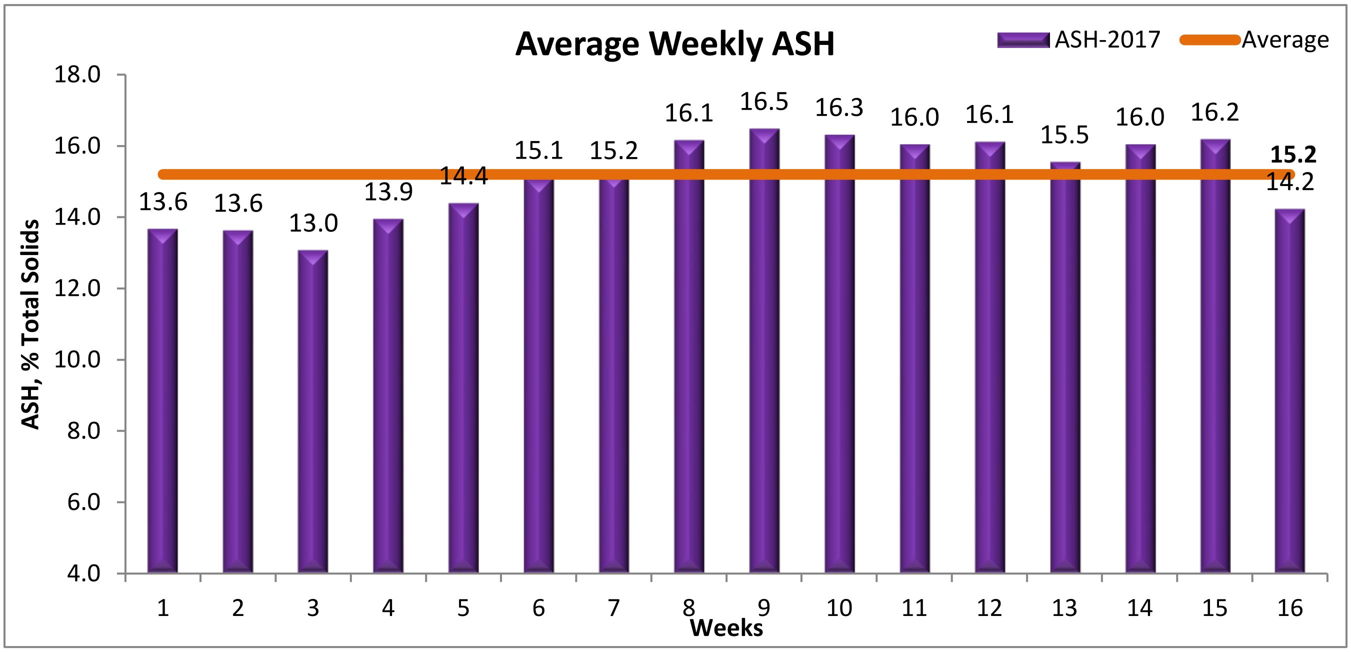

Fig. 2 – 2017 Average Weekly Conductivity Ash

In general, there has been a significant downward trend, relative to time, in the amount of reducing sugar in final molasses. In the 2017 season, the reducing sugars decreased throughout the season. The maximum was 18.9 and the minimum occurred in the middle of the season with 10.1. The reducing sugars weekly average was 12.9. (Figure 3)

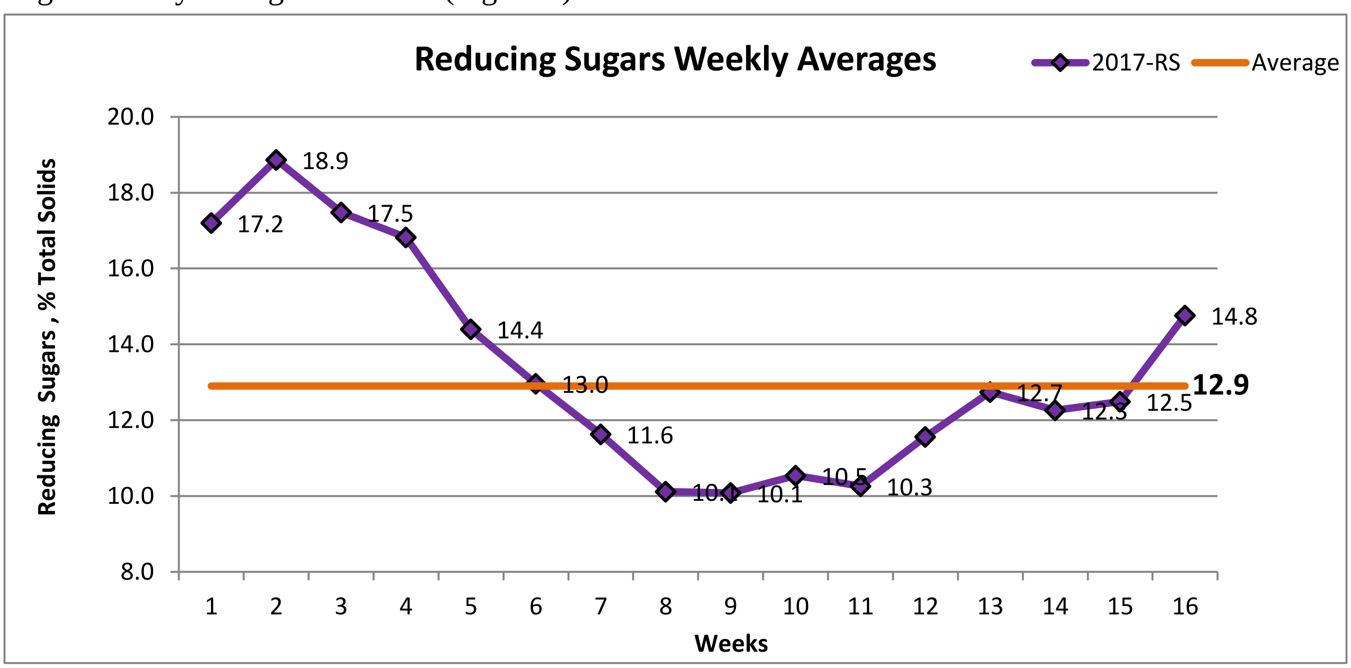

Fig. 3 –2017 Reducing Sugars Weekly Averages

Comparing the results from the 2017 season to the results from the previoud seasons showed the yearly average TPD of 8.3 a slight increase. This is demonstrated in **Figure 4.** The 2017 season maximum TPD was 11.2. The minimum TPD for 2017 was 6.1.   (Table 1)

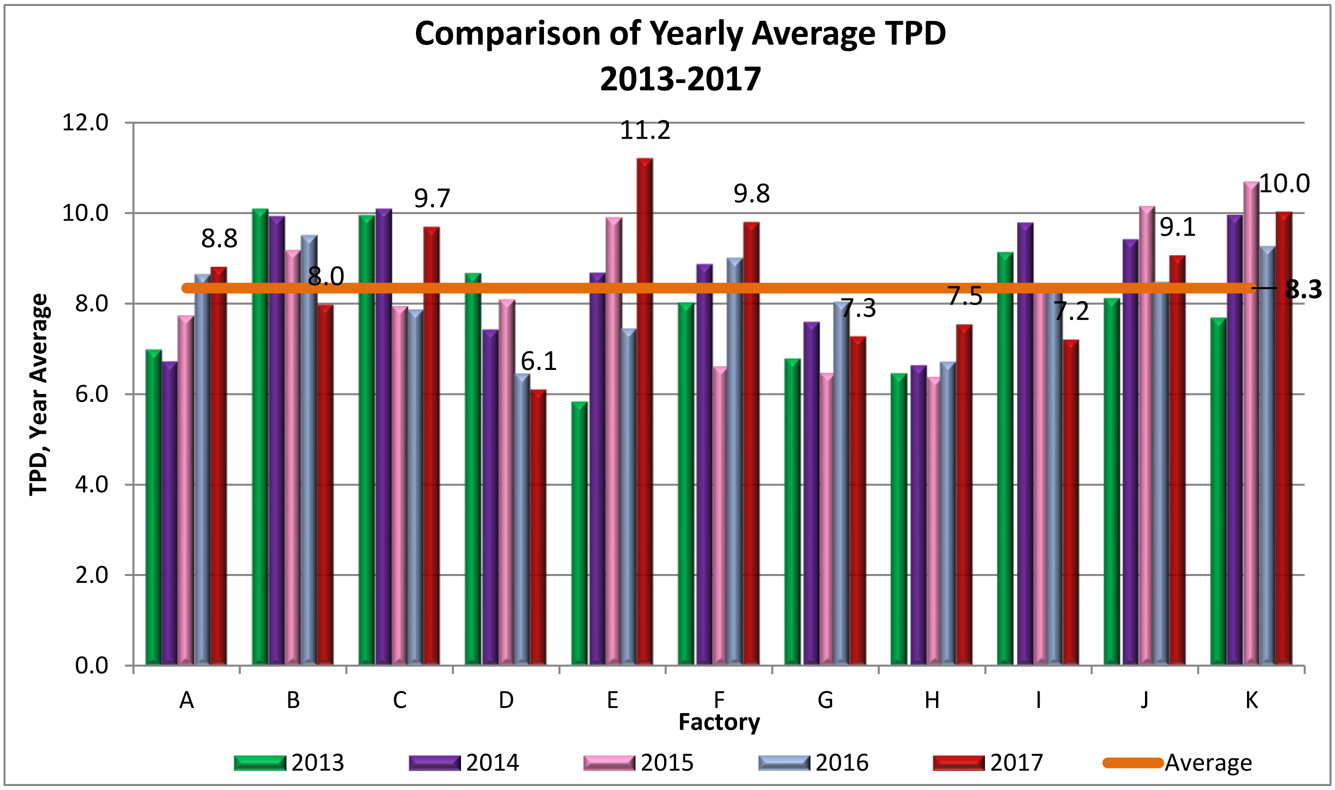

Fig. 4 – Comparison of Yearly Averages TPD 2013-2017

TPD Data Summary for 2013-2017			
Year	**TPD Minimum**	**TPD Maximum**	**TPD Average**
2013	5.8	10.1	8.0
2014	6.6	10.1	8.6
2015	6.4	10.7	8.3
2016	6.5	9.5	8.2
2017	6.1	11.2	8.3

Table 1 – Summary of Yearly TPD 2013-2017

The sugar cane juice from the sugar mill has been analyzed for the past 8 years. In **Table 2**, shows the summary from the analysis. Over the last eight seasons, the average brix is 14.5%, a true purity average of 88.9% and reducing sugars 5.2%.

Juice Survey Summary for 2010-2017			
Year	**Ref. Brix (%Juice)**	**True Purity (% Juice)**	**Reducing Sugars (%Juice)**
2010	14.5	89.3	3.8
2011	15.1	87.2	5.0
2012	14.6	88.1	3.6
2013	14.1	91.1	10.8
2014	14.8	88.7	4.1
2015	13.5	88.9	3.2
2016	15.1	88.9	5.2
2017	14.5	88.8	6.1
Average	**14.5**	**88.9**	**5.2**

Table 2 – Summary of Juice Survey 2010-2017

CONCLUSIONS

The seasonal average TPD was 8.6 for the 2017 season, which was a slight increase from the 2016 season. The ash decreased for the 2017 season to 15.2%. The reducing sugars decreased for the 2017 season to 12.9% from 13.3% from the previous season.

The differences can be attributed to a wide range of factors which included weather conditions and harvest conditions, cane maturity and increased awareness at the cane delivery/mill level.

The mills are conscious of their TPD and are continuing to improve.

For the 2017 season, the juice had an average brix of 14.5%, a true purity of 88.8% and reducing sugars of 6.1%.

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Fallow-land Application Trial with Filter Press Mud/Bagasse Mixture:

Louisiana sugar mills pile approximately 900,000 tons of bagasse and also discard about 350,000 tons of filter press mud (FPM) annually**.** Cost to transport and store these waste streams totals millions of dollars and requires significant land areas for deposition. A field trial to evaluate sugarcane response to application of a FPM/bagasse mixtures was initiated in the summer of 2017. A mixture of two parts FPM and one part bagasse by volume was applied on fallow land with a spreader at rates of 1.45, 2.91, 5.82 and 11.64 tons/A. Variety L01-299 was planted in the fall of 2017. Plant cane and sugar yields will be measured in the fall of 2018 and soil nutrient levels will be monitored for the duration of the trial. Soil nutrient levels determined in the spring of 2018 are shown in the table below. There exist a trend for P and K levels to increase with increasing application rates. Levels, however, for P and K for all treatments are considered low by soil test standards.

Application rate of FPM/bagasse, tons/A	Phosphorus, ppm	Potassium, ppm	Organic matter %
0	9.95	83.0	1.69
1.45	9.20	85.0	1.73
2.91	13.58	82.6	1.90
5.82	12.08	82.4	1.74
11.64	14.60	90.0	1.75

Spreader applying FPM/bagasse mixture to fallow field

Surface coverage of mixture at highest application rate

De-ashing sugar streams for increased sugar recovery

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Invert sugar and ash are the main impurities in sugar cane juice, affecting the recovery of sucrose. Ash reduces the potential for sucrose to crystallize and is the limiting factor in the target purity. A typical final molasses (2015/2016 average) with an ash content of 16.5% exhibits a target purity of 34.4%. If the ash level would be reduced one-half, i.e. 8.25% the target purity would fall to 31.2% and allow for additional sucrose recovery. In rough overall numbers: a reduction in the ash by 50% could yield up to 34 million pounds of more sugar recovered from molasses for the Louisiana industry. In addition the removal of the ash would also increase capacity and increase the overall purity in the molasses. Electrodialysis is suggested as superior de-ashing method, with key advantages for sugar production: no pH change, it is a cross-flow technology without major pressure resistance, small build and no chemical input. The project aimed at testing the electrodialysis for ash reduction in the factory.

The key question, which stream should be de-ashed for best efficiency, was addressed via the Sugars modelling software. The simulation effort led by Dr. Aragon showed that the point of ash removal does not affect the increase in sugar recovery, i.e. regardless if syrup, A- or B- molasses are being de-ashed, for a typical Louisiana sugar mill a recovery of 0.58 lbs per lbs ash removed can be expected.

Viscosity, absolute ash level (conductivity) and fouling are the dominant factors governing the practical efficiency of the electrodialysis. Low viscosity and high ash (high conductivity) are desirable. As such filtrate is a likely target for the application of electrodialysis.

Disk centrifugation:

Because typical filtrate in Louisiana contains too much mud to be considered for electrodialysis, a small GEA disk centrifuge was tested for its potential to yield solutions clear enough. The pilot-scale centrifuge was tested with fresh filtrate at Sterling and Cajun.

The expectation that the disk centrifuge could yield juices with a clarity exceeding clear juice was not met; however, turbidities improved significantly, effectively removing all mud. Samples of the best centrifugates were collected for testing with the bench-scale electrodialysis system.

Disk centrifugation of clarifier feed (with bagacillo removed through screening) showed improved clarity compared to clear juice from the clarifier; however, the turbidities did not reach levels similar to microfiltration (complete removal of suspended matter). This discrepancy is due to the nature of the remaining particulate matter, which exhibits densities lower or equal to the solution density. In this case gravitational separators such as clarifiers and centrifuges cannot eliminate all turbidity.

Electrodialysis De-ashing: Background

The process of Electrodialysis uses ion selective membranes and electric current to move ions between closely spaced separate liquid chambers. Movement is out of the “diluate” chamber to the “concentrate” chamber.

Current work is built off previous work done at Audubon with this electrodialysis system, work that led to conclusions of which brand of membranes to use and what, if any, are the effects on efficiency of temperature of operation.

Previous tests were of three brands of ion-exchange membrane pairs: FAS/FKS, AMX/CMX, AMI/CMI. They were tested for energy efficiency, and water and sugar transport, concluding that AMX/CMX and AMI/CMI both had acceptable losses. However the AMI/CMI membranes are the best choice because they can operate up to 90C while the other pair cannot. Cooling down an entire process stream to accommodate the de-ashing process would limit practicality.

While the earlier tests used an ideal model solution, the most recent used the clarified real-world mill samples. While the model solution was a mixture of sucrose and potassium chloride, real stuff has sugar, invert sugar, starch, dextran, mono- and divalent cations and anions, organic acids and much more. Considering its more complex makeup, it seems reasonable processing with electrodialysis may also be more challenging.

Method, result, and conclusion:

The unit was operated on filtrate collected at Cajun and on diluted syrup from St. Mary, primarily at 40C with one test at 70C. Samples were taken and analyzed with cation chromatography (IC). Using this data it was possible to draw conclusions regarding the primary cations of consequence in the filtrate as well as electrical efficiency of the unit. The IC tested for K^+, Mg^{2+}, Ca^{2+}, Na^+, NH_4^+, and of those the first three were present in significant quantities (table 1). From 4L of filtrate at 10 Bx, electrodialysis was able to remove almost 2/3 of cations in 1-hr using 25 watt-hours of electricity or over 4/5 in 2-hr using 42 w-h. (table 2)

	K^+	Mg^{2+}	Ca^{2+}
10 Bx filtrate sample 1	851	96	272
10 Bx filtrate sample 2	846	95	298

Table 1: ppm

K^+	Mg^{2+}	Ca^{2+}	
%removed			Total w-h
0	0	0	0
48	33	41	16
66	57	66	26
76	71	79	34
84	82	89	42

Table 2: cations % removed

There were some unexpected problems encountered during these trials. First, the pH did not maintain as anticipated. Instead it dropped in the diluate and rose in the concentrate. Second, precipitate (or scale) formed in the concentrate that restricted flow, reducing the flow rate. The same occurrence resulted whether filtrate or dilute syrup was used, independent of the operating temperature. The pH imbalance led to about pH 3 in the diluate and pH 11 in the concentrate. Future work with this system needs to focus on overcoming these problems.

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