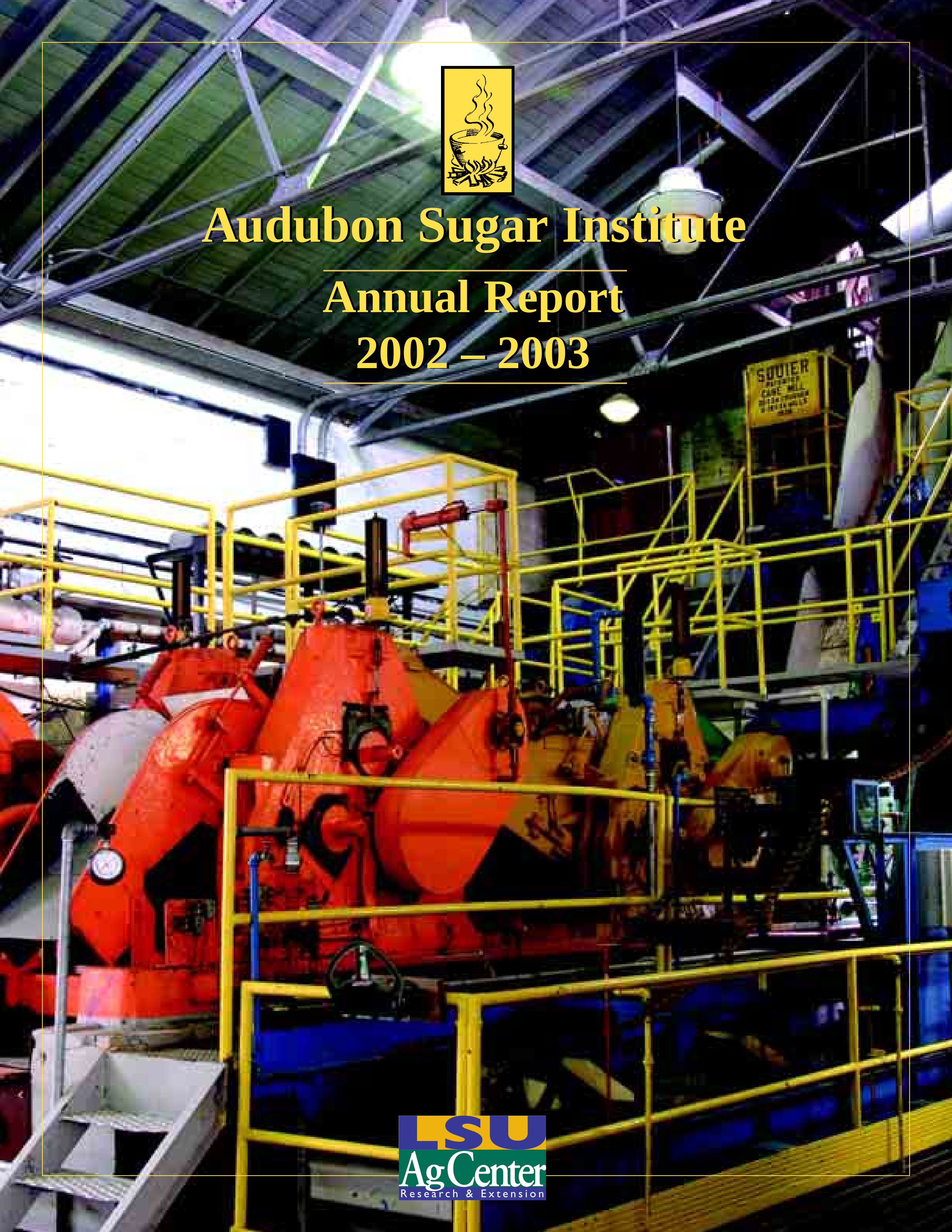
Audubon Sugar Institute

Annual Report
2002 – 2003



LSU AgCenter
Research & Extension

TABLE OF CONTENTS

On the cover: *The Audubon Sugar Factory cane mill, which consists of a cane crusher and three mills, was built in 1938.*

Audubon Sugar Institute
Louisiana State University Agricultural Center
South Stadium Drive
Baton Rouge, LA 70803
USA

Tel 225-578-2211 Fax 225-578-2708

Web site: www.lsuagcenter.com/audubon

Louisiana State University Agricultural Center
William B. Richardson, Chancellor
Louisiana Agricultural Experiment Station
William H. Brown, Vice Chancellor and Director
Louisiana Cooperative Extension Service
Paul D. Coreil, Vice Chancellor and Director

Produced by LSU AgCenter Communications

CHANCELLOR'S FORWARD

Sugar: Vital to Louisiana's Prosperity

Innovate. Educate. Improve lives. That is the motto the LSU AgCenter has adopted to help people understand what it is that we do and stand for. The Audubon Sugar Institute is certainly an example of this motto in action. The ASI scientific team is among our most creative and productive. Note the long list of recent publications at the end of this report. This past year, Dr. Michael Saska received one of the sugar industry's most prestigious awards – the Sugar Industry Technologists' Crystal Award. This award is made annually to only one technologist in the world who has made a significant contribution to advancing the technology of the international sugar industry.

The Audubon Sugar Institute is dedicated to the enhancement of Louisiana's sugar factories through education and technology transfer. Note the accomplishments and findings in the research reports that follow. The ASI also offers short courses to industry professionals and provides individual consultations for factories to help keep Louisiana's industry competitive. The academic specialization in sugar engineering now available at LSU will ensure that technically trained individuals are available to operate Louisiana factories.

The LSU AgCenter provides the base of operations for the ASI, but we rely heavily on our partners, the members of the American Sugar Cane League, to help support specific studies that are high industry priorities. The ASI and the AgCenter leadership are proud of our long partnership with the League and grateful for its guidance and financial support.

The sugar industry continues to be critical to the economic development of our state. Our financial figures from 2002 indicate that sugarcane leads our crop commodities in gross farm income ($334,336,300), value added ($213,975,200) and total value ($548,311,500). Only forestry and poultry had higher numbers.

Under the capable leadership of Dr. Peter Rein, the Audubon Sugar Institute will continue to advance and keep the Louisiana sugar processors (and producers) efficient, profitable and sustainable. Please let me know if you have any questions, and please visit our Web site www.lsuagcenter.com to find out about our latest innovations.

William B. Richardson

William B. "Bill" Richardson
Chancellor

William B. "Bill" Richardson

MISSION, GOALS, ADVISORY BOARD

Mission Statement

To foster a center of excellence for applied and original sugar research,
which exceeds the expectations of our stakeholders in Louisiana and the international sugar industry,
through innovative research, technology transfer and education.

Goals of the Audubon Sugar Institute

Goal 1
To enhance the productivity and profitability of the Louisiana sugar and other sugar process-related industries.

Goal 2
To improve the practice of sugar manufacture through education and technology transfer.

Goal 3
To conduct research toward a diversified sugar process industry.

Goal 4
To attract, retain and develop a world-class staff to serve our stakeholders.

Goal 5
To encourage use of low environmental impact technologies in sugar processing.

Audubon Sugar Institute Advisory Board

Dr. William Brown – LSU AgCenter
Michael Daigle – LULA-Westfield
Neville Dolan – Raceland Raw Sugar Corporation
Trevor Endres – Enterprise Factory
Barry Forse – Cinclare Central Factory
Ronald Guillote – St. Mary Sugar Coop., Inc.
Roddy Hulett – South Louisiana Sugar Coop., Inc.
Windell Jackson – American Sugar Cane League
Dr. Benjamin Legendre – LSU AgCenter
Duane Legendre – LaFourche Sugar Corporation
Greg Nolan – LaFourche Sugar Corporation
Anthony Parris – Iberia Sugar Coop., Inc.
Rivers Patout – Sterling Sugars, Inc.
Robert Roane –Jeanerette Sugar Co., Inc.
Dr. Peter Rein – Audubon Sugar Institute
Chip Savoie – Westfield Sugar Factory
Charles Schudmak – Cora-Texas Mfg. Co., Inc.
David Stewart – Alma Plantation
Jackie Theriot – Louisiana Sugar Cane Coop., Inc.
Tommy Thibodeaux – Cajun Sugar Coop., Inc.

(As of March 2003)

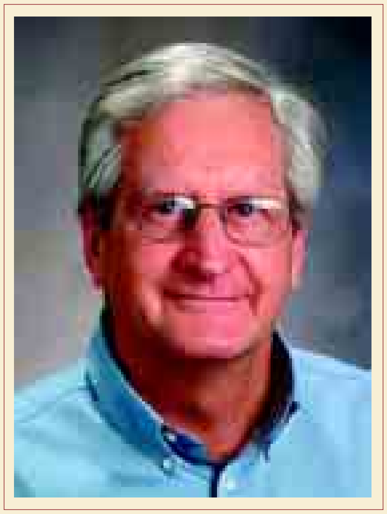
Report from the Head of Audubon Sugar Institute

April 2002 – March 2003

Audubon has made significant progress during the past year. We have concentrated on getting the basics right. The Audubon factory building has been repaired and improved; new equipment and instruments have been acquired through successful Board of Regents grants and funds made available from the AgCenter; the basic infrastructure including a useful filing system and an upgraded library has been put in place; we have eliminated the debt overhanging the Institute and are now financially viable. Most important perhaps is the commitment to the essence of our mission and goals, focusing on research, extension and training, for the benefit of our stakeholders. It is now time to build on the more solid base and move on to new achievements.

Last year our research effort at the Louisiana mills was hampered by the atrocious weather conditions. With the short season in Louisiana, the successful execution of factory-based research is difficult at the best of times. A major problem in the past year was the phenomenon of hard-to-boil massecuites. Little progress was made in establishing all the factors implicated, but some interesting progress is described in the research reports following. Our graduate research program continues to be built up with graduate students at Audubon registered in the chemical, mechanical and biological engineering departments, as well as food science. Our major source of outside funding is still the American Sugar Cane League, with other contributions from the Louisiana Board of Regents and various companies sponsoring contract research. New grant initiatives currently involve collaboration with the LSU departments of Chemistry and Mechanical Engineering.

Reasonable support was received for the sugar process engineering and sugar factory design courses offered through the College of Engineering for the first time. These are available to undergraduate and graduate students, and provide both with the opportunity to graduate with some specialized sugar engineering knowledge. These courses continue, and are attracting an increasing amount of attention from sugar-producing areas around the world. Final year design projects have been undertaken on sugar processing topics by senior mechanical engineering students supervised by Audubon. By awarding scholarships to juniors and seniors, the American Society of Sugar Cane Technologists is helping to foster interest from the local Louisiana industry.



Dr. Peter Rein

Last year we started a policy of running short courses given by world experts from outside Audubon. A course on boiler operation and design given by Norman Magasiner and colleagues on bagasse boilers was a great success. This approach continues again this year, with outside experts giving courses on automatic vacuum pan control and cane preparation and milling.

Audubon's role and modus operandi in extension is still being developed. We try to engage regularly in meeting with representatives of the Louisiana industry in an attempt to establish some common priorities. The past season plagued by hurricanes and incessant rain made the task of fulfilling the Louisiana mills' extension requirements more difficult. The League generously sponsored a new post at Audubon to relieve faculty of some paperwork, enabling us to spend more time at the mills. This is a great help, and it is hoped that this will continue.

What of the future? The next stage in the revitalization of Audubon Sugar Institute must include a radical improvement to our facilities and an expansion of the faculty. This should leave us better placed to grasp the new opportunities available. Some of these involve the exploitation of cane biomass for chemicals and energy production, and may be extremely far-reaching in their implications.

We anticipate playing a more meaningful role in the Louisiana mills in research, extension and training. We also look forward to more international collaboration. We already have a collaborative agreement with Cenicana in Colombia, and with other prospects in the wings. Our graduate students from many sugar-producing nations in the world reflect the part that Audubon can play internationally.

What we have been able to achieve has been largely because of the support of the American Sugar Cane League and the LSU AgCenter. The League has been very supportive of what we do, and we are grateful to it. I would also like to thank the AgCenter staff who do a great deal for us and especially Vice-Chancellor Dr. Bill Brown, who is always encouraging and willing to help Audubon at every opportunity. We look forward to the future with growing confidence.

Cane Composition

The concerns with increasing amounts of green trash, leaves and tops that are brought with the cane to the factory prompted a more detailed investigation into the chemical composition of leaves and tops.

In approximately three-week intervals, green LCP 85-384 variety cane at the St. Gabriel Sugar Station was sampled before and during the processing season. In each case, the manually separated leaves, tops and stalk were subjected to direct analysis and the water extract analyzed for the content of sugars, anions and cations. The content of various scale contributing ions in the juice of the tops is three to 10 times as high as in the clean cane juice and is contributing to the scale problem in Louisiana mills.

Table 1. Composition of the juice of sugarcane stalk (percent RDS).

Test Date	Mg	Ca	Oxal.	Phosph.	T-Acon.
25-Jul-02	0.27	0.35	0.06	0.34	4.5
8-Aug-02	0.24	0.33	0.08	0.45	5.8
21-Aug-02	0.16	0.18	0.03	0.30	3.4
4-Sep-02	0.24	0.37	0.06	0.39	7.4
18-Sep-02	0.11	0.15	0.01	0.29	2.5
21-Oct-02	0.20	0.31	0.01	0.31	3.7

Table 2. Composition of the juice of sugarcane tops (percent RDS).

Test Date	Mg	Ca	Oxal.	Phosph.	T-Acon.
25-Jul-02	0.53	0.86	0.40	1.50	12.8
8-Aug-02	0.58	1.00	0.57	1.40	12.2
21-Aug-02	0.60	0.85	0.51	2.00	14.3
4-Sep-02	0.63	1.10	0.13	1.70	15.8
18-Sep-02	0.45	1.40	0.45	1.30	14.4
21-Oct-02	0.72	2.00	0.58	1.70	12.2

Nicolas Gil Zapata, graduate assistant at ASI, inspecting cane stalks at Cinclare Central Factory.

Use of Mixed Dithiocarbamate Biocide for Preserving Fresh Sugarcane Juice

Regardless of method of preparation, sugarcane juice is both chemically and biologically labile to decomposition. Contaminating bacteria can produce the enzyme dextransucrase. This enzyme cleaves sucrose into glucose and fructose, concurrently synthesizing dextran. Within 6 to 10 hours, sufficient dextran can form to produce significant Pol error. Proper factory control requires that factory laboratories receive samples of juice that are representative of the state at time of collection.

To prevent biological decomposition, use of a biocidal agent is imperative. An ideal biocide would prevent microbiological loss of sucrose yet not interfere with analysis of the juice. The ideal candidate would not be toxic to people and should not constitute an environmental hazard. The agent in question should be active at low concentration.

We studied the efficacy of mixed dithiocarbamate (mDTC) biocide to preserve fresh sugarcane juice. A comparison was made of the mDTC agent at various concentrations against the more traditional biocides sodium azide and mercuric chloride. Samples were taken periodically and examined for sucrose, glucose and fructose by HPLC. The samples were analyzed concurrently for sucrose by polarimetry. The samples were frozen at –74 degrees C and analyzed for dextran by antibody method at a later date. The results were compiled and compared against control samples as follows: the negative control will have no added biocide (worst case); positive control will contain 500ppm of sodium azide or 200ppm of mercuric chloride (best case).

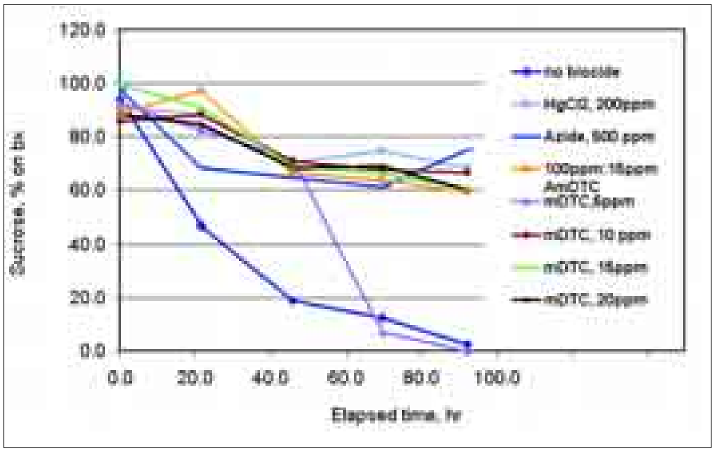
The degradation of samples is striking both to the eye and the nose. Unpreserved samples, or those exhibiting biocide failure, lose their original dark green/brown color, turning yellow. The yellow samples smell foul. The test samples are shown in Figure 1.

Figure 1. Samples held at 30 degrees C for 92.17 hours. 1-untreated; 2-$HgCl_2$ 200ppm; 3-NaN_3 500ppm; 4-7-mDTC at 5, 10, 15 and 20 ppm; 8-NaN_3 100 ppm and mDTC 15 ppm.

As seen in Figure 2, the untreated control exhibits a typical exponential decay of sucrose over time. The sample treated with 5ppm mDTC began to decompose after 45 hours. The downward slope resulting from chemical loss of sucrose diverges strongly from those samples that are still effectively under control. Notice that, excluding losses to chemical degradation, the 10ppm mDTC sample exhibits constant sucrose levels, remaining stable though the end of the experimental trials. The sample treated with 500ppm

of sodium azide was not stable from t=0 to t=21 hours; it degraded rapidly during this interval, but stabilized thereafter.

Figure 2. Sucrose loss over time for selected biocide treatments, results provided by HPLC.



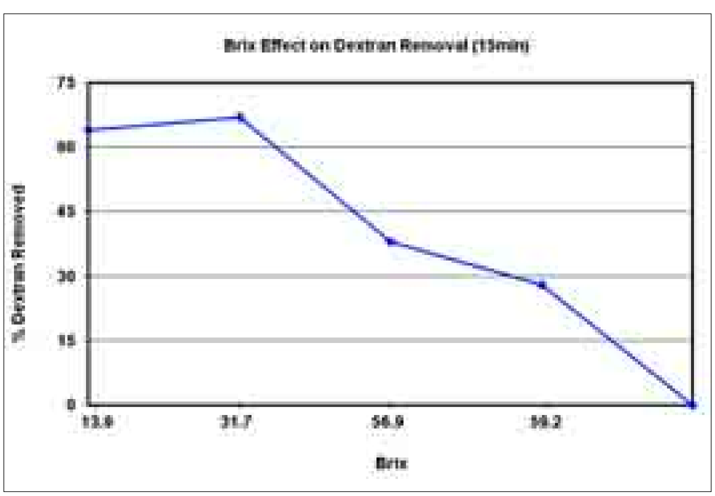
The control containing no biocide exhibited sucrose loss and significant dextran formation immediately. The 200ppm $HgCl_2$ control remained fresh, exhibiting neither sucrose loss nor increased dextran. The 500ppm NaN_3 behaved similarly.

The test mixtures containing mDTC at 5 and 10 ppm failed at 20 and 45 hours, respectively. Test mixtures containing 15 and 20ppm mDTC withstood storage at 30 degrees C for 92 hours at least as well as those fortified with 500 ppm NaN_3. For DAC extracts about 4 Brix, mDTC at these levels are appropriate. For standard mixed juice, about 13 Brix, a dosage between 100 and 150ppm is recommended for preservation.

Enzyme Usage in Louisiana Sugar Mills

All the sugar mills in Louisiana used dextranase and amylase in 2002. The most effective site for addition of dextranase was found to be under the mill, because the temperature, pH and hydration were such as to give the fastest action. Addition to syrup can be a point of secondary addition but is probably only useful when high dextran C-sugar is being recycled. Figure 3 illustrates the effect of high Brix (low water) on dextranase activity.

Figure 3. Effect of High Brix on Dextranase Activity.



Enzymes are sold and purchased in Louisiana by weight. This deceptive practice does not allow a direct price comparison of the same enzyme sold by different suppliers. In most industries, enzymes are sold by function. Table 3 shows a comparison of commercial dextranases and amylases used in the local sugar industry as a function of their activity. A standard unit (IU) was determined as the number of micromoles of product produced by 1.0 ml of enzyme in 1 minute under defined assay conditions. The assay conditions for amylase and dextranase are different, so activity measurement can be compared only for the same type of enzyme.

Table 3. Activity of commercial enzyme preparations from different suppliers.

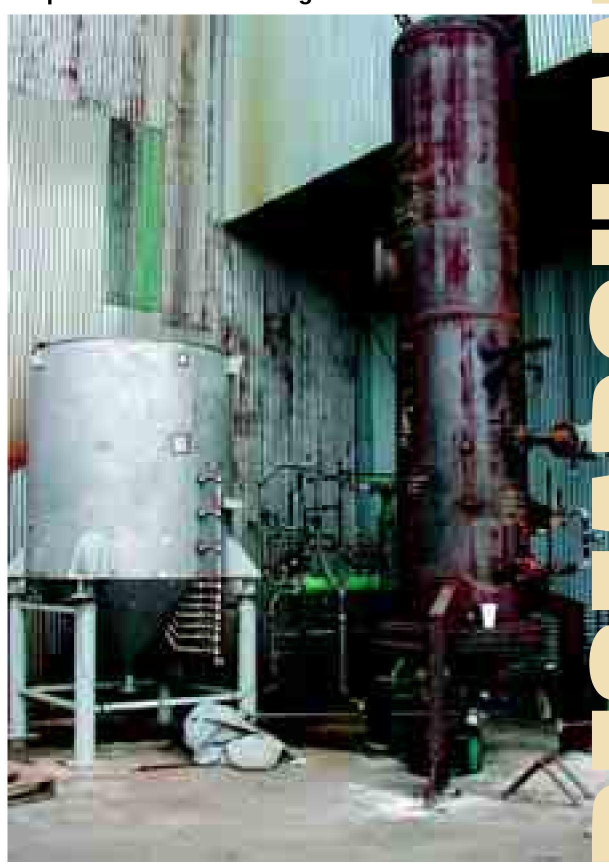
Enzyme	Source	Activity (IU/ml)
Dextranase	A	55.5
	B	19.9
	C	151.5
Amylase	D	7.16
	E	3.15

A standardization of enzyme units, common methods of analysis and common modes of application are recommended for improvement of results from use of these industrial catalysts.

Clarification Studies

A series of pilot clarification tests done with Audubon Sugar Institute (ASI) equipment located at Cinclare Sugar Mill was performed to study effects of pH in hot liming on clarification performance and elimination of non-sugars, particularly of those known to be or suspected to be components of evaporator scale.

Figure 4. ASI pilot clarifier (left) and falling film evaporator at Cinclare Sugar Mill.



In addition, milk of lime was replaced in several tests with soda ash for pH adjustment of hot juice, because soda ash was found in smaller scale tests at ASI last year to give clarified juice of quality comparable with the traditional lime but much lower in calcium. Since calcium salts of oxalate, phosphate and other anions are known major components of evaporator scale, replacing lime with soda ash is expected to prove beneficial in reducing scale formation. Tables 4 and 5 show the results from the clarification study. Of interest is the increase in pH from clarified juice to syrup in the hot soda ash clarification compared to the decrease in pH obtained in the liming method. While the clarification with soda ash was good, and produced syrups that in sugar boiling and heat transfer trials at ASI proved indistinguishable from those prepared by conventional liming, the issues of melassigenicity and increased sodium levels in final molasses are yet to be considered. Molasses exhaustion in Louisiana is obviously controlled by factors other than equilibrium limitations (approach to target purity as high as five to 10 points are routinely seen), so the melassigenicity from increased sodium levels may not be an issue. Increase in sodium is offset by reduction in calcium, which is quoted by some as a possible factor in difficult boiling.

Table 4: Clarification study using hot soda ash.

Pilot Hot Soda Ash				
CJ pH (h)	Syrup pH(amb)	delta (pH)	percent P_2O_5 removed	percent Si removed
8	8.6	0.6	94	71
8.1	8.7	0.6	93	58
7.7	8.2	0.5	94	36
7.8	8.7	0.9	98	77
7	7.1	0.1	92	46

Table 5: Clarification study using hot milk of lime.

Pilot Hot MOL				
CJ pH (h)	Syrup pH(amb)	delta (pH)	percent P_2O_5 removed	percent Si removed
8.5	7.9	-0.6	99	58
8.5	7.9	-0.6	100	45
7.7	7.5	-0.2	95	51
8.8	8.3	-0.5	97	60

Evaporator Scaling

Scaling of evaporators in the Louisiana sugar industry is an important issue. Cleaning time represents down time or else reduced throughput, which is costly, quite apart from the cost of the chemicals. Cost of chemicals alone varies from $0.045 to $0.06 per ton of cane.

Samples of scale have been collected from evaporators from a number of different mills, covering different evaporator effects and different cane supply areas.

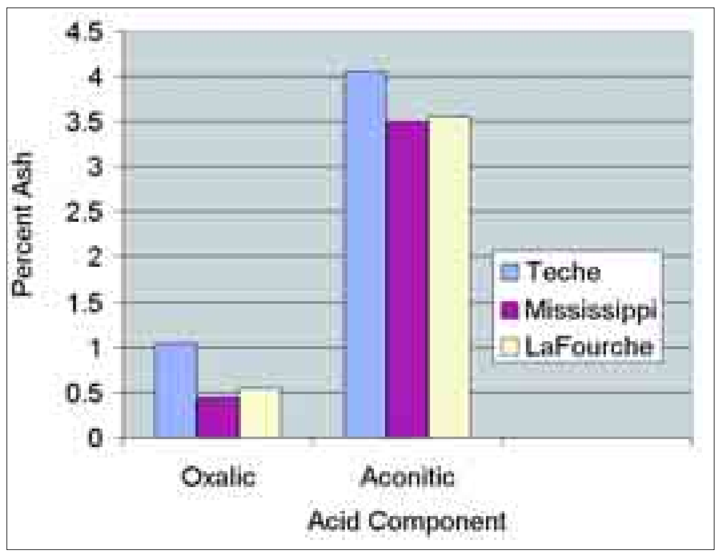
The scale is composed of moisture (low), organic matter and inorganic salts (ash). Results of the ash analyses of scale samples are shown in Table 6. Silicon scale is the most difficult to remove. It can be seen from this data that silicon is much higher in scale from later evaporator effects and higher in scale from mills in the Teche area.

Aconitic and oxalic acid levels in scale were calculated from the differences in the content of their components in clarified juice and syrup. These calculations were checked by direct analysis of scale and were found to be reliable. Results are shown in Figure 5.

Table 6. Louisiana scale composition (individual elements expressed as percent on ash).

	Ash percent Scale	Ca	Si	P	Mg	S	Fe	Al
LaFourche								
Factory 1								
Pre-evap 1	84.6	6.1	1.9	6.5	2.6	0.8	1.4	0.1
Pre-evap 2	83.9	16.2	3.4	6.3	3.7	0.6	1.1	0.1
Effect 1	88.9	21.2	2.8	8.9	2.2	0.6	0.6	0.1
Effect 2	87.7	9.8	5.9	10.7	1.9	0.5	0.6	0.1
Effect 3	87.5	12.4	13.1	4.0	3.0	0.4	0.8	0.1
Teche								
Factory 2								
Pre-evap	84.7	20.6	1.3	6.1	2.8	0.7	0.4	0.1
Effect 1	94.5	22.3	6.3	6.4	4.5	0.7	0.7	0.1
Effect 2	92.1	22.6	1.9	11.8	2.7	0.6	0.9	0.1
Effect 3	85.3	18.0	6.9	10.3	1.6	0.4	0.4	<0.1
Effect 4	89.7	12.5	14.6	2.7	2.1	0.4	1.3	<0.1
Factory 3								
Effect 4	82.0	20.1	17.8	3.6	4.4	0.2	1.1	<0.1
Factory 4								
Effect 4	88.7	18.1	19.0	3.9	3.9	0.2	0.9	0.1
Factory 5								
Effect 4	86.3	17.9	19.7	4.0	3.7	0.2	0.8	0.1
Mississippi								
Factory 6								
Effect 4	86.7	15.7	13.8	3.4	2.7	0.3	0.9	<0.1
Factory 7								
Effect 4	87.0	14.1	14.0	3.7	2.8	0.4	0.7	0.1
Factory 8								
Effect 4	84.2	13.4	12.3	3.3	2.6	0.3	2.6	<0.1

Figure 5: Oxalic acid and aconitic acid in scale (fourth effect), percent ash.



The thickness of evaporator scale was measured at the bottom, middle and top of the tubes, and the quantity of scale per ton of cane processed was computed. The results are shown in Table 7. The thickness of the scale is greater at the bottom of the tubes, where the velocity is lowest, and decreases up the tube.

X-ray powder diffraction was used to assess the crystalline phases in scale samples. Together with differential thermal analysis, the extent of the amorphous and crystalline phases could be assessed. Figure 6 shows calcium silicate crystals, and Figure 7 an oxalate film followed by different silicates, coating the underlying scale. Amorphous silicates are generally more amenable to cleaning with strong alkali.

Table 7. Louisiana scale data.

	g/ft^2	g/tc	top (mm)	middle (mm)	bottom (mm)
LaFourche					
Factory 1					
Effect 3	16.3				
Effect 4	31.1	43.1	0.7	0.8	1.1
Teche					
Factory 2					
Pre-evap	15.8		0.3	0.5	0.8
Effect 1	3.9		0.5	0.6	0.7
Effect 2	5.9		0.6	0.7	0.9
Effect 3	7.8		0.6	0.6	0.8
Effect 4	14.8	50.2	0.9	1.0	1.1
Factory 3					
Effect 4	22.4	49.1	1.0	1.1	1.4
Factory 4					
Effect 4	21.2	47.8	0.9	1.1	1.3
Factory 5					
Effect 4	20.1	42.1	0.8	0.9	1.3
Mississippi					
Factory 6					
Effect 4	17.2	39.4	0.8	0.9	1.1
Factory 7					
Effect 4	18.3	38.7	0.8	0.9	1.1
Factory 8					
Effect 4	16.9	37.1	0.6	0.8	1.0

Figure 6. Calcium silicate crystals.

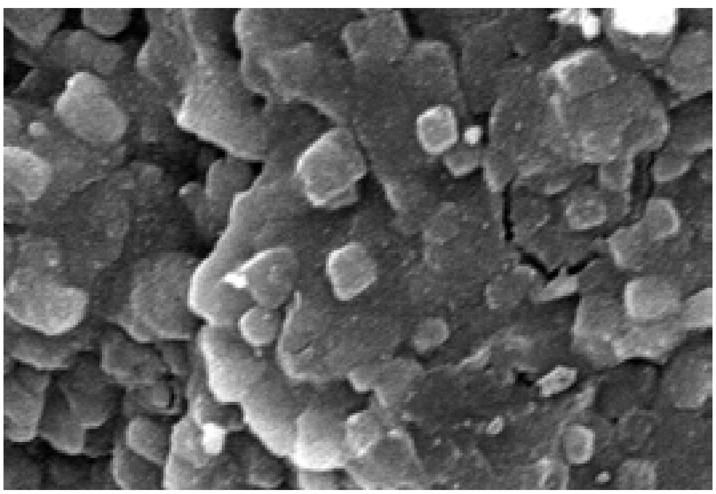
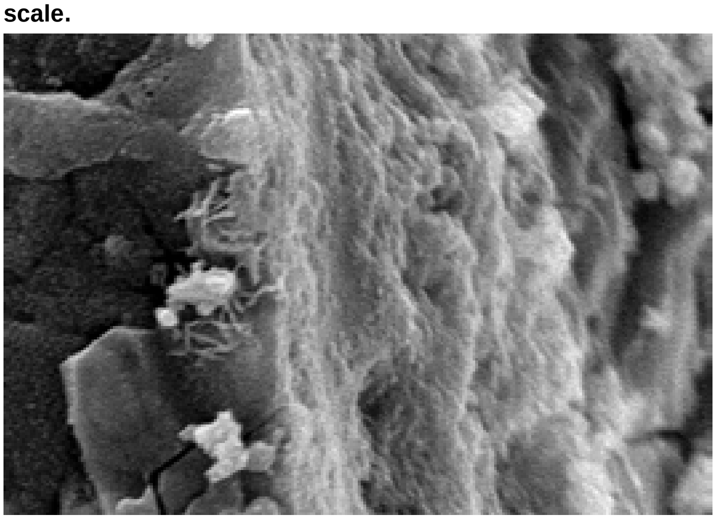


Figure 7. Oxalate film with other silicates coating underlying scale.



Evaporator Scale Removal

The most common practice for removing scale in Louisiana is to wash with water and then boil for several hours with a caustic soda solution or a 70/30 combination of caustic soda and soda ash. Caustic soda concentrations range from 6 percent to 30 percent and boiling times range from 4 to 6 hours. Following the alkali boil, the material is dumped (for re-use), a water wash is given and an acid boil with hydrochloric acid plus inhibitor is given for 1/2 to 3 hours. The acid concentration used is from 3 percent to 16 percent and the stronger the acid, the shorter the boiling time used. Fluorides may also be used to soften up silicates. The acid goes to waste treatment, and a water wash is given before the evaporator is started up again.

Calcium oxalate and calcium carbonate are mostly insoluble in caustic soda, hence the use of acid. Sequestering agents such as gluconic acid are occasionally added to the HCl. Phosphoric and sulfamic acid are also in use elsewhere, and, in some cases, chelates have been tested to replace a phosphoric acid wash because this is expensive. Both EDTA (Ethylene Diamine Tetra Acetic Acid) and gluconic acid have been used to clean second and third effects. EDTA has also been used to remove calcium oxalate scales in Australia. EDTA forms stable, soluble, complexes with chiefly the calcium and magnesium in scales. Discarded NaOH is becoming more problematic from an environmental point of view because of the high sodium content.

Various cleaning agents were tested for their effectiveness. EDTA in the sodium form is an excellent chelating or sequestering agent. It reacts with most divalent and trivalent metallic ions forming soluble metal chelates. Several EDTA products were obtained from BASF for testing purposes. The best results were obtained with the use of 5 percent concentration level of a liquid product in the tetra sodium form and containing 3 percent NaOH (Trilon B). The liquid Trilon B product is (slowly) biodegradable and should be compatible with the wastewater treatment process used in Louisiana. In 2-hour laboratory boiling tests, it removed all the scale from first, second and third effect evaporator tubes. It removed all the scale from fourth effect tubes in one instance and up to 99.8 percent in others. Large-scale factory tests (3-hour boilings) confirmed this data.

When very high silicon dioxide levels are present, fluorides may be required to partially dissolve the silicates, and the EDTA will do the rest in most cases. Ammonium bifluoride (ABF) and sodium fluoride both work well. The corrosion rate of EDTA (5 percent) with 0.15 percent ABF is only 0.000013 mm/h of boiling. Solutions of 2.0 percent w/w EDTA, 1.0 percent NaOH and 0.75 percent ABF cleaned fourth effect tubes in less than 1 hour of boiling time. The use of an appropriate surfactant or wetting agent and a new chemical improved the cleaning efficiency even further. This product shows considerable promise.

A 5 percent solution of hydrochloric acid with additives, including corrosion inhibitor, was tested. It cleaned first, second and third effect tubes but could not totally clean fourth effect tubes in 3 hours of boiling time. Addition of 0.25 percent ABF achieved satisfactory cleaning. However, the corrosion rate with Rodine inhibitor on pure copper was 0.0018 mm/h of boiling time or well over 100 times that of the EDTA solution used. The acid did clean juice heater tubes well; however, it will eventually create disposal problems.

$NAHSO_4$ or sodium acid sulfate is among other things used to clean scaled distillation (stripping) columns in the bioethanol industry. Product obtained from Jones-Hamilton was tested. A (near) 10 percent w/w solution worked best. It cleaned first, second and third effect tubes in 3 hours of boiling time. Fourth effect tubes, however, were cleaned up to 99 percent. By adding 0.18 percent ABF, it would remove the scale. The corrosion rate on pure copper

was 0.00195 mm/h of boiling time and it may create disposal problems. This product does, however, show promise in combination with EDTA.

The idea of using CO_2 in water to clean evaporator tubes was tested. A piece of tube was put in a pot in a closed system. Water was added with dry ice. The solution of carbonic acid at around 5 psi was pumped around for 1 hour. Upon inspection, very little scale had been removed. Next, a section of tube (18 inches) from the bottom of Westfield's last effect was treated with caustic soda (8 percent w/w) for 30 minutes near the boiling point and then put in the closed loop carbonic acid system. In an hour of circulation at ambient temperature, the tube was essentially clean. A total of 12.7 g/ft^2 of scale had been removed. Hence, carbonic acid could replace the acid boil.

Glycolic acid and Glyclean XL (glycolic acid plus proprietary surfactants) were tested. A 10 percent solution of both glycolic acid and Glyclean-XL cleaned a fourth effect tube in 1 hour of boiling time. A 4 percent solution of glycolic acid did not clean it totally, but a 4 percent solution of Glyclean-XL essentially did clean it.

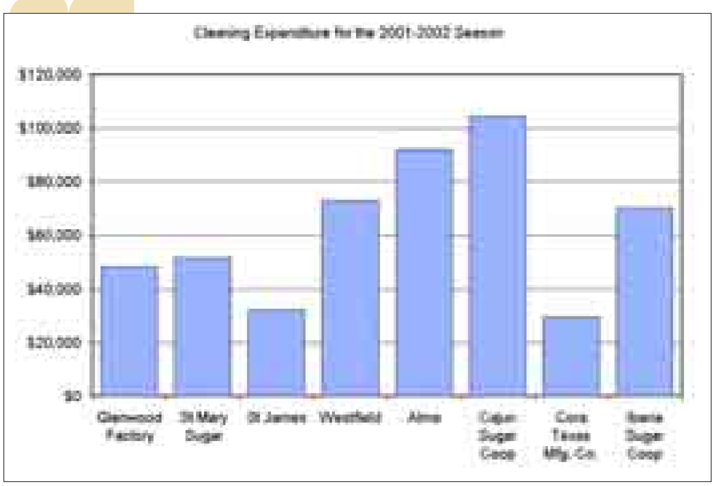
A solution of 4 percent EDTA, 2 percent Glyclean-XL and 0.2 percent ABF cleaned tube sections with 12.9 g/ft^2 in 30 minutes of boiling time. A 4 percent EDTA and 0.2 percent ABF solution also cleaned it in roughly 30 minutes. A 6 percent sodium acid sulfate, 2 percent EDTA and 0.2 percent ABF solution also cleaned similar tube sections in roughly 30 minutes.

Some additional work is required, but it is obvious that better cleaning systems than those being used are possible.

Evaporator Cleaning Procedures and Costs

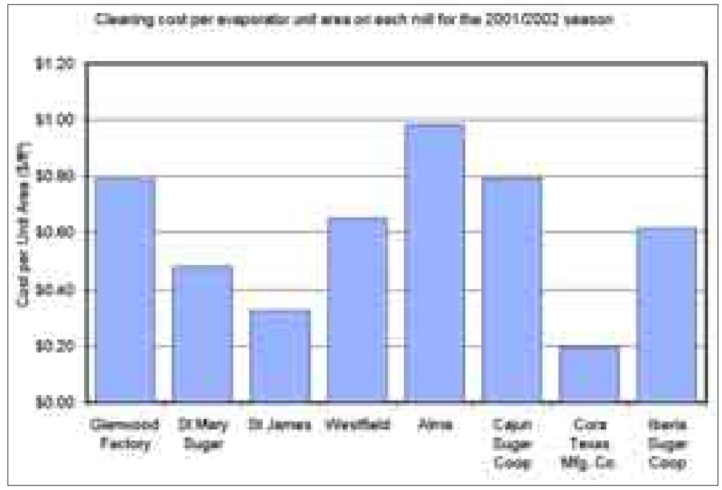
Data were collected from a survey of typical mill chemical costs for scale removal during the 2001-2002 season. Comparisons of the cleaning chemical costs and cleaning procedures were made to see if any particular procedure has a cost benefit over any other. During the season, an average of $62,780 was spent per mill on cleaning chemicals for scale in evaporator trains. The mills were each asked to provide the cost of their cleaning chemicals, what chemicals they used and how long cleaning took. Other information such as the area of the evaporators in the train and cleaning procedures was also requested. The cost of chemicals for cleaning evaporators at various mills is shown in Figure 8. Not all the mills included costs, and some of the costs reported are estimates. The costs for Alma and Cajun mills were estimated from their consumption of caustic soda and hydrochloric acid for the year.

Figure 8. The total cost of cleaning chemicals for evaporator trains for various mills during the 2001-2002 milling season.



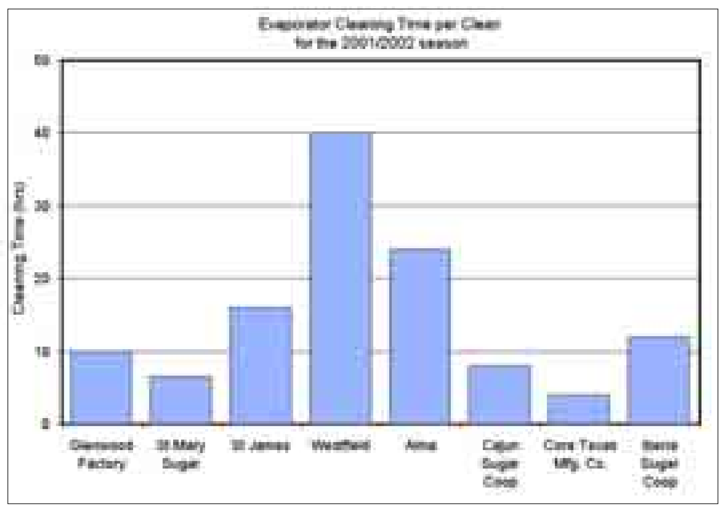
The mills have different areas for evaporation that need to be cleaned, so a total cost can be misleading for factory performance. The cost per unit area is shown in Figure 9. In general, one would assume a mill of larger area for their evaporators to have a lower cost per unit area because of economies of scale.

Figure 9. The total cost per unit area of cleaning evaporator trains for various mills during the 2001-2002 milling season.



The cleaning procedures vary slightly from mill to mill. The total cleaning time (to clean the evaporator train) for each mill's evaporators is shown in Figure 10. In general, evaporators are cleaned at least once every eight to nine days.

Figure 10. The total cleaning time for evaporator trains for various mills during the 2001-2002 milling season.



The procedures to establish when an evaporator train requires cleaning vary from fixed time between cleaning to monitoring various process variables. To determine if the cleaning was performed satisfactorily, most factories visually inspect the bottom of the tubes in the last effect. If the tubes are clean in the last effect, the evaporator train is assumed to have been cleaned adequately. The scaling is usually heaviest in the last effect, so it is used as the control on the evaluation of cleaning effectiveness. Some factories use the throughput of juice after cleaning as an indication of how well the cleaning was performed. Others use a combination of visual inspection and checking for evidence of throughput upon restart.

The various chemicals used for cleaning are limited, in most cases, to a few common chemicals (hydrochloric acid and caustic soda), together with additional special chemicals such as inhibitors and other additives. The strength of caustic soda used in clean-

ing the evaporators varies between 12 percent and 50 percent. For acid concentration in cleaning cycles, the strengths vary between 2 percent and 17 percent.

The mills that seem to have the lowest cost per unit area appear to be the ones that monitor a number of process variables to evaluate when cleaning is required. These evaluations are similar to calculating a heat transfer coefficient. In evaluating a number of variables, mills ensure the vessel's performance drop is because of a need for cleaning and not for other mill abnormalities further upstream.

Falling Film Plate Evaporator as a Fourth Effect

The Audubon Sugar Institute's pilot falling film plate evaporator was installed at Cinclare in parallel with the fourth effect. The feed to the pilot unit is the discharge from the third effect, and the heating vapors also are from this effect. The vapor discharge was connected immediately before the barometric condenser.

Clarification problems at Cinclare produced clarified juice containing large quantities of bagacillo and occasionally some mud. The quality of the clarified juice resulted in feed conditions from the third effect that were unfavorable to the pilot unit operation. The bagacillo carryover in the feed caused rapid plugging, making it necessary to clean one of the two strainers every 10 minutes. The frequent cleaning required was an interference that prevented continuous operation of the system.

The first test at steady state conditions operated the system for two and one-half hours. The feed was 32.9 Brix and 85.3 pounds per minute at 188 degrees F. The vacuum was 27.1 inches Hg, and the vessel temperature 137 degrees F. The heating vapors were near 192 degrees F and the measured condensate 2,712 pounds per hour. Hence, at 9 gallons per minute feed, the evaporation rate was near 8 pounds per hour and the overall heat transfer coefficient 188 Btu/h.ft^2. degrees F (1.07 kW/m^2. degrees C).

BDT (now GEA Ecoflux, the plate pack manufacturer) visited the unit at Cinclare and advised on an increase in the feed rate to achieve higher wetting numbers and possibly better performance. An additional test in December was conducted when the unit was operated for 5 hours continuously. The feed rate was 15 gallons per minute at 31.9 Brix and syrup at 64.7 Brix, to yield an overall heat transfer coefficient of 202 Btu/h.ft^2. degrees F. At a feed rate of 20 gallons per minute, the overall heat transfer coefficient increased to 210 Btu/h.ft^2. degrees F (1.19 kW/m^2. degrees C).

The falling film plate evaporator does not operate with a liquid head, as is the case in rising film or Robert units. Consequently, the effective temperature differential is higher and the overall heat transfer rate increases. The above results were obtained with a clean unit, and further work is anticipated to investigate the effect of the fouling and optimum cleaning procedures.

Boiling Point Elevation of Technical Sugarcane Solutions

A series of boiling point elevation measurements was made with sugarcane liquors at three purity levels and three absolute pressures and an equation

$$\Delta t_b = A_X\left(\frac{W_{DS}}{100-W_{DS}}\right)^{B_X}\left(\frac{273+t_{bW}}{100}\right)^{C_X}\left(\frac{Q}{100}\right)^{D_X}$$

($A_X = 0.1660$ $B_X = 1.1394$ $C_X = 1.9735$ $D_X = 0.1237$)

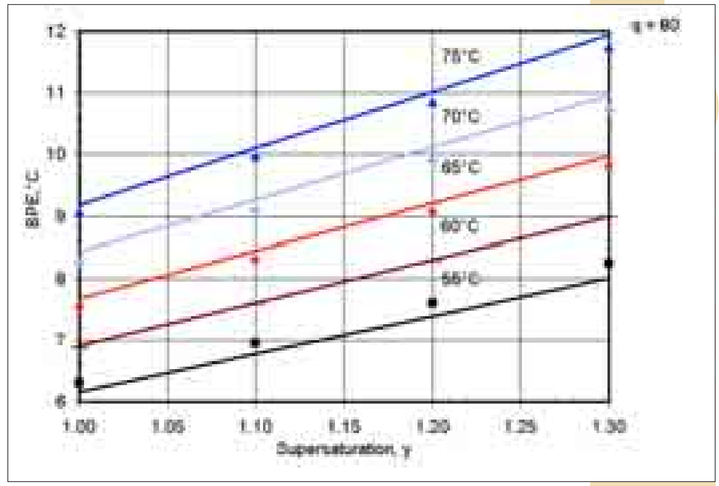
developed that fits the experimental data well. Through an introduction of the solubility and supersaturation concepts, a general equation

$$\Delta t_b / y = a_X t_b Q^{bX} - c_X Q^{dX}$$

($a_X = 0.4702$, $b_X = -0.2586$, $c_X = 0.0688$ and $d_X = 0.7875$)

and a series of graphs were produced that are suitable for use in, or indirect incorporation into, the software of automatic control of sugar boiling in the sugarcane industry.

Figure 11. BPE (degrees C) vs. supersaturation, at 80 purity and temperatures from 55 to 75 degrees C.



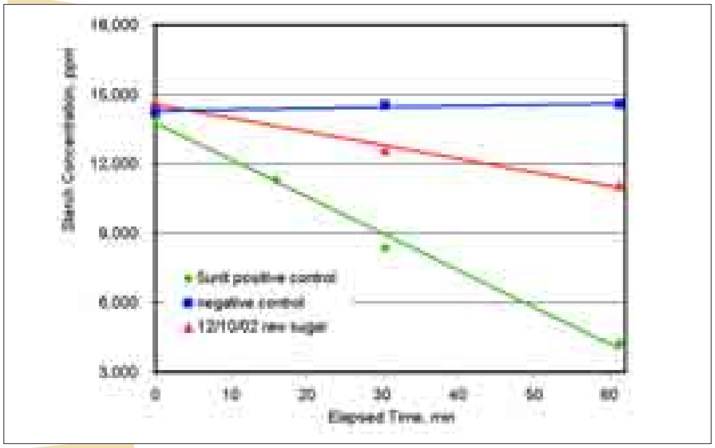
The HPAEC with PAD used by analytical chemist Brian White is capable of detecting trace quantities of carbohydrates and alcohols.

High Temperature Amylase

To avoid possible carryover of the amylase activity into raw and refined sugar, an intermediate temperature amylase is routinely used in the Louisiana mills rather than the high temperature type. Because the starch levels in Louisiana raw sugar of 100 – 200 ppm are common despite the amylase addition, which most often is into the fourth effect of the evaporator, the efficacy appears limited in the 50 – 60 Brix and 60 degrees C environment. Dosing of a high-temperature amylase in the clarifier inlet would present favorable low Brix environment and a long residence time, and was tested in a series of pilot scale experiments. Residual enzyme activity was determined in the clarified juice withdrawn from the clarifier at various time intervals, as well as in the raw sugar and molasses produced from the amylase-treated clarified juice. At a 5 ppm dose on the clarified juice, starch hydrolysis is nearly complete within 5 minutes and about 30 percent of the enzyme activity was carried

over to the sugar. A much lower amylase dose, at less than1ppm on clarified juice would, apparently, still be sufficient for complete starch hydrolysis within the 60 or so minutes available in most clarifiers. Whether the residual activity in the sugar would then be negligible will need to be verified in further experiments.

Figure 12. The residual amylase activity is proportional to the rate (slope of the lines) of the hydrolysis of starch-rich substrate.

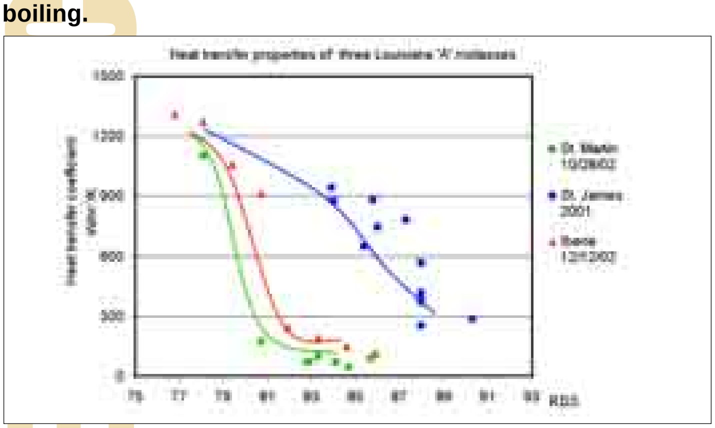


Hard to Boil Massecuites

Several incidents during the 2002 crop season of severe difficulties with boiling massecuites were reported by the mills, presumably related to the inclement weather conditions during those periods. About 1 ton of refractory 'A' molasses was collected at the end of October at the LASUCA mill in St. Martinville and, again in mid-December at the Iberia Sugar Coop mill in New Iberia. A series of heat transfer measurements carried out at the ASI pilot facility confirmed the mills' observations. The overall boiling heat transfer coefficient at the Brix levels found during boiling is drastically lower than for the standard materials (St. James 2001 'A' molasses).

Further investigations indicated that neither the known indicators of cane deterioration, for example dextran, nor those of immature cane or cane with excessive amounts of tops and leaves, for example, starch, correlate with the observed behavior. A number of various treatments of the refractory materials with activated carbon and adsorbent resins, and clarification using 50 percent ethanol, with the addition of antifoams, surfactants, sodas ash and min-

Figure 13. Heat transfer correlation with Brix levels during boiling.



eral acids were tested. While considerable improvement of the boiling was noted as a result of treatment with the solid adsorbents, indicating initial presence and partial removal of culprit compounds, the only possible economical recourse at present appears acidification directly in the pan with hydrochloric acid.

Figure 14. Effect of acid treatment on pH in 'A' molasses.

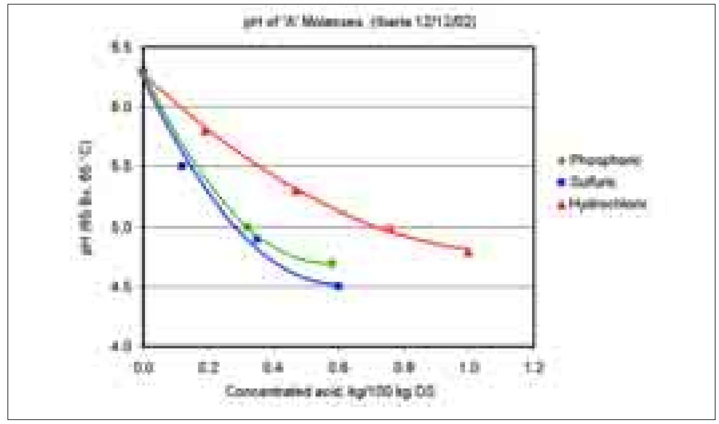
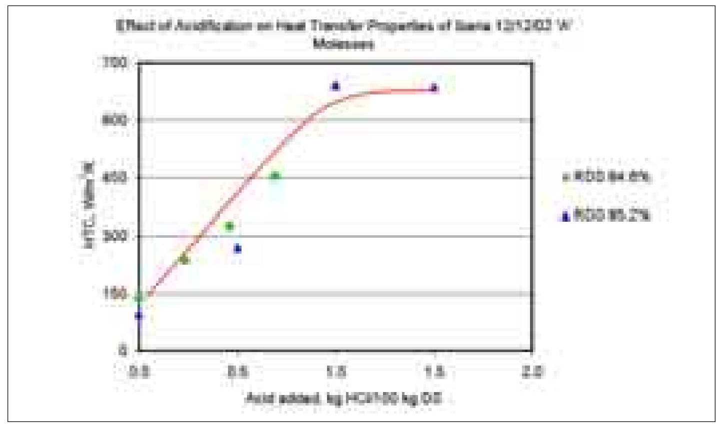


Figure 15. Effect of acidification on heat transfer.



The feasibility of acidification from the standpoint of acid cost, sucrose inversion (at 65 degrees C, pH around 5.0 and 85-88 percent RDS) and other issues are still under investigation.

Sucrose Gels in Massecuites

As part of the study on hard-to-boil (HTB) massecuites, the formation of gels by calcium sucrates with small amounts of carbon dioxide was investigated. The carbon dioxide can be produced by microorganisms, especially heterotrophic soil bacteria that will produce both organic acids and carbon dioxide. Large quantities of these bacteria enter the factories with the soil on the cane and in wash water and/or on cane. The gel structure produced in the factory is a branched form of Ca-CO_3-Ca-$C_{12}H_{10}O_{11}$-Ca- (etc.) as determined by Nuclear Magnetic Resonance Spectroscopy.

After more than 60 trials in the laboratory, this gel was produced in a synthetic mixture of sucrose, water and milk of lime (pH 7.81 and Brix 13.9) to which small amounts of carbon dioxide were added. The CO_2 was produced from dry ice in a closed Erlenmeyer connected to a sintered steel sparger yielding 60 micron bubbles of carbon dioxide in a graduated cylinder with the sugar solution. The dry ice slowly sublimated and, when the pressure in the Erlenmeyer was able to overcome the hydrostatic pressure in the graduated cylinder, the carbonation began. Too much carbon dioxide prevents the formation of the gel.

Figure 16 shows synthetic mixtures after gel formation poured into ethanol (final concentration 80% v/v) precipitating gels/gums. The same was done with mixtures to which clarified juice from Alma was added, which was known to yield HTB massecuites. The result was simply more precipitate, which also contained some true gums. The gel disappeared after mixing a small amount of EGTA (ethylene glycol tetra acetic acid) to the middle cylinder. EGTA

will specifically chelate calcium (and works better than EDTA). The only evidence left were a few flakes at the bottom of the graduated cylinder.

This confirms that dextran and starch are not actively involved in HTB gel formation as already had been demonstrated at CoraTexas.

If HTB massecuites appear, a calcium measurement will allow the determination of how much EGTA has to be added.

Figure 16.Precipitated gel (center) and gel and gums (at ends).

Analysis of the Fluid Flow in Sugar Crystallization

One of the last stages in the sugar mill process is the crystallization of sucrose in batch or continuous vacuum pans. Valuable experimental work has been done on the process, and acceptable designs of batch vacuum pans are available, which in recent years have extended rapidly to continuous pans. Sugar crystallization is yet to be fully understood, however, and there is a need for more experimental data and optimization of the current vacuum pan designs.

Currently, ASI and the mechanical engineering department at Louisiana State University are conducting a joint research project using computational fluid dynamics (CFD) and experimental techniques to study the sugarcane crystallization process. The main goal is to understand better the flow patterns inside process vessels and provide the capability to produce design alternatives to improve circulation. Improved circulation leads to maximum throughput in process equipment and improved sugar quality.

A scaled-down model to duplicate the flow patterns inside vacuum pans is being developed. Anemometry techniques will be applied for the analysis to consider different factors important during a strike (viscosity, strike height, circulation rate, bottom geometry, downtake size) and validate the numerical results obtained with a commercial CFD code (FLUENT). This experiment is intended to develop a tool for analyzing industrial equipment and identifying alternatives to optimize the process.

Figure 17. Scale model designed to represent and measure the flow inside a sugar vacuum pan.

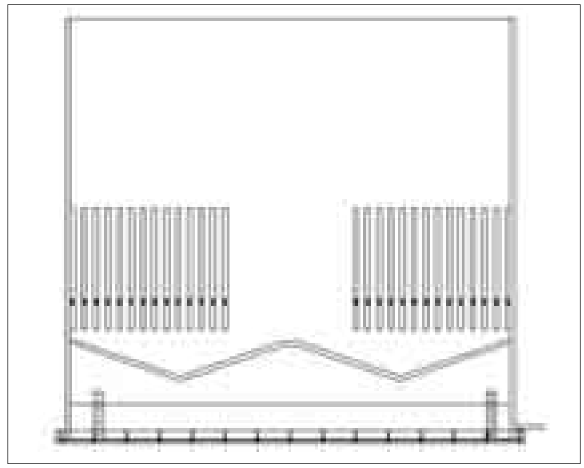
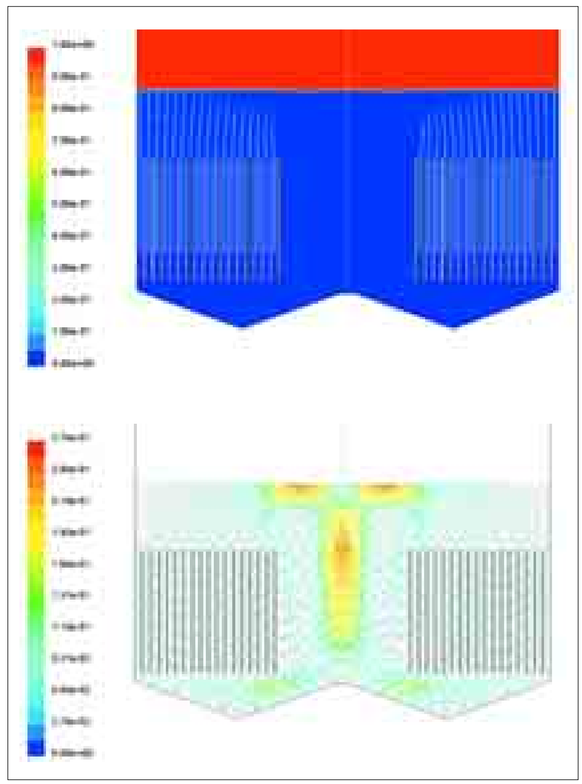


Figure 18. Phases contour and liquid velocity vectors predicted using CFD.



Horizontal and Vertical Crystallizers and Batch and Continuous Pans

As part of a program to test and evaluate new types of equipment installed in the Louisiana sugar industry, work was conducted this year on vertical crystallizers and on continuous pans.

Vertical Fletcher-Smith, Silver and Honiron crystallizers were tested together with Werkspoor and several Blanchard types.

A Nutsch device fitted with a low grade centrifugal screen and operated with 100 psig air was used to obtain mother liquor samples from the massecuite leaving the pan, leaving the crystallizers and leaving the massecuite reheater. Samples were analyzed for refractometer Brix and apparent purity.

Vacuum Pan – Crystal Yields and Purity Drops

The crystal yields (crystal content percent massecuite solids) for the A, B and C strikes are summarized in Table 8. Purity drop (Massecuite purity – Molasses Purity) for the A, B and C strikes are summarized in Table 9.

Table 8: Vacuum pan crystal yields.

	Crystal Yield, percent			
	Continuous Pans		Batch Pans	
	Range	Average	Range	Average
A Strikes	56.1	56.1	55.2-59.1	56.8
B Strikes	50.4	50.4	45.0-51.1	49.1
C Strikes	26.2-37.1	33.0	22.8-41.9	29.1

Table 9: Vacuum pan crystal yields.

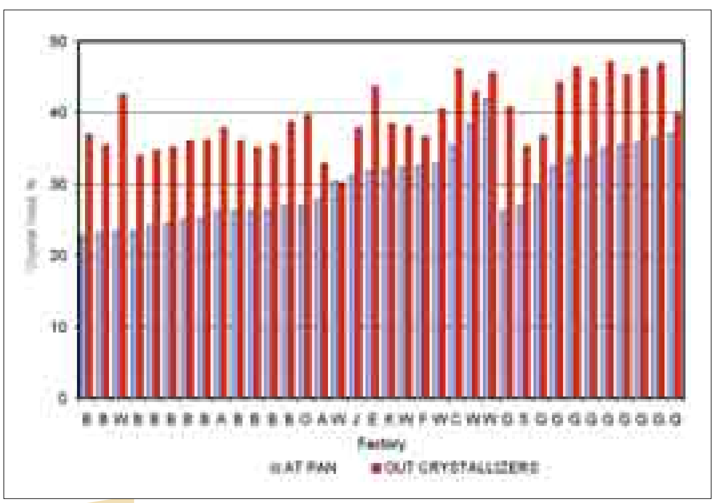
	Purity Drops			
	Continuous Pans		Batch Pans	
	Range	Average	Range	Average
A Strikes	21.0	21.0	17.4-19.7	18.6
B Strikes	28.4	28.4	20.8-29.5	24.1
C Strikes	14.8-26.0	19.4	11.5-23.2	16.8

While the above figures illustrate the wide variations in crystal yields and purity drops, these appear to be caused by operational variations rather than by type of pan.

C Pan and Crystallizers – Crystal Yield

Figure 19 shows the crystal yield leaving the pan together with the final crystal yield leaving the crystallizers. On average, crystal yields increased from 30.0 percent leaving the pan to 39.5 percent leaving the crystallizers.

Figure 19. C crystal yield at pan and out crystallizer.



Massecuite Reheater

The purity rise across the reheater is shown in Figure 20. Average temperature rise was 6 degrees F, with a maximum of 30 degrees F; purity rise averaged 1.2 purity points with a maximum of 3.3 purity points.

Residence Time in Vertical Crystallizer

Ten pounds of a zinc tracer were injected to the inlet of a Honiron vertical crystallizer. A plot of the zinc concentration in the massecuite leaving the vertical crystallizer is shown in Figure 21. The plot indicates severe channeling, because the peak tracer concentration was reached in less than 3 hours while the nominal residence time in the crystallizer was 15 hours.

Figure 20. Purity rise on reheating.

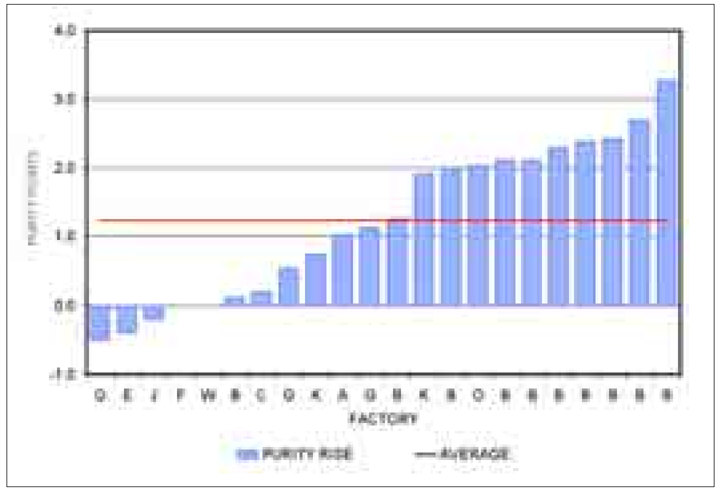
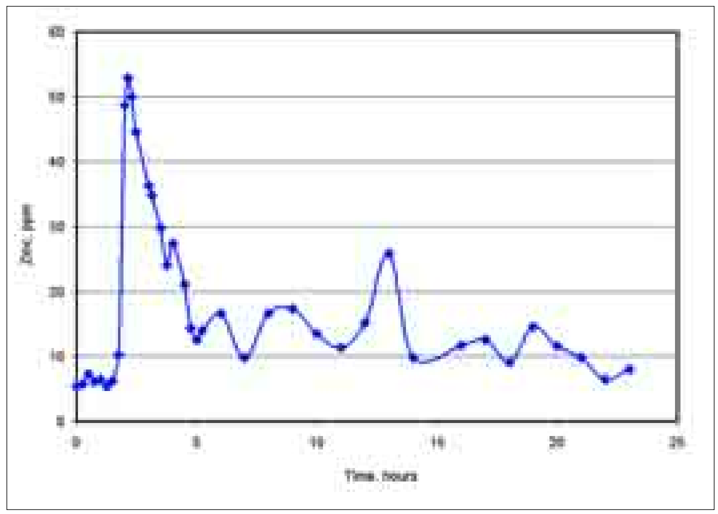


Figure 21. Crystallizer tracer test.



Modeling Adsorption of Cane Sugar Juice Colorant in Packed-bed Ion Exchangers

The removal of cane sugar solution colorant by packed-bed ion exchangers was modeled using a linear driving force adsorption model. Adsorption of colorant is a complex subject, since color is an indiscrete mixture of many components, making it difficult to measure and even more challenging to model. Gel Permeation Chromatography (GPC) was used as a tool to measure color of pseudo-components and was found to be particularly useful because it allows the components to behave differently in a process model. Three resins were investigated: a strong acid cation (SAC), a weak-base anion (WBA) and a standard sugar industry strong-base anion decolorizing resin. Batch testing of the resins produced linear isotherms, indicating that the colorant is dilute.

Results from column testing showed that a plug-flow model with a constant linear isotherm was sufficient in all cases except the SAC resin. The SAC showed particularly interesting dynamics, which are illustrated for component D in Figure 22. The SAC adsorption parameter decreased sharply as the pH increased, causing colorant to be desorbed from the resin. Affinity of colorants for this resin is seriously affected by pH. As the pH increases, the adsorption parameter decreases greatly, causing some components to elute from the column and others to be retained less strongly by the resin. This situation must be avoided if optimal decolorization is to be achieved.

Figure 22. A typical SAC breakthrough curve.

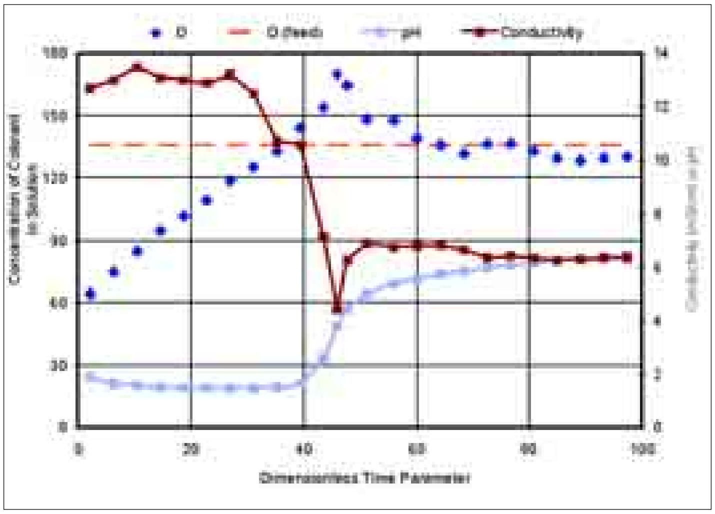


Figure 23. Regression of UV 300nm chromatograms with eight Gaussian profiles.

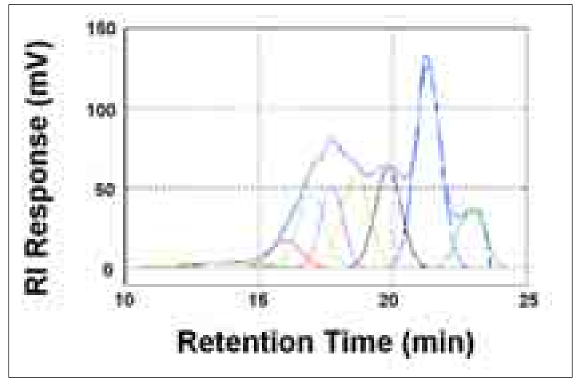
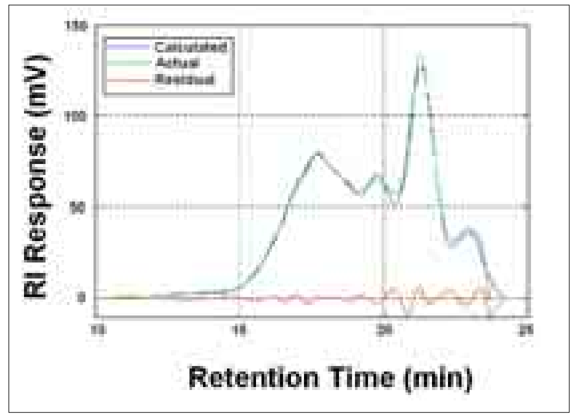


Figure 24. Comparison of regressed and measured UV 300nm data (r^2 = 0.9944).



Deconvolution of GPC Chromatograms of Sugar Solutions

Chromatography is a multi-component separation method based on differential migration of components through a packed column. Gel Permeation Chromatography (GPC) is a separation process based on molecular size. GPC of sugar solutions using refractive index (RI) and ultraviolet-visible (UV) detectors yields chromatograms containing overlapping peaks. Further separation or deconvolution may be performed using a mathematical treatment after the GPC analysis by representing the chromatogram as a number of Gaussian distributions. A deconvolution technique using nonlinear least-squares optimization was developed that allows for accurate quantification of GPC chromatograms.

Parameters of the distributions were obtained using a stepwise nonlinear optimization routine. The method is a mathematical separation that creates quantitative information on particular components that can be examined to investigate the effects of unit operations on high molecular weight material.

Absorbance chromatograms are typically measured at 420 nm in the visible region of the spectrum or at some point in the UV region. Deconvolution at 420 nm was able to quantify only two components because insufficient separation was achieved in the GPC columns. At this wavelength, the different colored species behave similarly, making it impossible to split the chromatogram up into more components. The UV region shows significant benefits over the visible region owing to the greater absorption of energy:

- Better separation
- Smoother baseline
- More components

Figures 23 and 24 show the regressed components at 300 nm and the comparison of measured and regressed data.

The retention time data obtained from the regressions may be compared to determine similarities between the peaks (Table 10). From this table it is clear that there is some correlation among all the chromatograms. Since RI detects quantity and not color of different molecular weight species, the absence of an RI peak corresponding to an absorbance peak could represent a small quantity of high intensity colorant. Likewise the absence of an absorbance peak corresponding to an RI peak could represent material with zero color.

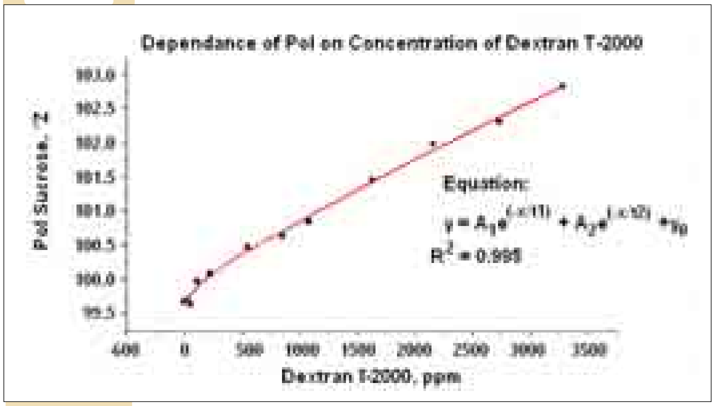
Table 10. Regressed retention times (min).

	Peak Number									
Sample	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
RI	12.53	13.91	16.54		17.75	18.60	19.38	20.78		
254nm			16.34		17.72	18.68	20.11	21.22	22.68	23.67
300nm		14.06	16.29	17.14	17.78	18.55	19.80	21.29	22.87	
420nm				17.42				20.61		

Effects of Dextran on Pol/Sucrose Measurements

Dextran, a high molecular weight α-D-(1→6) polyglucan, is produced by the action of the dextransucrase enzyme excreted by the indigenous bacteria, *Leuconostoc mesenteroides*. Possessing an optical rotation of [α]D = +199, it can cause polarimetric sucrose assays to appear artificially high. This is quite important, since payment schemes for sugarcane revolve around a sucrose determination that relies on polarimetric methods. Figure 25 shows the effect of varying amounts of T-2000 (2,000,000 D) dextran in 1N solutions of analytical grade sucrose.

Figure 25. The effect on pol (°Z) as read by polarimetric saccharimeter for solutions of 1N sucrose prepared to contain varying amounts of T-2000 dextran.



On average, the overestimation of pol due to T-2000 dextran is ~0.10°Z/100 ppm. The following equation can be used to correct non-lead clarified sugar pol values. Pol sucrose (°Z) can be determined by adding the maximum pol (99.7 for analytical grade sucrose) to the number calculated using this equation.

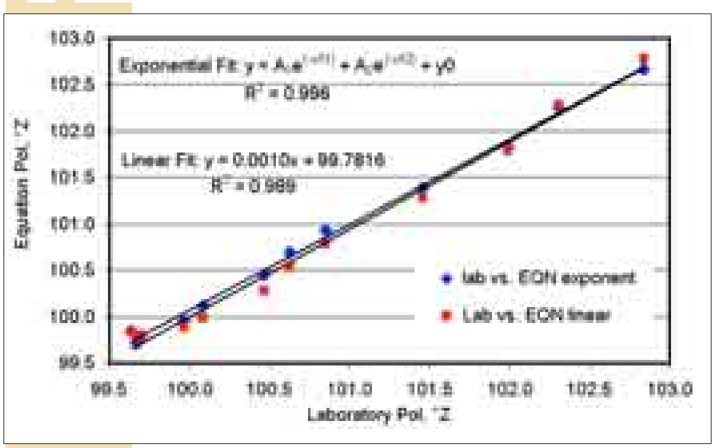
For pure (analytical grade, 99.7°Z) sucrose:

$$\frac{\partial Z}{x} = A_1 e^{(-x/t1)} + A_2 e^{(-x/t2)} + y_0$$

Where:

A_1 = constant = -0.2591
t_1 = constant = 120.37746
A_2 = constant = -14.51561
t_2 = constant = 14422.79624
y_o = constant = 114.39247
x = dextran, ppm

Figure 26. Correlation of laboratory data to predictions made by the equation for T-2000 Dextran in 1N analytical grade sucrose.



Raw sugars can contain significant amounts of reducing sugars (glucose and fructose). Both of these components can have a profound influence on pol sucrose assay. At full mutarotation, the contribution of glucose to optical rotation can be given as *gl*=0.0003 glucose (ppm) – 0.0117, and for fructose, *fr*=-0.0005 fructose (ppm) – 0.0036. When these terms are included, a good prediction of pol error can be calculated using the following equation. The predicted results from this equation correlated very well with the pol results achieved using lead clarifier (r^2 = 0.954).

$$\frac{\partial Z}{x} = (A_1 e^{(-x/t1)} + A_2 e^{(-x/t2)} + y_0) - 99.7 + gl + fr$$

Where:

A_1 = constant = -0.2591
t_1 = constant = 120.37746
A_2 = constant = -14.51561
t_2 = constant = 14422.79624
y_o = constant = 114.39247
x = dextran, ppm
gl = net contribution, °Z, from glucose, ppm
fr = net contribution, °Z, from fructose, ppm

In either case, the values achieved using non-lead clarifiers can be corrected by subtracting dZ/*x* from the result. These corrected values correlate very well with those achieved using leaded clarifiers.

A New Functional Food Additive

The term functional foods refers either to processed foods containing ingredients that aid specific bodily functions, in addition to being nutritious, or food ingredients that provide health benefits beyond that expected from their components. One of the most sophisticated approaches to customizing health benefits is occurring in the area of probiotics. Probiotics are defined as "live microorganisms that confer a health effect on the host when consumed in adequate amounts." *Bifidobacterium* and *Lactobacillus* species have been the focus of probiotic interest because large populations of these bacteria in the intestinal tract are generally considered to be indicative of a healthy microbiota; however, there are barriers in human body that block the use of live bacteria in foods, such as acidic pH in the stomach and enzymes and bile in small intestine. An alternate approach to introducing live bacteria directly is to

Faculty member Dr.Donal Day operates research in detection and control of microbial-based problems in sugar processing.

Figure 27. Mannitol, crude nutraceutical and purified nutraceutical produced from sucrose.

increase the number of *Bifidobacteria* and *Lactobacilli* in the intestinal microbiota through the use of prebiotics. Prebiotics are nondigestible dietary components that pass through the digestive tract to the colon and selectively stimulate proliferation and/or activity of populations of desirable bacteria *in situ*.

Use of a chain shortening acceptor and a microbial strain that primarily produces highly branched polymers resulted in production of selected α-glucooligosaccharides from sucrose. These oligosaccharides were branched polymers between DP 2 and 8 in size. The branches were single glucose molecules in length. Oligosaccharides synthesized by this bacterium had α-1,6 backbone with α-1,3 and/or α-1,4-branched side chains. The oligosaccharide yield was 90 percent of the theoretical yield oligosaccharides. The fermentation was essentially complete in 24 hours. The production rate was about 0.9 g/L hour. Changing the acceptor to carbon source ratio altered the relative proportion of different size oligosaccharides produced by the fermentation. Concentration after mannitol removal produced a clear syrup containing primarily oligosaccharides. The fructose portion of the sucrose molecule was converted to mannitol during the course of the fermentation. Upon concentration and cooling, the mannitol crystallized from solution and was recovered as a 99.99 percent pure product. The weight conversion was 60:40 in favor of oligosaccharides. Less than 5 percent of other products was produced in this process.

Growth of *S. typhimurium* or *E. coli* on these oligosaccharides was less than 40 percent of the growth on an equivalent amount of glucose and similar to growth on commercial fructooligosaccharides. The bacteria *Lactobacillus johnsonii* and *B. longum* showed no difference in growth rate on glucose or the oligosaccharide preparations. When *L. johnsonii* and *S. typhimurium* were grown together on the oligosaccharide preparations, the oligomers stimulated the growth of the *Lactobacillus* but were not readily used by the pathogenic organism. It appears that these oligosaccharides are used preferentially by probiotic strains.

Use of these oligosaccharides as prebiotics should lead to the production of intestinal lactic acid, increases in short-chain fatty acid production and lower pH's in large intestines. With appropriate application, they may be useful food additives to help prevent establishment of pathogenic organisms. Similar effects have been seen in studies on the effect of fructooligosaccharides in feed trials with broilers. Oligosaccharides reduced the susceptibility to *Salmonella* colonization of the intestine of chickens, increased *Bifidobacterium* levels and reduction in the level of *Salmonella* present in the caecum. Our studies do not allow direct prediction of "in vivo" effects but indicate that this type of oligomer can be a prebiotic for intestinal microflora.

Biocide Study

A simple and fast-acting biocide has been developed at Audubon Sugar Institute that is both bactericidal and sporicidal against a wide range of pathogenic microorganisms including potential bioterrorism agents such as *Bacillus anthracis*, the causative agent of anthrax. The two compounds that make up this biocide are both user and environmental friendly and are approved by the United States Food and Drug Administration.

Potential uses of this biocide as a disinfecting and/or decontaminating agent are endless. Raw chicken is a significant source of the bacterial pathogens *Escherichia coli* and *Salmonella*. Poultry processing for consumption presents many opportunities in which carcasses and other raw products can become newly contaminated or cross contaminated with these microorganisms. *Salmonella* and *E. coli* infections have been linked to poultry and meats in several foodborne illness outbreaks, primarily because of the consumption of raw or undercooked products. Table 11 shows the effectiveness of LSU biocide in achieving several microbial log reductions in contaminated raw poultry during the chilling process.

Table 11. Microbial killing effect of LSU biocide on raw poultry.

	Log Survival Cells/Whole Chicken		
Treatment	***Escherichia coli***	***Salmonella spp.***	**TPC***
Control	5.69	3	5.87
Chilled Water	5.69	3.09	6.09
LSU Biocide	<1	<1	<1

**Total microbial count.*

In response to growing concerns of domestic terrorism, the LSU biocide was tested as a potential decontaminating agent against several office materials previously contaminated with *Bacillus subtilis* (an anthrax stimulant). The current recommendation for *Bacillus anthracis* spore disinfection is 15 percent bleach for a contact time of an hour, or use of glutaraldehyde or formaldehyde. A contact time of only 5 to10 minutes for LSU biocide is needed to achieve several log reductions of spore-contaminated surface office materials. In addition, the biocide is also effective against microorganisms entrapped within biofilms, a polysaccharide matrix

Graduate student Giovanna Dequeiroz measures light absorbance of samples using a UV/Vis spectrophotometer.

that serves as a penetration barrier for most biocides. There is also a possibility that this biocide may be used to inactivate acetyl cholinesterase inhibitors commonly found in nerve gases.

Table 12. Decontaminating effect of LSU biocide on *Bacillus subtilis* spores-contaminated materials.

Material	Kill Time (min)	Log Survival Spores/in² Before Decontamination	Log Survival Spores/in² After Decontamination
Concrete Block	5	6.17	0.28
Acoustic Ceiling Tile	5	5.87	1
Tightly Woven Carpet	10	6.07	0
Rough Surface Tile	5	6.09	0.87
Smooth Surface Tile	10	5.83	1.8
Wood Floor Tile	10	6.69	0

Mixed Juice Analysis

Four Louisiana sugar mills participated in a survey of mixed juice quality during the 2002 grinding season. The survey resulted from an interest generated when one of the participating factories had its mixed juice analyzed during the 2001 season. The survey was a valuable opportunity to evaluate effective sample collection methods while producing valid and useful data.

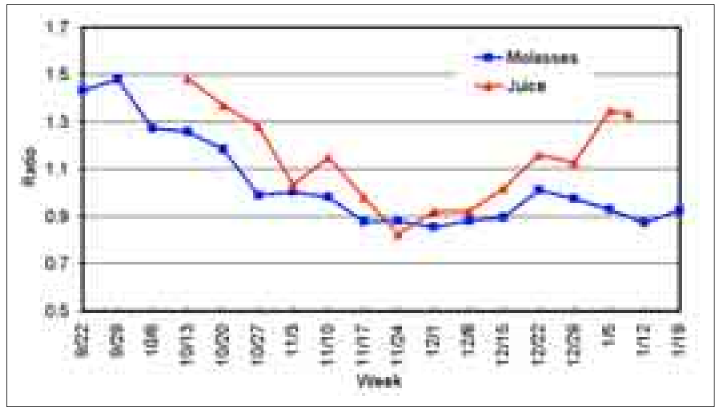
Each mill collected hourly samples that were heat sealed into individual plastic bags after being treated with biocide. The samples were then frozen at -70 degrees C. When the samples arrived at ASI, they were combined into daily and weekly composites. Weekly composites were analyzed using the same methods and instrumentation that are used during the molasses survey. Results were submitted to the mills upon completion.

Mixed juice F/G ratios averaged 1.06 for the season and ranged from 0.96 to 1.25. The average (F+G)/ash ratio of the mixed juice and the final molasses from the participating mills trended similarly, demonstrating increased ratios at the end of each season as shown in Figure 28. The pol to sucrose ratio averaged 0.97. This means that the mixed juice contains 3 percent more sucrose on average than is predicted by pol. In other words, more sucrose is coming into the mill than is indicated by calculations based on pol data. This data was used by the Raceland mill to establish a more accurate recovery based on true sucrose, rather than pol.

Phosphate data have been completed for some samples despite a delay caused by instrumentation problems. The completed data showed that at times the phosphate levels fell below recommended levels for good clarification. All of the samples will be analyzed for phosphate during the off-season. A different method of phosphate analysis will be needed to provide faster results without compromising accuracy and precision.

Integrity of the results will depend on the sample quality. It is therefore recommended that the participating mills formulate efficient sample transport logistics and install special –70 degrees C freezers. Standardized biocide addition for all participating mills is also recommended.

Figure 28. 2002 juice survey (F+G)/ash weekly averages.



Student worker John Daigle analyzes mixed juice and molasses samples for pol.

Table13. 2002 Mixed juice analytical results – mill averages.

Ref. Brix	App. Purity	True Sucrose	Ratio Pol /Sucrose	True Purity	Fructose F	Glucose G	F/G Ratio	Cond. Ash	(F+G)/ Ash
%juice	%	%juice		%juice	%juice	%juice		%juice	
12.5	84.3	10.83	0.971	86.8	0.31	0.29	1.06	0.56	1.10

Final Molasses Survey

One of the largest losses suffered by a sugar mill is the loss of sugar to molasses, so reliability in the data on molasses exhaustion is important. Routine measurements made at a sugar mill laboratory produce inaccurate results, especially at the low purity levels such as in the final molasses. In the past, Audubon Sugar Institute (ASI) undertook analyses of molasses samples for the mills in Louisiana but discontinued doing so after the 1997 season. The final molasses survey was reintroduced for the 2000 season. Continuous efforts to improve the handling and analysis of samples were made to increase accuracy and turnaround time.

The degree of exhaustion of the molasses is benchmarked by a "target purity" equation. The target purity equation used by ASI was developed in South Africa and has been shown to apply to Louisiana conditions. The difference between the true purity and the target purity is known as the target purity difference (TPD). TPD is a chief concern to the mills because lowering the TPD increases overall recovery and consequently profitability. TPD differences down to 5.0 have been achieved at a Louisiana mill. The average for the last three seasons has been twice that, so there is room for much improvement.

Expected trends due to startup and liquidation and cane maturity continued. One should note that the last average TPD for 2002 on the chart in Figure 29 represents only one point. This TPD was higher than the previous few weeks for the same mill, which follows the trend. Figure 30 illustrates the weekly TPD averages for 2002 based on geographical region. Peak TPD values were noted for all mills during the periods of hurricane Lili and tropical storm Isidore. The data confirm that the crop damage caused by the combination of Lili, Isidore and the seasonal rains adversely affected the processing of the cane during the 2002 season.

Figure 29. Average weekly target purity comparison – 2000 to 2002.

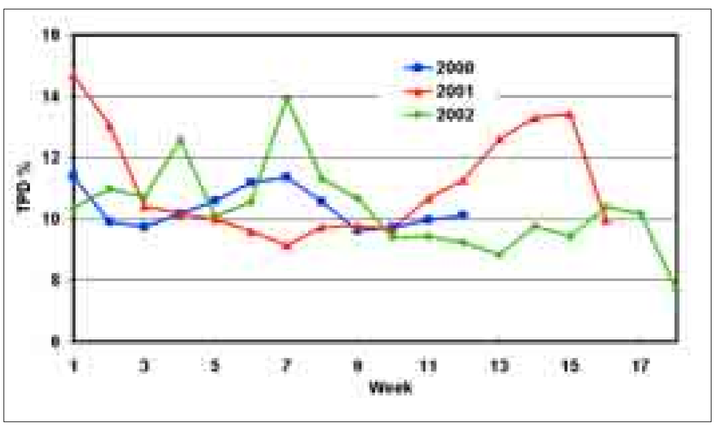
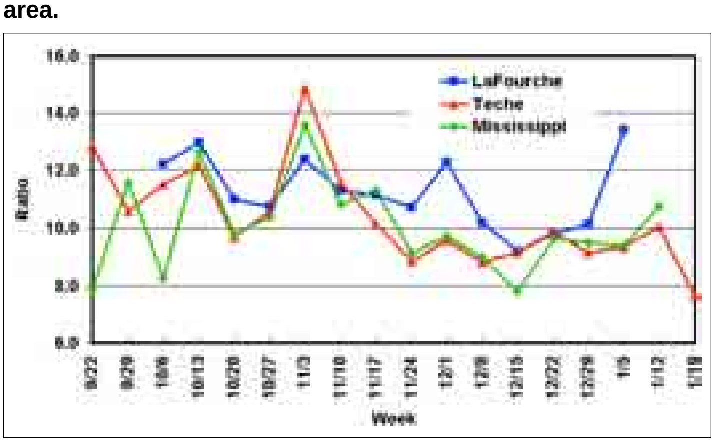


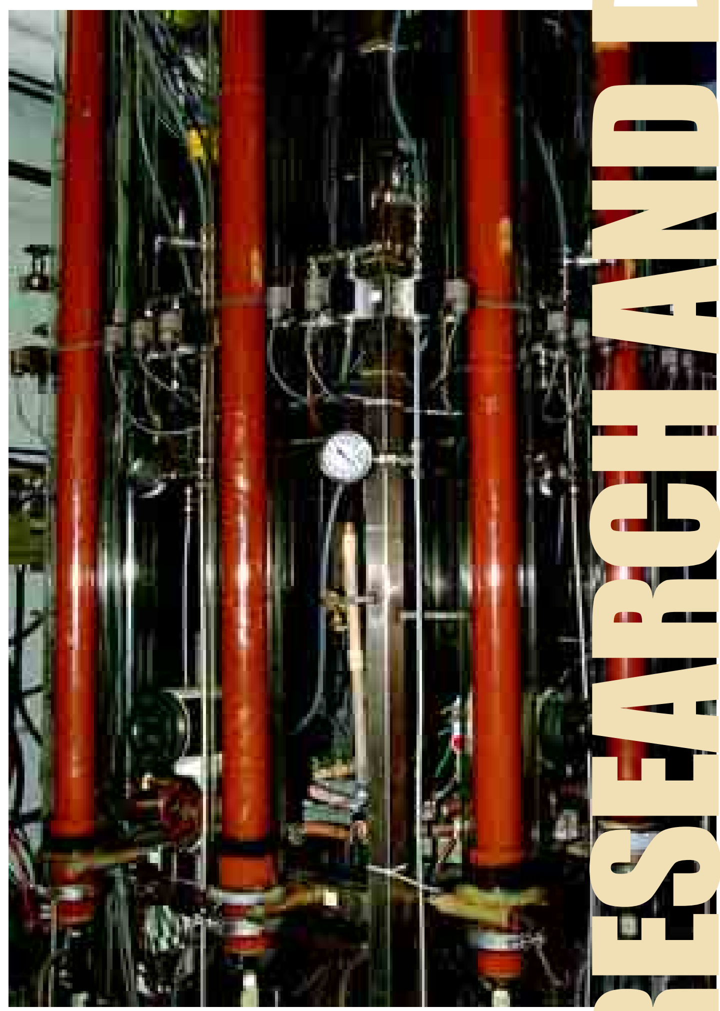
Figure 30. 2002 average weekly target purity difference by area.



Dr. Dorothy Wood weighs molasses samples for analysis.

The 2002 season average TPD was similar to the previous two seasons. This overall average indicates that the sugar industry was able to overcome the challenges of this unique season.

The fructose to glucose (F/G) ratio is often used as an indicator of the extent of Maillard reaction in massecuites since glucose is used preferentially in the reactions. The F/G ratio in mixed juice was measured for four mills over the season and averaged 1.06; the average F/G value was 1.44 for the industry in molasses. For 2000, the average F/G ratio was 1.68 and 1.41 for 2001. The last two years have shown improvement over the 2000 season, indicating a reduction in the Maillard reaction in the process.



This simulated moving bed ion exchange system at ASI is used for the continuous separation of compounds.

EXTENSION WORK

Extension Work

Bagasse Ash Content

Ash percent bagasse was determined for several factories that experienced poor boiler performance. The ash content of the bagasse was unusually high this year as a result of Hurricane Lili and heavy rains.

Boiler Tests

Boiler efficiency tests were performed at several factories where natural gas consumption was much higher than normal. Boiler emission tests were monitored at one factory that installed a new boiler for the 2002 crop.

Pan Circulations

Designs for steam-assisted circulation in pans (jigger steam) were undertaken for some mills experiencing boiling problems.

Cane Quality Payment System

Audubon continued to be involved in various industry and other group discussions on options for a new cane payment system that will encourage greater productivity in the Louisiana sugar industry.

Preparation Index and Milling Tests

The preparation index and the extraction achieved at each mill in the tandem were determined at two factories during the season.

Core Lab Procedures

Several factories requested help in standardizing core lab procedures. Inadequate drying of the residue samples was the primary problem noted this year.

Undetermined Losses

High undetermined losses were investigated at a few factories. Low juice pH's and the ditching of mud and/or entrainment of filtrate juices, as a result of high mud volumes this year, were the primary causes of the high undetermined losses.

Cold Tolerance Tests

The rate of deterioration of various cane varieties following the freeze in January was monitored in collaboration with LSU AgCenter Extension and USDA personnel.

Automatic Pan Controls

Audubon assisted in the specification of a new automatic pan boiling system at St. James and assisted in its evaluation.

Alcohol Production

A proposal for the production of alcohol at a Louisiana sugar mill was undertaken.

Handling of High Brix C Massecuites

Advice was given to some of the mills on modifications necessary to handle high Brix C massecuites, a prerequisite for good molasses exhaustion.

Clarifier Modifications

Modifications necessary to improve the performance of Dorr clarifiers by changing juice offtakes were recommended for two mills.

Audubon Sugar Institute Analytical Capabilities

In 2002, Audubon Sugar Institute (ASI) continued to invest significantly in time and money to improve its analytical capabilities. New and used equipment was either purchased or received as gifts. New and used instruments were funded by grants. Personnel attended training seminars on the use of analytical equipment and software. Existing analytical instruments were also upgraded and automated. Through this continuous effort, ASI has further improved both the accuracy and the capacity of its analytical laboratories.

ASI now has seven operational HPLC systems. Three units are ion chromatography units, one set up for cation analyses and the other two for anion analyses including organic acids. One unit is a GPC unit for dextran analyses with both a UV-Visible and a Refractive Index detector. ASI also has an ion exchange chromatography unit used for alcohol, sugar and oligosaccharide analyses. One HPLC is used for routine sugar analyses on juice, syrup and molasses and other process samples. This unit has been upgraded with a new refractive index detector for improved accuracy and reliability. Another HPLC is set up for sugar analyses directed toward a specific project and is essentially dedicated to that project.

Other instrumentation includes a refractometer with 0.01 Brix resolution and temperature compensation capabilities, a new polarimeter with 0.01 degree Z resolution and both 589 and 880 wavelength for sucrose by polarization and a conductivity meter with temperature compensation for conductivity ash. A gas chromatograph has been purchased and installed; it has been used mainly in analyses of alcohols.

ASI purchased a Near-Infrared Transmittance Spectrophotometer. All final molasses survey samples for the last three seasons have been analyzed on this instrument, and conventional analyses will be completed on these samples. Data will be used in creating a calibration for Louisiana molasses. Also mixed juice samples from four mills were collected and will be used to develop a calibration for Louisiana mixed juice.

ASI has been able to acquire, in the last few years, several new analytical instruments. Included in these purchases are both a new refractometer and a new polarimeter. Some of the remaining analytical equipment is dated, but is capable of producing good results. The personnel in place have the talents and abilities to maintain and operate the equipment to get the most out of it.

Overall, significant improvements have been made to increase the capability and accuracy of the analyses that ASI conducts. ASI is embracing new technologies to improve the efficiency in all areas, including the analytical capabilities.

LSU AgCenter, Audubon Sugar Institute Short Courses

Six short courses were presented at Audubon Sugar Institute in 2002. The courses were offered to increase knowledge in the sugar industry, and they qualify for Continuing Professional Development for registered professional engineers. One new course was added in 2002, and some of the classes from the previous year were revised and updated.

An innovation introduced this year was the holding of a course given by international experts from outside the USA. The course on Boiler Design and Operations was presented by Norman Magasiner of South Africa and Dr. Mike Inkson of the United Kingdom and drew 24 delegates.

All courses offered at Audubon Sugar Institute are available online on our Web site at www.lsuagcenter.com/audubon

Introduction to the Technology of Sugar Production – Two days

This course provided a non-technical overview of the important aspects of sugar production. The overview introduced issues that affect capacity and costs and the factors that reduce losses and improve quality.

Technology Refresher-Improving Raw Sugar Factory Operations and Profitability – Two days

This new course was developed for individuals who are involved in the operation or the design of raw sugar mills to enhance their technical skills and get up to date with important issues that affect the efficiency and profitability of raw cane sugar production.

Boiler Design and Operation – Two days

This class was designed for engineers involved in running a sugar factory or project engineers associated with the industry. The course provided an understanding of modern boiler and co-generation technology.

Continuous Vacuum Pan Boiling – One day

This course provided a detailed understanding of continuous pan boiling and how it compares with batch processing. It was intended for factory operations personnel and those involved in the design and planning of factory modifications and expansions.

Vacuum Pan Instrumentation and Control – One day

The main objective of this course was to provide a good understanding of the practical principles of automatic control of vacuum pans and to maximize the performance and capacity of the pan station.

Introductory Sugar Boiling – Three days

This class offered individuals with little or no experience in sugar boiling an overview of the sugar boiling process. It not only provided an understanding of the principles involved but also taught how to boil pans and allowed hands-on trials in making sugar at ASI's pilot plant.

Degree Courses for Sugar Engineers at LSU

Sugar Engineering Courses

Two courses in the College of Engineering introduced by the Audubon Sugar Institute (ASI) were offered for the first time in 2002 and will continue to be available every year. They are a course in Sugar Process Engineering, which teaches all the background to sugar processing (BE 4342), and Sugar Factory Design (BE 4347), which introduces the student to the detail of equipment design in a factory. Prerequisites to these courses are listed on our Web site at www.lsuagcenter.com/audubon.

Minor in Sugar Engineering

The objective of this program is to produce a graduate ideally suited to the operation and management of a sugar-producing facility. In all cases, the student is encouraged to work as a part-time student at ASI. He or she is given maximum exposure to sugar processing at every opportunity.

A set of courses has been prescribed so that students studying in biological, chemical or mechanical engineering may be able to earn a minor in sugar engineering by choosing the two sugar courses described above and their electives to meet the requirements. If possible, the student should also choose a design project in a sugar engineering related topic, which could be overseen by the staff of the Audubon Sugar Institute. Sugar Process Engineering should preferably be taken in the Junior year.

To earn the minor, students in the College of Engineering must complete 18 hours of required courses with a grade of "C" or higher. Visit our Web site at www.lsuagcenter.com/audubon for the list of required courses.

Another option involves spending the fall semester at an operating sugar mill, using this period as an internship yielding 3 credit hours (allowed for in BE 3249). This could substitute for one of the above but requires a slightly longer time in which to complete the degree.

Master's in Chemical, Mechanical or Biological Engineering Specializing in Sugar Engineering

Students are recruited to take a master's degree in chemical, mechanical or biological engineering. This is targeted at people who have a first degree and wish to gain some specific sugar-processing expertise through further study.

Following the thesis option, the master's academic requirement is 24 credit hours in the nominally 21-month program. The course requirements include the Sugar Process Engineering and Sugar Factory Design courses listed above. Depending on the first degree of the individual concerned, he or she will be encouraged to choose electives appropriate to supporting a strong sugar expertise.

A thesis will be required, and this should be related to a relevant sugar-processing topic.

In all cases, the student will be encouraged to take on a research assistantship in ASI for the duration of his course. He or she will be given maximum exposure to sugar processing at every opportunity.

Options for presenting the Sugar Engineering Courses as Condensed, Intersession or Continuing Education Courses.

As an alternative or in addition to the normal course arrangement, consideration will be given to condensing the sugar engineering courses into full-time intensive courses held in a three-week period during the summer semester. This course could be opened to outsiders through a Continuing Education program.

TRAINING AND EDUCATION

LIBRARY AND PUBLICATIONS

Library

The Audubon Sugar Institute Library has more than 2,200 books and is still growing. It is a great research resource for the department and many related to the sugar industry. The theses cataloged here have doubled in the past year. In addition to the books, ASI has many professional sugar periodicals from local and international sources such as The Sugar Bulletin, ZuckerIndustrie, Louisiana Sugar Journal and International Sugar Journal.

Publications

Broadhurst, H.A., and Rein, P.W. (2002). Characterization of Colorants Produced in Cane Sugar Processing. SPRI Conference, 292-310.

Broadhurst, H.A., Rein, P.W. (2003). Deconvolution of GPC Chromatograms of Sugar Solutions. ZuckerIndustrie. 127, 2: 96-99.

Broadhurst, H. A. and Rein, P.W. (2003). Modeling Adsorption of Cane Sugar Solution Colorant in Packed-bed Ion Exchange. AIChE. Journal. in press.

Day, D.F., Chung, C.H. (2002). Glucooligosaccharides from *Leuconostoc mesenteroides* B-742 (ATCC 13146): a potential prebiotic. Industial Microbiol and Biotechnol. 29: 196-199.

Day, D.F., Chung, C.H. (2002). Probiotics from Sucrose, 102nd Annual Meeting American Society for Microbiology. Salt Lake City, May 19-23.

Day, D.F., Cuddihy, J., Rauh, J. (2002). Versatility of the Antibody Dextran Test Method. ASSCT. Amelia Island Plantation, Florida, June 26-28.

Day, D.F., Kampen, W.H. (2002). Organic Acids in the Sugar Factory Environment. ASSCT. Amelia Island Plantation, Florida, June 26-28.

Day, D.F., Yoo, S.K., Kyun, Sun and Kim, D. (2001). Co-Production of Dextran and Mannitol by Leuconostoc Mesenteriodes. Microbiology and Biotechnology, 11: 880-883.

Day, D.F., and Yoo, S.K. (2003). Bacterial Metabolism of X- and B-Pinene and Related Monoterpenes by Pseudomonas sp. Strain PIN. Process Biochemistry, in press.

Day, D. F., Ott, C. M., Mayo, J.A., Kim, K. (2003) A Multi-Component Safe Biocidal Complex, US Patent filed August 24, 1999.

Day, D.F. (2003) Methods of Dextran Analysis, Sugar Bulletin, 81,7: 15-16.

Endres, T, Muzzell, D., Rein, P.W., White, B. (2003) Measurement of Recoveries and Losses at Raceland Mill. ASSCT. Baton Rouge, La.

Kampen, W.H. (2002). Biorefinery and Sugarcane. Louisiana Agriculture. 45, 4: 28-29.

Kampen, W.H. (2002). Improved Removal of Evaporator Scale. Sugar Bulletin. 80, 11: 15.

Kampen, W.H. (2003). The Biorefinery. Int. Sugar J. in press.

Kampen, W. H., D. F. Day. (2003). Organic Acids (+). Annual Meeting ASSCT, Louisiana Division, Baton Rouge, La.

Losso,J.n., Ogawa, M., Moody, M., Portier, R.J., McMillin, K.W., Day, D.F., Bell, J., Schexnayder, M. (2002) Protamine and Collagen. Two Value-added Products at Louisiana Seafood Processing Facilities. Louisiana Agriculture. 45, 4: 11-12.

Madsen II, L., Rein, P.W., and White, B. (2003). Evaluation of a Near Infrared Spectrometer for the Direct Analysis of Sugar Cane. Am. Soc. of Sugar Cane Technol. 23, 80-92.

Rein, P.W. (2003) The importance of Achieving a High Crystal Content in High Grade Massecuites. Sugar Bulletin. 81, 8: 12-17.

Rein, P.W. and Kampen, W. (2002). Evaporators in Cane Sugar Mills. Sugar Journal. 65, 2: 18-21.

Rein, P.W. (2002). The Optimum pH for Juice Clarification. Sugar Bulletin. 80, 12:17-19.

Rein, P.W. (2002). Education and Training in Sugar Process Engineering. Sugar Bulletin. 80, 7:11-15.

Rein, P.W. (2002). Energy Conservation from Cane Yard to Extraction Plant. ISSCT Engineering Workshop. Berlin, Germany.

Rein, P.W. (2002). Aspects of Louisiana Sugar Industry of Interest to South African Technologists. Proc. S. Afr. Sugar Technol. Ass. Conf. 76: 36-41.

Rein, P.W. (2003). Education and Training at the Audubon Sugar Institute. Int. Sugar J. 105, 1249: 20.

Rein, P.W. (2002). ISSCT Engineering Workshop on Energy Management in Raw Cane Sugar Factories. Sugar Journal. 65, 6: 22-24.

Rein, P.W. (2002). The Effects of Soil in Cane Delivered to the Mill and Options for Dealing With It. Sugar Bulletin. 81, 1: 13-15.

Rein, P.W. (2002). Planning Ahead for the Next Grinding Season, Sugar Bulletin. 81, 4: 18-19.

Saska, M., Rousset, F., Theoleyre, M., Gula, F. (2003) Raffinate Regeneration of Ion-Exchange Softeners in the Beet Sugar Industry. ASSBT, San Antonio, Tx.

Saska, M., Chen, F. (2002) Process for the Separation of Sugars. US Patent. US 6, 451, 123B1, Sep 17.

Saska, M. (2002) Boiling Point Elevation of Technical Sugarcane Solutions and its Use in Automatic Pan Boiling. Int. Sugar J. 104,1247: 500-507.

Saska, M. (2003) Hard to Boil Massecuites. ASSCT Conference Baton Rouge, La.

Saska, M. and Rein, P. W. (2001). Supersaturation and Crystal Content Control in Vacuum Pans. Proceedings of the Sugar Industry Technologists, Inc., 251-261.

Saska, M., Godshall, M. A., and Day, D. F. (2002). Dextran Analysis With Polarimetric and Immunological Roberts' and Haze Methods. SPRI Conference, New Orleans, La., 411-417.

Saska, M. and Kampen, W.H. (2002). Value-Added products from corn ethanol stillage and corn steep liquor. Corn Utilization & Technol. Conf. June. Kansas City, Missouri.

Saska, M. and Chou, Chung C. (2002). Antioxidant Properties of Sugarcane Extracts. Proc. 1st Biannual World Conf. on Recent Developments in Sugar Technol.

Saska, M. (2002). Comments on Juice Clarification Practice in Louisiana. Sugar Bulletin, 81, 2: 12-13.

Walker, T.H., Drapcho, C.M., Day, D.F. (2002). Bioconversion of Processing Byproducts and Wastes. Louisiana Agriculture. 45, 4:26-27

FACULTY AND STAFF

Faculty and Staff

Administrative Staff

Dr. Peter Rein, Professor and Head –BSc. and MSc. Chemical Engineering (University of Cape Town, South Africa), PhD. Chemical Engineering (University of Natal, South Africa)
Liz Thompson, University Administrative Specialist –B.S. Business Administration (Indiana Institute of Technology)
Lisa Lindsay, Secretary – B.A. Spanish (Louisiana State University)
Luke Theriot, Research Associate Specialist – B.S. Agribusiness (Louisiana State University), M.S. Ag Economics (Louisiana State University)

Analytical Lab

Brian White, Research Associate –Analytical Chemist –B.S. Chemistry (Freed-Hardeman University)
Dr. Dorothy Wood, Post-doctoral Researcher – B.S. Chemistry (University of Florida), PhD. Chemistry (Louisiana State University)
Lee Madsen, Research Associate – B.S. Chemistry (Louisiana State University)
John Daigle, Student Worker – B.S. Biology (Nicholls State University)

Factory Staff

Joe Bell, Research Associate – Factory Manager – B.S. Mechanical Engineering (Louisiana State University)
Scott Barrow, Research Associate – Electronics/ Instrumentation Engineer – B.S. General Studies (Alpena Community College)
Lamar Aillet, Maintenance Foreman
Chris Cavanaugh, Student Worker

Faculty and Staff

Dr. Donal Day, Professor – BSc. Biochemistry (University of New Hampshire), PhD. Microbiology (McGill University, Canada)
Dr. Michael Saska, Professor – B.S. Chemical Engineering (Prague Institute of Chemical Technology, Czechoslovakia), M.S. Chemical Engineering (Louisiana State University), PhD. Chemical Engineering (Georgia Institute of Technology)
Dr. Harold Birkett, Associate Professor – B.S. Chemical Engineering (Louisiana State University), M.S. Chemical Engineering (Louisiana State University), PhD. Chemical Engineering (Louisiana State University)
Dr. Willem Kampen, Associate Professor – B.S. (College of Sugar Tech, Amsterdam, Holland), M.S. Chemical Engineering (Louisiana State University), PhD. Food Science (Louisiana State University)
Jeanie Stein, Research Associate – B.S. Plant Science (Nicholls State University)
Stuart 'Lenn' Goudeau, Research Associate – B.S. Industrial Technology (Louisiana State University)
Niconor Reece, Graduate Assistant –B.S. Biological and Agricultural Engineering (Louisiana State University)
Dr. Chang-Ho Chung, Post-doctoral Researcher – B.S. Food Science (Sejong University, Korea), M.S. Food Science (Sejong University, Korea), PhD. Food Science (Louisiana State University)
Giovanna Dequiroz, Graduate Assistant – B.S. Food Science (Clemson University), M.S. Food Science (Clemson University)
Duwoon Kim, Graduate Assistant – B.S. Food Science (Chonnam National University, Korea), M.S. Food Science (Louisiana State University)
Luis Echeverri, Graduate Assistant – B.S. Mechanical Engineering (Universidad del Valle, Colombia)
Bruce Ellis, Graduate Assistant – B.S. Chemical Engineering (University of Natal, South Africa)
David Solberg, Graduate Assistant – B.S. Chemical Engineering (University of Natal, South Africa)
Nicolas Gil Zapata, Graduate Assistant – B.S. Chemical Engineering (Universidad Industrial de Santander)

Adjunct Faculty

Mary Godshall, SPRI –B.S. Biological Science (Louisiana State University, New Orleans), M.S. Biochemistry (University of New Orleans)
Dr. Terry Walker, Department of Biological Engineering –B.S. Engineering Science & Mechanics (University of Tennessee), M.S. Agricultural Engineering (University of Tennessee), PhD. Agricultural Engineering (University of Tennessee)

Staff Changes

Dr. Willem Kampen retired as of February 2003.
Luke Theriot transferred as of February 2003.
Melati Tessier, Research Associate Specialist – BSc. Chemical Engineering (Louisiana State University) as of March 2003

Representation on Technical Societies and Research Institutes

ISSCT (International Society of Sugar Cane Technologists)
Executive Committee and Immediate Past Chairman: P.W. Rein
Co-Products Section Committee: D.F. Day
SPRI (Sugar Processing Research Institute)
P.W. Rein (Member of Board of Directors)
International Sugar Journal
M. Saska (Referee)
American Society of Microbiology
D.F. Day
American Society of Advancement of Science
D.F. Day
Society for Industrial Microbiology
D.F. Day
Southern Region Development Committee – USDA
D.F. Day

Foreign Visitors to the Institute

April 2002
Luis Bento (Portugal), Pam Morel du Boil (South Africa), Robert Quirk (Australia)
May 2002
Earle Roberts (Jamaica), Joshua Jaddoo (Jamaica), Andree Nembhard (Jamaica), Carlos Briceño (Colombia), Norman Magasiner (South Africa), Ben Misplon (South Africa), Tito Silva (Nicaragua), Dr. Mike Inkson (United Kingdom)
June 2002
Alex Chavarro (Colombia)
July 2002
Michelle Hamilton (Jamaica)
September 2002
Ayub Quadri (Bangladesh)
October 2002
Klaus Niepoth (Germany), Alvaro Amaya (Colombia)
November 2002
Mike Getaz (England), Gerard Journet (France)
February 2003
Jose Jimenez (Cuba)
March 2003
Tim Diringer (Germany), Mario Tremblay (Canada), Dr. David Love (South Africa)

Meetings, Conferences and Workshops Attended

April 2002
ASI Annual Conference (all staff and faculty)
May 2002
SIT, Ft. Lauderdale, Fla. (P.W. Rein, W. Kampen, M. Saska)
June 2002
ASSCT, Amelia Island, Fla. (P.W. Rein, D.F. Day, H. Birkett, B. White, D. Wood, L. Madsen, J. Stein)
SunGrant Initiative, Dallas, Texas. (M. Saska)
Corn Utilization & Technology Conference, Kansas City, Mo. (M. Saska)
European Conf. and Tech. Exhibition on Biomass for Energy, Industry and Climate Protection, Amsterdam (W. Kampen)
August 2002
South African Sugar Technologists Conference (P. Rein and B. White)
Int'l Cong. of Chem. & Proc. Engineering, Prague (M. Saska)
FOSS NIR Users Conference, Fla. (P. Rein)
October 2002
ISSCT Engineering Workshop, Berlin (P. Rein)
January 2003
Philsurin Sugar Technology Training Program, Manila (P. Rein)
February 2003
ISSCT Executive Meeting, Guatemala (P. Rein)
February 2003
ASSBT, San Antonio, Texas. (P. Rein)
February 2003
ASSCT (La. Division) Baton Rouge, La. (all staff and faculty)

Dr. Stephen Clarke (left), 2002 president of SIT, presents the Crystal Award to Dr. Michael Saska at the SIT Conference held in Delray Beach, Fla., May 2002. The award recognizes his significant contribution to advancing the technology of the international sugar industry.
Photo courtesy of Sugar Industry Technologists Inc.

Audubon Sugar Institute
LSU AgCenter
South Stadium Drive
Baton Rouge, LA 70803
USA