PROPYLENE GLYCOLATE USED AS A TOP COAT SEAL TO PROTECT THICK JUICE FROM DEGRADATION IN ELLIPSOIDAL STORAGE TANKS

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Abstract:

From a “tail gate session”, to a literature review, to a modification from a literature review, propylene glycolate was evaluated at Spreckels Sugar, Brawley California. The paper will: Review the literature search, and history of thick juice storage; Laboratory evaluation of potential caustic modified top coat seals; Chemistry of propylene glycolate; Discuss the plant application of the top coat seal, Review the history of the past thick juice storage at Brawley, Review the chemistry and quality of the thick juice stored in this study; Results; Cost and Conclusion.

Introduction and Objective:

Early in 1944 the Holly Sugar Corporation experimented with the storage of purified evaporator thick juice for later processing[(1)]. The first large scale industrial storage of thick juice was also pioneered by Holly Sugar in Brawley California, 1960[(2)]. This Holly plant is the same location as this thick juice storage experiment we conducted, now called Spreckels Sugar.

Optimal conditions for thick juice storage have been determined to fall into a rather narrow Range of parameters in: pH, percent solids or brix, and temperature. High pH values inhibit bacterial degradation of sugar. The optimal pH has been determined to be greater than pH 8.8. Soda ash is typically used to buffer the thick juice. The brix target for evaporation has been determined to be greater than 68, at least 69. Temperature of the thick juice from the evaporator and going to storage should be below 20^0 C.[3,4]

Thick juice storage in Brawley California presents a challenge in that ambient temperatures can exceed 122^0F. (50^0 C), (Figures 1 & 2)

Figure 1

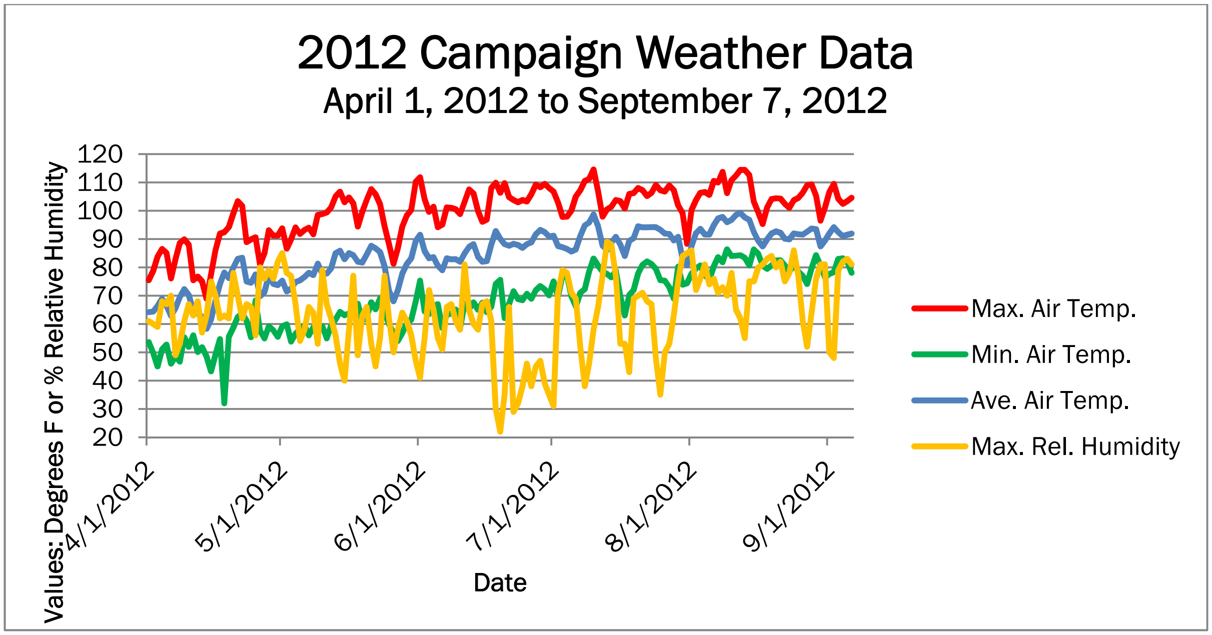
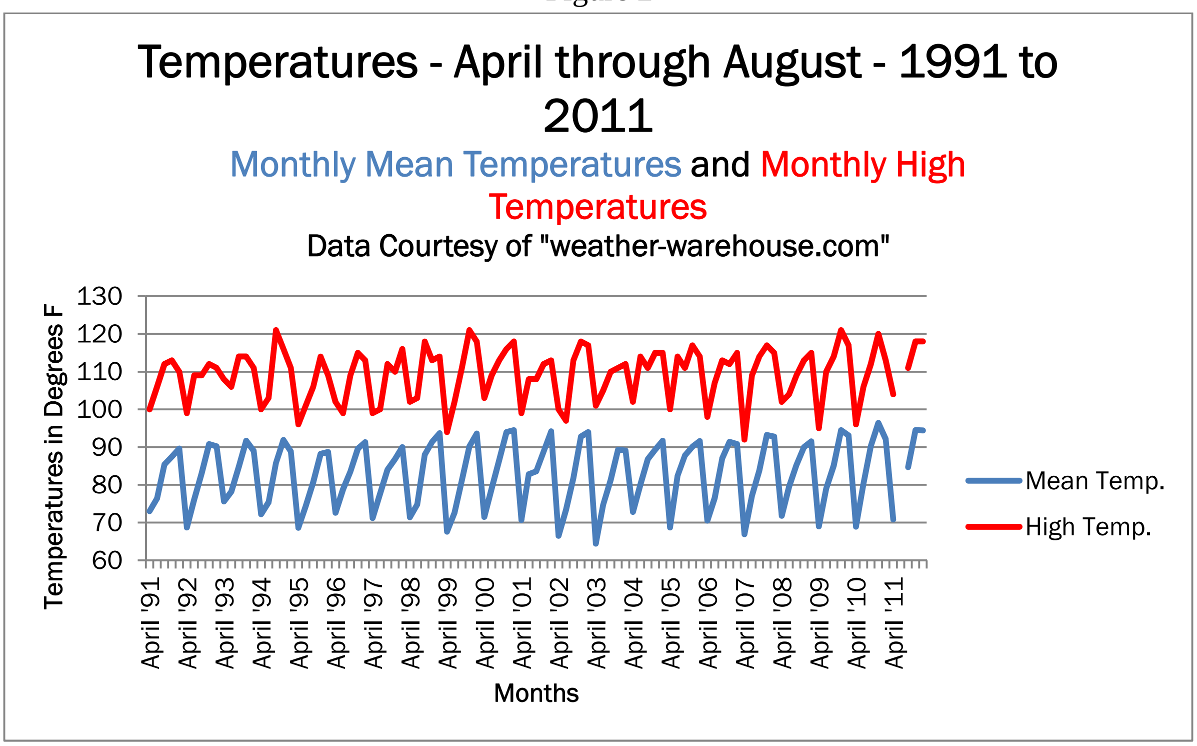


Figure 2



Many techniques have been used to help preserve the industrial storage of beet sugar and cane sugar thick juice:

- Tank design led to reducing the head space to reduce contact with air and condensation. Some tanks have floating tops as used in the petroleum industry. Construction of tanks with reduced internal surface area and reduced support structures. Some tanks were fitted with drying equipment to dehumidify the air in the tank's head space. Ellipsoidal tanks were designed to reduce the head space area as the tank fills. (Figure 3)

Figure 3

- Chemical treatments are used to help preserve the thick juice as it goes to storage. This treatment is applied to all the juice going into the tank. Most plants add soda ash to buffer the thick juice and to keep the pH around 9.0. Many plants have experimented with various sugar approved biocides and formalin. This has been documented to have some drawbacks with fermentation companies that purchased the molasses for a carbon source. Some plants have used hops with varying degrees of success.[5]
- Top coat treatments with chemicals, oils and foams are used to make a "seal" or barrier between the top of the juice and the air above the juice in the tank headspace. One source of contamination to the thick juice is the condensation of water inside the headspace. Utah-Idaho Sugar Company as well as Amalgamated did much of the early research on the use of mineral oil as a barrier.[6,7]
- The plant had been evaluating the use of floating 25% caustic soda on top of the thick juice for the past 2 years.[7] This treatment had one drawback. The caustic soda is heavy and

would diffuse, migrate or sink into the thick juice. This would leave areas unprotected, the tank would get contaminated. In 2011 this treatment failed, causing the pH to drop, and lactic acid and invert levels to rise dramatically. To minimize the contamination, the treatment needed to be reapplied. After the 2011 campaign, a “tail gate meeting” led to brainstorming as to how we could get the caustic soda to stay afloat.

- We went to the lab and experimented with various oils as well as other low density, food grade liquids. We discovered that if you made a mix of caustic soda and 1,2 propanediol, we had a potential for a stable, low density, floating, high pH, air tight, top coat seal.
- It was decided to give the propylene glycolate; 1,2-propanediol, sodium salt, a plant test.

Laboratory Methods:

Laboratory research began by utilizing the top coat mineral sealing oils we had experience with in the past to see if we could incorporate caustic soda. We discovered that we simply made a pasty mess. We tried to vary the viscosity of the mineral oils to no avail.

We tried various salad grade vegetable oils. Again we produced a pasty mess with the interaction of the hydroxide and triglycerides.

After we gave up on the mineral and vegetable oil theory, we started evaluating different compounds that we use to produce defoamers or antifoams used in the production of beet sugar. We looked at various diol polyols with some success. The lightest and least expensive is 1,2 propanediol. When we made this mixture we could couple a high percentage of caustic soda while keeping the product stable and very pumpable. The pH of the 1,2-propanediol, sodium salt, is very high, greater than 12.0, and stable. The specific gravity is very low, at 1.07. These two attributes allow it to work as the floating alkaline seal.

We made a 69% sugar solution by dissolving some standard sugar in a beaker. We put a 1/8 inch layer of the caustic soda 1,2 propanediol blend on the top of the solution in the beaker and simply observed the beaker for a period of two weeks to see if it was stable or would migrate into the sugar solution. The top coat solution was dyed red with phenolphthalein to assist in the observation. We observed the stability of the caustic soda 1,2 propanediol blend for 6 weeks. Everything from this laboratory study led us to run a plant test.

Chemistry:

1,2-propanediol + caustic = 1,2-propanediol, sodium salt, propylene glycolate
$CH_3CHOHCH_2OH + NaOH = CH_3CHOHCH_2O_{(neg)}Na_{(pos)} + H_2O$; or $C_3H_8O_2.xNa$

The reaction that happens is an associative reaction which forms a sodium salt of 1,2-propanediol (propylene glycol) and water. The material will exist as an ion and can shift back and forth from this to the reactants and propylene glycolate. The material acts as a humectant. (8) If all the water was removed, the product would remain as propylene glycolate.

Plant Test Methodology:

There are 6 ellipsoidal tanks at the Brawley facility. The diameter of each tank is 102 feet giving a surface area of 8,171 square feet. This is the diameter at 19 feet, or about half way up. The tanks are 40 feet in height. The diameter shrinks with the ellipsoidal tanks to 86 feet at 29 feet up, or about ¾ of the height, giving a surface area of 5,809 square feet.

The holding capacity is approximately 248,873 cubic feet, 1,861,699 gallons, or 20,500,000 pounds of thick juice. This is the equivalent of 110,000 to 120,000 cwt granulated sugar, depending on the purity.

The plant had a chemical feed system that had previously been used for applying 12.5% bleach as well as the 25% caustic soda solution to the top of the ellipsoidal tanks. It was decided that we would use the same system with a new pump as the viscosity of the propylene glycolate is greater than the bleach. A small gear pump was purchased and fitted with a variable speed motor to control the liquid pressure at the spray nozzle (Figure 4).

The pump pushed the top coat from ground level to the top of the ellipsoidal tank and through an air atomizing spray nozzle that made a mist to cover the tank top surface (Figure 5). The target was to apply 1mm to 2mm topcoat to the surface of the thick juice. Each tank was to be treated with 1 tote (metric ton) of propylene glycolate. The application of the propylene glycolate was started when the tank reached its greatest surface area at half full.

Figure 4

Figure 5

Figure 6

Figure 7

The amount of product used was two 1MT totes, 4,400 pounds or 2,000 liters, of product for three ellipsoidal tanks. The 1MT treated 5,000 MT of recovered sugar.

Quality Control Laboratory:

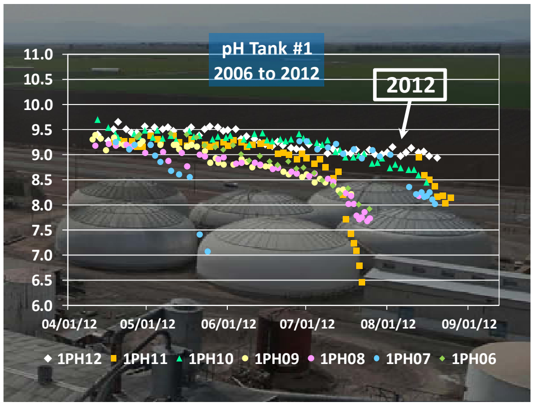
The quality control laboratory began testing the quality of the thick juice as the factory began transporting the thick juice to storage. The evaporator think juice is first concentrated to around 70 brix. This may be slightly adjusted up or down throughout the campaign in relationship to think juice purity. A pH of 9.0 to 9.4 is maintained by the addition of soda ash before the thick juice is cooled to less than 25 degrees C. A composite sampling system has been set up that collects thick juice to storage over a two-hour period. The laboratory runs an analysis of the composite sample for color, pH, brix and purity.

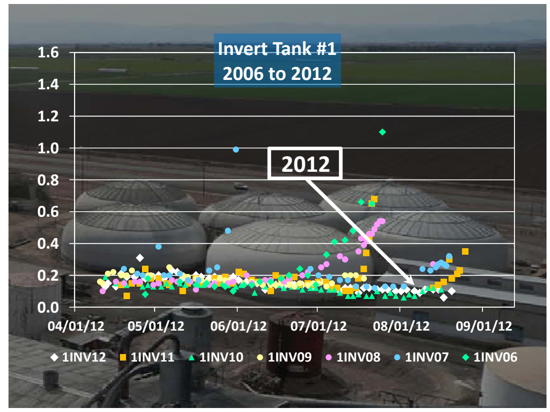
The target control points and the averages achieved:

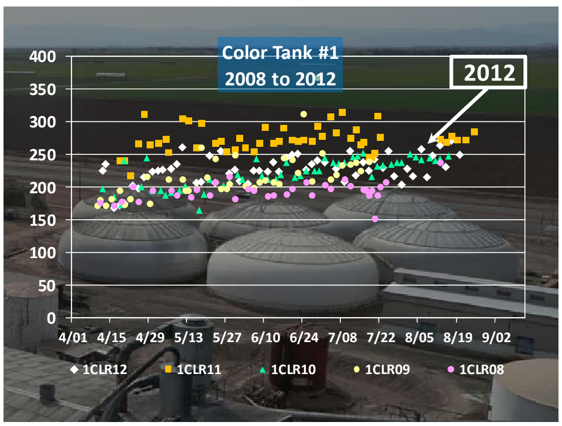
Tank #	pH	Bx	°C
Target	9.0 – 9.5	70 - 71	< 25.0
Tank 1	9.28	70.39	24.6
Tank 2	9.35	70.90	24.97
Tank 4	9.17	70.47	25.4

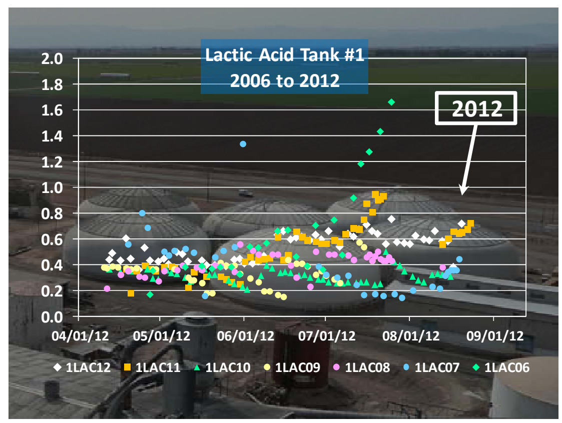
The laboratory ran quality tests on juice flowing to the tanks twice per shift. The tanks were checked for quality 3 times per week. The tanks have sample spigots spaced approximately 6 feet apart from bottom to top. Please review the past 8 years tank quality profiles for the average pH, invert, color, and lactic acid for each year of stored juice in comparison with the graphs for the tanks treated with the propylene glycolate in 2012.

Tank 1 History

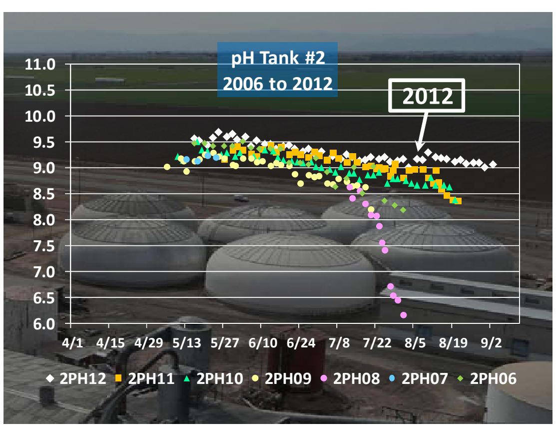


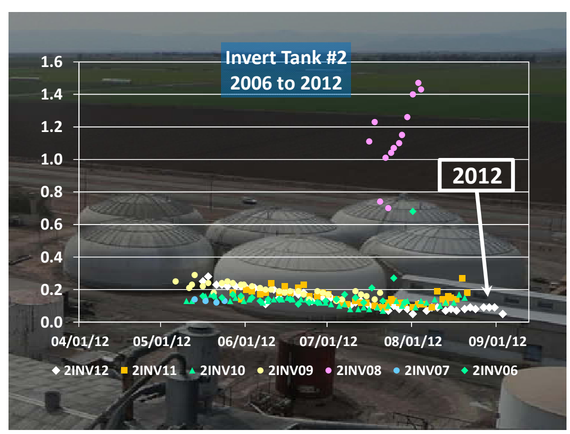


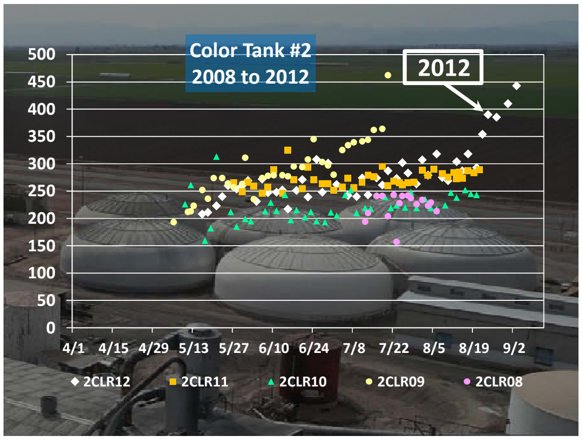


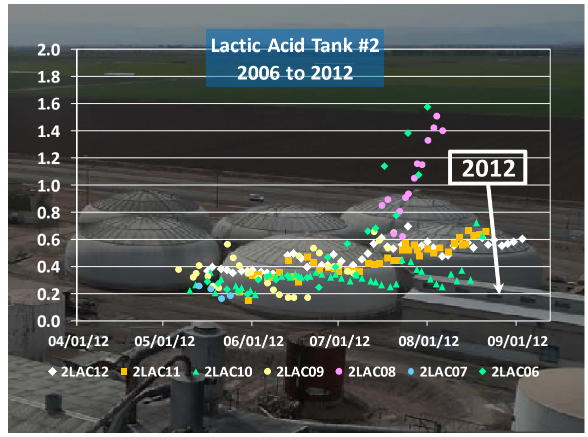


Tank 2 History

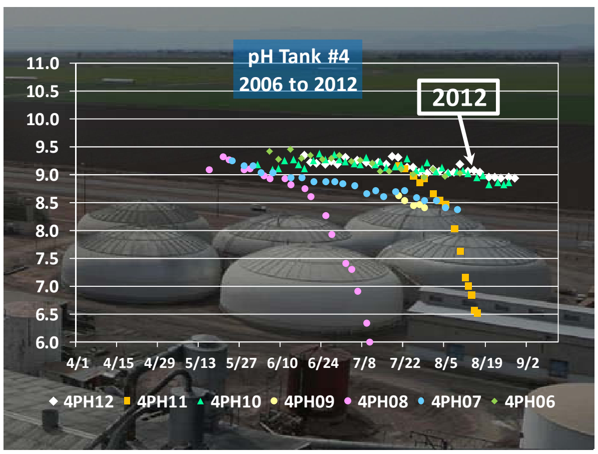


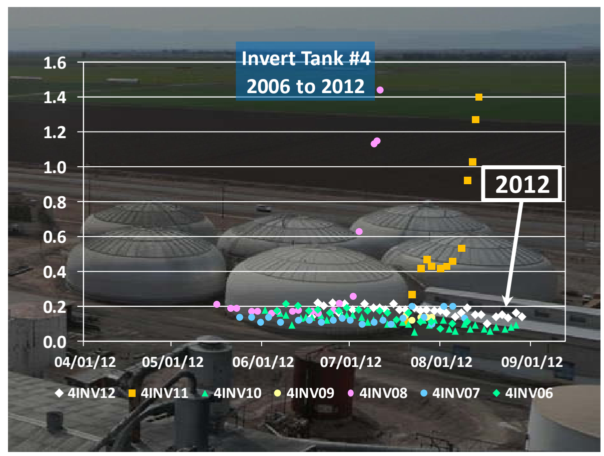


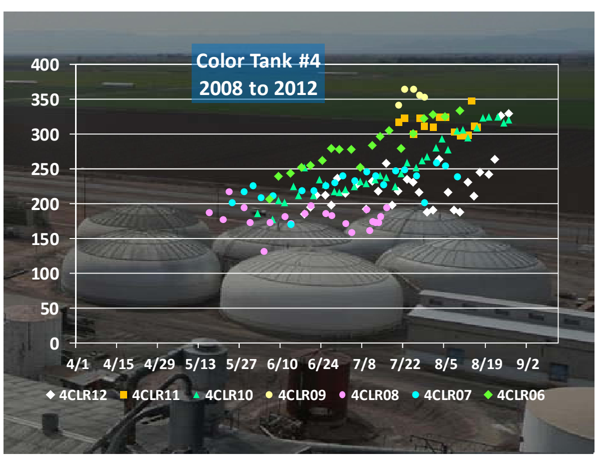


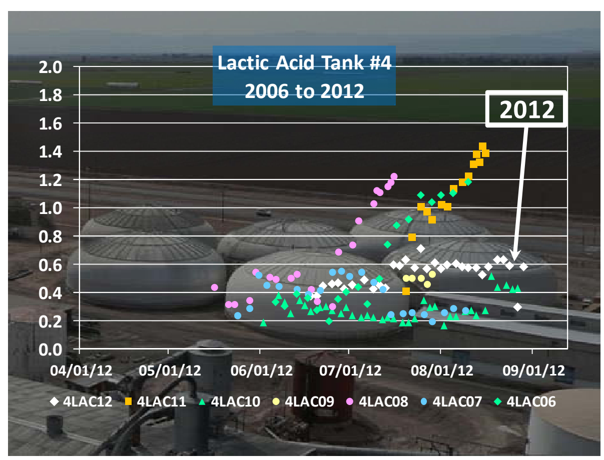


Tank 4 History



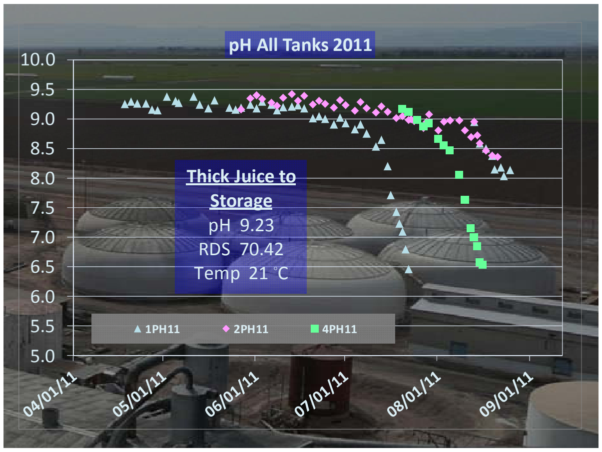


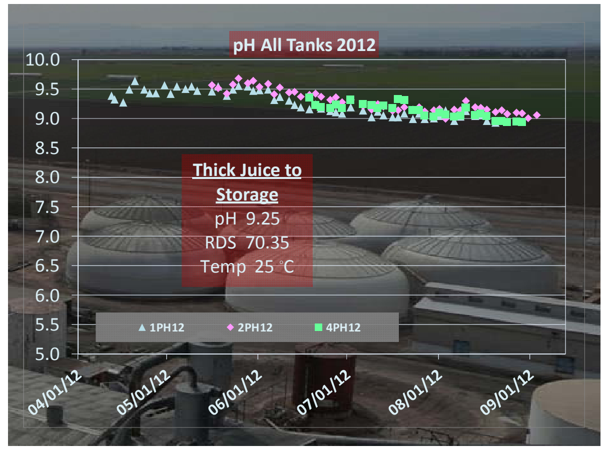




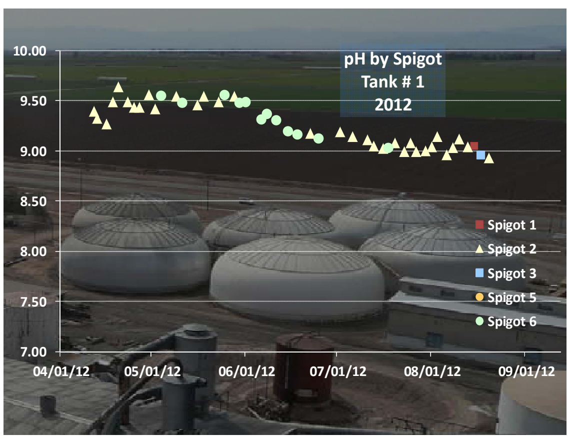
Results:

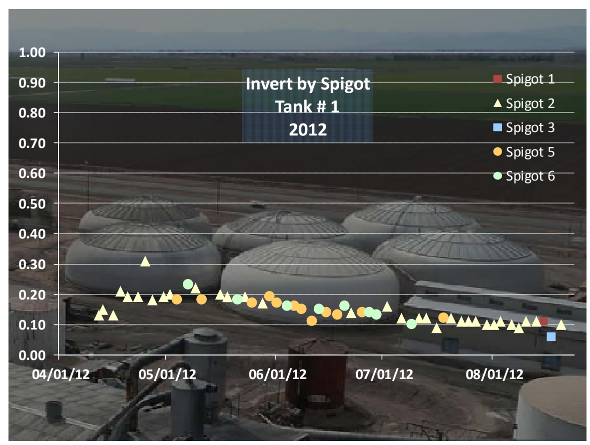
Comparison of pH in all juice storage tanks 2011 vs. 2012

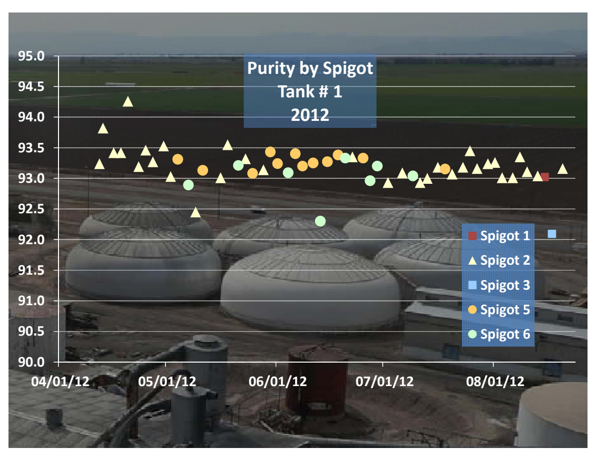




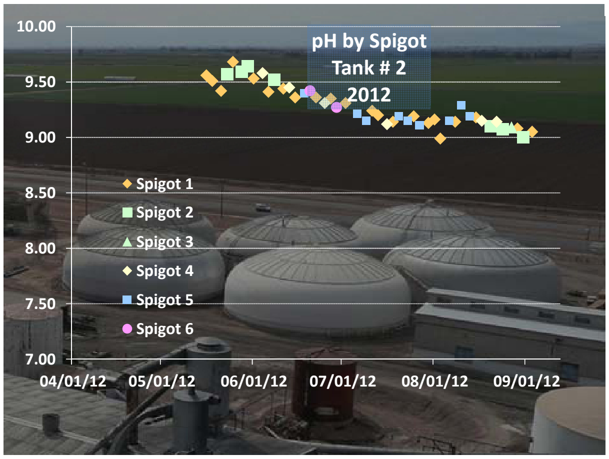
Tank 1 juice quality levels (pH, invert, color, and purity) by spigot.

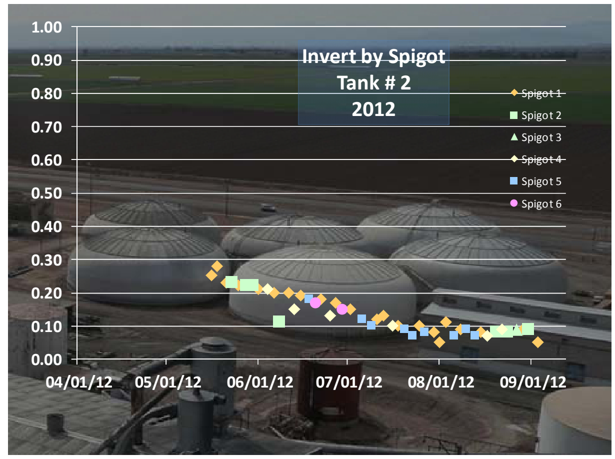


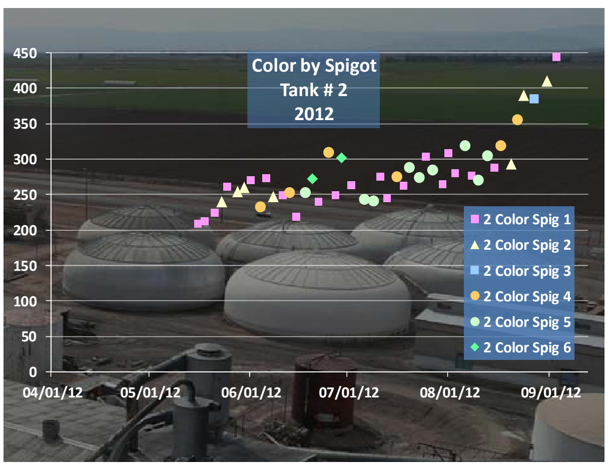


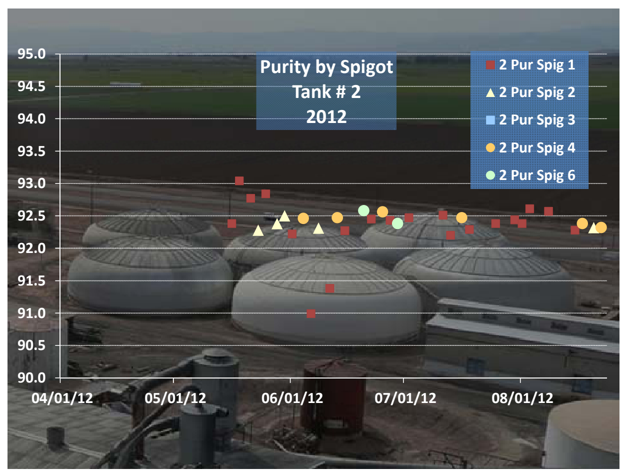


Tank 2 juice quality levels (pH, invert, color, and purity) by spigot.

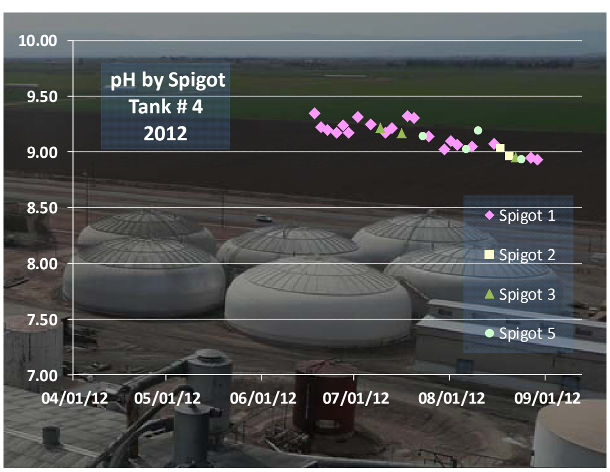


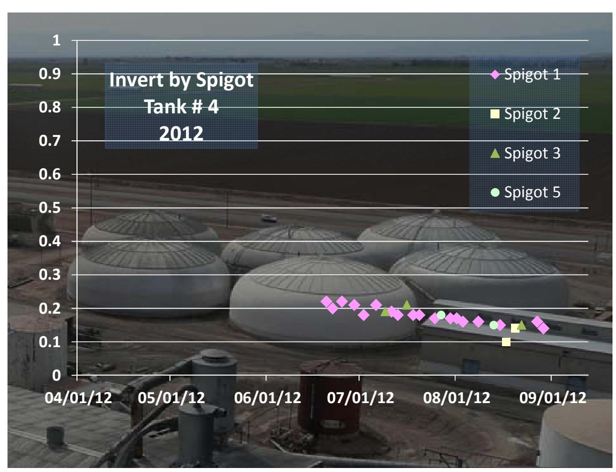


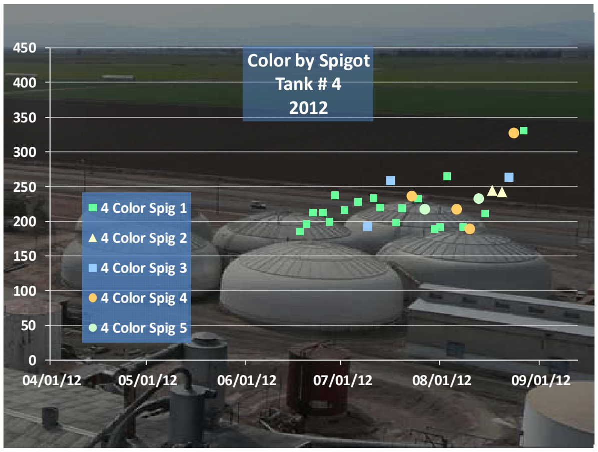


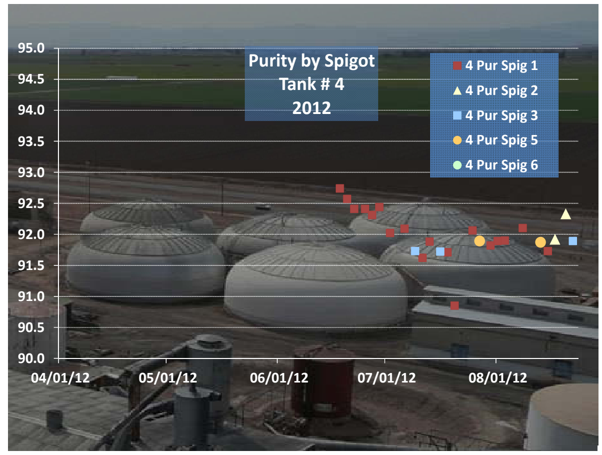


Tank 4 juice quality levels (pH, invert, color, and purity) by spigot.









Conclusion:

1. All the thick juice sent to storage was recovered and processed as sellable sugar.
2. Tanks 2 and 4 showed an unexpected rise in color.
3. The cost of the treatment was $0.02 per hundred weight of sugar.
4. The test will be resumed next campaign.

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